CHAPTER 11.
MARINE BIOLOGICAL RESOURCES

11.1 AFFECTED ENVIRONMENT

A description of the potentially affected environment for marine biological resources in Inner 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 of Volume 2 and Volume 4 should be read to understand the complete status of the existing marine environment in both Inner and Outer Apra Harbor.

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 primarily with muddy sand and rubble. 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 northwest 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 does not contain any of the shallow shoal patch reefs. 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).

Construction of the aircraft carrier wharf would involve placing fill material in approximately 3.6 acres (ac) (1.5 hectares [ha]) of nearshore and intertidal waters for either alternative. 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.

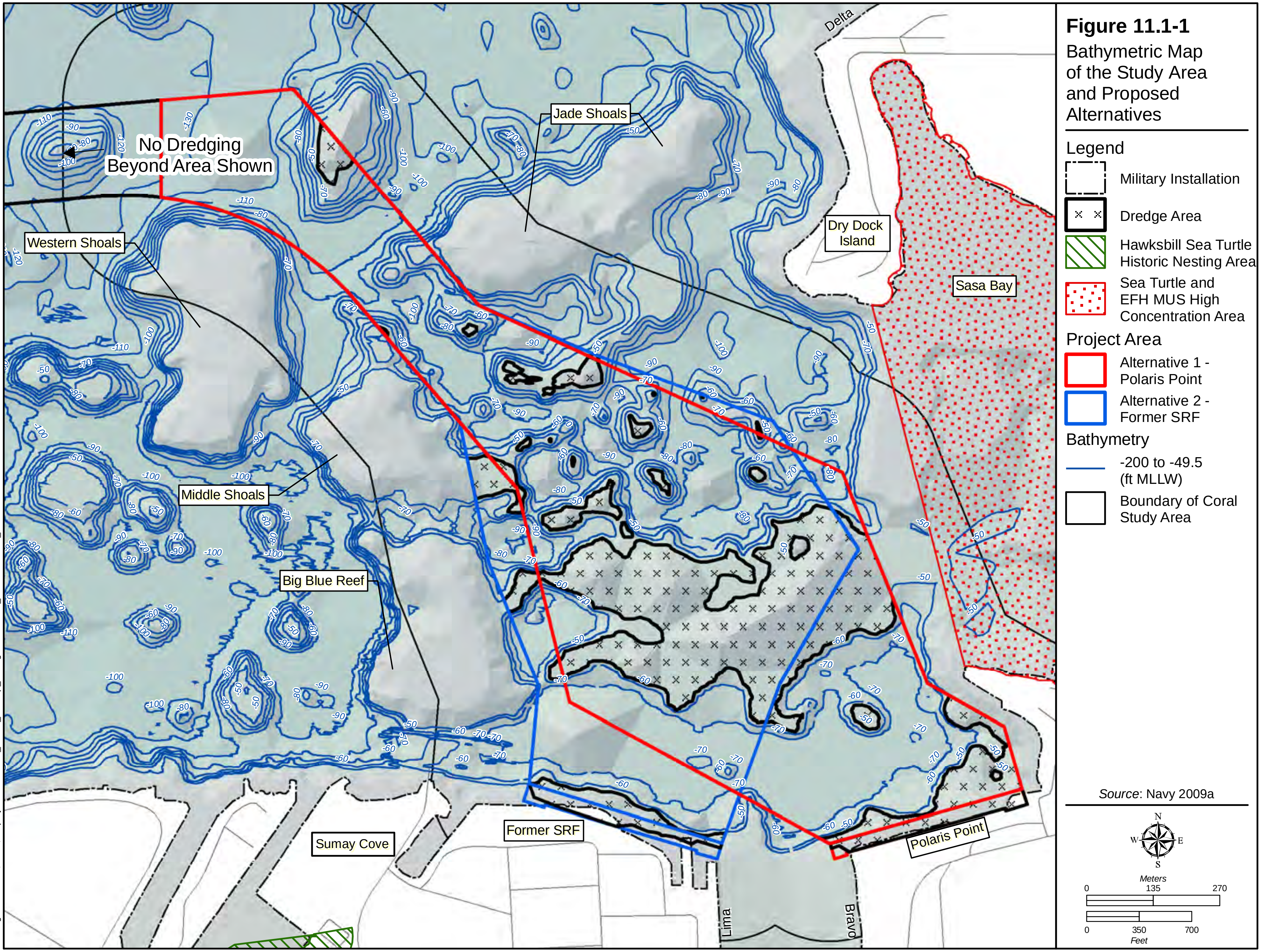

Figure 11.1-1
Bathymetric Map of the Study Area and Proposed Alternatives

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11.1.1 Navy Coral Assessment Methodology

As coral and coral habitat are extremely important resources, various reporting procedures are necessary to assess the extent of damage to or loss of these fragile resources when it occurs. When coral reefs held in United States public trust are injured by incidents such as vessel groundings or oil spills, a Natural Resource Damage Assessment (NRDA) may be conducted to quantify the resource service loss. Coral cover has been used as an indicator metric to represent lost services in Habitat Equivalency Analyses (HEA) for determination of compensatory restoration. Depending on the injury and habitat, however, lost services may be more comprehensively represented by alternative approaches such as composite metrics which incorporate other coral reef community characteristics, or a resource scale approach utilizing size-frequency distributions of injured organisms. Viehman et al. (2009) describe the evolving state of practice for capturing coral reef ecosystem services within the NRDA context, explore applications and limitations of current metrics, and suggest future directions that may increase the likelihood that NRDA metrics more fully address ecosystem services affected by an injury.

Coral reef restoration is currently an evolving field with new research methods continuously being developed. Few, if any, injuries to coral have been followed from impact to complete recovery as part of the NRDA process. Consequently, expert estimates about whether a site will recover in 30, 50, or 300 years, or not at all, are necessarily imperfect, but bear the responsibility of being the best available information at present. Almost all of the approaches detailed in Viehman (2009) rely heavily on expert opinion, which is unlikely to be universally accepted, and consequently, contributes to the adversarial nature of determining the extent and costs of restoration. Thus, the Viehman (2009) paper also provides encouragement for coral reef NRDAs to become a process that is objective (quantitative) rather than the current, often subjective process. As more informative data emerge from research, restoration monitoring, and HEA, the application should advance the NRDA process in conjunction with coral reef restoration science.

In its simplest form, the objective of coral reef restoration conducted through the NRDA process is to restore the services lost from the injuries caused by the responsible party. It is often difficult to know whether the trustee actions are sufficient to reach this objective given the current state of reef restoration science and NRDA practice. While the practical and measurable goals of restoration are to rapidly re-create the structure and functions of an injury 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. A nearly complete understanding of coral reef ecological services is required to objectively determine whether selected compensatory restoration projects adequately restore lost services for a given injury (Viehman 2009).

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

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 the Habitat Equivalency Analysis (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.

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. This document was peer reviewed by eight renowned coral scientists and the reviews are included in Volume 9, Appendix J. There are five sections (A through F) in the report and Sections B through F are considered stand-alone technical reports 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) 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.

