CHAPTER 11.
MARINE BIOLOGICAL RESOURCES

11.1 AFFECTED ENVIRONMENT

A description of the potentially affected environment fnor marine biological resources in Apra Harbor is presented in Volume 2, Chapter 11. This chapter describes the potentially affected environment for marine biological resources in Outer Apra Harbor, where the proposed aircraft carrier berthing would occur. The Marine Biological Resources chapters (Chapter 11) of both Volume 2 and Volume 4 should be read to understand the status of the existing marine environment in both Inner and Outer Apra Harbor with respect to the proposed action. See Volume 2, Chapter 16, Section 16.1.6 for a discussion of coral as it relates to an overall increased human population as a result of the proposed action.

Figure 11.1-1 shows a bathymetric map of the project area and the proposed aircraft carrier berthing alternatives (Alternative 1 Polaris Point and Alternative 2 Former Ship Repair Facility [SRF]). The proposed channel and turning basins are bordered by several large “patch reefs” or “shoal areas” that consist of shallow, flat-topped, and steep-sided features. The largest three of these reefs are Jade Shoals, Western Shoals, and Big Blue Reef (shoal areas). These reefs all consist of relatively flat and shallow upper surfaces that are covered with a mixture of live coral, rubble, algae-covered dead coral, and to a lesser extent, muddy sand. The western facing slopes of Western Shoals and Big Blue Reef are almost completely covered with living corals to a depth of approximately 50 to 60 feet (ft) (15 to 18 meters [m]), where the slopes intersect the channel floor. Coral cover on the eastern slopes of these two reefs is much less compared to the western slopes. The Jade Shoals site, located to the northeast of Western Shoals and Big Blue Reef, does not show the same degree of asymmetrical coral growth on the western edge, with most of the shoal ringed by slopes with high coral cover (Navy 2009a).

The area demarcated as the project area and turning basin, including the proposed wharf area, presently contains minimal areas of the shallow shoal patch reefs, including the deep edge areas of Jade Shoals and Middle Shoals and the western portion of an unnamed patch reef located to the northwest of Jade Shoals. This area was dredged in 1946 to allow safe access to the newly completed Inner Apra Harbor. As a result, the shallowest depth within the channel and turning basin is about 40 ft (12 m). It is likely that the large flat area in the southern end of the turning basin was another shoal area similar to the surrounding reefs prior to the 1946 dredging. Dredging likely removed the shallow area, resulting in the present configuration. While the top of the deep reef is essentially flat at a depth of approximately 40 ft (12 m), the remaining edges slope relatively steeply to the channel floor (Dollar et al. 2009). The elapsed time since dredging of the original channel suggests that much of the coral within the depth zone to be dredged for the aircraft carrier project (-49.5 ft [-15 m] mean lower low water [MLLW] plus 2 ft [0.6 m] of overdredge) is regrowth, which would indicate a community with a maximum age of 62 years (Dollar et al. 2009). As described by Smith (2007), a substantial percentage of the coral at all depth contours off Polaris Point was growing on metallic and/or concrete debris, was of marginal quality, and showed the greatest signs of stress. This stress appeared to be due in part to high levels of total suspended solids (TSS) coming from Inner Apra Harbor.

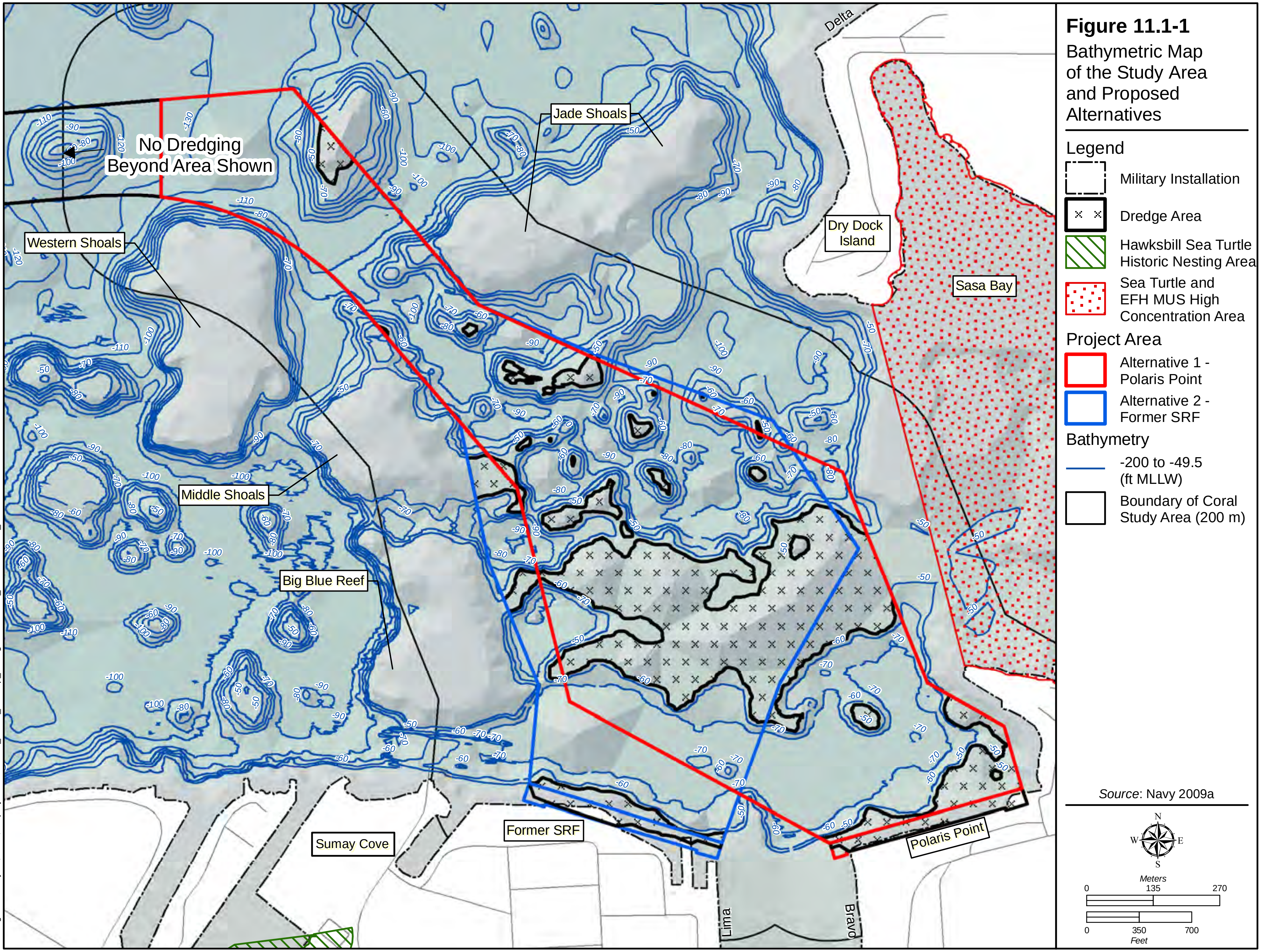

Figure 11.1-1
Bathymetric Map of the Study Area and Proposed Alternatives

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11.1.1 Coral Assessment Methodology

As coral and coral reef ecosystems are extremely important and fragile resources, various methods have been developed to quantitatively assess their condition and the nature and extent of human damage to coral populations and coral reef ecosytem functions and services when it occurs. A review by Viehman et. al. (2009) evaluates the pros, cons, and difficulties of alternative methods used to assess damage tocoral reefs. The Navy's methodology, including the use of Habitat Equivalency Analysis (HEA) and coral coverage measurements within the framework of natural resource damage assessment (NRDA), parallels the current state of science and practice as identified in the Viehman et al. (2009) review. The EPA and Resource Agencies recommended collecting additional size-frequency measurements to further define coral reef function.

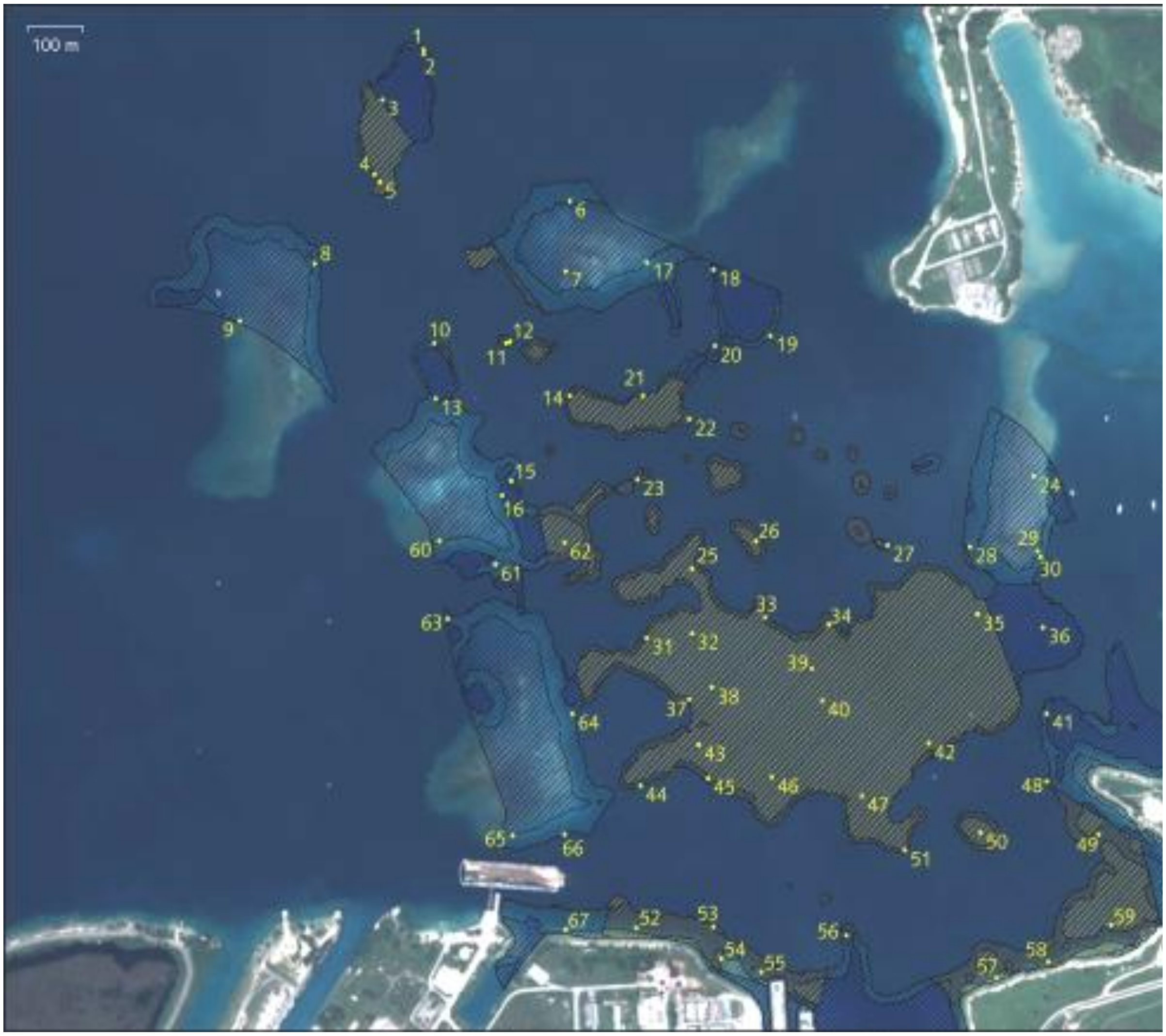
The original intent of NRDA was to address issues related to vessel groundings/oil spills, but the parameters used in NRDA to evaluate service loss and derive mitigation needs can also be applied to dredging or other types of impacts. Under the Clean Water Act (CWA), as identified in the 10 April 2008 compensatory mitigation rule (33 CFR 325, 332; 40 CFR Part 230), the issuance of a permit by the U.S. Army Corps of Engineers (USACE) for the discharge of dredged material or fill into the waters of the United States requires compensatory mitigation when necessary to ensure no net loss of ecosystem functions and services.

NRDA is an evolving science, and various methods of evaluating habitat loss exist. The use of HEA along with the incorporation of coral coverage measurements that are sufficient for the specific geographical area of habitat loss is one method that has been implemented and accepted by scientists as valid (Viehman et al. 2009).

The description of baseline conditions of the coral and coral reef ecosystem within Apra Harbor relies on several recent studies summarized below. Those studies that were prepared specifically for this proposed action are included in Volume 9, Appendix J.

i. *Assessment of Benthic Community Structure in the Vicinity of the Proposed Turning Basin and Berthing Area for Carrier Vessels Nuclear (CVN) Apra Harbor, Guam* (Dollar et al. 2009) included in Volume 9, Appendix J.

Survey data were collected from 67 transect points (Figure 11.1-2) to provide preliminary evaluation of the composition of benthic community structure within the area that would be affected by the proposed aircraft carrier wharf construction and operation. This was the primary source of affected environment and impact assessment information. The data were also used for inputs into an HEA. Volume 9, Appendix J provides detailed descriptions of survey methods, coral stress assessment, and remote sensing analysis. This report was peer reviewed by eight scientists and these reviews are also in Volume 9, Appendix J.



Source: Dollar et. al. 2009

Figure 11.1-2. Outer Apra Harbor Showing 67 Data Points/Transect Stations for Coral Habitat Surveys

(black hatching = potential direct impacts; blue hatching = potential indirect impacts)

ii. *Ecological Assessment of Stony Corals and Associated Organisms in the Eastern Portions of Apra Harbor, Guam* (Smith 2007).

The primary objective of this survey was to quantitatively assess the distribution and abundance of Scleractinian (stony) corals within seven selected portions of Apra Harbor. Data collection included determination of the presence of coral taxa, frequency of occurrence along transects (utilizing point-quarter methods), relative densities, size distribution, percentage of coral (hard and soft) coverage, and apparent "health." Qualitative and semi-quantitative data were also gathered on selected species of macroalgae and macrobenthic invertebrates, finfish, and sea turtles. Consideration was also given to Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPCs).

iii. *Habitat Equivalency Analysis (HEA) and Supporting Studies* (Navy 2009a).

This study is included in its entirety in Volume 9, Appendix E. The documents coral methodology was peer reviewed by eight world-renowned coral scientists and the reviews are included in Volume 9, Appendix J. The report contains an introduction (Section A), and five stand-alone technical reports (Sections B through F) as referenced below:

A. *Introduction*
B. *Reconnaissance Surveys of the Marine Environment, Eastern Outer Apra Harbor, Guam, and Baseline Assessment of Marine Water Chemistry* (MRC 2009a).
C. *Assessment of the Affected Marine Environment, Outer and Inner Harbor, Guam* (MRC 2009b).
D. *Marine Ecosystem Impact Analysis CVN Project Outer Apra Harbor, Guam* (MRC 2009c).
E. *Current Measurement and Numerical Model Study for CVN Berthing* (SEI 2009).
F. *Habitat Equivalency Analysis (HEA) Mitigation of Coral Habitat Losses* (IEI 2009).

iv. *Quantitative Assessment of the Reef Fish Communities in Apra Harbor, Guam (University of Guam* [UoG] 2009)

This study is also included in Volume 9, Appendix J. This assessment consisted of underwater surveys (Figure 11.1-2). The surveys were used to quantitatively assess species richness, abundance, and biomass of reef fish communities within and adjacent to the proposed project area. Multivariate analysis was performed on the data collected to determine groupings of fish communities based on depth/habitat gradient, diversity and biomass.

v. *Comparison of a Photographic and an In Situ Method to Assess the Coral Reef Benthic Community in Apra Harbor, Guam* (Minton et al. 2009).

The fifth study provided in Volume 9, Appendix J documents a joint-resource agency (U.S. Fish and Wildlife Service [USFWS], Guam Coastal Management Program, UoG, and National Marine Fisheries Service [NMFS]) effort to compare an *in situ* quadrat method (ISM) and a photographic quadrat method (PM) using eight different data types collected on a heterogeneous coral reef in Apra Harbor. This study has been used in the EIS for supplemental information.

Because the CVN project represents the first test of the functional assessment requirements (vs. area only) for large-scale coral reef impacts in the Pacific Ocean, EPA and the Resource agencies have recommended that additional size-frequency data be collected to augment the Navy's methodology.

11.1.2 Comparison of Methodologies to Assess Impacts to Coral

The Navy acknowledges there is no commonly accepted scientific methodology, nor regulatory mandated method to estimate coral reef function. In its simplest form, the objective of the NRDA process is to estimate the restoration services required to replace lost ecological services from the injuries caused by the responsible party. It is often difficult to know whether the proposed restoration actions are sufficientto reach this objective given the current state of reef restoration science. While the practical and measurable goals of restoration are to rapidly re-create the structure and functions of an injured habitat, the approaches for realizing this goal are continually evolving. There is a delicate balance between broad, general operating principles and site specificity. Careful selection of the theoretical NRDA approach (HEA-based using two-dimensional coral cover or composite metrics, or REA-based using size-frequency distributions) and metrics appropriate to both the degree and extent of injury and of habitat type will serve as a vital link between the damage assessment, recovery modeling, compensatory calculations, and recovery monitoring. An immense amount of information is necessary to fully understand the type and

magnitude of ecological services provided by the injured coral reef in its baseline condition, the manner in which those ecological services will recover following the injury, and the relationship of those services with those provided via compensatory restoration projects.

Size-frequency is an *in-situ* ("on-site" or "in place") measurement of discrete coral colonies to obtain size-frequency distribution data. Size-frequency measurements provide information about coral colonies and the roles individual corals play in an ecosystem. This size-frequency method has been proposed by other scientists as an additional quantifiable method of assessment.

Satellite imagery/rugosity consists of light detection and ranging (LIDAR) photographic imagery combined with *in-situ* measurements of coral community structure. The photographic data consists of satellite and underwater imagery. Satellite imagery was analyzed in a laboratory setting to obtain a percent coral cover estimate, and was added to subsequent rugosity data obtained in-situ at those sites.

The photographic percent coral cover and rugosity method was employed by the Navy to conduct the resource assessment during fieldwork performed. In addition to its current utility this method provides an opportunity for additional data to be derived as the science matures... Coral coverage estimates gleaned from remote sensing techniques capture the two-dimensional state of the habitat, can be

re-examined if necessary, can be replicated at any location, and is logistically simple and cost-effective to collect. This information, in addition with the rugosity data collected with subsequent surveys, provides an accurate and adequate representation of the coral habitat for the purposes of the programmatic decision to locate a transient CVN berthing facility.

It must be noted that all sampling methods used in a study area have limitations, but in this case and at this geographic location, the coral coverage method provides sufficient information for the programmatic decision to proceed with the proposed location of a CVN berthing facility on Guam, and additional studies will be conducted before the Navy decides where on Guam to propose to locate that facility.

The discussions with EPA, NOAA, and DOI also led to a better understanding on the part of the Navy regarding the concerns of the regulatory agencies and the public about the analysis presented in the DEIS. The discussions also clarified concerns about the sufficiency of the information that would be required to support future site selection and Federal permitting actions to allow for construction of the proposed transient aircraft carrier berth when it is time to make decisions on the specific site for the transient berth. Based on the level of concern expressed in comments on the DEIS, continued discussions with cooperating agencies under NEPA, and the Navy's continuing commitment to environmental stewardship, the Navy has elected to forego selection of a specific site for the transient aircraft carrier berth within Apra Harbor for the near term. The Navy will continue to proceed toward a decision whether to locate a transient aircraft carrier berth generally within Apra Harbor but will defer a decision on a specific site for the transient berth. Discussions with EPA, NOAA and DOI identified additional data these agencies would prefer to have available for analyzing specific sites for the CVN transient berth. The Navy will voluntarily collect additional data on marine resources in Apra Harbor at the alternative transient aircraft carrier berth sites still under consideration by the Navy. The type and scope of the additional data to be collected has been developed cooperatively with EPA, NOAA, and DOI and is described in the "Final Scope of Work Elements for Marine Surveys of the CVN Transient Berth Project Area, Potential Mitigation sites, and Habitat Equivalency Analysis" included in Volume 9. The additional data collected, associated analysis, and any other data that may be required by the USACE during the CWA and RHA permitting processes, will be used in the future to inform the selection of a specific site for the transient aircraft carrier berth and to support any CWA and RHA permitting decisions and appropriate compensatory mitigation. The additional data collected and analyzed for specific sites will be used by the Navy as provided in the CEQ regulations governing supplemental and tiered environmental impact analysis (40 CFR §§ 1502.09 and 1502.20). Based on those discussions, EPA, NOAA, and DOI acknowledged that the Navy's current analysis is sufficient to support a programmatic decision to locate a deep draft transient berth for a CVN on Guam. The Navy, EPA, NOAA, and DOI also recognize that the Navy has stated its preferred alternative and that decisions about the final location of the transient berth have not been made.

11.1.3 Marine Flora, Invertebrates, and Associated EFH

Similar to the information presented in Volume 2, this chapter provides a description of marine flora and macroinvertebrates found within the ROI, but also includes a substantially more detailed description of coral and coral reef ecosystems. For more detailed general descriptions of EFH within the ROI see Volume 2, Chapter 11, section 11.1.4.2. Organisms described include macroalgae (or seaweeds), sea grasses, emergent vegetation (plants that are rooted in the substrate beneath water, but grow tall enough to protrude above water or have leaves that float on the water), gastropods (snails), cephalopods (squid and octopus), crustaceans (lobsters and crabs), and sponges. These taxonomic groups are also included within the managed fisheries in the Western Pacific under five fisheries management plans (FMPs), now included in two recently approved fisheries ecosystem plans (FEPs), the Mariana Archipelago FEP and Pelagics FEP (NMFS 2010a): (1) coral reef ecosystems (2) bottomfish and seamount groundfish, (3) crustaceans, (4) precious corals, and (5) pelagic species. The FEPs identify specific management unit species (MUS) managed under the respective plan (Western Pacific Regional Fisheries Management Council [WPRFMC] 2009a and WPRFMC 2009b). Essential Fish Habitats defined under each FEP are described further below. Coral and coral reef ecosystem impacts are addressed under the EFH environmental consequences section.

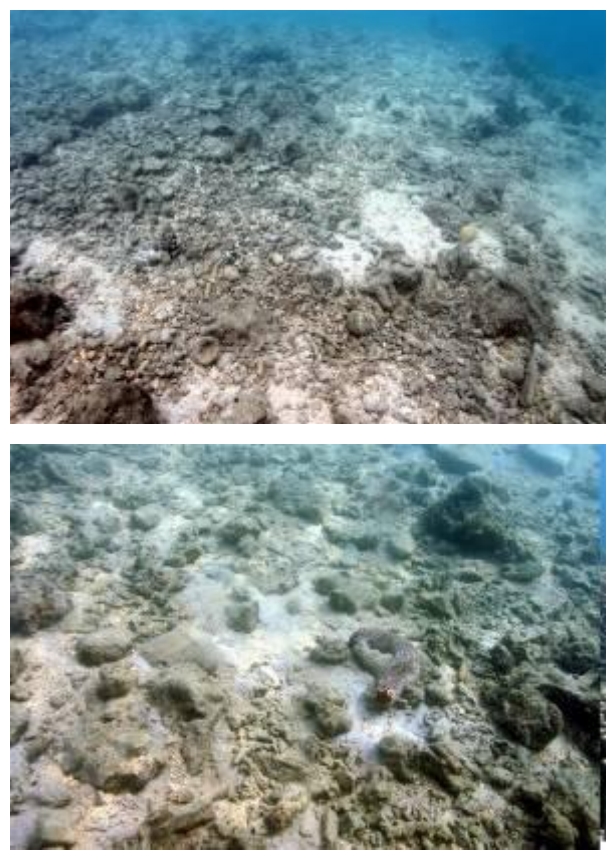


Figure 11.1-3. Sand-rubble bottom (0% coral coverage) at Transects 58 (upper) and 67 (lower) (both potential direct dredge impacted areas; 35% of the dredge area includes this bottom type).

The structure of the marine benthic environment off the eastern shoreline in the vicinity of the aircraft carrier channel and turning basin is composed primarily of three major biotopes and eight secondary biotopes. A biotope is defined as an area that is relatively uniform in environmental conditions and in its distribution of its animal and plant life (i.e., also benthic community structure). These three major areas are: 1) large flat-topped reefs 2) dredged reefs in the turning basin and entrance channel, and 3) soft sediment areas in the turning basin and entrance channel (Dollar et al. 2009). The eight secondary biotopes are described below with representative photos depicting examples of each secondary biotope. The photo captions also contain the approximate percentage of the proposed dredge area that would contain that particular type of biotope. The photos are representative visual examples of conditions observed throughout each secondary biotope during dive surveys.

11.1.3.1 Eight Secondary Biotopes of the Survey Area

Data on biotopes in the ROI were summarized by Dollar et al. (2009) and provided below, unless identified otherwise. "The survey area consists of a heterogeneous mix of a variety of several biotopes ranging from mud flats to algal meadows to a wide structural array of reef coral communities (in terms of both species assemblages and physical forms). Bray-Curtis similarity indices revealed seven distinct community groups with respect to the "general classes" of transect cover (e.g., algae, coral, sponges, sediment). When "detailed classes" containing all identified species and substratum types were analyzed, 16 distinct community groups emerge." Descriptions of these biotopes are summarized below. Transect locations are shown on Figure 11.1-2.

Figure 11.1-4. Algae dominated areas of the CVN study area (0% coral coverage) include mats of *Padina* spp. (40% of the dredge area includes an algal bottom type).

<u>Rubble, Mud and Sand</u>

Many regions of the aircraft carrier berthing study area were not colonized by any epi-benthic biota. Benthic cover in these areas consisted of plains of fine grained sand-mud (90% of the surficial sediments were very fine sand sized or coarser, and had a median grain size of approximately 0.004 in [0.1 mm] [very fine to fine sand]) (NAVFAC Pacific 2006), primarily composed of calcium carbonate (Figure 11.1-3). Numerous burrows and mounds from infaunal organisms like worms and crustaceans punctuated most of the sand-mud regions. In addition, the surface of the sediment was often covered with thin films of bacteria or micro-algae.

In addition to the sand-mud plains, some areas of the bottom were covered uniformly with a layer of mixed rubble and coarse sand. Most of the rubble is recognizable as dead coral fragments. The harbor floor associated with and fronting Polaris Point (Transects 57, 58, 35) and the Former SRF (Transects 52, 53, and 54), was composed predominantly of rubble and sand (Figure 11.1-3).

Algal Beds

In addition to hermatypic corals, the other dominant benthic organisms within the study area are macroalgae, which consists of approximately 40% of the identified benthic cover. While there are biotopes that consist of "coral-algal mixes" (see mixed coral-algae below), there are also areas of predominantly algae stands. Three genera of algae are most prevalent, and in some areas are present in nearly monospecific meadows that extend over hundreds of square meters. The most common plant appears to be the brown alga *Padina spp*, which was found throughout the survey area. This alga is characterized by large, calcified, fan-shaped blades that grow in multiple clusters attached to rubble, sand or hard bottom (Figure 11.1-4). Also abundant is the calcareous green alga *Halimeda spp*., with fronds consisting of vertical series of connected flat segments. Much of the *Halimeda* observed in Apra Harbor was growing in dense beds over sandy bottoms. In these areas white calcified remains of plant segments form a component of the sandy substratum. The third dominant alga is *Dictyota spp*. which occurs as narrow, spirally twisting branches that are split on the ends. *Dictyota* was often seen in mats of mixed algae and mixed coral-algae, and was particularly abundant over sand-covered bottom.

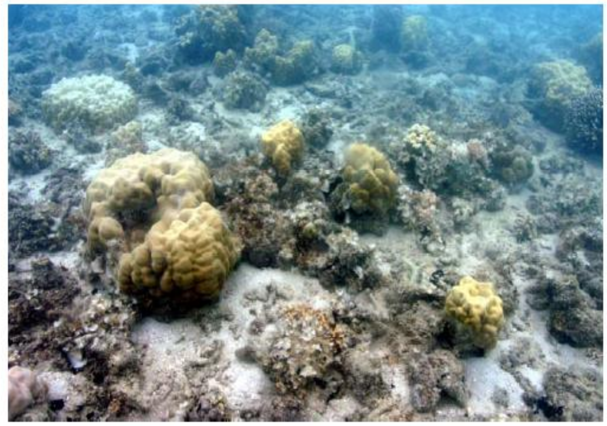


Figure 11.1-5. Representative areas of mixed algae and coral on Transect 17 (a potentially indirectly [siltation only] impacted site) is representative of an area with 30% to <50% coral coverage.

Mixed Coral-Algae

Several biotopes which comprise the majority of benthic cover consist of combinations of two or more of the predominant communities described above. One of these combination biotopes can be termed "mixed coral-algae." One such combination consisted of hemispherical heads of *Porites lutea* amid stands of *Padina spp*. on the shallow tops and sides of patch reefs (Figure 11.1-5). In the deeper areas, particularly on the tops of the dredged platforms and pinnacles in the turning basin, combined algal-coral communities occurred in a variety of forms, including films of benthic bacteria on mud surfaces, short turfs on rubble fragments, and mats of *Halimeda* and *Dictyota* interspersed with colonies of *Porites*. A unique coral-algal assemblage occurred on Transect 9, where stands of living *Acropora aspera* were interspersed with sectors of dead branches encrusted with a layer of algal turf and cyanobacteria.

Figure 11.1-6. Benthic cover of upper edges of patch reefs on Transect 21 (a potentially directly [dredged] impacted site) dominated by hemispherical colonies of *P. lutea* (represents 70% to <90% coverage) – 4.8% of this bottom type may be indirectly impacted.

Patch Reef Margins – P. lutea Zone

P. lutea generally occurs as hemispherical or helmet shaped colonies and is a major component of benthic cover on the margins of the tops of patch reefs in the aircraft carrier berthing study area. Water depth of these flats is the shallowest of all biotopes, and is generally in the range of 3-7 ft (1-2 m). Within this zone, colonies of *P. lutea* are often densely packed together with adjacent colonies in contact with one another. Other dominant corals in this biotope included *P. cylindrica*, occurring in branched clusters, and *P. rus*, which occurred primarily of flat-topped clusters of densely packed branches (Figure 11.1-6). Moving off the flat surfaces of the patch reefs, community structure rapidly changes to a more uniform cover of *P. rus*, as described in the sections above.

Patch Reef Margins – *A. aspera* Mat

Transect 9, located on the top of the northwestern edge of Western Shoals, consisted entirely of a contiguous mat of the branching coral *A. aspera* (Figure 11.1-7). The field of *A. aspera* was limited to the top of the patch reef, and did not extend beyond a depth of approximately 3-7 ft (1-2 m), below which the benthic community was dominated by *Porites* species (Figure 11.1-7). This biotope was not observed in the vicinity of any of the other transects in the study area. The uniqueness of the biotope may be a result of orientation of the western edge of Western Shoals to the long axis of Outer Apra Harbor. During surveys, swells entering the harbor mouth were breaking at the transect location. A distinctive characteristic of the *A. aspera* mat was the occurrence of large sections of dead branches that were encrusted with algae or cyanobacterial mats. As the dead portions of these *Acropora* stands were completely intact, the cause of mortality cannot be attributed to any type of physical forces applied to the fragile branching matrix.

In addition, there were distinct boundaries between areas of apparently healthy branches and patches of dead branches. Within the dead patches, there were also clumps of "new" live branches with no sign of any abnormalities. One possible cause of the patchy mortality of the *Acropora* field is infestation of a black sponge that occurred within the coral thicket, completely covering branches (refer to Figure 11.1-7). While the smothering of live coral by the black sponge may be a cause of mortality, the presence of the sponge appeared ephemeral, as it was not evident in much of the area of algal-encrusted coral skeletons. In addition, the presence of patches of apparently healthy coral resulting from either planular settlement or vegetative spreading within the thickets of dead branches suggests that there is an ongoing dynamic process of coral-sponge interactions of mortality and recovery within the biotope (refer to Figure 11.1-7). Other possible causes of coral mortality include coral bleaching and coral disease.

Figure 11.1-7. Monospecific field of *A. aspera* with black sponge smothering coral located at Western Shoals, Transect 9 (a potentially indirectly [siltation only] impacted site).

Mixed Coral Communities

Coral community structure on some areas of the flatter sections of patch reef slopes as well as deep reef flats consisted of higher cover of a more diverse community than in the areas dominated solely by *P. rus*. Along with *P. rus*, two branching species, *Porites cylindrica (P. cylindrica)* and *Pavona cactus*, comprise substantial proportions of bottom cover. *P. cylindrica* occurs as thin rounded upright branches, with individual branches separated by an encrusting matrix base. *Pavona cactus* occurs as thin, upright, contorted fronds, each attached to a solid base. Both of these corals grow in interconnected stands that can extend over large areas of the reef surface. In particular, on Transect 15, located on the eastern edge of the unnamed patch reef between Western Shoals and Big Blue Reef, *Pavona cactus*, *P. cylindrica*, and *P. rus* formed mixed complexes with substantial contributions from all three species. Thus, three of the four most abundant corals encountered in the aircraft carrier berthing area surveys (*P. rus*, *P. cylindrica* and *Pavona cactus*) often occur in the form of supracolonies or spreading mats composed of multiple branches or fronds in the vicinity of Transect 15.

Figure 11.1-8. Various plating and laminar growth forms of *P. rus*, including colonies with upper living surfaces partially covered with sediment.

<u>*Porites rus* "Supracolonies"</u>

By far, the most common coral in Apra Harbor is *P. rus*. Colonies of *P. rus* can be massive, columnar, laminar, or branching and encrusting, and single colonies can contain multiple growth forms (Figure 11.1-8). It is also common to see growth forms that fit under the definition coined by Pichon (1978) of "supracolonies." By this definition, one "colony" is a formation originating from one planula. As new colonies in close proximity grow in size, they fuse. Such a phenomenon, when constantly repeated, leads to a continuous living coral formation, composed of elements belonging to different generations. These conglomerate colonial structures, or supracolonies, may extend over tens or hundreds of square meters. In some instances supracolonies may be so large as to represent a whole ecological identity (i.e., a sub-community).

While *P. rus* occurs throughout the survey area, it is particularly widespread on the outer (with respect to the aircraft carrier entry channel and tuning basin) sloping sides of the five large patch reefs (Jade, Western, and Middle Shoals, and Big Blue Reef, and an unnamed reef) (Figure 11.1-9). *P. rus* occurs in a variety of contiguous supracolony structural forms that dominate the benthic surface. Most of these structures are composed of multitudes of overlapping thin semi-circular plates. Supracolonies have the form of vertical walls, massive dome-shaped structures, conical spires, masses of fallacious cup-shaped and tabular plates. The upper photo of Figure 11.1-8 shows a "supracolony" of *P. rus* comprised of

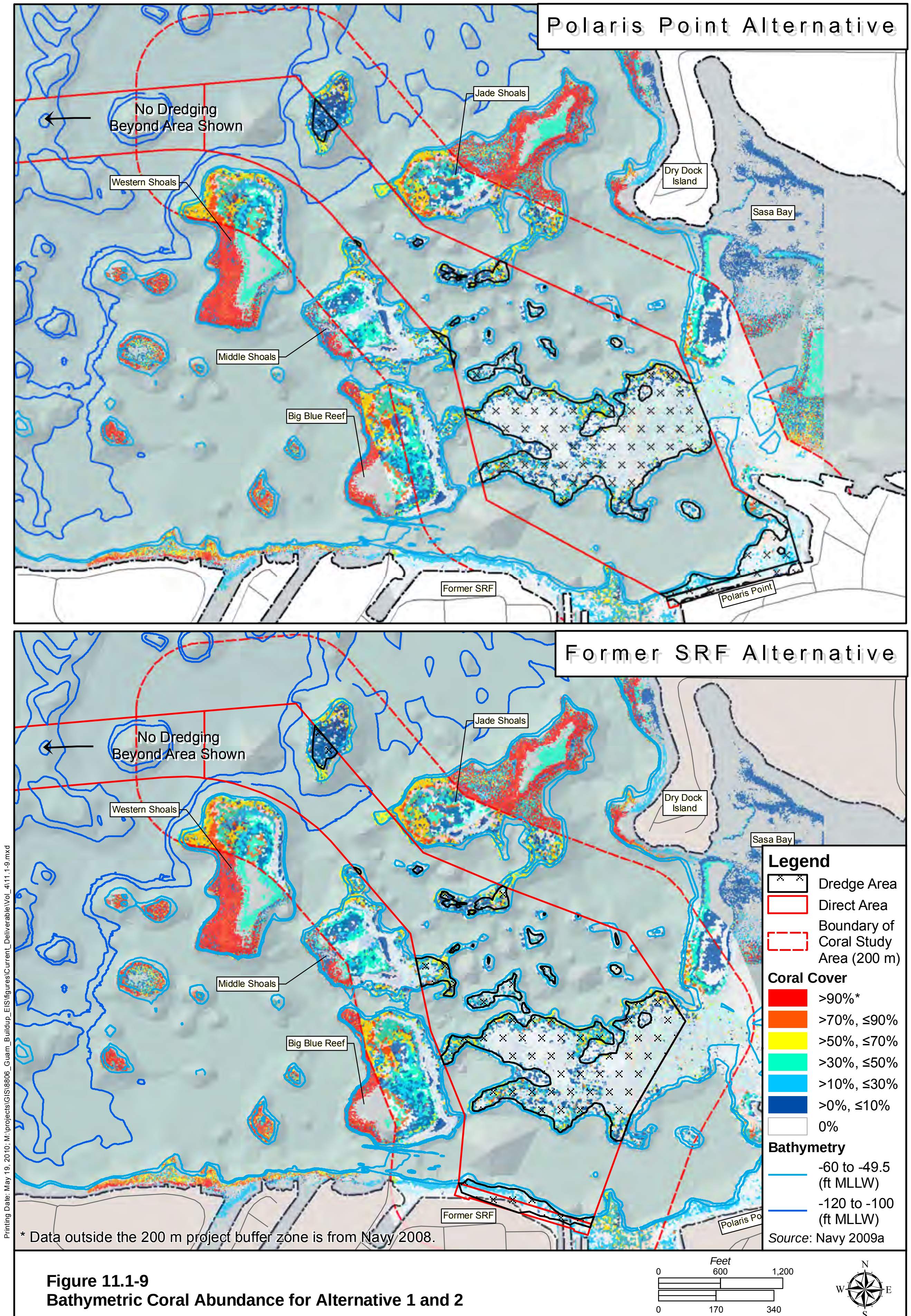


Figure 11.1-9
Bathymetric Coral Abundance for Alternative 1 and 2

the amalgamation of numerous smaller colonies (39 ft [12 m] in length) at Transect 15. The middle photo shows overlapping amalgamated plates.

In addition, colonies and supracolonies of *P. rus* can assume a variety of branching forms that occur in contiguous thickets covering large sections of the benthic surface. It is also common to see multiple growth forms (branches growing out of laminar plates" (Dollar et. al. 2009).

Coral on Sediment

With the exception of stony coral skeletons, the substratum of the study area consists primarily of sediment of various grain sizes (mud, sand, rubble). As a result, an important aspect of coral community structure is the interaction between corals and soft sediment. Throughout the aircraft carrier berthing study area, and particularly in the deeper survey sites, corals are growing on, or out of the sediment surface. *P. rus,* in particular, occurs in a variety of growth forms that can be considered adapted to colonizing areas of soft sediment. Many of these colonies do not have a solid attachment to the bottom, with upper living areas overlying a base of dead skeletal material that is partially buried in the mud. In addition, many colonies growing in areas of abundant sediment had portions of the colonies covered with fine-grained sand or mud. Supracolonies of *P. rus* in many of the deeper survey locations were made up of complexes of laminar plates comprised of sections of both dead and living tissue. Much of the dead plated surfaces on these structures contain an accumulation of fine grained sediment.

11.1.3.2 Coral and Coral Reef Community Data

Assessment of Benthic Community Structure in the Vicinity of the Proposed Turning Basin and Berthing Area for Carrier Vessels Nuclear (CVN) Apra Harbor, Guam (Dollar et al. 2009) is provided in Volume 9, Appendix J, and is the basis for the following summary, unless otherwise noted. This assessment is referred to hereafter as "the study."

The study area is shown in Figure 11.1-9. Solid lines indicate the boundary of the direct impact area associated with dredging. Three zones were evaluated to assess the potential indirect impacts from dredging. The dashed lines indicate the outer boundary of the coral study area and the quantitatively-derived "maximum adverse impact" scenario for indirect sediment impacts from dredging operations. This distance was set at a 656 ft (200 m) distance from the direct impact area boundary and was not modeled. As described later in this chapter, the 656 ft (200 m) distance represents a conservative overestimate of the potential indirect impact area; it bounds the maximum extent of potential benthic impacts and delimits the area for collection of baseline data at the associated patch reef and shoal areas. As described in the SEI (2009) plume modeling summary (Volume 9, Appendix E) discussed later in this chapter (Section 11.2.2.2 and Figures 11.2-2 and 11.2-3), the potential indirect impacts were modeled and indicated that sedimentation exceeding 0.009 ounces per square inch (oz/in^2) (40 mg/cm^2) or 0.008 in (0.2 millimeters [mm]) extended an average distance of 144 ft (44 m) from dredging. Additional modeling identified that an area located 40 ft (12 m) beyond the direct dredge impact area is anticipated to receive cumulative sedimentation totaling at least 0.2 in (5 mm); 0.2 in (5 mm), which was established as the cumulative sedimentation threshold for corals. The U.S. Army Corps of Engineers, Engineer Research and Development Center (ERDC) is evaluating the fate and transport of resuspended dredged sediment in Apra Harbor, Guam and refining, if necessary, the Navy sediment plume estimate. The model, being developed by the U.S. Army Corps of Engineers, is called the Particle Tracking Model (PTM), and its simulations will be used for the purpose of determining sediment pathways to coral reef regions from dredging locations associated with the proposed action. The results of this work will assist with quantifying deposition of dredged sediment onto coral reefs. Sediment pathway and fate assessment during dredging operations will provide critical data for the exposure segments of risk assessment needed for USACE CWA 404 permit.

The study assumed a 60 ft (18 m) dredge depth, which is an overestimate of the proposed dredge depth of -49.5 ft (-15 m) plus 2 ft (0.6 m) overdredge MLLW, representing an approximate 10-15% increase in assessed benthic habitat in the dredged area. For this reason, the total dredged area as noted in Table 11.1-1 differs from the dredged area provided in Volume 4, Chapter 4. The 60-ft (18-m) contours are shown on Figure 11.1-9, and those contours within the direct impact area indicate the areas where dredging would be required. In the indirect impact area, these contours represent the depth limit of the coral assessment. There is a substantial amount of overlap between the two alternative aircraft carrier wharf project areas. The total dredge area (coral and non-coral), as noted in Table 11.1-1, for Alternative 1 is 71.2 ac (28.8 ha) and for Alternative 2 is 60.8 ac (24.6 ha). These are overestimates of the proposed projects' dredge footprints due to the use of a 60 ft (18 m) dredge depth. As described in Volume 4, Chapter 2 where the true dredge depth of -49.5 ft [15-m.] plus 2 ft [0.6-m] overdredge was used, total dredge area is 53.0 ac (21.4 ha) for Alternative 1 and 44.3 ac (17.9 ha) for Alternative 2.

The most relevant findings from the Dollar et al. (2009) study are the following.

- There are five large patch reefs (Jade, Western, and Middle Shoals, Big Blue Reef and an unnamed reef) as shown on Figure 11.1-9. This area was dredged in 1946 to allow safe access to the newly completed Inner Apra Harbor.
- Coral cover was dominated by a single species, *P. rus*, which accounted for about 74% of total coral cover. Along with *P. rus*, the next three most abundant species (*P. lutea, Pavona cactus,* and *P. cylindrica*) accounted for 95% of coral cover.
- Throughout the aircraft carrier study area, and particularly in the deeper survey sites, corals are growing on, or out of the sediment surface. *P. rus*, in particular, occurs in a variety of growth forms that can be considered adapted to colonizing areas of soft sediment. Many of these colonies do not have a solid attachment to the bottom, with upper living areas overlying a base of dead skeletal material that is partially buried in the mud. In addition, many colonies growing in areas of abundant sediment had portions of the colonies covered with fine-grained sand or mud.

It is also evident that the area within the dredge boundaries contains relatively small areas of the densest classifications of very high cover (>50% coral). Areas that did contain the densest categories were generally along the sloping margins of the large patch reef outside of the dredge envelope. While the mapping results indicate that about 7-9% of bottom cover and 20% of coral cover for both alternatives is in the two highest cover classes (>50%), such areas are not concentrated in any particular biotope or region, but are spread across the dredge zones in relatively low densities.

Table 11.1-1. Coral Cover in Six Levels for Direct and Indirect Areas at Polaris Point and Former SRF Alternative Aircraft Carrier Wharf Sites, Apra Harbor Guam

	Alternative 1					
	Direct		*Indirect***		*Total*	
Coral Level	*ha*	*ac (% coral*)*	*ha*	*ac (% coral*)*	*ha*	*Ac (% coral*)*
Coral = 0%	**18.61**	**45.98**	**22.00**	**54.36**	**40.61**	**100.34**
0% < coral ≤ 10%	3.74	9.24 (37)	5.45	13.48 (29)	9.20	22.72 (32)
10% < coral ≤ 30%	2.61	6.44 (26)	3.85	9.52 (21)	6.46	15.96 (22)
30% < coral ≤ 50%	0.96	2.37 (9)	3.25	8.04 (17)	4.22	10.41 (15)
50% < coral ≤ 70%	1.80	4.44 (18)	4.19	10.35 (22)	5.99	14.79 (21)
70% < coral ≤ 90%	1.10	2.71 (11)	1.96	4.85 (11)	3.06	7.56 (11)
Total dredge area with coral	**10.20**	**25.20**	**18.71**	**46.24**	**28.91**	**71.44**
Total dredge area	**28.80**	**71.18**	**40.71**	**100.6**	**69.52**	**171.78**
Percent coral cover		**35%**		**46%**		**42%**
	Alternative 2					
	Direct		*Indirect*		*Total*	
Coral Level	*ha*	*ac (% coral*)*	*ha*	*ac (% coral*)*	*ha*	*ac (% coral*)*
Coral = 0%	**14.98**	**37.03**	**18.90**	**46.71**	**33.89**	**83.74**
0% < coral ≤ 10%	3.44	8.51(36)	5.34	13.20 (28)	8.79	21.72 (31)
10% < coral ≤ 30%	2.41	5.96 (25)	3.72	9.19 (20)	6.14	15.15 (21)
30% < coral ≤ 50%	0.93	2.29 (10)	3.45	8.53 (18)	4.38	10.82 (15)
50% < coral ≤ 70%	1.82	4.49 (19)	4.46	11.03 (23)	6.28	15.52 (22)
70% < coral ≤ 90%	1.01	2.48 (10)	2.13	5.25 (11)	3.13	7.74 (11)
Total dredge area with coral	**9.61**	**23.74**	**19.10**	**47.21**	**28.71**	**70.95**
Total dredge area	**24.59**	**60.77**	**38.06**	**93.92**	**62.60**	**154.69**
Percent coral cover:		**39%**		**50%**		**46%**

*Coral cover is rounded to the nearest percent and therefore may not total to 100%.

** Indirect impact area is based on a qualitatively-derived worse-case scenario limit of anticipated sediment effects out to the 200 foot estimated impact, and not upon the USACE PTM.

Source: Navy 2009a.

As indicated in Table 11.1-1, within the direct impact areas for both Alternative 1 and Alternative 2, the most represented class is that of the lowest non-zero coral cover (i.e., Class 2 [> 0% to ≤ 10%]). Of the areas in both alternatives that contain any coral, this class comprises about 38% of the total. For both alternatives, over half (~75%) of the areas with any coral cover are within Classes 2 and 3 (i.e., 0% < coral ≤ 30%).

The resultant analysis produced tables and maps showing six classifications of coral cover:

Class 1: 0% coral (See Figures 11.1-3 and 11.1-4 as an example)
Class 2: > 0% - ≤ 10%
Class 3: >10% - ≤ 30%
Class 4: >30% - ≤ 50% (See Figure 11.1-5 as an example)
Class 5: >50% - ≤ 70%
Class 6: >70% - ≤ 90% (See Figure 11.1-6 as an example)

Calibration-validation data to support the classification scheme were collected using field data in the form of photographic quadrat transects. Table 11.1-1 lists the coverage area of each coral class for Alternatives 1 and 2. Also shown for each alternative is the percentage of each coral class with respect to the total area of coral coverage, and the percentage of coral potentially impacted (direct and indirect) with respect to the total dredge area. Figure 11.1-10 displays the resulting benthic habitat map. Spectral resolution of the image allowed for distinction of six bottom classifications according to coral cover as described above. The extent and density of coral cover is delineated to a degree that can be of value for mitigation of reef area altered by the aircraft carrier wharf project.

Examination of the coverage table (Table 11.1-1) and coral map (Figure 11.1-10) reveals several important points:

- The total area of potential direct and indirect impacts to the region with coral is approximately 71.44 ac (28.91 ha) for Alternative 1 and 70.95 ac (28.71 ha) for Alternative 2.
- The total area of potential direct and indirect impacts of the region with and without coral is approximately 171.78 ac (69.52 ha) for Alternative 1 and 154.69 ac (62.60 ha) for Alternative 2.
- The total area of coral coverage of all classes associated with potential direct impacts is approximately 25.20 ac (10.20 ha) for Alternative 1 and 23.74 ac (9.61 ha) for Alternative 2. Hence, about 35% and 39% of the area to be dredged to reach the required depth presently contains some level of coral coverage for Alternative 1 and 2, respectively.
- It is also evident that the area within the project boundaries, as well as within the dredge area boundaries (Figure 11.1-10), does not contain any of the continuous areas of very high cover (>70% coral) that is the dominant cover category on the western margins of the large shoal reefs bordering the project area.
- While the mapping results indicate that about 10% of coral for both alternatives is in the highest cover class (>70%), such areas are not concentrated in any particular biotope or region, but are spread across the dredge zones in relatively low densities, mainly at the edges of the dredge perimeters.

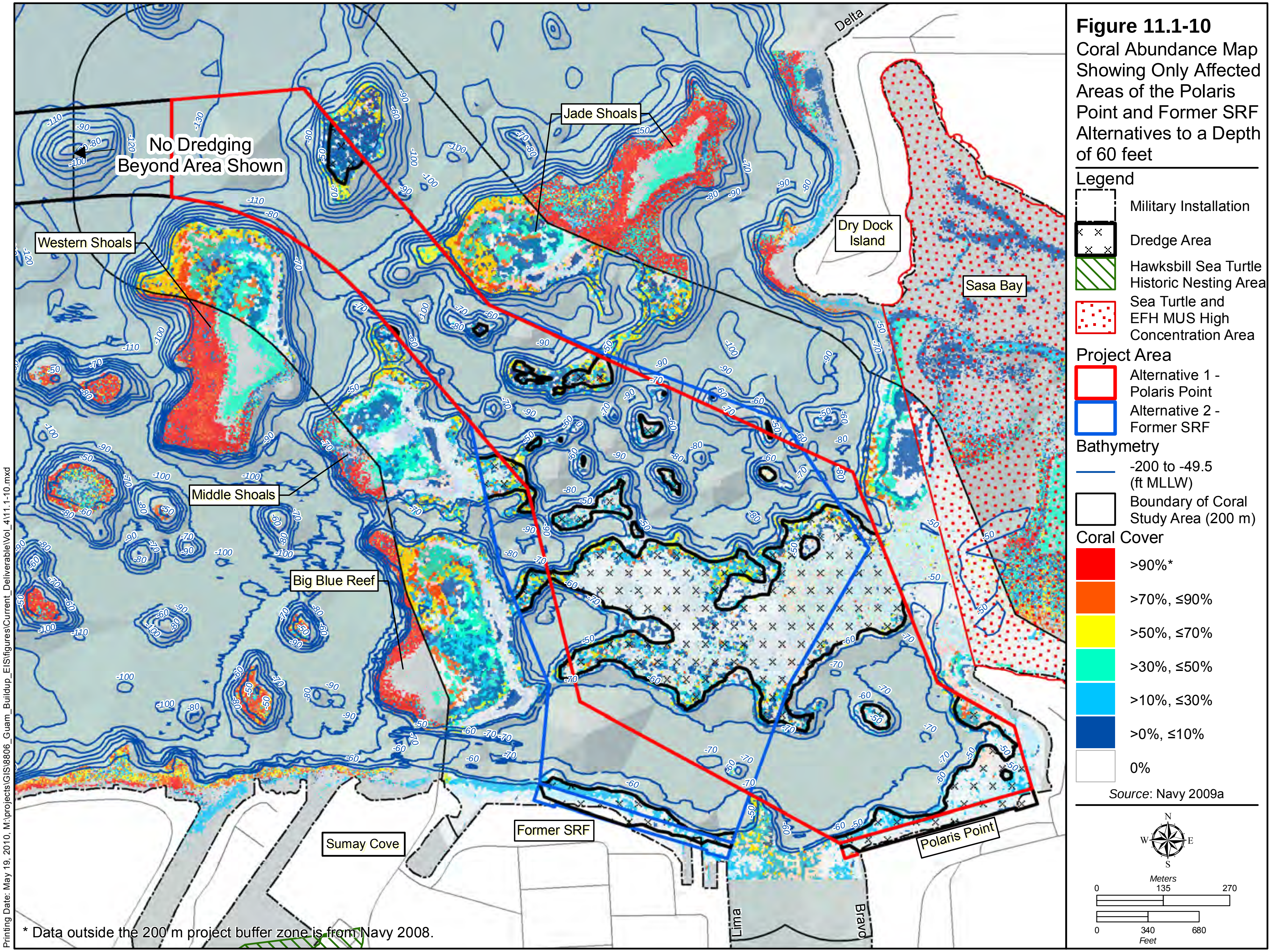


Figure 11.1-10
Coral Abundance Map Showing Only Affected Areas of the Polaris Point and Former SRF Alternatives to a Depth of 60 feet

For both alternatives, the single highest percentage class with coral to be removed is the lowest abundance class (>0 to ≤10% cover) at 37% for Polaris Point and 36% for Former SRF). Additionally, coral cover within the less than 30% cover classes accounts for 62% for Polaris Point and 60% for Alternative 2, respectively (refer to Table 11.1-1).

Transect Sites Unique to Each Alternative

As identified in Table 11.1-1, the total area to be dredged is approximately 71 ac (29 ha) for Alternative 1, and 61 ac (25 ha) for Alternative 2. The total area of coral coverage of all classes is 25 ac (10 ha) for Alternative 1 and 24 ac (10 ha) for Alternative 2. Hence, about 35% and 39% of the area to be dredged at Alternative 1 and Alternative 2 sites, respectively, contains some level of coral coverage.

Table 11.1-2 shows a similar assessment, including a representation of percent benthic cover within the direct removal footprint for each alternative. Of the 67 transect sites, 27 are co-located with Alternative 1 and 2 direct impact areas (i.e., benthic habitat that would be removed no matter which alternative is chosen), and 14 sites (8 from Alternative 1 and 6 from Alternative 2) are not associated with each other in regards to direct dredging activities (i.e., benthic habitat would only be indirectly impacted). Twenty six of the transect sites would receive indirect impacts (Figure 11.1-11).

The general benthic cover classes of these 14 sites are compared in Table 11.1-2, and show relative percentages of benthic cover within the direct foot print for both alternatives. If these numbers are compared with the total region to be dredged, the total percent coral coverage for all classes is approximately 10% for Alternative 1 and 17% for Alternative 2.

Table 11.1-2. General Classes of Benthic Cover Percentages Exclusively Associated with Either Alternative 1 or Alternative 2 Direct Impact Areas

Transect Number	*Algae*	*Stony Coral*	*Soft Coral*	*Sponge*	*Ascidians*	*Echinoderm*	*Sediment*	*Total*
Alternative 1								
42	1.08	0	0	0	0	0	98.92	100
48	37.07	6	0	0	0	0	59.93	100
49	18.80	48.13	0	3.47	0	0	29.60	100
50	82.67	0	0	0.53	0	0	16.80	100
51	86.15	0.46	0	0.62	0	0	12.77	100
57	50.67	0	0	0.40	0	0	48.93	100
58	26.40	0	0	2.27	0	0	71.33	100
59	19.33	24.53	0	1.47	0	0	54.67	100
Mean %	**40.27**	**9.89**	**0**	**1.19**	**0**	**0**	**49.14**	**100**
Alternative 2								
44	72.13	2.53	0	0.80	0	0	24.53	100
52	8.53	0	0	2.53	0	0	89.93	100
53	0	0	0	0	0	0	100	100
54	21.47	0	0	2.40	0	0	76.13	100
55	23.47	36.93	0	4.80	0	0	34.80	100
62	21	65.20	0	1.60	0	0	11.33	100
Mean %	**24.43**	**17.44**	**0**	**2.01**	**0**	**0**	**56.12**	**100**

Note: All benthic cover numbers are in percentages.

Source: Photo-quadrats from 67 transects was analyzed using CPCe software to obtain a quantitative dataset that can be used to describe the community (Dollar et al. 2009).

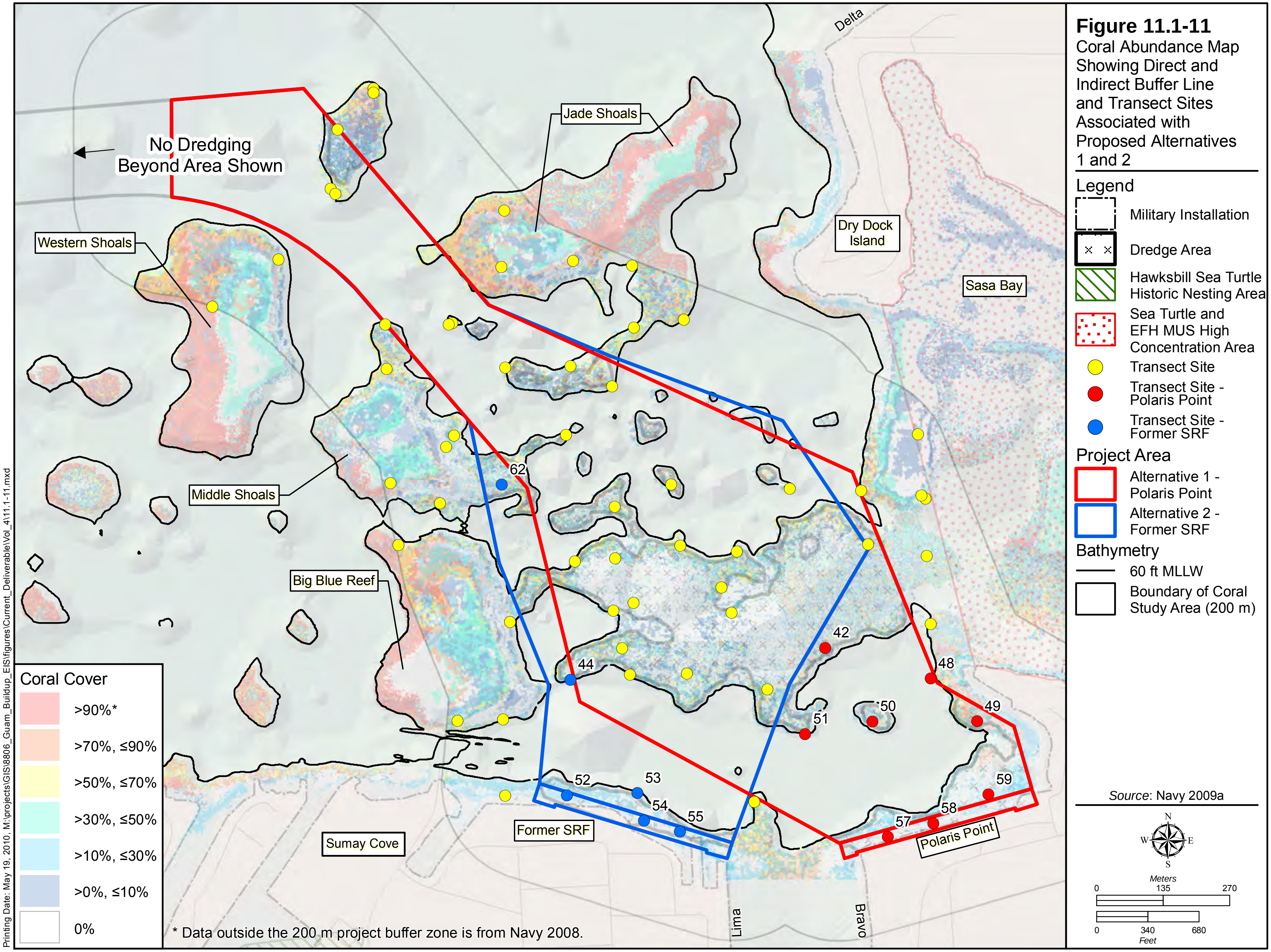


Figure 11.1-11
Coral Abundance Map Showing Direct and Indirect Buffer Line and Transect Sites Associated with Proposed Alternatives 1 and 2
Legend
Military Installation
Dredge Area
Hawksbill Sea Turtle Historic Nesting Area
Sea Turtle and EFH MUS High Concentration Area
Transect Site
Transect Site - Polaris Point
Transect Site - Former SRF
Project Area
Alternative 1 - Polaris Point
Alternative 2 - Former SRF
Bathymetry
60 ft MLLW
Boundary of Coral Study Area (200 m)
Source: Navy 2009a
Meters
0
135
270
0
340
680
Feet
Coral Cover
>90%*
>70%, ≤90%
>50%, ≤70%
>30%, ≤50%
>10%, ≤30%
>0%, ≤10%
0%
* Data outside the 200 m project buffer zone is from Navy 2008.
No Dredging Beyond Area Shown
Jade Shoals
Western Shoals
Middle Shoals
Big Blue Reef
Dry Dock Island
Sasa Bay
Delta
Sumay Cove
Former SRF
Polaris Point
Lima
Bravo
Printing Date: May 19, 2010, M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_4\11.1-11.mxd

In comparison, when data from all 67 transects were combined and analyzed, algae accounted for about 40% of benthic cover, sediment (sand, mud, and rubble) 35%, coral 22%, and sponges 3%. Algae occurred on all but one transect, and corals were present at 52 of the 67 survey sites. On transects with sediment cover greater than approximately 75%, corals were not present. All transects containing coral also contained algae. Coral cover was dominated by a single species, *P. rus*, which accounted for about 74% of total coral cover. Along with *P. rus*, the next three most abundant species (*P. lutea*, *Pavona cactus*, and *P. cylindrica*) accounted for 95% of coral cover (Dollar et al. 2009).

<u>Additional Survey Data in the Study Area</u>

Additional coral and coral reef community survey data are provided by Smith (2007). In general, coral development varies dramatically between sites and at different depths, with some locations supporting well developed complex coral reefs and other areas supporting only small patch reefs or sparsely scattered corals. Seventeen coral families were observed throughout the study area. The primary objective of the survey was to quantitatively assess the distribution and abundance of Scleractinian (stony) corals within seven selected portions of Apra Harbor. These seven areas included:

1. Mouth of Sumay Cove to mouth of Inner Apra Harbor
2. The Southeast component of the Western Shoals complex
3. Polaris Point and Polaris Bay
4. CVN turning basin between Inner Apra Harbor entrance, east side of Big Blue Reef, and south of Dry Dock Island
5. Fairway (navigation channel) shoals (Jade and Western)
6. Dry Dock Island
7. Delta/Echo Wharves on Dry Dock Island

Figure 11.1-12 shows the locations of dive survey sites in these seven areas. The major findings from the Smith (2007) study are as follows:

- Only one site (Big Blue Reef east) contained all of the observed coral families. At all other survey sites, the number of families ranged from 5 to 13. Point-quarter transect data revealed that of the 1,908 quarters surveyed, 69% contained coral, with 49% of all corals measured consisting of the single species *P. rus*.
- Mean coral size (maximum measurement parallel to the sea floor) was relatively low for Turning Basin sample locations (8.6 in [22 centimeters (cm)]), for shoal areas (8.3 in [21 cm]), and for Polaris Point (6.3 in [16 cm]). Qualitative observations of coral health revealed no areas of extensive bleaching or disease. Some colonies with hemispherical growth forms (e.g., *P. lobata*) at survey sites within the dredge footprint (Polaris Point, Fairway, and Turning Basin) were observed secreting copious amounts of mucus. As these areas are within the active ship transit lanes, the mucous secretion may be a sediment rejection response related to increased sediment resuspension from current ship activities.
- With respect to existing anthropogenic impacts to reef structure, there is some evidence of anchor and/or anchor chain damage at all sites. Movement of mooring chains on the southern side of the floating dry dock have produced a significant rubble field, although mooring chains on the northern (outer) side of the floating dry dock do not appear to have caused similar damage.

- The Polaris Point area, turning basin, Big Blue Reef east, navigation channel and Delta /Echo Wharves areas do not meet any of the HAPC criteria (See Volume 2, Section 11.1). However, Big Blue Reef west provides significant ecological function and is sensitive to human induced environmental degradation, thereby meeting two of the four criteria for HAPC designation.
- When reef survey zones are ranked by scaling a variety of measures of ecological function and value (percentage of sea floor covered by coral, reef complexity and rugosity, species diversity, coral health, size frequency distribution of coral colonies, diversity and abundance of sessile macro-benthos other than corals (e.g., sponges), diversity and abundance of mobile macro-invertebrates, and the diversity and abundance of finfishes), the areas within the dredge footprint (Turning Basin, shoal areas and Polaris Point) rank lowest on the scale, and are consistently lower ranked than the sites that are outside the footprint. The highest ranking was given to the Big Blue Reef west, likely owing to protection from exposure to water quality factors associated with Inner Apra Harbor and ship-induced sediment resuspension. The second highest ranking was given to the reefs off Dry Dock Island.
- Both Polaris Point and Dry Dock Island were artificially created during and shortly after World War II (WWII). While the two areas were created at essentially the same time, the coral communities are substantially different, suggesting that different environmental stressors have affected coral community development in the two areas. Potential differences in environmental stressors are the higher range of turbidity and suspended sediment originating from Inner Apra Harbor and the level of ship activities in the vicinity of Polaris Point relative to Dry Dock Island.
- The coral reef in the Polaris Point/Bay segment is of marginal quality and showed the greatest signs of stress. This stress appeared to be due in part to high levels of TSS coming from Inner Apra Harbor.
- Coral diversity (as measured by relative densities) is low. Although multiple coral taxa were observed at sampling locations within the project area, *P. rus*, *P. cylindrica* and *Porites spp*. comprised a substantial majority of all coral observed.
- Coral mean size (maximum measurement parallel to the sea floor) is relatively low, and some corals in the project area appear to show signs of stress. In the Polaris Point/Bay area, a substantial percentage of the coral at all depth contours was growing on metallic and/or concrete debris. It is arguable whether or not the Polaris Point/Bay community should be considered a coral reef. What is clear, however, is that more of the corals within the Polaris Point/Bay segment had copious mucous secretions and more algal overgrowth than at any other location in Apra Harbor evaluated during the current study or other recent Navy studies.

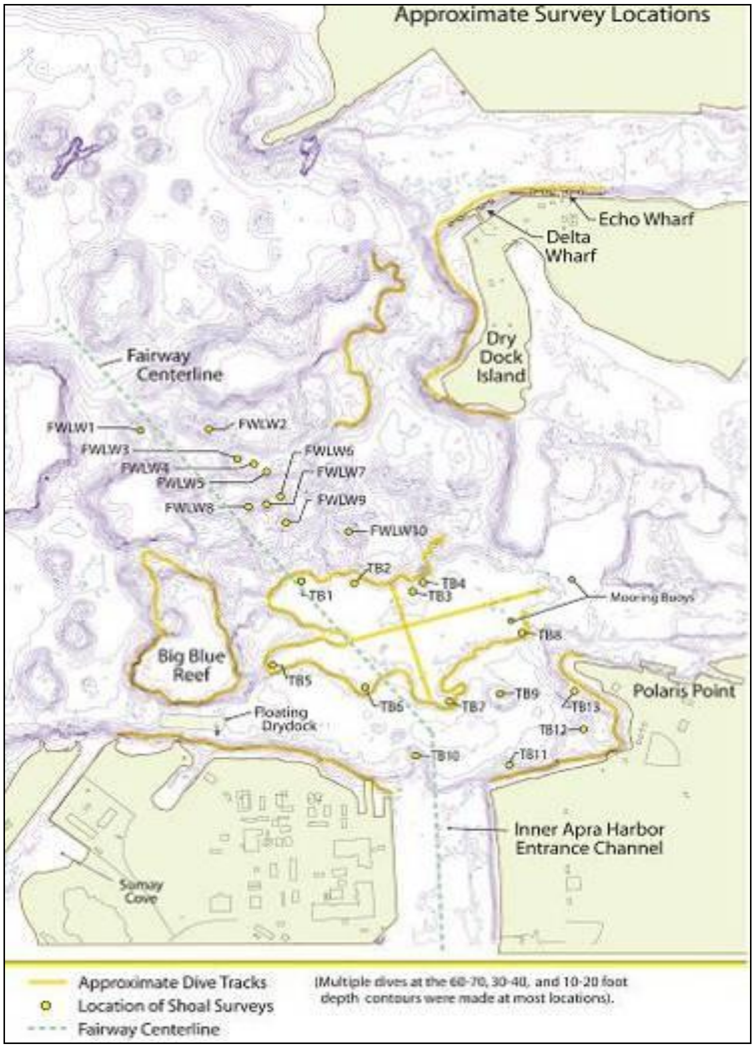


Figure 11.1-12. Dive Surveys and Transects

(Smith 2007)

Other field data collected by Dollar et al. (2009) included spectral reflectance of representative corals to develop a "stress index," coral size-frequency analysis, and analysis of sediment samples to determine the composition of material that would affect communities during dredging operations. The results of these analyses are briefly described in the Sediment Characteristics and Loading Stress subsection, below.

Sediment Effects on Coral

On a global scale, increased sedimentation is one of the most common and serious anthropogenic influences on coral reefs (e.g., Grigg and Dollar 1990). The scientific literature includes numerous documented cases of impacts to coral reefs by sedimentation related to human activity (i.e., anthropogenic), as well as laboratory investigations that quantify impacts under controlled conditions. Reviews by Brown and Howard (1985), Grigg and Dollar (1990), Rogers (1990) and Fabricius (2005) provide comprehensive treatment of all aspects of the effects of sedimentation to coral reefs. Impacts associated with sedimentation and sediment burial include reduced photosynthesis and increased respiration (e.g., Riegl and Branch 1995; Philipp and Fabricius 2003; and Weber et al. 2006), tissue mortality (e.g., Rogers 1983), reduced growth (e.g., Dodge et al. 1974; Rice and Hunter 1992), and reduced fertilization, larval survivorship, and recruitment (e.g., Gilmour 1999; Smith 2006).

While it is clear that increased sedimentation can have a deleterious effect on corals, it is also apparent from the scientific literature that the deleterious effects are not uniform or consistent, with responses depending primarily on a variety of factors including coral growth form and physiological capabilities, duration of exposure, and physicochemical composition of the sediment. When evaluating the effects of human-induced sedimentation, it is important to consider that sediments are also resuspended by natural processes in many reef environments, and as a result, most corals are adapted to withstand some level of sediment load. It has been well documented since the pioneering work on environmental tolerances of reef corals that some taxa are more resilient to turbidity and sedimentation than others (e.g., Mayer 1915; Yonge 1930; Marshall and Orr 1931; Hubbard and Pocock 1972; Riegl 1995; Wesseling et al. 1999). It has also been shown that corals growing in waters of moderate to extremely high turbidity are not automatically more stressed than their clear-water counterparts (Roy and Smith 1971; Done 1982; Johnson and Risk 1987; Acker and Stern 1990; Riegl 1995; Kleypas 1996; McClanahan and Obura 1997; Larcombe et al. 2001). Sanders and Baron-Szabo (2005) describe "siltation assemblages" of corals that occur in turbid water and/or muddy reef environments as a result of resilience to sediment through either effective rejection mechanisms or physiological tolerance to intermittent coverage.

Sediment resistance is generally distinguished as occurring by two separate processes, sediment rejection and sediment tolerance, which are reviewed in detail by Sanders and Baron-Szabo (2005). Sediment rejection is the active removal of sediment particles by polyp expansion by water uptake and expulsion ("pumping"), tentacle movement, ciliary action, and mucous secretion. Of note, it has been found that for all corals, it is more difficult to reject sediment from a horizontal surface than from an inclined or vertical surface (e.g., Bak 1976), and on flat surfaces sediment may be pushed to "dump areas" on the corallum (Reigl 1995). Experiments (Anthony 1999) and field measurements (Anthony 2000) indicate that corals from turbid water reefs have a background rate of sediment rejection two to four times higher than their conspecifics in clear-water reefs (Anthony and Fabricius 2000). For sediment clearance, the growth form of a coral is crucial, with branched and erect-foliaceous forms by far the most effective in clearance of sediment of silt to coarse sands (Hubbard and Pocock 1972; Stafford-Smith and Ormond 1992; Stafford-Smith 1993).

The outcome of various levels of sediment tolerance, or the ability of a coral to withstand a coating of sediment, differs markedly, ranging from death to localized necrosis to survival without any signs of damage or stress (Hodgson 1989; Wesseling et al. 1999). Hodgson (1989) reported that for some massive corals, tissue necrosis remained confined to flat and concave surfaces veneered by sediment, whereas unveneered short columns and convex knobs on the same colonies remained in good condition. The acroporid *Montipora* is quite sediment tolerant, and may be veneered for weeks without signs of permanent physiological damage (Hodgson 1989). Similarly, *Porites* is highly tolerant of being sediment-veneered, and can recover even after complete burial for up to three days (Stafford-Smith and Ormond 1992; Stafford-Smith 1993; Wesseling et al. 1999). Sofonia and Anthony (2008) found that the coral *Turbinaria mesenterina* on nearshore reefs in the central Great Barrier Reef lagoon was tolerant to sediment loads an order of magnitude higher than the most severe sediment conditions occurring *in situ*. The likely mechanisms for such high tolerance were that corals were able to clear themselves rapidly, and that the sediment provides a particulate food source.

It has also been suggested that small colonies may be more resistant to prolonged sedimentation than large colonies, owing to higher efficiency in terms of energy expenditure in sediment-rejection behavior (Dodge and Vaisnys 1977). With respect to impacts of sediment stress as a function of frequency, Connell's (1997) pioneering long-term studies of coral reef response to both acute and chronic disturbances have shown that reef systems are more vulnerable to chronic disturbance than to acute, infrequent episodes of stress. Hence, recovery from acute episodes of elevated sedimentation may take place, while the same or even lower levels of sediment stress on a continual basis would result in more extensive, or even permanent detrimental change. Sanders and Baron-Szabo (2005) also report that pulses of a few hours to a few days of rapid sediment fallout exert less of a lasting influence than frequent or chronic sedimentation at lower rates.

While it is generally believed that corals can only survive in waters with low turbidity and suspended particulate loads, it has been documented that apparently flourishing coral communities are found in naturally turbid conditions, although these communities are generally very different than those found in clearer water. For example, a turbid lagoon at Fanning Island (Central Pacific) had an abundance of primarily branching colonies, although the coral community was less diverse than in the clear lagoon with mostly massive and encrusting corals (Roy and Smith 1971). Roy and Smith (1971) conclude that while there was a decrease in abundance of coral knolls from the clear to the turbid water (less than 6.5 ft [2 m] visibility), both areas had lush reef development. In a study of the distribution of coral communities located near two rivers on Guam, Randall and Birkeland (1978) concluded that observed decreases in natural sedimentation rates along a gradient from the river mouths to the open sea explained the increase in number of coral species, from less than 10 in the area exposed to high sedimentation to over 100 in the areas farthest from riverine influence. The authors predicted that sedimentation rates ranging from 0.005 to 0.007 ounces per 0.39 inches per day (oz/in/d) (162 to 216 milligrams per centimeter per day [mg/cm/d]) would be associated with less than 10 total species in an area, while rates of 5 to 32 mg/cm/d (open ocean) would be associated with over 100 species in an area (data converted from original).

As summarized in Rogers (1990), the response to coral communities from dredging and other activities which increase sediments in the water can range from only localized or negligible effects on corals to long-term changes. Rogers (1990) makes the point that dredging often affects not only the portion of the reef which is actually removed or smothered, but also downstream areas where currents carry increased concentrations of fine suspended particles. However, impacts are not always severe and long-lasting. The dumping of 2,200 tons (1,996 metric tons) of kaolin clay cargo from a freighter grounded on a reef at French Frigate Shoals in the Northwestern Hawaiian Islands created large plumes of the suspended clay but had no apparent adverse effects beyond a radius of about 164 ft (50 m) from the grounding site (Dollar and Grigg 1981). Based on a brief qualitative survey, Sheppard (1980) suggested that dredging and blasting in Diego Garcia Lagoon (Indian Ocean) had resulted in variable and low coral cover but no reduction in coral diversity. Construction of Honokohau Harbor on the Island of Hawaii by dredging actually resulted in an overall increase in coral cover because of colonization of newly created harbor surfaces (USACE 1983). In 1979, work began to extend the runway of the airport at St. Thomas (U.S. Virgin Islands) 2,382 ft (726 m) into water 89 ft (27 m) deep. Monitoring over a period of 31 months of fish populations, seagrass beds and coral reefs in the vicinity revealed no significant deterioration attributable to the plume from the dredge and fill operation (Rogers 1982).

Pre- and Post-Monitoring of Dredging Sediment Effects on Coral Reefs

Although the effects of anthropogenic sedimentation on reef corals have been widely discussed and reviewed in the scientific literature, there are relatively few studies that specifically address the effects of dredging on reef corals at sites where the community has been monitored before, during and after the event. Marszalek (1981) surveyed reef areas before and after a large-scale dredging project off of Florida, where dredging took place for 3 months every year for 5 years. He reported no mass mortality of hard corals after short-term exposure to sediments (a few days), although several colonies showed partial mortality and excessive mucus secretion after prolonged exposure to suspended sediment. Marszalek (1981) suggested that prolonged turbidity was more detrimental than short-term accumulation of sediments. Brown et al. (1990) had the opportunity to utilize long-term ecological monitoring to conduct before, during and after studies of the effects of a 9-month dredging of a deep channel to adjacent reef flats at Phuket, Thailand. Reef corals, primarily massive heads of *Porites lutea*, showed as much as 30% reduction in living cover one year after the start of dredging, with a significant decline in diversity. However, after the termination of dredging, the reef recovered rapidly with coral cover values and diversity indices restored to former levels within approximately 22 months after dredging began. No significant changes in linear growth rate, calcification or skeletal density were measured in corals subjected to the increased sediment loads. The authors speculate that the rapid recovery was a result of regeneration of living tissue over formerly dead surfaces of colonies that suffered only partial mortality. The lack of change of growth rate, calcification rate and skeletal density was attributed to the short time that corals were subjected to fatally high concentrations of sediments (days to weeks). Changes that may have occurred during this short period may have been insufficient to affect the annual growth rate or calcification.

Sediment Characteristics and Loading on Coral Stress

Numerous studies have been conducted to evaluate the effects of sediment exposure to corals, and a universal theme is that impacts vary depending on a variety of factors such as oceanographic conditions, which coral species are present and their ability to adapt, the type of sediments being deposited, and the duration of exposure. The following text summarizes findings from some of the most informative and relevant studies with respect to the study area. An important consideration in the evaluation of sediment effects to corals is the duration of the stress. In an experimental design exposing corals to ten different sediment types at environmentally relevant concentrations 0.001 to 0.002 ounces per 0.15 square inch (oz/in^2) (33-160 milligrams per square centimeter [mg/cm^2]), Weber et al. (2006) found that the highest stress levels (in terms of reduction of photosynthetic yield of the coral *Montipora peltiformis*) occurred from short-term (20 to 44 hours [hr]) exposure to nutrient-rich silts, whereas no effect was measurable after greater than 48-hr exposure to fine and medium sand and pure aragonite (calcium carbonate) silt. All treatments that showed reduction in photosynthetic yield from sediment loading also exhibited immediate reversal of the trend following removal of sediment exposure, although recovery was not complete within the 48-hr recovery period after experiments were terminated. These authors conclude that their findings suggest a fundamentally different outcome of corals exposed to sedimentation by sandy nutrient-poor sediments, such as storm resuspended marine carbonate sediments, compared to sedimentation of silt-sized sediments rich in organic matter and nutrients. Philipp and Fabricius (2003) also showed that the photosynthetic activity of *M. peltiformis* decreased linearly with both the amount of sediment and the time it remained on the tissues, which indicated that any threshold value for sedimentation tolerance should incorporate both amount and time. *M. peltiformis* was able to recover function to pre-stress levels if the duration of stress was short (< 24 hr) or if doses were low. Wesseling et al. (1999) evaluated recovery of corals after full burial in field experiments in the NW Philippines where corals were buried for 0, 6, 20 and 68 hr. Species of *Porites* were not affected by 6-hr burial compared to controls, while increasing burial time had increasingly more serious effects in terms of discoloration and bleaching. Following removal of sediment, recovery took place, with time of recovery (2 to 4 weeks) proportional to time of burial. Colonies of *Acropora*, however, showed much more sensitivity, with all colonies dying after the 20-hr treatment.

Riegl and Branch (1995) measured the changes in physiological reactions to sediments. Under what was considered the observed sedimentation levels on South African reefs 0.007 oz/0.015 in^2 (200 mg/cm^2), corals that had been adapted to laboratory conditions for 6 weeks prior to the experiments in filtered seawater showed changes in energy balance by forcing respiratory losses up and photosynthetic production down, and displaying elevated mucus secretion. However, these experiments were not conducted with other varying sediment loads, and recovery was not measured following removal of the sediment.

Some corals have adapted to fluctuating levels of sedimentation. Lirman and Manzello (2009) documented the patterns of resistance and resilience of *Siderastrea radians* to sub-optimal salinity and sediment burial in a series of short-term, long-term, acute, chronic, single-stressor, and sequential-stressor experiments. Under conditions of no salinity stress, *S. radians* was very effective at clearing sediments, and >50% of the colonies' surfaces were cleared within 1 hr of burial. However, as burial periods increased, and colonies were covered at multiple chronic intervals, sediment burial resulted in extended photosynthetic recovery periods, reduced growth, and mortality.

It is important to note that effects from deposition of terrigenous sediments emanating from runoff can be substantially different than effects from sediments of marine origin. Te (2001) found that terrigenous sediments had a greater light extinction capability than carbonate (reef-derived) sediments. As noted above, Weber et al. (2006) found distinctly different responses depending on sediment composition, with substantially less effects from marine carbonates compared to organic-rich terrigenous sediments. Fine silts and sand composed of calcium carbonate have been shown to produce no negative effects on photosynthetic activity in one species of coral after more than 2 days of exposure (Weber et al. 2006).

Results of sediment core analysis reported by Weston Solutions (NAVFAC Pacific 2006) indicated that sediment in Outer Apra Harbor (within the aircraft carrier berthing action dredge footprint) and the entrance to Inner Apra Harbor were coarser-grained, comprised predominantly of gravelly sand. Analysis of twelve sediment samples collected within the aircraft carrier berthing action dredge footprint revealed that 79-96% of the samples by weight were composed of calcium carbonate, presumably of marine origin. Hence, terrigenous (i.e., non-carbonate) muds are not a major component of the sediment in the proposed dredge area (Dollar et al. 2009).

The effects to reef corals from increased sedimentation do not appear to result from any specific "threshold" level. Te (2001) states that "numerous forces in nature and the ability of corals to adjust to higher sediment loading levels makes it impossible to definitively state a generalized threshold level for sediment loading in corals." A summary of the existing scientific literature that categorizes the effects to reef corals, corresponding to the rates and exposure periods of sedimentation, is presented in Volume 9, Appendix J, Section D.

The range of effects to corals extends through the entire spectrum of stresses. As expected, the general trend is that the higher the deposition rate and the longer the period of deposition, the greater the effect. However, it is also apparent that this trend is very species specific. For instance, Hodgson (1989) found that under the same rates of sedimentation in both the field and in aquaria, the response varied considerably between species. Of 22 species exposed to a constant sedimentation rate of 40 mg/cm/d for 7 days in aquaria, 6 suffered mortality, 7 suffered sublethal tissue damage, and 9 did not incur visible damage. Of 36 species exposed to a sedimentation rate of 0.0007 oz/0.15 in^2/d (20.8 mg/cm^2/d) for 120 days in the field, 7 suffered mortality, 12 experienced tissue damage, and 17 were not visibly affected.

Te (2001) developed a predictive model that tested the hypothesis that the lower the light level as caused by increased turbidity and sediment loads, the lower the photosynthetic production of corals. His work indicated that while light was the most influential force in coral growth and survival, field experiments in which transplanted corals were subjected to sedimentation rates of <0.00003oz/0.15 in^2/d (<1 mg/cm^2/d) to greater than 0.01oz/0.15 in^2/d (300 mg/cm^2/d) resulted in no mortality and showed no significant effect on growth rates or survivability. Corals used in his study were able to adjust and adapt to even the worst sediment loading levels achieved in the laboratory and the field. No corals subjected to the worst conditions died, and many grew at rates similar to corals growing in areas unaffected by sediment. Rather, strong waves caused by storm events were found to be more detrimental to coral growth and survival in the field than increased sediment loading. In addition, turbidity, as linked to light availability but not sediment deposition, was found to significantly affect coral growth rates, but not coral survival in both field and laboratory experiments. Te (2001) also found that corals exposed to moderate to high sediment loading, and those growing under shade conditions were able to photo-adapt by increasing light harvesting capacity as evidenced by greater chlorophyll content and increased photosynthetic ability. When re-introduced into conditions with high light intensities, however, corals underwent photo-inhibition that disrupted photosynthetic functions.

The overall conditions in the study conducted by Te (2001) are comparable to reported conditions in the Inner Apra Harbor Channel, adjacent to the aircraft carrier dredge area, as well as the aircraft carrier dredge area *per se*. Observations in these areas indicate a layer of sediment on virtually all benthic surfaces that are not colonized by living organisms.

Marine Research Consultants (2005) and Smith (2004) have documented well-developed communities of reef corals in the northern portion of the Inner Apra Harbor Channel. Remote sensing using satellite imagery allowed mapping and quantification of the area coverage of the coral communities. Integrating the mapped area of coral cover revealed a total area of 3.32 ac (1.34 ha) of sparse coral and 6.8 ac (2.8 ha) of dense coral, for a total area of approximately 10.2 ac (4.1 ha) of coral cover in the Inner Apra Harbor Entrance Channel (Figure 11.1-13). The entire non-living benthic surface consists of calcareous sediment, ranging in grain size from fine silty muds to coral rubble. In addition, in areas where the predominant grain size is in the mud-silt range, sediment is easily re-suspended with subsequent re-deposition. As a result, all of the biotic components of the community must have the physiological adaptations to deal with a physical environmental characterized by soft bottoms (Dollar et al. 2009).

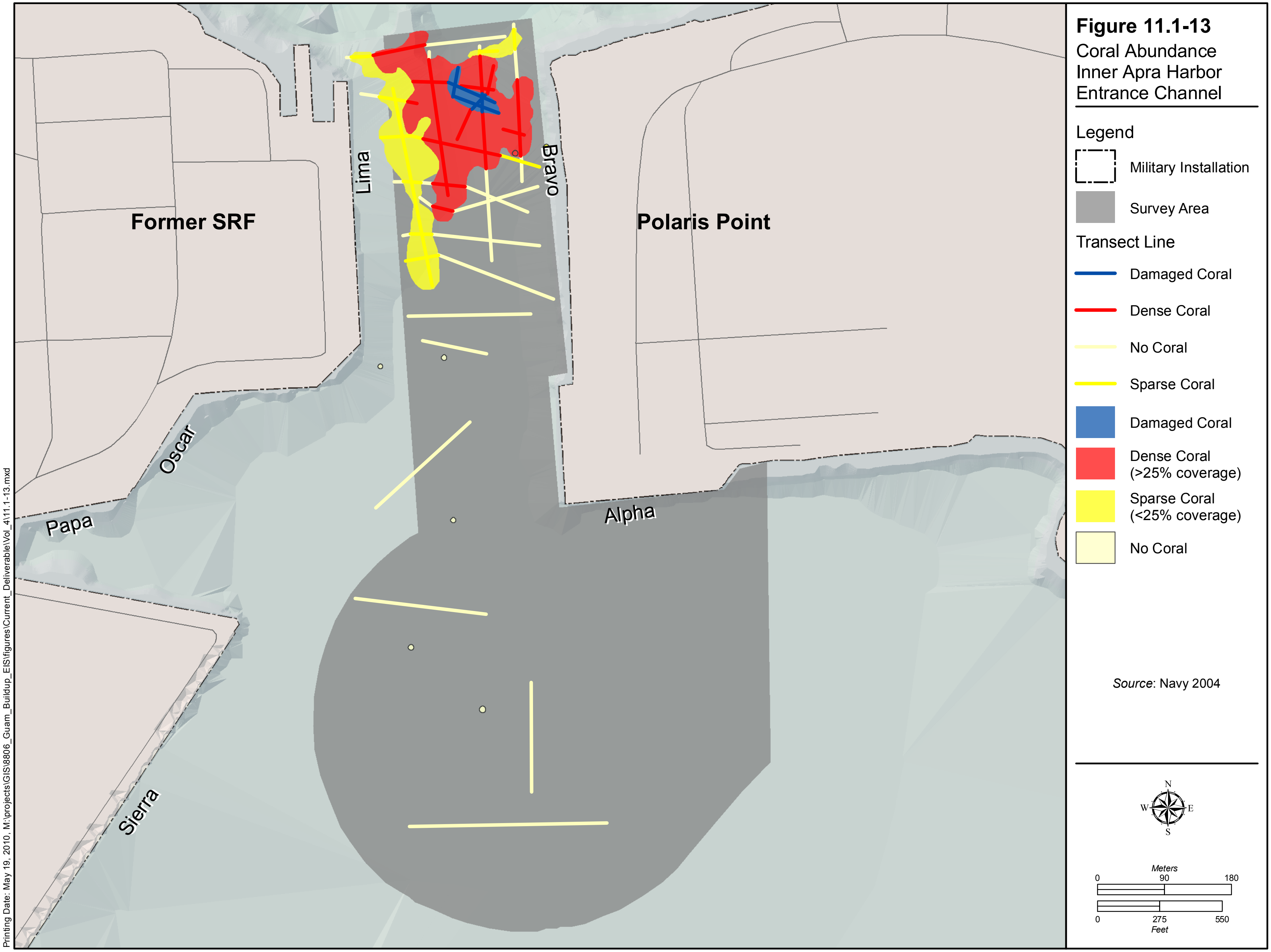


Figure 11.1-13
Coral Abundance
Inner Apra Harbor
Entrance Channel
Legend
Military Installation
Survey Area
Transect Line
Damaged Coral
Dense Coral
No Coral
Sparse Coral
Damaged Coral
Dense Coral
(>25% coverage)
Sparse Coral
(<25% coverage)
No Coral
Source: Navy 2004
Former SRF
Polaris Point
Lima
Bravo
Oscar
Papa
Alpha
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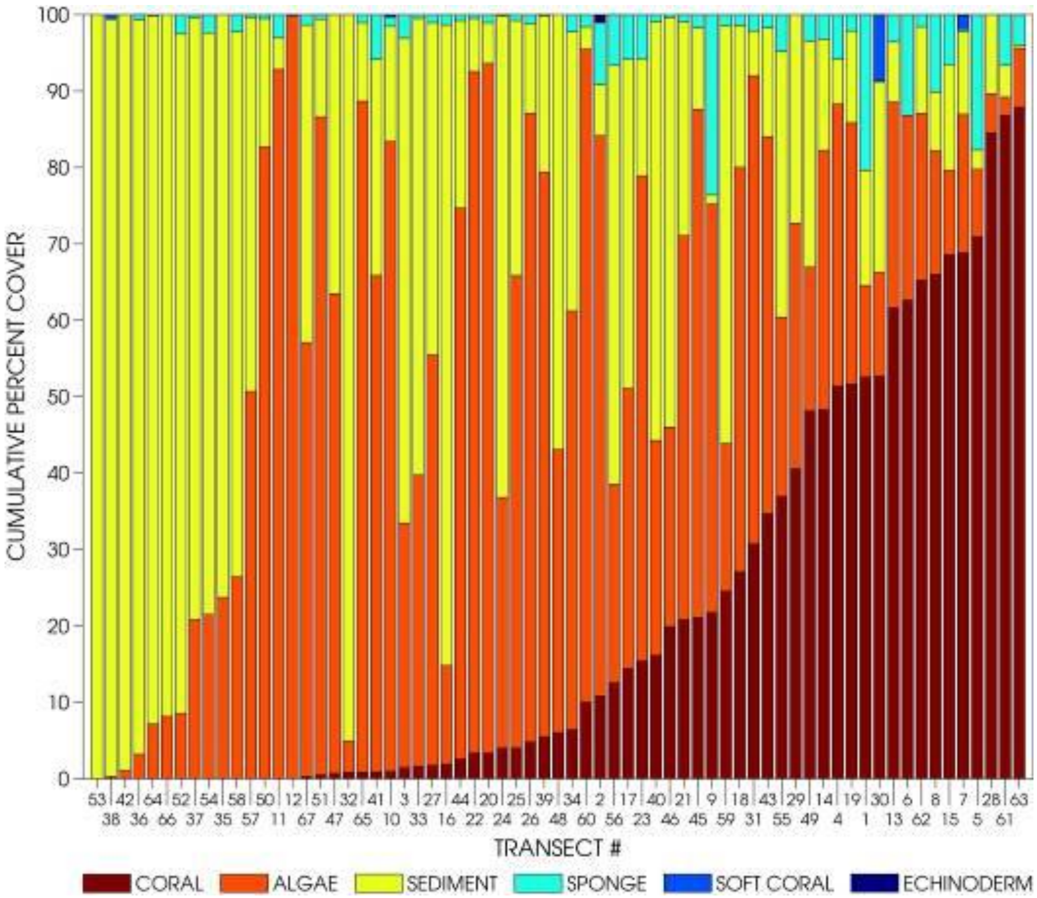
<u>Index of Coral Stress</u>

In situ spectral reflectance measured at the surfaces of the two most abundant species of coral (*P. rus*, *P. lutea*) were used to compute the Normalized Difference Vegetation Index (NDVI) for 27 sites in the aircraft carrier survey area. NDVI is a relative scale indicating amount of chlorophyll present; higher values indicate more chlorophyll, and therefore lower "stress." Although NDVI increased slightly withdepth, there was no apparent trend in the horizontal spatial distribution of NDVI. The lack of a spatial pattern suggests no difference in chlorophyll between the direct and indirect strata, and hence no difference in relative stress.

11.1.3.3 Evaluation of the Benthic Community Structure

Dollar et al. (2009) performed an evaluation of the benthic community structure of Outer Apra Harbor with respect to the 67 transect points associated with the aircraft carrier dredge area. A summary of the evaluation follows.

The general classes consisted of algae, stony coral, sponges, soft coral, ascidians, echinoderms and sediment. Sediment consisted of sand, mud and rubble. Algae and sediment each occurred on 66 transects, coral occurred on 52 transects, and sponges occurred on 55 transects. Ascidians occurred on three transects and echinoderms on four transects. In terms of ranges of cover of general classes, all classes had minimum cover of zero on at least one transect. Maximum transect cover of general classes were 100% for algae and sediment, 88% for coral, 24% for sponges, 9% for soft coral, 1% for echinoderms, and about 0.3% for ascidians. Cumulative means of general classes for each transect reveal the overall pattern of decreasing algae and sediment with increasing coral cover (Figure 11.1-14).

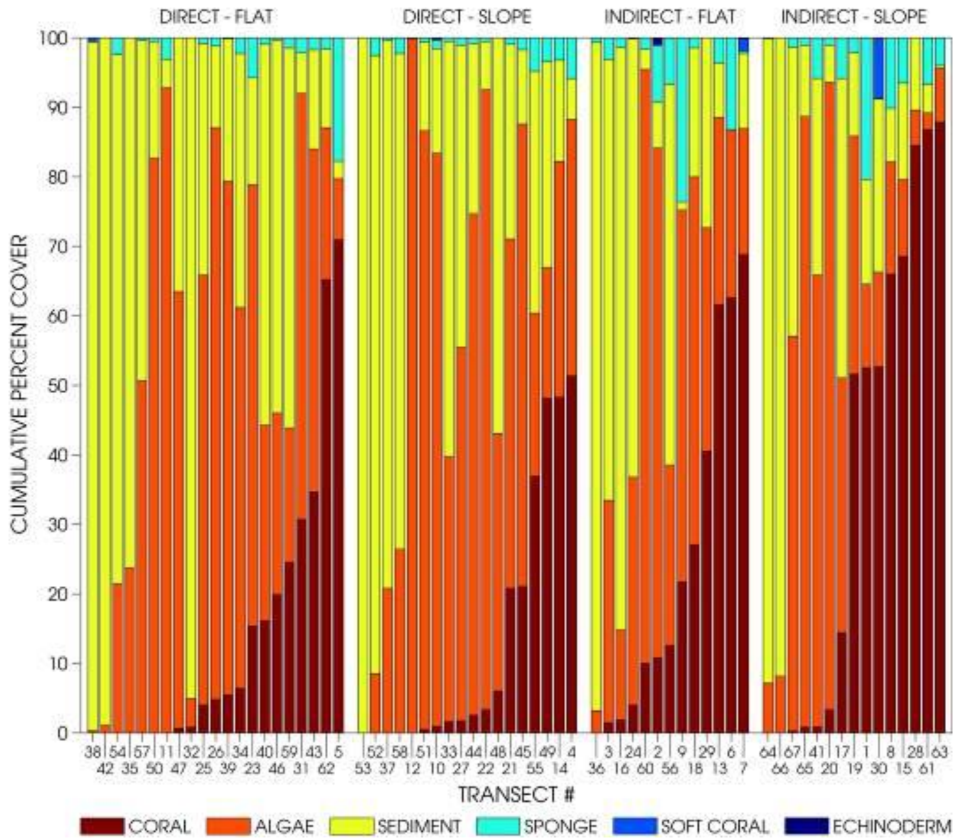


Source: Dollar et. al. 2009

Figure 11.1-14. Stacked Bar Graph Showing Cumulative Percent Covers for Each General Class in Each Transect. Transects are Arranged in Order of Lowest to Highest Coral Cover.

The detailed classes of benthic cover consisted of 37 categories identified in transect photo-quadrats. The most prevalent class of biota was mixed macroalgae, which occurred on 65 transects with a maximum transect cover of 74%. In terms of occurrence of a single macroalgal species, the most common was *Halimeda*, which was present on 30 transects, with a maximum transect cover of 59%, followed by *Dictyota* (23 transects; max cover of 37%) and *Padina* (15 transects; max cover of 27%). With respect to distribution of corals, the most abundant was *P. rus* which appeared on 47 transects with a maximum transect cover of 85%, followed by *P. lutea* (26 transects; max of 37%), *P. cylindrica* (18 transects; max of 12%) and *Pavona cactus* (13 transects; max transect cover of 43%) (Dollar et al. 2009).

Figure 11.1-15 shows benthic cover of general classes separated into four strata (Direct-Flat, Direct Slope, Indirect Flat, Indirect Slope). The "strata" are not the typical strata that most ecologists think of, which are biologically defined, which if not statistically different would not need to be discussed separately. However, these strata are artificially defined in terms of dredging zones (direct, indirect impact etc) so they have to be discussed separately. Mean algal cover within strata varied from a low of 31% in the Indirect Slope stratum to a high of 48% on the Direct Slope transects. The mean coral cover trend was opposite the trend for algae, with the highest cover on the Indirect Slope (38%) and the lowest on the Direct Slope (14%). On the combined Direct strata transects, mean algal cover was 45%, while mean coral cover was 14%. On the combined Indirect transects, mean algal cover was 33% compared to mean coral cover of 32%. When all transects are combined, mean algal cover was 40% compared to mean coral cover of 22% (Dollar et al. 2009).



Source: Dollar et. al. 2009

Figure 11.1-15. Cumulative Percent Covers for Each General Class in Each Transect, Arrange by Survey Stratum

When all species of coral are listed by order of abundance on transects, *P. rus* was an order of magnitude more abundant than any other species, accounting for 74% of all corals (Table 11.1-3). Along with *P. lutea*, *Pavona cactus*, and *P. cylindrica*, the four most abundant species comprise about 95% of coral cover of the aircraft carrier action survey area. When transects within a strata are ordered according to percent cover of *P. rus*, the overall pattern of coral cover is similar. In each zone, one-half of the transects had cover of *P. rus* less than 2% of bottom cover. Distribution of ranked order of *P. rus* throughout the other half of the transects within each strata occurred as a progressive increase with little overlap of mean cover up to the maximum value in each strata. As a result, the mean value of coral cover within any strata is influenced by both the relatively large number of transects with essentially no coral, as well as the steep gradient of increasing cover on transects that do contain coral (Dollar et al. 2009).

Table 11.1-3. Prevalence of All Coral Species from Photo-quadrat Transect Data

Coral Species	*Count*	*Fraction*	*Percentage*	*Cumulative Percentage*
Porites rus	7,935	0.745	74.458	74.458
Porites lutea	959	0.090	8.999	83.457
Pavona cactus	849	0.080	7.967	91.423
Porites cylindrica	409	0.038	3.838	95.261
Acropora aspera	147	0.014	1.379	96.641
Acropora nasuta	130	0.012	1.220	97.861
Herpolitha limax	69	0.006	0.647	98.508
Pachyseris speciosa	35	0.003	0.328	98.836
Astreopora myriophthalma	26	0.002	0.244	99.080
Lobophyllia corymbosa	25	0.002	0.235	99.315
Pocillopora damicornis	24	0.002	0.225	99.540
Lobophyllia hemprichii	17	0.002	0.160	99.700
Acrhelia horrescens	12	0.001	0.113	99.812
Astreopora randalli	5	0.000	0.047	99.859
Fungia echinata	5	0.000	0.047	99.906
Montipora verrucosa	4	0.000	0.038	99.944
Pavona varians	4	0.000	0.038	99.981
Lobophyllia (cf.) hataii	2	0.000	0.019	100.000
Total Coral Points	**10,657**			

Source: Dollar et. al. 2009

To select the most important community components in terms of percent of total variance explained, Dollar et al. (2009) applied a principal component analysis (PCA) to the detailed class percent cover data. In PCA, the first principal component (PC) describes the highest proportion of variance in the data, the second PC describes the second highest proportion of variance, and so on. In the present data set, the first five PCs describe >90% of the variance, and virtually all of the variability in the data is described by the first 14 PCs. This result indicates that the data are essentially five-dimensional (as opposed to the 38 dimensions described by the individual detailed classes). By plotting the coefficient value for each PC against the individual detailed classes, it is possible to identify which detailed classes are responsible for each PC, and thus which detailed classes are responsible for the variance in the whole data set. For PC 1, the two detailed classes with the highest coefficient (absolute) values were mud and *P. rus*. In PC 2, the two most important classes, other than the two from PC 1 (mud, *P. rus*), were mixed algae and *Halimeda* sp. In PC 3, the two most important additional classes were rubble and *P. lutea*. In PC 4, the two most important additional classes were *Padina* sp. and cyanobacteria. Finally, in PC 5, the two most important additional classes were turf algae and *P. cactus*. Together, these 10 classes are the most important to describe variability in benthic cover in the data set.

There are several other methods used to demonstrate the relationship between the three major types of benthic cover (algae, sediment, coral), which are described in Dollar et al. (2009). Several findings of interest include the following: 1) when sediment cover exceeds approximately 75% of transect cover, there is essentially no coral cover; no coral occurs without the presence of algae; and there is a weak trend of increasing rugosity with increasing coral cover; and 2) where sediment cover is less than about 75% and coral cover above approximately 5%, there is a relatively even distribution between algae and coral throughout the survey area.

Additional Marine Flora, Invertebrates and Associated EFH Data

Several species of marine flora were identified during the Smith (2007) survey, although a specific algal survey was not conducted. The crests of many of the shoals were rubble and sand with dense brown algae (*Padina*). Calcareous green algae (*Halimeda*) was common at depths of less than 20 ft (6.1 m) at Big Blue Reef east. Species that provide forage for sea turtles are discussed further below under the Special-Status Species, Section 11.1.5. Additional marine flora and invertebrate survey data are provided in Smith 2007.

Smith (2007) noted that large sea cucumbers (*Thelenota annas*) were common on the seafloor at the shoal areas. Elephant ear sponges (*Ianthell basta*), as well as oval shaped free living corals (*Family Fungidae*) were common on the slopes in deeper water of most shoals in the study areas. Other species of sea cucumbers were present at every study site and were abundant in the turning basin and shoal areas. Relatively few of the important harvested invertebrate species identified by Porter et al. (2005) were observed. Those that were observed were all at Big Blue Reef west and included octopus, top shell, spider conch, double-spined rock lobster, and xanthid reef crabs (Smith 2007).

The Navy surveys (Navy 2009a) yielded similar observations to those of Smith (2007) regarding the commonly harvested invertebrates identified by Porter et al. (2005). More specifically, octopus, top shell, spider conch, double-spined rock lobster, and xanthid reef crab "…were rarely seen during these surveys, and those that were observed were regarded as 'small' in size." None of these species were observed at Polaris Point or adjacent areas, Turning Basin or shoal areas sampling locations. These observations support the conclusions of Porter et al. (2005) that overfishing is a significant problem on Guam, and that finfish and harvested invertebrate stocks are biologically depressed (Navy 2009a).

Dollar et al. (2009) summarized invertebrate data in terms of mobile and sessile species counts at each transect within each strata, and taxa richness for all invertebrates. A summary of these data from Dollar et. al. (2009) is listed below:

- A total of 55 mobile species from 45 genera were encountered. The grand totals of the mean occurrence of mobile species (individuals per 1076 square feet [ft^2])(individuals per 100 square meters [m^2]) were higher in both Indirect strata than Direct strata, and higher on the flats of each strata relative to the slopes. With one exception, the most abundant phylum in each strata was the Mollusca, followed in order by the Echinodermata, Crustacea, Platyhelminthes, and Cnidaria (the exception being slightly higher numbers of crustaceans than echinoderms in the Indirect Slope stratum). Overall, abundance of each phylum was also greater in the Indirect strata than Direct strata.
- A total of 62 sessile species from 34 genera were encountered during surveys. Unlike mobile species, the grand totals of the means (individuals per 269 ft^2) (individuals per 25 m^2) were higher in both Slope Strata compared to both Flat strata. Overall, there was no consistent pattern of greater abundance between the Direct and Indirect areas. The overwhelmingly dominant phylum of sessile invertebrates in all strata was the Porifera, followed by the Ascidia, and with minor contributions from the Molluscs and Polycheates. Probably the most conspicuous member of the Porifera within the survey area was the "elephant-ear sponge" (*Ianthella spp*.), with individuals up to one meter in width commonly occurring in the deeper areas of the harbor floor.

- Invertebrate surveys were replicated at three transects (15, 49 and 61) during the day and night. The grand total of counts on the three transects was higher at night than during day. The greatest difference occurred on Transect 49, where a total of 144 individuals were counted at night compared to 10 during the day. The predominant difference was the occurrence of 117 crustacea at night compared to none during the day. Taxa richness at night was also greater on all transects compared to daytime. The greatest difference again occurred on Transect 49 where 15 species of crustacea were encountered at night compared to none during the day.
- Counts of mobile invertebrates at all 67 transect sites revealed considerably higher mean density in the two Indirect strata (26 Flat; 24 Slope) compared to the Direct strata (12 Flat, 7 Slope). Mobile invertebrate species composition consisted primarily of molluscs, with smaller contributions from echinoderms and crustaceans. Populations of sessile macroinvertebrates (other than stony corals) consisted predominantly of a wide variety of sponges (*Porifera*), with smaller contributions from the ascidians, molluscs and polycheates. Mean values of sessile invertebrates were higher on the Slope strata (92 Direct, 119 Indirect) than the Flat strata (71 Direct, 86 Indirect).

11.1.4 Essential Fish Habitat

As discussed in Volume 2, Sections 11.1 and 11.2, all of Apra Harbor is considered EFH and Jade Shoals is a HAPC. Figures 11.1-3 – 11.1-7 in Volume 2, Chapter 11, show the EFH and HAPC designated within Guam waters for various life stages of Management Unit Species (MUS). Information pertaining to the affected environment for coral and coral reef ecosystem, which is an important EFH, was addressed in Section 11.1.2 above, including a quantitative evaluation of the benthic community structure.

Coral and coral reef ecosystems are important substrate habitat components of EFH within Apra Harbor. The coral reef ecosystem is highly complex and contain a diversity of invertebrates, fishes, and vertebrate animals, such as sea turtles. Although reefs cycle some nutrients to and from other environments, they are largely self contained.

Coral reef fish communities are diverse and dense on many tropical reefs. However, due to local anthropogenic influences, the reefs within Apra Harbor are relatively depauperate (reduced diversity and density). Coral reef fishes, such as butterflyfishes and damselfishes, live not only among the reef-building corals, but also with sea fans and soft corals, sponges and sea anemones. Some fishes rest on patches of sand or peep out of holes in the reef, others hover above the reef or swim actively, and visitors from the open ocean come in to prey on the residents. Coral reefs within Outer Apra Harbor support fish communities.

A brief summary of sensitive marine biological resources and habitats of Apra Harbor is provided below and in Figure 11.1-16. The following five known MUS from the CRE group of the Mariana Archipelago FEP are associated with EFH within Apra Harbor(Table 11.1-4) and they include: Napoleon or humphead wrasse (NMFS species of concern [SOC] and EFH-Currently Harvested Coral Reef Taxa [CHCRT]); Bigeye scad (EFH-CHCRT); Scalloped hammerhead (EFH-Potentially Harvested Coral Reef Taxa [PHCRT]); Sessile MUS (EFH-PHCRT), including stony corals, soft corals, sponges, algae, etc.; and the Bumphead parrotfish (NMFS candidate species and EFH-CHCRT).

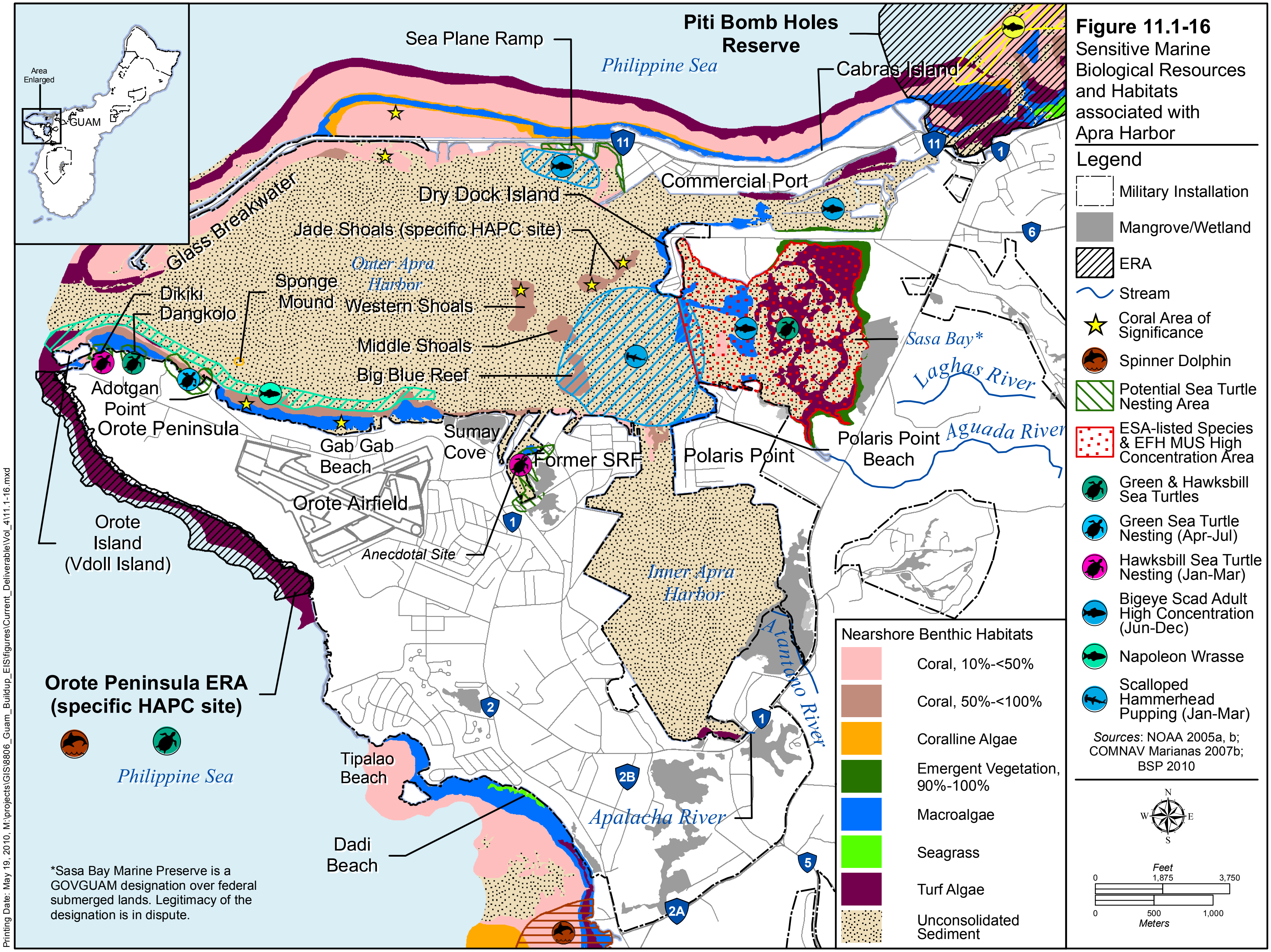


Figure 11.1-16
Sensitive Marine Biological Resources and Habitats associated with Apra Harbor
Legend
Military Installation
Mangrove/Wetland
ERA
Stream
Coral Area of Significance
Spinner Dolphin
Potential Sea Turtle Nesting Area
ESA-listed Species & EFH MUS High Concentration Area
Green & Hawksbill Sea Turtles
Green Sea Turtle Nesting (Apr-Jul)
Hawksbill Sea Turtle Nesting (Jan-Mar)
Bigeye Scad Adult High Concentration (Jun-Dec)
Napoleon Wrasse
Scalloped Hammerhead Pupping (Jan-Mar)
Sources: NOAA 2005a, b; COMNAV Marianas 2007b; BSP 2010
Feet
0
1,875
3,750
0
500
1,000
Meters
Nearshore Benthic Habitats
Coral, 10%-<50%
Coral, 50%-<100%
Coralline Algae
Emergent Vegetation, 90%-100%
Macroalgae
Seagrass
Turf Algae
Unconsolidated Sediment
Area Enlarged
GUAM
Sea Plane Ramp
Piti Bomb Holes Reserve
Philippine Sea
Cabras Island
Commercial Port
Dry Dock Island
Glass Breakwater
Jade Shoals (specific HAPC site)
Outer Apra Harbor
Sponge Mound
Western Shoals
Dikiki
Dangkolo
Middle Shoals
Big Blue Reef
Sasa Bay*
Laghas River
Aguada River
Adotgan Point
Orote Peninsula
Gab Gab Beach
Sumay Cove
Former SRF
Polaris Point
Polaris Point Beach
Orote Airfield
Orote Island (Vdoll Island)
Anecdotal Site
Inner Apra Harbor
Atantano River
Orote Peninsula ERA (specific HAPC site)
Philippine Sea
Tipalao Beach
Dadi Beach
Apalacha River
*Sasa Bay Marine Preserve is a GOVGUAM designation over federal submerged lands. Legitimacy of the designation is in dispute.
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Table 11.1-4. Sensitive CRE MUS Associated with EFH for Apra Harbor

Group	*Common Name/Chamorro Name*	*Status** *Federal*	*Guam*
Coral Reef Ecosystem (CRE)			
Fish MUS	Napoleon wrasse/*Tanguisson*	SOC EFH-CHCRT	SOGCN
	Bigeye scad/*Atulai*	EFH-CHCRT	SOGCN
	Scalloped hammerhead/*Halu'u* (general term)	EFH-PHCRT	SOGCN
	Bumphead parrotfish/*Atuhong*	C-EFH-CHCRT	SOGCN
Sessile Benthic MUS**	Stony coral/*Cho' cho'*	EFH-PHCRT	SOGCN

Notes: *E = endangered, T = threatened; SOC = NMFS Species of Concern; SOGCN = Species of Greatest Conservation Need; C= NMFS candidate species. There is no critical habitat designation for any marine species on Guam.

** includes algae, sea grass, and assorted invertebrates (sponges, hard and soft corals, etc.)

Sources: WPFRMC 2009a, USFWS 2009a, and NMFS 2010a.

The Napoleon wrasse has been observed in the area from Orote Point to Sumay Cove; however, it was not identified in the recent quantitative fish survey (UoG 2009). The bigeye scad is present at two areas in high concentrations in Apra Harbor; however, it is not directly associated with the study area (NOAA 2005b).

Early life history stages of the scalloped hammerhead (e.g. pupping)are reported to occur, although rarely (Navy 2009b), in areas outside the Inner Apra Harbor Entrance Channel (NOAA 2005b, BSP 2010). This species typically pups near structures (Navy 2009c). Stony corals are found in high concentrations in Outer Apra Harbor along with other sessile and motile invertebrates.

The bumphead parrotfish, a NMFS candidate species (NMFS 2010a), is reported nearby within Piti Bomb Holes Reserve (NOAA 2005b), however, no observations in Apra Harbor have been documented. Piti Bomb Holes Reserve is located approximately 4 mi (6 km) from Outer Apra Harbor Entrance Channel.

Additional fish MUS are found in the harbor area, and are discussed below.

11.1.4.1 Finfish Assessment

Reef fish assemblages vary considerably over multiple spatial scales. This "patchy" nature of most reef fish communities is easily explained by the variability in environmental parameters, such as nutrient availability, water quality, and most importantly, habitat structure. Habitat structure plays a very important role in structuring reef fish communities because many species are dependent on certain habitats at both small and large spatial scales. Predicting the response of reef fish communities to habitat disturbance, however, is much more complicated. Such predictions rely on the magnitude of environmental impact and the mobility and site-fidelity of particular species. Reef fish are arguably less affected than other reef organisms to many physical disturbances. However, there are many species that are highly site-attached (have high site fidelity) and remain within a very small home range throughout their entire lives (UoG 2009). Marnane (2000) studied site fidelity and homing behavior in tagged coral reef cardinalfishes (*Apogon doederlini*, *Cheilodipterus artus* and *Cheilodipterus quinquilineatus*) and study results indicated that fish persisted to within an average of 14 to 39 in (36 to 99 cm) of their initial resting positions within One Tree Reef lagoon for over 8 months. In addition, 56–81% of tagged fish displaced approximately 3,280 ft (1,000 m) and 33–63% of tagged fish displaced 6,500 ft (1,981 m) returned to their point of collection within 3 days. Sale and Dybdahl (1975, 1978) repeatedly removed fish from a series of small isolated coral heads and followed recolonization. They concluded that the species of such small assemblages recolonized by almost entirely a matter of chance.

They detected no fine-scale microhabitat discrimination, no mutual exclusion by pairs of species, and no separation of species by time of year at which recruitment occurred.

Quantitative Assessment of Reef Fish Communities (UoG 2009)

For the purposes of this EIS, the abundance and occurrence of fish families were estimated quantitatively through finfish population surveys performed in July 2009 (UoG 2009). Other qualitative fish studies were used to supplement this information. For a detailed description of the UoG (2009) methodology, results and discussion, survey points, and tables and figures showing mean diversity, biomass, and species richness, see Volume 9, Appendix J. The following text summarizes the findings of the UoG study.

An assessment of reef fish communities within the Outer Apra Harbor dredge footprint was conducted to quantify species richness, abundance, and biomass of reef fish communities within and adjacent to the proposed project area. The survey also recorded the dominant habitat type at each site as either coral-dominated, macroalgae-dominated, rubble-dominated, or sand-dominated. One additional site, unique to all others and referred to as the "dump site," was comprised entirely of cinder blocks that had been deposited onto the seafloor at approximately 50 ft (15 m), creating an artificial habitat.

A total of 119 species representing 28 families were recorded. On average, the families Acanthuridae ("thorn tail" - is the family of surgeonfishes, tang, and unicornfishes), Caesionidae (fusilier fishes - related to the snappers, but adapted for feeding on plankton, rather than on larger prey), *Lutjanidae* (snappers), *Scaridae* (parrottfishes), and *Lethrinidae* (porgies, rudderfishes, scavengers, and emperors) had the highest biomass per transect, and the commercially important groupers of the family Serranidae were more common than anticipated, yet still rare. The most numerically dominant families were *Pomacentridae* (damselfishes and clownfishes), *Scaridae, Caesionidae, and Acanthuridae*. In this study, *Pomacentrids* represented 60% of the total fish abundance across the site.