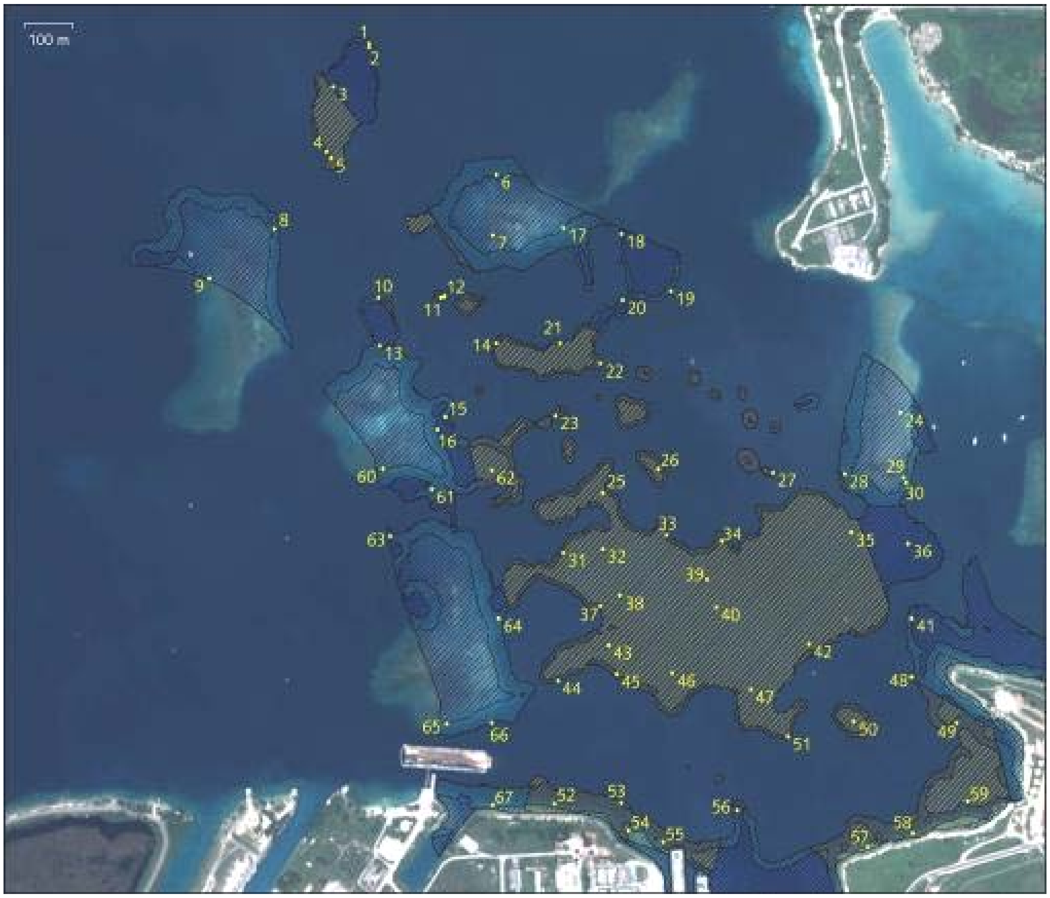

Figure 11.1-2. Outer Apra Harbor Showing 67 Data Points/Transect Stations for Coral Habitat Surveys

11.1.1.1 Resource Agency Preferred Methodology

The fifth study provided in Volume 9, Appendix J, *Comparison of a Photographic and an In Situ Method to Assess the Coral Reef Benthic Community in Apra Harbor, Guam* (Minton et al. 2009), 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. It is provided as supplemental material, but did not provide data for this EIS/OEIS.

11.1.2 Marine Flora, Invertebrates, and Associated EFH

Similar to the assessment in Volume 2, this chapter provides a description of marine flora and macroinvertebrates found within the ROI, including a more detailed description of coral and coral reef ecosystems. 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): (1) coral reef ecosystems (2) bottomfish and seamount groundfish, (3) crustaceans, (4) precious corals, and (5) pelagic species. Each of these FMPs identifies specific management unit species (MUS) managed under the respective plan (Western Pacific Regional Fisheries Management Council [WPRFMC] 2005). Essential Fish Habitats defined under each FMP are described further below. Coral and coral reef ecosystem impacts are addressed under the EFH environmental consequences section.

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 not necessarily representative of conditions throughout each secondary biotope.

11.1.2.1 Eight Secondary Biotopes of the Survey Area

Data on biotopes in the ROI were summarized from Dollar et al. (2009). 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.

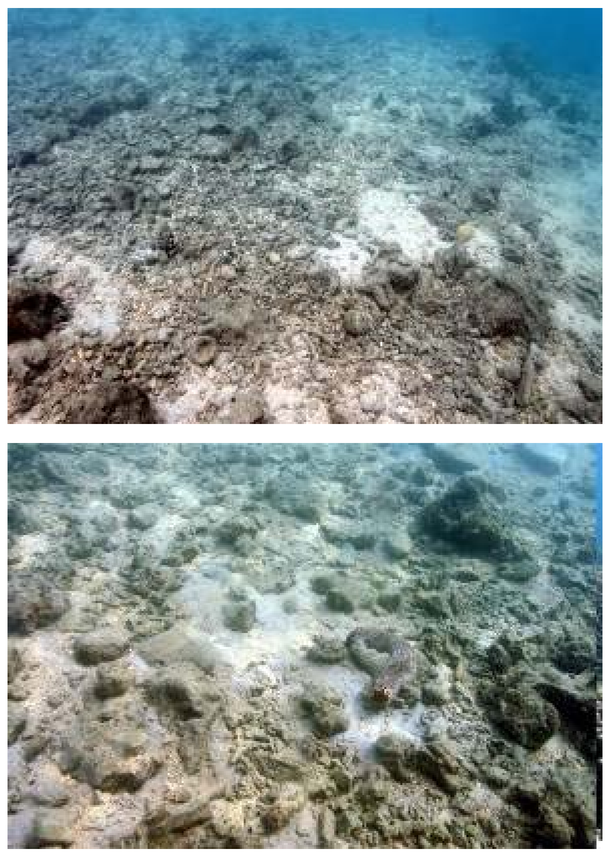

Figure 11.1-3. Sand-rubble bottom (0% coral coverage) at Transects 58 (upper) and 67 (lower) (both potential direct dredge impacted areas; 35% of the dredge area includes this bottom type).

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

Many regions of the aircraft carrier berthing study area were not colonized by any epi-benthic biota. Approximately 46 ac (17 ha) totaling 35% of the total area fell within this category. 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 0.1 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 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 almost entirely 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 essentially pure stands of algae. 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 11.1-4. 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).

Mixed Coral-Algae

Several biotopes which comprise the majority of benthic cover consist of combinations of two or more of the "pure" communities described above. One of these combination biotopes can be termed "mixed coral-algae." One such combination consisted of hemispherical heads of *Porites l utea* amid stands of *Padina* spp. on the shallow tops and sides of patch reefs (Figure 11.1-5). In the

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.

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.

Patch Reef Margins – P. lutea Zone

P. l utea 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. r us*, as described in the sections above.

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 – *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 (2-3 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

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).

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. The likely 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 the 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).

<u>Mixed Coral Communities</u>

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 c actus* 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 c actus*) often occur in what can described as indeterminate growth forms, in the form of supracolonies or spreading mats composed of multiple branches or fronds in the vicinity of Transect 15.

<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 four large patch reefs (Jade, Western, Big Blue, and the unnamed reef). *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. r us* comprised of 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. r us* 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.)

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

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. r us* 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.

11.1.2.2 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 impacts associated with dredging, and dashed lines indicate the outer boundary of the designated potential indirect impact area, which was set at a 656 ft (200 m) distance from the direct impact area boundary. As described later in this chapter, the 656 ft (200 m) distance represents a gross overestimate of the projected indirect impact area, and allows for collection of baseline data at the associated patch reef and shoal areas. As described in the SEI (2009) plume modeling summary discussed later in this chapter (Section 11.2.2.2 and Figures 11.2-2 and 11.2-3), only the area located 39 ft (12 m) beyond the direct dredge impact area is anticipated to receive cumulative sedimentation totaling at least 0.2 inches (in) (6 millimeters [mm]); 0.2 in (6 mm) was established as the cumulative sedimentation threshold for corals.

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 (direct impact), as noted in Table 11.1-1, for Alternative 1 Polaris Point (referred to as Alternative 1) is 71.2 ac (28.8 ha) and for Alternative 2 Former SRF (referred to as 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 [0.65-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 four large patch reefs (Jade, Western, Big Blue, and the unnamed reef) as shown on Figure 11.1-9. The project area where dredging would occur (direct impact area) does not contain shallow shoal patch reefs. 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.