Among the major habitat types surveyed, those dominated by coral and sand had the least similar fish communities, which is not surprising given that coral-dominated sites have high habitat complexity, while sand-dominated sites naturally lack fish habitat. Sites dominated by coral were generally the most speciose (comparatively rich in number of species) and diverse whereas the opposite was true for sand-dominated sites. The species most responsible for this difference were the staghorn damsel and daisy parrotfish, whose abundance increased by an order of magnitude in coral-dominated sites, and the blue devil damsel, whose abundance was greater in sand dominated sites. In general, the vast majority of species recorded increased in abundance at coral-dominated sites. The lone "dump site" stood out as a unique site with a high mean dissimilarity value compared with other habitats. This was due to the unusually high number of red breast wrasses, brassy trevally, and black-tailed snapper, which apparently favored the artificial habitat, and a very low abundance of *pomacentrid* species (staghorn damsel, blue devil damsel, and green chromis), which are very common in most other habitats.

Multivariate analyses indicated that fish assemblages were largely grouped along a depth/habitat gradient, and fish diversity and biomass were greatest at sites of high coral cover. Biomass of commercially important species is reported highest at the coral-dominated sites while those sites dominated by sand have depauperate fish communities. When analyses were performed with depth as a factor, there was a strong grouping among sites below 40 ft (12 m). The greater variability in fish assemblages among sites within the depth range of 40-60 ft (12-18 m) is likely explained by previous dredging of many of these sites. When sites were coded for their location with respect to future direct or indirect impacts of dredging, it can be seen that many of the low diversity sites would be directly affected. However, 50% (9 of 18) of the sites dominated by coral and having the most significant fish assemblages (identified above) would also be directly affected.

Water visibility during the Apra Harbor surveys is a major potential source of sampling bias, especially for quantification of fish communities. Water visibility was poor at several sites - three of those sites (56, 44 and 66) which were all associated with the Alternative 2 direct impact area, had to be removed from the study due to poor visibility. The sites are located as follows: Site 56 is just west of inner harbor entrance channel, Site 44 is near Big Blue Reef's eastern end, and Site 66 is located near Big Blue Reef's southern end (see Figure 11.1-16 above).

11.1.5 Special-Status Species

This section includes a brief summary of key points included within Volume 2, Chapter 11 as baseline information for this resource. A brief summary of special-status species is provided below. Sensitive marine biological resources and habitats of Apra Harbor are shown in Figure 11.1-16. The three special-status species potentially associated with Apra Harbor study area are listed in Table 11.1-5.

Table 11.1-5. Special-Status Species Potentially Occurring within Apra Harbor

	*Status**	
Common Name/Chamorro Name	*Federal*	*Guam*
Green sea turtle/*Haggan bed'di*	T	T
Hawksbill sea turtle/*Hagan karai*	E	E
Spinner dolphin/*Toninos**	MMPA	SOGCN

Notes: *E = endangered, T = threatened, MMPA= Marine Mammal Protection Act, SOGCN= species of greatest conservation need. There is no critical habitat designation for any marine species on Guam. Spinner dolphins are occasionally sighted near the entrance of Outer Apra Harbor.

Sources: NMFS 2009; USFWS 2009a.

Recently 82 coral species were identified as NMFS candidate species for potential listing, some of which occur in the ROI (WPRFMC 2009a, NMFS 2010b). Also recently, the bumphead parrotfish was identified as a NMFS candidate species (NMFS 2010a). As candidate species are afforded no special protection, they will not be analyzed for potential impacts under Endangered Species Act (ESA); corals are considered EFH and the bumphead parrotfish is an EFH MUS, so they are included in the EFH analysis.

In accordance with Section 7 of the ESA, a Marine Resources Biological Assessment was prepared by the Navy and addressed the potential effects of the proposed federal action on all threatened, endangered, and proposed species known or suspected to occur in the proposed action influence area. Threatened, endangered, and proposed species are managed under the authority of the federal ESA (16 USC 1531 *et seq*.). The ESA requires federal agencies to ensure that all actions which they "authorize, fund, or carry out" are not likely to jeopardize the continued existence of any threatened, endangered, or proposed species. Agencies are further required to develop and carry out conservation programs for these species.

Spinner dolphins are noted on a rare, but somewhat regular basis at the entrance of Apra Harbor (personal communication, Roy Brown, September 2007 from COMNAV Marianas 2007b). Brown runs dolphin tours on Guam's waters and estimates that spinner dolphins are seen up to four times a year in Outer Apra Harbor near the entrance channel, which ranges from 7,500 - 11,250 ft (2,286 – 3429 m) away from the proposed action depending upon the stage of dredging. The pier construction would be at the furthest distance identified above.

The green and hawksbill sea turtles are the only special-status species reported in Apra Harbor, with observations of green sea turtles occurring on a more regular basis. Sasa Bay is a year round, high concentration area for sea turtles as identified by NOAA (2005b). Smith (2007) observed nine green sea turtles, five of which were on Big Blue Reef. All turtles sighted at Big Blue Reef west were 15 to 23 in

(38 to 58 cm) in length, with no visible fibropapilloma tumors or other signs of injury. No hawksbill sea turtles were observed. A cooperative effort between the Navy and resource agencies is ongoing for monitoring sea turtle nesting activity, however tagging programs and density information for sea turtles in Apra Harbor is deficient.

Algal species (and sea grass to a lesser degree) are reported at multiple other areas throughout Apra Harbor (NOAA 2005a, 2005b; Dollar et al. 2009), hence potential sea turtle foraging and resting areas are not limited. Although algal surveys were not conducted, Smith (2007) suggests that potential sea turtle resting habitat and preferred algal forage species were present on Big Blue Reef west and the shoal areas, where most turtle sightings occurred. Balazs et. al (1987) identified ten genera of algae that he considered to be preferred forage for green sea turtles in Hawaii.

Preferred sea turtle forage species observed included green algae (*Dictyospheria spp*. and *Ulva spp*.), brown algae (*Sargassum spp*.), and red algae (*Gracillaria spp*., *Jania spp*., *Hypnea spp*., *Acanthophora spicifera* and *Laurencia spp*.). Green sea turtles are probably opportunistic feeders; however, within the preferred food items listed above, three species (*Dictyospheria versluysii*, *Sargassum obtusifolium, and Acanthophora specifera*) have been reported from Guam (Lobban and Tsuda 2003), and were tentatively identified on Big Blue Reef west and the shoal areas. None of the algae listed above were abundant at any of the study sites during recent surveys (Smith 2007).

The reef area in the aircraft carrier dredge footprint does not represent a unique or unusual habitat in comparison to the entire Apra Harbor reef complex, and does not contain an abundance of important algal forage species that cannot be found elsewhere in Apra Harbor. Smith (2007) reported that five of the nine green sea turtles observed during a 2-day survey in the project area were at Big Blue Reef. Sasa Bay is reported as an area of high concentration for both ESA-listed sea turtle species (NOAA 2005b).

There have been limited studies on green sea turtle hearing capabilities, but the available data suggests hearing in the moderately low frequency range, and a relatively low sensitivity within the range they are capable of hearing (Bartol et al. 1999; Ketten and Bartol 2006). NOAA (2005b [pp 3-88 and 3-89]) identifies sea turtle hearing sensitivity, and includes the following information. The range of maximum sensitivity for sea turtles is 100 to 800 Hz, with an upper limit of about 2,000 Hz. Hearing below 80 Hz is less sensitive but still potentially usable to the animal (Lenhardt 1994). Green turtles are most sensitive to sounds between 200 and 700 Hz, with peak sensitivity at 300 to 400 Hz. They possess an overall hearing range of approximately 100 to 1,000 Hz (Ridgway et al. 1969). Sensitivity even within the optimal hearing range is apparently low—threshold detection levels in water are relatively high at 160 to 200 dB with a reference pressure of one dB re 1 μPa-m (Lenhardt 1994).

TEI (2006) gathered unpublished data on hearing thresholds for green sea turtles from an Office of Naval Research study at the New England Aquarium and combined these data with other information (Ruggero and Temchin 2002) to present the hearing thresholds in Table 11.1-6. These data shows results similar to those presented above and provide the best available estimates for the green sea turtle. The hearing bandwidth was relatively narrow, 50 to 1,000 Hz, with maximum sensitivity around 200 Hz. In addition, these animals have very high hearing thresholds at over 100 dB re 1 μPa in low frequencies where construction sound is concentrated.

Table 11.1-6. Hearing Thresholds and Bandwidth for Sea Turtles

Hearing Bandwidth 1/3 Octave Band (Hz)	*Hearing Threshold Sea Turtle (dB re 1 µPa*
50	149
63	142
80	131
100	119
125	118
160	117
200	115
250	119
315	123
400	130
500	136
630	144
800	154
1,000	166

Source: TEI 2006 and Ruggero and Temchin 2002.

As mentioned in Volume 2, Chapter 10 and 11, sea turtles have been observed nesting during all months of the year on Guam; however, the peak of nesting activity occurs from April to July. Sea turtle nesting activity has been reported from three Apra Harbor locations (see Figure 11.1-15): *Adotgan Dangkolo* (*Dangkolo*) (green sea turtles), *Adotgan Dikiki* (*Dikiki*) (hawksbill sea turtles), and *Kilo Wharf* (green sea turtles). Historic records of sea turtle nesting include a hawksbill reported at a beach near Sumay Cove in 1997, and a general report of nesting at a beach near the Sea Plane Ramp (COMNAV Marianas 2007a) (refer to Figure 11.1-15.) No nesting activity has occurred at these areas since that time (Grimm and Farley 2008; Navy 2009b). In general, sea turtles nest and hatch at night. They use natural light cues to orient toward the ocean. However, the bright lights from the dredging platforms may confuse nesting turtles and hatchlings, and result in them orienting away from the open ocean (COMNAV Marianas 2007a). See Volume 2 and 4, Chapter 11 Terrestrial Biological Resources for more detailed information.

See Volume 2, Chapter 11, for more baseline information on special-status species.

<u>Critical Habitat</u>

There is no critical habitat designation for any marine species on Guam.

11.2 ENVIRONMENTAL CONSEQUENCES

11.2.1 Approach to Analysis

11.2.1.1 Methodology

The methodology for identifying, evaluating, and mitigating impacts to marine biological resources was based on federal laws and regulations including the ESA, MMPA, Magnuson-Stevens Fishery Conservation and Management Act or Magnuson-Stevens Act (MSA), Section 404(b)(1) Guidelines (Guidelines) of the CWA, and Executive Order (EO) 13089, *Coral Reef Protection*. Significant marine biological resources include all species that are ESA-listed as threatened and endangered under ESA, species protected under the MMPA, or species with designated EFH or HAPC established under the MSA. The MSA defines EFH as “. those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” ‘Waters’ include aquatic areas and their associated physical, chemical, and biological properties that are used by fish. ‘Substrate’ includes sediment, hard bottom, structures underlying the waters, and associated biological communities. ‘Necessary’ means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem, and 'spawning, breeding, feeding, or growth to maturity' covers a species' full life cycle (16 U.S. Code [USC] 1801 et seq.). Additionally, at least one or more of the following criteria established by the NMFS must be met for HAPC designation: 1) the ecological function provided by the habitat is important, 2) the habitat is sensitive to human-induced environmental degradation, 3) development activities are, or will be, stressing the habitat type, or 4) the habitat type is rare. It is possible that an area can meet one HAPC criterion and not be designated an HAPC. The Western Pacific Regional Fishery Management Council (WPRFMC) used a fifth HAPC criterion, not established by NMFS, that includes areas that are already protected, such as Overlay Refuges (WPRFMC 2009a).

The guidelines of the CWA 404(b)(1) are federal regulations developed between the U.S. Environmental Protection Agency (USEPA) and U.S. Department of the Army (Army) to articulate policies and procedures to be used in the determination of the type and level of mitigation necessary to demonstrate CWA compliance, with the objective to restore and maintain the chemical, physical, and biological integrity of the Nation's waters, including special aquatic sites (SAS). SAS are those sites identified in 40 CFR 230, Subpart E (i.e., sanctuaries and refuges, wetlands, mud flats, vegetated shallows, coral reefs, and riffle and pool complexes). The guidelines are binding on the USACE as the agency charged with implementing the Section 404 permitting program. The USACE is prohibited from issuing a permit for any discharge of dredged or fill material in waters of the U.S. that does not comply with the Guidelines.

In general, the main intentions of the four federal acts listed above are as follows:

- The ESA establishes protection over and conservation of threatened and endangered species and the ecosystems upon which they depend, and requires any action that is authorized, funded, or carried out by a federal entity to ensure its implementation would not jeopardize the continued existence of listed species or adversely modify critical habitat.
- The MMPA was established to protect marine mammals by prohibiting take of marine mammals without authorization in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S.
- The MSA requires NMFS and regional fishery management councils to minimize, to the extent practicable, adverse effects to EFH caused by fishing activities. The MSA also requires federal agencies to consult with NMFS about actions that could damage EFH.
- The CWA Guidelines set forth a goal of restoring and maintaining existing aquatic resources, including SAS (i.e., coral reefs, wetlands etc.).

The ESA, MMPA, and MSA require that NMFS and/or the USFWS be consulted when a proposed federal action may adversely affect an ESA-listed species, a marine mammal, EFH or HAPC. In addition, while all habitats are important to consider, 'coral reef ecosystems' are perhaps the most important habitats and the analysis is included under EFH. As a note, EO 13089 also mandates preservation and protection of U.S. coral reef ecosystems that are defined as "… those species, habitats and other natural resources associated with coral reefs in all maritime areas and zones subject to the jurisdiction and control of the U.S." This guidance is intended to clarify and reemphasize the protection afforded the Nation's valuable coral reef ecosystems under the Clean Water Act Section 404 regulatory program, Rivers and Harbors Act (RHA) Section 10 requirements, and federal projects conducted by the Corps.

In regard to dredging activities, the USACE first makes a determination that potential impacts have been avoided to the maximum extent practicable (striving to avoid adverse impacts); remaining impacts would be mitigated to the extent appropriate and practicable by requiring steps to reduce impacts; and finally, compensate for aquatic resource values. This sequence is considered satisfied where the proposed mitigation is in accordance with specific provisions of a USACE-approved comprehensive plan that ensures compliance with the compensation requirements of the Guidelines.

11.2.1.2 Determination of Significance

This section analyzes the potential for impacts to marine biological resources from implementation of the action alternatives and the no-action alternative. The factors used to assess the significance of the effects to marine biological resources include the extent or degree that implementation of an alternative would result in permanent loss or long-term degradation of the physical, chemical, and biotic components that make up a marine community. The following significance criteria were used to assess the impacts of implementing the alternatives:

- The extent, if any, that the action would diminish the habitat, population size, or distribution of a special-status species, negatively affecting the species' prospects for conservation and recovery.
- The extent, if any, that the action would permanently reduce the quality or quantity of designated EFH (especially HAPC) for the sustainment of managed fisheries.
- The extent, if any, that the action would be likely to jeopardize the continued existence of any federally listed species or result in the destruction or adverse modification of designated critical habitat of such species.
- The extent, if any, that the action would result in a substantial loss or degradation of habitat or ecosystem functions (natural features and processes) essential to the persistence of native flora or fauna populations.
- The extent, if any, that the action would be inconsistent with the goals of the Navy's Integrated Natural Resources Management Plan (INRMP).

The MMPA generally defines harassment for military readiness activities, i.e., training, as Level A or Level B. Public Law (PL) 108-136 amended. This MMPA definition of Level A and Level B harassment for military readiness activities applies to a portion of this action.

- Level A harassment includes any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild (activities associated with the proposed action would not result in any Leval A harassment).
- Level B harassment is now defined as "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered." Unlike Level A harassment, which is solely associated with physiological effects, both physiological and behavioral effects may cause Level B harassment (activities associated with the proposed action would not result in any Level B harassment for marine mammals).

ESA specifically requires agencies not to "jeopardize" the continued existence of any ESA-listed species, or destroy or adversely modify habitat critical to any ESA-listed species. Under Section 7, "jeopardize" means to engage in any action that would be expected to reduce appreciably the likelihood of the survival and recovery of a listed species by reducing its reproduction, numbers, or distribution. Section 9 of the ESA defines "take" as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect.

Effects determinations for EFH are either "no adverse effect on EFH" or "may adversely affect EFH" (WPRFMC 2009a). Pursuant to 50 CFR 600.910(a), an "adverse effect" on EFH is defined as any impact that reduces the quality and/or quantity of EFH. Adverse effects to EFH require further consultation if they are determined to be permanent versus temporary (NMFS 1999). An example of temporary (or short-term) and localized impacts would be dredging of soft bottom, benthic communities, living in shallow-water estuarine and nearshore environments that are well adapted to frequent physical disturbance. Tides, currents, waves, and storms cause sediments to be lifted, deposited, or shifted. The resilience of benthic organisms to these environmental changes allows them to recolonize areas of the seafloor affected by dredging (TEI 2009 as identified from NOAA 2007 [see Section 11.2.2.2 1.a.]).

Temporary or minimal impacts are not considered to “adversely affect” EFH. 50 CFR 600.815(a)(2)(ii) and the EFH Final Rule (67 FR 2354) were used as guidance for this determination. Temporary effects are those that are limited in duration and allow the particular environment to recover without measurable impact (67 FR 2354). Minimal effects are those that may result in relatively small changes in the affected environment and insignificant changes in ecological functions (67 FR 2354). Whether an impact is minimal would depend on a number of factors (DoN 2010):

- The intensity of the impact at the specific site being affected
- The spatial extent of the impact relative to the availability of the habitat type affected
- The sensitivity/vulnerability of the habitat to the impact
- The habitat functions that may be altered by the impact (e.g., shelter from predators)
- The timing of the impact relative to when the species or life stage needs the habitat

The analysis of potential impacts to marine biological resources considered direct, indirect, and cumulative impacts. The *Council on Environmental Quality (CEQ), Section 1508.08 Effects*, defines direct impacts as those caused by the action and occur at the same time and place, while indirect impacts occur later in time or farther removed in distance, but are still reasonably foreseeable. CEQ defines cumulative impacts as “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other action.”

Direct impacts may include: removal of coral and coral reef habitat (a CWA special aquatic site), “taking” of special-status species, increased noise, and lighting impacts resulting from construction or operational activities.

Indirect impacts, for the purposes of this evaluation, may include physiological effects on marine organisms that result from project-related changes in water quality, including any sedimentation/siltation of coral reef ecosystems resulting from construction or operational activities (i.e., dredging resuspension of sediment), or increased recreational activities in the vicinity of the resource that may lead to impacts to special-status species and EFH.

If marine resources could be significantly impacted by proposed project activities, potential impacts may be reduced or offset through implementation of appropriate Best Managment Practices (BMPs) or mitigation measures. "Significantly" as used in NEPA (per 43 FR 56003, Nov. 29, 1978; 44 FR 874, Jan. 3, 1979) requires considerations of both context and intensity:

- Context. This means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of the proposed action. For instance, in the case of a site-specific action, significance would usually depend upon the effects in the locale rather than in the world as a whole. Both short- and long-term effects are relevant.

- Intensity. This refers to the severity of impact. Responsible officials must bear in mind that more than one agency may make decisions about partial aspects of a major action. The following should be considered in evaluating intensity:

3. Impacts that may be both beneficial and adverse. A significant effect may exist even if the federal agency believes that on balance the effect will be beneficial.
4. The degree to which the proposed action affects public health or safety.
5. Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.
6. The degree to which the effects on the quality of the human environment are likely to be highly controversial.
7. The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.
8. The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.
9. Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.
10. The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources.
11. The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.
12. Whether the action threatens a violation of federal, state, or local law or requirements imposed for the protection of the environment.

11.2.1.3 Issues Identified during Public Scoping Process

The following analysis focuses on possible effects to marine biological resources that could be impacted by the proposed action. As part of the analysis, concerns related to marine biological resources that were mentioned by the public, including regulatory stakeholders, during the public scoping meetings were addressed. A general account of these comments includes the following:

- Potential impacts on the Apra Harbor marine environment from aircraft carrier berthing, fully documenting impacts from dredging (acreage and ecosystem characteristics of affected area, depth of dredging operations, duration of effects)
- Potential impacts to endangered species (including nesting habitats), species of concern, and federal trust species such as corals and marine mammals
- Potential impacts from military expansion from all project sites on the marine resources, including removal or disturbance of the marine habitat
- Impacts to culturally significant marine-related areas for subsistence fishing and beliefs

- Increased "high impact" recreational use that would damage the ecosystem and impact fish habitat (e.g., Sasa Bay Marine Reserve)
- Increased land runoff impacting beaches and marine life (erosion and sediment stress)
- Increased anthropogenic factors impacting the coral reef ecosystem and concerns about the education and training that would be provided for newly arriving military and their dependants regarding reef protection
- Mitigation measures and non-structural alternatives to avoid and minimize impacts to coral reefs

11.2.2 Alternative 1 Polaris Point (Preferred Alternative)

11.2.2.1 Onshore

Alternative 1 Polaris Point (referred to as Alternative 1) has the potential to impact the quality and quantity of the surface runoff, during both the construction and operational phases of the project, without the application of appropriate BMPs. Both construction activities as well as long-term operation activities may cause erosion and sedimentation that can degrade coastal waters and potentially impact nearshore marine biological resources. In addition, the action alternatives would increase the potential for leaks and spills of petroleum, oil, lubrications (POLs), hazardous waste, pesticides, and fertilizers. These potential impacts may affect the coastal waters and in turn the biological resources and habitats.

CONSTRUCTION

Proposed onshore construction activities would occur in an area that is composed of fill material. Embankment excavation would be required to expand the existing shoreline north of the proposed aircraft carrier berthing and the face of the wharf. While alterations to the onshore environment have the potential to result in indirect impacts that could alter the harbor water quality as described above (see also Chapter 4, Water Resources), these potential effects (short-term and localized disturbances from noise, subsurface reverberations, and siltation of marine biological resources adjacent to the site) would be minimized by complying with all applicable orders, laws and regulations, including low impact development stormwater management strategies and BMPs (Volume 7).

Marine Flora, Invertebrates and Associated EFH

No direct impacts on these resources are expected. Construction activities associated with Alternative 1 would include the implementation and management of appropriate construction permit BMPs. These resources would not be appreciably modified from existing conditions by indirect impacts identified from temporary increases in suspended sediments and noise. Indirect impacts as a result of actions associated with Alternative 1 would not be significant for marine flora, invertebrates, or associated EFH, and would not adversely affect associated EFH.

Potential impacts to species included in a regional FEP are addressed accordingly under EFH.

Essential Fish Habitat

No direct impacts on these resources are expected. Construction activities associated with Alternative 1 would include the implementation and management of appropriate construction permit BMPs. These resources would not be appreciably modified from existing conditions by indirect impacts identified from temporary increases in suspended sediments and noise from construction activities. Indirect impacts as a result of actions associated with Alternative 1 would not be significant and would not adversely affect EFH.

Special-Status Species

No direct impact on this resource is expected with the implementation and management of appropriate construction permits, and BMPs.

This resource would not be appreciably modified from existing conditions by indirect impacts. No serious injury or mortality of any marine mammal species is reasonably foreseeable and no adverse effects on the annual rates of recruitment or survival of any of the species and stocks is expected with the implementation of Alternative 1. For impacts on green sea turtles associated with onshore construction activities, see Chapter 10 of this Volume. Therefore, Alternative 1 would result in a less than significant impact to special-status species.

Non-native Species

There would be no direct impacts in relation to non-native species introduction caused by activities associated with Alternative 1. Any potential introduction/transport of non-native species may be lessened or even prevented through appropriate BMPs and implementation of the Micronesia Biosecurity Plan (MBP).

The MBP is being developed to address potential non-native invasive species impacts associated with this EIS as well as to provide a plan for a comprehensive regional approach. The MBP will include risk assessments for potentially invasive non-native species throughout Micronesia and procedures to avoid, minimize, and mitigate these risks. It is being developed in conjunction with experts within other federal agencies including the National Invasive Species Council (NISC), U.S. Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS), the U.S. Geological Survey (USGS), and the Smithsonian Environmental Research Center (SERC). The plan is intended to be a comprehensive evaluation of risks in the region, including all Marine Corps and Navy actions on Guam and Tinian and specifically those being proposed in this EIS.

The DoN will adopt protective measures associated construction, on shore, and near shore impacts of the proposed action to reduce the likelihood of the introduction and spread of non-native invasive marine species. These measures may include clarifying biosecurity requirements for all Navy vessels (including chartered Military Sealift Command [MSC] ships), improving hull husbandry documentation, and incorporating into contractual agreements with vessels chartered to support the military relocation specific criteria to ensure low levels of biofouling and ballast water management.

Therefore, Alternative 1 would result in a less than significant impact regarding non-native species introduction.

Based on the analysis presented above for onshore construction activities, Alternative 1 would result in less than significant impacts to marine biological resources.

OPERATION

The operational phase of Alternative 1 would increase the area of impervious surface which would result in an associated relatively minor increase in stormwater discharge intensities and volume. This increase would be accommodated by stormwater infrastructure, and stormwater flow paths would continue to mimic area topography. Furthermore, stormwater would be pre-treated to remove contaminants prior to discharge into the harbor, as detailed in a design-phase plan that would cover the entire project area. It is the intent that all designs would result in 100% capture and treatment, if required, of stormwater runoff.

While onshore operation activities have the potential to result in indirect impacts that could alter the harbor water quality as described above (also see Chapter 4, Water Resources), these potential effects (localized disturbances from noise, subsurface reverberations, and decreased water quality for marine biological resources adjacent to the site) would be minimized by complying with all applicable orders, laws and regulations, including industrial management strategies and BMPs (Volume 7). Potential impacts from the operational phase of Alternative 1 are described below for each marine resource category.

Marine Flora, Invertebrates and Associated EFH

No direct impacts on these resources are expected. Operation activities associated with Alternative 1 would include the implementation and management of appropriate BMPs. These resources would not be appreciably modified from existing conditions by indirect impacts identified from minimal increases in suspended sediments and noise. Indirect impacts as a result of actions associated with Alternative 1 would not be significant for marine flora, invertebrates, or associated EFH, and would not adversely affect associated EFH.

Essential Fish Habitat

No direct impacts on these resources are expected. Operation activities associated with Alternative 1 would include the implementation and management of appropriate BMPs (see Volume 7). These resources would not be appreciably modified from existing conditions by indirect impacts identified from minimal increases in suspended sediments and noise. Indirect impacts as a result of actions associated with Alternative 1 would not be significant and would not adversely affect EFH.

Special-Status Species

No direct impact on this resource is expected with the implementation and management of appropriate BMPs.

This resource would not be appreciably modified from existing conditions by indirect impacts. No serious injury or mortality of any marine mammal species is reasonably foreseeable and no adverse effects on the annual rates of recruitment or survival of any of the species and stocks is expected with the implementation of Alternative 1. Green sea turtles may be disturbed by increased activity in the area, specifically, artificial lighting, but potential impacts would be minimal (see Chapter 10, Volume 2 and Volume 4). Alternative 1 would result in a less than significant impact to special-status species.

Non-native Species

There would be no direct impacts in relation to non-native species introductions caused by activities associated with Alternative 1.

There may be increased potential for transport of non-native species to and from other locations within the Mariana Islands chain. This increase above existing conditions is expected to be minimal. Any potential introduction/transport of non-native species may be lessened or even prevented through appropriate BMPs and implementation of the MBP. The DoN will adopt protective measures associated with operational onshore and near shore impacts of the proposed action to reduce the likelihood of the introduction and spread of non-native marine species. These measures may include clarifying biosecurity requirements for all Navy vessels (including chartered Military Sealift Command [MSC] ships), improving hull husbandry documentation, and incorporating into contractual agreements with vessels chartered to support the military relocation specific criteria to ensure low levels of biofouling and ballast water management.

Therefore, Alternative 1 would result in a less than significant impact regarding non-native species introduction.

Onshore operation activities for Alternative 1 would result in less than significant impacts to marine biological resources.

11.2.2.2 Offshore

CONSTRUCTION

The proposed in-water construction-related activities under Alternative 1 would significantly impact and/or may adversely affect marine biological resources by permanently removing benthic substratum, including coral and coral reef habitat, upon which marine flora and fauna are dependent. Given the proposed action as currently defined and existing environmental information on sea turtle habitat in outer Apra Harbor, the data at this point in time tends to suggest that sea turtles may be adversely affected by the proposed in-water activities. However, because the Navy has elected to defer selection of a specific site within Apra Harbor, no definitive conclusion can be reached regarding the impact on ESA-listed species. The Navy will voluntarily collect additional data and/or conduct additional analysis regarding marine resources within specific locations in Apra Harbor. When a proposal regarding the selection of a specific site is put forward, Section 7 consultation will be reinitiated.

Construction of the aircraft carrier wharf would involve dredging, pile driving and placement of fill material in approximately 3.6 ac (1.5 ha) of nearshore/intertidal waters under the proposed wharf structure. Potential construction impacts to marine life are summarized below for each resource type.

This EIS assumes five scenarios for the placement of dredged material: 100% disposal in a proposed ocean dredged material disposal site (ODMDS), 100% disposal upland, 100% beneficial reuse, 20-25% beneficial reuse/75-80% ocean disposal and 50% beneficial reuse/50% ocean disposal. These five scenarios are explained further below in Volume 4, Section 2.3.5.

Marine Flora, Invertebrates and Associated EFH

Potential impacts to marine flora and non-coral invertebrates include direct impacts to those organisms residing in the immediate dredge and fill areas. Large areas of live/hard bottom (non-coral) and submerged aquatic vegetation (SAV) would be removed. Organisms residing in the areas adjacent to and outside the dredged and fill impact areas could experience indirect impacts due to increased sedimentation from dredging activities. Coral impacts are addressed under Essential Fish Habitat. Physical impacts associated with this effort were estimated using the amount of the harbor bottom removed by dredging. Figure 11.2-1 shows the approximate limits of proposed dredging activities and associated coral abundance within and in the vicinity of the project area. The proposed dredge area includes all areas shallower than –51.5 ft (–15.7 m) mean lower low water (MLLW) (-49.5 ft [-15 m] plus 2 ft [0.6 m] overdredge). While mitigation measures such as the use of silt containment devices in deeper waters to protect sensitive coral areas would be employed during dredging operations, particulate material would be released by the breaking up of the reef surface, the re-suspension of particulate material contained within the fossil framework, and the leakage of sediment slurry out of the clamshell during uplift and transfer to scows for dredged material transport and disposal or reuse.

Those mobile organisms in the project area that are not directly subjected to removal or fill activities could sustain impacts as a result of transport, suspension and deposition of dredging-generated sediments.

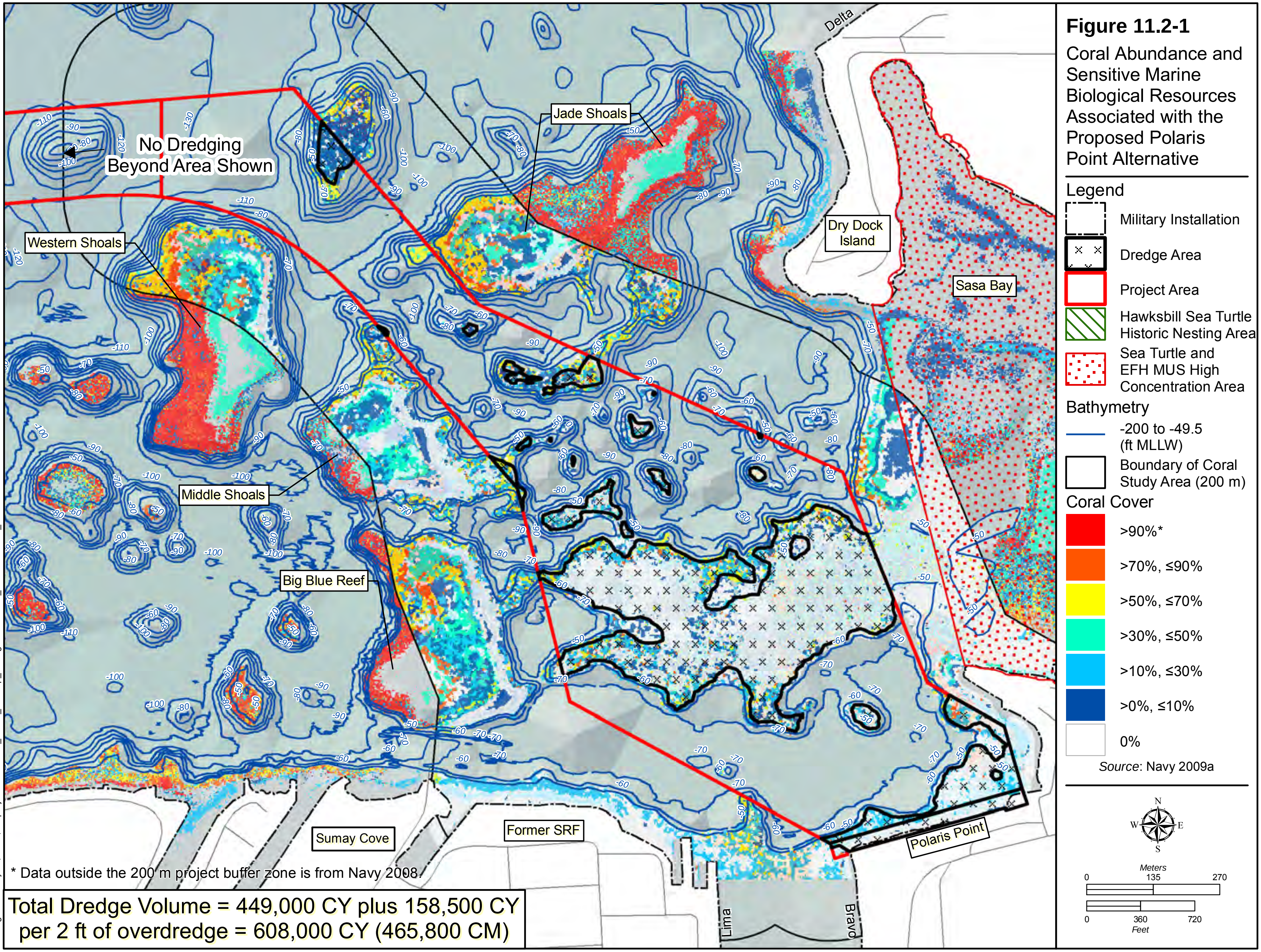

Figure 11.2-1
Coral Abundance and Sensitive Marine Biological Resources Associated with the Proposed Polaris Point Alternative

Sessile organisms such as marine floral communities (macroalgae) have been found to be the predominant benthic community residing within the area to be dredged. Marine algae can outcompete coral and overgrow coral reef sites under certain conditions. Removing the algae and improving water quality could improve the chances of coral reef recovery and growth. Nuisance and non-native invasive algae removal has been successfully implemented in Hawaii by the Nature Conservancy. Under Alternative 1, dredging and fill activities would have direct and permanent impacts on marine flora and sessile invertebrates in the dredged area through removal and subsequent maintenance dredging. Motile invertebrates would likely vacate the area once project activities begin due to the increased disturbance. Although mortality would occur to marine flora and sessile invertebrates, new recruits would most likely replenish these populations post-construction Taylor Engineering, Inc. (TEI) 2009) (TEI) (2009) performed a literature review of effects of beach nourishment, dredging and disposal projects on benthic infaunal-type and other habitats. The following paragraphs cite the reviewed articles and list the key findings related to benthic habitat effects:

1. NOAA Benthic Habitat Mapping. 2007. Applying Benthic Data: *Dredging and Disposal of Marine Sediment*.
    a. "Benthic organisms living in shallow water estuarine and nearshore environments are well adapted to frequent physical disturbance. Tides, currents, waves, and storms cause sediments to be lifted, deposited, or shifted. The resilience of benthic organisms to these environmental changes allows them to recolonize areas of the seafloor affected by dredging."
2. Dredging Operations and Environmental Research (DOER). 2005. *Sedimentation: Potential Biological Effects of Dredging Operations in Estuarine and Marine Environments.*
    a. "most shallow benthic habitats in estuarine and coastal systems are subject to deposition and resuspension events on daily or even tidal time scales"
    b. "Many organisms have physiological or behavioral methods of dealing with sediments that settle on or around them, ranging from avoidance to tolerance of attenuated light and/or anaerobic conditions caused by partial or complete burial"
3. Section 404(b) Evaluation, *Pinellas County Florida Beach Erosion Control Project Alternative Sand Source Utilization."*
    a. "Fill material will bury some benthic organisms."
    b. "Most organisms in this turbid environment are adapted for existence in an area of considerable substrate movement"
    c. "Re-colonization will occur in most cases within one year following construction"
4. Greene. 2002. *A Review of the Biological and Physical Impacts.*
    a. "Studies from 1985-1996 report short-term declines in infaunal abundance, biomass, and taxa richness following beach nourishment, with recovery occurring between 2 and 7 months"
    b. "Studies from 1994-2001 reported recolonization of infauna occurred within two weeks"
5. U.S. Army Corps of Engineers Coastal Engineering Research Center. 1982. *Biological Effects of Beach Restoration with Dredge Material on Mid-Atlantic Coasts*.

a. "animals that spend their entire life cycle in the substrate were not seriously impacted by burying from beach nourishment"

b. "nourishment destroyed or drove away the inertidal macrofauna; but, based on other regional studies, recovery should occur within one or two seasons (i.e. 3-6 months)

TEI (2009) identified short-term impacts to benthic habitat after conducting a thorough literature review. Impacts were considered short-term because most benthic flora and fauna have the ability to adapt for existence in areas of considerable substrate movement. Although most of the studies TEI included in their review involved natural substrate movement as opposed to substrate movement caused by human activities, the recovery of organisms after such events provided useful information on impacts from short-term sediment disturbances.

A beneficial long-term impact for the recruitment of marine flora and invertebrates and the ecology of the immediate area is expected with the increased area for potential settlement provided by the proposed aircraft carrier wharf armor rip rap and vertical pilings. These artificial substrates would provide suitable habitat for benthic algae and sessile invertebrates including sponges, tunicates, sea urchins, starfish, and mollusks, which are currently poorly represented within Inner Apra Harbor and the entrance channel areas (COMNAV Marianas 2006). The structures and associated biota would also provide shelter and food resources for fishes. Based on Paulay et. al. (2002), non-indigenous species occur primarily on artificial substrates in Apra Harbor and, along with indigenous species, would be likely to colonize the new structures. Paulay et al. (2002) did not find evidence that the non-indigenous species were spreading into and significantly impacting natural habitats in the region.

Due to the large size of live hard bottom and SAV to be removed (>40 acres [ac]) (>16.2 hectares [ha]), context and intensity, and cumulative effects of the impacts associated with dredging in a variety of habitats, the impact to SAV and live hard bottom would "be above minimal" (refer to Section 11.2.1.2). The staggered, 18-month dredging duration, will allow some SAV habitat to recolonize before the SAV habitat is fully removed during the dredging operation, therefore a temporary impact. The live hard bottom will be permanently removed and will not have time to recover during subsequent maintenance dredging operations anticipated to occur every 10 years. Therefore, the implementation of the offshore component of Alternative 1 may adversely affect EFH, specifically Live/Hard Bottom.

Essential Fish Habitat

As described in Volume 2, Chapter 11, all of Apra Harbor is considered EFH, which is defined as those waters and substrate necessary to fish (finfish, mollusks, crustaceans and other forms of marine animal and plant life other than marine reptiles, marine mammals and birds) for spawning, breeding, feeding, or growth to maturity (WPRFMC 2009a). EFH for managed fishery resources is designated in the FEPs prepared by the local regional fisheries management council - WPRFMC - and in conjunction with the Guam Division of Aquatic and Wildlife Resources (GDAWR), which among other duties, manages the fisheries resources on Guam. The WPRFMC recently shifted to managing fisheries in the Western Pacific under FEPs, and those which pertain to Guam include the Mariana Archipelago FEP and Pacific Pelagic Fisheries FEP. The Mariana Archipelago FEP includes demersal organisms grouped in the same categories as past FMPs, including the Bottomfish and Seamount, Crustaceans, Precious Corals, and Coral Reef Ecosystems. Due to the highly migratory nature of some pelagic species, an individual FEP was created for pelagic species in the entire Western Pacific region (WPRFMC 2009b). The new FEPs identify areas of EFH and HAPC for different life stages of species managed under the respective plan in the same fashion as the FMPs did (WPRFMC 2009a 2009b). There is no designated EFH or HAPC for precious corals or seamount groundfish around Guam, but other designations do apply (COMNAV Marianas 2007a).

The Navy is consulting with the National Marine Fisheries Service (NMFS) on proposed activities that may adversely affect EFH (see Volume 9, Appendix C). There are four steps in the EFH consultation process (NMFS 1999):

1. The federal agency provides a project notification to NMFS of a proposed activity that may adversely affect EFH.
2. The federal agency provides an assessment of the effects on EFH with the project notification. The EFH Assessment (EFHA) prepared as part of this EIS includes: (1) a description of the proposed action; (2) an analysis of the effects, including cumulative effects, of the proposed action on EFH, the managed species, and associated species by life history stage; (3) the federal agency's views regarding the effects of the proposed action of EFH; and (4) proposed mitigation, if applicable.
3. NMFS provides EFH conservation recommendations to the federal agency. These recommendations may include measures to avoid, minimize, mitigate, or otherwise offset adverse effects on EFH and are to be provided to the action agency in a timely manner.
4. The federal agency provides to NMFS a detailed written response, within 30 days of receiving the NMFS EFH conservation recommendations (at least 10 days before final approval of the action for decisions that are rendered in fewer than 30 days).

The Navy is currently at Step 3, awaiting conservation recommendations from NMFS.

Jade Shoals, just west of Dry Dock Island, is a specific HAPC site. Potential effects to EFH may include direct or indirect impacts to the habitat and/or the individual species that occupy the habitat. These are evaluated as described in Section 11.2.1 Approach to Analysis.

The key assumptions for the assessment of coral impacts are as follows:

- Dredging is anticipated to last from 8 to 18 months to complete the entire proposed action based on dredging 24 hr/d; however, dredging frequency and duration would be determined at the final design stage.
- The impact analysis assumes that all areas less than 60 ft (18 m) deep within the dredged area would be removed, although in reality, the dredge or direct impact area would be at a depth of -49.5 ft [-15.1 m] plus 2 ft [0.6 m] overdredge and remove less coral than described in Table 11.2-1. The coral loss in the direct impact areas is assumed to be permanent.
- The boundary of the coral study area extended approximately 656 ft (200 m) outside the dredge footprint. The severity of indirect impacts from sediment accumulation would extend at varying degrees out from the dredge footprint, not anticipated to exceed the coral study area.
- Indirect impacts were modeled and indicated that sedimentation exceeding 0.001oz/0.15in^2) (40 mg/cm^2)or 0.008 in (0.2 mm) extended an average distance of 144 ft (44 m) from the dredging. This is the assessment of the benthic communities area and may be within the coral's physiological tolerance limit for sediment accumulation (e.g., Hubbard and Pocock 1972).
- A 40 ft (12 m) adverse impact area extending from the dredged footprint was derived from the SEI (2009) oceanographic cumulative plume modeling estimations. This area is anticipated to

receive cumulative sedimentation totaling at least 0.2 in (5 mm), which was established as the cumulative sedimentation threshold for corals (adverse impact area) (Dollar 2009).

The following summarizes the direct and indirect impacts to corals from Alternative 1 actions (Table 11.2-1):

- Areas with the greatest coral abundance (>70 to ≤ 90%) would comprise the smallest portion (10%) of the total coral coverage category that would be lost due to proposed dredging.
- Areas with the least amount of coral coverage (0 – ≤10%) would comprise the largest portion (approximately 36%) of the total coral coverage category that would be lost due to proposed dredging.
- About 62% of the area proposed for dredging contains corals with a coverage of less than 30%. Approximately 3% of the total area proposed for dredging contains corals in the 70-90%, coverage category and 10% for the 50-90% range of coverage.
- The total area impacted is about 172 ac (69.6 ha), which includes direct and indirect impacts of 72 ac (29.1 ha) and 101 ac (40.9 ha), respectively. This equates to a percent coral cover impact of 42%, which includes direct (35%) and indirect (46%) impacts of the total area affected, respectively.

In general, approximately 35% of the proposed dredge area contains some coral coverage and virtually all of the area consists of reefs that were dredged 60 years ago during the creation of Inner Apra Harbor.

In addition to dredging and fill activities, direct impacts to benthic habitats may occur from construction activities related to securing or anchoring the dredge barge and supporting vessels. Anchor chains and mooring cables would not be placed on or over reef areas that support high percentages of coral cover or complex reef structures. Therefore, there would be unavoidable permanent significant impacts to coral and coral reef ecosystem from dredged removal of approximately 25 ac (10 ha) of live coral (all classes [>0% to ≤90%]) with the implementation of Alternative 1.

Table 11.2-1. Estimated Coral Area and Percentages Impacted by Proposed Dredging Activities with Implementation of Alternative 1

Coral Level	*Alternative 1*					
	Direct		*Indirect*		*Total*	
	ha	*ac (% coral[1])*	*ha*	*ac (% coral[1])*	*ha*	*ac (% coral[1])*
coral = 0%	18.61	45.98	22.00	54.36	40.61	100.34
0% < coral ≤ 10%	3.74	9.24 (37)	5.45	13.48 (29)	9.20	22.72 (32)
10% < coral ≤ 30%	2.61	6.44 (26)	3.85	9.52 (21)	6.46	15.96 (22)
30% < coral ≤ 50%	0.96	2.37 (9)	3.25	8.04 (17)	4.22	10.41 (15)
50% < coral ≤ 70%	1.80	4.44 (18)	4.19	10.35 (22)	5.99	14.79 (21)
70% < coral ≤ 90%	1.10	2.71 (11)	1.96	4.85 (11)	3.06	7.56 (11)
Total with coral	**10.20**	**25.20**	**18.71**	**46.24**	**28.91**	**71.44**
Total dredge area	**28.80**	**71.18**	**40.71**	**100.6**	**69.52**	**171.78**
Percent coral cover		**35%**		**46%**		**42%**

[1]Coral percents are rounded to the nearest percent and therefore may not sum to 100%

Source: Dollar et al. 2009

Although the boundary of the coral study area extends out to 656 ft (200 m) from the dredged footprint, it's important to restate that estimated indirect impacts, based on SEI (2009) oceanographic modeling, extended an average distance of 144 ft (44 m) from the dredging footprint and the temporary adverse affects from indirect impacts extended approximately 40 ft (12 m).

Dredging of reef material within the aircraft carrier project area would result in elevated suspended sediments in the water column as a result of both leakage of excavated material from the dredge bucket, and the release of fine-grained calcium carbonate mud (micrite) from the interstitial reef framework (MRC 2009a, Dollar et al. 2009). However, as described in Chapter 4 of this Volume, Water Resources, sediment grain size analyses indicate that sediments in the area of the navigation channel and proposed turning basin, in areas that do not contain coral, consist primarily of sand and rubble; silty sediments are found along the proposed berthing areas (NAVFAC Pacific 2006). The coarse grain size of the material to be dredged indicates that the majority of the resuspended sediment would settle out of the water column rapidly.

The majority of the sediment (e.g., >50%) is comprised of larger grained material and, therefore is generally referred to as being "coarse" in the EIS. Sediment grain size data is presented as a percentage and is discussed as such in the EIS. The EIS will be updated to include a clear presentation of collected grain size data. The three-dimensional circulation and transport model of the project area was developed using the Environmental Fluid Dynamics Code (EFDC). The model included wind and tide forcing, and fresh water inflow into the Inner Apra Harbor; the dredge plume was simulated by loading the water column with specified quantities of suspended sediment composed of 5 different grain sizes. The sediment grain distribution was determined from bottom samples taken in the project area.

While sediment retention devices (i.e., silt curtains) would be deployed to minimize dispersal of this material, it is anticipated that some fraction would escape containment and potentially impact coral reef communities. A sediment plume is an inevitable effect of in-water construction activities and the Navy proposes to minimize by using silt curtains and operational controls of dredging equipment. On Guam, the use of silt curtains in the nearshore, shallow environment (e.g. around wharves) is considered a BMP, as it is a standard operation procedure. The use of silt curtains within the channel to protect sensitive coral habitat (i.e. shoal areas), would be considered a mitigation measure. Other BMPs and mitigation measures will be determined and agreed upon during the U.S. Army Corps of Engineers (USACE) permit phase of the projects. The Navy has monitoring dredging activity at Kilo Wharf and is aware of issues involving the subcontractor managing the silt curtain BMPs. Changes to the height of the silt curtains and some operational changes have been made to correct these issues and will be passed on to future dredging activities. The Kilo wharf project and the proposed action occur in very different areas of Apra Harbor. The setting of Kilo wharf is much more exposed to wind and wave action that impact the BMPs and mitigation measures. The proposed action area is anticipated to be less challenging with regard to the Navy's ability to minimize environmental impacts from sediment plumes. The dredging plume models that were run for the Draft EIS were based on high silt curtain sediment retention of 90% that were observed at other locations in Apra Harbor having similar conditions to the proposed action area. During pile driving or dredging activities, if a visible plume is observed over sensitive coral habitat outside the silt curtains, the construction activity would stop, silt curtain would be evaluated, and corrective measures taken. Construction would not resume until the water quality has returned to ambient conditions.

In addition, breakage of coral by the dredge that is not removed from the seafloor can also result in impacts to the reef habitats that are bordering the dredge sites. For the purposes of this document, these effects are termed "potential indirect impacts."

It is well documented since the pioneering work on environmental tolerances of reef corals that some taxa are more resilient to turbidity and sedimentation than others (e.g., Mayer 1915; Yonge 1930; Marshall and

Orr 1931; Hubbard and Pocock 1972; Riegl 1995; Wesseling et al. 1999). It has also been shown that corals growing in waters of moderate to extremely high turbidity are not automatically more stressed than their clear-water counterparts (Roy and Smith 1971, Done 1982, Johnson and Risk 1987, Acker and Stern 1990, Riegl 1995, Kleypas 1996, McClanahan and Obura 1997, Larcombe et al. 2001). Sanders and Baron-Szabo (2005) describe "siltation assemblages" of corals that occur in turbid water and/or muddy reef environments as a result of resilience to sediment through either effective rejection mechanisms or physiological tolerance to intermittent coverage. See Affected Environment, Section 11.2.2.2, Sediment Effects on Coral.

Review of the scientific literature to identify harmful sedimentation rates on corals revealed that there was no specific threshold level of sedimentation that resulted in coral mortality. The literature review (described in Volume 9, Appendix E, Section D) did reveal, however, that negative effects of sediment loading to reef corals were dependent on both the duration and the rate of sediment deposition. As expected, the general trend is that the higher the deposition rate, and the longer the period of deposition, the greater the effect. Threshold rates cited in the literature range from 0.0001oz/0.15in^2/d to 0.003oz/0.15in^2/d (5 mg/cm^2/d to 100 mg/cm^2/d). The extent of this impact is species-specific based on tolerances, the location or organisms relative to the construction activities, and water currents during proposed construction and dredging activities. Since these parameters cannot be specified for each individual, it is assumed that the impact to EFH and FEP MUS would occur throughout the area potentially impacted by turbidity plumes with sediment deposition rates greater than or equal to 0.008 in (0.2 mm), or 0.03oz/0.15 in^2 (1,000 mg/cm^2) (0.9 in [23 mm]) total, for the estimated dredging duration (Navy 2009a).

Sediment Deposition Models. The Current Measurement and Numerical Model Study for CVN Berthing (SEI 2009) is included in Volume 9, Appendix E, Section E. It presents the current modeling and sediment transport modeling specific to the proposed aircraft carrier project, including the details of methodology and the modeling graphics. The following summarizes the most relevant findings:

- Currents are predominantly wind-driven, and occur as a two-layer system. The surface layer flows in the direction of the wind, and the deeper layer flows in the opposite direction. During typical trade wind conditions, surface flow is to the west out of the harbor, while deeper flow is directed to the east, into the harbor. The exception to this is the entrance channel to Inner Apra Harbor, where currents may reverse with the tides. Local bathymetric features and pronounced reef shoals also control local current directions.
- Currents in the project vicinity are normally weak, which means sediment plumes will not be spreading appreciably.
- The highest current speed measured in Inner Apra Harbor was 1.2 knots (0.62 m/s), with east winds of 8 to 12 knots (4.1 to 6.2 m/s) during a high water slack tide. This example reveals that even with some wind, currents are weak.
- In Outer Apra Harbor, the fastest drogue current speed was 1.7 knots (0.87 m/s) with east wind of 12 knots (6.2 m/s), also during a high water slack tide. A two-layer flow was evident for some deployments. Most data showed that the surface layer moved in westerly directions and the deeper water layer deviated in speed and direction from the surface layer.
- Tidal effects are small in the harbor basins, but are important in the entrance channel to Inner Apra Harbor, where currents may reverse with the tides.

Twenty model cases were completed, bracketing a range of wind forcing conditions, dredging duration, production rates and dredge locations, and suspended sediment release. Model runs were completed for nine different locations throughout the project area. Silt curtain effectiveness was simulated based on 145 days of TSS measurements inside and outside of the silt curtain deployed for the Alpha-Bravo Wharves dredging project in Inner Apra Harbor. These measurements showed that the silt curtains retained 90% of the material inside of the curtain. Model computed TSS levels compared well with the Alpha-Bravo Wharves project measurements outside the silt curtain. Possible maximum adverse impacts conditions were simulated by approximating the highest 10% TSS levels recorded outside of the silt curtain during the Alpha-Bravo dredging project during strong trade wind conditions.

The Navy is monitoring dredging activity at Kilo Wharf and is aware of issues involving the subcontractor managing the silt curtain. Changes to the height of the silt curtains and some operational changes have been made to correct these issues. The Kilo Wharf project and the proposed action occur in very different areas of Apra Harbor. The setting of Kilo Wharf is much more exposed to wind and wave action that impact the effectiveness of the silt curtain. The proposed action area is anticipated to be less challenging with regard to the Navy’s ability to minimize environmental impacts from sediment plumes. Additionally, if a visible plume is observed over sensitive coral habitat outside the silt curtains, the construction activity would stop, be evaluated, and corrective measures taken. Construction would not resume until the water quality has returned to ambient conditions.

One of the scenarios that could result in the maximum potential adverse impact assumed the 24-hr per day dredging generating 1,800 cubic yards (cy) (1,376 cubic meters [m^3]) was located in an area close to Big Blue Reef. Figure 11.2-2 shows the contours of sediment deposition equal to 0.0001, 0.0003, 0.001, 0.003, 0.01 oz/0.15in^2/d (5, 10, 40, 100, 500 mg/cm^2/d) and shows that virtually all of the plume at deposition rates of 0.01 and 0.003 oz/0.15in^2/d (500 and 100 mg/cm^2/d) is retained within the dredge footprint. None of the plume extends past the dredged boundary (i.e., where the shovel impacts the hard surface) near Big Blue Reef for Alternative 1. Similar scenarios for the remaining model runs indicate little extension of the plumes beyond the project area (SEI 2009, Volume 9, Appendix E, Section E of this EIS). The dispersion beyond the dredge area and cumulative deposition effects are based on several inter-related factors as described earlier and include wind speed, current speed, tide, dredging operation duration, and silt curtain effectiveness.

Results of the SEI (2009) modeling are summarized below:

- Sediment deposition resulting from the dredging would be largely confined to the immediate vicinity of the specific dredge site. Maximum sediment deposition of 0.06oz/0.15in^2 (1,742 mg/cm^{-2}), or 0.4 in (10 mm), was calculated assuming 24 hr of dredging at a rate of 1,800 cy/day (1,376 m^3/day) (Model Case 6.3). The modeling indicated that sedimentation exceeding 0.001oz/0.15in^2 (40 mg/cm$^{2)}$, a cited threshold for coral impacts, would extend an average distance of 144 ft (44 m) from the dredging.
- Thickness of substrate to be dredged is only 1.6 to 3.3 ft (0.5 to 1 m) throughout most of the project area. Dredging would therefore pass rapidly from site to site; a 75.5 x 75.5 ft (23 by 23 m) grid area would require only a half day for dredging. This means that exposure to sediment plumes and significant sedimentation >0.001oz/0.15in^2/d (>40 mg/cm^2/d) would be limited to only one or two days. The exception to this is at the Polaris Point coastline, where sediment thicknesses of 13 ft (4 m) or greater would be dredged.

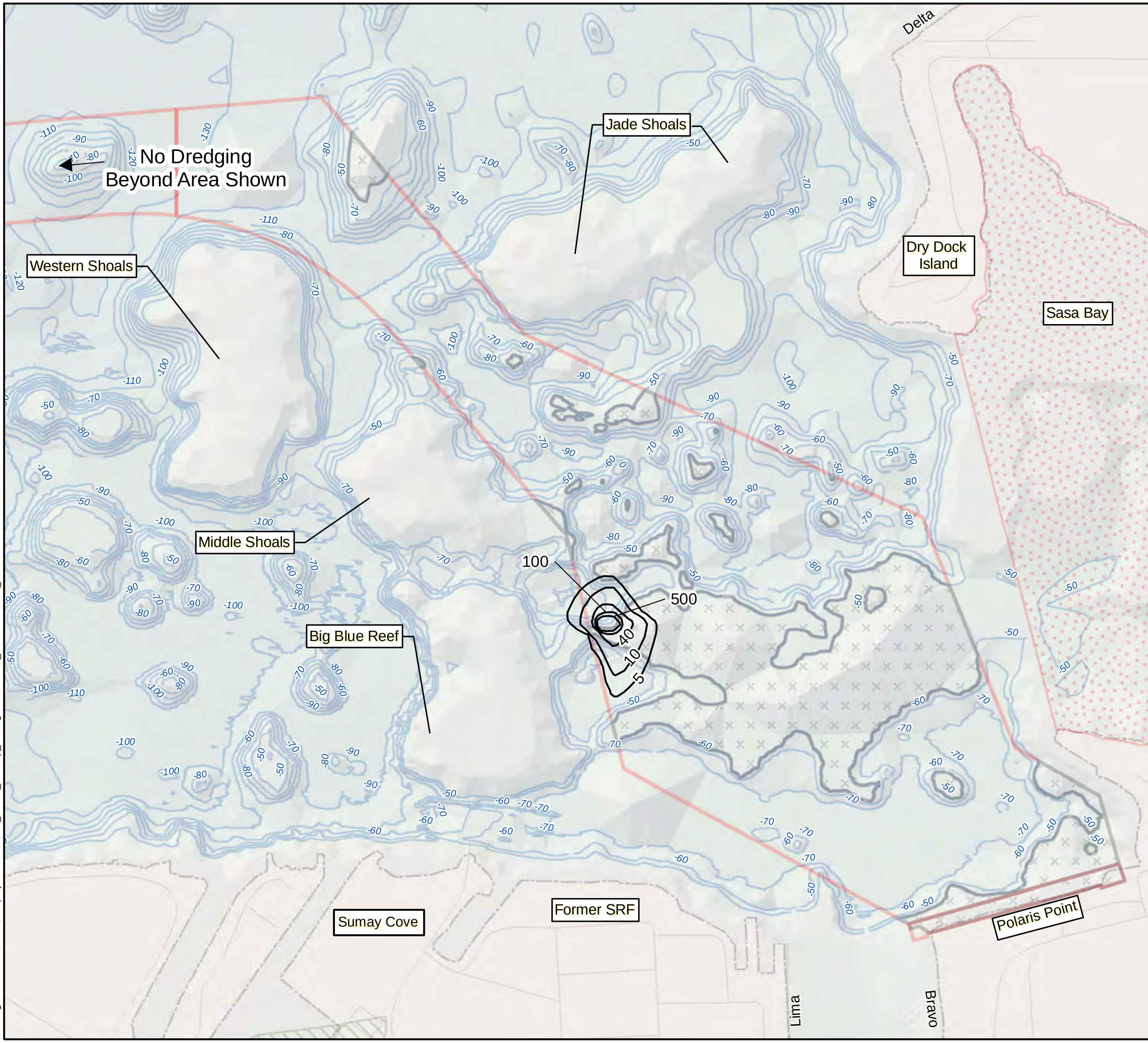

Figure 11.2-2
Sediment Deposition Contours from SEI Model Run 7B

Legend
Military Installation
Dredge Area
Project Area
Hawksbill Sea Turtle Historic Nesting Area
Sea Turtle and EFH MUS High Concentration Area

Model Contours
5 to 500 (mg/cm^2)

Dredge Depth = -49.5 ft (-15.1 m) plus 2 ft of allowable overdredge

Source: Navy 2009a

Meters
0 140 280
0 400 800
Feet

Printing Date: Mar 2, 2010, M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_4\11.2-2.mxd

- Analysis of possible total sediment accumulation during the project indicates that accumulations of greater than 0.03oz/0.15in^2 (1,000 mg/cm^2), or 0.2 in (5 mm) (and adverse impact to EFH)), would be confined to within 75.5 ft (23 m) of the dredge limits at Polaris Point, and to within 32.8 ft (10 m) of the dredge limits in the rest of the project area.
- Surface TSS plumes exceeding background levels of 0.0004 ounces/gallon (3 mg/L) are generally predicted to occur only directly at the dredge site. Plumes near the bottom would be more extensive because most of the suspended sediment would be released into the bottom layer, and it also receives all of the TSS contained by the silt curtain. Plume concentrations exceeding the background levels of 0.0004 ounces/gallon (3 mg/L) would typically extend 262.5 to 394 ft (80 to 120 m) from the dredge site. The plumes would dissipate rapidly following completion of the dredging.
- The maximum environmental adverse impact scenarios were simulated by increasing the sediment release rate from 1% to 2%, and decreasing silt curtain effectiveness by a factor of four. This approximates the highest 10% TSS measurements recorded outside the silt curtain during recent dredging at Alpha-Bravo Wharves. During these conditions, maximum sediment deposition at the dredge site would be 0.09 oz/0.15 in^2 (2,690 mg/cm^2), or 0.6 in (15 mm), and deposition greater than 0.001 oz/0.15 in^2 (40 mg/cm^2), or 0.008 in (0.2 mm), would occur to a distance of 262.5 ft (80 m) from the dredge site.