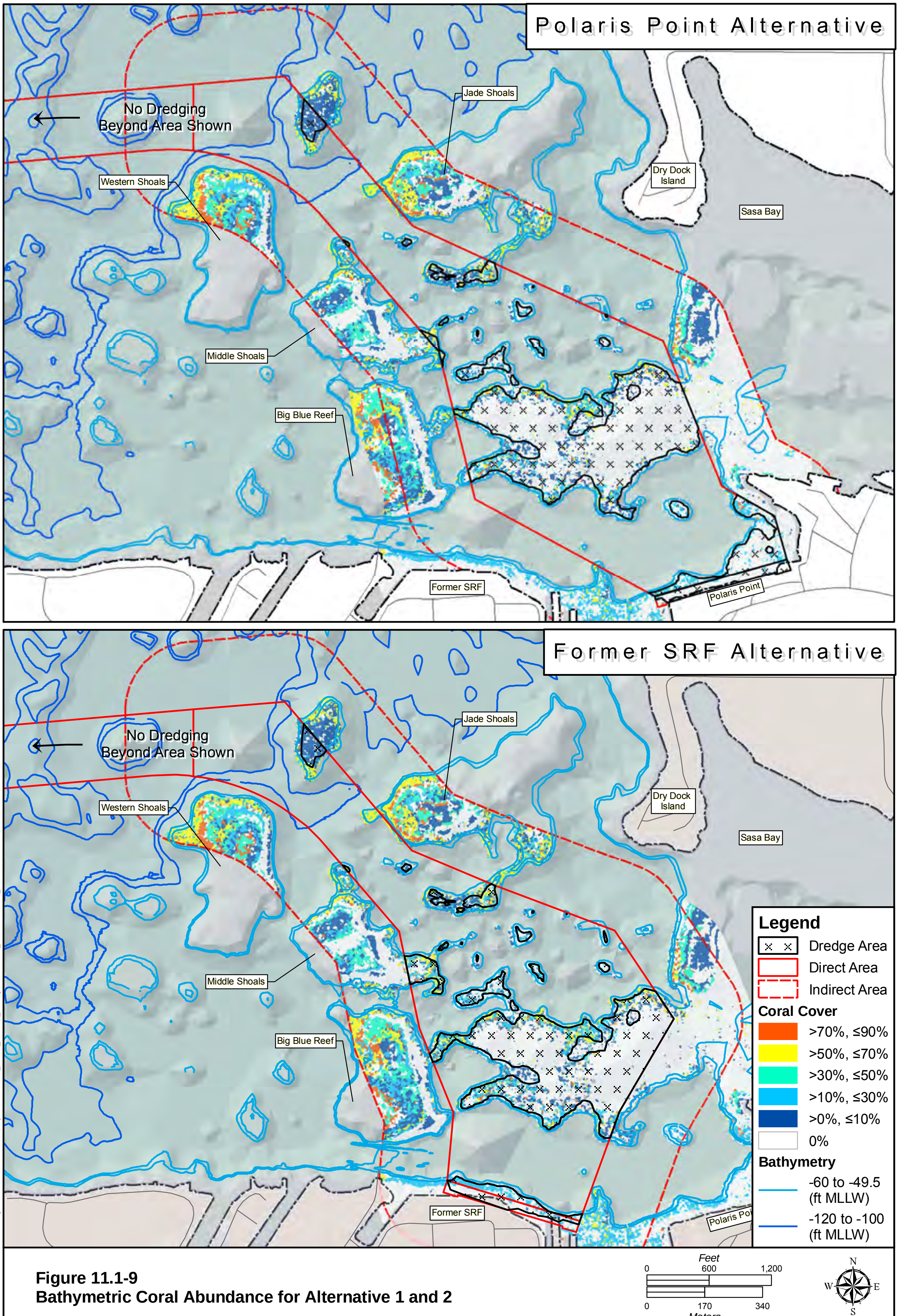

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Figure 11.1-9
Bathymetric Coral Abundance for Alternative 1 and 2

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 Polaris Point					
	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 with Coral	**10.20**	**25.20**	**18.71**	**46.24**	**28.91**	**71.44**
Total dredge area with coral	**28.80**	**71.18**	**40.71**	**100.6**	**69.52**	**171.78**
Percent coral cover		**35%**		**46%**		**42%**
	Alternative 2 Former SRF					
	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 with Coral	**9.61**	**23.74**	**19.10**	**47.21**	**28.71**	**70.95**
Total dredge area with coral	**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%.
Source: NAVFAC Pacific 2009b.

As indicated in Table 11.1-1, within the direct impact areas for both the Former SRF and Polaris Point alternatives, 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%).

Data analysis for the 67 transects was conducted "*ex situ*" using a visual basic program, Coral Point Count with excel extensions [CPCe], that has gained wide acceptance for coral reef monitoring studies. All benthic cover analyses were performed by three separate investigators and the final data set contained complete investigator agreement on all point counts. Calibration-validation data collected from 67 sites in the field to spectral signatures of remote sensing imagery was used to create a map of coral cover over the entire survey area. Figure 11.1-10 displays a satellite image of those points/transect stations that were surveyed for benthic community composition. Black- and blue-hatched areas delineate the potential direct and indirect impact areas, respectively.

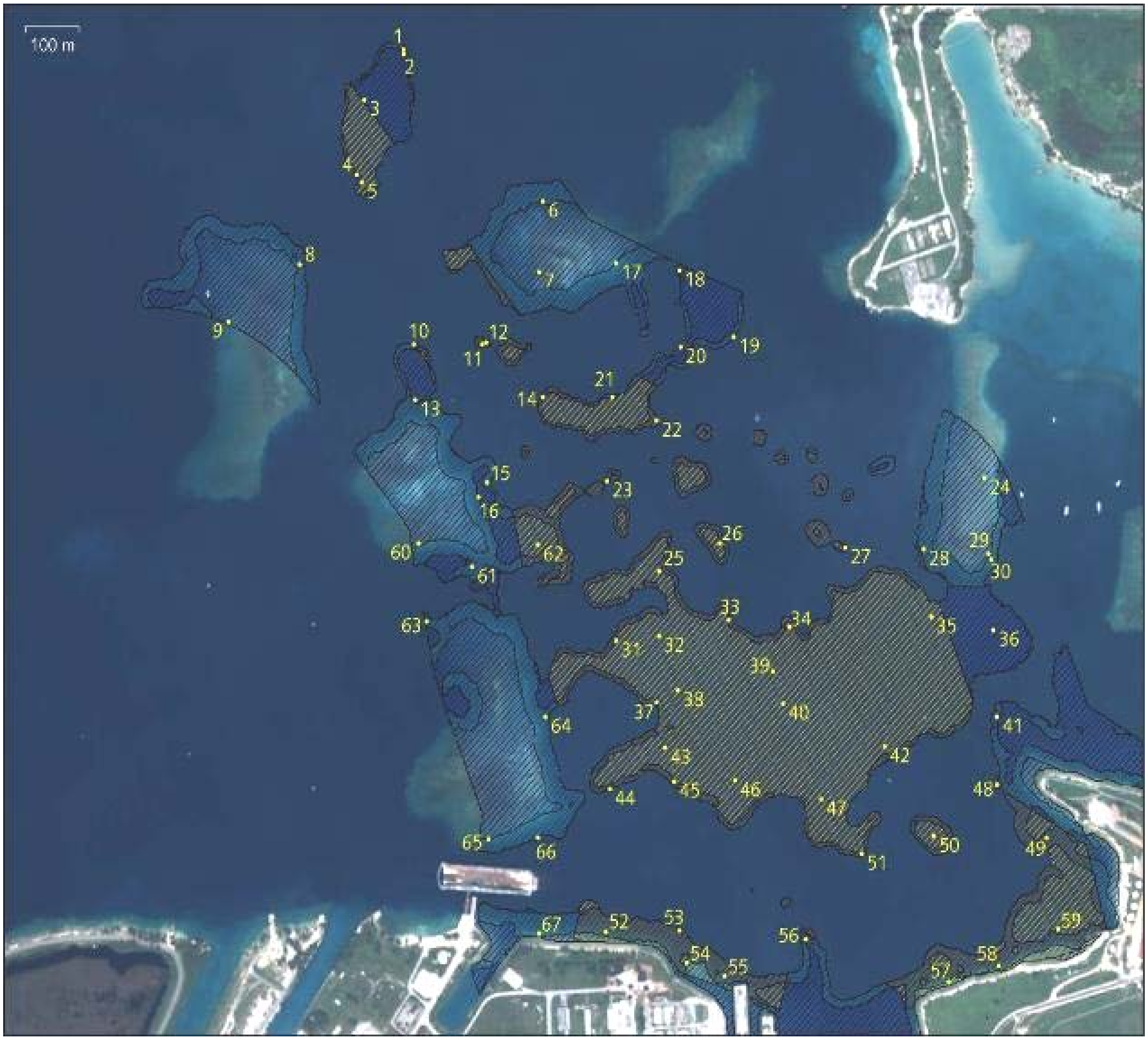


Figure 11.1-10. Outer Apra Harbor Showing 67 Ground-Truth Data Points/Transect Stations Used to Develop the Classification Scheme for Coral Habitat Mapping.

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

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 11.1-11 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 potential mitigation of reef area altered by the aircraft carrier wharf project.

Examination of the coverage table (Table 11.1-1) and coral map (Figure 11.1-11) reveals several important points. The total area of potential direct and indirect impacts of the region with coral is approximately 71.44 ac (28.91 ha) for Alternative 1 (Polaris Point) and 70.95 ac (28.71 ha) for Alternative 2 (Former SRF). The total area of coral coverage of all classes associated with potential direct impacts is approximately 25 ac (19 ha) for the Polaris Point alternative and 24 ac (19 ha) for the Former SRF alternative. Hence, about 35% and 39% of the area to be dredged to reach the required depth presently contains some level of coral coverage for the Polaris Point and Former SRF alternatives, respectively. It is also evident that the area within the project boundaries, as well as within the dredge area boundaries, 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.

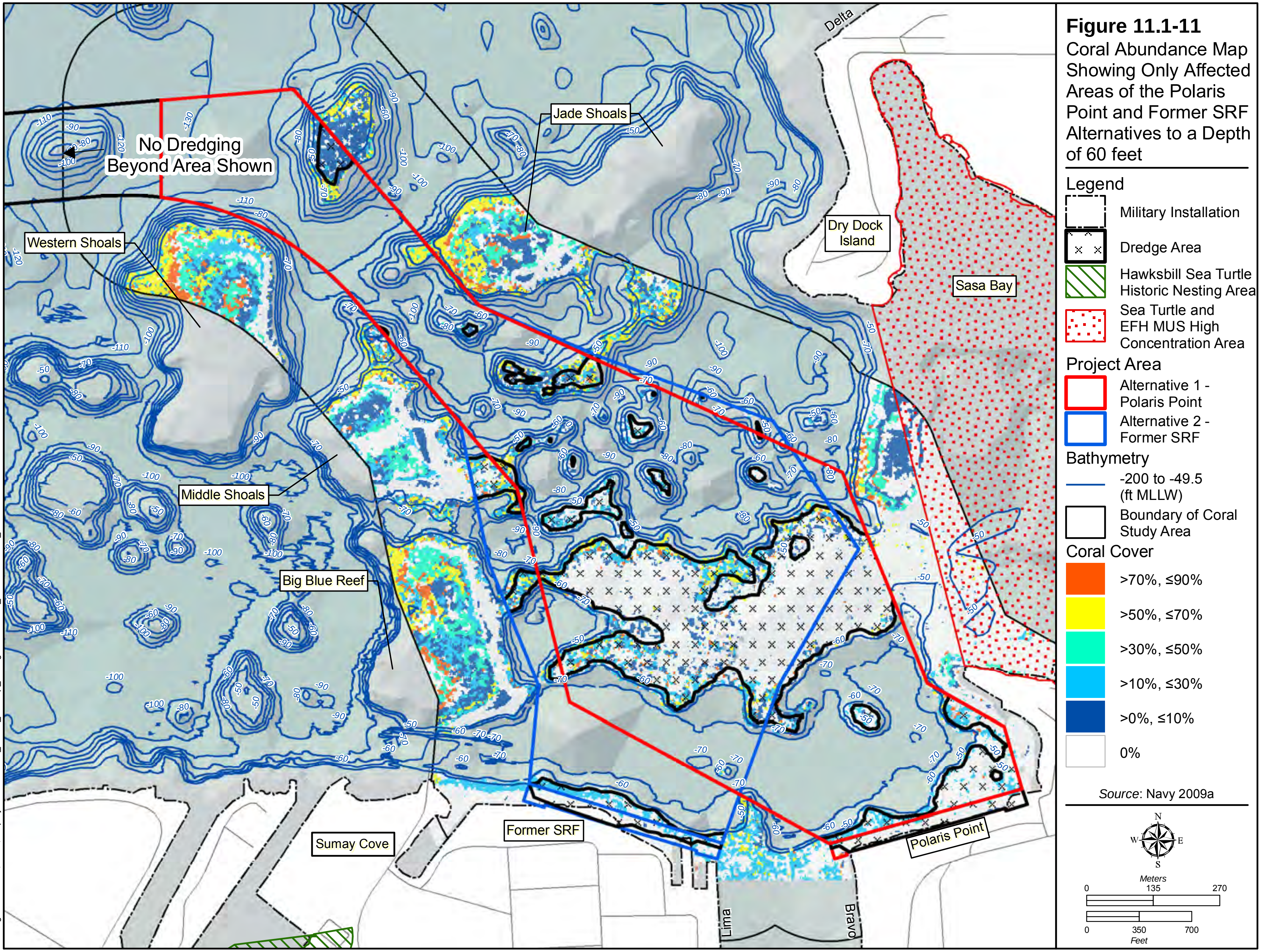
For both alternatives, the single highest percentage class with coral to be removed (37% for Polaris Point and 36% for Former SRF) is the lowest abundance class (>0 to 10% cover) . Additionally, 62% for Polaris Point and 60% for the Former SRF alternative, respectively, of coral cover is within the less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

<u>Transect Sites Unique to Each Alternative</u>

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 the Polaris Point alternative and 24 ac (10 ha) for the Former SRF alternative. Hence, about 35% and 39% of the area to be dredged at the Polaris Point and Former SRF alternatives, respectively, contains some level of coral coverage, Polaris Point having approximately 4% less coral to be removed.

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, 53 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) (Figure 11.1-12).

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.



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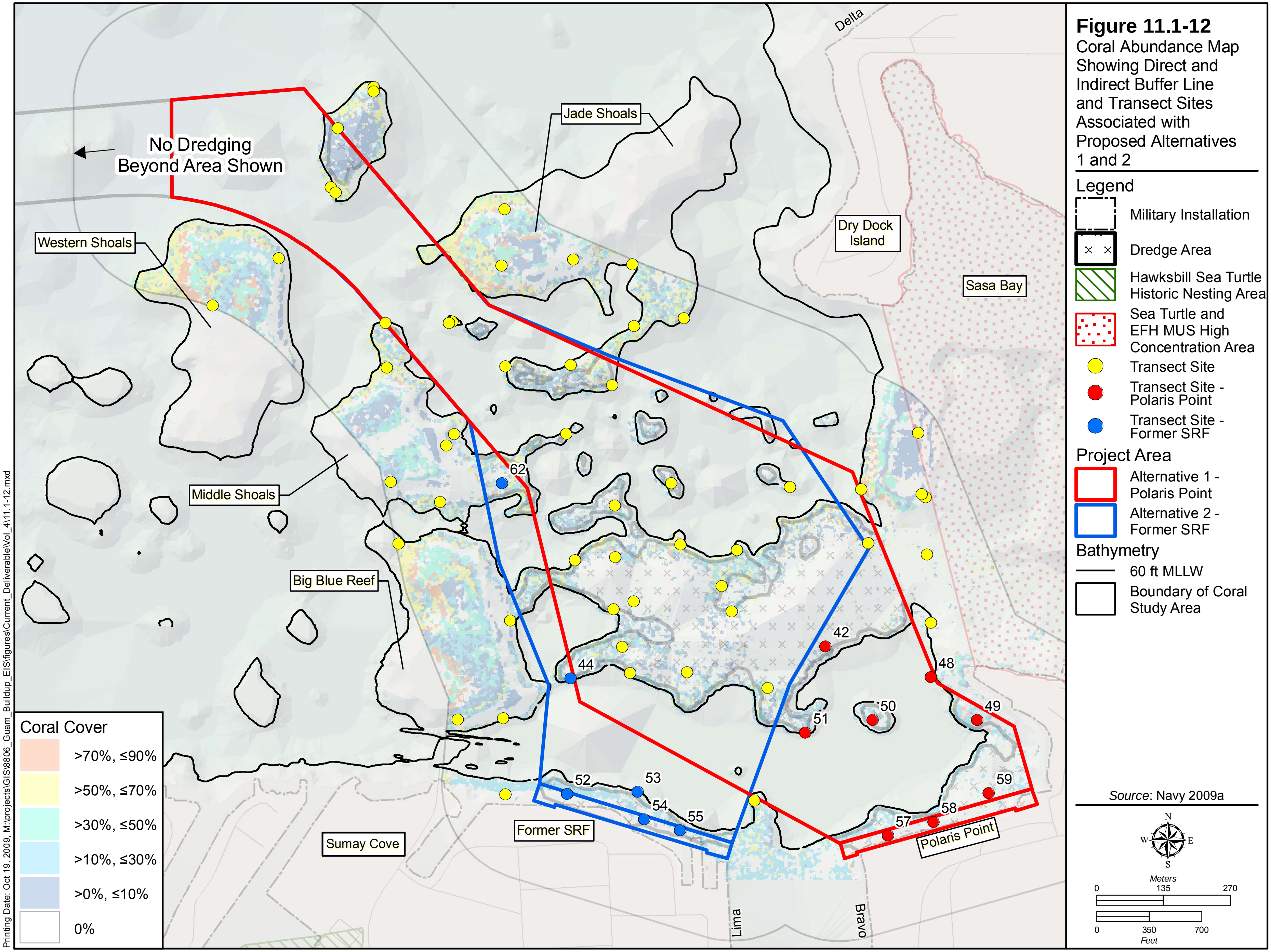
Figure 11.1-12
Coral Abundance Map Showing Direct and Indirect Buffer Line and Transect Sites Associated with Proposed Alternatives 1 and 2
Legend
Military Installation
Dredge Area
Hawksbill Sea Turtle Historic Nesting Area
Sea Turtle and EFH MUS High Concentration Area
Transect Site
Transect Site - 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
Source: Navy 2009a
Meters
0 135 270
0 350 700
Feet
No Dredging Beyond Area Shown
Western Shoals
Jade Shoals
Dry Dock Island
Sasa Bay
Middle Shoals
Big Blue Reef
Former SRF
Sumay Cove
Polaris Point
Delta
Lima
Bravo
Coral Cover
>70%, ≤90%
>50%, ≤70%
>30%, ≤50%
>10%, ≤30%
>0%, ≤10%
0%
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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 Polaris Point								
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 Former SRF								
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).