Surface and bottom TSS concentrations exceeding typical background levels of 0.0001oz/0.2 gallons (3 mg/L) would extend 262.5 to 328 ft (80 to 100 m) from the dredge site, respectively. This numerical analysis was designed to approximate, to the extent practical, the dredging that may occur during the aircraft carrier project. The circulation model was verified with actual current data recorded in the project area. The sediment grain size was derived from numerous bottom samples collected in the area.

Cumulative Sediment Deposition Model. Possible cumulative sedimentation during the project was assessed by extrapolating in time and space the daily results, assuming a 24-hr dredging operation and dredging production of 1,800 cy (1,376 m^3) per day (SEI 2009 Model Cases 6.1 to 6.7). Throughout almost the entire dredge area, only 1.6 to 3.3 ft (0.5 to 1 m) of sediment would be removed. The exception is at the proposed Polaris Point Wharf area where the embankment would be dredged. Dredging operations at the rate identified above would proceed through two 75.5 by 75.5 ft (23 by 23 m) grids per day throughout all of the project area except the Polaris Point Wharf area. Such rapid passage of the dredging operation means that prolonged exposure to plumes and significant accumulation of sediment would not occur in most of the project area. In the area adjacent to Polaris Point, it is estimated that two to three days of dredging would be required for each 75.5 by 75.5 ft (23 by 23 m) grid, compared to a half of a day in the remainder of the project area.

Application of these dredging rates per model grid cell to the daily computed sediment loads provides an estimate of cumulative sedimentation. Sedimentation of 0.03 oz/0.15 in^2 (1,000 mg/cm$^{2)}$, or 0.9 in (23 mm), was selected as a reasonable threshold of sediment accumulation over the duration of the dredging project (8 to 18 months). This thickness corresponds to less than 0.25 in (6.4 mm) for the duration of dredging, or less than an average of 0.04 in (1 mm) accumulation per month. Accumulation of sediment greater than 0.25 in (6.4 mm) thick for the duration of dredging activities would occur only within a distance of 39.4 ft (12 m) from the dredge limit in most of the project area, and within 75.5 ft (23 m) of the dredge limit adjacent to Polaris Point. Figure 11.2-3 illustrates the additional area (outlined in green) that may be impacted by this accumulated sediment.

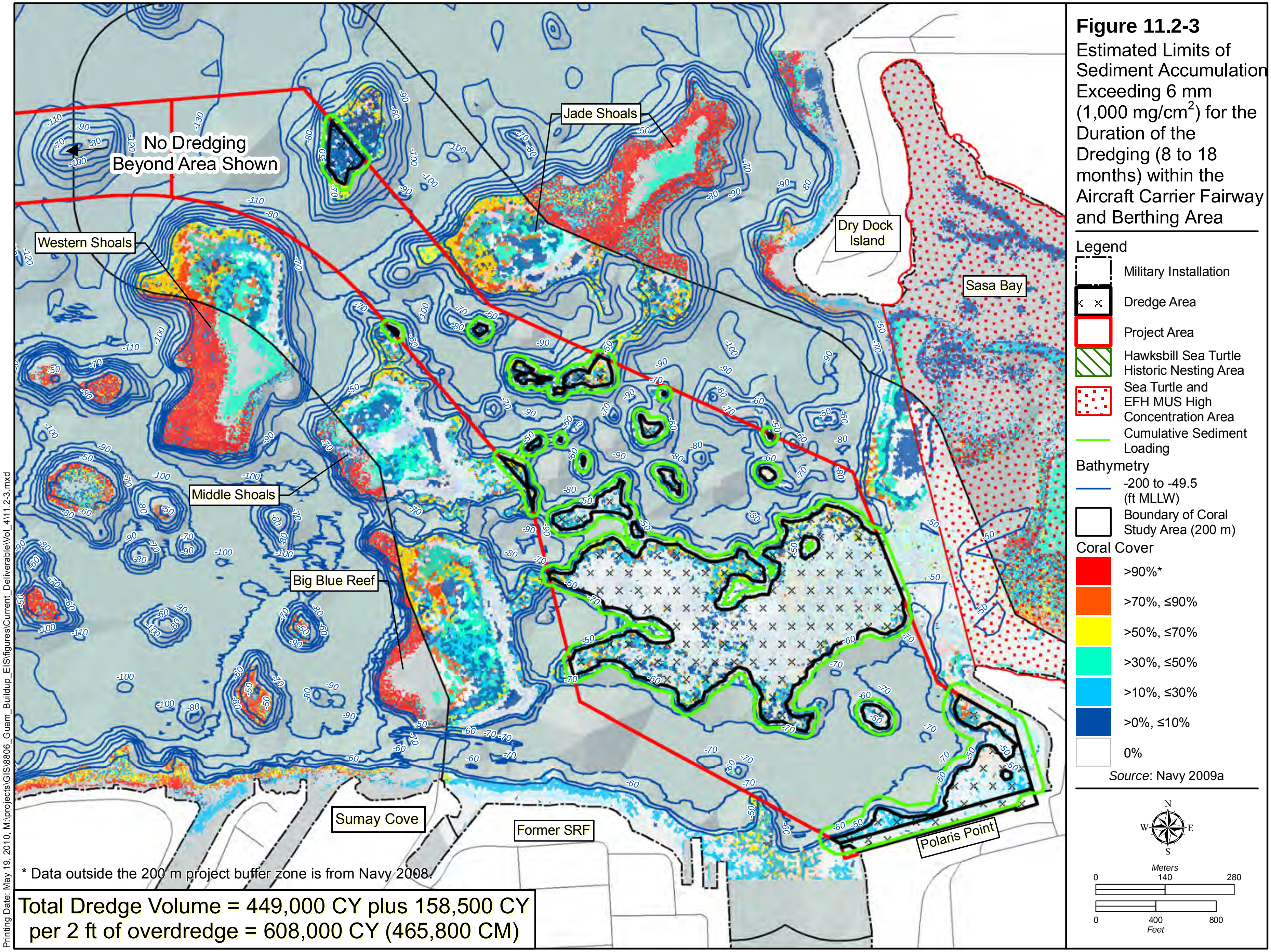

Figure 11.2-3
Estimated Limits of Sediment Accumulation Exceeding 6 mm (1,000 mg/cm^2) for the Duration of the Dredging (8 to 18 months) within the Aircraft Carrier Fairway and Berthing Area

Plume Modeling Summary. The plume modeling results suggest that cumulative sediment deposition during project construction totaling at least 0.03 oz/0.15 in^2 (1,000 $mg/cm^{2)}$ (approximately 6 mm based on site-specific sediment characteristics) would accumulate up to 39 ft (12 m) beyond the area subject to direct impacts. Additionally, some larger-grained sediments generated by the dredging activity above have the potential to accumulate in depressions on plate forms of coral, causing negative impacts. This would be the maximum adverse effects on coral scenario under EFH.

While these estimates of potential indirect impacts represent relatively small percentages of the total area of coral reef habitat, they are likely overestimates for several reasons:

1. The deposition rate of >0.008 in (0.2 mm)/day may be within the coral's physiological tolerance limit for sediment accumulation (e.g., Hubbard and Pocock 1972).
2. Sediment can be resuspended and removed from coral surfaces by physical processes such as wave and current action that occur within reef habitats. Currents in the project area are known to be weak, with surface currents during trade wind conditions typically 4 to 8 cm/second while bottom layer currents were typically 0.06 to 0.13 ft/second (2 to 4 cm/second) (SEI 2009). Brown et al. (1990) suggest that relatively slow current speeds <0.09 ft/second (<3 cm/second) are often sufficient to remove the small aggregates from the tops and flanks of mound-shaped and branching corals. Modeling indicates that following the cessation of dredging, TSS in the water column would return to background levels within several hours SEI (2009). With TSS returning to background levels, sediment deposition to the reef surface would also
3. return to background levels within a very short time. Such a scenario could result in regular periods where corals can utilize a physiological cleaning mechanism to shed deposited sediment MRC 2009c).
4. The slope of the reef faces for the majority of the proposed dredged footprint is steep. Most of the dredge area consists of the flattened tops of previously dredged pinnacles and patch reefs. These features all have steeply sloping margins that extend to the sandy harbor floor. While these reef slopes are among the areas of highest coral cover, indirect impacts from suspended sediment would be mitigated by down gradient flow with little accumulation on the steep reef face (MRC 2009c). It is possible that negative impacts to species with plate forms, such as *P.rus*, could occur.

It is evident from the SEI (2009) modeling results that a large portion of the deposition plume contour would occur in habitats other than the coral reef slopes. A large percentage of the sediment plume contour would cover the coral platform within the dredge envelope, as well as the areas of the harbor floor that are not covered with coral. These areas without coral are characterized by substantial cover of "unconsolidated sediment" that is primarily sand and rubble. The composition of the sand and rubble in these habitats is reef material and is qualitatively similar to the sediment that would be generated by the dredging activity. Hence, while the deposition rate of suspended material may increase temporarily during the period of dredging, it is not likely that this would represent any qualitative change to the sand-covered habitats. Organisms that inhabit these habitats are either infaunal (living within the seafloor) or epifaunal (living on the surface of the seafloor), and the potential additional deposition of sediment associated with dredging would not represent a change in the integrity of this habitat. Any impact to infaunal or epifaunal organisms would be short-term and localized, as discussed previously in this Chapter (MRC 2009c).

Coral Dislodgement. An additional secondary or indirect effect at the dredge area boundaries is dislodgment of coral colonies by dredging operations without the collection of these colonies within the dredge bucket. These uncollected colonies may subsequently tumble down the sloping sides of the patch reefs and pinnacles. While such tumbling downslope is likely to result in some damage to other corals, possibly creating more fragments, there is also the possibility that not all the fragments would die. In fact, fragmentation as a mode of asexual reproduction in coral has been documented in the scientific literature. Highsmith (1982) states that fragmentation and subsequent cascading caused primarily by storm wave energy is "the predominant mode of reproduction in certain corals and an important mode in others." This review also points out that the ecological and geomorphological consequences of fragmentation can be "beneficial" in terms of expanding reef area to sand bottoms that cannot be colonized by larvae, and decreasing reef recovery time from disturbances over strictly sexual reproductive recovery. Highsmith (1980) found that the net effect of frequent storms on Caribbean reefs may be to maintain the reefs in the highest range of reef calcification through high survivorship of coral fragments.

Downward movement of coral fragments following hurricanes and tropical storms has been well-documented in French Polynesia (Harmelin-Vivien and Laboute 1986) and in Hawaii (Dollar 1982 and Dollar and Tribble 1993). In Hawaii, downslope movement of living coral fragments broken by intermediate intensity storm action appears to widen the narrow reef slope zone area, thereby increasing overall coral cover and adding suitable substratum for planular (flat, free-swimming, ciliated larva of coral) settlement and growth in areas that were previously sand. Other high intensity events in the same area of a magnitude that turned virtually all broken fragments into non-living coral rubble did not have the same effect of extending the horizontal margin of the reef (Dollar and Tribble 1993). Stimson (1978) has suggested that for branching corals in Hawaii and Eniwetok that apparently do not planulate, asexual reproduction by means of colony fragments may be the normal mode of reproduction. In Guam, Birkeland (1997) reported most colonies of staghorn coral (*A. aspera*) were derived from fragments, with 79% of colonies living unattached and the remainder, though attached, apparently originating from fragments. Fragmentation, combined with regeneration and fast growth rates, account for dominance of *A. aspera* and *A. acuminata* on inner reef flats on Guam (Highsmith 1982).

On a dredged coral knoll at Diego Garcia Lagoon, Sheppard (1980) found many fragments and detached corals had survived, and subsequent to the dredging many of these living fragments were found to have reattached, contributing significantly to consolidation of the dredge-produced talus. Lirman and Manzello (2009) found that the survivorship and propagation of *Acropora palmata (A. palmata)* was tied to its capability to recover after fragmentation. Survivorship was not directly related to size of fragments, but by the type of substratum, with the greatest mortality observed on sand. Fragments placed on top of live colonies fused to the underlying tissue and did not experience any loss. *A. palmata* is a Caribbean coral, which is typically found in high-wave-energy, generally shallow fore-reef type environments.

Due to the low-wave-energy environment at the base of the dredged area, it is not likely that unattached coral fragments would be moved to the extent of damaging other neighboring corals.

Coral Impacts Significance Discussion. As described in the beginning of the chapter, an adverse effect is: 1) more than minimal, 2) not temporary, 3) causes significant changes in ecological function, and 4) does not allow the environment to recover without measureable impact. These criteria are used in the following text to determine the degree of impacts to coral.

Anticipated indirect effects from the dredging associated with the proposed aircraft carrier project are not expected to exceed the "normal" conditions observed over several days in the Inner Apra Harbor Entrance Channel (MRC 2009c). There are distinct water quality differences (i.e., turbidity zones) in Apra Harbor. While turbid conditions in the Inner Apra Harbor Entrance Channel were not as poor as in the Inner Apra Harbor Basin, field observations during surveys indicated substantially higher turbidity in the Inner Apra

Harbor Entrance Channel than in the proposed aircraft carrier turning basin dredge area. It was also observed that ships transiting through the Inner Apra Harbor Entrance Channel created plumes of resuspended sediment that reached the surface directly over the area occupied by "dense coral communities" within the Inner Apra Harbor Entrance Channel (Smith 2007; MRC 2005; MRC 2009a; Dollar et al. 2009). Hence, the continued existence of these communities supports the expectation that minimal indirect impacts would occur as a result of the proposed dredging. A major difference, however, is that the effects associated with the Inner Apra Harbor Entrance Channel communities are essentially continuous due to turbid discharges from the Apalacha and Atantano rivers into the southeastern portion of Inner Apra Harbor, while the proposed dredging associated with the aircraft carrier at any particular location would occur for only a matter of days (MRC 2009c; SEI 2009) (see Volume 9, Appendix E, Section E).

Based on previous fieldwork and studies, the primary limiting factor for coral recruitment and development in Apra Harbor is believed to be substrate rather than the suspended sediment levels (MRC 2007b personal communication in COMNAV Marianas 2007b). Where adult coral colonies presently exist, either recruitment of coral planulae (sexual reproduction and subsequent successful settlement and growth) or some mode of asexual reproduction (i.e., fragmentation) has resulted in the establishment of living coral communities. Results of reconnaissance surveys that have been conducted throughout the entirety of Inner and Outer Apra Harbor for the purpose of characterizing the distribution, abundance, and condition of reef corals indicate that at present, nearly all areas with suitable substratum in the form of hard bottom that is not subjected to sediment stress (either in the form of bottom cover or abrasion), are colonized by corals and associated reef organisms (MRC 2007b personal communication in COMNAV Marianas 2007b). In other words, corals are well developed in virtually all portions of Apra Harbor that contain suitable substrate (hard stable surfaces). In contrast, areas that do not presently contain coral communities are characterized by unsuitable substratum, primarily in the form of permanent sediment cover of the bottom. Areas that lack hard stable surfaces, such as sand, mud, and algae covered sea floor areas, do not support substantial coral growth. Many portions of the harbor are routinely subjected to moderate to high levels of TSS. Some areas, such as Dry Dock Island, have both suitable substrate and high TSS levels, and have well developed coral reefs. Other areas with lower levels of TSS that lack hard stable surfaces do not support coral growth. These areas are not expected to experience adverse effects on coral recruitment from the increased sedimentation during dredging because sedimentation does not appear to be the limiting factor for coral recruitment and growth in Apra Harbor (Smith 2007b personnel communication in COMNAV Marianas 2007b).

Notwithstanding the above description of coral growth in Apra harbor, there would be a significant and permanent direct impact to the Coral Reef Ecosystem Management Unit Species (CREMUS), specifically hard corals, through direct removal that would adversely affect EFH. The removal of the hard coral benthic community may adversely affect some high fidelity species that were dependent upon that habitat for refuge and forage. The area of potential effects comprises a relatively small fraction (approximately 1%) of the total live reef area mapped in Apra Harbor (Dollar Hochberg 2010). Long-term, localized impacts to coral and coral reef ecosystem would not result in a significant change to the existing EFH conditions in Apra Harbor and would also not likely result in decreased reproductive potential (i.e., coral spawning) of the Apra Harbor reef community as a whole with the required implementation of USACE Section 10/404 permit requirements (i.e. stopping in-water work during coral spawning periods).

Based on the most environmentally adverse scenario model run, none of the projected contours of sediment deposition extend to the large patch reefs characterized as benthic communities with high coral coverage (i.e., Big Blue Reef, Jade Shoals, and Western Shoals). Additionally, the coral community in the potentially affected area is not comprised of unique species; almost two thirds (63%) of the area to be dredged contains coral coverage of less than 30%, the project area is previously disturbed, having been dredged in 1945, and although not "unhealthy," the coral in the project area is sediment-laden and not as healthy as coral at the shoal area further away from the channel (Dollar 2009).

Analysis of possible total sediment accumulation during the project (HEA Volume 9, Section E) indicated that accumulations of greater than 0.03 oz/0.15 in^2 (1,000 mg/cm^{2}), or 0.25 in (6.4 mm), were confined to within 75 ft (23 m) of the dredge limits at Polaris Point, and to within 40 ft (12 m) of the dredge limits in the remainder of the project area. The modeling indicated that sedimentation exceeding 0.001oz/0.15 in^2 (40 mg/cm^2) or 0.008 inch (0.2 mm) extended an average distance of 144 ft (44 m) from the dredging.

For an assessment of the maximum extent of indirect impacts it is assumed that the area of varied sediment deposition would extend an average distance of 144 ft (44 m) from the dredging as modeled, based on sedimentation exceeding 0.001oz/0.15 in^2 (40 mg/cm^2) or 0.008 inch (0.2 mm). The 656 ft (200 m) wide "buffer area" surrounding the direct impact dredge area is considered the coral study area boundary. The area of coral within the coral study area that is shallower than 60 ft (18 m) is assumed to receive temporary adverse indirect impacts from increased dredging-related sediment deposition. Compared to the modeled sediment dispersion contours of 40 ft. (12 m) described above, the size of the coral study area potentially receiving indirect impacts is approximately 16 times larger than the modeled adverse indirect impact area assumed to be permanent.

Therefore, Alternative 1 may have an initial temporary adverse effect on EFH within the coral study area boundary 656 ft (200 m) and a permanent adverse effect on EFH directly located in the dredge footprint based on estimated modeling. Compensatory mitigation would compensate for a 25% and 100% loss in ecological services, respectively, based on the HEA [Navy 2009a]). The temporary adverse indirect impacts would be considered short-term and localized, as recovery would be expected within five years. This is based on references provided in Section 11.1.2.2, Sediment Affects on Coral, Specifically Brown et. al. (2009), and detailed in Navy 2009a. A compensatory mitigation plan that offsets unavoidable losses to aquatic resources, including but not limited to coral reef resources, will be finalized prior to issuance of a Department of Army (DA) permit.

Potential Impacts to Finfish Including EFH. As identified in Table 11.2-1, there would be direct and indirect impacts from the proposed project. In regards to impacts to EFH and reef fish MUS designated under existing FEPs, in-water construction activities would result in direct impacts from dredging removal or fill activities, noise (from dredging and impact pile driving from wharf construction), and indirect impacts from degradation of water quality and sedimentation of habitat.

The removal of coral and coral reef habitat would reduce the structural complexity of Apra Harbor's reef system, resulting in fewer places of refuge for fish from predation. Predicting the impact on the fish communities at these sites is difficult and highly dependent on the impacts to the benthic habitat and availability of adjacent habitat. Sites in close proximity to the dredged footprint would likely suffer more than others. Although the effect on highly mobile species could be variable, it is expected to be negligible. Finfish species occupying habitats that would be permanently removed (coral-, macroalgae-, rubble-, or sand-dominated) would either be displaced to other adjacent sites and adapt, or perish due to habitat modification and loss. Site-attached species such as those from the families Pomacentridae and Chaetodontidae may be adversely affected by changes in habitat structure. Pomacentrids are commonly used to measure community change across sites because of their high abundance, small home ranges, and site specificity. It is anticipated that most displaced finfish species would recolonize other adjacent sites if available. Some finfish would be directly impacted through habitat removal. Other finfish species would be temporarily displaced (e.g., habitats disturbed but remain intact after dredging), possibly returning to those habitats, or repopulating other habitat areas, assuming vacant habitats are available.

Direct impacts from Alternative 1 dredging activities would have an adverse affect on EFH and FEP MUS due to the permanent removal of coral reef ecosystem habitat. Direct removal of other benthic habitat (0% coral with macroalgae, rubble, sand = 45.98 ac [18.61 ha]) would result in no adverse effect by itself, however when considered cumulatively with other habitat removal, leads to a may adversely affect EFH determination. A temporary adverse effect to EFH is expected during the time dredging and in-water construction activities are occurring because the motile MUS would avoid the area due to noise and sedimentation, but may return once these activities were completed. A 25% initial loss was assumed based on these temporary impacts, which is consistent with the estimate that cumulative sediment caused by dredging would be low (i.e. < 0.40 in [< 1 cm]), and the relatively low sensitivity of dominant corals in the affected area (i.e., *P.rus* and *P.cylindrica*) to such levels of sedimentation. A permanent, indirect adverse effect to EFH is expected within the estimated 40 ft (12 m) limits, as identified in Figure 11.2-3. Implementation and enforcement of USACE permit required BMPs and mitigation measures would reduce the direct and indirect effects of dredging and in-water construction activities on EFH.

Noise is another potential source of negative impacts associated with in-water construction activities. Noise disturbances would likely cause fish to disperse and leave the area. Noise from dredging activities (87.3 dB at 50 ft [15 m]) and pile driving (average 165 dB at 30 ft [9 m]) would be below levels determined by NMFS to harm fish hearing (> 180 dB). Sound levels would decline to ambient levels (120 dB) within approximately 150 ft (45.7 m) from in-water construction activities (NMFS 2008b). See Chapter 4 for more information on noise levels. Results of a recent study on three diverse species of fish determined that the 180 dB threshold level identified by NMFS was found to be very conservative, as harm to fish only occurred at markedly higher sound exposure levels (Popper et al. 2006). "Short-term behavioral and/or physiological responses to finfish (e.g., swimming away and increased heart rate) would result for all in-water work, however, such responses would not be expected to compromise the general health or condition of individual fish" (COMNAV Marianas 2007b). Therefore, due to the mobility of finfish and the short-term and localized nature of the disturbance, impacts would be temporary and minimal.

Construction vessel transport would increase during dredging activities. It is estimated that a tug and scow would make 1 round trip/day for 8 to 18 months for dredged material disposal. Wharf construction is anticipated to take three and a half years with some periodic vessel transport expected. (See Volume 2, Chapter 14, Marine Transportation for a detailed description.) The vessels would use the existing Outer Apra Harbor navigational channel to access the ocean dredge disposal site and return to Inner Apra Harbor. The noise associated with in-water construction activities and vessel movements would result in short-term and localized disturbances to organisms living in or on the shallow portions of the benthic substrate.

The EFH for planktonic eggs and larvae of all species as identified for Coral Reef, Bottomfish, Pelagic Fish, and Crustacean MUSs may be impacted by Alternative 1 actions. These life stages typically are weak swimming forms carried about by local currents (COMNAV Marianas 2007b). Based on wind and current measurements (SEI 2009), which show counter surface- and sub-surface currents, planktonic larvae of many species most likely never leave the confines of the harbor. "Some recruitment to Apra Harbor may occur from eggs and larvae being carried into the harbor by local currents, as well as by active recruitment (swimming into and settling in the area) by juveniles. The relative contributions from each of these sources of larvae are unknown, although recruits from outside Apra Harbor must pass through the relatively narrow entrance channel (relative to the volume of Apra Harbor)" (COMNAV Marianas 2007b). Therefore, the probability of their occurrence in the vicinity of the Alternative 1 action area is small. However, the eggs and larvae of these MUS in the water column of the project area would experience short-term and localized impacts. Based on the small coverage areas, these impacts would be temporary or minimal , and therefore, there would be no adverse effect on EFH for planktonic eggs and larvae.

Table 11.2-2 shows the EFH areas within Apra Harbor and their potential construction-related impacts.

Table 11.2-2. EFH Areas Associated with Apra Harbor and Potential Construction-related Impacts with Implementation of Alternative 1

Habitat	*Area of Occurrence*	*Associated Activity*	*Impact*
Live/Hard Bottom	Outer Apra Harbor	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction Increased vessel movements	• May adversely affect EFH through direct, permanent and localized removal. Due to the large area and intensity of the impact, and cumulative impacts associated with dredging of a variety of habitats (refer to Section 11.2.1.2), there would be "more than minimal" significant effects on live/hard bottom habitat. • No adverse effect from indirect short-term and localized vessel movements.
Soft Bottom	Apra Harbor	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction and increased vessel movements	• No adverse effect. Direct removal and indirect, periodic and localized resuspension of sediment. Benthic infaunal community is expected to reestablish quickly from adjacent, undisturbed areas.
Corals/Coral Reef Ecosystem	Outer Apra Harbor Shoal Areas, Entrance Channel	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction	• May adversely affect EFH through direct, permanent and localized removal. • May adversely affect EFH through indirect, short-term and localized increase in underwater noise and localized resuspension of sediments out to 39 ft. (12 m) from dredged area (> 0.2 in. [5 mm] cumulative sedimentation). • No adverse effect on sessile (non-coral) invertebrate benthic community as they are expected to recolonize from adjacent, undisturbed areas • No adverse effect from indirect short-term and localized resuspension of sediments out to 144 ft. (44 m) from dredged area (approximately. 008 in. [0.2 mm] cumulative sedimentation),

Table 11.2-2. EFH Areas Associated with Apra Harbor and Potential Construction-related Impacts with Implementation of Alternative 1

Habitat	*Area of Occurrence*	*Associated Activity*	*Impact*
		Increased vessel movements	increase of noise and potential pollutants • No adverse effect on EFH from increased short term and localized vessel movements.
Water Column	Apra Harbor	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction and other in-water construction activities. Increased vessel movements	• No adverse effect on EFH from direct and indirect, temporary and localized elevation of turbidity, noise, and potential pollutants with implementation of required USACE permits and BMPs • No adverse effect on EFH from direct and indirect short-term, localized resuspension of sediments, increase of noise and potential pollutants from an increase in vessel movements with implementation of USACE permits and BMPs.
Estuarine Emergent Vegetation	Apra Harbor, Sasa Bay	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction. Increased vessel movements	• No effects • No adverse effect on EFH from short-term and localized increase of noise, resuspension of sediment, and potential increase of pollutants.
Submerged Aquatic Vegetation (SAV)	Apra Harbor, Sasa Bay	Dredging of aircraft carrier channel, turning basin, and berth. Increased vessel movements	• No adverse affect to EFH from direct, short-term and localized removal of approximately 10 acres of algae bed habitat. Although a large area will be removed, and the intensity of the impact, and cumulative impacts associated with dredging of a variety of habitats (refer to Section 11.2.1.2) points toward a "more than minimal" significant effects on SAV habitat, effects are temporary. • No adverse effect on EFH from indirect short-term and localized in-water work and vessel movement.
Estuarine Water Column	Sasa Bay	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction Increased vessel movements	• No adverse effect on EFH from direct and indirect temporary and localized elevation of turbidity, noise, and potential pollutants • No adverse effect on EFH from direct and indirect short-term, localized resuspension of sediments, increase of noise and

Table 11.2-2. EFH Areas Associated with Apra Harbor and Potential Construction-related Impacts with Implementation of Alternative 1

Habitat	*Area of Occurrence*	*Associated Activity*	*Impact*
			potential pollutants

Table 11.2-3 shows the sensitive months for EFH MUS found in Apra Harbor, while Figure 11.2-4 identifies all sensitive marine biological resources and habitats in Apra Harbor. The seasonal pupping of scalloped hammerhead sharks (NOAA 2005b, BSP 2010), although reported to be extremely rare in the project area (DoN 2010), and seasonal high concentrations of adult bigeye scad, may also be temporarily disturbed by increased vessel traffic and in-water construction activities. EFH for these PHCRT species would not likely be adversely affected with appropriate NMFS-recommended BMPs and conservation measures; the probability of collisions between vessels and adult and juvenile fish, which could result in injury, would be extremely low due to this highly mobile life stage and slow moving vessels within the navigational channel and shipping lanes in the project area (Navy 2009a).

Table 11.2-3. Sensitive Months for EFH MUS within Apra Harbor

Species	*Status*	*Location*	*Months*
Adult bigeye scad	EFH-CHCRT	See Figure 11.2-4	Jun – Dec
Scalloped hammerhead	EFH-PHCRT	Aircraft carrier turning basin - see Figure 11.2-4	Pupping (Jan – Mar)
Juvenile fish*	EFH	Sasa Bay and other nearshore areas	Nursery (Jan – Dec)
Hard corals	EFH-PHCRT	Apra Harbor	Full Moon Spawning (Jul-Aug)

Note: *Includes barracudas, emperors, goatfishes, groupers, mullets, parrotfishes, puffers, snappers, surgeonfishes, wrasses, and small-toothed whiptails. Sources: NOAA 2005b; BSP 2010; WPRFMC 2009a

EFH Assessment Summary. Alternative 1 dredging impacts to EFH would be greatest for all life stages of coral and sessile reef species, and some crustacean MUS. Site-attached reef fish and pelagic egg/larval stages of bottomfish and pelagic MUS may also be affected. Coral reef habitat would be permanently lost and would be compensated for through mitigation. Dredging activities would cause turbidity plumes and underwater noise that would temporarily disturb FEP MUS. These indirect impacts to EFH would include adverse effects from degradation of water quality as a result of suspended solids, reduction of light penetration and interference with filter-feeding benthic organisms. However, the increase in turbidity would be short-term and localized.

The proposed construction of the aircraft carrier wharf would change the bottom habitat of Polaris Point. However, considering that the area has been previously dredged and that dynamic physical conditions dominate the area, it is expected that pre-construction conditions would return relatively quickly. An exception to this would be the area changed by the presence of back fill and pilings, which would add benthic habitat suitable for colonization by sessile organisms. Impact pile driving would have effects similar to those of dredging activities, including noise and degradation of water quality, but these effects would be of shorter duration and more localized. The noise generated would be somewhat higher than that of dredging.

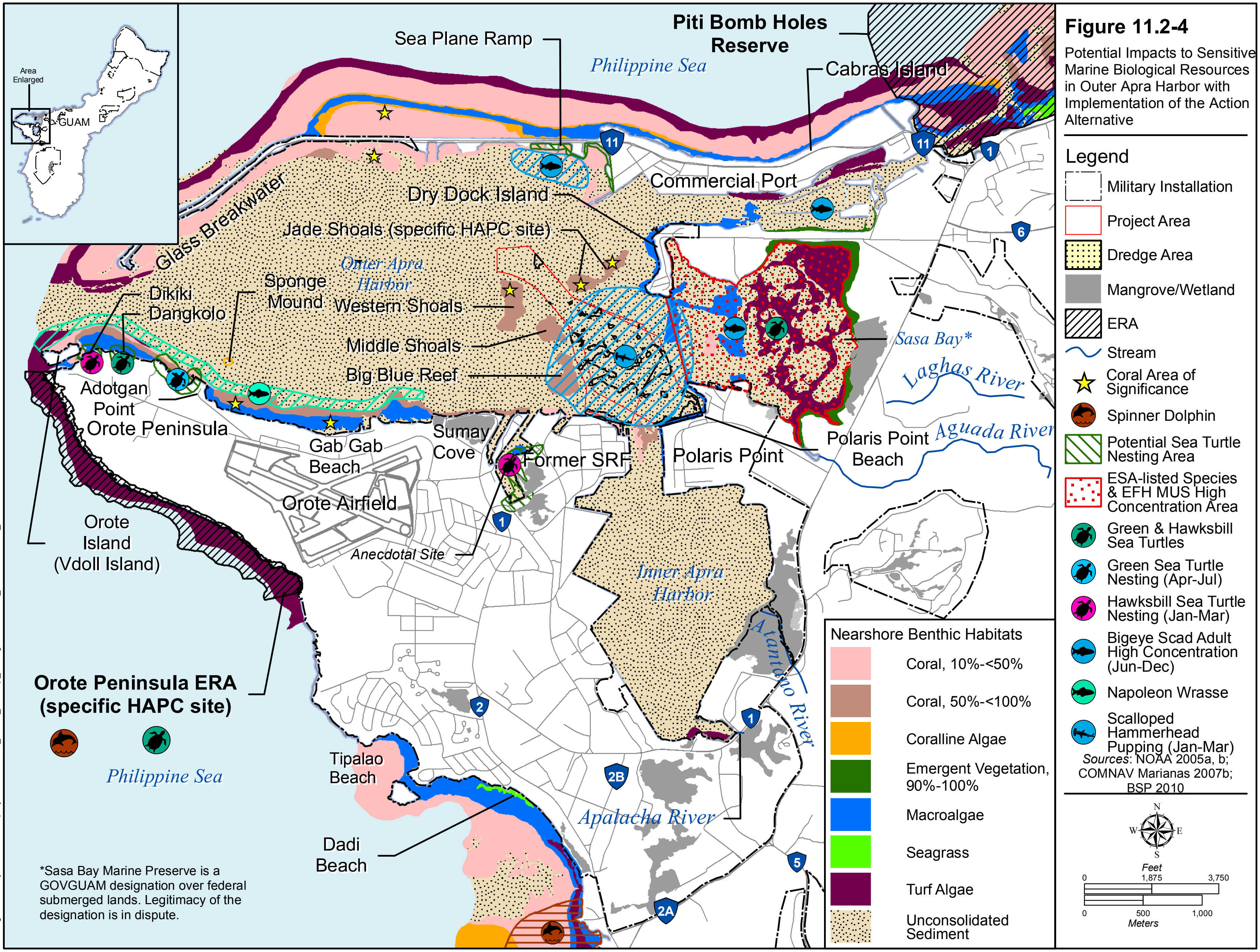

Figure 11.2-4

Potential Impacts to Sensitive Marine Biological Resources in Outer Apra Harbor with Implementation of the Action Alternative

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The placement of the aircraft carrier wharf and associated piles would introduce an artificial hard surface that opportunistic benthic species could colonize, as evidenced by inner harbor studies (Paulay et al. 2002) (see also Volume 2, Chapter 11). Minor changes in species compositions associated with soft bottom communities could also occur (Hiscock et al. 2002). Fish and invertebrates would likely be attracted to the newly formed habitat complex, and the abundance of seafloor organisms in the immediate vicinity of the pilings likely would be higher than in surrounding areas away from the structures (see Volume 2, Chapter 11).

Due to the close proximity to Sasa Bay, juvenile fish might recruit from that area and establish themselves. The overall change in the habitat could result in some beneficial changes in local community assemblages that would partially offset potential short-term, localized negative impacts after the aircraft carrier wharf construction is complete and hard surfaces are populated.

The EFH Assessment (EFHA) prepared for Alternative 1 construction-related actions concluded that the action could result in the following:

- Permanent, localized destruction to 25.20 ac (10.20 ha) of live coral and coral reef habitat (all coverage >0% to ≤ 90%) resulting in a direct adverse effect on EFH.
- Long-term and localized adverse impacts to live/hard bottom due to the intensity and cumulative impacts of the project resulting in an initial direct adverse effect on associated EFH.
- Short-term and localized adverse impacts to SAV due to the intensity and cumulative impacts of the project resulting in an initial direct adverse effect on associated EFH.
- Long-term and localized indirect impact to coral reef ecosystem and displacement of species (could take years to recover) from excessive accumulation of sediment, resulting in an adverse effect on EFH.
- Permanent loss to some displaced, site-attached finfish species, resulting in an adverse effect on EFH.
- Short-term and localized temporary adverse effect on EFH from displacement of mobile FEP MUS (fish and some invertebrates) during in-water construction activities.
- Short-term and localized degradation to water quality (i.e., increases of siltation and turbidity), resulting in a temporary adverse effect to EFH.
- Short-term and localized minor indirect impacts to live coral and coral reef habitat (46.24 ac [18.71 ha]) from increased siltation (below 6 mm accumulation levels) and noise, resulting in no adverse effect on EFH.
- Short-term and localized significant impacts to FEP MUS in planktonic eggs and larvae stages of development, however based on small coverage areas temporary and minimal, resulting in no adverse effect on EFH.
- Short-term and localized minor disturbances to coral reef ecosystems from increased vessel movements, resulting in no adverse effect on EFH.
- Short-term seasonal disturbances to potentially pupping scalloped hammerhead sharks and high concentrations of adult bigeye scad. Considering the rarity of this action (pupping), the mobility of this species and preference for in-water structures for pupping (see earlier references), there would be no adverse effect on these EFH MUS.
- Aircraft carrier wharf structure would most likely result in an increase of community assemblages partially offsetting the short-term, localized adverse effects on EFH.

- Total coral coverage impacted (direct and indirect) is 71.44 ac (28.91 ha).

Based on this assessment, Alternative 1 may adversely affect EFH in Outer Apra Harbor. Some of these impacts would be offset (e.g. some indirect effects) or reduced through implementation and management of USACE permit required BMPs and mitigation measures. Unavoidable loss of ecological function will be offset with appropriate compensatory mitigation measures.

Special-Status Species

Green and hawksbill sea turtles and spinner dolphins are the only special-status species reported in Apra Harbor. The green sea turtle is sighted on a regular basis, while hawksbills are less common, and spinner dolphins are rare. Based on the rarity of their presence within Apra Harbor, no serious injury or mortality of any marine mammal species (spinner dolphins) is reasonably foreseeable. No adverse effects on the annual rates of recruitment or survival of any of the species and stocks are expected with the implementation of Alternative 1. Table 11.2-4 shows the sensitive months for sea turtles within Apra Harbor, while Figure 11.2-4 identifies all sensitive marine biological resources and habitats in Apra Harbor.

Table 11.2-4. Sensitive Months for Sea Turtles within Apra Harbor

Species	*Status*	*Location*	*Months*
Green sea turtle	ESA- Threatened	See Figure 11.2-4	Nesting (Jan – Mar) Foraging (Jan – Dec)
Hawksbill Sea Turtle	ESA-Endangered	See Figure 11.2-4	Nesting (Apr – Jul) Foraging (Jan – Dec)

Legend: *E = endangered; SOGCN = Species of Greatest Conservation Need; T = threatened.
Sources: Navy 2005, GDAWR 2006, USFWS 2009a, NMFS 2009.

As identified in the affected environment section, no sea turtle density information is available for Apra Harbor, however thousands of dive hours have been conducted by the Navy and it's contractors in the past seven years. Sea turtles have not been observed foraging or resting within the proposed project area; it has been observed to function as a transit area to and from Sasa Bay (Navy 2009c).

The available data on sea turtle hearing suggests auditory capabilities in the moderately low frequency range, and a relatively low sensitivity within the range they are capable of hearing (Bartol et al. 1999; Ketten and Bartol 2006). Green turtles are most sensitive to sounds between 200 and 700 Hz, with peak sensitivity at 300 to 400 Hz (Ridgway et al. 1969). Sensitivity even within the optimal hearing range is apparently low—threshold detection levels in water are relatively high at 160 to 200 dB with a reference pressure of one dB re 1 µPa-m (Lenhardt 1994).

As described earlier, the ability of sea turtles to detect noise and slow moving vessels via auditory and/or visual cues would be expected based on knowledge of their sensory biology (Navy 2009a). Noise from dredging activities (87.3 dB at 50 ft [15 m]) and pile driving (average 165 dB at 30 ft [9 m]) would occur. Sound levels would decline to ambient levels (120 dB) within approximately 150 ft (45.7 m) from in-water construction activities (NMFS 2008b). (See Chapter 4 for more information on noise levels.)

Tech Environmental (2009) predicted underwater sound levels of pile driving perceived by sea turtles-all species (hearing threshold sound levels – dB_{ht} re 1 µPa) is 56 at 1640 ft (500 m), 60 at 1049 ft (320 m), and 80 at 98 ft (30 m). Research shows marine animals avoidance reactions occur for 50% of individuals at 90 dB_{ht} re 1 µPa, occur for 80% of the individuals at 98 dB_{ht} re 1 µPa, and occur for the single most sensitive individual at 70 dB_{ht} re 1 µPa. This threshold for significant behavioral response is consistent with NOAA/NMFS guidelines defining a zone of influence (i.e., annoyance, disturbance). For estimating the zone of injury for marine mammals, a sound pressure level of 130 dB_{ht} re 1 µPa (i.e., 130 dB above an animal's hearing threshold) is recommended (Nedwell and Howell 2004). Therefore the calculated zone of behavior response for significant avoidance reaction (i.e., distance where dB_{ht} = 90 dB re 1 µPa and avoidance reaction may occur) to pile driving for sea turtles-all species is <98 ft (<30 m) (Tech Environmental, Inc. 2006). In other words, no injury to any marine animals, including sea turtles, is predicted even if an individual were to approach as close as 98 ft (30 m) to pile driving because all dB_{ht} values at this minimum distance are well below specified thresholds.

To be protective of sea turtles, it is anticipated that NMFS-trained monitors would perform visual surveys prior to and during in-water construction work as part of the USACE permit conditions. If sea turtles are detected (within a designated auditory protective distance), in-water construction activities would be postponed until the animals voluntarily leave the area. In-water work can continue work fifteen minutes after the sea turtle submerges and is no longer seen. This practice is the same for turtle seen within or outside the silt curtains. These mitigation measures are currently being employed at Kilo Wharf, Apra Harbor and are described further in Volume 7.

Sea turtles are highly mobile and capable of leaving or avoiding an area during proposed dredging and in-water wharf construction (i.e., pile driving) activities. Sea turtles are expected to avoid areas of noise and disturbances. Dredging and pile driving activities would likely deter green sea turtles from closely approaching the work area. As a result, the likelihood that a green sea turtle would swim close enough to experience any effects is remote, especially with the silt curtain barriers and other BMPs and mitigation measures in place. Additionally, "during surveys conducted during active Kilo Wharf dredging and chiseling operations during the four periods of December 2008, March 2009, May 2009, and November 2009 in surveys covering waters up to the seaward edge of the silt curtain. All turtle sightings were green turtles; hawksbill turtles were not sighted. All turtles sighted were normal in both appearance and behavior (*e.g.*, swimming or resting), and gave no indication of being disturbed by the dredging or chiseling operations despite being in close proximity of 328 to 656 ft (100 to 200 m) to the operation. In particular, during the dives of 17-21 March 2009, the diver reported that although no SPL measurements were made, the sounds from chisel drop impacts onto the fossilized reef bed qualitatively were of *sufficient impulsive energy to make his body noticeably vibrate physically*, yet nearby observed turtles, including a female ~100m from the operation, were exhibiting normal resting and swimming behaviors" (Navy 2010).

Additionally, the Navy would comply with USACE permit conditions, which include resource agency recommended BMPs for sea turtle avoidance and minimization measures and protocols during in-water construction activities (dredging and pile driving) and vessel operations. These measures (including look outs, stop work policies when turtles approach the area, "ramping up" on pile driving activities, and others) are described in detail in the Mitigation Measures section, Volume 7, and are expected to considerably lessen any potential impacts to sea turtles in the area.

Potential impacts to sea turtles in the marine environment with implementation of Alternative 1 include short-term and isolated impacts through temporary disruption of normal behavioral patterns (swimming, resting or foraging behaviors at Sasa Bay and Big Blue Reef) during the estimated three and ½ year duration for all in-water construction activities. Potential impacts include the following:

- The total dredging duration is estimated at 8 to 18 months; however, work to widen and deepen portions of the existing channel near the bend would not be anticipated to affect sea turtles.
- Given the proposed action as currently defined, pile-driving and wharf construction would last approximately 6-18 months and may affect, and would be likely to adversely affect, sea turtles if they are present in the immediate vicinity.

- Increased vessel movement and in-water mitigation measures may impact sea turtle behavior. There would be a short-term and localized minimal increase in potential for vessel strikes of sea turtles due to the proposed in-water construction increase in ship traffic. The implementation of BMPs and mitigation measures would minimize these potential effects to sea turtles to less than significant. Alternative 1 may affect, but is not likely to adversely affect ESA-listed sea turtles through the short-term increase in ship traffic associated with in-water construction.

In general, sea turtle nesting and hatching activities occur at night. "They cue in on natural light to orient toward the ocean; however, the bright lights from the dredging platforms may confuse adult nesting turtles and hatchlings so that they orient away from the open ocean" (COMNAV Marianas 2007b). Due to the distances of Adotgan Point, Kilo Wharf and the historic Seaplane Ramp nesting areas from the proposed action under Alternative 1, it is unlikely that any nesting-related activities would be affected by the action alternatives, including night work and the associated lights and noise. The Sumay Cove historic nesting site is in close proximity and adult nesting or hatchlings entering the water would potentially be disturbed or disoriented by lights used during night-time construction operations. However, as mentioned previously, this site has not been active since an anecdotal reporting of a hawksbill nesting event in 1997.

The Navy recognizes that there are many on-going and recent past studies of potential noise exposures to sea turtles and other marine species from pile driving actions. Further research and validation of these studies are necessary prior to being able to determine the applicability of the methodologies and results to the proposed action within this EIS. The Navy would continue to monitor these studies and where appropriate, incorporate and apply methodologies, analyses, and results to the on-going impact analysis to sea turtles from the proposed action. Applicability of these studies would also be coordinated through consultations with the National Marine Fisheries Service. Further information on in-water sound, as it relates to impacts on sea turtles, can be found in the Biological Assessment (Navy 2010) prepared for Section 7 consultation with NMFS.

In summary, it is anticipated that implementation of Alternative 1 may affect, but is not likely to adversely affect the ESA-listed green sea turtles with regards to dredging associated with forage habitat loss, nesting and physical injury. Given the proposed action as currently defined, the pile driving components of Alternative 1, although not likely to take sea turtles, due to limited visibility from elevated turbidity of waters in the action area, may potentially expose sea turtles to noise levels that exceed the NOAA's criterion for Level B Take. Therefore, activities associated with pile driving may affect, and are likely to adversely affect the green sea turtle and the hawksbill sea turtle.

Given the proposed action as currently defined and existing environmental information on sea turtle habitat in outer Apra Harbor, the data at this point in time tends to suggest that sea turtles may be adversely affected by the proposed in-water activities. However, because the Navy has elected to defer selection of a specific site within Apra Harbor, no definitive conclusion can be reached regarding the impact on marine biological resources. The Navy will voluntarily collect additional data and/or conduct additional analysis regarding marine resources within specific locations in Apra Harbor. When a proposal regarding the selection of a specific site is put forward, Section 7 consultation will be reinitiated.

Non-native Species

Although terrestrial introductions (exemplified by the brown tree snake) have received much attention, marine introductions had been minimally studied until five major marine biodiversity surveys were conducted on Guam between the mid-1990s and 2001. Although coverage was uneven both taxonomically and in terms of habitats surveyed, approximately 5,500 species were recorded in these surveys (Paulay et al. 2002). Most of the 85 non-native species were found to be restricted to Apra Harbor

(Paulay et al. 2002). Potential long-term impacts to the marine habitat within Apra Harbor from non-native marine organisms, pathogens, or pollutants taken up with ship ballast water (or attached to vessel hulls) are a real threat.

As discussed in Volume 2, Chapter 11, non-native species in Apra Harbor include both purposeful introductions for fisheries and aquaculture, and inadvertent introductions of species that arrived with seed stock or by hull and ballast transport with shipping traffic. These species are found to be more prevalent on artificial structures than natural reef bottoms (Paulay et al. 2002), thus some non-native species recruitment from the inner harbor area to the new aircraft carrier wharf pilings may be expected. Minor changes associated with softer sediments may also be expected to occur around pilings (Hiscock et al. 2002). There would be a need for additional requirements and hull inspection of vessels (e.g., dry docks, tugboats, barges, and dredging scows) before leaving/entering harbors after extended stays.

In addition, the Navy, in cooperation with USEPA, fully complies with the Uniform National Discharge Standards. National Discharge Standards regulate discharges incidental to normal vessel operation and apply out to 12 nautical miles (nm) (22.2 kilometers) from shore. All vessels are required to maintain a vessel-specific ballast water management plan. The Vessel Master is responsible for understanding and executing the management plan (COMNAV Marianas 2007b).

The DoN will adopt protective measures associated with offshore impacts of the proposed action to reduce the likelihood of the introduction and spread of non-native invasive marine species. These measures may include clarifying biosecurity requirements for all Navy vessels (including chartered Military Sealift Command [MSC] ships), improving hull husbandry documentation, and incorporating into contractual agreements with vessels chartered to support the military relocation specific criteria to ensure low levels of biofouling and ballast water management.

Less than significant impacts from construction-related actions associated with introduction of non-native species are anticipated from Alternative 1, if appropriate U.S. Coast Guard (USCG) and Navy ballast water and hull management policies are followed.

OPERATION

As described in Volumes 2 and 4, Chapter 2 and 14, the number of annual visits would increase by approximately four over current conditions with anticipated length of 21 days or less per visit. This would increase the in-port days for the Carrier Strike Group (CSG) from 16 to cumulative total of up to 63 days per year.

Marine Flora, Invertebrates and Associated EFH

Less than significant impacts would be expected to occur for marine flora, invertebrates and associated EFH. Increased vessel traffic may disturb organisms living in the upper water column or in or on the sediments due to propeller wash and resuspension of sediments as described under the construction section and Volume 2, Chapter 11 operation section. Increased impacts to marine flora and invertebrates would be proportionate to the extra transient trips into Apra Harbor and is considered minor over the no-action alternative. Therefore, Alternative 1 would result in less than significant impacts to marine flora, invertebrates and associated EFH, and would not adversely affect associated EFH.

Essential Fish Habitat

There would be long-term, minor and localized impacts associated with use of the aircraft carrier turning basin and wharf at Polaris Point. Although the depth will be increased, the tugboats may still disturb bottom sediments that could potentially be deposited on corals in and near the turning basin, including Big Blue Reef. However, analysis of grab samples collected within the turning basin area indicated that approximately 90% of the surficial sediments were very fine sand sized or coarser, and had a median grain size of approximately 0.0003 in (0.1 mm) (very fine to fine sand). Sediment cores from the same area classified the material as well-sorted sand consisting of 73% sand and gravel and 17% silt (NAVFAC Pacific 2006). These data suggest that most of the material on the seafloor in the deeper turning basin area that may be resuspended by tug-assisted aircraft carrier maneuvering would be sand-sized or greater, thereby minimizing the extent and duration of possible plumes that may result from vessel operation. Additionally, as described earlier, research findings suggest a fundamentally different outcome for corals exposed to sedimentation by sandy, nutrient-poor sediments, such as vessel resuspended marine carbonate sediments found in Apra Harbor, compared to sedimentation of silt-sized sediments rich in organic matter and nutrients.

The operational indirect impacts would be far less than those modeled for 10 to 24 hours of dredging (Volume 9, Appendix E, Section E of this EIS), as the deposition contours do not extend to Big Blue Reef. The use of the aircraft carrier wharf for other ships would result in fewer impacts than for the aircraft carrier because only two tugboats would be required. While the turning point would remain in the center of the turning basin, the ships would be much shorter and the tugboats would be further from Big Blue Reef.

Other ship traffic (including commercial vessels) would use the proposed aircraft carrier navigation channel, which would have the same centerline as the current channel, but would be wider. Other ships would navigate along the centerline and would not use the full width of the aircraft carrier channel. There would be a long-term localized increased potential, although negligible, for direct impacts to EFH and HAPC (Jade Shoals) from coral reef strikes due to an increase in harbor activities (e.g., aircraft carrier traffic, tugboats, ship berthing and unberthing). The aircraft carrier beam (most extreme width or breadth) at the water line is 134 ft (41 m). The narrowest passage within the aircraft carrier fairway is at Jade Shoals at approximately 551 ft (168 m), allowing for roughly a 210 ft (64 m) buffer on either side of the aircraft carrier at this point in the channel. This buffer zone, in addition to strict Navy ship operation protocols within the harbor, including navigating the centerline of the channel, would decrease the potential for direct impacts to Jade Shoals and other nearby areas. The indirect impacts of ship traffic within the proposed aircraft carrier channel on nearby coral shoals would be comparable to existing impacts for current ship traffic, which are minor and short-term.

Indirect disturbances of EFH for reef fish MUS may occur. The impacts would be similar to those described under the construction section above and in Volume 2, Apra Harbor construction and operation. However, the construction of the aircraft carrier wharf would likely provide refuge for finfish and invertebrates. A beneficial long-term impact to the recruitment of finfish and invertebrate MUS and the ecology of the immediate area would be expected with the added relief and settlement potential the aircraft carrier wharf vertical pilings and rip rap would provide. Short-term and periodic minor disturbances to these new recruits during aircraft carrier docking would be expected. Benthic invertebrates such as sponges, sea urchins, starfish, and mollusks, as well as finfish are poorly represented within Inner Apra Harbor, except for on vertical wharf structures (COMNAV Marianas 2006). Smith B.D. et. al., (2008) identified that man-made structures (i.e., wharves, vertical pilings) provided considerable habitat for a diverse array of fishes compared to the reef at Abo Cove or the harbor floor offshore from the wharves. Benthic species, such as cardinalfishes, damselfishes, and gobies, favored corals, debris, sand, soft corals, and the wharf wall and pilings. Species that were active swimmers, such as butterflyfishes, emperors, snappers, surgeonfishes, sweetlips, trevallys and jacks, etc., were found in the water column directly adjacent to the wharves.

Fish within the Apra Harbor channel and associated nearby shoals and nurseries (Sasa Bay) may be disturbed by increased aircraft carrier and MEU embarkation and commercial ship movement through underwater noise or physical disturbances and resuspension of sediments from proposed dredging or propeller wash. However, there may also be additional recruitment potential of juvenile finfish from Sasa Bay to the aircraft carrier wharf as an extended nursery area. While fish may exit the immediate area during vessel movement, it is not likely that there would be any permanent impacts to the present populations.

The deeper channel resulting from dredging activities could help reduce resuspension of fine sediment, decreasing turbidity during vessel operations in Apra Harbor, including carrier operations near the proposed wharf.

Operation impacts to EFH for sensitive MUS potentially present (i.e., Napoleon wrasse, bigeye scad, and scalloped hammerhead) would be short-term and localized, and therefore, there would be no adverse affects to EFH for these species. As described within the EFH construction section above, the impacts to EFH for planktonic eggs and larvae of all species present in the upper water column could be impacted by Alternative 1 actions. However, based on the small coverage areas, these impacts would be negligible, and therefore, no adverse effect on EFH for planktonic eggs and larvae is anticipated.

EFH Assessment. Alternative 1 operation activities, including an increase in vessel movements and operational pollutants could result in:

- Long-term, however, minor, periodic and localized disturbance and displacement of motile species (fish) during in-water transit activities
- Long-term, however, minor, periodic and localized increase of turbidity and pollutants (decreased water quality) in the water column from propeller wash and operation activities
- Long-term, however, minor, periodic and localized increase in benthic sedimentation
- Long-term, however, periodic and localized potentially significant impacts to eggs and larvae in the upper water column from increased vessel traffic
- Seasonal disturbances to potentially pupping scalloped hammerhead sharks and high concentrations of adult bigeye scad

Based on this assessment, all impacts would be minimal, and therefore there would be no adverse effect on EFH from operations. Therefore, Alternative 1 would result in less than significant impacts to Essential Fish Habitat with the implementation of Standard Navy operating procedures and BMPs to protect marine resources, as discussed in Volume 7. Measures would be implemented by vessels while underway within Apra Harbor. Table 11.2-5 summarizes the EFH present in the project area and potential effects with implementation of Alternative 1.

Special-Status Species Summary

The MMPA-protected species and fish species of concern are not expected to occur in the project area.

There would be a long-term, localized increase in the potential for vessel strikes of sea turtles due to the proposed increased ship traffic associated with Alternative 1. Increased vessel movements associated with the aircraft carrier and MEU embarkation operation and commercial shipping traffic have the potential for increased sea turtle disturbances and strikes in route to and from Sasa Bay (a high turtle concentration area) within Apra Harbor. However this increase (approximately 3 extra trips per year) is considered negligible in regards to impacts on the sea turtle population. Potential impacts would be as described in the construction section above and the operation section of Volume 2, Apra Harbor.

Table 11.2-5. EFH Areas Associated with Apra Harbor and Operational Impacts with Implementation of Alternative 1

Habitat	*Area of Occurrence*	*Associated Activity*	*Impact*
Live/Hard Bottom	Outer Apra Harbor	Increased vessel movements and harbor operation	No adverse effect on EFH from long-term periodic (operation) localized vessel movements.
Soft Bottom	Apra Harbor	Increased vessel movements and harbor operation	No adverse effect on EFH; increased vessel movements are not expected to disturb soft bottom communities.
Corals/Coral Reef Ecosystem	Outer Apra Harbor Shoal Areas, Entrance Channel	Increased vessel movements and harbor operation	No adverse effect on EFH from increased localized vessel movements and harbor operations.
Water Column	Apra Harbor	Increased vessel movements and harbor operation	No adverse effect on EFH from direct and indirect long-term but periodic, localized resuspension of sediments, increase of noise and potential pollutants from increased vessel movements and harbor operations. A beneficial impact may be seen to water quality (and associated marine biological resources) from the removal of fine benthic sediment and reduced turbidity within the Outer Apra Harbor Channel
Estuarine Emergent Vegetation	Apra Harbor, Sasa Bay	Increased vessel movements and harbor operation	No adverse effect on EFH from localized potential increase of pollutants from increased vessel movements and harbor operations.
Submerged Aquatic Vegetation	Apra Harbor, Sasa Bay	Increased vessel movements and harbor operation	No adverse effect on EFH from long-term (but periodic) and short-term localized in-water work, vessel movements, and harbor operations.
Estuarine Water Column	Sasa Bay	Increased vessel movements and harbor operation	No adverse effect on EFH from long-term (but periodic) and short-term localized in-water work, vessel movements, and harbor operations.

The long-term, periodic impacts associated with Alternative 1 actions may affect, but are not likely to adversely affect, ESA-listed sea turtles associated with in-water areas (excludes beaches). Therefore, Alternative 1 would result in less than significant impacts to special-status species. Impacts to nesting sea turtles on the beach are addressed in more detail in Volume 4, Chapter 10 (Terrestrial Biological Resources).

The implementation of NOAA/NMFS-recommended BMPs (Volume 7) would be anticipated to reduce any potential impacts of vessel interactions with sea turtles. These BMPs would be implemented while vessels are underway within Apra Harbor (including within the vicinity of Sasa Bay). Additionally, general maritime measures in place by the military, including lookouts trained to sight marine mammals or sea turtles, are in use and designed to avoid collisions with protected species.

Non-native Species

Impacts would be similar to those described under the construction section above. Less than significant operation-related impacts associated with introduction of non-native species would be anticipated from Alternative 1, when appropriate USCG and Navy ballast water and hull management policies are followed. The MBP would further reduce, and assist with control of and response to any potential non-native species introduction.

Avoidance and Minimization Measures

Implementation of Alternative 1 would result in potentially significant impacts to marine biological resources from proposed in-water and nearshore construction activities. Through project design, the Navy has taken significant steps to reduce these potential impacts to marine aquatic resources. Actions taken during the planning phase to avoid and minimize impacts included:

- Realignment of the initially proposed straight channel approach to use the existing commercial shipping channel and widening this channel to accommodate the aircraft carrier
- Minimizing the turning basin diameter to the minimum needed to safely maneuver the aircraft carrier to lessen direct impacts to coral communities
- Identification of Polaris Point as the least environmentally damaging of the two alternatives considering both construction and operational impacts (further away from Big Blue Reef)
- Reduction of the area to be dredged at the eastern end of Alternative 1 to avoid removing coral communities.