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 11.1-13 shows the locations of dive survey sites in these seven areas. The major findings from the Smith (2007) study are the following:

- 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.
- When reef survey zones were ranked according to variables that included coral coverage, diversity, rugosity, health, and size-frequency distribution, the areas within the proposed dredge footprint (Turning Basin, shoal areas and Polaris Point) ranked lowest on the scale, and were ranked consistently lower than the sites that are outside the project footprint. The highest ranking was given to Big Blue Reef west, owing to protection from exposure to poor 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 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.
- The coral habitat expected to be impacted by the proposed aircraft carrier project currently is, in general, “of marginal to modest ecological value.”
- When reef survey zones are "ranked" by scaling a variety of variables (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 effects.

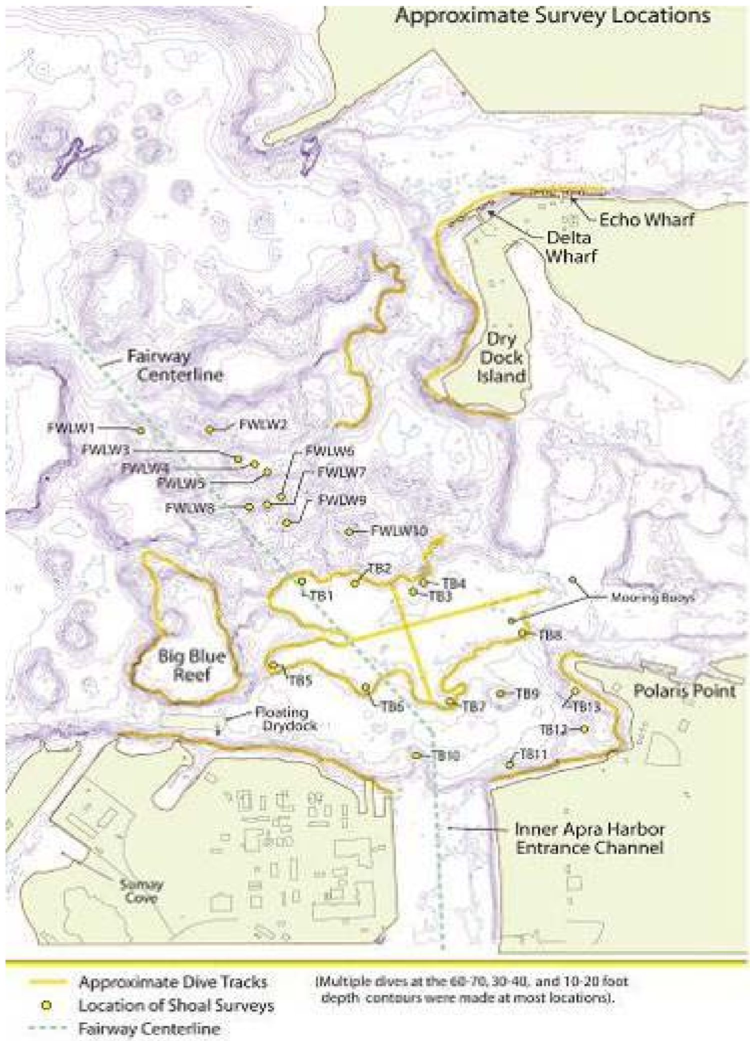

Figure 11.1-13. Dive Surveys and Transects (Smith 2007)

- When reef survey zones are "ranked" by scaling a variety of variables (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 effects.

- The coral reefs at the shoal areas and Turning Basin appear to be of marginal to modest ecological value, based upon the eight criteria.
- 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.

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.

<u>Sediment Effects on Coral</u>

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 the activities of man (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 in 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 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 (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 hrs) 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 (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 (Dollar et al. 2009). Hence, terrigenous (i.e., non-carbonate) muds are not a major component of the sediment in the proposed dredge area.

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 20.8 mg/cm^2/day 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 <1 mg/cm^2/d to greater than 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 (2.77 ha) of dense coral, for a total area of approximately 10.2 ac (4.11 ha) of coral cover in the Inner Apra Harbor Entrance Channel (Figure 11.1-14). 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).

Index of Coral Stress

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 with depth, 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.

Coral Size-Frequency Analysis

Coral site-frequency metrics were collected during the “Spring surveys” to represent resource agency concerns. Dollar et al. (2009) evaluated size-frequency of coral colonies from transect photo-quadrats using a built-in function of CPCe software to determine greatest chord length. Size-frequency distribution of the longest chord length of the four most abundant corals in the aircraft carrier survey area are provided and grouped into seven size classes (from x < 2 cm to x < 160 cm). Dollar et al. (2009) state “For all four corals in all four strata (Direct Flat, Direct Slope, Indirect Flat, and Indirect Slope), the least abundant size classes are the smallest (x<0.8 in [x<2 cm]) and largest (31.5 in [80 cm]≤ x < 63 in [160 cm])”. Of the four species, the largest size occurs predominantly for *P. rus*, and occasionally for the branching growth forms of *P. cylindrica* and *Pavona cactus*. *P. lutea*, which occurs as discrete hemispherical or lobate colonies, was never encountered with a long dimension greater than 31.5 in (80 cm). While the mean number of colonies of *P. rus* varied within each size class in each stratum, the pattern of size class abundance was similar in all stratum (see Figure 11.1-15). In all strata, the two size classes with a lower bound of 2 in (5 cm) and an upper bound of 7.9 in (20 cm) were the most abundant. Size class distributions of the two branching species (*P. cylindrica, Pavona cactus*) were similar in all strata, although the mean number of small (4 in [<10 cm]) colonies of *Pavona cactus* was substantially higher on the slope of the direct impact area than elsewhere. *P. lutea*, which occurred very rarely in the direct impact area, had identical patterns of size-frequency distribution in both the flat indirect impact area and the slope indirect impact area (Figure 11.1-15). Histograms in figure 11.1-15 are arranged left-to-right by coral species and top-to-bottom by survey stratum and show mean values determined across all transects within a given stratum.