In addition, the potential impacts described previously are expected to be minimized by implementation of BMPs. Some of these practices would be consistent with OPNAVINST 5090.1C Chapter 4 Pollution Prevention; OPNAVINST 5090.1C Chapter 9, Clean Water Ashore; OPNAVINST 5090.1C Chapter 11, Oil Management Ashore; OPNAVINST 5090.1C Chapter 12, Oil and Hazardous Substance Spill Preparedness and Response; OSHA Regulation 29 CFR 1910.119 Process Safety Management of Highly Hazardous Chemicals; OSHA Regulation 29 CFR 1910.120 Hazardous Waste Operations and Emergency Response, the ESA, and the Coastal Zone Management Protection Act (CSMA).

- Contractors are required to have and to implement a contingency plan to control and contain toxic spills, including petroleum products. Appropriate materials to contain and clean potential spills would be maintained and readily available at the work site.
- All construction project-related materials and equipment placed in the water would be free of pollutants. The project manager and heavy equipment operators would perform daily pre-work equipment inspections for cleanliness and leaks. All heavy equipment operations would be postponed or halted should a leak be detected, and would not proceed until the leak is repaired and equipment cleaned. This information would be written into the construction contract conditions.
- Fueling of construction project-related vehicles and equipment would take place at least 50 feet away from the water, preferably over an impervious surface. With respect to construction equipment (dredging barges) that cannot be fueled out of the water, spill prevention booms would be employed to contain any potential spills. Any fuel spilled would be cleaned up immediately.
- Turbidity and siltation from upland construction would be minimized through employment of modern designs that promote infiltration and natural processes to the greatest extent practicable.

- Turbidity and siltation from project-related work would be minimized and contained through the appropriate use of effective silt containment devices and the curtailment of work during adverse tidal and weather conditions. Silt curtains will completely enclose dredging operations, including use of curtains that extend fully between the surface and the sea floor, to the maximum extent practicable.
- During pile driving or dredging activities, if a visible plume is observed over sensitive coral habitat outside the silt curtains, the construction activity would stop, be evaluated, and corrective measures taken. Construction would not resume until the water quality has returned to ambient conditions.
    - Adherence to Navy INRMP measures
    - Do not attempt to feed, touch, ride, or otherwise intentionally interact with any ESA-listed sea turtles.
- Anchor lines from construction vessels would be deployed with appropriate tension to avoid entanglement with sea turtles. Construction-related materials that may pose an entanglement hazard would be removed from the project site if not actively being used.

Non-Native Invasive Species Control.

As described in Volume 2, Section 11.1.4.4, a MBP is being developed to address potential invasive species impacts associated with this EIS, as well as to provide a plan for a comprehensive regional approach. The MBP will include risk assessments for invasive species throughout Micronesia and procedures to avoid, minimize, and mitigate these risks. It is being developed in conjunction with experts within other federal agencies including the NISC, U.S. Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS), the U.S. Geological Survey (USGS), and the Smithsonian Environmental Research Center (SERC). The plan is intended to be a comprehensive evaluation of risks in the region, including all Marine Corps and Navy actions on Guam and Tinian and specifically those being proposed in this EIS.

The DoD will adopt appropriate BMPs recommended by MBP working groups during the MBP development to reduce the likelihood of the introduction and spread of invasive marine organisms. Some example BMPs may include clarifying biosecurity requirements for all Navy vessels (including chartered Military Sealift Command [MSC] ships), improving hull husbandry documentation, and incorporating into contractual agreements with vessels chartered to support the military relocation specific criteria to ensure low levels of biofouling and ballast water management.

Volume 7 includes a more detailed description of a MBP.

11.2.2.3 Summary of Alternative 1 (Preferred Alternative) Impacts

Table 11.2-6 summarizes Alternative 1 impacts.

Table 11.2-6. Summary of Alternative 1 Impacts

Area	*Project Activities*	*Project Specific Impacts*
Onshore	Construction	Negligible, short-term and localized impacts associated with lighting, ground vibrations, noise, and a potential decrease in water quality from pollutant runoff.
	Operation	Negligible, short-term and localized impacts associated with lighting, ground vibrations, noise, and a potential decrease in water quality from pollutant runoff.
Offshore	Construction	Significant impacts from direct and indirect effects associated with in-water construction (i.e., dredging and impact pile driving) activities on Essential Fish Habitat and special-status species, respectively. • Marine Flora, Invertebrates and Associated EFH: Unavoidable, long-term and short-term adverse direct impacts to marine flora, non-coral invertebrates and associated EFH are anticipated. Permanent physical removal of live hard bottom would occur within the dredge footprint. SAV is anticipated to reestablish within the dredge footprint from adjacent areas after construction. Considering the size of the impact area, and due to the context and intensity, and cumulative effects (see Section 11.2.1.2), the impacts to live hard bottom and SAV would be "more than minimal," but temporary for SAV. Motile invertebrates would likely vacate the area due to the increased disturbance and find other habitat. Some may perish if seeking cover in reef holes being removed. • Essential Fish Habitat: Unavoidable, long-term significant direct impacts from dredged removal of 25 ac (10 ha) of coral reef habitat (>0% to ≤ 90%) and 46 ac (19 ha) of other benthic habitat (0% coral). Short-term and localized adverse indirect impacts from sediment accumulation (> 0.2 in. or 5 mm in depth) on a portion of an additional 46 ac (19 ha) of coral reef habitat (>0% to ≤ 90%) and 54 ac (22 ha) of other benthic habitat (0% coral) adjacent to, but outside of, the dredge footprint to approximately 39 ft. (12 m). Indirect impacts from sedimentation may adversely affect a portion of the site-attached finfish species. Limited injury or mortality to site-attached finfish and fish eggs and larvae is expected. Short-term and localized disturbance to water column is anticipated. There would be an insignificant long-term population-level effect or reduction in the quality and/or quantity of EFH for finfish with implementation of identified BMPs and mitigation measures. However, after all mitigation efforts, there still would remain unavoidable adverse impacts associated with coral and coral reef ecosystem removal (direct impact) and associated sedimentation (indirect impact). Compensatory mitigation would be required. The HEA assumed dredging impacts accounted for an initial 100% ecological loss from direct impacts and an initial 25% loss of ecological services from indirect impacts. • Special-Status Species: Short-term and localized significant effects on sea turtle behavior during in-water construction may occur; however, there are many alternate sea turtle foraging and resting sites throughout Apra Harbor unassociated with the proposed action, so sea turtle foraging and resting habitat would not be impacted during dredging activities. Mitigation measures would postpone in-water work if sea turtles approach the construction area. Impacts to sea turtles would be reduced with the implementation of identified BMPs and potential mitigation measures, including USACE permit conditions. The Navy is working with NMFS through the ESA Section 7 consultation process to ensure that adverse effects to sea turtles are minimized and significant impacts do not result from implementation of the proposed

Table 11.2-6. Summary of Alternative 1 Impacts

Area	*Project Activities*	*Project Specific Impacts*
		action. All of Alternative 1 actions, except noise from pile driving activities, may affect, but are not likely to adversely affect sea turtles. Pile driving activities may significantly impact sea turtles from increased noise levels. Increased noise from pile driving activities may affect, and is likely to adversely affect, ESA-listed sea turtles. • Non-native Species: Less than significant impacts are expected from introductions of non-native species since construction vessels would comply with USCG and Navy requirements for ballast water and hull management policies. The Navy would also prepare a MBP with risk analysis (see Volume 7 for more details).
	Operation	Less than significant impacts from direct and indirect effects associated with an increase in operational activities. A beneficial impact may be seen to water quality (and associated marine biological resources) from the removal of fine benthic sediment and decreased resuspension within Outer Apra Harbor. • Marine Flora, Invertebrates and Associated EFH: Long-term, localized and infrequent minor impacts from increased tubulance and resuspension of sediment during vessel movements, and the potential for increased discharges of pollutants into the water column. • Essential Fish Habitat: Long-term, however minor, localized and infrequent impacts associated with increased vessel movements and harbor operation resulting in disturbance to water column and finfish through noise, potential increased discharge of pollutants into the water column, and re-suspension of sediments. Limited injury or mortality to fish eggs and larvae. Insignificant long-term populations-level effects or reduction in the quality and/or quantity of EFH. • Special-Status Species: Short-term, periodic and localized minimal effects on sea turtle behavior during increased operation activities and vessel movements with implemented BMPs, mitigation measures, and Navy vessel policies. • Non-native Species: Less than significant impacts from introduction of non-native species are expected as vessels operating within Apra Harbor would comply with USCG and Navy requirements for ballast water and hull management policies. The Navy would also prepare a MBP with risk analysis (see Volume 7 for more details).

11.2.2.4 Alternative 1 (Preferred Alternative) Proposed Mitigation Measures

Because the Navy has voluntarily deferred selection of a transient aircraft carrier berth site in Apra Harbor, the collection of mitigation measures that follows has not been finalized. The proposed mitigation measures may include but are not limited to those outlined below. The results of consultations and permit discussions may form the basis of mitigation measures and may be included in a future ROD or permit.

In addition to those measures contained in Chapter 4 and Chapter 10 of this Volume and summarized in Volume 7, the Navy will consider the following measures:

- No in-water blasting would be allowed.
- Water quality would be monitored for in-water construction projects during the construction phase.
- Preliminary shutdown safety zones corresponding to where sea turtles could be injured or harassed would be established based upon empirical field measurements of pile driving sound levels at the construction site. The sound pressure levels (SPLs) would be monitored on the first

day of pile driving to ensure accuracy of contours. Until validation of the harm threshold, no pile driving may occur within 328 ft (100 m) of sea turtles and no dredging operations shall occur within 164 ft (50 m) of sea turtles. Safety zones would be re-established to accommodate validated harm threshold and reported to NMFS with acoustic monitoring data. Monitoring of sea turtle harassment safety zones would be conducted by qualified observers, including two observers for safety zones around each pile driving and dredging site. Monitoring shall commence 30 minutes prior to the start of pile driving. If a sea turtle is found within the safety zone, pile driving or dredging of the segment shall be halted until the animal(s) has been visually observed beyond the impact zone or 30 minutes have passed without re-detection. Pile driving of dredging may continue into the night, but where there has been an interruption of the activity the activity would not be initiated or re-initiated during nighttime hours when visual clearance cannot be conducted.

- Pile driving and dredging would commence using soft-start or ramp-up techniques, at the start of each work day or following a break of more than 30 minutes. Pile driving would employ a slow increase in hammering, whereas dredging would commence with slow and deliberate deployment of the bucket or chisel to the bottom for the first several cycles to alert protected species and allow them an opportunity to vacate the area prior to full-intensity operations.
- No pile driving or dredging would be conducted after dark unless that work has proceeded uninterrupted since at least one hour prior to sunset, and no protected species have been observed near the respective safety range for that work.
- If a sea turtle or other listed species is found injured within the vicinity of the action area, all in-water pile driving or dredging activities shall cease immediately, regardless of their effect on the noted turtle and the Navy would contact the regional NMFS stranding coordinator.
- Construction related vessels within Apra Harbor shall remain at least 50 yards (45 m) from sea turtles, reduce speed to 10 knots (514 cm/second) or less in the proximity of sea turtles (if practicable, 5 knots [257 cm/second] or less in areas of suspected turtle activity), and, when consistent with safety practices, put engine in neutral and allow the turtle to pass if approached by a turtle. Additionally, sea turtles shall not be encircled or trapped between multiple construction-related vessels or between construction-related vessels and the shore.
- All construction-related equipment would be operated and anchored to avoid contacting coral reef resources during construction activities or extreme weather conditions. Anchor lines from construction vessels would be deployed with appropriate tension to avoid entanglement with sea turtles. Construction-related materials that may pose an entanglement hazard would be removed from the project site if not actively being used.
- Anchors, anchor chain, wire rope and associated anchor rigging from construction related vessels would be restricted to designated anchoring areas within the construction footprint (ie, soft bottom) or within the area that would be permanently impacted.
- As prescribed in permits for previous construction activities (ie, Kilo Wharf) during pile driving or dredging activities, if a visible plume is observed outside the silt curtains, the construction activity would be suspended, evaluated, and corrective measures taken.
- No barge overflow during dredging operations.
- Where practicable, installation of silt curtains during channel and/or harbor dredging operations to maintain water quality and provide coral protection.

- The Micronesia Biosecurity Plan is being developed to address potential invasive species impacts associated with the actions proposed in this EIS as well as to provide a plan for a comprehensive regional approach. The MBP would include risk assessments for invasive species throughout Micronesia and procedures to avoid, minimize, and mitigate these risks. It is being developed in conjunction with experts within other federal agencies including the NISC, USDA-APHIS, the USGS, and the SERC. The plan is intended to be a comprehensive evaluation of risks in the region, including all Marine Corps and Navy actions on Guam and Tinian.
- Incorporate seasonal dredging prohibitions , which may include:
    - Cessation of dredging operations during the period of peak coral spawning (7-10 days after the full moon in July) in consultation with the University of Guam (UoG) Marine Lab.
    - Dredging or filling of tidal waters would not occur during hard coral spawning periods, usually around the full moons of June, July, and August.
    - Construction related vessels would be restricted from Sasa Bay so as to reduce potential impacts to sea turtles and other protected marine and/or wildlife species.
    - Provide natural resource education and training to military personnel on ESA, MMPA, and EFH. This may include Base Orders, natural resource educational training (i.e., watching of short ERA/MPA video) and documentation (i.e., preparation of *Military Environmental/ Natural Resource Handbook, distribution of natural resource educational materials to dive boat operators*), or a combination of all.
    - Compensatory Mitigation for coral (see Section 11.2.2.5) for a detailed discussion.
    - See Section 4.2.2.4, Chapter 4 of this Volume for mitigation measures associated with water resources.
    - Aboard dredge-related tug, barge or scow vessels at sea, use the minimum lighting necessary to comply with navigation rules and best safety practices.

Mitigation Projects for Coral Reefs

Because the Navy has voluntarily deferred selection of a transient aircraft carrier berth site in Apra Harbor, the collection of specific coral reef mitigation projects that follow have not been finalized. The proposed coral reef mitigation projects may include but are not limited to those discussed below. The results of consultations and permit discussions may form the basis of mitigation measures and may be included in a future ROD or permit.

The proposed action would result in unavoidable impacts to coral communities and compensatory mitigation would be required and identified through a compensatory mitigation plan prepared by the Navy (Section 11.2.3, below). Compensatory mitigation is defined as the restoration, establishment, enhancement, and/or preservation of aquatic resources to offset unavoidable impacts to waters of the U.S. (including SAS such as coral reefs). After all efforts to minimize and avoid the impacts of the aircraft carrier project, there remain unavoidable adverse impacts associated with dredging coral reef ecosystems in Outer Apra Harbor. The compensatory mitigation is subject to approval by USACE, under Section 404 and Section 10 permit requirements.

As identified in the 10 April 2008 Federal Register, 40 CFR Part 230, the final USACE compensatory mitigation rule, permit applicants are required to mitigate to no net loss of ecological services and function. The regulations establish performance standards and criteria for the use of permittee-responsible compensatory mitigation, mitigation banks, and in-lieu programs to improve the quality and success of compensatory mitigation projects for activities authorized by Department of the Army permits. Habitat Equivalency Analysis is a tool that has been used in a variety of legal and technical contexts to quantify impacts to natural resources and the services/functions they provide, and quantify the amount of restoration/mitigation required to offset documented losses. The Navy's preparation and approval of a compensatory mitigation plan would meet the requirements of the compensatory mitigation rule.

HABITAT EQUIVALENCY ANALYSIS (HEA)

Coral loss assessment, coral restoration and the parameters used in a HEA are an evolving science. HEA, like any model, relies on user-specified inputs and calculations that simplify complex processes, both of which can introduce uncertainties into model results. However, HEA applications have been published in peer-reviewed technical literature, courts have upheld the use of HEA in litigation, and HEA often underlies settlements reached on cases involving the impacts to and restoration/mitigation of natural resource services and functions. To address the concern of USFWS and USEPA that coral cover as a single metric is inadequate, the revised HEA model is based on percent coral cover plus rugosity (horizontal: vertical measurements) to capture the 3-D complexity of the reef.

The USACE has regulatory authority; compensatory mitigation would be developed during permitting and appropriate units for quantifying credits and debits would be determined by district engineers on a case-by-case basis. District engineers are encouraged to use science-based assessment methods for determining aquatic habitat condition, such as the index of biological integrity, where practicable.

One example of HEA use was to establish the appropriate scale of compensatory restoration in the context of damage assessments conducted under the 1990 Oil Pollution Act and the Comprehensive Environmental Response, Compensation and Liability Act. A HEA was used for the Kilo Wharf dredging project in Apra Harbor.

A HEA model was conducted for both aircraft carrier alternatives and a report entitled *Habitat Equivalency Analysis (HEA) Mitigation of Coral Habitat Losses* was prepared. It is included in Volume 9, Appendix E, Section F of this EIS. The scientific basis for the affected environment description and many of the HEA assumptions is described in *Assessment of Benthic Community Structure in the Vicinity of the Proposed Turning Basin and Berthing Area for Carrier Vessels Nuclear (CVN)*, which is included in Volume 9, Appendix J of this EIS.

The assessment of benthic communities report assumes a 60 ft (18 m) dredge depth, which is an overestimate of the proposed dredge depth of -49.5 ft (-15 m) MLLW plus 2 ft (0.6 m) overdredge, representing an approximately 10-15% increase in assessed benthic habitat in the dredged area. For this reason, the total dredged area differs from the dredged area provided in Volume 4, Chapter 4.

The indirect impacts were modeled and indicated that sedimentation exceeding 0.001oz/0.15 in^2 (40 mg/$cm^{2)}$ or 0.008 inch (0.2 mm) extended an average distance of 144 ft (44 m) from the dredging, the assessment of benthic communities assumes this distance, however the HEA assumes an indirect impact distance of 656 ft (200 m) from the direct impact area boundary, which is an overestimate of the impact area. As previously noted in Section 11.1.2.2, this is an overestimate because the SEI (2009) plume modeling summary identifies only 40 ft (12 m) beyond the direct dredge impact area as anticipated to receive cumulative sedimentation totaling at least 0.2 in (5 mm), which was established as the cumulative sedimentation threshold for corals.

The total direct impact dredge area (as noted in Table 11.1-1) for Alternative 1 is 71 ac (29 ha) and 61 ac (25 ha) and for Alternative 2. As discussed above, this total direct dredged area assumes a 60 ft (18 m) depth. This is an overestimate of the proposed project's dredge footprint (-49.5 ft [-15 m] MLLW, plus 2 ft. (0.6m) overdredge) noted in Volume 4, Chapter 2 where the total dredge area is 53 ac (21 ha) for Alternative 1 and 44 ac (18 ha) for Alternative 2, respectively.

The description below is a brief summary of a HEA that was created as an evaluation tool for this document. The findings for both the Polaris Point and the Former SRF alternatives are provided together in this section to facilitate comparison.

The HEA addresses direct and indirect impacts to coral habitat arising from dredging to support aircraft carrier berthing and maneuvering in Outer Apra Harbor. The basic HEA steps include:

Loss calculation: Document and estimate the duration and extent of injury from the time of injury until the resource recovers to baseline, or possibly to a maximum level below baseline.

Restoration calculation: a) Document and estimate the services provided by the compensatory project over the full life of the habitat, and b) Calculate the size of the replacement project for which the total increase in services provided by the replacement project equals the total interim loss of services due to the injury.

Loss Calculation (Step 1). As a first step in determining appropriate mitigation, HEA impact inputs to estimate potential coral habitat losses due to dredging were developed, based on currently available information. These inputs reflect site-specific data and analyses, information from relevant literature, and the professional judgment of technical experts familiar with the project plans, potentially affected habitats and biota, environmental impact assessment, and the HEA methodology.

The estimated input values for the variables needed to perform HEA loss calculations, included:

- The acreage of coral habitat expected to be affected by dredging, including direct (dredging) and indirect (dredging-related sedimentation) impacts. Based on pixel counts from the remote sensing map, the total area ("plan" view) with any level of coral coverage is about 25.20 ac (10.20 ha) for Alternative 1 and 23.74 ac (9.61 ha) for the Alternative 2 in the direct impact area.
- The coral habitat index was generated by merging Quickbird multispectral imagery, field survey habitat data (Dollar et al. 2009, Volume 9, Appendix J), and reef rugosity derived from bathymetric data (airborne LIDAR and boat hydrographic surveys). The coral habitat index is on a logarithmic scale. Ten categories of coral habitat index ranges were defined as shown in Table 11.2-7. Category 1 represents the least coral cover and least complex structure and Category 10 represents the greatest coral cover and most complexity.
- The expected severity and duration of expected impacts, relative to baseline conditions (i.e., the anticipated future condition of coral habitat in the project area if the CVN project never occurred); and
- The shape of the recovery curve, the period over which losses are calculated, expected project timing and an appropriate discount rate.

Table 11.2-7. Coral Habitat Index Ranges

Coral Habitat Index Category	*Coral Habitat Index Range of Values (log_{10})*
Category 1	0 to ≤ 0.235
Category 2	0.235 to ≤ 0.471
Category 3	0.471 to ≤ 0.706
Category 4	0.706 to ≤ 0.942
Category 5	0.942 to ≤ 1.177
Category 6	1.177 to ≤ 1.413
Category 7	1.413 to ≤ 1.648
Category 8	1.648 to ≤ 1.884
Category 9	1.884 to ≤ 2.119
Category 10	2.119 to ≤ 2.355

This analysis focused on the coral habitat expected to be either permanently lost due to dredging or temporarily affected by sedimentation. Much of the habitat within the dredge footprint is unconsolidated soft sediment with no coral cover (Smith 2007, Dollar et al. 2009). Soft bottom habitat was not addressed in the HEA.

The total area (three dimensional view) of habitat with some coral coverage is approximately 33 ac (13 ha) for Alternative 1, and approximately 32 ac (13 ha) for Alternative 2.

Based on these inputs, an estimate was made of the discounted service acre-years expected to be lost due to aircraft carrier dredging-related activities. The "acre-year" metric allows the analysis to consider not only the number of acres lost, but also injury severity and recovery over time. A loss of one acre-year equates to a complete loss of ecological function provided by the identified habitat for one year. Such a loss could be arrived at in numerous ways (e.g., 50% degradation of two ac [0.8 ha] of habitat for one year, 10% degradation of five ac (2 ha) of habitat for two years, 5% degradation of one ac (0.4 ha) of habitat for 20 years, etc.).

The simplified examples above do not take into account the effects of discounting, which is applied in the HEA methodology to convert losses occurring in different years into a single, common year. A 3% annual discount rate is added to the calculations, which is the most common discount rate used in HEA applications and one that research indicates reasonably reflects society's general preference for current use and enjoyment of resources, compared to future resource use and enjoyment (NOAA 1999; Freeman 1993). The sum of these discounted losses across years represents the present value acre-years of ecological services lost.

Tables 11.2-8 and 11.2-9 summarize the data used in the HEA calculations to estimate aircraft carrier-related coral habitat impacts and the resulting loss estimates. As shown in these tables, Polaris Point (Table 11.2-8) is expected to result in a loss of approximately 1,048 discounted service acre-years (DSAYs) of coral habitat (across all coral habitat categories), approximately 996 DSAYs due to direct impacts and 52 DSAYs due to indirect impacts. The Alternative 2 is expected to result in a loss of approximately 1,023 DSAYs, 969 DSAYs due to direct impacts and 54 DSAYs due to indirect impacts.

Table 11.2-8. HEA Loss Calculations for Direct Impacts Arising from the Aircraft Carrier Project

Project Alternative	*Habitat Index Category*	*Year Dredging Occurs*	*Estimated Post-Dredging Service Level (Initial)*	*Year Recovery Begins*	*Length of Recovery Period (years)*	*Shape of Recovery Curve*	*Post-Dredging Service Level*	*End of HEA Analysis Period*	*Estimated Loss (2009 DSYs)*
Direct Impacts									
Polaris Point	Category 1 Category 2 Category 3 Category 4 Category 5 Category 6 Category 7 Category 8 Category 9 Category 10 Subtotal	2012 (a)	0% (b)	None (c)	No Recovery (c)	NA (c)	0% (c)	Perpetuity (d)	303.93 243.99 179.40 163.39 71.23 26.92 7.17 0.35 0.00 0.00 996.37
Former SRF	Category 1 Category 2 Category 3 Category 4 Category 5 Category 6 Category 7 Category 8 Category 9 Category 10 Subtotal	2012 (a)	0% (b)	None (c)	No Recovery (c)	NA (c)	0% (c)	Perpetuity (d)	288.95 232.69 178.32 166.13 70.06 26.15 5.88 0.18 0.00 0.00 968.36

Notes:

a) Estimated year for dredging implementation.

b) Assumes complete loss of coral habitat services, beginning immediately after dredging.

c) Assumes ongoing maintenance of dredge channel would prevent significant re-establishment of coral in dredged areas.

d) HEA impacts calculated in perpetuity.

Refer to Table 11.2-6 for the Coral Habitat Index range per category.

Table 11.2-9. HEA Loss Calculations for Indirect Impacts Arising from the Aircraft Carrier Project

Project Alternative	*Habitat Index Ca*	*Year Dredging Occurs*	*Estimated Post-dredging Service level (Initial)*	*Year Recovery Begins*	*Length of Recovery Period (Years)*	*Shape of Recovery Curve*	*Post-Dredging Service Level*	*Estimated Loss (2009 DSYs)*
Indirect Impacts								
Polaris Point	Category 1 Category 2 Category 3 Category 4 Category 5 Category 6 Category 7 Category 8 Category 9 Category 10 **Subtotal**	2012 (a)	75% (b)	2013 (c)	5 (d)	Linear (e)	100% (f)	10.31 9.46 11.75 7.79 5.09 3.82 2.42 0.80 0.21 0.13 **51.79**
Former SRF	Category 1 Category 2 Category 3 Category 4 Category 5 Category 6 Category 7 Category 8 Category 9 Category 10 **Subtotal**	2012 (a)	75% (b)	2013 (c)	5 (d)	Linear (e)	100% (f)	10.70 9.48 12.04 8.28 5.45 4.24 2.80 0.97 0.23 0.13 **54.32**

Notes:

a) Estimated year for dredging implementation.
b) A modest (25%) initial service level loss is consistent with the expectation that cumulative sedimentation caused by dredging is expected to be low (less than approximately 1 cm), and the expected low sensitivity of dominant corals in affected area (*P. rus* and *P. cyindrica*) to such levels of sedimentation.
c) Recovery is assumed to begin the year after the completion of dredging (i.e. 2013).
d) A 5-year recovery time is conservative in light of the expected low level of initial impact and relevant literature (e.g., Brown et al. (1990) study of dredging impacts on intertidal coral reefs at Ko Phuket, Thailand, which suggests a one to two year recovery period is reasonable for impacts of this type).
e) For simplicity (and in the absence of field data warranting a different approach), a linear recovery rate is utilized for HEA purposes.
f) Affected coral communities are expected to fully recover to baseline condition.

Refer to Table 11.2-7 for the Coral Habitat Index range per category

Initial Service Loss and Duration of Injury. For direct impacts, the HEA assumed an initial 100% loss in ecological services (i.e., the resource suffers a complete loss of ecological function). For indirect impacts, affected habitat is expected to experience an initial 25% loss. This estimate is consistent with the expectation that cumulative sedimentation caused by dredging is expected to be low (i.e. < 0.40 in [< 1 cm]), and the relatively lower sensitivity of dominant corals in the affected area (*P. rus* and *P. cylindrica*) to such levels of sedimentation.

Areas directly impacted by dredging are considered permanently injured, and therefore experience a 100% loss in ecological services in perpetuity (i.e., no recovery). Any recovery would be lost during future maintenance dredging. Indirect impacts are expected to be temporary, and affected areas are expected to recover to baseline condition within five years, which the Navy believes to be a conservative assumption in light of the expected low level of initial impact and relevant literature (e.g. Brown et. al. 1990) described earlier in the EFH indirect impacts subsection above.

Restoration Calculation (Step 2). Step 2 requires a mitigation project and artificial reefs were the mitigation approach used in the HEA. There is a discussion later in this section on the rationale for using artificial reefs.

A typical pattern for Z-block placement utilized by the state of Hawaii deploys up to approximately 300 Z-blocks per ac (0.4 ha) of subtidal bottom in approximately six "sets" of 50 Z-blocks each, resulting in 15 ft (w) x 15 ft (l) x 12 ft (h) [4.6 m (w) x 4.6 m (l) x 3.7 m (h)] dimensions for each set (COMNAV Marianas 2007b). An alternate deployment proposed for the Kalaeloa artificial reef intended to mitigate impacts to coral reef ecosystem arising from the Ocean Pointe Marina project (also referred to as Hoakalei Marina) would place 350-400 Z-blocks in a single set with dimensions approximately 100 ft (30.5 m) in diameter and 20 ft (6 m) in height (HDNAR 2007).

Applying the algorithm used to assign injuries to Habitat Index Categories, 1 ac (0.4 ha) of artificial reef (i.e., 300 Z-blocks deployed in a site-appropriate configuration) would be classified in Category 1. Therefore, the Navy utilizes a 1:1 ratio for artificial reef to injured Category 1 reef. Recognizing the greater coral cover, surface area, and/or rugosity of Category 2 habitat, the Navy assumes a 2:1 artificial reef to injured Category 2 reef, a 3:1 ratio artificial reef to injured Category 3 reef, and so on.

For simplicity (and in the absence of field data warranting a different approach), a linear recovery rate from the use of artificial reefs was utilized for HEA purposes. This implies an annual service gain of 10%, based on a 10-year period post-deployment for artificial reefs to provide comparable replacement functions and services. This type of artificial reef was estimated to provide ecological benefits for 100 years. This estimate was based on the two-block design described above, and the inclusion of substantial maintenance and contingency allowances in the project budget.

Some soft bottom habitat would be lost if mitigation measures include the placement of an artificial reef. That is, the habitat directly underlying the footprint of the reef structure and its corresponding ecological services would be permanently altered. This would be offset by placing the reefs in areas with limited ecological contributions. Although the HEA assumes permanent loss of habitat due to dredging, in reality there would be coral regrowth that would provide minor functions/services in the dredged areas. This could offset losses of habitat on which artificial reefs are placed.

The HEA was used to develop an estimate of the discounted service acre-years (DSAYs) gained per acre of artificial reef, discounted in the same manner as HEA loss calculations. Given a total expected loss of 1,048 DSAYS, a total of approximately 123 ac (49.8 ha) of artificial reef would be required to compensate for coral habitat impacts expected due to Alternative 1. Results indicate that each acre of artificial reef would provide approximately 22.1 DSAYs. Approximately 121 ac (49.0 ha) of artificial reef would be required for mitigation of impacts due to Alternative 2.

The HEA example was used to establish the appropriate scale of compensatory restoration in the context of coral damage assessments. Compensatory mitigation would be developed during permitting and appropriate units for quantifying credits and debits would be determined by USACE for identified projects. The compensatory mitigation plan to be prepared by the Navy would include information received from resource agencies on how the data will be used in the HEA.

11.2.2.5 Implementation of Coral Restoration

Within DoD, regulatory agencies and other stakeholders on Guam support the use of In-Lieu-Fee or mitigation banking programs to manage, implement and monitor the success of natural resource compensatory mitigation projects on Guam. These programs are not yet established on Guam and would be developed in a timely manner to the satisfaction of the USACE. Direct mitigation by the Navy is the alternative to these programs.

Regardless of whether the Navy implements the mitigation project directly or provides funds to a In-Lieu-Fee or Mitigation Bank program, all mitigation projects require a mitigation plan approved by USACE that would include the following components:

- Objective(s) of the compensatory mitigation project
- Site protection instrument to be used
- Baseline information (impact and compensation site)
- Mitigation work plan
- Maintenance plan
- Ecological performance standards
- Monitoring requirements
- Financial assurances
- Site selection information
- Number of credits (fee) to be provided
- Long-term management plan
- Adaptive management plan

11.2.2.6 Development of Compensatory Mitigation Proposals

The *HEA and Supporting Studies* report (Volume 9, Appendix E, Section A) provides background on the mitigation proposals discussed among regulatory agencies and DoD. Many ideas were proposed at a HEA workshop that was hosted by USFWS in 2008 (Guam agencies were unable to attend due to scheduling difficulties). Regulatory agencies prefer a watershed management approach to the use of artificial reefs as mitigation, as agencies believe that watershed management projects would result in greater beneficial impacts to the marine environment; however, as described further below, the effectiveness of either artificial reefs or upland watershed management schemes to replace coral loss have been studied and conclusions concerning success differ. Guidelines for project acceptability were:

- Project would replace the loss functions and services of coral reef ecosystems.
- Scientific data are available that the project would, in fact, have the desired result of in-kind replacement. In other words, there must be confidence in the success of the project.

- The ratio of restoration to loss is quantifiable.
- The project is legal.
- The project is feasible.
- Project may enhance but not replace activities that are already occurring or be used to achieve ongoing mandated responsibility.

All proposals discussed would benefit the environment, but some were dismissed outright for not meeting CWA requirements for compensatory mitigation including the guidelines above. The dismissed ideas and the primary reason for dismissal are listed below:

- Increase enforcement of existing marine protected areas. Dismissed because transferring DoD funds to other federal agencies or local agencies to support policing action may encounter fiscal law constraints and enforcement is a pre-existing mandated responsibility.
- Purchase land for new preserve or to prevent future development that could degrade water quality. Dismissed because it is not feasible in a reasonable time-frame and it would be difficult to demonstrate that coral restoration would be the result.
- Prepare management plans for submerged lands and lands, DoD lands or island-wide. Dismissed because compensatory mitigation cannot be used to achieve other mandated responsibility as in the case of DoD lands. Plans by themselves do not restore ecological function; therefore, they are not considered suitable mitigation.
- Pursue aquaculture to increase biomass. Dismissed because it would not replace or restore coral function.

The Navy is considering a suite of four categories for compensatory mitigation for the loss of ecological service provided by corals being adversely impacted in Outer Apra Harbor. The four categories developed include Watershed Restoration and Management, Coastal Water Resource Management, Apra Harbor Water Resource Management, and In-Lieu Fee or Mitigation Banking Programs. The results of an interagency working group, led by the CEQ, identified potential compensatory mitigation projects for implementation by federal agency principals. These CEQ recommended mitigation project options were developed by EPA, USFWS and NOAA, with input from NPS, USACE, and Guam environmental agencies. These are described in detail below.

1. Coral reef restoration via water quality improvements through protection and watershed restoration. The goal is to reduce the negative effects of land runoff through actions that reduce erosion and organic matter runoff. Physical corrective measures could include afforestation, stream bank stabilization**,** riparian restoration, road stormwater BMPs, erosion control practices, wetland enhancement, and designation of conservation areas. A public education program would be associated with these measures to promote public support and respect for conservation.

2. Coral reef restoration via water quality improvements through WWTP upgrades/ improvements. A number of WWTPs throughout Guam are not performing up to their design standards for water quality output. If those WWTPs were upgraded to meet their design performance criteria, outflow quality would be improved and that would improve water quality near outflow sites.

3. Coral reef restoration via site-specific water quality improvements through retrofitting road stormwater controls at a range of sites on Guam.

Past restoration projects and scientific evidence support the notion that coral reef restoration follows water quality improvements (*e.g.*, Kaneohe Bay and Mamala Bay, Hawaii following improved water quality after sewage diversion; Pago Pago Harbor, American Samoa after removal of tuna effluent; Kahoolawe, Hawaii after erosion control).

4. Coral reef restoration within non-DOD federal property lands. The Navy could participate in coral reef restoration on other lands owned by the Federal Government, including providing erosion control, wetland restoration, boundary marking, law enforcement, and monitoring for ecosystem health. A public education program associated with this effort would serve to promote public support and respect for conservation.

Federal property affords long-term protection for resources on the land, particularly when appropriate infrastructure and enforcement are implemented. The National Historic Parks are examples of fully protected federal property often cited for conserving natural resources and providing a resource to the public. Restoration of coral reefs by the Navy could provide similar protection of marine resources (Sandin et al. 2008).

5. Aquaculture of native herbivorous fish. This measure would include the construction, oversight, and maintenance of a fish hatchery. The species would be grown and released to enhance herbivory on coral reefs and improve coral reef conditions. Some reef areas around Guam suffer from depauperate fish populations, and the paucity of herbivorous fishes allows macroalgae to outcompete the coral.

Coral reef sites with healthy fish assemblages tend to have healthy reefs. Science supports the importance of herbivorous fish as an important part of fish communities in maintaining healthy reefs. Fish hatcheries are a proven method for enhancing local fish populations and husbandry is feasible for many fish and invertebrate species.

6. Coral transplantation. The Navy can contract with local experienced scientists who have demonstrated success with transplanting coral. Sites for artificial reefs or natural reef sites can be chosen with careful attention to environmental factors that would promote the healthiest reefs. This type of measure can be used in conjunction with other measures to rapidly establish healthier reefs in areas with reefs in decline.

Moving coral that will be affected by construction projects or taking small fragments from healthy reefs and placing them on an artificial reef structure or available natural sites is an effective means of starting a new reef and/or managing coral reef community composition. Past projects on Guam have had survivorship rates of 70% or better. Expanding and dispersing new reef may increase the coral larval supply for Guam.

7. Establishment of marine protected area(s) (MPA(s)). This is a measure that would allow for the protection of healthy reefs and other high-quality environments as well as threatened areas to be protected and set aside.

Establishment of MPAs has already been successfully executed on Guam in Tumon Bay MPA. Maintaining high-quality reef is easier than restoring a damaged reef or creating a new reef, and MPAs are a clear method for protecting specific sites.

8. Artificial reefs. This measure provides a mechanism for establishing reefs in areas with ideal nutrient and oxygen transport, good water quality, and light penetration, but lack sufficient substrate for establishing coral.

Artificial reefs have been established successfully throughout the world, particularly in tropical climates. The coral community composition on an artificial reef can be manipulated to encourage a diverse and healthy reef development. New reefs may increase the coral larval supply for Guam.

9. Support for enhanced enforcement of fishing and recreational diving regulations. Although regulations exist to reduce impacts of fishing and recreational activities, lack of enforcement allows the impacts to continue. GovGuam would receive help from the Navy in enforcing already existing laws and regulations.

Enhanced enforcement can help reduce stress on existing coral reefs, particularly in areas that have Ecological Reserve Area (ERA) or MPA designation. When this measure is used in conjunction with other options, it may help to ensure greater conservation success.

10. Marine debris removal. The Navy has assets and personnel capable of removing debris from coral reefs. A marine debris removal program could be implemented in combination with public outreach that diverse parties could agree on. GovGuam supports marine debris removal.

The USCG removes tons of marine debris from the Northwest Hawaiian Islands each year in the Papahanaumokuakea Marine National Monument. This has contributed to the renewed health of the underwater portion of the Monument. A public outreach program would provide good awareness of marine debris issues which could improve islandwide compliance across Guam.

11. Remove nuisance algae. Marine algae can outcompete coral and overgrow coral reef sites under certain conditions. Removing the algae and improving water quality could improve the chances of coral reef recovery and growth.

Nuisance and non-native invasive algae removal has been successfully implemented in Hawaii by the Nature Conservancy.

12. Installation of recreational mooring buoys. In Apra Harbor recreational areas, the Navy would contract for the installation of permanent mooring buoys that would obviate the need to drop anchor to keep vessels in place. This measure allows the public to continue enjoying the coral reefs while reducing their effects on coral reefs.

Anchors and anchor chains cause serious damage to coral reefs. Removing the need for vessels to drop anchor in recreational areas around coral reefs will contribute to the continued health of growing coral.

13. Coral reef restoration inside Apra Harbor through water quality and habitat improvements. The suite of mitigation measures outlined above could be implemented in the immediate vicinity of Apra Harbor to have more immediate effects on coral reef health in the Outer Harbor. The measures could include erosion control, stormwater management, artificial reefs, afforestation, wetland enhancement, and establishing an ERA.

The following list of four categories for coral mitigation incorporates all 13 of the CEQ potential compensatory mitigation projects, categorized by type of mitigation or program. The CEQ projects are discussed in detail in terms of specific mitigation projects in the compensatory mitigation impact analysis section (11.2.3, below).

Watershed Restoration and Management

- Afforestation
- Stream bank stabilization
- Riparian restoration
- Road stormwater BMPs
- Erosion control

- Wetland enhancement
- Land/submerged land acquisition/easement for conservation
- Education

Coastal Water Resource Management

- Road stormwater control at a range of sites on Guam
- Shallow water reef enhancement within non-DoD federal lands (e.g. National Historic Parks)
- Land acquisition
- Erosion control
- Wetland restoration
- Artificial reefs
- Coral transplanting
- Boundary marking & enforcement
- Monitoring
- Education
- Aquaculture (e.g. fish hatchery) for native herbivorous species
- Support for enhanced enforcement of fishing and recreational diving regulations
- Protection and conservation actions
- Marine debris removal
- Nuisance algae removal
- Installation of recreational mooring buoys
- Establishment of marine protected area(s) (MPAs)
- Upgrades/Improvements Wastewater Management Systems

Apra Harbor Water Resource Management

- Erosion control
- Stormwater management (roads, wharves, industrial facilities)
- Artificial reefs
- Coral transplantation
- Glass breakwater modifications
- Wetland enhancement
- Revise Navy management plans
- Support for enhanced enforcement of fishing and recreational diving regulations
- Education
- Protection and Conservation Actions
- Marine debris removal
- Nuisance algae removal
- Installation of recreational mooring buoys

In-Lieu Fee or Mitigation Banking Program

- In-lieu fee or mitigation banking programs are generally considered methods for implementing mitigation strategies and projects. However, for purposes of determining coral reef compensatory mitigation, In-Lieu fee and Mitigation Banking programs are considered separate categories to implement specific projects and adaptive management strategies.

The Navy has not advanced a proposal at this time and specific mitigation measures would be subject to the permitting action/mitigation decision of the USACE. The effectiveness of either upland watershed management or artificial reefs schemes to replace coral loss have been studied and conclusions concerning success differ. Section A of the *HEA and Supporting Studies* report (Volume 9, Appendix E, Section A) summarizes key points of discussion that were raised during review of the draft HEA, including relative merits (pros and counterpoints/cons) of artificial reefs and watershed management projects (HEA Section A, 3.3.4, Table 2 and 3, respectively). Compensatory mitigation for unavoidable coral community impacts includes the following categories.

Watershed Restoration and Management

Watershed restoration and management is a collective term to describe a variety of projects that would remove or diminish anthropogenic stresses on receiving coastal waters in order to improve water quality, resulting in recolonization or improved growth of existing coral in those coastal waters. Restoration of a watershed returns the ecosystem to as close an approximation as possible of its state prior to a specific incident or period of deterioration and restores the ability of the ecosystem to function. Watershed restoration can be complicated because an ecosystem has a myriad of interactions. These include interactions between the watershed's inhabitants, water level and flow, nutrient cycling, and the inevitable, natural changes that occur over time that change ecosystem dynamics (e.g., soil erosion and replacement). When deterioration of a watershed occurs gradually, restoration can require rigorous scientific protocols and involve lengthy, complicated, and costly investigations.

The approach to address reef degradations from discharge of eroded sediments from upland sources is watershed/restoration conservation. Restoring vegetation to barren areas to reduce soil runoff and subsequent discharge into coastal waters is a major step in watershed restoration and thus improvement of coastal waters. Most potential watershed restoration projects would involve planting tree seedlings in grasslands and badland areas as well as in fertile valley areas of watersheds. Other important elements of a successful watershed restoration project include but are not limited to animal control, monitoring and continuous watershed management.

EPA looks at the watershed restoration process as consisting of the following major steps: (1) build partnerships, (2) characterize the watershed to identify problems, (3) set goals and identify solutions, (4) design an implementation program, (5) implement the watershed plan, (6) measure progress and make adjustments (GEPA 2008).

The following projects could be used separately or in conjunction to develop a conceptual mitigation plan for watershed restoration:

AfForestation. Coastal marine waters and associated rivers and watersheds on Guam have been recommended by resource agencies for potential compensatory mitigation for coral reef impacts. The approach to restoration/conservation of sites rather than a detailed assessment is described to address on-going problems of reef degradation from discharge of eroded sediments from upland sources.

The Navy has held several conversations with federal and Guam resource agencies on coral impact assessment and compensatory mitigation methods associated with the Guam Military Relocation EIS. Resource agencies have recommended coastal marine waters and associated rivers and watersheds as restoration candidates for potential compensatory mitigation for coral reef impacts. USFWS recently provided the following potential sites for watershed afforestation coral reef restoration options (USFWS 2009a). The information below is also supplemented by information from GEPA (2008).

- *Achugao Subwatershed* – Coastal waters and beach south of Achugao Point located in the southwestern portion of Guam. This beach is the discharge point for Agaga River associated with the Cetti Watershed.
- *Fouha Subwatershed* – Coastal waters at the head of Fouha Bay, located south of Cetti Bay, in the southwestern portion of Guam. Fouha Bay is the discharge point for the La Sa Fua River associated with Umatac Watershed in the southwestern portion of Guam.
- *Geus Watershed* – Coastal waters and marine bay (5 mi^2 [13 km^2]) associated with Cocos Lagoon located at the southern tip of Guam. The Geus River, associated with the Geus Watershed, discharges into the Cocos Lagoon.
- *Ajayan Subwatershed* – Coastal waters and intermittent beach at Ajayan Bay located east of Cocos Lagoon. The Ajayan River, associated with the Manell Watershed, discharges into Ajayan Bay.

The recommended watersheds have not been fully evaluated to determine their suitability, but are being considered by the Navy as options for mitigation. These watersheds are associated with reefs that are degraded by sedimentation, but were healthy a few decades ago (USFWS 2009b).

Additional restoration/enhancement projects as recommended by Guam Bureau of Statistics and Plans (BSP) (2009) include the following Project Locations: Apra, Tumon, Tamuning, Piti, Asan, Fonte, Southern Agat, Togcha, Ylig, Pago, and Ugum. Project objectives would be to improve water quality and forest habitat restoration in these watersheds as they flow into waters that host marine preserves and other valuable marine resource areas. Most of the potential restoration projects would involve the planting of native seedlings in grasslands and badland areas as well as in fertile valley areas of watersheds. Other important elements of a successful watershed restoration project include but are not limited to animal control, monitoring and continuous watershed management.

Guam BSP (2009) provided figures delineating the boundary of the watershed area in which the listed projects would occur (Figures 11.2-5 through 11.2-8 provided below without modification, except for the addition of a location map.). The drainage area of the watersheds shown on the figures is approximately 22.18 mi^2 (57.45 km^2) along the southwestern coast of Guam, extending from south of Naval Base Guam (*Agat watershed*) to the southern point of Guam and Cocos Island (*Manell watershed*). The watershed areas (*Agat, Taelayag, Cetti, Umatac, Toguan, Geus, and Manell*) were selected because there is evidence that coral communities have previously existed in the receiving coastal waters. Under improved water quality conditions, these coral communities could be restored.

The Talofofo watershed (22.37 mi^2 [57.94 km^2]) and Ugum watershed (7.31 mi^2 [18.93 km^2]) associated with the Naval Munitions Site (NMS) is located on Navy-owned land. The watershed currently suffers from soil erosion which manifests in sediment transfer to various streams that feed into Talofolo Bay. The NMS Watershed of savanna grassland vegetation would be restored and protected within the northeastern portion to address an on-going problem of reef degradation in Talofofo Bay from the transport of eroded sediments.

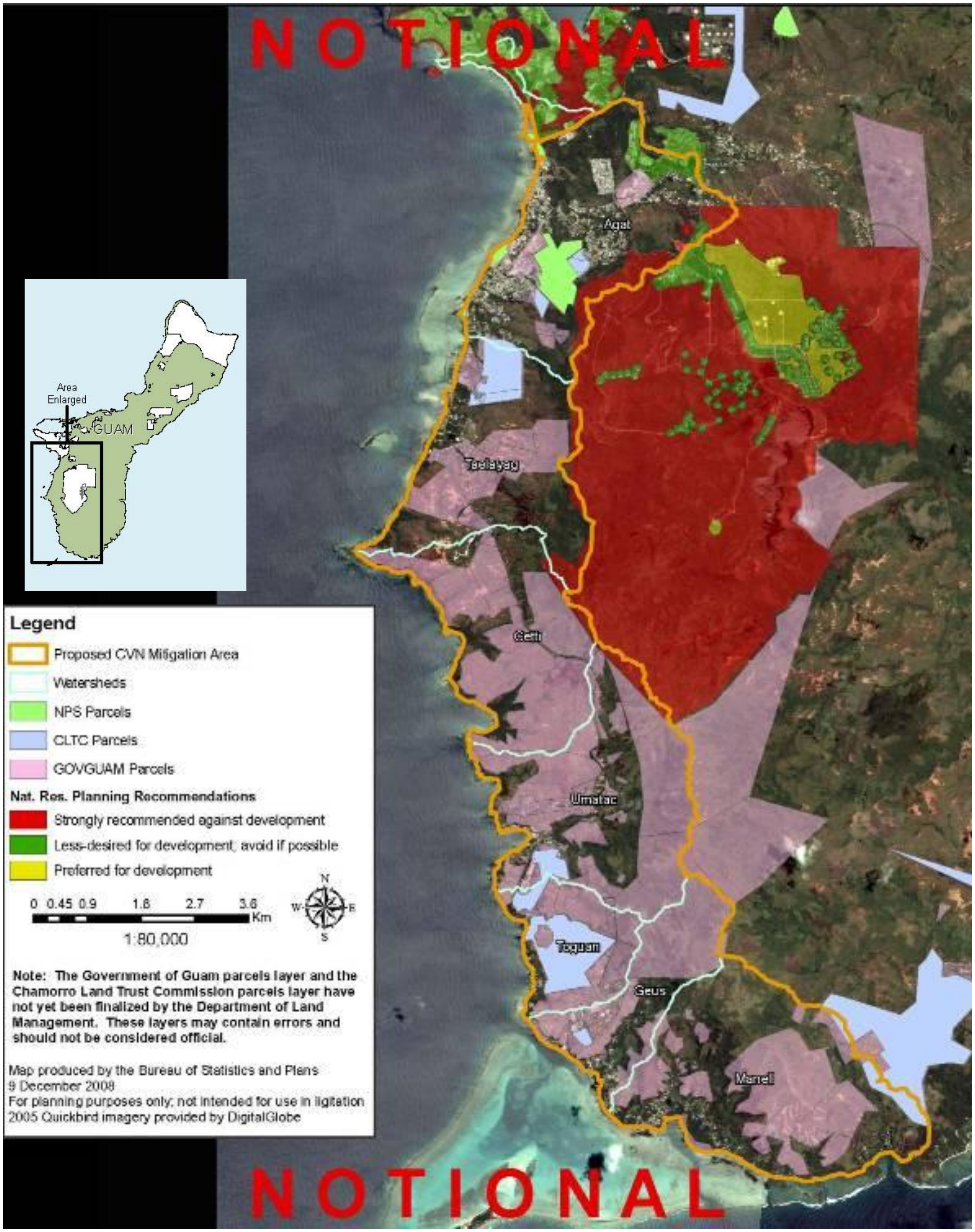

Figure 11.2-5. Boundary of Guam Agency Proposed CVN Mitigation Area

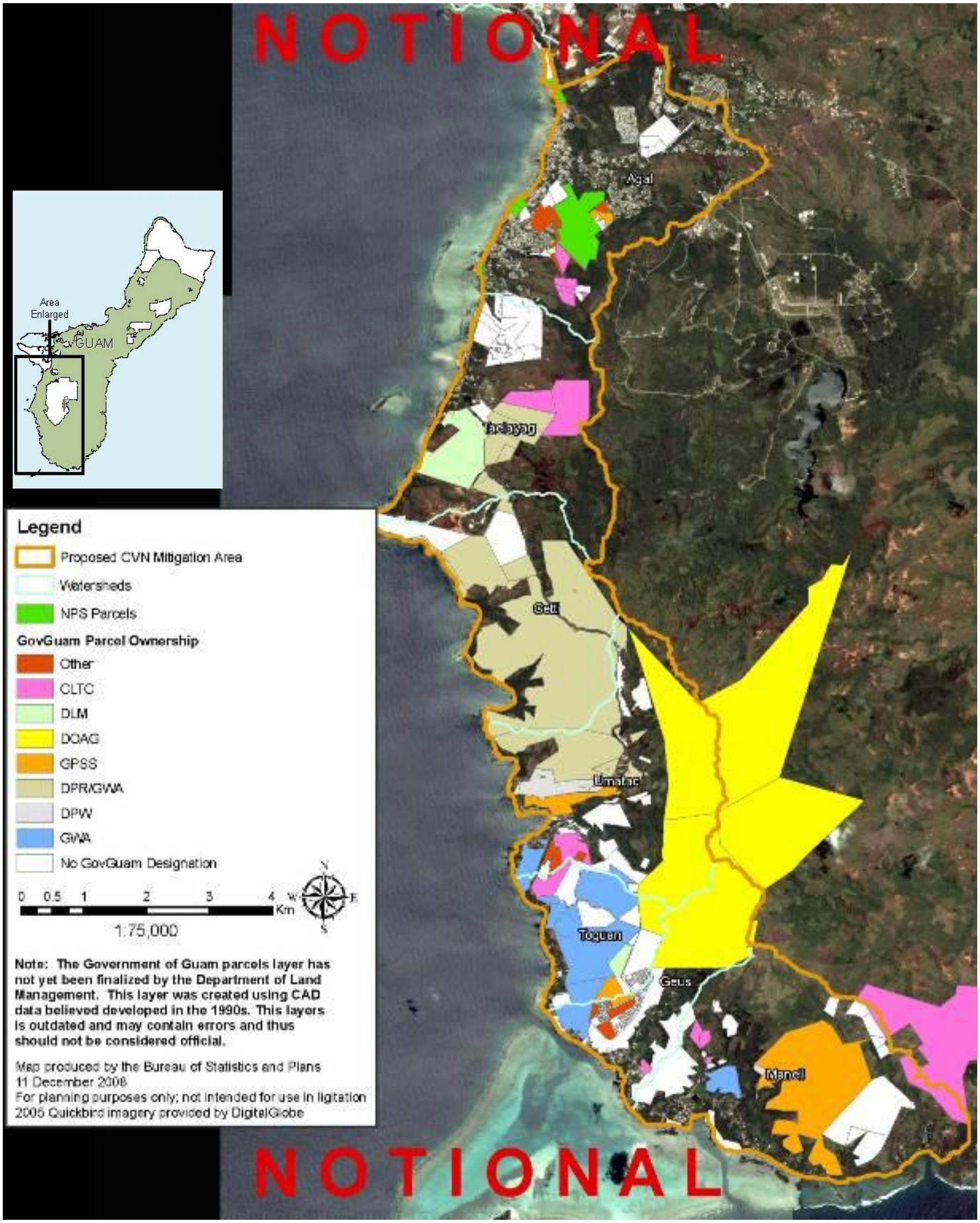

Figure 11.2-6. Mitigation Area, GovGuam Parcel Ownership

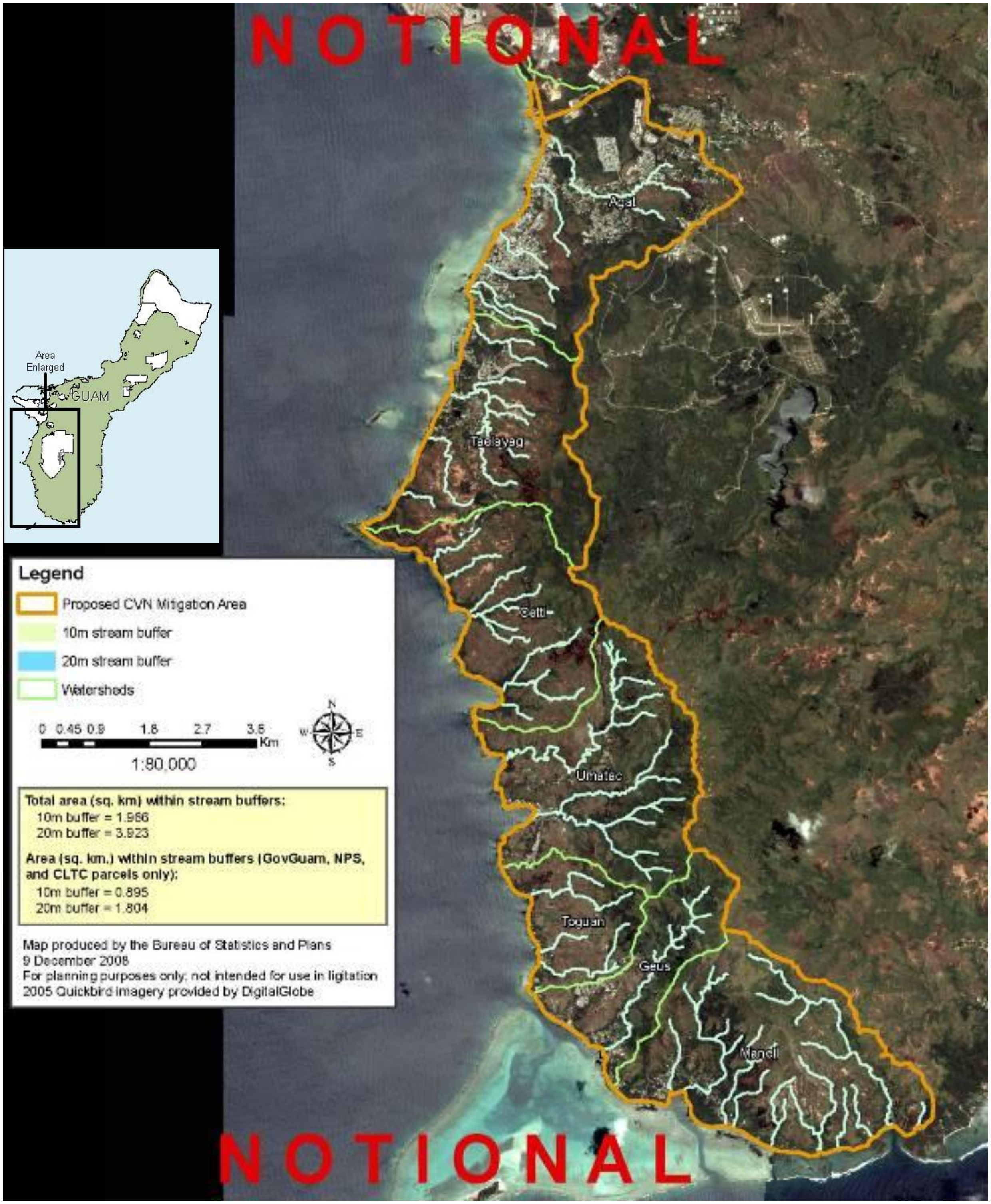

Figure 11.2-7. Mitigation Area, Riparian Buffers for Stream

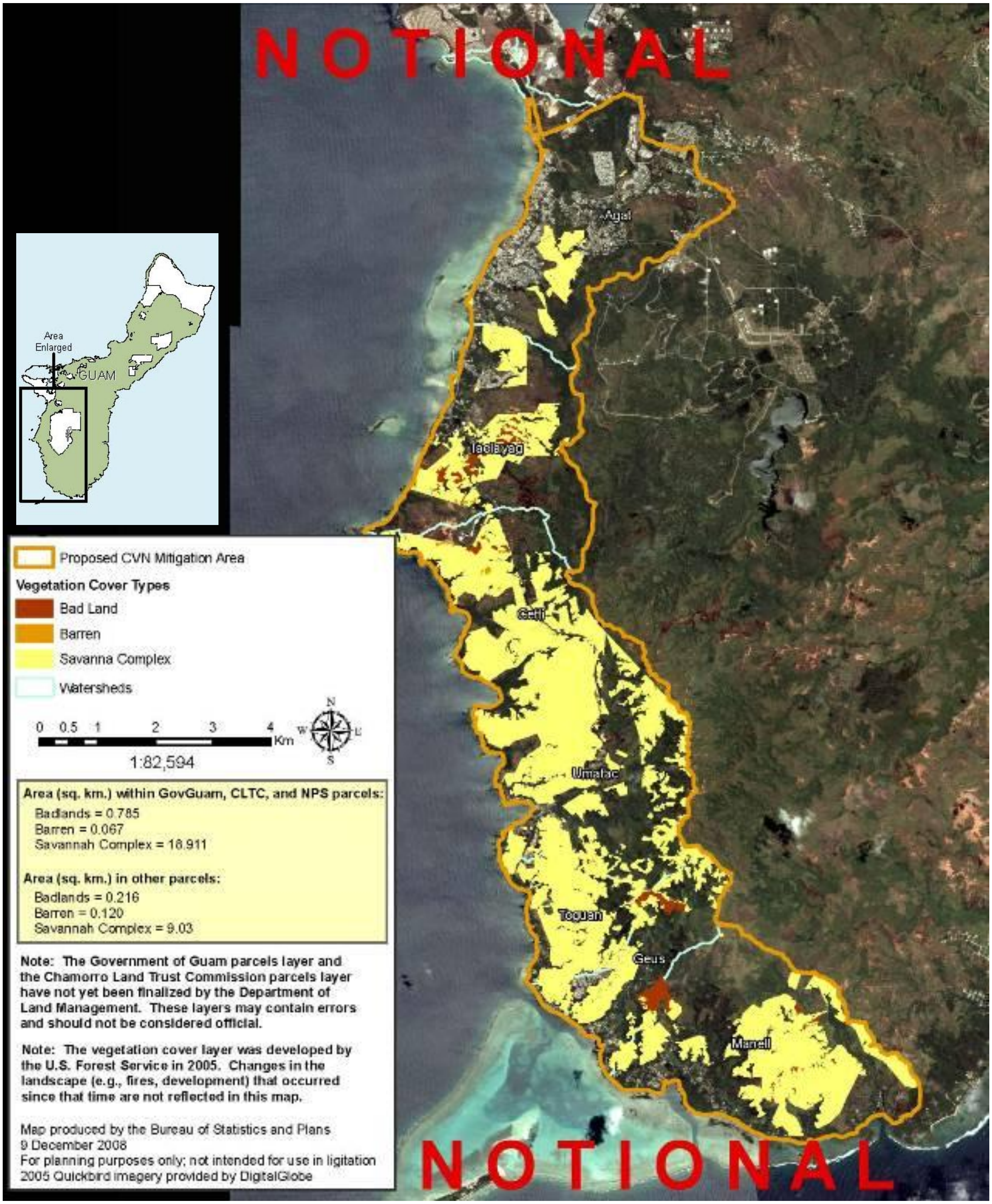

Figure 11.2-8. Mitigation Area Vegetation Types

The potential for watershed restoration on privately owned lands would be limited as these types of projects require full control of the land and its uses to be successful. A Sella Bay watershed restoration project was proposed as compensatory mitigation for coral loss at Kilo Wharf. However, because land use was not totally controlled and management agreements could not be concluded, the project had to be moved to Cetti Watershed on GovGuam land. It may be possible, however, to have a combination of reforestation/afforestation on some smaller scale when done in conjunction with watershed restoration projects on Navy-owned or GovGuam lands, artificial reef installation within Apra Harbor or other areas, and/or riparian enhancement that would benefit fish, corals, and other marine organisms. According to GDAWR (2010) "The Ceti Bay watershed restoration project is a ten year project and currently the project is only in its third year. Logistical issues are more of a concern than control of land."

Stream bank stabilization. Stabilization of stream banks within watersheds would involve the placement of vegetation and/or mechanical rip rap revetment on banks of rivers and streams to minimize erosion and sediment laden run-off from entering sensitive riverine systems. The design's major factors would include: a) capability of conveying peak runoff flows produced by major storms and b) maintenance crew accessibility to structural BMPs for vegetation maintenance (i.e., through cutting vs. spraying) and rip rap/revetment repair.

Coastal Water Resources Management

Coastal water resource management is a collective term to describe a variety of projects that would improve the quality or diminish anthropogenic stresses on nearshore coastal waters in order to improve management efforts and water quality, resulting in recolonization or improved growth of existing coral in those coastal waters. Addressing upland watershed issues prior to coastal efforts is an important process.

The following projects could be used separately or in conjunction to develop a conceptual mitigation plan for coastal water resources management:

Shallow Water Reef Enhancement – coral transplanting within non-DoD lands (e.g. National Historic Parks). This type of project would include the transplanting of a significant quantity of coral that would be removed by the proposed dredging project. The objective of shallow water reef enhancement is to minimize coral colony mortality by transplanting coral to several new sites on Navy submerged lands. Transplantation site selection criteria would include physical, chemical, and biological factors. Studies have shown that larger intact colonies survive transplanting much better than small or fragmented colonies. Larger colonies also have far greater reproductive potential than small ones. Therefore, these types of projects often focus on transplanting large specimens. A detailed transplantation plan would be prepared which would include methods for moving large colonies, techniques for stabilizing the colonies at the transplant site, and monitoring protocols.

A direct and predictable relationship between a specific watershed project(s) and replacement of coral function is difficult to determine. Therefore, it would be difficult to predict how many watershed projects and of what type would be required to restore the productivity lost due to dredging. On the other hand, the effectiveness of artificial reefs would be more readily quantified as to its success in replacing lost coral function and value. However, all mitigation options are under consideration at this time.

Wetland/mangrove restoration. This type of project would include mangrove and/or wetlands enhancement. This may be determined using the Guam BSP developed system of reference wetlands as a baseline for future classification and to establish a basis for ecological function when formulating the scope and extent of potential compensatory mitigation.

Establishment of Marine Protected Areas. This would include the addition of special conservation areas associated with federally-owned submerged lands in and around Guam and the possibility of agreements with GovGuam to create contiguous areas. This option may also include the expansion of existing federally-owned marine and adjacent terrestrial conservation areas around Guam, including the beaches and limestone forest area inland from the marine conservation areas. The expanded marine conservation areas would include shallow water benthic habitat that contains both hard and soft corals. The management plans for the creation of new conservation areas or the expansion of existing conservation areas would be modified, in coordination with GOVGUAM, to provide for adaptive management which could include limitations on activities that could result in adverse effects to EFH.

Additional information would be provided in the compensatory mitigation plan prior to issuance of the USACE permit.

Upgrades/Improvements Wastewater Management Systems. This project would involve upgrading Guam treatment plants and ocean outfalls to have refurbished primary and/or upgraded to secondary treated effluent to improve coastal water quality that may result in benefits to the coral reef community and EFH in the coastal zone of Guam.

Apra Harbor Water Resource Management

This category includes a variety of projects that intend to diminish anthropogenic stresses on Apra Harbor in order to improve water quality, resulting in improved conditions and growth for the coral reef ecosystems present.

The following projects could be used separately or in conjunction to develop a conceptual mitigation plan for Apra Harbor water resources management:

Artificial reefs. An artificial reef is a man-made, underwater structure, typically built for the purpose of promoting marine life in areas of generally featureless bottom. Artificial reefs can be created by a number of different methods. Many reefs "are built" by deploying existing materials in order to create a reef (e.g., sinking oilrigs, scuttling ships, or by deploying rubble, tires, or construction debris). Other artificial reefs are purpose built (e.g., the reef balls) from PVC and/or concrete. Regardless of construction method, artificial reefs are generally designed to provide hard, 3-dimmentional surfaces to which algae and invertebrates attach, which in turn attracts fish species providing food habitat for fish assemblages. Car and Hixon (1997) "identified that methods used to evaluate the performance of an artificial reef will vary according to the purpose for which the reef was built. They found that artificial reefs with structural complexity and other abiotic and biotic features similar to those of natural reefs would best mitigate in-kind losses of reef fish populations and assemblages from natural reefs – specifically they compared colonization and subsequent assemblage structure of reef fishes on coral and artificial (concrete block) reefs where reef size, age, and isolation were standardized. Although species richness and fish abundance (all species combined) were greater on natural reefs vs. artificial structures, substantial differences in species composition were not detected."

This type of project would be a direct application of a HEA derived artificial reef project in Apra Harbor. The Navy would install an artificial reef in approximately 80+ ft (24.4 + m) of water (to ensure its survival even in a super-typhoon) using one or more agreed upon artificial reef concepts. Reef alternatives may include "Z blocks" (used in Hawaii), Biorock, and Reefballs. Suggestions of other artificial reef options would be welcomed. Placement would be on the harbor floor and would not affect hard substrate. A mitigation site would be located within the ESQD arc of Kilo Wharf (to prevent the reef from being used as a Fish Aggregation Device that would invite recreational or commercial fishing or diving activities). As part of the artificial reef proposal, the HEA restoration project would include the potential use of transplanted coral as part of its compensation strategy.

Success criteria would be based on a replacement of benthic structure and on percent coral cover, as a proxy to ecosystem function. Long-term monitoring would be implemented to measure success. Potential Guam INRMP projects associated with the artificial reef could include assessment of functions these structures provide. Artificial reefs, though quantitatively easier to scale for a ratio between replacement and function lost than watersheds, have been criticized as being primarily fish aggregating devices that do not increase coral community productivity. In other words, the replacement of structure does not necessarily equate to a restoration of coral community function.

Shallow water reef enhancement – coral transplanting. This may include transplantation of a significant quantity of coral that would be impacted by the proposed dredging action. The objective of shallow water reef enhancement is to minimize coral colony mortality by transplanting coral to several new sites on Navy submerged lands within Apra Harbor. Transplantation site selection criteria would include physical, chemical, and biological factors.

Wetland/Mangrove enhancement. This would include mangrove and/or wetlands enhancement in Apra Harbor. This may be based on the Guam BSP developed system of reference wetlands as a baseline for future classification and to establish a basis for ecological function when formulating the scope and extent of potential compensatory mitigation.

In-Lieu Fee or Mitigation Banking Program

Within the HEA Administrative Working Group, DoD, and other stakeholders on Guam, there remains support for the use of In-Lieu Fee or mitigation banking programs to manage, implement and monitor the success of natural resource compensatory mitigation projects on Guam. Revised regulations by the USACE and EPA in March 2008 govern compensatory mitigation for authorized impacts to waters of the U.S. under Section 404 of the CWA. In-lieu fee mitigation and mitigation banks have not been established on Guam.

Under mitigation banks, units of restored, created, enhanced, or preserved resources are expressed as "credits" which may subsequently be withdrawn to offset "debits" incurred at a project development site. Ideally, mitigation banks are constructed and functioning in advance of development impacts, and are seen as a way of reducing uncertainty in the USACE Regulatory program by having established compensatory mitigation credit available to an applicant.

In-Lieu-Fee mitigation occurs in circumstances where a permittee provides funds to an In-Lieu-Fee sponsor instead of either completing project-specific mitigation or purchasing credits from an approved mitigation bank. The program sponsor periodically funds a consolidated mitigation project from the proceeds of the accumulated In-Lieu-Fees. A memorandum of understanding would be executed among DoD, regulators and stakeholders that establishes an In-Lieu-Fee Mitigation Sponsor (typically a non-government organization) and a Review Team to determine how the bank would work.

The In-Lieu-Fee amount is based upon the compensation costs that would be necessary to restore, enhance, create or preserve coral ecosystems or other habitats with similar functions or values to the one affected. The fee is banked in an investment account until a project is approved for implementation. The In-Lieu-Fee mitigation bank would be managed by the In-Lieu-Fee Mitigation Sponsor (Sponsor) that uses the accumulated funds to implement projects that restore, enhance, or preserve ecosystems with similar functions and values that are located within the same biophysical region as the permitted disturbance. Key stakeholders, including regulatory agencies, DoD and the Sponsor, form an advisory committee that determines the projects that would be implemented, which provides for effective natural resource adaptive management. The Sponsor is responsible for implementing the project according to an approved work plan.

DEVELOPMENT OF COMPENSATORY MITIGATION PLAN

As more information is gathered on the likely impacts and costs of the compensatory mitigation projects under consideration, a more detailed mitigation plan would be developed to comply with requirements of the USACE-GEPA 2008 Compensatory Mitigation Rule. The preparation and implementation of an approved Compensatory Mitigation Plan is the Navy's mitigation for adverse impacts to coral. A USACE permit would be required for the construction of the aircraft carrier wharf due to alteration of navigable waters and discharge of fill materials into the water. This permit is the vehicle through which compensatory mitigation will be implemented. Under the permit, selection, scaling, and implementation of compensatory mitigation projects would be carried out in consultation with USACE, NOAA, USFWS, USEPA and GovGuam. The HEA discussed previously is one tool designed to quantify the ecological loss to coral reef habitat. The HEA or other ecological equivalency evaluation tools would then be used to evaluate the ecological benefits from the proposed compensatory mitigation projects. The permit, which includes the compensatory mitigation plan, would determine the ecological loss and the equivalent ecological benefit (i.e. no net ecological loss) from the proposed compensatory mitigation projects. The financial aspect does not come into consideration until after the mitigation projects have been selected (e.g., execution costs of the mitigation projects).

11.2.3 Compensatory Mitigation Impact Analysis

Both Alternative 1 and Alternative 2 berthing alternatives underwent the Navy's project planning and development process, which included detailed engineering, oceanographic, and biological studies in an effort to avoid and/or minimize adverse impacts to coral reefs or coral reef habitat, and special aquatic resources, while also considering necessary operational and cost factors. The construction alternatives would have unavoidable adverse impacts to coral reefs. The impact analysis for each alternative is summarized in Section 11.2.5 and found that direct impacts on coral reef communities from dredging removal would be long-term, while indirect impacts from dredging-related sedimentation may be initially adverse out to 40 ft (12 m), long-term adverse impacts are likely to be minimal and reversible.

Impacts to coral reef communities will also be prevented and lessened through the implementation of BMPs during the construction process. In particular, placement of construction barge and vessel anchors and mooring lines, cables, and chains will be prohibited on areas of high (i.e., >90 %) live coral cover. Silt curtains will also be employed to reduce the potential impacts of increased sedimentation on the coral reef community. During pile driving or dredging activities, if a visible plume is observed over sensitive coral habitat outside the silt curtains, the construction activity would stop, be evaluated, and corrective measures taken. Construction would not resume until the water quality has returned to ambient conditions.

As described earlier in this Chapter, a USACE permit would be required for both Alternatives for alteration of navigable waters and discharge of fill material into the water. This permit is the vehicle through which compensatory mitigation would be implemented. The project will be designed to avoid coral reef habitat impacts and to minimize any unavoidable impacts. Unavoidable impacts will be mitigated through implementation and/or funding of mitigation measures to compensate for the resulting loss of ecological functions and/or services. Selection, scaling, and implementation of appropriate compensatory mitigation actions is being carried out in consultation with USACE, NOAA Fisheries, USFWS, USEPA, and GovGuam resource agencies. The action alternatives would take place on DoD lands. The Navy determined that both Alternatives would be consistent with the Guam Coastal Management Program to the maximum extent practicable. As previously stated, there are three programmatic compensatory mitigation categories, which may include a combination of projects from each category, under consideration (described earlier in this Chapter and evaluated later in this Section): (1) Watershed Restoration and Management; (2) Coastal Water Resource Management; and (3) Apra Harbor Water Resource Management.

Reducing the flow of terrigenous sediments into Guam's southwest coastal areas associated with the four main watersheds would have beneficial impacts to coral reef communities and associated habitats adversely affected by ongoing sedimentation and decreased water quality by allowing them to re-establish themselves, other anthropogenic or natural factors notwithstanding (e.g., overfishing, major storm events, bleaching events, etc.). The USACE has indicated that compensatory mitigation projects need to be maintained in perpetuity, requiring the execution of binding agreements in perpetuity. Parties need to execute long-term agreements that meet federal and GovGuam real estate and legal requirements for watershed projects to be implemented. Accordingly, the Navy, with USACE support, will identify a package of compensatory mitigation projects to be implemented on lands that can be committed in perpetuity. The Navy's compensatory mitigation plan will consist of three categories, including multiple project components of each: Watershed Restoration and Management; Coastal Water Resource Management, and Apra Harbor Water Resource Management (Table 11.2-10).

Table 11.2-10: Summary of Compensatory Mitigation Actions

Proposed Mitigation Action	*Description*
Proponent: Federal & Territory Resource Agencies	
Watershed Restoration and Management	Reforestation/Afforestation of savanna vegetation in four potential watersheds (Ugum, Umatac, Toguan, and Geus) to address on-going problems of reef degradation due to eroded sediments from upland sources. This may also include: stream bank stabilization; riparian restoration; road stormwater BMPs; erosion control; wetland enhancement; land acquisition/easement for conservation; and educational efforts.
Coastal Water Resource Management	Restoration and improved water quality and natural resource management of the following subwatershed and watershed areas: • Achugao Subwatershed – Coastal waters and beach south of Achugao Point located in the southwestern portion of Guam. This beach is the discharge point for *Agaga River* associated with the Cetti Watershed. • Fouha Subwatershed – Coastal waters at the head of Fouha Bay, located south of Cetti Bay, in the southwestern portion of Guam. Fouha Bay is the discharge point for the *La Sa Fua River* associated with Umatac Watershed in the southwestern portion of Guam. • Geus Watershed – Coastal waters and marine bay (5 mi^2 [13 km^2]) associated with Cocos Lagoon located at the southern tip of Guam. The *Geus River*, associated with the Geus Watershed, discharges into the Cocos Lagoon. • Ajayan Subwatershed – Coastal waters and intermittent beach at Ajayan Bay located east of Cocos Lagoon. The *Ajayan River*, associated with the Manell Watershed, discharges into Ajayan Bay. Also included: road stormwater control at a range of sites on Guam; shallow water reef enhancement within non-DoD lands (e.g. National Historic Parks) (e.g. acquisition, erosion control, wetland restoration, artificial reefs, coral transplanting, boundary marking & enforcement, monitoring, education); aquaculture (e.g. fish hatchery) for native herbivorous species; support for enhanced enforcement of fishing and recreational diving regulations, protection and conservation actions (e.g. marine debris removal, nuisance algae removal, installation of recreational mooring buoys); establishment of marine protected areas(s); upgrades/improvements to wastewater management systems
Apra Harbor Water Resource Management	• Improved water quality and natural resource management, including the following types of projects: erosion control; stormwater management (e.g. roads, wharves, industrial facilities); artificial reefs in deep water artificial reef in Outer Apra Harbor; shallow water reef enhancement – coral

Table 11.2-10: Summary of Compensatory Mitigation Actions

Proposed Mitigation Action	*Description*
Proponent: Federal & Territory Resource Agencies	
	transplanting; glass breakwater modifications; wetland/mangrove enhancement; revised Navy management plans; support for enhanced enforcement of fishing and recreational diving regulations; education; protection and conservation actions (e.g. marine debris removal, nuisance algae removal, installation of recreational mooring buoys); • Artificial reefs would be either scaled to complement other mitigation projects or fully offset estimated acre-year losses from either Alternative 1 or 2. Four sites (Glass Breakwater, Kilo Wharf, San Luis Beach, and Sasa Bay) have been evaluated as candidate deep water artificial reef sites. The artificial reef will increase overall biomass and provide direct compensation for lost ecological services through new benthic habitat. • Shallow water reef enhancement may include transplantation of a significant quantity of coral that would be impacted by the proposed action to several new sites on Navy submerged lands in Outer Apra Harbor.
In-Lieu Fee	• As described above, mitigation banking of units of restored, created, enhanced, or preserved resources are expressed as "credits" which may subsequently be withdrawn to offset "debits" incurred at a project development site. Ideally, mitigation banks are constructed and functioning in advance of development impacts, and are seen as a way of reducing uncertainty in the USACE Regulatory program by having established compensatory mitigation credit available to an applicant. • In-Lieu-Fee mitigation occurs in circumstances where a permittee provides funds to an In-Lieu-Fee sponsor instead of either completing project-specific mitigation or purchasing credits from an approved mitigation bank. The program sponsor periodically funds a consolidated mitigation project from the proceeds of the accumulated In-Lieu-Fees. A memorandum of understanding would be executed among DoD, regulators and stakeholders that establishes an In-Lieu-Fee Mitigation Sponsor (typically a non-government organization) and a Review Team to determine how the bank would work. • The In-Lieu-Fee amount is based upon the compensation costs that would be necessary to restore, enhance, create or preserve coral ecosystems or other habitats with similar functions or values to the one affected. The fee is banked in an investment account until a project is approved for implementation. The • In-Lieu-Fee mitigation bank would be managed by the In-Lieu-Fee Mitigation Sponsor (Sponsor) that uses the accumulated funds to implement projects that restore, enhance, or preserve ecosystems with similar functions and values that are located within the same biophysical region as the permitted disturbance. Key stakeholders, including regulatory agencies, DoD and the Sponsor, form an advisory committee that determines the projects that would be implemented, which provides for effective natural resource adaptive management. The Sponsor is responsible for implementing the project according to an approved work plan.

11.2.3.1 Watershed Restoration and Management for Ugum, Umatac, Toguan, and Geus Areas

The recommended watersheds have not been fully evaluated to determine their suitability, but are being considered by the Navy as options for mitigation. These watersheds are associated with reefs that are degraded by sedimentation, but were healthy a few decades ago (USFWS 2009a).

Project objectives would be to conduct forest habitat restoration to ultimately improve water quality in a watersheds that has waters that flow into valuable marine resource areas. Most of the potential restoration projects would involve the planting of tree seedlings in grasslands and grasses or tree seedlings in badland areas as well as in fertile valley areas of watersheds. Important elements of a successful watershed restoration project include but are not limited to animal control, monitoring and continuous watershed management.

The watershed areas total approximately 12,500 ac (5,058 ha) along the southwestern coast of Guam, extending from south of Naval Base Guam to the southern point of Guam and Cocos Island. The watershed area was selected because there is evidence that coral communities have previously existed in the receiving coastal waters. Under improved water quality conditions, these coral communities could be restored. A general summary of each watershed is described below and shown on Figure 11.2-9.

UGUM

"The Ugum watershed is located in the southwest of Talofofo Bay. It is an inland watershed, which drains into Talofofo watershed. It has a drainage area of 7.31 mi^2 (18.93 km^2). The main rivers in the watershed include Ugum River, Bubulao River, Atate River and Leygo River with approximate lengths of 6.05 mi (9.7 km), 4.84 mi (7.7 km), 1.24 mi (1.9 km) and 1.16 mi (1.8 km) respectively. Leygo River discharges to Atate River, which merges to Ugum River in the southwest of the watershed. Bubulao River discharges to Ugum River from west to east. Uguam River discharges to Talofofo River. The highest elevation is about 1,227 feet (374 meters) in the southwestern boundary of the watershed. The vegetated area is about 96.9%. This is a less developed watershed. The soil types mainly include Ylig clay, Akina-Atate silty clay, Akina silty clay, Togcha-Akina silty clays, Pulantat clay, Akina-Badland complex, Agfayan clay, Sasalaguan clay, rock and urban land complex" (WERI 2010).

UMATAC

"The Umatac watershed is located in the southwest coast of Guam, in the north of Merizo and the south of Agat. It has a drainage area of 3.84 mi^2 (9.9 km^2). The main rivers in the watershed include La Sa Fua River, Laelae River, Madog River, Chagame River and Astaban River with approximate lengths of 2.11 mi (3.3 km), 1.9 mi (3.0 km), 1.59 mi (2.5 km), 1.02 mi (1.6 km) and 0.2 mi (0.3 km) respectively. Chagame River flows from north to south, and merges to La Sa Fua River which discharges to Fouha Bay in the Philippine Sea. Astaban River discharges to Madog River, which merges to Umatac River. Laelae River drains from east to west to Umatac River. Umatac River discharges to Umatac Bay. The highest elevation is about 1,243 ft (379 m) in the eastern boundary of the watershed. The vegetated area is about 97.4%, and urban area is about 2%. The soil types mainly include Ylig clay, Akina-Atate silty clays, Togcha-Akina silty clays, Akina-Badland complex, Inarajan clay, rock and urban land complex" (WERI 2010).

TOGUAN

"The Toguan watershed is located between the villages of Umatac and Merizo. It has a drainage area of 1.41 mi^2 (3.6 km^2). The main rivers in the watershed include Toguan Creek, Pigua River and Bile River with approximate lengths of 1.38 mi (2.2 km), 1.09 mi (1.7 km) and 0.73 mi (1.1 km) respectively. Toguan Creek drains to Toguan Bay in the Philippine Sea, and Bile River and Piguan River discharge to Bile Bay in the Philippine Sea. All these rivers flow from east to west. The highest elevation is about 1043 ft (318 m) in the eastern boundary of the watershed. The vegetated area is about 94.6%, and urban area is about 4%. The soil types mainly include Ylig clay, Togcha-Akina silty clays, Akina-Badland complex, Sasalaguan clay, Inarajan clay, rock and urban land complex" (WERI 2010).

GEUS

"The Geus watershed is located in the southwest of Guam. Most of the watershed is located in Merizo Village. It has a drainage area of 1.73 mi^2 (4.5 km^2). The main river Geus River with approximate lengths of 2.71 mi (4.3 km). Geus River discharges to the Philippine Sea. The highest elevation is about 833 feet (254 m) in the east of the northern watershed. The forest area is about 90.1%, and the developed area is about 4.8%. The soil types mainly include Ylig clay, Inarajan clay, rock and urban land complex" (WERI 2010).

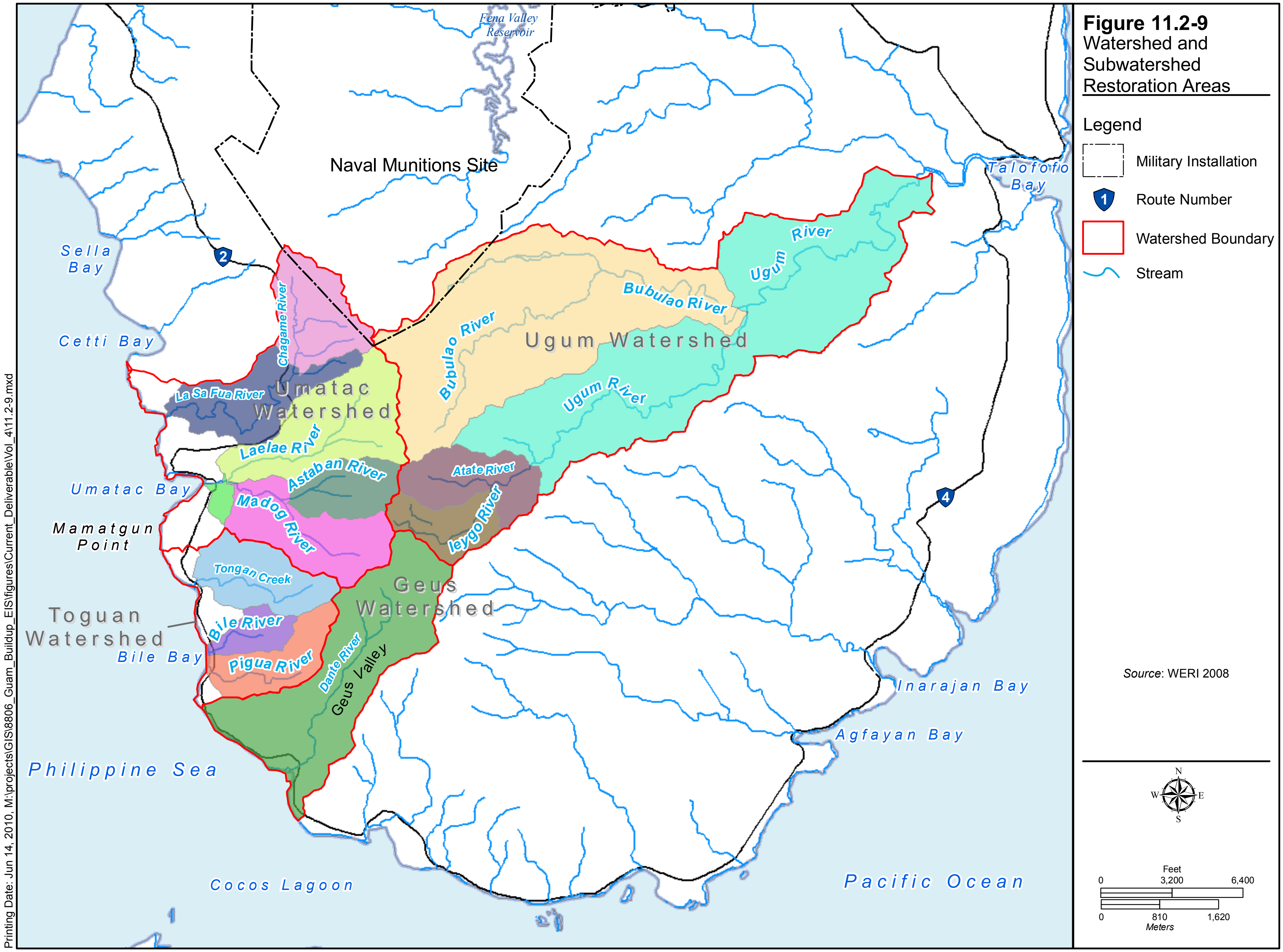
Figure 11.2-9
Watershed and Subwatershed Restoration Areas
Legend
Military Installation
Route Number
Watershed Boundary
Stream
Source: WERI 2008
Feet
0
3,200
6,400
0
810
1,620
Meters
N
S
E
W
Naval Munitions Site
Fena Valley Reservoir
Ugum Watershed
Umatac Watershed
Geus Watershed
Toguan Watershed
Ugum River
Bubulao River
Chagame River
La Sa Fua River
Laelae River
Astaban River
Atate River
Madog River
Ieygo River
Tongan Creek
Bile River
Pigua River
Dante River
Geus Valley
Talofofo Bay
Sella Bay
Cetti Bay
Umatac Bay
Mamatgun Point
Bile Bay
Inarajan Bay
Agfayan Bay
Philippine Sea
Cocos Lagoon
Pacific Ocean
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AFFECTED ENVIRONMENT

The discussion of the existing watershed environment includes a summary of the physical, marine and terrestrial biological setting, social and economic environment; infrastructure and services; and hazardous and regulated materials and waste.

Air Quality

Guam's air quality is discussed in Chapter 5 of this Volume. The subject watersheds contain Badlands or areas of bare soil subject to high erosion rates and dusty conditions and the watershed experiences wild land fires which create dust and smoke particulates in the area.

Geology and Soils

The subject watersheds are located in the southern structural province of Guam which is predominantly volcanic in origin and underlain by highly weathered basalt and tuff-derived sedimentary rocks. The western boundary of some of the watersheds coincides with Mount Jummulong Manglo, rising to 1,095 ft (334 m) above sea level. These watersheds are largely underlain by the Facpi Formation, one of the two oldest geologic units on Guam. The Facpi Formation is composed of Eocene age volcanics which underlie all other exposed rock units on the island. This formation contains a series of pillow basalts and water-laid pyroclastic rocks ranging from tuffaceous shale to coarse boulder conglomerate and breccias (Gingerich 2003). Separate volcanic rocks of Oligocene to late Miocene age comprise the Umatac Formation and lay on top of the Alutom Formation. They crop out principally in the south-central highlands and plateaus and contain reef and forereef limestone, tuff breccia and volcanic conglomerate, and basalt flows (Meijer and others 1983; Reagan and Meijer 1984). The permeability of the formation is considered low (Gingerich 2003). The drainage pattern within the southern structural province is the result of numerous faults. A range of low mountains forms the majority of the topographic divide of the catchment area (GovGuam DOA GEPA 2007).

Volcanic rocks of southern Guam are locally overlain by limestone. The top of the mountainous ridge and central basin are covered by old limestone units. They are Miocene to Pliocene age and are known as Bonya and Alifan Limestone. Eastern coast and Orote Peninsula comprise of younger limestone. It is

Pliocene to Pleistocene age and is called Mariana Limestone. This limestone is clay-rich in the vicinity of volcanic uplands.

Finally, there are minor reef limestone, beach deposits, and alluvium of Holocene age. The beach deposits are composed of poorly consolidated calcareous sand and gravel or volcanic sand. Alluvial deposits fill stream valleys and cover parts of the coastal lowlands.

Southern Guam has eight simplified soils: Akina-Agfayan, Akina-Togcha-Ylig; Guam; Guam-urban land-Pulantat; Inarajan; Pulantat; Pulantat-Kagman-Chacha; and Ritidian-rock outcrop-Guam (WERI 2010). Specific soil types for each water shed are described in Table 11.2-11.

Table 11.2-11 Watershed Soil Types

Watershed	*Main Soil Types**
Ugum	Ylig clay, Akina-Atate silty clay, Akina silty clay, Togcha-Akina silty clays, Pulantat clay, Akina-Badland complex, Agfayan clay, Sasalaguan clay, rock and urban land complex
Umatac	Ylig clay, Akina-Atate silty clays, Togcha-Akina silty clays, Akina-Badland complex, Inarajan clay, rock and urban land complex
Toguan	Ylig clay, Togcha-Akina silty clays, Akina-Badland complex, Sasalaguan clay, Inarajan clay, rock and urban land complex.
Geus	Ylig clay, Inarajan clay, rock and urban land complex

Source: WERI 2010

The Akina soils, which are formed in residuum derived dominantly from tuff and tuff breccia, are generally very deep and well drained. This contrasts with Agfayan soils, which are also formed in residuum, although derived predominantly from marine-deposited tuffaceous sandstones and are very shallow and well drained. Included in these soils are severely eroded areas, commonly called Badlands, as well as small areas of Rock outcrop on ridgelines and knobs. Both Akina and Agfayan are highly susceptible to sheet and rill erosion if not adequately protected by plant cover and litter (COMNAV Marinas 2007b).

Talofofo Bay has a well-documented history of excessive sedimentation. Estimated erosion rates from annual soil detachment from sheet and rill erosion for the nearby Navy-land in Fena subwatershed (included in the Talafofo Watershed) is 49 tons (44 mt) per ac (0.4 ha) per year. The average annual rate of detachment from forested landscapes was estimated at 31 tons (28 mt) per ac (0.4 ha) per year (COMNAV Marinas 2007b).

Current mitigation activities on Navy-land includes manual cutting of vegetation (site preparation), nursery propagation of Acacia seedling, seedling planting at a minimum of 435 seedlings per ac (176 trees/ha), pre- and post-planting monitoring of height and canopy growth. The desired future condition of this area is forested plant community with a minimum tree canopy cover of 70 % (within five years) and less than 30 % exposed soil. Once established, the planted mitigation sites will be identified as protected sites and will be maintained in perpetuity through operations and maintenance funds identified in the COMNAV Marinas INRMP (COMNAV Marinas 2007b).

Hydrology

On Guam, streams are present only in the south where low-permeability volcanic rocks slow the infiltration of rainwater and allow groundwater to discharge to streams. In southern Guam, much of the fresh groundwater discharges directly to stream valleys above sea level where the ground surface intersects the water table. Minor perched systems are found in some of the higher-altitude limestone overlying the volcanic rocks of southern Guam. Groundwater flows laterally along the impervious layers of volcanic rock unit until it diffuses into seeps, springs, streams, or wetlands. The quantity of surface water stored in streams and wetlands is dependent on the seasonality, intensity, and duration of rainfall. Once the soil profile is saturated, any additional rainfall is diffused into the streams and travels to the ocean (Gingerich 2003).

As described previously in this Section and shown below in Table 11.2-12, the watersheds and their hydrologic information as described by WERI (2010) is summarized:

The Ugum watershed is has a drainage area of 7.31 sq. miles (2.8 km^2). The main rivers in the watershed include Ugum River, Bubulao River, Atate River and Leygo River with approximate lengths of 6.05

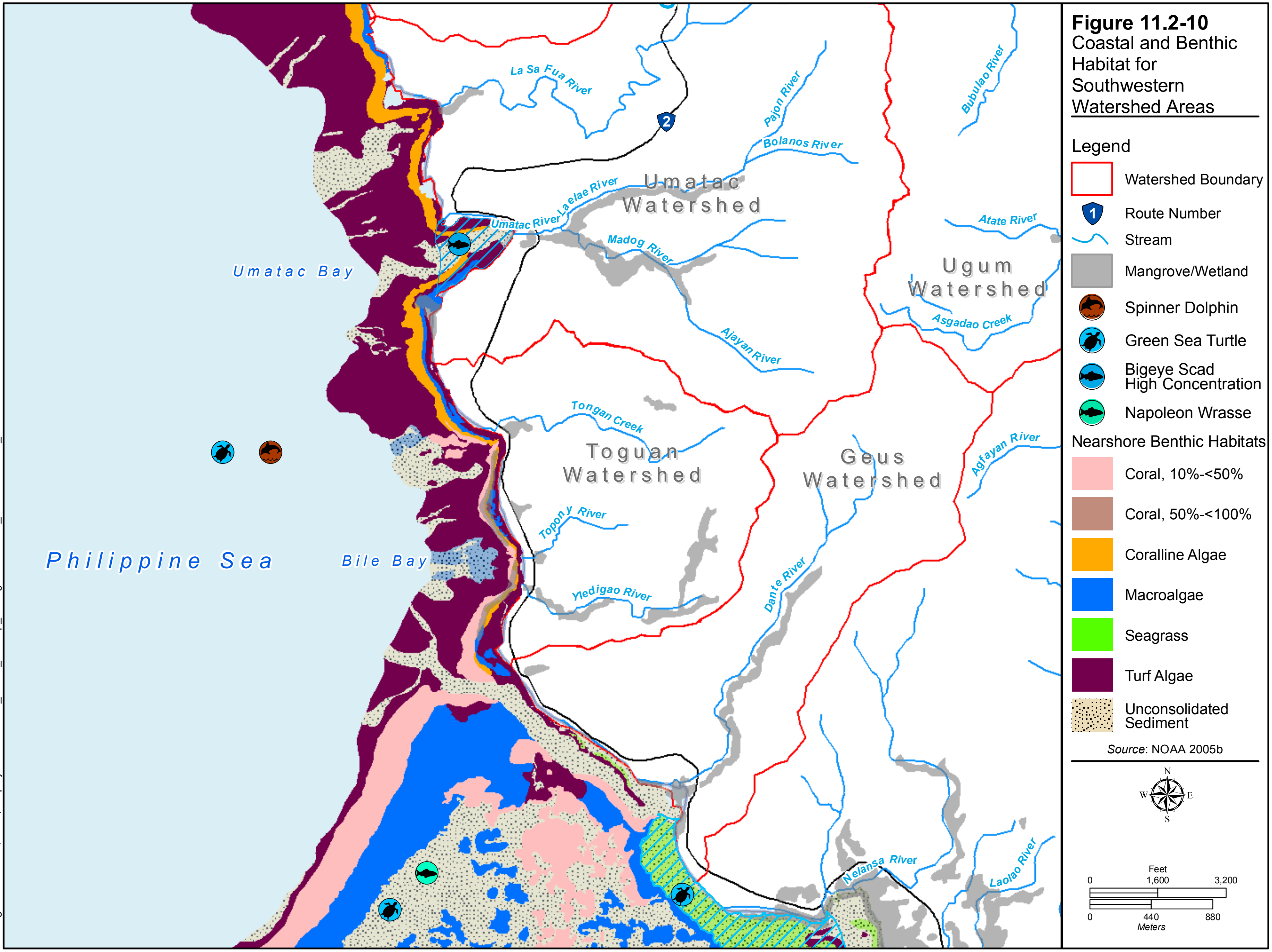
miles (9.7 km), 4.84 miles (7.7 km), 1.24 miles (1.9 km) and 1.16 miles (1.8 km) respectively. The Leygo River discharges to Atate River, which merges to Ugum River in the southwest of the watershed. Bubulao River discharges to Ugum River from west to east. The Ugum River discharges to Talofofo River. The highest elevation is about 1,227 feet (374 meters) in the southwestern boundary of the watershed. The Umatac watershed has a drainage area of 3.84 square miles (9.9 km^2). The main rivers in the watershed include La Sa Fua River, Laelae River, Madog River, Chagame River and Astaban River with approximate lengths of 2.11 miles (3.3 km), 1.9 miles(3.0 km), 1.59 miles (2.5 km), 1.02 miles (1.6 km) and 0.2 mile (0.3 km) respectively. Chagame River flows from north to south, and merges to La Sa Fua River which discharges to Fouha Bay in the Philippine Sea. Astaban River discharges to Madog River, which merges to Umatac River. Laelae River drains from east to west to Umatac River. Umatac River discharges to Umatac Bay. The highest elevation is about 1,243 feet (379 meters) in the eastern boundary of the watershed. The Toguan watershed has a drainage area of 1.41 sq. miles (3.6 km^2). The main rivers in the watershed include Toguan Creek, Pigua River and Bile River with approximate lengths of 1.38 miles (2.2 km), 1.09 miles (1.7 km) and 0.73 mile (1.1 km) respectively. Toguan Creek drains to Toguan Bay in the Philippine Sea, and Bile River and Piguan River discharge to Bile Bay in the Philippine Sea. All these rivers flow from east to west. The Geus has a drainage area of 1.73 sq. miles (4.4 km^2). The main river Geus River with approximate lengths of 2.71 miles (4.3 km). Geus River discharges to the Philippine Sea. The highest elevation is about 833 feet (254 meters) in the east of the northern watershed.

Table 11.2-12. Watershed Hydrologic Characteristics

Watershed	*Total Area*	*Main Rivers*	*River Lengths*	*Highest Elevation*
Ugum (and Talofofo)	7.31 mi^2 (2.8 $km^{2)}$	Ugum Bubulao Atate Leygo	6.05 mi (9.7 km) 4.84 mi (7.7 km) 1.24 mi (1.9 km) 1.16mi (1.8 km)	1,227 ft. (374 m)
Umatac	3.84 mi^2 (9.9 km^2)	La Sa Fua Laelae Madog Chagame Astaban	2.11 mi (3.3 km) 1.9 mi (3.0 km) 1.59 mi (2.5 km) 1.02 mi (1.6 km) 0.2 mi (0.3 km)	1,243 ft. (379 m)
Toguan	1.41 mi^2 (3.6 km^2)	Toguan (creek) Pigua Bile	1.38 mi (2.2 km) 1.09 mi (1.7 km) 0.73 mi (1.1 km)	1,043 ft. (318 m)
Geus	1.73 mi^2 (4.4 km^2)	Geus	2.71 mi (4.3 km)	833 ft. (254 m)

Coastal Environment

Figure 11.2-10 and 11 provides the coastal wetland and benthic habitat mapping for the watersheds of southern Guam (Burdick 2006).



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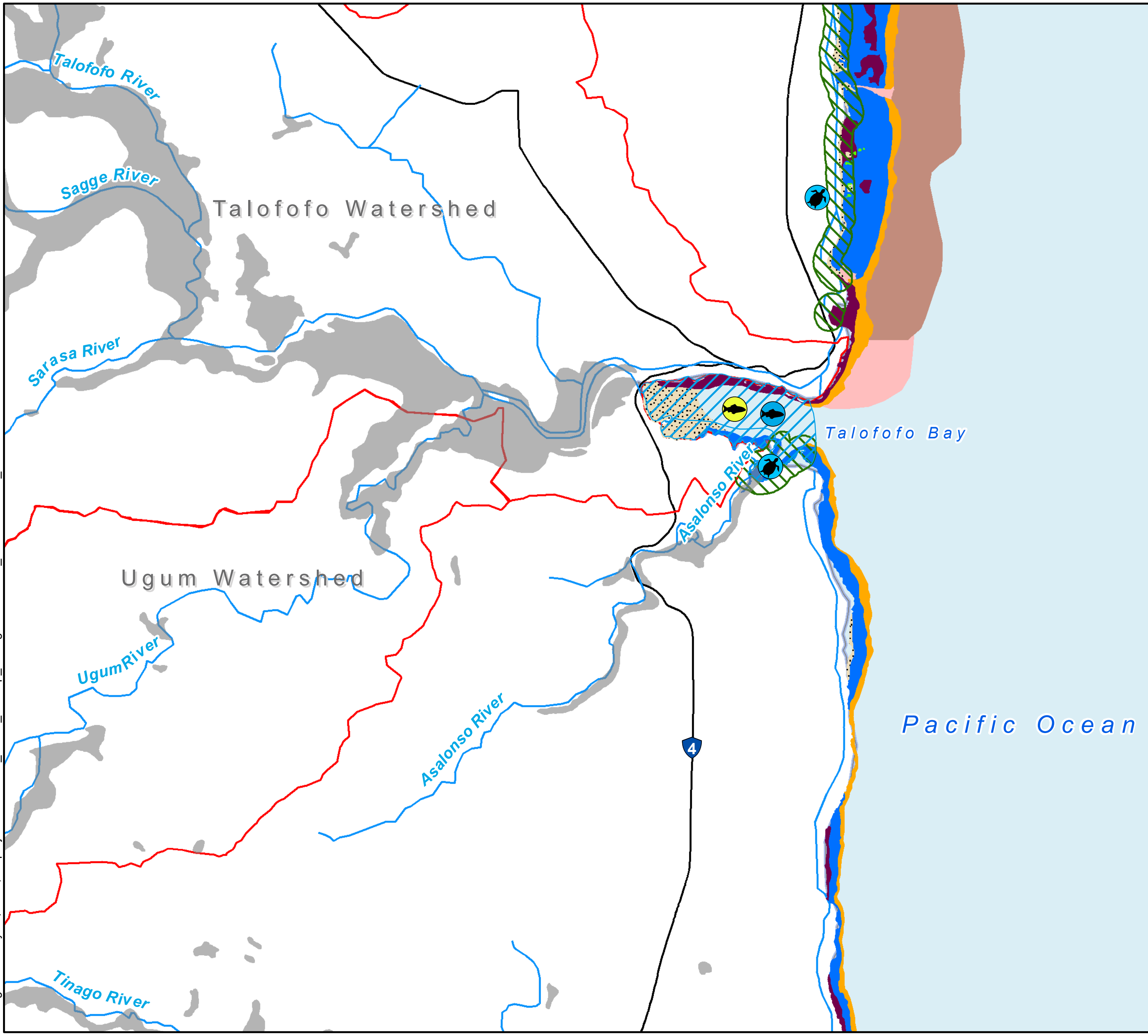

Figure 11.2-11
Coastal and Benthic Habitat for Southeastern Watershed Areas

Legend

- Watershed Boundary
- Route Number
- Stream
- Mangrove/Wetland
- Potential Sea Turtle Nesting Area
- Green Sea Turtle Nesting (Apr-Jul)
- Bigeye Scad High Concentration
- Bumphead Parrotfish

Nearshore Benthic Habitats

- Coral, 10%-<50%
- Coral, 50%-<100%
- Coralline Algae
- Macroalgae
- Turf Algae
- Unconsolidated Sediment

Source: NOAA 2005b

With respect to the Ugum and Talofofo watersheds, WERI states: “The Ugum water shed (and Talofofo watershed) drains to Talofofo Bay on the east side of the island. It is a long, narrow embayment, heavily influenced by the Talofofo River. Dimensions of the bay are about 1,000 ft (305 m) wide by 3,500 ft (1,067 m) long, comprising about 1.5 mi (2.4 km) of coastline (between Adjoulan Point and Matala Point – the two prominent headlands). Benthic habitats identified by NOAA (NCCOS 2005) include a large uncolonized area adjacent to the Talofofo River estuary with turf and macroalgae margins on north and south sides of the bay, respectively (refer to Figure 11.2-11). Coraline algae and coral reef habitats are found outside the mouth of the bay on the north side around Adjoulan Point. The beach and harbor bottom consists of fine, chocolate-brown sand deposited by the river which gives the water in the bay a murky orange color. The shoreline of the bay is eroding in places and shoreline hardening projects have been implemented to protect public facilities” (WERI 2010).

As described by WERI (2010) reefs almost completely surround southern Guam. They are cut by numerous bays at the mouths of the large permanent streams that drain volcanic uplands. Reefs in southern Guam are extremely diverse environments and consist of many distinct habitats.

Reef flats are relatively flat platforms that extend from the shoreline to the wave-washed reef margin. They can be from just a few meters to over a kilometer wide. Some reef flats are intertidal and nearly completely exposed during low tides. Others have deeper areas known as "moats", which retain water at all times. The reef flat zone can be covered by algal pavement, sea grass beds, staghorn (*Acropora*) thickets, *Porites* microatolls, fields of sand and rubble, and macroalgae.

Reef margin is the edge of a fringing reef, where the waves crash against the reef. They are almost always washed with surf and support encrusting algae and other tough organisms that can resist constant wave action.

The area extending seaward from the reef margin is known as the reef front. Coral communities in this zone are directly related to the level and frequency of wave action. Areas protected from severe waves usually have gentle slopes with tabular or branching corals. Areas with more wave action are steeper and dominated by lower, stout branched corals. The most typical feature of this zone are alternative ridges and vertical sides channels known as "spur and groove" formations.

Slopes descending from the reef to deep water belong to the outer reef zones. They support various coral communities that remain rich and diverse to depths of 131.2 to 196.8 ft. (40-60 m).

Field surveys supplementing the WERI (2010) information discussed above were conducted in May 2010 to assess and document the existing conditions of near-shore marine resources offshore of watersheds on the southwestern coastal area of Guam from Fouha Bay to Bile Bay. Surveys included all reef areas extending from the shoreline to a depth limit of 60 feet (18.3 m). The report is considered a preliminary review and is included in Volume 9, Appendix J.

Surveys were conducted by collecting a total of 780 “calibration/validation” points, each of which consisted of five digital photographs comprising 35.5 ft^2 (3.3 m^2) of the benthic surface (294 sites were within the southwestern watersheds). Preliminary results of these surveys based on visual interpretation of benthic composition were used to develop an initial assessment of the overall reef community structure (Dollar and Hochberg 2010).

The overall physiographic structure of each of the four bays, Fouha Bay, Bile Bay, Toguan Bay, and Umatac Bay, that receive drainage from the southwestern watersheds is similar, consisting of U-shaped bays bisected by sand-filled paleostream channels. On either side of the channels shallow reef flats extend from the shoreline to steeply sloping reef edges that extend to the sandy channel floors. The reef flats are colonized by a variety of small corals and in many cases abundant algae. The reef slopes generally consist large colonies of *Porites* spp. Terrigenous mud from river drainage is apparent on the inner reefs of all of the bays, although in greatly varying amounts, with a north-south gradient of decreasing occurrence. The effects of mud to reef community structure are most apparent in Fouha Bay, where impacts are substantial throughout nearly the entire embayment. In Toguan and Bile Bays, the effects of sediment are restricted to the areas close to the points of river discharge, with the remainders of these bays showing virtually no effects of sediment. The reefs between the embayments consist of gently sloping platforms that extend from the shoreline to offshore sand flats. At the time of the surveys in May 2010, benthic cover of the between-bay areas was dominated by two species of algae (*Padina* sp. and *Chrysocystis fragilis*) which are known to be seasonal in occurrence and will likely disappear during the winter. Based on collected field data, there is a total of 53 acres (21.4 ha) of coral within the survey area of the southwestern watershed reefs, a total of 342 acres (138.4 ha) of frondose and turf algae, and 34 acres (13.7 ha) of mud covered bottom (Dollar and Hochberg 2010).

There are four wetland type communities in southern Guam; freshwater marshes, freshwater swamps, estuaries, and mangrove forests and are described briefly below as stated in WERI (2010).

- Freshwater marshes are a common type of wetlands in southern Guam. These freshwater wetlands in southern Guam are dominated by dense, nearly pure stands of *Phragmites karka* (WERI 2010). Grasses (e.g. *Panicum muticum*), sedges (e.g. *Eleocharis ochrostachys* and *Cyperus spp*.) and the fern *Acrostichum aureum* are also common but are less prevalent (WERI 2010). Freshwater marshes are important habitats for the endangered Marianas Common Moorhen (*Gallinula chloropus guami*) and migratory birds (WERI 2010).

- A second wetland type in southern Guam are freshwater swamps. These swamps are wetlands that contain woody vegetation. Freshwater swamps are typically found on the edges of marshes, along river courses, and in wet depressions in forests (WERI 2010). The largest tract of swamp forest on the island is the Talofofo River Valley (WERI 2010). The most common species found in these areas are *Hibiscus tiliaceus* and *Barringtonia racemosa* (WERI 2010). Others that may be present are *Pandanus tectorius, Cynometra ramiflora* and *Areca catechu* (WERI 2010).

- A third wetland type found in southern Guam are estuaries in coastal regions where fresh and marine waters mix. These areas are characterized by daily tidal flushing or brackish water, and occur primarily of lower channels of rivers. Of Guam's 46 rivers that flow directly into the ocean, nine have true estuarine zones (WERI 2010). The lower channels of these rivers, which are typically only 16.4 ft to 65.6 ft (5-20 m) wide and 3.2 ft to 13.1 ft (1-4 m) deep, have elevated salinity levels that extend 0.3 to 0.99 mi (0.5-1.6 km) upstream (Wilder 1976). The most common indicator plant of river zones with brackish water regimes is *Nypa fruticans* (WERI 2010). Estuarine areas are important habitats for juveniles of many fish species, including jacks, snappers, and surgeonfish (WERI 2010). These areas are also important habitat for adults of many species of rabbitfish, snappers, and several other families of fish (WERI 2010). There are several types of fish and other aquatic organisms that are found only in this type of habitat, including ponyfish, mudskippers, an abundance of crab, oysters, and snails (WERI 2010).

- The fourth type of wetland in southern Guam are mangroves. This wetand is a type of estuarine swamp environment dominated by mangroves and other saltwater-tolerant trees (WERI 2010). WERI notes that all mangrove areas on Guam are located in the southern half of the island, with largest concentrations found along the eastern shores of Apra Harbor and smaller zones present in Merizo and Inarajan (WERI 2010). Guam's mangrove species include *Rhizophora mucronata, R.*

apiculata, Bruguiera gymnorrhiza, Avicennia marina, Lumnitzera littorea, N. fruticans, Xylocarpus moluccensis, Heritiera littoralis, H. tiliaceus and *Acrostichum aureum* (Fosberg 1960; Moore and others 1977). Mangroves are important habitats for juveniles and adults of many fish species, as well as many specialized aquatic invertebrates. In addition, they act as filters, trapping sediment from rivers before it can be deposited on sensitive coral reef habitat. Many species of migratory shorebirds also use Guam's mangrove areas as feeding and resting areas (WERI 2010).

A preliminary identification of wetlands that may be subject to the regulatory jurisdiction of the USACE under section 404 of the Clean Water Act (CWA) (33 Code of Federal Regulations [CFR], parts 320-330), in areas on Guam that may be affected by the proposed alternatives in the Guam and CNMI Military Relocation EIS was conducted in June 2010. The preliminary identification was conducted with remote sensing using multispectral imagery and field determinations (NAVFAC Pacific 2010a).

Wetlands identified are shown in overview format in the wetland study found in Volume 9, Appendix K. Results in each field study area are summarized below.

- Apra Harbor Marine Corps Drive - Numerous wetlands were identified along the Apra Harbor Marine Corps Drive corridor in addition to those previously identified on Navy land by the Navy 2009 study. Some 2009 boundaries in this area were also adjusted, although there were no major changes. Wetlands within the field study area were a mix of palustrine emergent, scrub/shrub, forested, and a few estuarine intertidal wetlands. In some cases the wetlands were probably created by restriction of drainage due to Marine Corps Drive.
- Polaris Point Proposed Armored Amphibious Vehicle Area – A small palustrine forested wetland dominated by *Hibiscus tiliaceus* was found in this area at the shoreline around a man-made drainage feature.
- NMS High Road Proposed Magazine Area – The wetland in this area was found to be less extensive than shown in the Navy 2009 wetland study. The wetland was a mix of palustrine emergent and scrub/shrub.
- South of Fena Lake - The drainage along the Imong River south of Fena Lake had far less wetlands than had previously been mapped. Numerous ravines and river floodplains had been mapped as wetlands and review of previous documentation did not indicate soils had ever been examined in these determinations. In nearly all areas, except for seeps, soils were bright and were not hydric. It is likely these areas are inundated for short periods during high rainfall events but not for periods long enough to develop hydric soils. Seeps were generally palustrine emergent wetlands.
- Almagosa Basin - The large wetland in Almagosa basin was confirmed to have boundaries similar to those previously identified. An additional smaller wetland was found to the east of the large wetland. The large palustrine emergent wetland interior is almost exclusively *Phragmites karka* with various shrubs or trees such as *Hibiscus tiliaceus*, and *Pandanus tectorius*, and in some cases the swamp fern *Acrostichum aureum*, around the perimeter. The smaller wetland to the east had less *Phragmites karka*.
- Access Route to West NMS - Only one small wetland was documented in the field study areas west of NMS; most of this drainage was steep and the stream channel deeply cut. The wetland was on the boundary of a forested and open area and therefore was a mix of palustrine scrub/shrub and emergent.

- Barrigada - On Air Force Barrigada and the southern portion of Navy Barrigada the NWI identified wetlands were found to meet the three USACE wetland criteria (NWI boundaries were adjusted), although the jurisdictional status of these wetlands remains to be determined because they are isolated. These wetlands were typically palustrine emergent but in some cases were scrub/shrub. Typically they occupied slightly depressed topographic areas. The NWI wetland identified in north-central Navy Barrigada was not found to meet wetland criteria.
- NCTS Finegayan - Several areas, including two sinkholes, a major storm drainage route, and a flat area that appeared to be a slight topographic low were investigated by observation and documentation of with wetland plots on NCTS Finegayan but no wetlands were found there. NCTS Finegayan has no surface waters, no NWI-identified wetlands, and no hydric soils mapped. Soils observed were typically brightly colored with little indication of any saturation. Soils throughout are typically thin over the limestone bedrock in the area.

Vegetation

Plant communities and vegetation resources of Guam have been studied by Fosberg (1960), Raulerson and others (1978), Mueller-Dombois and Fosberg (1998) and the U.S. Department of Agriculture (2002). According to these researchers, Guam has a diverse flora of over 600 species of vascular plants, including more than 100 species of trees. From their research, it has been documented that the distribution of vegetation is influenced by two main factors, the sharply contrasting soil types between the north and south and anthropogenic (e.g. urban development and fire) and natural (i.e. wind throw from hurricanes) disturbances. As a result of these factors, the northern part of Guam is covered by scrub and forests and the southern part is dominated by savanna vegetation and patches of forest. The most recent survey by USDA Forest Service established the following classification of vegetation types on Guam:

1. Forest on elevated limestone plateaus and cliffs;
2. Savanna Complex;
3. Swamp Forest Complex, including Mangroves;
4. Ravine Forest on Volcanic Soil and on Limestone Outcrops in Valleys;
5. Secondary Thickets and Partially Cultivated Scrub Forest;
6. Coconut Plantation;
7. Predominantly Open Ground and Pastures;
8. Urban Vegetation around DoD lands and cities; and
9. Reed Marsh

All of the above vegetation types can be found in southern Guam (Figure 11.2-12).

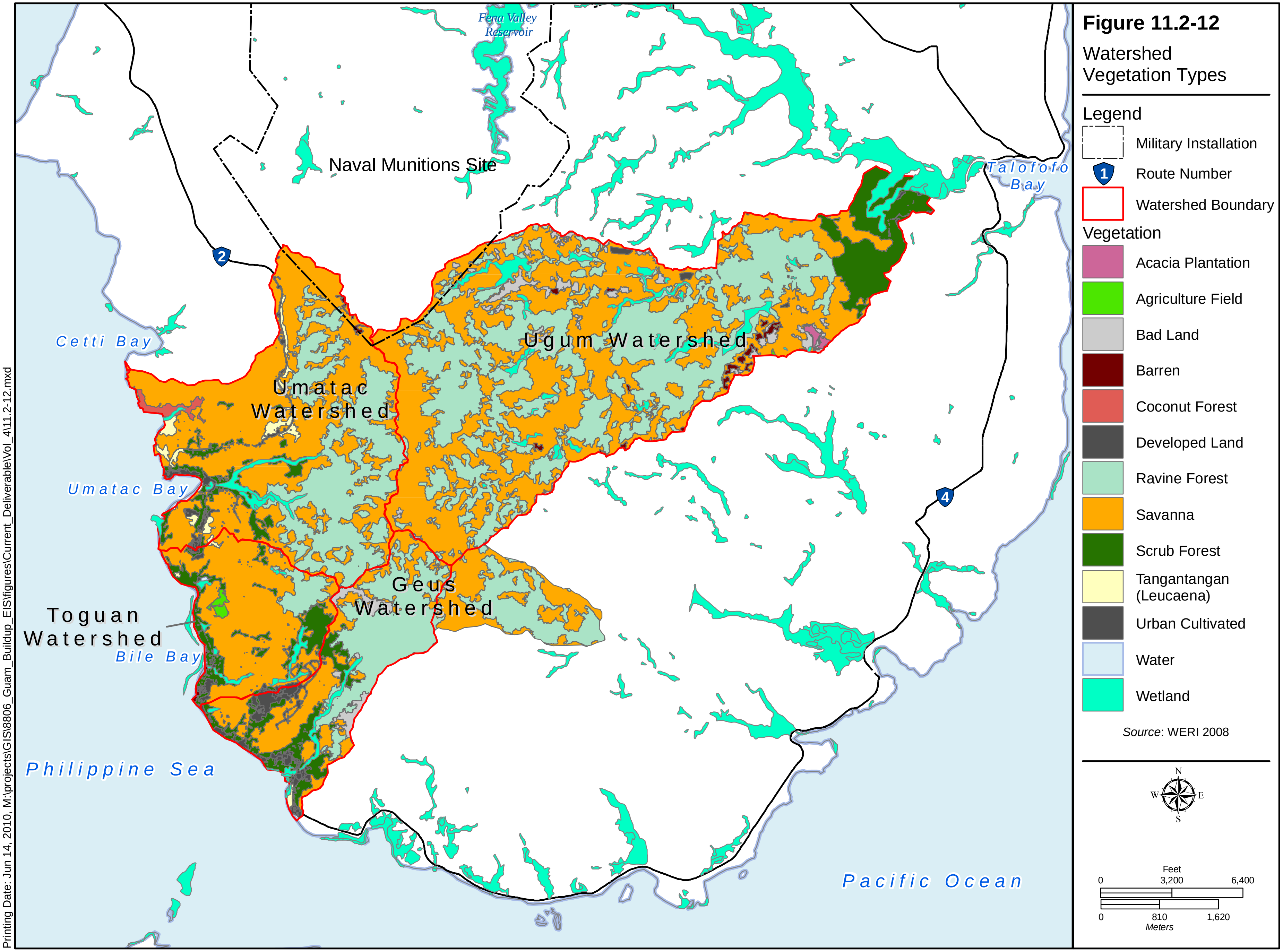
Figure 11.2-12
Watershed Vegetation Types
Legend
Military Installation
Route Number
Watershed Boundary
Vegetation
Acacia Plantation
Agriculture Field
Bad Land
Barren
Coconut Forest
Developed Land
Ravine Forest
Savanna
Scrub Forest
Tangantangan (Leucaena)
Urban Cultivated
Water
Wetland
Source: WERI 2008
Feet
0
3,200
6,400
0
810
1,620
Meters
N
S
E
W
Fena Valley Reservoir
Naval Munitions Site
Talofofo Bay
Cetti Bay
Umatac Watershed
Ugum Watershed
Umatac Bay
Geus Watershed
Toguan Watershed
Bile Bay
Philippine Sea
Pacific Ocean
2
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Southern Guam, where the watersheds are located, was originally forested; however, after centuries of human impacts including logging, fire, and grazing, the watershed areas are extensively covered in savanna grasslands. The remaining ravine and limestone forests of the watersheds are largely secondary in nature anquite variable (GovGuam DOA,GEPA 2007). According to NRCS soils information, the watersheds are comprised of six major vegetation types; savanna complex, coconut plantation, ravine forest, limestone forest, urban buildup, and scrub forest (NRCS 2006, WERI 2010).