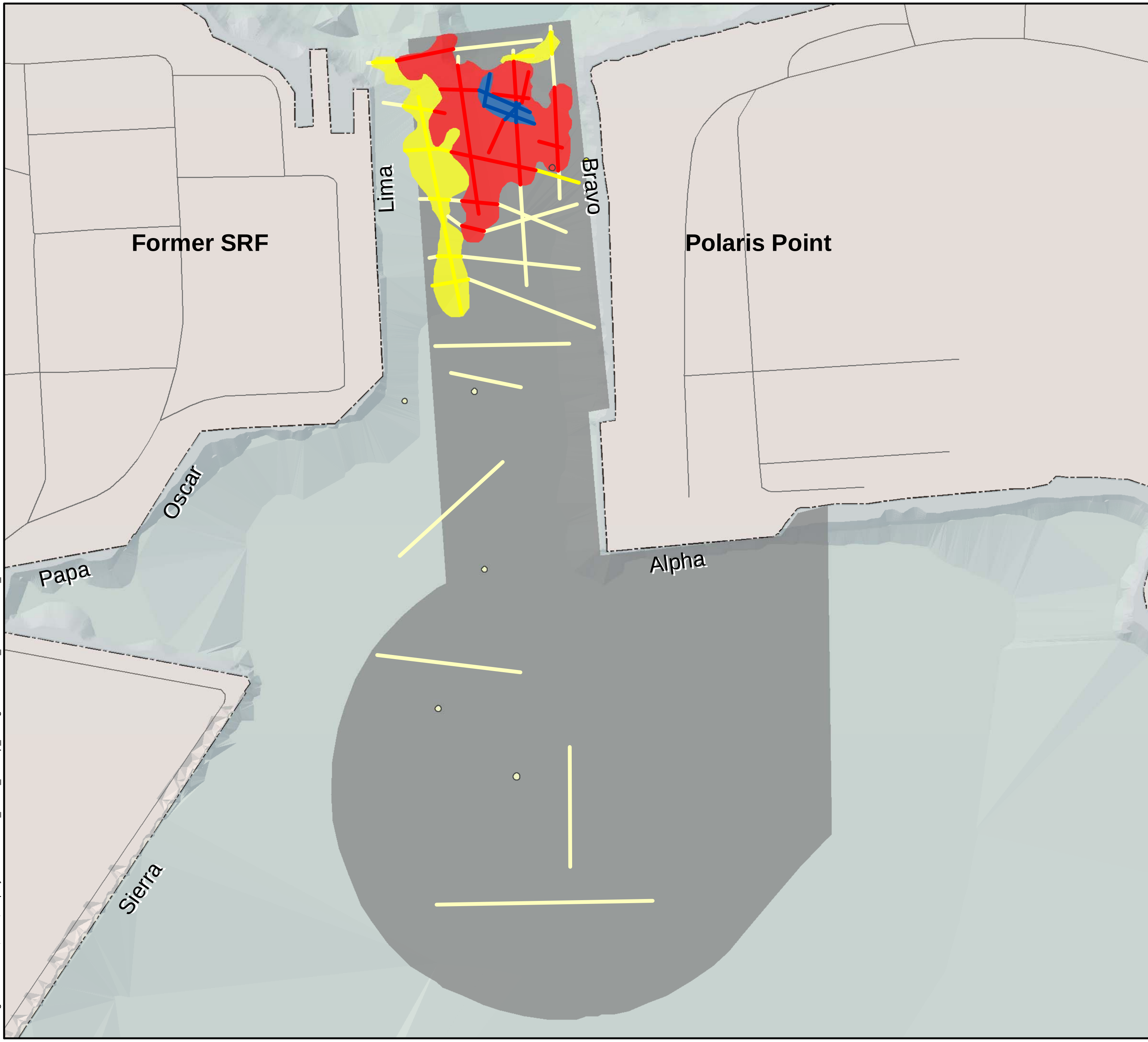

Figure 11.1-14
Coral Abundance
Inner Apra Harbor
Entrance Channel

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 2003b

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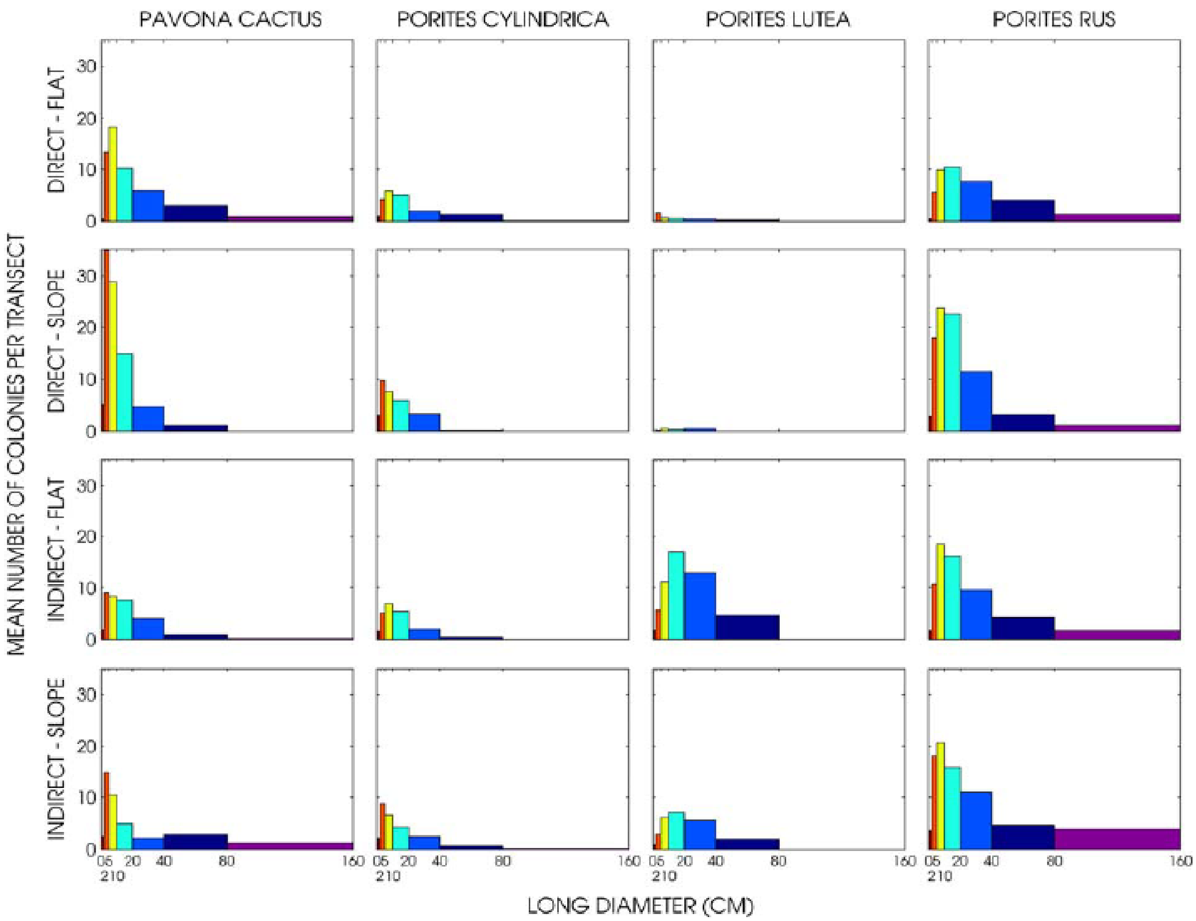

Figure 11.1-15. Size-frequency Distribution of the Four Most Abundant Corals for the Apra Survey Area

11.1.2.3 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 11.1-16).