The composition of existing plant communities within the watershed areas are greatly influenced by the tropical climate, soils, and periodic burning events. Wildland fire events have been occurring for decades, if not centuries. Periodic burning strongly influences the composition of plant communities by (1) preventing ecological succession by hindering the establishment of woody plant species; and (2) exposing the volcanic soils to accelerated erosion, which reduces the inherent soil productivity.

The reforestation project will focus mainly on savanna grasslands, the predominate vegetation type comprising of the watershed (Table 11.2-13). Grassland is dominated by the tall grass, Miscanthus floridulus, and may contain other species such as Pennisetum polystachyon and Dimeria chloridiformis (GovGuam DOA 2005).

Table 11.2-13 Watershed and Target Vegetation Acreage within Bolanos Reserve Area

Watershed	*Total Acres (Hectares)*	*Acres in Reserve (Hectares)*	*Vegetation Area*	*Restoration Veg. Type*	*Ac. in Reserve that are Savanna(Hectares)*
Ugum	4676 ac (1892 ha)	1332 (539 ha)	96.9%	Savanna	787 (318 ha)
Umatac	2459 (995 ha)	580 (235 ha)	97.4%	Savanna	266 (108 ha)
Toguan	900 (364 ha)	76 (31 ha)	94.6%	Savanna	47 (19 ha)
Geus	1109 (449 ha)	384 (155 ha)	94.6%	Savanna	157 (64 ha)

Terrestrial and Marine Protected Species

Surveys for protected terrestrial species were not conducted for the watershed reforestation project area. Information regarding federal-listed and/or territory-listed species with habitat on Guam's savanna grasslands was obtained from the Guam Comprehensive Wildlife Conservation Strategy (GovGuam DOA 2005). The only threatened and endangered species management area in the central to southern Guam region is the Guam Wildlife Refuge Overlay of DoD lands. The overlay is confined to the Fena Watershed. No protected plant, mammal, seabird, reptilian, or gastropod species occur within Guam's savanna grasslands. The following protected species could be present within adjacent limestone forest and coastal areas.

- *Forest birds.* There are no known federal- or territory-listed forest bird colonies located within Guam's savanna grasslands; however, the Island swiftlet (*Aerodramsu vanikorensis bartschi*) (which is both federal- and territory-listed as endangered) nest and roost in limestone caves and may forage for insects over savanna complex. It is possible they may occur within the proposed reforestation site.
- *Wetland birds.* The federal- and territory-listed wetland bird the Mariana common moorhen (*Gallinula chloropus guami*) prefers freshwater habitats including lakes, ponds, and springs. This bird would not be expected to be present in the grassland areas due to lack of suitable habitat.

- *Sea Turtles.* The federal-listed threatened and Guam-listed green sea turtle (*Chelonia mydas*) and the federal- and Guam-listed endangered hawksbill sea turtle (*Eretmochelys imbricata*) have been observed along all coastlines on Guam and embayment areas.

Land Use Compatibility

The southern Guam watersheds include areas that posses scenic value (e.g., Agat to Merizo highway and Guam Territorial Seashore Park) and a popular location for hiking and includes a trail into the valley. It is also a popular location for boating. The watershed area is part of the rural Umatac District of southern Guam and Umatac village, one of Guam's smallest villages. The Talofofo/Ugum watershed includes two drinking water sources (Fena Reservoir and Ugum Water Treatment Plant) with good potential for new sources.

Cultural Resources

Previous archaeological research in the Ugum watershed (Reinman 1977) has indicated that the lower reaches were likely farmed to support both coastal and inland populations, similar to the more disturbed Talofofo drainage to the north. In particular, sites MaGI-9 and MaGI-10 are located on the lower east bank of the Ugum River above the coast, and both consisted of Latte Period pottery scatters with midden soil indicating intensive human activity, even though no *latte* stone columns were recorded to indicate permanent habitation. Many of these stones have been removed after WWII with the introduction of mechanized agriculture. Sites MaGI-9 and MaGI-10 are located on the east bank of the Ugum River much further upstream and contained not only pottery and midden soil, but also numerous stone tools, slingstones, and mortars or *lusong*, perhaps indicating the area's use as a quarry and workshop for the production of these tools using locally available mudstone and basalt.

The Umatac watershed is much longer in extent than the Toguan and has been severely impacted by Spanish Colonial occupation, often serving as the Manilla Galleon season residence of the governor of Guam near his warehouse of trade goods and its Colonial church. Previous archaeological research (Reinman 1977) has indicated that the lower reaches of the north bank of the Laelae River were likely farmed to support nearby coastal populations. In particular, site MaGU-7 was located on the coastal north bank of the river near the modern Magellan Monument. Also present on the hillsides overlooking Umatac Bay are four Spanish fortresses, including Fort Santo Angel built in 1756, Fort San Jose built in 1805, and Fort Soledad built in 1810.

The Toguan watershed is shorter in extent than the Geus, but previous archaeological research (Reinman 1977) has indicated that the lower reaches of both banks were likely farmed to support nearby coastal populations. In particular, site MaGMe-8 located on the coastal south bank of the Toguan River had pottery while site MaGMe-8 contained at least one *latte* set implying permanent habitation, plus Latte Period pottery scatters with stone and marine shell tools.

The Geus watershed is similar in extent to the Ajayan and both catch runoff and spring water from Mount Sasalaguan (which means "hell" in the Chamorro language) that figures in legends about Chaife, a god of the underworld in Chamorro legend (http://guampedia.com/chaife-folktale/). Previous archaeological research (Reinman 1977) has indicated that the lower and upper reaches of both banks were likely farmed to support both coastal and inland populations. In particular, sites MaGMe-9 and MaGMe-10 located on the east bank of the Geus River each contained at least one *latte* set implying permanent habitation, while site MaGMe-11 on the west bank and coast contained a *latte* set and Spanish-era pottery, and site MaGMe-6 with Spanish pottery continued along the coast to the Spanish Village of Malesso and its Colonial church. Table 11.2-14 identifies the historic properties in these watersheds.

Table 11.2-14 Historic Properties in Ugum, Umatac, Toguan, and Geus Watersheds*

Watershed	*Site Number*	*Setting*	*Type*	*Age*
Ugum	MaGI-9	Ugum River, east bank, lower interior	Pottery and midden soil	Latte Period
Ugum	MaGI-10	Ugum River, lower east bank	Pottery and midden soil	Latte Period
Ugum	MaGI-28	Ugum River, east bank, upper interior	Pottery, stone tools, slingstones, and midden soil	Latte Period
Ugum	MaGI-29	Ugum River, east bank, upper interior	Pottery, stone tools, mortars, and midden soil	Latte Period
Umatac	MaGU-7	Laelae River, north bank and coastal	Pottery	Latte Period and Spanish era Umatac Village
Toguan	MaGMe-8	Toguan River, south bank coastal	Pottery	Latte Period
Toguan	MaGMe-9	Toguan River, north bank coastal	Latte set, pottery, stone tools, shell tools,	Latte Period
Geus	MaGMe-6	Geus River, west bank coastal to Merizo	Pottery	Latte Period and Spanish era Malesso Village
Geus	MaGMe-9	Geus River, east bank, upper interior	Latte set	Latte Period
Geus	MaGMe-10	Geus River, east bank, lower interior	Latte sets and pottery	Latte Period
Geus	MaGMe-11	Geus River, west bank, lower interior	Latte set, mortar, and Spanish pottery	Latte Period and Spanish era
Toguan	MaGMe-8	Toguan River, south bank coastal	Pottery	Latte Period
Toguan	MaGMe-9	Toguan River, north bank coastal	Latte set, pottery, stone tools, shell tools,	Latte Period
Fouha	MaGU-6	La Sa Fua River, north bank and coastal	Pottery	Latte Period and Spanish era Funa Village
Achugao	MaGU-1	Agaga River, north bank coastal	Latte set and pottery	Latte Period
Achugao	MaGU-2	Agaga River, south bank coastal	Pottery and marine shell	Latte Period

*After Reinman 1977

In general, the coastal areas of the watersheds have a rich history that is documented in the Guam Register of Historic Places and the National Register of Historic Places. The embayment areas along the coast have an important place in the Chamarro culture and pre and post European history of Guam (GovGuam DOA, GEPA 2007). The coastal areas of the watershed are also the site of Jati, a historic village of the Spanish period, which was occupied from before 1700 to the early 1800s. This village and coastal area were served by a historic Spanish road that linked Agana with Umatac.

Infrastructure and Services

Guam is one of the most built-up islands in the Pacific. The development has been concentrated in northern and central parts of Guam, so large areas in southern Guam have been spared of urbanization. Villages in southern Guam have far fewer inhabitants and much lower population density than in the north. Consequently, the watersheds have less infrastructure. The road network in southern Guam is not as complex as in the north. Its core is the coastal road (Routes 2 and 4) circling around the southern Guam and the cross-island road (Route 17) joining Talofofo and Santa Rita (WERI 2010).

Hazardous and Regulated Materials and Wastes

Because these watersheds are an undeveloped area, hazardous and regulated materials and wastes are not expected to be present in reportable quantities.

POTENTIAL IMPACTS

The discussion of the potential impacts of the watershed reforestation project(s) parallels the presentation of information in the preceding section (e.g., physical, marine and terrestrial biological setting, social and economic environment; infrastructure and services; and hazardous and regulated materials and waste).

Air Quality

Implementation of the reforestation project will reduce the frequency and intensity of wildland fire due to changes in fuel type and loadings, which will result in a beneficial impact on local climate and air quality. Because forest trees are more efficient in sequestering carbon than grass plant communities, it would also have a positive effect on the reduction of greenhouse gases.

Geology and Soils

Changes in plant community structure would not affect the underlying geology of the project site. However, any reduction of the frequency and intensity of wildland fire due to changes in the structure of wildland fires could potentially reduce gully erosion and thereby have localized indirect beneficial impacts. Project implementation (conversion from savanna grassland communities to an Acacia and native forest community) would have direct beneficial impacts to soil resources. These benefits would be derived by (1) improvement in soil structure; (2) improved caution-exchange capacity in the soil; (3) increased water percolation in soil; and (4) reduced sheet and rill erosion.

Hydrology

Project implementation would have direct beneficial impacts to fresh water systems by reducing the quantity of detached sediment delivered into the fresh water streams. While difficult to quantify the permanent reduction in sediment entering stream systems, and depending upon the amount of restoration sites, over time, a reduction of hundreds of tons of suspended sediment entering the marine environment at Talofofo Bay (from Ugum Watershed), Fouha Bay and Umatac Bay (from Umatac Watershed), Toguan Bay and Bile Bay (from Toguan Watershed), and Geus River in the Philippine Sea (from Geus Watershed) could be seen. This would be considered an indirect beneficial effect to marine waters.

Coastal Environment

Marine organisms are likely to receive indirect beneficial effects from improved water quality due to the reduction of sediment load into the nearshore environment as a result of the watershed and coastal resource management project(s). Relief from sediment impacts in the coastal waters is anticipated to improve the marine water quality and indirectly to promote recovery of coral reef biota. No adverse effects are expected to occur. No adverse effects to protected sea turtles are expected to occur as a result of project implementation. This mitigation action would have beneficial effects on Guam's coastal management zone. The mitigation action would be consistent to the maximum extent practicable with the enforceable policies of Guam's approved Coastal Management Program. GovGuam BSP will review the Navy's determination and provide a concurrence letter for CZMA determination, if deemed appropriate.

Vegetation

Under the watershed and reforestation project, existing savanna grassland community would be converted to forest community, although components of the savanna grassland community would continue to be present in the understory. The non-native trees (*Acacia*) and the native plants that would be used to reforest the watershed would return the lands to a forested community, beneficially impacting vegetation by reducing erosion, and propagating native plant species. The Acacia trees used in the reforestation project are not considered invasive. Ungulates that would be systematically removed include; Pigs (*Sus scrofa*), Philippine deer (*Cervus mariannus*), and Asiatic water buffalo (*Bubalus bubalis*). Removal from areas of the watershed would be accomplished through hunting and the use of exclusion fencing. These ungulates are not native to Guam and have a detrimental impact to native plant species and soil erosion. The reduction of ungulates in the watershed areas would have a beneficial impact on native plant species and would also reduce soil erosion impacting coastal waters.

Terrestrial Protected Species

The reforestation and coastal resource management project(s) are not expected to adversely affect federal- or territory-listed threatened or endangered species because the federal- and territory-listed Island swiftlet, which may occur within the reforestation area, is adapted to both savanna and forest communities. It would not impact the avian population since the bird species present are adapted to both forest and savanna communities. The conversion of the existing grass plant communities to a forest community is expected to improve the habitat for reptile species by increasing the diversity of niches.

Social and Economic Environment

There would be no impacts to the social and economic environment, since the project will not result in changes to population, employment, development patterns, or other socio-economic factors. No land use compatibility conflicts are expected as a result of the watershed reforestation and coastal resource management project(s) because the project(s) and its objectives will not foreseeably introduce uses incompatible with surrounding uses. Because predictive models for settlement patterns do not suggest past habitation within the reforestation area(s), the presence of archaeological sites in the proposed reforestation areas is not anticipated, and no adverse impacts to cultural resources are expected through implementation of BMPs and mitigation measures if restoring areas deemed culturally sensitive.

Infrastructure and Services

The proposed reforestation and coastal resource management project(s) would not increase the demand for or otherwise impact existing infrastructure systems and services.

Cultural Resources

Because historic property surveys have not been carried out in the proposed reforestation areas, survey work would be required prior to initiation of any watershed reforestation and coastal resource management project(s). Compliance with Section 106 of the NHPA would be required.

Hazardous and Regulated Materials and Wastes

There would be no change in the generation or disposal of hazardous and regulated materials and wastes as a result of the watershed reforestation and coastal resource management project(s).

11.2.3.2 Coastal Water Resources Management

CONSERVATION AREAS FOR CORAL REEF ECOSYSTEM PROTECTION

Designated conservation areas can provide protection to pristine and high value coral habitats. One purpose of a designated conservation area is to provide protection of an area with similar ecological functions as the resources diminished from the implementation of a proposed action. General objectives include:

- Identify and protect examples of ecosystems and of physical or biological phenomena
- Provide research and educational opportunities for scientists in the observation and study of the environment
- Preserve the full range of biological diversity
- Provide a basis for organized research and exchange of information on these areas

For example, conservation areas have been established on Guam in the past. Under a 15 March 1984 agreement between the Chief of Naval Operations and the Government of Guam, Ecological Reserve Areas (ERAs) were established at Orote Point and Haputo as compensatory mitigation projects for the loss of approximately 14.7 ac (5.95 ha) of benthic and coral reef habitat due to initial construction of a munitions wharf (Kilo Wharf) at Adotgan Point in Outer Apra Harbor, Guam. The primary purpose of the ERAs was to preserve terrestrial and marine environments while permitting low impact recreational activities that conform to GovGuam DAWR fishing and hunting regulations.

The 163-ac (66-ha) Orote ERA is located on Navy lands, on the south facing shore of Orote Peninsula, opposite the Kilo Wharf site. A watershed approach was used in establishing the ERA, which includes both a Terrestrial Unit (TU) and a Marine Unit (MU). The 30-ac (12-ha) TU includes land extending from the shoreline to the upper cliff line, and the 133-ac (54-ha) MU includes submerged lands adjacent to the TU, extending seaward to the -120 foot (-36.6 m) depth contour. The ERA extends from the former Orote Landfill on the east to the tip of the Orote Peninsula on the west, spanning about 1.9 mi (3.1 km) of shoreline. The north shoreline of the Orote Peninsula forms the southern boundary of Outer Apra Harbor, and the south shoreline–where the existing ERA is located-abuts the Philippine Sea.

The Haputo ERA, located on the northwest coast adjacent to NCTS Finegayan, is 252 ac (102 ha) in area and was also established to protect two separate biological units, a terrestrial and marine unit. The terrestrial unit supports a remnant native limestone forest providing important habitat for forest birds. The marine unit, which includes the Double Reef area, a valuable fringing reef, provides a nursery for marine species of subsistence and commercial fishery value (NAVFAC Pacific 1986). The 72-ac (29-ha) marine unit originates at the mean lower low water (MLLW) line and extends to the edge of the outer coral reef (refer to Figure 11.1-8 in Volume 2).

Project Description

The Navy will consider adding new and/or expanding existing conservation areas on federal submerged lands or through agreements with GovGuam to keep submerged conservation lands/submerged lands contiguous. The forthcoming Compensatory Mitigation Plan will detail this proposal, but could include marine and terrestrial unit expansion or establishment. The proposal would, when possible, follow the watershed approach used to establish the original marine conservation areas and may include the following:

- The management plan for the Orote ERA MU would be modified to limit consumptive activities that could adversely affect EFH—similar to limitations placed on GovGuam's MPAs. Non-consumptive recreation and scientific study would still be allowed to occur, although access to the area is already restricted by its location within an active Navy base, SDZs from existing small arms ranges, and ordnance handling activities on Kilo Wharf (Figure 11.2-14).
- The Haputo ERA MU may be expanded to the north and south on federally-owned submerged lands and seaward. The management plan for the Haputo ERA MU would be modified to limit consumptive activities that could adversely affect EFH—similar to limitations placed on GovGuam's MPAs. Non-consumptive recreation and scientific study would still be allowed to occur, although access to the area will be restricted by its location adjacent to existing Navy small arms range and their requisite SDZs.
- The Ritidian MRA, currently controlled by the Department of the Interior, could be expanded to the south to join the Haputo ERA, and expanded to the east to join the Pati Point Marine Reserve Area on federally-owned submerged lands. The TU could be expanded inland of the MU on federal lands and would be compatible with the existing Guam National Wildlife Refuge. The management plan for the Ritidian MRA MU could be modified to limit consumptive activities that could adversely affect EFH—similar to limitations placed on GovGuam's MPAs. Non-consumptive recreation and scientific study would still be allowed to occur.
- The Pati Point MPA could be expanded to the south. Development of small arms firing ranges along Route 15 will result in SDZs over land and marine waters. Expansion of the Pati Point MPA MU and the Pati Point Natural Area inland of the MU into the Route 15 SDZs and through agreements with GovGuam could result in an expanded MPA from Pagat to Jinapsin. The management plan for the Pati Point MPA MU could be modified to limit consumptive activities that could adversely affect EFH—similar to limitations placed on GovGuam's MPAs. Non-consumptive recreation and scientific study could still be allowed to occur, although access to the area will be limited by its location within the future Navy range SDZ of the coast of the Route 15 lands.

The implementation of the expanded marine conservation areas, with the cooperation of GovGuam, could be a contiguous protected areas from the GovGuam Falcona conservation area north around Ritidian and Pati point to the southern portion of the Rt. 15 range lands. These expanded protected areas could track the following general milestones:

- Joint Region Marianas (JRM) nominating package
- JRM inclusion of expanded conservation areas into joint region INRMPS
- JRM has primary land stewardship responsibility for all DoD lands on Guam including the Orote ERA. As with the existing Orote ERA TU, the expanded conservation areas would be cooperatively managed by the Navy, USFWS and GovGuam. Fishing and hunting regulations

enforceable under the Sikes Act would apply to the existing and expanded conservation areas and enforceable by federal or Guam DAWR Conservation Officers.

AFFECTED ENVIRONMENT

A study to assess potential changes to the existing ERAs was prepared for COMNAVREGMARIANAS (HHF 2007) for the Kilo Wharf EIS (COMNAV Marianas 2007b) that involved terrestrial and marine surveys of the expansion areas considered (I Tanó Services, LLC 2005 and MRC 2005a). The affected environment for the resources below are described for Orote Point ERA. The affected environment for the other potential bulleted study areas above are described in detail in the Final EIS for the Guam and CNMI Military Relocation as provided below:

- Geology and Soils – Volumes 2 and 4, Chapter 3
- Marine Biological Resources – Volumes 2 and 4, Chapter 11
- Terrestrial Biological Resources – Volumes 2 and 4, Chapter 10
- Threatened and Endangered Species – Volumes 2 and 4, Chapter 10 and 11
- Social and General Services – Volumes 2 and 4, Chapter 16

Thirteen other resources in the Final EIS for the Guam and CNMI Military Relocation were used to provide related affected environment information utilized for the compensatory mitigation impact analysis below.

Geology and Soils

The potential expansion of the Orote Point TU encompasses land from a coastal strand and forest along the shore and cliff. The ERA expansion seaward out to Orote Island would encompass extremely jagged karst limestone and pits, while the northern coast of Orote Peninsula is a steep cliff line with less severe karst features. Karst limestone leads to heavily drained soils. Orote Peninsula consists of ancient coral deposits of dense Marianas limestone, with Guam clay soil. The steep limestone slopes have little soil development.

Marine Biological Environment and EFH

The potential MU expansion is comprised of submerged lands off Orote Island and Spanish Steps. The expanded MU area includes portions of the Orote Point reef slope and reef flat, with areas of shallow fringing reef between the western end of Orote Peninsula and Orote Island that experience strong currents while being protected from normal wave action. The area supports substantial soft and stony coral cover. The shelter afforded by Orote Island creates a reef community with limited physical forces acting upon it. The reef slope is dominated by Porites rus, although other species are better represented here than at any other location along the harbor side of Orote Peninsula. While the exposed reef flats are largely devoid of corals, the flat behind Orote Island is colonized by a variety of large coral colonies, as well as a diverse array of fish.

Terrestrial Biological Environment

The potential TU expansion area includes halophytic-xerophytic plant communities on the cliff face and Orote Island. The TU has a mix of strand habitat, which occurs along and just inland from the sandy beaches, and native forest communities that are unique to the Mariana Islands. Halophytic-xerophytic forest is a type of native limestone forest that occurs in environments subjected to high salt spray, considerable wind action, and karst limestone. The forest is dominated by native trees with very low populations of non-native tree species. The forest provides potential nesting and resting habitat for sea birds, linking the TU with the MU. The most common plant species include: Umumu (*Pisonia grandis*), Fagot (*Neisosperma oppositifolia*), Lulujut (*Maytenus thompsonii*), Agatelang (*Eugenia palumbis*), and Cycad (*Cycas circinalis*). Fagellaria indica and Polypodium scolopendria are the dominant understory species. The strand portion is mostly comprised of Gausali (*Bikkia mariannensis*) and Cycad.

Orote Island supports Guam's highest known population of Ufa halomtano (*Heritiera longipetiolata*), a relatively rare endemic forest tree species that is territory-listed as endangered. Orote Island is also vegetated with many native species including: Cycad, Mastwood (*Calophyllum inophyllum*), Fig (*F. prolixa*), Pandanus (*Pandanus sp.*), Ufa halomtano, Gausali, and Half flower (*Scaevola taccada*). Gausali occurs around both the western and eastern cliff lines. The most common tree species found on the western side of the island are Cycad and Ufa halomtano, while the eastern area of the island is dominated by Cycad, Ufa halomtano, and Mastwood.

Black noddies (*Anous minutus*) are found along the shores, the islet, and on Adotgan Rock in fairly high numbers. The Yellow bittern (*Ixobrychus sinensis*), the Philippine turtle dove (*Streptopelia bitorquata*), the Black citrus swallowtail (*Papilio polytes*), and the Blue spotted butterfly or Blue-branded king crow (*Euploea eunice*) also are found in the proposed TU expansion area.

The inlet between Orote Island and the coast contains a very unique wetland habitat. The open water wetland is fed by fresh water but also receives ocean water during storm surges. The bank of the pond has thick dark brown mud populated by the marsh fern Acrostichum aureum. The pond is inhabited by both fish and eels.

The forest communities do not appear to suffer from ungulate browsing or rooting, although signs of Philippine deer (*Cervus marianus*) have been noticed. This appears to be the only remaining native limestone forest on Guam that is not affected by feral ungulates. Feral animals, including Pigs (*Sus scrofa*), Goats (*Capra hircus*), and Asiatic water buffalo (*Bubalus bubalis*) have been responsible for degradation of native forest on Guam.

Hermit crabs (*Coenobita sp*) are present, and there is evidence that Coconut crabs (*Birgus latro*) are present as well. Coconut crabs are indigenous to the Mariana Islands and are an important wildlife resource culturally and ecologically. Coconut crabs inhabit the ocean and the land during different parts of their life cycle. Adult Coconut crabs are nocturnal and live in limestone caves, crevices, and holes. Ecologically it is very possible that crabs are responsible for seed distribution in some native species as they feed on native tree seeds (Grubb 1971 in I Tanó 2005). Coconut crabs need native forest and the protection that they provide.

Threatened, Endangered and Protected Species

As described in Sections 10.1.4 and 11.1.7 of this Volume, federally-listed threatened green sea turtle nesting signs (i.e., tracks on the beach) have been observed at a beach west of Adotgan Beach (within the proposed expanded conservation area). Green and hawksbill sea turtles (*Eretmochelys imbricate*) are known to occur in the coastal waters of Guam. Sea turtles have been frequently sighted from Orote Point east towards Apra Harbor. A number of MBTA-protected seabirds are known to frequent Guam (see Sections 10.1 and 11.1 of this Volume for discussion of special-status species for the study areas).

Social and Economic Environment

The Orote Peninsula is difficult to gain access to as it is part of an active Navy installation, is encumbered by the Kilo Wharf ESQD arcs, and is surrounded on three sides by steep limestone cliffs. Nearshore waters are miles away from inhabited areas and public boat launch facilities and are only accessible via larger watercraft capable of exposure to the open ocean swells present in the vicinity of the harbor entrance channel. There are several popular dive sites located in the existing MU that are frequented by dive charter operators originating from Piti Channel, 6-7 mi (10-11 km) to the east. There are no reported dive sites within the proposed MU expansion area and its location is exposed to major trade wind and open ocean swells, making it a difficult area in which to operate watercraft.

The primary purpose of the ERA is to preserve and protect the natural environments that exist within the boundaries. Research of the natural environment is encouraged and recreational use is permitted as long as the use is compatible with the primary purpose. Development within the ERA is generally not permitted as it is incompatible with the purpose of the ERA. The Orote Historical Complex (Site # G-R 66-03-1009), listed on both the National and Guam Registers of Historic Places, is comprised of four features situated along the northern edge of Orote Peninsula. A portion of the site lies within the potential TU expansion area.

POTENTIAL IMPACTS

Discussion of impacts is limited to those resource areas that have the potential to be affected by the mitigation action.

Geology and Soils

No impacts to geology and soils are expected from the potential expansion of the ERAs or MPAs since no development or other land disturbing activities would occur.

Marine Biological Environment and EFH

The potential MU expansion area(s) could have beneficial impacts on the marine biological environment by protecting a relatively diverse assemblage of nearshore biotic habitats. The additional layer of protection would reinforce existing federal protections of sea turtles, and their potential nesting site west of Adotgan Point in the expanded conservation area (described in Section 10.1.4 of this Volume). The proposed fishing limitations would provide protection for fish and other marine species. Experience with MPAs on Guam with no-take regulations (Pati Point, Tumon Bay, Piti Bomb Holes, Sasa Bay, and Achang Reef Flat) suggests that the preserves have a positive effect on local reef fish populations. Therefore, beneficial impacts to EFH can be expected from this potential mitigation action. According to a recent published report, spawning mass is significantly higher in the marine preserves than in the control sites, indicating that the preserves may function as “egg banks” and provide higher production potential (Porter et al. 2005). An expanded conservation area is expected to increase fish diversity and biomass both within and adjacent to the ERA. This will benefit corals and associated organisms inside the ERA and in the adjacent areas (Porter et al. 2005).

Terrestrial Biological Environment

Any expansion of conservation areas is expected to have beneficial impacts on terrestrial biological resources by adding an additional layer of protection to sensitive cliff line and nearshore habitats in the general vicinity. The existing TU is very small and is almost entirely composed of steep cliff line habitat. The primary vegetation is Halophytic-shrub, with few native and endemic species (USFWS 1986 in I Tanó 2005). In contrast, the TU expansion area has several native and endemic species, and one listed as endangered by the Guam DAWR. Additionally, the TU expansion area harbors some of the few remaining bird species, albeit introduced, on Guam.

Most endemic plant species in the Mariana Islands occur in native habitats, which makes the native forests of the Marianas unique ecological systems and the primary habitat for native wildlife (Vogt and

Williams 2004 cited by I Tanó 2005 in HHF 2007). The preservation of native forests, which the proposed expanded TU includes, ensures a habitat for existing native wildlife and any future reintroductions. Also, the absence of feral ungulates at some of these locations reinforces the importance, the uniqueness, and potential of these areas for conservation. With much of Guam and the Northern Mariana Islands suffering from ungulate devastation in the native forests, areas such as those on Orote Peninsula could become important ecological banks. These intact native forests are valuable as genetic and ecological repositories of the native forest species. From a watershed perspective, conservation of the cliff line environment benefits the health of nearshore coral reef habitats.

Threatened, Endangered and Protected Species

Because the potential mitigation action would increase protections within its proposed boundaries, expansion of conservation areas will not impact federal- or territory-listed threatened, endangered, or protected species.

Social and Economic Environment

Fishing within Guam waters is subject to GovGuam laws and regulations and there are no specific Guam regulations regarding fishing within Navy designed ERAs. Enforcing the no-take regulations will be challenging on several fronts. Fishing is an important cultural, recreational, and subsistence activity on Guam, as elsewhere in the Pacific Islands. Restrictions of any kind of fishing activity–regardless of long-term beneficial effects– are therefore met with strong opposition by a broad cross section of the community. The expanded conservation areas are remote, making enforcement problematic. The Navy and Coast Guard maintain close surveillance of the Apra Harbor Entrance Channel and Kilo Wharf area, and these patrols may be able to contribute to enforcement of the no-take regulations in this area. Increases in local fish stocks resulting from no-take restrictions may have long-term, indirect beneficial impacts to recreational and cultural fishing practices outside the MU.

Scientific research on undisturbed plant communities in the native limestone forest community–one of the general objectives of the ERAs–would be possible and since future development will be restricted, research could be ongoing. This will add positively to the educational knowledge of these ecosystems. Because no development or increases in human activities are proposed, the TU expansion is not expected to affect cultural resources, including the Orote Historical Complex.

11.2.3.3 Apra Harbor and Coastal Water Resource Management

As identified above, reducing the flow of terrigenous sediments into Guam's southwest coastal areas associated with the four main watersheds would have beneficial impacts to coral reef communities and associated habitats adversely affected by ongoing sedimentation and decreased water quality. This option was established if watershed ownership parties fail to execute long-term binding agreements that meet USACE, Navy, and GovGuam real estate and legal requirements. These agreements are necessary so that watershed compensatory mitigation project(s) may be maintained in perpetuity. The Navy, with USACE support, has identified a package of compensatory mitigation projects to be implemented on Navy lands–that can be committed in perpetuity–in the event the some or any watershed and coastal resource management mitigation projects could not be implemented to meet the no net loss of ecological service requirement.

Table 11.2-10 identifies the alternatives within this category. The scale of the deep water artificial reef component can either fully offset the ecological services lost (as conservatively estimated in the Navy's HEA) or compliment other compensatory mitigation measures to reach the no net ecological services lost goal. The Navy's forthcoming compensatory mitigation plan will identify the details of this proposal.

Potentially all components would be implemented—i.e., the combined contingency mitigation actions would provide greater offsetting benefits than the estimated ecological service losses. These components are discussed below.

AFFECTED ENVIRONMENT

Deep Water Artificial Reef Sites

The establishment of deep water artificial reef habitats within Outer Apra Harbor (i.e., the ROI) would provide a measurable comparative restoration to offset the ecological service losses anticipated from Alternative 1 or Alternative 2. The Navy would use the analysis in the HEA it prepared (Volume 9, Appendix E) to appropriately scale the deep water artificial reef project. The Navy will use a conservative estimate and work with the resource agencies to come up with agreed upon an acre-year loss of ecological services. This mitigation component would then be scaled to offset the ecological services lost due to the implementation of Alternative 1 or Alternative 2.

The Navy identified and studied several candidate locations in the ROI during the Kilo Wharf EIS (COMNAV Marianas 2007b) that meet the following minimum criteria:

- water depth between 40 and 120 ft (12 and 37 m) to meet minimum navigational draft requirements and within safe diving depths
- relatively level substratum
- sufficient size to accept construction of a reasonably sized reef
- devoid of live coral
- adequate surrounding benthic community
- protected from storm waves

In the aggregate, these candidate locations provide the potential area needed to develop artificial reefs to offset the ecological services lost.

Field surveys were conducted in May 2010 to assess and document the existing conditions of near-shore marine resources offshore of watersheds on the southwestern coastal area of Guam from Fouha Bay to Bile Bay, as well as the entirety of Apra Harbor west of the proposed CVN turning basin. Surveys included all reef areas extending from the shoreline to a depth limit of 60 feet (18.2 m). The report is considered a preliminary review and is included in Volume 9, Appendix J.

Surveys were conducted by collecting a total of 780 "calibration/validation" points, each of which consisted of five digital photographs comprising 35.5 ft^2 (3.3 m^2) of the benthic surface (486 sites were in Apra Harbor). Preliminary results of these surveys based on visual interpretation of benthic composition were used to develop an initial assessment of the overall reef community structure (Dollar and Hochberg 2010).

Reef structure within Apra Harbor consists generally of a shallow reef flat that extends from the shoreline to a steeply sloping reef face that terminates at the sandy floor of the harbor. The sloping reef faces throughout the harbor are generally fully colonized by a multitude of growth forms of a single species of coral (*Porites rus*). Several pinnacles with flat tops at depths less than 60 feet (18.2 m) occur throughout the Harbor, with the tops and sides often completely covered with coral. Two large patch reefs (Jade Shoals and Western Shoals) at the eastern end of the Outer Harbor bound the CVN turning area. The outer (western and northern) regions of these patch reefs which were examined in this survey also are colonized by extensive and diverse coral assemblages. While there is abundant calcareous sands and mud within the harbor, there were no observations of red terrigenous sediment that occurred on the reefs within the embayments receiving input from the southwestern watersheds. Based on collected field data, there are a total of about 129 acres (52.2 ha) of coral within the Apra Harbor survey areas, and about 79 acres (31.9 ha) of algae and algal turf (Dollar and Hochberg 2010).

The literature indicates deep water artificial reefs rapidly establish a full range of environmental services and can potentially maintain an equilibrium level of services significantly higher than natural reefs. "Well designed and located deep water artificial reefs have demonstrated their effectiveness in establishing productive reef habitat for the complete matrix of marine life associated with natural reefs (e.g., macrobenthos, marine invertebrates, fishes, and corals)" (COMNAV Marianas 2007b.) Therefore, deep water artificial reefs are viewed as an appropriate mitigation as they can provide relatively direct habitat replacement within the general vicinity of the lost habitat.

The analysis of deep water artificial reef equivalency assumed a reef design in which sets of concrete or limestone blocks are grouped on the sea floor at regular intervals to create artificial reef for coral colonization and habitat for other marine biota, with one ac (0.4 ha) of deep water artificial reef comprised of approximately six "sets" of 50 Z-block modules, although alternative deployments will be evaluated and identified in the compensatory mitigation plan (Navy 2009a). Deep water artificial reefs can rapidly establish biomass that significantly exceeds the biomass supported by an equivalent area of reef flat (COMNAV Marianas 2007b). After the deep water artificial reef is deployed, corals and other marine organisms begin utilizing the structure and intervening spaces, and a relatively uniform rate of coral colonization could be expected across each "face" of the reef (Volume 9, Appendix E).

Because the marine habitats affected by Alternative 1 and Alternative 2 ranged in coral cover (0 % to 90 %) and ecological productivity, equivalency ratios were developed between impacted habitats and expected coral cover on the deep water artificial reef. These equivalence ratios were established to calculate how much "new" habitat would be required to compensate for the injured habitat. The analysis made assumptions about deep water artificial reef design and spacing in order to estimate equivalence ratios between the injured habitats and restored habitats, and were intended to result in conservative results (i.e., more likely to underestimate than overestimate ecological benefits provided by deep water artificial reefs).

For purposes of this analysis, and applying the algorithm used to assign injuries to Habitat Index Categories, an acre (0.4 ha) of artificial reef (i.e., 300 Z-blocks deployed in a site-appropriate configuration) would be classified in Category 1. Therefore, the Navy utilizes a 1:1 ratio for artificial reef to injured Category 1 reef. Recognizing the greater coral cover, surface area, and/or rugosity of Category 2 habitat, the Navy assumes a 2:1 artificial reef to injured Category 2 reef, a 3:1 ratio artificial reef to injured Category 3 reef, and so on for most of the affected Alternative 1 associated habitats (Navy 2009a) (refer to Table 11.2-8 and 11.2-9 earlier in this Chapter).

These adjustments to the equivalence ratios are intended to account for the greater levels of ecological service expected from affected habitats with a greater proportion of live coral, however may be adapted within the compensatory mitigation plan prepared collaboratively with USACE.

The deep water artificial reef equivalency analysis also considered the recovery period for the deep water artificial reef habitat, lifespan of the new habitat, and impacts of the reef structure on the bottom habitat it would displace (i.e., footprint of the underlying artificial reef).

The HEA was used to develop an estimate of the discounted service acre-years (DSAYs) gained per acre of artificial reef, discounted in the same manner as HEA loss calculations. Given a total expected loss of

1,048 DSAYS, a total of approximately 123 ac (49.8 ha) of artificial reef would be required to compensate for coral habitat impacts expected due to Alternative 1. Results indicate that each acre of artificial reef would provide approximately 22.1 DSAYs. Approximately 121 ac (49.0 ha) of artificial reef would be required for mitigation of impacts due to Alternative 2. Other deep water artificial reef designs or technologies may result in different equivalency ratios (Navy 2009a).

PROJECT DESCRIPTION

This mitigation action consists of the establishment of deep water introduced artificial reef habitats on federally-owned lands within Outer Apra Harbor that would provide direct restoration to offset potential ecological service losses from either Alternative 1 or Alternative 2. Deep water introduced artificial reef would provide marine habitats that provide both shelter and food for fish recruitment and a suitable surface for colonization by benthic invertebrates (e.g., corals and sponges). Information for this section has been excerpted from a deep water artificial reef feasibility study prepared for COMNAVREGMARIANAS (COMNAV Marianas 2007b).

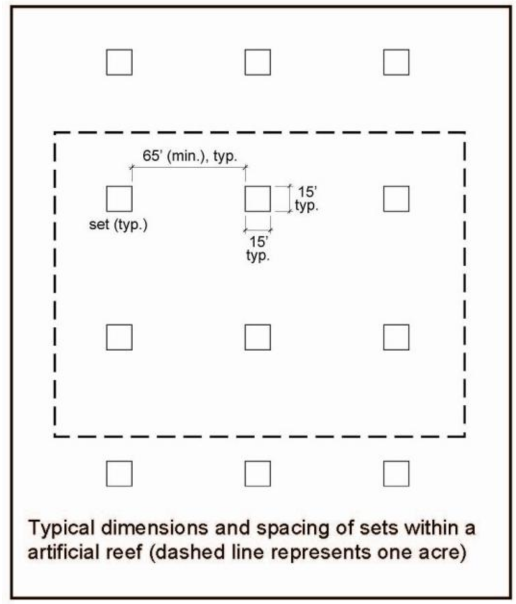
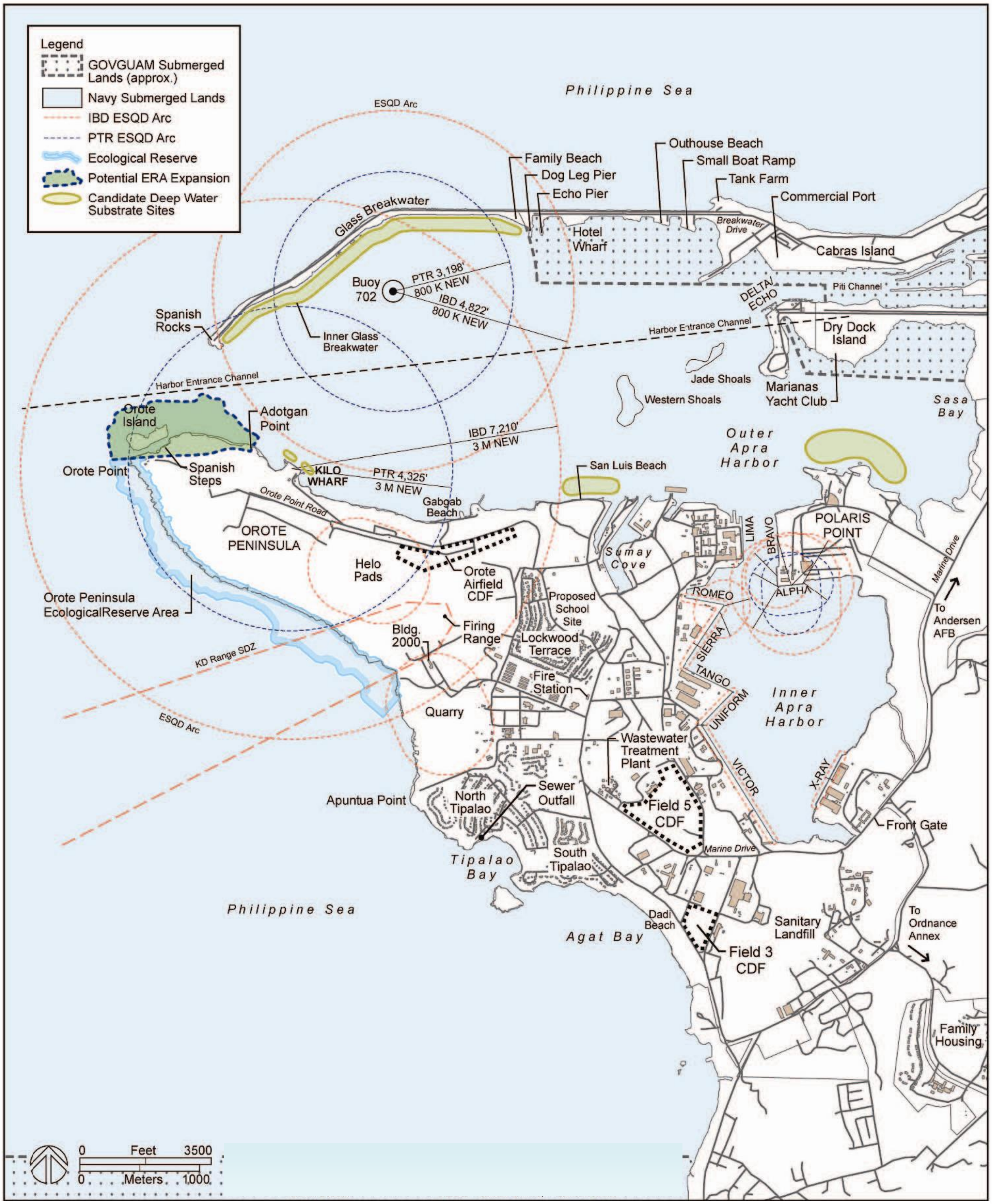


Figure 11.2-13. Deep Water Artificial Reef Schematic

Numerous reef designs would be considered as described above, reflecting restoration objectives and budgets, and encompassing a variety of potential materials, configurations, and locations. Reefs colonized on introduced artificial reef range in size from industrial reefs in Japan covering many square miles (or kilometers) of seabed, to very small deployments (e.g., <500 ft^2 or <46 m^2).

An example of a configuration considered suitable for Guam waters is based on the state of Hawaii's artificial reef program. Each unit (or reef area) of deep water artificial reef is comprised of five to ten "sets" within a sea floor area of between 0.8 to 1.6 ac (0.32 to 0.65 ha). Each set is approximately 215 ft^2 (20 m^2) in size, about 13 ft (4 m) high and comprised of between 30 to 50 concrete blocks, each cast in the form of a "Z." Each block is about 4 ft wide, 10 ft long, and 6 inches thick (1.2 m x 3 m x 15 cm). Five to ten reef sets are spaced 65 to 100 ft (20 to 30 m) apart (see Figure 11.2-13 for a schematic drawing), within visual range of one another. This grouping of sets–together with the interviewing spaces of harbor floor–is analogous to a single "artificial reef." Arranging the reef sets within visual range of each other decreases the vulnerability of fish to being captured by fishermen by enabling the fish to swim from one set to another if pursued. Also, the dense lattice provided by the stacked blocks of each set provides refuge from higher level predators. Other suitable materials found on-island could be substituted for pre-cast concrete blocks, such as large (4 to 6 ft [1.2 to 1.8 m] diameter) quarried limestone boulders, which would also be arranged in clusters or piles at an appropriate spacing.

Candidate locations include sites offshore of Kilo Wharf, south of the western end of Glass Breakwater ("Inner Glass Breakwater"), Sasa Bay, and offshore of San Luis Beach (Figure 11.2-14).



Source: COMNAV Marianas 2007b

Figure 11.2-14. Candidate Apra Harbor Deep Water Artificial Reef Sites and Orote Point ERA Expansion

As discussed earlier and in Volume 9, Appendix J, a total of approximately 123 ac (49.8 ha) of artificial reef would be required to compensate for coral habitat impacts expected due to Alternative 1. Results indicate that each acre of artificial reef would provide approximately 22.1 DSAYs. Approximately 121 ac (49.0 ha) of artificial reef would be required for mitigation of impacts due to Alternative 2 (Navy 2009a). Once deployed, the deep water artificial reef is assumed to take five years to reach full function. Both the time delay in achieving full ecological function and the amount of benthic habitat and ecological services lost due to the establishment of the deep water artificial reef modules have been factored into these acreage requirements.

Tasks required for implementation include: planning, site selection, and design; obtaining required USACE permit(s); reef unit construction, and/or acquisition; deployment of modules; post-deployment inspections; operational period monitoring; and operational period maintenance and repair. The Navy would be responsible for the implementation, monitoring, maintenance, and repair of this mitigation project.

AFFECTED ENVIRONMENT

The following section describes the four candidate deep water artificial reef sites in Outer Apra Harbor. They are discussed by location rather than resource area. These four general sites contain areas that meet the minimum location criteria listed above. Any introduction of introduced artificial reefs into Apra Harbor would be based on a coastal engineering study that would evaluate appropriate materials, securing methods, and specific locations that would best achieve goals of resource recovery (COMNAV Marianas 2007b).

Inner Glass Breakwater

Glass Breakwater extends in the westerly direction from Cabras Island for approximately 2.7 mi (4.3 km) where it defines the mouth of Outer Apra Harbor. The Breakwater sits atop Luminao Reef, which presently consists of a wide reef flat outside the eastern half of the breakwater and Calalan Bank near the harbor entrance. Inside the breakwater, Luminao Reef consists of a relatively narrow, shallow (-3 to -6 ft [-1 to -2 m]) reef flat extending westward from Family Beach to the point where the breakwater changes angle. The flat transitions to the harbor bottom via a steeply sloped fore reef. The inshore areas of Calalan Bank include a shallow (-20 ft [-6 m]) submerged ledge, transitioning to a steeply sloped fore reef ending at the harbor floor.

The reef flat extending from the edge of the breakwater consists of sand-rubble bottom covered with a dense mat of the brown alga *Padina spp*. It is of note that *Padina* occurred abundantly throughout the entire diverse array of marine habitats surveyed in the vicinity of Apra Harbor and Orote Peninsula, although the abundance of Padina shows seasonal variability. At the seaward edge of the reef flat, stony and soft corals were the dominant bottom cover. Of particular note is the reef flat named "Dogleg Reef" which consists of a finger reef that extends diagonally from the breakwater. Coral cover on the reef top was denser than many other areas within Apra Harbor, and consisted of a diverse assemblage of corals including several species of Acropora.

At the edge of the reef flat, the angle of the reef face increases sharply and forms a sloping face that extends to the harbor floor. The reef slope is largely covered with a variety of growth forms of *P.rus*, including overlapping plates, spires, and mounds. The *P. rus* communities on the reef slope on the inner side of Glass Breakwater are similar to the communities on the reef slope on the southern shoreline of outer Apra Harbor between Gabgab Beach and Orote Island. At the base of the reef slope, bottom composition consists of fine white sand with scattered corals growing on rubble fragments. While coral is abundant on the reef flats and slopes off the inner face of Glass Breakwater, this zone is rather narrow in width. In addition, the reef flats are too shallow for deep water artificial reef structures, while the reef slopes are too steep for suitable stability. However, the sandy substratum of the harbor floor off inner Glass Breakwater beyond the base of the reef slope would function as a very suitable site for deep water artificial reef structures because it meets the minimum criteria identified and listed earlier in this section (e.g., water depth, level, sufficient size, storm wave protection, etc.).

Kilo Wharf

COMNAVREGMARIANAS and USCG enforce a 500-ft (152-m) minimum physical security standoff distance from Navy ships and wharves. Deep water artificial reefs located within Kilo Wharf's security zone would essentially be within a de facto no fishing zone. This area is particularly well suited for an artificial reef/substrate because it has the most vigorous water movement within Apra Harbor. The high levels of water movement and superior water circulation would increase the rate of recruitment for both fishes and invertebrates as well as provide improved feeding and forage opportunities, particularly for many key planktivores from the damselfish and surgeonfish - unicornfish families. The sea floor fronting the wharf drops off quickly from the -45-ft (-14-m) plateau (Zone 1). Candidate deep water artificial reef sites within the security zone are located to the northwest and northeast of the wharf at the base of the ledge (see Figure 11.2-14).

San Luis Beach

San Luis Beach lies on the southern shoreline of Outer Apra Harbor between the eastern end of Gabgab Beach and the entrance channel to Sumay Cove (see Figure 11.2-14). Most of the shoreline in the area consists of sheet piling or fill material. Seaward of the shoreline, a narrow sand-rubble covered reef flat terminates at a steep reef slope that extends to the sand floor of the harbor. The northern portion of the candidate site has a fairly level bottom area at about 100-ft (30-m) depth. The area is outside the main shipping channel, within Navy submerged lands and in an area without coral cover. The southern portion of the candidate site lies just off the San Luis Beach coral reef. The candidate site is outside Kilo Wharf's IBD ESQD Arc. Gabgab Reef (Gabgab 1) - a popular dive location - lies to the west of the candidate site.

Sasa Bay

Sasa Bay lies in the easternmost area of Outer Apra Harbor, between Dry Dock Island and Polaris Point. This bay differs considerably from the rest of Outer Apra Harbor in that it is far more estuarine in nature owing to upland drainage. As a result, except in dredged channels, water depths are far shallower than in the other parts of Outer Apra Harbor. In addition, suspended sediment causes water clarity to be substantially less than in other parts of Outer Apra Harbor and there is considerably greater deposition of terrigenous sediments on the reef surfaces. Much of the structure of Sasa Bay consists of patch reefs that have shallow top surfaces and steeply sloping sides. The steep sloping reef faces terminate in the sandy floor of the harbor. While Sasa Bay is characterized by high turbidity and sediment deposition, coral cover is nevertheless substantial, particularly on the sloping sides of the patch reefs. The primary coral species on the patch reefs is *P. rus*. The candidate introduced artificial reef area is within the southwestern corner of Sasa Bay, just north of Polaris Point in an area about 45-ft (14-m) deep. The area is outside shipping channels, adjacent to but not on top of coral reef areas, and within Navy submerged lands. The area is also within a GovGuam-established no-fishing area.

POTENTIAL IMPACTS

As identified by COMNAV Marianas (2007b) the following environmental resource areas have the potential to be affected by the introduction of deep water artificial reef into Apra Harbor: water quality, marine biological setting (including benthic habitats and fisheries), and submerged cultural resources. In this section, impacts are discussed by resource area (vice location).

Water Quality

If not properly screened, pollutants from the deployed materials may leach into the water column. The potential for this would be avoided or minimized by the selection of appropriate materials (e.g., that do not contain or have been properly cleaned of potential pollutants). Based on the estimated increase in biomass (see marine biological environment below), including sessile macro-invertebrate filter feeders, a net benefit may be seen to water quality.

Marine Biological Environment

The placement of new material on the sea floor in the candidate deep water artificial reef sites would have primarily beneficial effects by replacing ecological services lost to the proposed action. Introduced artificial reef provide a stable structure for the attachment of marine invertebrates such as corals and sponges. These stationary animals feed on plankton suspended in the moving ocean currents and ultimately encrust onto the artificial structure to form a “live carpet” of attached growth. This growth serves as a hiding place and food source for mobile invertebrates that live upon and within the attached growth. As smaller animals become more abundant, larger animals are attracted to the area to feed upon them. Ultimately, a deep water artificial reef structure can create a complete food web and function comparable to natural reefs (HHF and EA LLC 2007a).

This mitigation action is not expected to adversely impact EFH. A substantial body of evidence suggests that properly designed and sited deep water artificial reefs can enhance marine habitats and local fishery stocks. This enhancement initially occurs because these ecosystems are shelter limited rather than food limited. With time and more complete development of surrounding benthic communities, deep water artificial reef surfaces may play a significant role in providing forage areas for local fish and can positively impact fishery resources (HHF and EA LLC 2007a). The greatest potential adverse biological impact of deep water artificial reef construction and deployment is if they serve only to aggregate the last few fish in an over-exploited fishery, making them vulnerable to capture. Proper sitting (e.g., in appropriately spaced reef sets close to natural reefs) and design (e.g., ample refuge spaces within the structures) reduce this potential by providing shelter to which fish may flee to escape capture (Brock 2005 in HHF and EA LLC 2007a). Additionally, as discussed in Volume 2, Chapter 11, non-native species in Apra Harbor include both purposeful introductions for fisheries and agriculture, and inadvertent introductions of species that arrived with seed stock or by hull and ballast transport with shipping traffic. These species are found to be more prevalent on artificial structures than natural reef bottoms (Paulay et al. 2002), thus some non-native species recruitment to these new deep water artificial reef structures may be expected. The new structures would replace existing underlying benthic habitat so it is critical in sitting to ensure that new structures are placed in areas that are not already considered sensitive or rare (e.g., live coral reefs). Habitat equivalency analysis needs to include the loss of small areas of existing benthic habitat under the reef structures in the calculation of net acre year gains provided by the structures (and has been factored into the Navy’s HEA estimates of deep water artificial reef needed to offset acre-year losses for Alternative 1 and 2).

A number of earlier studies suggest that deep water artificial reefs not only aggregate but also increase local productivity as an integral part of fishery enhancement (Ogawa 1979, Stone et al. 1979, Buckley 1982, Buckley and Hueckel 1985, cited by Brock 2005 in HHF and EA LLC 2007a). The current status of the question was well summarized by Sheehy (1982a): "Although most American reef researchers continue to debate whether deep water artificial reefs actually increase productivity or merely attract and concentrate organisms from surrounding areas, Japanese scientists generally have little doubt that deep water artificial reefs when properly designed, sited, and placed, can be used to increase the production of desired species" (Brock 2005 in HHF and EA LLC 2007a). Natural reefs support a biomass of approximately 1.7 oz/ 10.76 ft^2 (50 gm/m^2). Within one month, deep water artificial reefs can support a biomass of 17.6 oz/10.76 ft^2 (500 gm/m^2) increasing to 52.9 to 70.5 oz/10.76 ft^2 (1,500-2,000 gm/m^2) after one year, then falling to an equilibrium level in the range of 24.6 oz/10.76 ft^2 (700 gm/m^2) (ibid).

Potential adverse effects from the deployment of deep water artificial reef include:

- Damage to natural reefs or injury to recreational divers if the deployed components are toppled, moved or become unstable due to storm-driven waves and storm surge
- Damage to/removal of the underlying benthic resources (i.e., habitats and infauna)
- Increased non-native sessile macro-invertebrates

The potential for these adverse outcomes would be minimized by the selection of appropriate materials (e.g., materials of a suitable size, shape, and weight to withstand storm wave energy); the protected conditions of Apra Harbor; and compliance with USACE permit conditions. As described earlier in this section, the bottom habitat that would be permanently altered by the new reef structures was included in sizing the required deep water artificial reef. In other words, the ecological services lost under the footprint of the introduced reef were calculated and included in the amount of deep water artificial reef required to offset acre-year losses of approximately 123 ac (49.8 ha) for Alternative 1 and 121 ac (49.0 ha) for Alternative 2, respectively (Navy 2009a) (see Volume 9, Appendix J for detailed discussion).

Appropriate USACE permits would be obtained prior to project implementation. With adherence to permit conditions, screening of deep water artificial reef materials and locations, and proper deployment techniques, no adverse impacts to marine protected species (e.g., sea turtles) are expected.

Cultural Resources

A comprehensive, joint survey of Apra Harbor by the National Park Service, Department of the Navy, and the Guam SHPO identified 30 submerged resources, including ones that are historic properties, (e.g., shipwrecks, plane crashes, etc.) in Apra Harbor. Siting of a deep water artificial reef would be planned and implemented to avoid affecting any submerged historic properties; therefore, no adverse effects on historic properties are anticipated.

SHALLOW WATER REEF ENHANCEMENT

The main objective of shallow water reef enhancement is to minimize coral colony mortality associated with the proposed action in Apra Harbor. This will be done by physically transplanting a significant quantity of coral that would have been removed or covered by the channel and tuning basin dredging and wharf rehabilitation/construction efforts to several new sites on Navy submerged lands in Outer Apra Harbor or within Non-DoD federal lands (e.g. National Historic Parks). Coral transplantation related to mitigation and rehabilitation projects has been occurring since the 1970s. Past studies have shown success in establishing new coral habitats with transplanted coral (HHF and EA LLC 2007a). This type of shallow water reef enhancement was conducted by UoG Marine Laboratory in Apra Harbor associated with the MILCON P-431, Alpha and Bravo Wharves Improvement project. Coral colonies were transplanted from the Inner Harbor entrance channel to the Sumay reef mound in 2005 and 2006. Findings from this project show that there was roughly a 50% success rate.

Additional components of this project, within Apra Harbor and National Historic Parks may include: land acquisition; erosion control, including stormwater management BMPs (roads, wharves, industrial facilities); wetlands restoration; artificial reefs and coral transplanting (at National Historic Parks outside Apra Harbor); boundary marking & enforcement; monitoring; and education.

Project Description

As part of the CVN Wharf Construction mitigation, the Navy would enter into an agreement with a qualified organization, such as the UoG, to physically move and transplant as much live coral as feasible to sites on Navy-owned, federally-owned, or Non-DoD federal-owned submerged lands. Larger intact colonies have been shown to survive transplanting much better than small or fragmented colonies. Larger colonies also have far greater reproductive potential than small ones. Therefore, this project will focus on transplanting large specimens. A detailed coral transplanting plan will be prepared and included within the Compensatory Mitigation Plan, which will include methods for moving large colonies, techniques for stabilizing the colonies at the transplant site, and monitoring protocols. The monitoring plan will utilize accepted marine ecological procedures to monitor associated macro-invertebrates, fishes, and macro-algae, as well as the transplanted corals.

Potential recipient sites for transplanted corals within federal-owned submerged lands in Apra Harbor or other federal-owned submerged lands locations will be identified by the Navy in consultation with GovGuam and the organization performing the transplanting. Transplant site selection criteria shall include physical, chemical, and biological factors.

Management of the shallow water reef enhancement sites on Navy-owned submerged lands will be the responsibility of the Navy, as it is the primary trustee of all natural resources within its terrestrial and submerged lands. Other Non-DoD federal-owned submerged lands may be managed by the National Park Service or other identified responsible party.

AFFECTED ENVIRONMENT

This section discusses the environmental resource areas relevant to this proposal.

Marine Biological Environment and EFH

The recipient sites in Outer Apra Harbor (or other area outside Apra Harbor) will need to be of similar habitat as the original coral sites (e.g. reef flat, reef slope, etc.) with firm substratum to ensure successful transplantation. The recipient sites will likely support existing sessile species and possibly macroalgae.

Social and Economic Environment

Outer Apra Harbor is presently used extensively by both Guam residents and visitors for recreational diving and snorkeling because the reefs are in good condition and access to them is protected by the Glass Breakwater. The harbor is also an important commercial port, which fuels Guam's economy.

POTENTIAL IMPACTS

Discussion of impacts is limited to those resource areas that have the potential to be affected by the mitigation action.

Marine Biological Environment and EFH

The benthic conditions of recipient sites will be changed from rubble, pavement, or dead coral artificial reef (i.e., not presently colonized) to transplanted live corals. Benthic organisms already living in the recipient sites could be negatively impacted or even destroyed by placement of transplanted corals. Survival rates of transplanted species could be affected by harvesting, delays in transplanting, and storm events. Lessons learned in the MILCON P-431 transplantation project would be followed to minimize adverse effects.

Coral transplantation is anticipated to have a beneficial impact on the marine biological environment. More complex habitat will be created and the physical rugosity will increase. Transplantation has the potential to increase overall biomass and improve EFH. The project is expected to save a significant percentage of corals within the CVN Wharf dredging and construction site, which would otherwise be lost. It will also create new assemblages of corals which it is hoped will persist over time and attract resident fish and macroinvertebrate populations. No impacts to protected species in the recipient site areas are expected.

This project will also provide an opportunity for research of coral transplant techniques, the role of diversity in the persistence of transplanted populations, and how coral topography affects coral growth and survivorship. There will also be opportunities to study rates of colonization at recipient sites by algae, invertebrates, and fishes. Research from this project can be used to create greater success of rehabilitation or transplantation in the future by improving current technology and knowledge of coral transplantation.

Social and Economic Environment

Restoring or establishing new productive reefs in Apra Harbor will indirectly result in improved EFH, benefiting Guam's recreational and commercial fisheries and relieving pressure on existing reefs in the harbor and other areas adjacent to the transplant sites.

11.2.3.4 Summary of Mitigation Effects

Table 11.2-15 summarizes the environmental effects of the compensatory mitigation projects identified. Others projects would be evaluated as identified in the compensatory mitigation plan.

11.2.4 Alternative 2 Former SRF

11.2.4.1 Onshore

Similar to Alternative 1, proposed activities under Alternative 2, Former SRF (referred to as Alternative 2) would include construction activities in an onshore area that is composed of fill material. Impact analysis would be similar to Alternative 1, and is included below for each marine resource category.

Alternative 2 has the potential to impact the quality and quantity of the surface runoff, during both the construction and operational phases of the project, without the application of appropriate BMPs. Both construction activities as well as long-term operation activities may cause erosion and sedimentation that can degrade coastal waters and potentially impact nearshore marine biological resources. In addition, the action alternatives would increase the potential for leaks and spills of petroleum, oil, lubrications (POLs), hazardous waste, pesticides, and fertilizers. These potential impacts may affect the coastal waters and in turn the biological resources and habitats.

CONSTRUCTION

Proposed onshore construction activities would occur in an area that is composed of fill material. Embankment excavation would be required to expand the existing shoreline north of the proposed aircraft carrier berthing and the face of the wharf. While alterations to the onshore environment have the potential to result in indirect impacts that could alter the harbor water quality as described above (see also Chapter 4, Water Resources), these potential effects (short-term and localized disturbances from noise, subsurface reverberations, and siltation of marine biological resources adjacent to the site) would be minimized by complying with all applicable orders, laws and regulations, including low impact development stormwater management strategies and BMPs (Volume 7).

Marine Flora, Invertebrates and Associated EFH

Alternative 2 onshore impacts to these resources would be similar to those described under Alternative 1. No direct impacts on these resources are expected, therefore, there would be no adverse effect on EFH. Potential impacts to species included in a regional FEP are addressed accordingly under EFH.

Essential Fish Habitat

Alternative 2 onshore impacts to these resources would be similar to those described under Alternative 1. No direct impacts on these resources are expected, therefore, there would be no adverse effect on EFH.

Special-Status Species

Alternative 2 onshore impacts to these resources would be similar to those described under Alternative 1, therefore, there would be no adverse effect on special-status species. No direct impact on this resource is expected with the implementation and management of appropriate construction permits, BMPs, therefore, Alternative 2 would result in a less than significant impact to special-status species.

Non-native species

Alternative 2 onshore impacts to these resources would be similar to those described under Alternative 1. There would be no direct impacts in relation to non-native species introduction caused by activities associated with Alternative 2.

Based on the analysis presented above for onshore construction activities, Alternative 2 would result in less than significant impacts to marine biological resources.

OPERATION

The operational phase of Alternative 2 would increase the area of impervious surface which would result in an associated relatively minor increase in stormwater discharge intensities and volume. This increase would be accommodated by stormwater infrastructure, and stormwater flow paths would continue to mimic area topography. Furthermore, stormwater would be pre-treated to remove contaminants prior to discharge into the harbor, as detailed in a design-phase plan that would cover the entire project area. It is the intent that all designs would result in 100% capture and treatment, if required, of stormwater runoff.

While onshore operation activities have the potential to result in indirect impacts that could alter the harbor water quality as described above (also see Chapter 4, Water Resources), these potential effects (localized disturbances from noise, subsurface reverberations, and decreased water quality for marine biological resources adjacent to the site) would be minimized by complying with all applicable orders, laws and regulations, including industrial management strategies and BMPs (Volume 7). Potential impacts from the operational phase of Alternative 2 are described below for each marine resource category.

Marine Flora, Invertebrates and Associated EFH

Alternative 2 onshore impacts to these resources would be similar to those described under Alternative 1. No direct impacts on these resources are expected, therefore, indirect impacts as a result of actions associated with Alternative 2 would not be significant for marine flora, invertebrates, or associated EFH, and there would be no adverse effect on associated EFH.

Essential Fish Habitat

Alternative 2 onshore impacts to these resources would be similar to those described under Alternative 1. No direct impacts on these resources are expected therefore, there would be no adverse effect on EFH.

Special-Status Species

Alternative 2 onshore impacts to these resources would be similar to those described under Alternative 1. No direct impact on this resource is expected with the implementation and management of appropriate BMPs, therefore, Alternative 2 would result in a less than significant impact to special-status species.

Non-native species

Alternative 2 onshore impacts to these resources would be similar to those described under Alternative 1. There would be no direct impacts in relation to non-native species introductions caused by activities associated with Alternative 2; therefore, Alternative 2 would result in a less than significant impact regarding non-native species introduction.

Based upon the analysis presented above, onshore operational activities associated with Alternative 2 would result in less than significant impacts to marine biological resources.

11.2.4.2 Offshore

Offshore activities associated with Alternative 2 would be similar to those of Alternative 1. Volume 4, Section 2.6 describes this Alternative in detail. Potential impacts are included below by marine resource type for construction and operation activities associated with Alternative 2.

CONSTRUCTION

Marine Flora, Invertebrates and Associated EFH

The anticipated impacts to these resources resulting from the implementation of Alternative 2 are similar to the those described for Alternative 1, however in-water dredging activities would be closer to Big Blue Reef and Middle Shoals, so additional direct, indirect and cumulative effects may be expected. This includes removal of an eastern "peninsula portion" of Big Blue Reef and Middle Shoals that will not be removed under Alternative 1. Under Alternative 2, dredging activities would have direct and permanent impacts to marine flora and invertebrates (not including coral and coral reef ecosystems which are discussed in more detail under EFH), particularly to sessile organisms. Motile invertebrates would likely vacate the area due to the increased disturbance. Mortality would occur to marine flora and sessile invertebrates, these organisms would be anticipated to reestablish once project activities cease. Although the SAV resource is expected to recolonize over time the live hard bottom will not. Due to the large size of the area, context and intensity, and cumulative effects of the impacts associated with dredging in a variety of habitats, this impact would "be above minimal" (refer to Section 11.2.1.2). Therefore, the implementation of the offshore component of Alternative 2 may adversely affect EFH, specifically Live/Hard Bottom.

Essential Fish Habitat

The anticipated impacts to this resource resulting from the implementation of Alternative 2 are similar to the impacts described for Alternative 1. Although there are appears to be minor differences in the location of dredging activities and in coral removal acreages and percent removals, the in-water dredging activities would be closer to Big Blue Reef and Middle Shoals, so additional direct, indirect and cumulative effects may be expected. This includes, direct removal of an eastern "peninsula portion" of Big Blue Reef and Middle Shoals. Under Alternative 2, as with Alternative 1, impacts to EFH would be greatest for all life stages of coral and sessile reef species, some crustacean MUS and site-attached reef fish. Pelagic egg/larval stages of bottomfish and pelagic MUS may also be affected.

Based on the assumptions described in the *Assessment of the Benthic Community Structure in the Vicinity of the Proposed Turning Basin and Berthing Area for Carrier Vessel Nuclear (CVN) Apra Harbor, Guam,* Alternative 2 (Figure 11.2-15) would require the dredging of approximately 61 ac (25 ha) as compared to 71 ac (29 ha) for the Alternative 1 (Table 11.2-16). The total area impacted is about 155 acres (63 ha), which includes direct and indirect impacts of 61 ac (25 ha) and 94 ac (38 ha), respectively.

Table 11.2-16 summarizes the direct and indirect impacts of dredging to corals based on coral coverage categories with the implementation of Alternative 2. Similar to Alternative 1, areas with the greatest coral abundance (>70 to ≤ 90%) would comprise the smallest portion (10%) of the total coral coverage category that would be lost due to the proposed dredging. Areas with the least amount of coral coverage (0 – ≤10%) would comprise the largest portion (approximately 36%) of the total coral coverage category that would be lost due to the proposed dredging. About 62% of the area proposed for dredging contains corals with a coverage of less than 30%. Approximately 3% of the total area proposed for dredging contains corals in the 70-90% coverage category and 10% in the 50-90% range of coverage.

Table 11.2-16. Estimated Coral Area and Percentages Impacted by Proposed Dredging Activities with Implementation of Alternative 2

Coral Level	*Alternative 2*					
	Direct		*Indirect*		*Total*	
	ha	*ac (% coral[1])*	*ha*	*ac (% coral[1])*	*ha*	*ac (% coral[1])*
coral = 0%	14.98	**37.03**	18.90	**46.71**	33.89	**83.74**
0% < coral ≤ 10%	3.44	8.51(36)	5.34	13.20 (28)	8.79	21.72 (31)
10% < coral ≤ 30%	2.41	5.96 (25)	3.72	9.19 (20)	6.14	15.15 (21)
30% < coral ≤ 50%	0.93	2.29 (10)	3.45	8.53 (18)	4.38	10.82 (15)
50% < coral ≤ 70%	1.82	4.49 (19)	4.46	11.03 (23)	6.28	15.52 (22)
70% < coral ≤ 90%	1.01	2.48 (10)	2.13	5.25 (11)	3.13	7.74 (11)
Total with Coral	**9.61**	**23.74**	**19.10**	**47.21**	**28.71**	**70.95**
Total dredge area	**24.59**	**60.77**	**38.06**	**93.92**	**62.60**	**154.69**
Percent coral cover:		**39%**		**50%**		**46%**

[1]Coral percents are rounded to the nearest percent; therefore total coral % may not sum to 100%

Source: Derived from Classified Habitat Map Using Quickbird Satellite Imagery.

Adverse affects on EFH for reef fish MUS may occur due to the direct removal of corals and coral reef ecosystem habitat (>0% - 90% coral = 23.74 ac [9.61 ha]). Direct removal of other benthic habitat (0% coral with macroalgae, rubble, sand = 37.03 ac [14.98 ha]) would result in no adverse effects on reef fish MUS.

Short-term adverse effects on EFH are expected from indirect impacts from sedimentation to coral habitat (>0% - 90% coral = 47.21 ac [19.10 ha]) and other benthic habitat (0% coral with macroalgae, rubble, sand = 46.71 ac [18.90 ha]) even with appropriate implementation of in-water BMPs and mitigation measures. A 25% initial loss was assumed based on sediment impacts, which is consistent with the estimate that cumulative sediment caused by dredging would be low (i.e. < 0.40 in [< 1 cm]) and the relatively low sensitivity of dominant corals in the affected area (e.g., *P.rus* and *P.cylindrica*) to such levels of sedimentation.

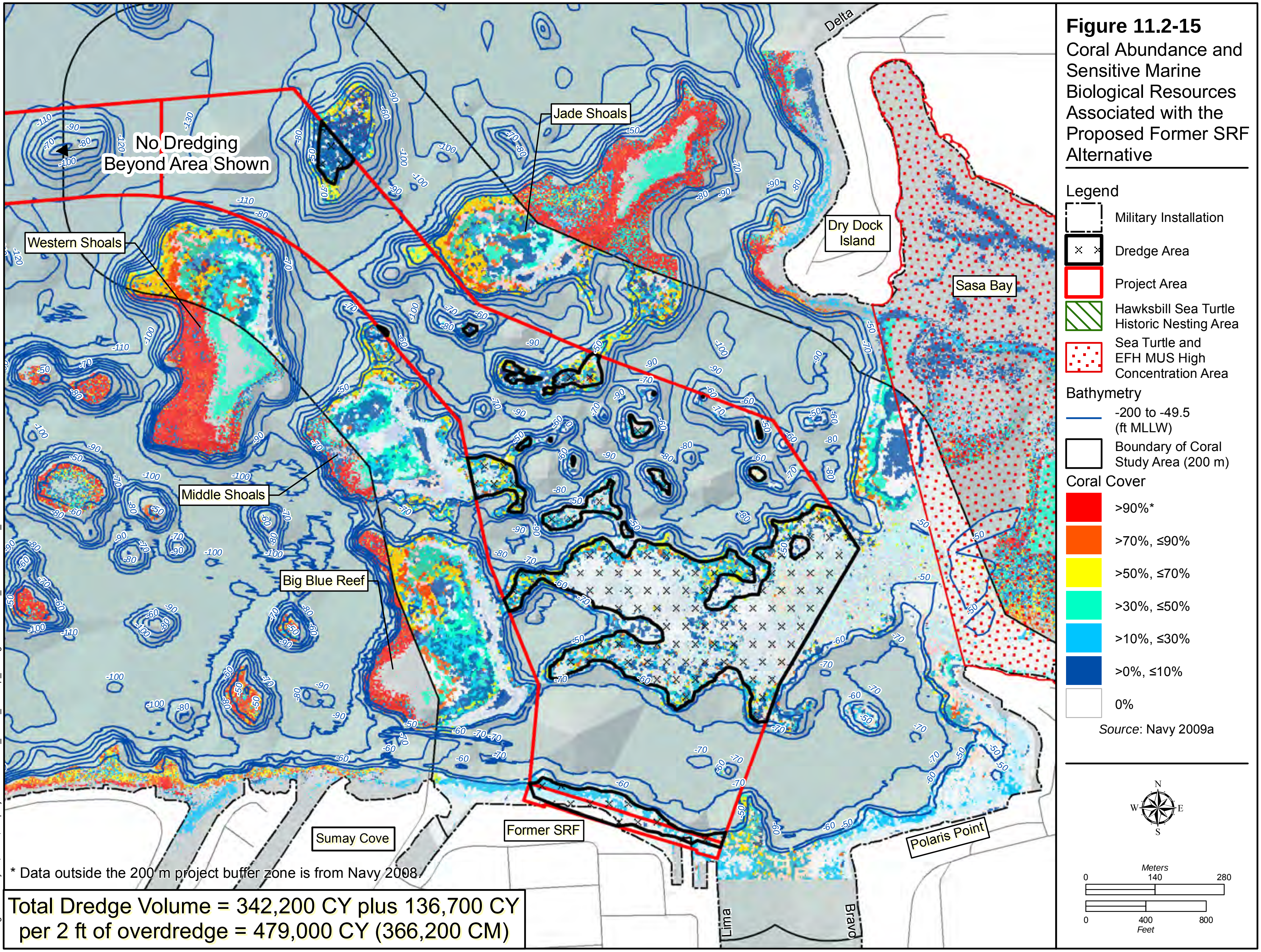


Figure 11.2-15
Coral Abundance and Sensitive Marine Biological Resources Associated with the Proposed Former SRF Alternative

Alternative 2 impacts to Essential Fish Habitat would be similar to those described for Alternative 1. The removal of habitat would decrease the structural complexity of Apra Harbor's reef system, resulting in fewer places of refuge for fish from predation. Finfish species occupying habitats that would be permanently removed would either be displaced to other adjacent sites and adapt or perish due to habitat modification and loss. Site-attached species such as those from the families Pomacentridae and Chaetodontidae may be adversely affected by changes in habitat structure, however it is anticipated that most displaced species would relocate to other adjacent sites if available.

Direct impacts from Alternative 2 dredging activities would be long-term and significant, and may adversely affect EFH. Implementation and enforcement of appropriate BMPs and mitigation measures would reduce effects. Indirect impacts from Alternative 2 actions would be similar to those described under Alternative 1 and, although short-term and localized, may adversely affect EFH.

Table 11.2-17 summarizes the EFH present in the project area and potential dredging-related effects with implementation of Alternative 2, which would be the same as Alternative 1.

Table 11.2-17. EFH Areas Associated with Apra Harbor and Potential Construction-related Effects with Implementation of Alternative 2

Habitat	*Area of Occurrence*	*Associated Activity*	*Effect*
Live/Hard Bottom	Outer Apra Harbor	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction	May adversely affect EFH through direct, permanent and localized removal. Due to the large area and intensity of the impact, and cumulative impacts associated with dredging of a variety of habitats (refer to Section 11.2.1.2), there would be "more than minimal" significant effects on live/hard bottom habitat.
		Increased vessel movements	No adverse effect from indirect short-term and localized vessel movements.
Soft Bottom	Apra Harbor	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction and increased vessel movements	No adverse effect. Direct removal and indirect, periodic and localized resuspension of sediment. Benthic infaunal community is expected to reestablish themselves quickly from adjacent, undisturbed areas.
Corals/Coral Reef Ecosystem	Outer Apra Harbor Shoal Areas, Entrance Channel	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction	May adversely affect EFH through significant direct, permanent and localized removal. May adversely affect EFH through indirect, increase in localized resuspension of sediments out to 39 ft. (12 m) from dredged area (> 0.2 in. [5 mm] cumulative sedimentation). No adverse effect on sessile (non-coral) invertebrate benthic

Table 11.2-17. EFH Areas Associated with Apra Harbor and Potential Construction-related Effects with Implementation of Alternative 2

Habitat	*Area of Occurrence*	*Associated Activity*	*Effect*
			community as they are expected to recolonize from adjacent, undisturbed areas No adverse effect from indirect short-term and localized resuspension of sediments out to 144 ft. (44 m) from dredged area (approximately. 008 in. [0.2 mm] cumulative sedimentation), increase of noise and potential pollutants
		Increased vessel movements	No adverse effect on EFH from increased short term and localized vessel movements.
Water Column	Apra Harbor	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction and other in-water construction activities.	No adverse effect on EFH from direct and indirect, temporary and localized elevation of turbidity, noise, and potential pollutants with implementation of required USACE permits and BMPs
		Increased vessel movements	No adverse effect on EFH from direct and indirect short-term, localized resuspension of sediments, increase of noise and potential pollutants from an increase in vessel movements with implementation of USACE permits and BMPs.
Estuarine Emergent Vegetation	Apra Harbor, Sasa Bay	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction. Increased vessel movements	No effects No adverse effect to EFH from short-term and localized increase of noise, resuspension of sediment, and potential increase of pollutants.
Submerged Aquatic Vegetation	Apra Harbor, Sasa Bay	Dredging of aircraft carrier channel, turning basin, and berth.	No adverse affect to EFH through direct, temporary and localized removal. Due to the large area and intensity of the impact, and cumulative impacts associated with dredging of a variety of habitats (refer to Section 11.2.1.2), there would be "more than minimal" significant effects on SAV habitat, however temporary.
		Increased vessel movements	No adverse effect on EFH from indirect short-term and

Table 11.2-17. EFH Areas Associated with Apra Harbor and Potential Construction-related Effects with Implementation of Alternative 2

Habitat	*Area of Occurrence*	*Associated Activity*	*Effect*
			localized in-water work and vessel movement.
Estuarine Water Column	Sasa Bay	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction Increased vessel movements	No adverse affect on EFH from direct and indirect temporary and localized elevation of turbidity, noise, and potential pollutants No adverse affect on EFH from direct and indirect short-term, localized resuspension of sediments, increase of noise and potential pollutants

The EFH Assessment (EFHA) prepared for Alternative 2 construction-related actions concluded that the action could result in the following:

- Permanent, localized destruction to 24 ac (10 ha) of live coral and coral reef habitat (all coverage >0% to ≤ 90%) resulting in a direct adverse effect on EFH.
- Long-term and localized adverse impact to associated EFH (Live/Hard Bottom). Due to size of impact area, context and intensity, and cumulative effects of impacts (refer to Section 11.2.1.2).
- Short-term and localized adverse impact to associated EFH (SAV) due to size of impact area, context and intensity, and cumulative effects of impacts (refer to Section 11.2.1.2).
- Long-term and localized indirect impact to coral reef ecosystem and displacement of species (could take years to recover) from excessive accumulation of sediment, resulting in an adverse effect on EFH.
- Permanent loss to some displaced, site-attached finfish species, resulting in an adverse effect on EFH.
- Short-term and localized temporary adverse effect on EFH from displacement of mobile FEP MUS (fish and some invertebrates) during in-water construction activities.
- Short-term and localized degradation to water quality (i.e., increase in siltation and turbidity), resulting in a temporary adverse effect to EFH.
- Short-term and localized minor indirect impacts to live coral and coral reef habitat (47 ac [19 ha]) from increased siltation (below 6 mm accumulation levels) and noise, resulting in no adverse effect on EFH.
- Short-term and localized significant impacts to FEP MUS in planktonic eggs and larvae stages of development, however based on small coverage areas temporary and minimal, resulting in no adverse effect on EFH.
- Short-term and localized minor disturbances to coral reef ecosystems from increased vessel movement, resulting in no adverse impacts on EFH.
- Short-term and localized seasonal disturbances to potentially pupping scalloped hammerhead sharks and high concentrations of adult bigeye scad. Considering rarity of this action (pupping),

the mobility of these species and preference for in-water structures for pupping (see earlier references), there would be no adverse effect on these EFH MUS.

- The aircraft carrier wharf structure would most likely result in an increase of community assemblages partially offsetting the short-term, localized adverse effects on EFH.
- Total coral coverage impacted (direct and indirect) is 70.95 ac (28.71 ha).

Based on this assessment, Alternative 2 may adversely affect EFH in Outer Apra Harbor. Some of these impacts would be offset (e.g. some indirect effects) or reduced through implementation and management of USACE permit required BMPs and mitigation measures. Unavoidable loss of ecological function will be offset with appropriate compensatory mitigation measures as described under Alternative 1.

Special-Status Species

The anticipated impacts to this resource resulting from implementation of Alternative 2 are similar to the impacts described for Alternative 1. However, due to its closer proximity to the western portion of Big Blue Reef, sea turtles resting and foraging in that area may be impacted to a greater extent over Alternative 1.

In summary, it is anticipated that implementation of Alternative 2 may affect, but is not likely to adversely affect the ESA-listed green sea turtles with regards to dredging and associated forage habitat loss, nesting activities and physical injury. The pile driving components of Alternative 2, although not likely to take sea turtles, due to limited visibility from elevated turbidity of waters in the action area, may potentially expose sea turtles to noise levels that exceed the NOAA's criterion for Level B Take. Therefore, pile driving may affect, and is, likely to adversely affect the green sea turtle and the hawksbill sea turtle. The Navy will be requesting an Incidental Take Permit for the pile driving action associated with the CVN MILCON. The Navy is working with NMFS through the ESA Section 7 consultation process to ensure that adverse effects on sea turtles are minimized and that significant impacts to sea turtles do not result from implementation of the proposed action.

Non-Native Species

The anticipated impacts of non-native species introduction resulting from implementation of Alternative 2 would be similar to the impacts described for Alternative 1. Less than significant impacts from non-native species introductions would occur under Alternative 2, with the implementation of appropriate Navy and USGS maritime protocols.

OPERATION

Marine Flora, Invertebrates, and Associated EFH

Alternative 2 impacts to these resources would be similar to those described under Alternative 1, except that vessel movements would be closer to Big Blue Reef and the southern portion of Middle Shoals, so additional indirect and cumulative effects may be expected from tugboat propeller wash over Alternative 1 operations.

Essential Fish Habitat

Alternative 2 direct and indirect impacts to this resource would be similar to those described under Alternative 1, except vessel movement would be closer to Big Blue Reef and the southern portion Middle Shoals, so additional indirect and cumulative effects may be expected from tugboat propeller wash over Alternative 1 operations.

EFH Assessment Summary. Alternative 2 operation activities, including an increase in vessel movements and operational pollutants, would be as described for Alternative 1 and could result in:

- Long-term; however, periodic and localized disturbance and displacement of motile species (fish) during in-water transit activities
- Long-term; however, periodic and localized increase of turbidity and pollutants (decreased water quality) in the water column from propeller wash and operation activities, a slight cumulative increased over Alternative 1, due to the closer proximity to Big Blue Reef and Middle Shoals.
- Long-term; however, periodic and localized increase in benthic sedimentation, a slight cumulative increased over Alternative 1, due to the closer proximity to Big Blue Reef and Middle Shoals
- Long-term; however, periodic and localized potentially significant impacts to eggs and larvae in the upper water column from increased vessel traffic
- Seasonal minor disturbances to potentially pupping scalloped hammerhead sharks and high concentrations of adult bigeye scad

Based on this assessment, there would be no adverse effect on EFH from operations. Therefore, Alternative 2 would result in less than significant impacts to Essential Fish Habitat from operation.

Standard Navy operating procedures and measures to protect marine resources, as discussed in Volume 7, would reduce any potential impacts. Measures would be implemented by vessels while underway within Apra Harbor.

Special-Status Species

Alternative 2 impacts to this resource would be similar to those described under Alternative 1.

Non-native Species

Alternative 2 impacts from non-native species introductions would be similar to those described under Alternative 1.

11.2.4.3 Summary of Alternative 2 Impacts

Table 11.2-18 summarizes Alternative 2 impacts, which would be similar to those of Alternative 1, except increased cumulative impacts due to the close proximity to Big Blue Reef and Middle Shoals.

Table 11.2-18. Summary of Alternative 2 NEPA Impacts

Area	*Project Activities*	*Project Specific Impacts*
Onshore	Construction	Negligible, short-term and localized impacts associated with lighting, ground vibrations, noise, and a potential decrease in water quality from pollutant runoff.
	Operation	Negligible, short-term and localized impacts associated with lighting, ground vibrations, noise, and a potential decrease in water quality from pollutant runoff.
Offshore	Construction	Significant impacts on EFH from direct and indirect effects associated with in-water construction (i.e., dredging and impact pile driving) activities. Adverse noise effects to special-status species (sea turtles) from pile-driving activities. Marine Flora, Invertebrates and Associated EFH: Unavoidable, short-term adverse direct impacts to marine flora, non-coral invertebrates and associated invertebrates. Mortality to this resource from physical removal would occur within the dredged footprint. Due to the size of the impact area, context and intensity, and cumulative effects (see Section 11.2.1.2); these impacts would be "more than minimal" for live/hard bottom and SAV. However, most of these species are anticipated to

Table 11.2-18. Summary of Alternative 2 NEPA Impacts

Area	*Project Activities*	*Project Specific Impacts*
		reestablish themselves from adjacent areas after construction (i.e. SAV and sessile invertebrates), and therefore the impacts would be temporary. Live/hard bottom community would be permanently removed through maintenance dredging before full recovery. Motile invertebrates would likely vacate the area due to the increased disturbance and find other habitat. Essential Fish Habitat: Unavoidable, long-term significant direct impacts from dredged removal of 24 ac (10 ha) of coral reef habitat. Short-term and localized adverse indirect impacts from sediment accumulation (at least 6 mm) to a portion of an additional 47 ac (19 ha) of coral reef habitat (all coverage classes) and 46 ac (19 ha) of other benthic habitat (0% coral) adjacent to, but outside of, the dredge footprint. Short-term and localized disturbance to water column and finfish. Limited injury or mortality to fish eggs and larvae. Insignificant long-term population-level effects or reduction in the quality and/or quantity of EFH. Indirect impacts from sedimentation would be the same as under Alternative 1: may adversely affect a portion of the site-attached finfish species. Limited injury or mortality to site-attached finfish and fish eggs and larvae is expected. Short-term and localized disturbance to the water column is anticipated. There would be an insignificant long-term population-level effects or reduction in the quality and/or quantity of EFH for finfish with implementation of identified BMPs and mitigation measures. However, even with mitigation efforts, there would still remain unavoidable adverse impacts associated with corals and coral reef habitat removal (direct impact) and associated sedimentation (indirect impact); compensatory mitigation would be required. The HEA assumed dredging impacts accounted for an initial 100% ecological loss from direct impacts and an initial 25% loss of ecological services from indirect impacts. Special-Status Species: Similar to Alternative 1, except short-term construction, dredging and pile driving operations would be closer to the western portion of Big Blue Reef, a known sea turtle foraging and resting habitat. Short-term and localized effects on sea turtle behavior during the dredging would be expected, but turtle foraging and resting sites would not be impacted. Mitigation measures would postpone operation if sea turtles approach the construction area. Increased noise from pile driving activities may affect, and is likely to adversely affect ESA-listed sea turtles. Impacts to sea turtles would be reduced with the implementation of identified BMPs and potential mitigation measures, including USACE permit conditions. The Navy is working with NMFS through the ESA Section 7 consultation process to ensure that unavoidable significant effects to sea turtles do not result from implementation of the proposed action. Non-native Species: Same as for Alternative 1. Less than significant impacts from introductions are expected as construction vessels would comply with USCG and Navy requirements for ballast water and hull management policies.

Table 11.2-18. Summary of Alternative 2 NEPA Impacts

Area	*Project Activities*	*Project Specific Impacts*
	Operation	Same as Alternative 1 impacts, except long-term operational activities would be closer to Big Blue Reef and Middle Shoals having potentially increased cumulative effects. Less than significant impacts from direct and indirect effects associated with an increase in operational activities. Marine Flora, Invertebrates and Associated EFH: Long-term, localized and infrequent minor impacts from increased noise and resuspension of sediment during vessel movements, and the potential for increased discharges of pollutants into the water column. Essential Fish Habitat: Long-term, localized and infrequent impacts associated with increased vessel movements resulting in long-term, periodic and localized disturbance to water column and finfish through noise, potential increased discharge of pollutants into the water column, and re-suspension of sediments. Limited injury or mortality to fish eggs and larvae. Insignificant long-term population-level effects or reduction in the quality and/or quantity of EFH. Special-Status Species: Short-term, periodic and localized minimal effects on sea turtle behavior during increased operational activities and vessel movements, with implemented BMPs, mitigation measures, and Navy vessel policies. Non-native Species: Less than significant impacts from introduction of non-native species are expected since vessels operating within Apra Harbor would comply with USCG and Navy requirements for ballast water and hull management policies. The Navy would also prepare a Regional Biosecurity Plan with risk analysis (see Volume 7 for more details).

11.2.4.4 Alternative 2 Proposed Mitigation Measures

Proposed mitigation measures for Alternative 2 would be the same as for Alternative 1. As part of the mitigation evaluation process, a cost estimate for an artificial reef mitigation project was developed though the HEA and a suite of watershed management projects were identified for potential evaluation. The cost estimates cover all stages of the projects, including: planning, site selection and design, construction, acquisition and deployment, monitoring and maintenance, coral transplantation, contingency, and oversight. Approximately 121 acres (48.97 ha) of artificial reef would be required for mitigation of impacts due to the Former SRF Alternative.

11.2.5 No-Action Alternative

Under the no-action alternative, no construction, dredging, or operation associated with the aircraft carrier berthing would occur. Existing operations at Polaris Point, as a military training and recreational facility, and the Former SRF, as a commercial ship repair facility, would continue. Therefore, the no-action alternative would not have significant impacts to marine biological resources, other than those (if any) that were previously documented through other reports.

11.2.6 Summary of Alternative 1 (Preferred Alternative) and Alternative 2 Impacts

Table 11.2-19 summarizes the potential impacts of each action alternative and the no-action alternative. A text summary is provided below.

11.2.6.1 Summary of EFH Assessment

The EFHA, comparing Alternative 1 and 2, is summarized in Table 11.2-20, and a brief text description of impacts on corals and coral reef ecosystem follows. Table 11.2-21 shows the estimated coral area and percentages impacted with the implementation of Alternative 1 and 2 proposed dredging activities.

Both alternatives require the removal of coral from within the project footprint and would result in unavoidable significant direct impacts requiring compensatory mitigation approval by the USACE under the CWA, through the Section 404/10 permit requirements (USACE, USEPA, USFWS, and NOAA 2000). About 35% (Alternative 1) and 39% (Alternative 2) of the total area to be dredged to reach the required depth contains some level of coral coverage.

Direct impacts to EFH in the proposed dredging area can be summarized as follows:

- Permanent localized destruction to coral reef, including some site attached FEP MUS
- Long-term disruption to corals and coral reef ecosystem (recovery could take years)
- Long-term localized adverse cumulative impacts to Live/Hard Bottom associated EFH
- Short-term localized adverse cumulative impacts to SAV associated EFH

Indirect impacts to EFH adjacent to the proposed dredging area can be summarized as follows:

- Short-term and localized disturbance and displacement of mobile FEP MUS (fish and some invertebrates) during in-water construction activities
- Short-term and localized degradation of water quality (i.e., increase of siltation and turbidity) due to in-water construction activities
- Short-term and localized significant impacts to eggs and larvae
- Short-term and localized indirect impacts to corals and coral reef ecosystem from siltation

There are other factors to consider when assessing the scale of potential impacts. The coral community to be dredged is not pristine because it lies within an existing navigation channel that was first dredged during the creation of the Inner Apra Harbor some 60 years ago. Dive surveys indicate that the overall coral community composition within the dredge area yields marginal to modest ecological value, based upon the following eight criteria: percentage of sea floor covered by coral, reef complexity and rugosity, species diversity, coral health, size frequency distribution of coral colonies, diversity and abundance of sessile macro-benthos other than corals (e.g., sponges), diversity and abundance of mobile macro-invertebrates, and the diversity and abundance of finfish.

Table 11.2-19. Summary of Impacts

Alternative 1	*Alternative 2*	*No-Action Alternative*
Marine Flora, Invertebrates and Associated EFH		
SI • Significant long-term and localized adverse impacts due to size of area, context and intensity, and cumulative impacts of project removal of species and habitat (Live/Hard Bottom) during construction activities. Species are not expected to re-populate due to maintenance dredging, and a “more than minimal” impact to associated EFH MUS is expected. • Short-term and localized adverse impacts due to size of area, context and intensity, and cumulative impacts of project removal of species and habitat (SAV) during construction activities. There would be a more than minimal impacts to associated EFH MUS, however temporary. • Short-term, localized and infrequent minor impacts from increased construction and operation vessel movements. A slight increase in cumulative impacts to Sasa Bay over Alternative 2 may be seen due to the closer proximity, however this areas is already highly turbid due to the influx of streams in this area.	SI • Significant long-term and localized adverse impacts due to size of area, context and intensity, and cumulative impacts of project removal of species and habitat (Live/Hard Bottom) during construction activities. Species are not expected to re-populate due to maintenance dredging, and a “more than minimal” impact to associated EFH MUS is expected. • Short-term and localized adverse impacts due to size of area, context and intensity, and cumulative impacts of project removal of species and habitat (SAV) during construction activities. There would be a more than minimal impacts to associated EFH MUS, however temporary. • Short-term and long-term, localized infrequent minor increased impacts from construction and operation vessel movements. The operational and construction activities would be closer to Big Blue Reef and Middle Shoals for Alternative 2 and may have increased direct, indirect, and cumulative impacts from construction activities and turning basin maneuvers.	NI
Essential Fish Habitat		
SI • Significant, long-term direct adverse effects to coral and coral reef ecosystems. • Short-term and localized potential indirect less than significant impacts from sediment accumulation during dredging activities. A slight increase in cumulative impacts to Sasa Bay over Alternative 2 may be seen due to the closer proximity, however this areas is already highly turbid due to the influx of streams in this area. • Short-term and localized less than significant disturbance to water column and finfish, limited injury or mortality to fish eggs and larvae from construction activities. • Insignificant long-term and infrequent disturbances to water column and finfish, limited injury or mortality to fish eggs and larvae with no population-level effects or reduction in the quality and/or quantity of EFH from operational activities. • Beneficial long-term impacts to finfish and invertebrate MUS and the	SI • Significant, long-term direct adverse effects to coral and coral reef ecosystems. • Short-term and long-term, localized infrequent minor increased impacts from construction and operation vessel movements. The operational and construction activities would be closer to Big Blue Reef and Middle Shoals for Alternative 2 and may have increased direct, indirect, and cumulative impacts from construction activities and turning basin maneuvers. • Short-term and localized less than significant disturbance to water column and finfish, limited injury or mortality to fish eggs and larvae from construction activities. • Insignificant long-term and infrequent disturbances to water column and finfish; limited injury or mortality to fish eggs and larvae with no population-level effects or reduction in the quality and/or quantity of EFH from operational activities. Long-term operational	NI

Table 11.2-19. Summary of Impacts

Alternative 1	*Alternative 2*	*No-Action Alternative*
ecology of the immediate area with the added hard surfaces and settlement potential the aircraft carrier wharf boulder rip rap and vertical pilings would provide. • Similarly, additional recruitment potential of juvenile finfish from Sasa Bay to the aircraft carrier wharf area as an extended nursery area.	activities would be closer to Big Blue Reef and may have increased indirect impacts on coral and coral reef ecosystem from resuspension of sediment during turning basin maneuvers. • Beneficial long-term impacts to finfish and invertebrate MUS and ecology of the area with the added hard surfaces and increased settlement potential the aircraft carrier boulder rip rap and wharf vertical pilings would provide.	
Special-Status Species		
SI • Significant adverse effect from pile driving activities leading to a may affect, likely to adversely affect determination. All other construction and operations activities would affect, but not likely to adversely effect sea turtles.	SI • Significant adverse effect from pile driving activities leading to a may affect, likely to adversely affect determination. All other construction and operations activities would affect, but not likely to adversely effect sea turtles.	NI
Non-native Species		
LSI • Expected because vessels would comply with USCG and Navy requirements for ballast water and hull management policies. The preparation of the MBP would assist in prevention, control, and response actions that would keep non-native invasive species introductions to minimal levels.	LSI • Expected because vessels would comply with USCG and Navy requirements for ballast water and hull management policies. The preparation of the MBP would assist in prevention, control, and response actions that would keep non-native invasive species introductions to minimal levels.	NI

Legend: SI = Significant impact, LSI = Less than significant impact, NI = No impact

Table 11.2-20. EFHA Summary for Alternative 1 and Alternative 2 Proposed Actions

Project Activities	*Alternative 1*	*Alternative 2*
Construction	The proposed action may adversely affect EFH from direct and indirect impacts during dredge removal actions and cumulative siltation of the benthic habitat. No adverse effects would be seen from noise, turbidity, decreased water quality, and other disturbances on EFH and FEP species during dredging and in-water construction activities, including dredged spoils tug and scow movements through Outer Apra Harbor to the ocean disposal site. • Unavoidable permanent significant direct impacts to coral reefs from	The proposed action may adversely affect EFH from direct and indirect impacts during dredge removal actions and cumulative siltation of the benthic habitat. No adverse effects would be seen from noise, turbidity, decreased water quality, and other disturbances on EFH and FEP species during dredging and in-water construction activities, including dredged spoils tug and scow movements through Outer Apra Harbor to the ocean disposal site. • Unavoidable permanent significant direct impacts to coral reefs

Table 11.2-20. EFHA Summary for Alternative 1 and Alternative 2 Proposed Actions

Project Activities	*Alternative 1*	*Alternative 2*
	removal of approximately 25 ac (10 ha) of live coral (all classes [>0% to ≤90%]), which may adversely affect EFH and coral reef ecostem MUS. Compensatory mitigation would be implemented through ACOE Section 10/404 permitting process. • Unavoidable, removal of approximately 46 ac (19 ha) of Live/Hard Bottom and SAV (0% coral), which may adversely affect EFH. SAV is anticipated to recolonized, therefore a temporary impact. Live hard bottom removal will be permanent through maintenance dredging. • Unavoidable short-term and localized indirect impacts to corals and coral reef ecosystem from siltation. Approximately 46.24 ac (18.71 ha) of live coral (all classes [>0% to ≤90%]) may be impacted, resulting in no adverse affect on EFH. • Total area impacted is 171.78 ac (69.52 ha), which includes direct and indirect impacts of 71.18 ac (28.80 ha) and 100.60 ac (40.71 ha), respectively. The EFHA for Apra Harbor found that the construction-related activities could result in: • Long-term, localized permanent removal of coral colonies. • Long-term localized removal of live / hard bottom. Recolinization is not expected due to maintenance dredging. an adverse impact due to size, intensity and cumulative impacts is expected on EFH. • Short-term localized removal of SAV. Although recolinization is expected, a temporary adverse impact due to size, intensity and cumulative impacts is expect on EFH. • Short-term and localized disturbances and displacement of motile species during dredging activities and in-water work. A slight increase in cumulative impacts over Alternative 2 may be seen due to the closer proximity of Sasa Bay. • Some eggs and larvae and site attached finfish mortality may be seen, however most finfish species are expected to return to the area after impact to their area subsides or seek other adjacent habitat. • Short-term, periodic, and localized disturbance and displacement of motile species (finfish) during in-water transit activities. • Short-term, periodic, and localized increase of turbidity (decreased water quality) in the water column from propeller wash. A slight	from removal of approximately 23.74 ac (9.61 ha) of live coral (all classes [>0% to ≤90%]), which may adversely affect EFH and coral reef ecosystem MUS. Compensatory mitigation would be implemented through ACOE Section 10/404 permitting process. • Unavoidable removal of approximately 37 ac (15 ha) of Live/Hard Bottom and SAV (0% coral), which may adversely effect EFH. SAV is anticipated to recolonized, therefore a temporary impact. Live hard bottom removal will be permanent through maintenance dredging. • Unavoidable short-term and localized indirect impacts to corals and coral reef ecosystem from siltation. Approximately 47.21 ac (19.10 ha) of live coral (all classes [>0% to ≤90%]) may be impacted, resulting in no adverse affect on EFH. • Total area impacted is 154.69 ac (62.60 ha), which includes direct and indirect impacts of 60.77 ac (24.59 ha) and 93.92 ac (38.01 ha), respectively. The EFHA for Apra Harbor found that the construction-related activities could result in: • Long-term, permanent removal of flora and sessile invertebrates, including coral. • Long-term localized removal of live / hard bottom. Recolinization is not expected due to maintenance dredging. an adverse impact due to size, intensity and cumulative impacts is expected on EFH. • Short-term localized removal of SAV. Although recolinization is expected, a temporary adverse impact due to size, intensity and cumulative impacts is expect on EFH. • Short-term and localized disturbances and displacement of motile species during dredging activities and in-water work. A slight increase in cumulative direct impacts over Alternative 1 may be seen due to the close proximity of Big Blue Reef and Middle Shoals • Some eggs and larvae and site attached finfish mortality may be seen, however most finfish species are expected to return to the area after impact to their area subsides or seek other adjacent habitat. • Short-term, periodic, and localized disturbance and displacement of motile species (finfish) during in-water transit activities.

Table 11.2-20. EFHA Summary for Alternative 1 and Alternative 2 Proposed Actions

Project Activities	*Alternative 1*	*Alternative 2*
	increase in cumulative impacts to Sasa Bay over Alternative 2 may be seen due to the closer proximity, however this areas is already highly turbid due to the influx of streams in this area. • Short-term, periodic, and localized increase in benthic sedimentation. • Short-term, periodic, and localized potentially significant impacts to eggs and larvae in the upper water column from increased vessel traffic. • Seasonal disturbances to spawning coral reef species and pupping scalloped hammerhead sharks, which would be mitigated. • Beneficial effect to local community assemblages after the aircraft carrier wharf construction is complete and hard surfaces are populated. This would in essence offset any effects to the depauperate community. Based on this assessment, the Navy has determined that these long-term impacts associated with Alternative 1 may adversely affect EFH.	• Short-term, periodic, and localized increase of turbidity (decreased water quality) in the water column from propeller wash. A slight increase in cumulative impacts over Alternative 1 may be seen due to the close proximity of Big Blue Reef and Middle Shoals. • Short-term, periodic, and localized increase in benthic sedimentation. A slight increase in cumulative impacts over Alternative 1 may be seen due to the close proximity of Big Blue Reef and Middle Shoals. • Short-term, periodic, and localized potentially significant impacts to eggs and larvae in the upper water column from increased vessel traffic. • Seasonal disturbances to spawning coral reef species and pupping scalloped hammerhead sharks, which would be mitigated. • Beneficial effect to local community assemblages after the aircraft carrier wharf construction is complete and hard surfaces are populated. This may partially offset effects from construction to the already depauperate community. Based on this assessment, the Navy has determined that these long-term impacts associated with Alternative 2 may adversely affect EFH.
Operation	The proposed action would have direct, indirect and cumulative impacts from noise, resuspension of sediment, decreased water quality, and other disturbances to EFH and FEP MUS due to increased vessel movements in Outer Apra Harbor. A beneficial impact may be seen to water quality (and associated marine biological resources) from the removal of fine benthic sediment within the Outer Apra Harbor Channel • The EFHA for Outer Apra Harbor found that the increased movement of aircraft carrier and MEU support vessels could result in: • Long-term, however, periodic and localized disturbance and displacement of motile species (fish) during in-water transit activities. • Long-term, however, periodic and localized increase of turbidity (decreased water quality) in the water column from propeller wash. A slight increase in cumulative impacts to Sasa Bay over Alternative	The proposed action would have direct, indirect and cumulative impacts from noise, resuspension of sediment, decreased water quality, and other disturbances on EFH FEP MUS due to increased vessel movements in Outer Apra Harbor. A beneficial impact may be seen to water quality (and associated marine biological resources) from the removal of fine benthic sediment within the Outer Apra Harbor Channel • The EFHA for Outer Apra Harbor found that the increased movement of aircraft carrier and MEU support vessels could result in: • Long-term, however, periodic and localized disturbance and displacement of motile species (fish) during in-water transit activities. • Long-term, however, periodic and localized increase of turbidity (decreased water quality) in the water column from propeller wash. A slight increase in cumulative impacts at Big Blue Reef and

Table 11.2-20. EFHA Summary for Alternative 1 and Alternative 2 Proposed Actions

Project Activities	*Alternative 1*	*Alternative 2*
	2 may be seen due to the closer proximity, however this areas is already highly turbid due to the influx of streams in this area. • Long-term, however periodic and localized increase in benthic sedimentation. • Long-term, however, periodic and localized potentially significant impacts to eggs and larvae in the upper water column from increased vessel traffic. • Seasonal disturbances to spawning coral reef species and pupping scalloped hammerhead sharks, which would be mitigated. Based on this assessment, the Navy has determined that these temporary and/or minimal impacts associated with Alternative 1 would result in no adverse effect on EFH with the implementation of BMPs and mitigation measures.	Middle Shoals may be seen over Alternative 1 due to the close proximity. • Long-term, however periodic and localized increase in benthic sedimentation. A slight increase in cumulative impacts over Alternative 1 may be seen due to the close proximity of Big Blue Reef and Middle Shoals. • Long-term, however periodic and localized potentially significant impacts to eggs and larvae in the upper water column from increased vessel traffic. • Seasonal disturbances to spawning coral reef species and pupping scalloped hammerhead sharks, which would be mitigated. Based on this assessment, the Navy has determined that these temporary and/or minimal impacts associated with Alternative 2 would result in no adverse effect on EFH with the implementation of BMPs and mitigation measures.

Table 11.2-21. Estimated Coral Area and Percentages Impacted with Implementation of Alternative 1 and 2 Proposed Dredging Activities

Coral Level	*Alternative 1*					
	Direct		*Indirect*		*Total*	
	ha	*ac (% coral[1])*	*ha*	*ac (% coral[1])*	*ha*	*ac (% coral[1])*
Coral = 0%	**18.61**	**45.98**	**22.00**	**54.36**	**40.61**	**100.34**
0% < coral ≤ 10%	3.74	9.24 (37)	5.45	13.48 (29)	9.20	22.72 (32)
10% < coral ≤ 30%	2.61	6.44 (26)	3.85	9.52 (21)	6.46	15.96 (22)
30% < coral ≤ 50%	0.96	2.37 (9)	3.25	8.04 (17)	4.22	10.41 (15)
50% < coral ≤ 70%	1.80	4.44 (18)	4.19	10.35 (22)	5.99	14.79 (21)
70% < coral ≤ 90%	1.10	2.71 (11)	1.96	4.85 (11)	3.06	7.56 (11)
Total with Coral	**10.20**	**25.20**	**18.71**	**46.24**	**28.91**	**71.44**
Total dredge area	**28.80**	**71.18**	**40.71**	**100.6**	**69.52**	**171.78**
Percent coral cover:		**35%**		**46%**		**42%**
Coral Level	*Alternative 2*					
	Direct		*Indirect*		*Total*	
	ha	*ac (% coral[1])*	*ha*	*ac (% coral[1])*	*ha*	*ac (% coral[1])*
Coral = 0%	**14.98**	**37.03**	**18.90**	**46.71**	**33.89**	**83.74**
0% < coral ≤ 10%	3.44	8.51 (36)	5.34	13.20 (28)	8.79	21.72 (31)
10% < coral ≤ 30%	2.41	5.96 (25)	3.72	9.19 (20)	6.14	15.15 (21)
30% < coral ≤ 50%	0.93	2.29 (10)	3.45	8.53 (18)	4.38	10.82 (15)
50% < coral ≤ 70%	1.82	4.49 (19)	4.46	11.03 (23)	6.28	15.52 (22)
70% < coral ≤ 90%	1.01	2.48 (10)	2.13	5.25 (11)	3.13	7.74 (11)
Total with Coral	**9.61**	**23.74**	**19.10**	**47.21**	**28.71**	**70.95**
Total dredge area	**24.59**	**60.77**	**38.06**	**93.92**	**62.60**	**154.69**
Percent coral cover:		**39%**		**50%**		**46%**

[1]Coral percents are rounded to the nearest percent; therefore total coral % may not sum to 100%

Source: Derived from Classified Habitat Map Using Quickbird Satellite Imagery.

Although multiple coral taxa were observed at sampling locations within the project area, *P. rus*, *P. cylindrica* and *Porites spp*. comprised the large majority of coral at all sites within the dredge footprint. Some corals in the project area appear to show signs of stress. Hemispherical species, such as *P. lobata* were observed to have copious secretions of mucous. It has been shown that corals increase mucus secretion to remove fine particles when turbidity levels are high. These areas are routinely subject to high levels of TSS; therefore, this response to turbidity is not surprising, and may indicate that these corals are stressed.

Essential Fish Habitat for all FEP MUS, with the exception of the coral reef ecosystem species (specifically hard corals under EFH-PHCRT [sessile MUS]), could be negatively impacted, although impacts would be minor. It is not likely that early life stages of pelagic and bottomfish FEP MUS would be present in the area impacted by the proposed activity. Both alternatives would result in significant impacts to hard corals under EFH-PHCRT. Both alternatives would result in long-term impacts to live/hard bottom EFH by dredging removal. This results in a "may adversely effect" determination. Both alternatives would result in less than significant impacts to all other EFH and FEP MUS. A compensatory mitigation plan would be prepared by DoD to off set the ecological services lost from the implementation of the propose action.

11.2.6.2 Summary of Impact Analysis Considerations

The project area is previously disturbed; most of the coral that would be dredged is marginally to modestly healthy (Smith 2007; Dollar 2009) and consists of "re-growth" on the bared reef surfaces that were dredged approximately 60 years ago during the creation of Inner Apra Harbor (Navy 2009a).

Potential indirect impacts were overestimated in the coral reef assessment and the HEA relative to the sediment deposition modeling results. It is unlikely that the project's indirect impacts would result in a significant overall decrease of reproductive potential (i.e., coral spawning) of the Apra Harbor community. The modeled area of potential effects comprises a relatively small fraction of the total reef area of Apra Harbor, composed in large part of soft sediment that is not a suitable substratum for coral planular settlement. The duration of dredging and increased sedimentation at a given particular location is expected to be short (a day or less), and turbidity plumes restricted in size, so that potential impacts to reproductive cycles would not be prolonged.

It is also possible that the area of actual indirect effect would be smaller than the area of potential indirect effect analyzed due to a combination of factors including:

- Inherent physiological tolerance of corals to sediment, including the ability to remove sediment from living tissue
- Likely sediment composition that would be released during dredging (i.e., sand and limestone silt) have been shown to have low impact to corals
- Short duration (~1 day) of dredging at a particular location 990 ft^2 [92 m^2]
- Current velocity sufficient to aid in sediment resuspension and removal
- Relatively steep reef slopes that promote removal of sediment rather than accumulation

To date, the coral community in the potentially affected area has not been documented to be comprised of unique species that could be lost from the Apra Harbor system. As the project area was dredged in 1946, the existing community is the time-integrated response to the previous impact. Hence, the existing coral community structure provides an estimate of the expected pattern of response to the proposed action.

While fish and sea turtles may exit the immediate area adjacent to construction activities, it is not likely that there would be a permanent effect to the present populations as a result of the alternative actions. Impacts on most reef fish populations would be short-term and localized. It is anticipated that coral-associated biological communities (i.e., marine flora, invertebrates, fish, etc.) would repopulate or move back into the areas after in-water dredging activities cease. Some mortality may be seen in site attached species (e.g., damselfishes) that have lost their habitat.

Impacts to infaunal or epifaunal organisms and water quality would be short-term, periodic and localized. No significant impacts to these resources were identified and no compensatory mitigation is proposed.

11.2.7 Summary of Proposed Mitigation Measures

Table 11.2-22 summarizes the proposed mitigation measures.

Table 11.2-22. Summary of Mitigation Measures

Alternative 1	*Alternative 2*
Construction Activities	
• No in-water blasting would be allowed. • Water quality would be monitored for in-water construction projects during the construction phase. • Preliminary shutdown safety zones corresponding to where sea turtles could be injured or harassed would be established based upon empirical field measurements of pile driving sound levels at the construction site. The sound pressure levels (SPLs) would be monitored on the first day of pile driving to ensure accuracy of contours. Until validation of the harm threshold, no pile driving may occur within 100 m of sea turtles and no dredging operations shall occur within 50 m of sea turtles. Safety zones would be re-established to accommodate validated harm threshold and reported to NMFS with acoustic monitoring data. Monitoring of sea turtle harassment safety zones would be conducted by qualified observers, including two observers for safety zones around each pile driving and dredging site. Monitoring shall commence 30 minutes prior to the start of pile driving. If a sea turtle is found within the safety zone, pile driving or dredging of the segment shall be until the animal(s) has been visually observed beyond the impact zone or 30 minutes have passed without re-detection. Pile driving of dredging may continue into the night, but where there has been an interruption of the activity the activity would not be initiated or re-initiated during nighttime hours when visual clearance cannot be conducted. • Pile driving and dredging would commence using soft-start or ramp-up techniques, at the start of each work day or following a break of more than 30 minutes. Pile driving would employ a slow increase in hammering, whereas dredging would commence with slow and deliberate deployment of the bucket or chisel to the bottom for the first several cycles to alert protected species and allow them an opportunity to vacate the area prior to full-intensity operations. • No pile driving or dredging would be conducted after dark unless that work has proceeded uninterrupted since at least one hour prior to sunset, and no protected species have been observed near the respective safety range for that work. • If a sea turtle or other listed species is found injured within the vicinity of the action area, all in-water pile driving or dredging activities shall cease immediately, regardless of their effect on the noted turtle and the Navy would contact the regional NMFS stranding coordinator. • Construction related vessels within Apra Harbor shall remain at least 50 yards from sea turtles, reduce speed to 10 knots or less in the proximity of sea turtles (if practicable, 5 knots or less in areas of suspected turtle activity), and, when consistent with safety practices, put engine in neutral and allow the turtle to pass if approached by a turtle. Additionally, sea turtles shall not be encircled or trapped between multiple construction-related vessels or between construction-related vessels and the shore. • All construction-related equipment would be operated and anchored to avoid contacting coral reef resources during construction activities or extreme weather conditions. Anchor lines from construction vessels would be deployed with appropriate tension to avoid entanglement with sea turtles. Construction-related materials that may pose an entanglement hazard would be removed from the project site if not actively being used. • Anchors, anchor chain, wire rope and associated anchor rigging from construction related vessels would be restricted to designated anchoring areas within the construction footprint (ie, soft bottom) or within the area that would be permanently impacted. • As prescribed in permits for previous construction activities (ie, Kilo Wharf) during pile driving or dredging activities, if a visible plume is observed outside the silt curtains, the construction activity would be suspended, evaluated, and corrective measures taken. This mitigation measure is also applicable to the water resources category (WR). • No barge overflow during dredging operations. This mitigation measure is also applicable to the water resources category (WR).	The same mitigation measures identified for Alternative 1 would apply to Alternative 2.

Table 11.2-22. Summary of Mitigation Measures

Alternative 1	*Alternative 2*
• Where practicable, installation of silt curtains during channel and/or harbor dredging operations to maintain water quality and provide coral protection. This mitigation measure is also applicable to the water resources category (WR). • The Micronesia Biosecurity Plan is being developed to address potential invasive species impacts associated with the actions proposed in this EIS as well as to provide a plan for a comprehensive regional approach. The MBP would include risk assessments for invasive species throughout Micronesia and procedures to avoid, minimize, and mitigate these risks. It is being developed in conjunction with experts within other federal agencies including the NISC, USDA-APHIS, the USGS, and the SERC. The MBP is intended to be a comprehensive evaluation of risks in the region, including all Marine Corps and Navy actions on Guam and Tinian. For actions proposed in this EIS, biosecurity measures would be implemented to supplement existing practices to address invasive species. • Incorporate seasonal dredging prohibitions , which may include: • Cessation of dredging operations during the period of peak coral spawning (7-10 days after the full moon in July) in consultation with the University of Guam (UoG) Marine Lab. • Dredging or filling of tidal waters would not occur during hard coral spawning periods, usually around the full moons of June, July, and August. • Construction related vessels would be restricted from Sasa Bay so as to reduce potential impacts to sea turtles and other protected marine and/or wildlife species • Provide natural resource education and training to military personnel on ESA, MMPA, and EFH. This may include Base Orders, natural resource educational training (i.e., watching of short ERA/MPA video) and documentation (i.e., preparation of *Military Environmental/ Natural Resource Handbook, distribution of natural resource educational materials to dive boat operators*), or a combination of all. • Aboard dredge-related tug, barge or scow vessels at sea, use the minimum lighting necessary to comply with navigation rules and best safety practices to help reduce potential impacts on species such as sea turtles. This mitigation measure may also be applicable to the terrestrial biology category (TB). Coral • The following are being considered as elements for coral mitigation for consideration under the development of the compensatory mitigation plan: • Coral reef restoration via water quality improvements through watershed restoration. • Coral reef restoration via water quality improvements through WWTP upgrades/improvements. • Coral reef restoration via site-specific water quality improvements through retrofitting road stormwater controls at a range of sites on Guam. • Coral reef restoration within non-DOD federal property. • Aquaculture of native herbivorous fish • Coral transplantation • Establishment of marine protected area(s) MPA(s) • Artificial reefs • Support for enhanced enforcement of fishing and recreational diving regulations.	

Table 11.2-22. Summary of Mitigation Measures

Alternative 1	*Alternative 2*
• Marine debris removal • Remove nuisance algae • Installation of recreational mooring buoys • Coral reef restoration inside Apra Harbor through water quality and habitat improvements.	
Operational Activities	
Operation mitigation measures would be similar to those identified above under construction. No mitigation measures have been identified in addition to the existing federal, Guam, and military orders, laws, BMPs, and regulations.	Same as Alternative 1.