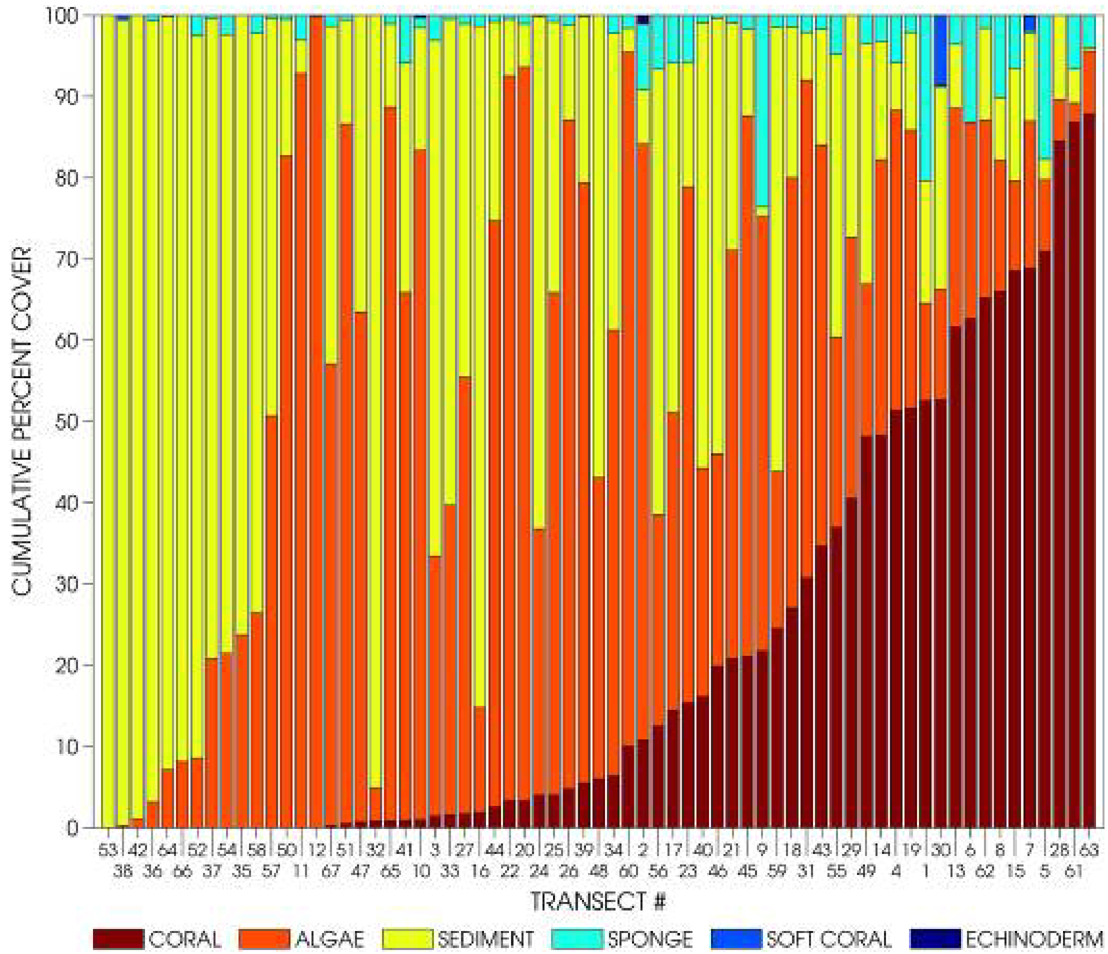

Figure 11.1-16. Stacked Bar Graph Showing Cumulative Percent Covers for Each General Class in Each Transect. Transects are Arranged in Order of Lowest to Highest Coral Cover.

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 11.1-17 shows benthic cover of general classes separated into four strata (Direct-Flat, Direct Slope, Indirect Flat, Indirect Slope). 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).

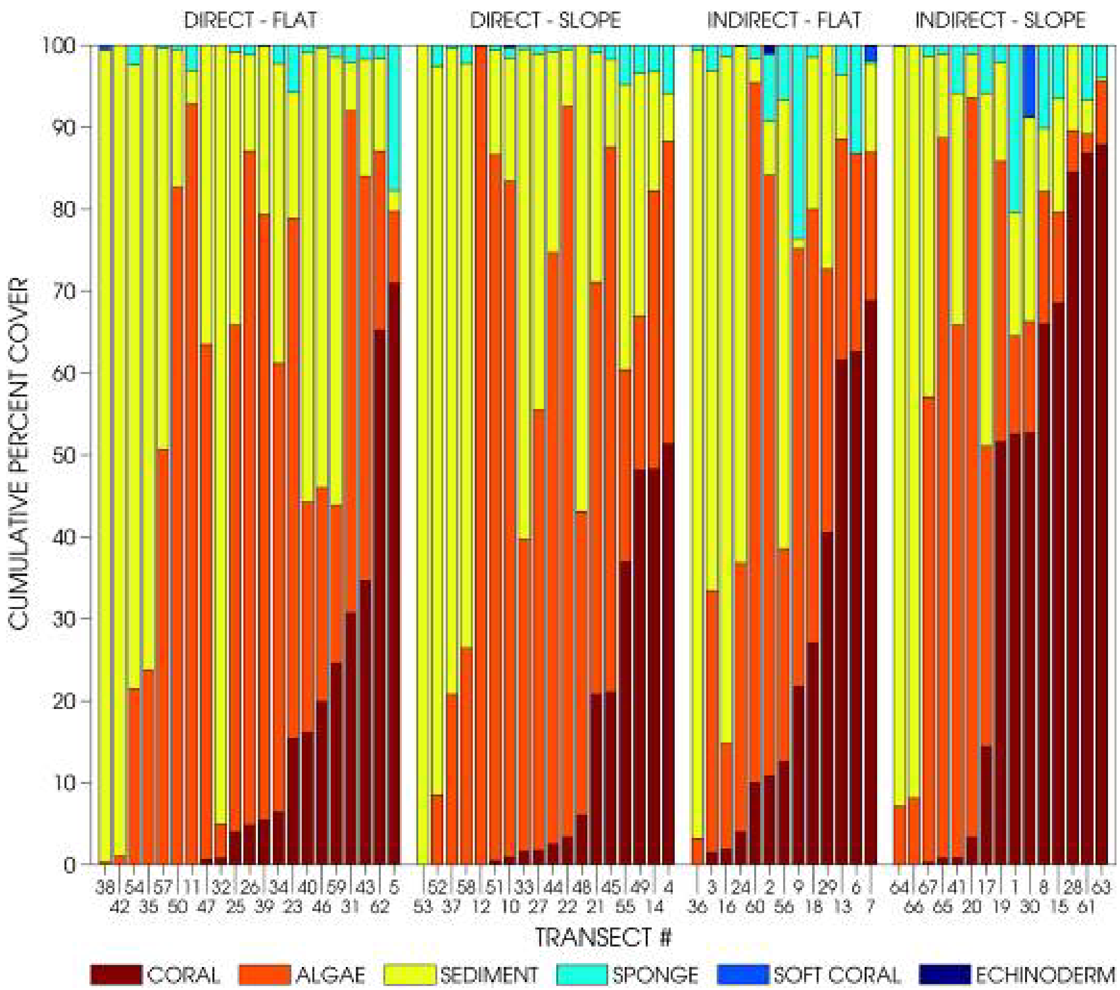

Figure 11.1-17. Cumulative Percent Covers for Each General Class in Each Transect, Arrange by Survey Stratum

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**			

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. Marine floral species are discussed further below under the Special-Status Species section with regards to “preferred forage” for green sea turtles. Additional marine flora and invertebrate survey data are provided in Smith 2007.

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 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 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.

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. Summaries of these data are as follows:

- A total of 55 mobile species from 45 genera were encountered. The grand totals of the mean occurrence of mobile species (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 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).

11.1.3 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 habitat, which is an important EFH, was addressed in Section 11.1.2 above, including quantitative evaluation of the benthic community structure.

A brief summary of sensitive marine biological resources and habitats of Apra Harbor is provided below and in Figure 11.1-18. Five MUS are associated with EFH within Apra Harbor (Table 11.1-4):

- 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.
- Bumphead parrotfish (NMFS SOC and EFH-CHCRT)

Table 11.1-4. MUS Associated with EFH for Apra Harbor

Group	*Common Name/Chamorro Name*	*Status**	
		Federal	*Guam*
Coral Reef Ecosystem Fishery Management Plan (CRE FMP)			
Fish MUS	Napoleon wrasse/*Tanguisson*	SOC	SOGCN
	Bigeye scad/*Atulai*	EFH-CHCRT	SOGCN
	Scalloped hammerhead/*Halu'u* (general term)	EFH-PHCRT	SOGCN
	Bumphead parrotfish/*Atuhong*	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. 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 2005, USFWS 2009a, and NMFS 2009.

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).

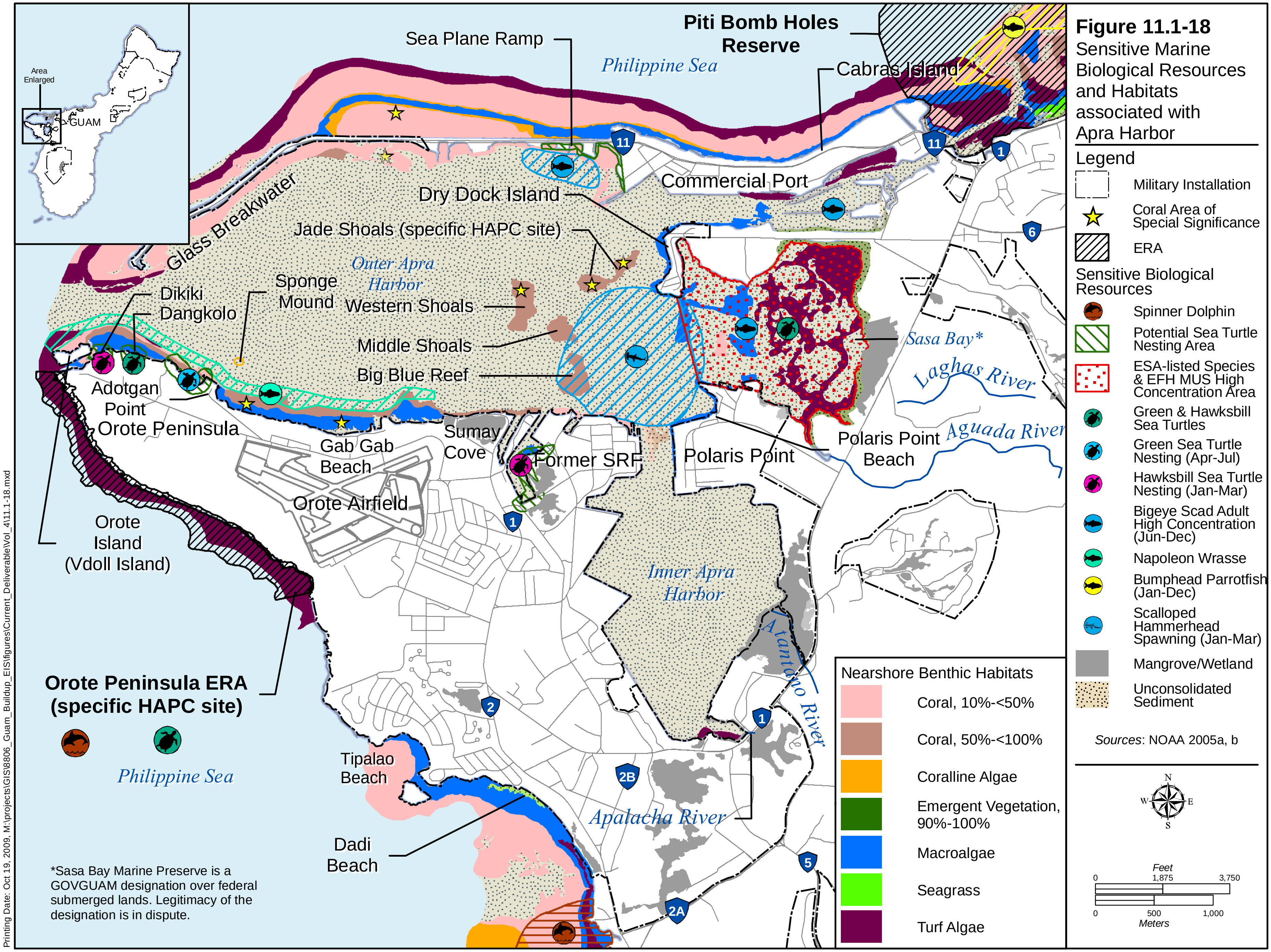
Figure 11.1-18
Sensitive Marine Biological Resources and Habitats associated with Apra Harbor
Legend
Military Installation
Coral Area of Special Significance
ERA
Sensitive Biological Resources
Spinner Dolphin
Potential Sea Turtle Nesting Area
ESA-listed Species & EFH MUS High Concentration Area
Green & Hawksbill Sea Turtles
Green Sea Turtle Nesting (Apr-Jul)
Hawksbill Sea Turtle Nesting (Jan-Mar)
Bigeye Scad Adult High Concentration (Jun-Dec)
Napoleon Wrasse
Bumphead Parrotfish (Jan-Dec)
Scalloped Hammerhead Spawning (Jan-Mar)
Mangrove/Wetland
Unconsolidated Sediment
Sources: NOAA 2005a, b
Nearshore Benthic Habitats
Coral, 10%-<50%
Coral, 50%-<100%
Coralline Algae
Emergent Vegetation, 90%-100%
Macroalgae
Seagrass
Turf Algae
Feet
0
1,875
3,750
0
500
1,000
Meters
N
S
E
W
Area Enlarged
GUAM
Piti Bomb Holes Reserve
Sea Plane Ramp
Philippine Sea
Cabras Island
Commercial Port
Dry Dock Island
Glass Breakwater
Jade Shoals (specific HAPC site)
Outer Apra Harbor
Sponge Mound
Western Shoals
Middle Shoals
Big Blue Reef
Dikiki
Dangkolo
Adotgan Point
Orote Peninsula
Gab Gab Beach
Sumay Cove
Former SRF
Polaris Point
Polaris Point Beach
Sasa Bay*
Laghas River
Aguada River
Orote Airfield
Orote Island (Vdoll Island)
Inner Apra Harbor
Atantano River
Orote Peninsula ERA (specific HAPC site)
Philippine Sea
Tipalao Beach
Dadi Beach
Apalacha River
11
11
1
6
1
2
2B
1
5
2A
*Sasa Bay Marine Preserve is a GOVGUAM designation over federal submerged lands. Legitimacy of the designation is in dispute.
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The scalloped hammerhead is reported to spawn, although rarely (Navy 2009b), in areas outside the Inner Apra Harbor Entrance Channel (NOAA 2005b). This species typically spawns near structures (Navy 2009d). Stony corals are found in high concentrations in Outer Apra Harbor along with other sessile and motile invertebrates.

The bumphead parrotfish 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.

11.1.3.1 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 doe derlini*, *Cheilodipterus ar tus* and *Cheilodipterus qui nquilineatus*) and study results indicated that fish persisted to within an average of 14 to 39 in (36 to 79 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 (2,000 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/OEIS, 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 (*Amblyglyphidodon curacao)* and daisy parrotfish (*Chlorurus sordidus)*, whose abundance increased by an order of magnitude in coral-dominated sites, and the blue devil damsel (*Chrysiptera cyanea)*, 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 (*Cheilinus fasciatus),* brassy trevally (*Caranx papuensis)*, and black-tailed snapper (*Lutjanus fulvus*), which apparently favored the artificial habitat, and a very low abundance of pomacentrid species (staghorn damsel [*Amblyglyphidodon curacao*], blue devil damsel [*Chrysiptera cyanea*], and the green chromis (*Chromis viridis*), 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 11.1-11 above).

11.1.4 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 11.1-18. The three special-status species potentially associated with Apra Harbor study area are the following (Table 11.1-5):

- Green sea turtle (Endangered Species Act [ESA]-listed as threatened)
- Hawksbill sea turtle (ESA-listed as endangered)
- Spinner dolphin (protected under the Marine Mammal Protection Act [MMPA])

A Marine Resources Biological Assessment is being prepared by the Navy and will address 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 Endangered Species Act (PL 93-205, as amended). The Endangered Species Act 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 within Apra Harbor (personal communication, Roy Brown, September 2007 from COMNAV Marianas 2007b). Brown runs dolphin tours in 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 (2,300 – 3400 m) away from the proposed action depending upon the stage of dredging. The pier construction would be at the furthest distance identified above.

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

Common Name/Chamorro Name	*Status**	
	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.
Sources: USFWS 2009a, NMFS 2009.

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 were 15 to 23 in (40 to 60 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 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 algal species that represent a major food source for sea turtles 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. Dredging activities within the vicinity of Big Blue Reef and turning basin could last 2 to 4 months. Dredging activities within the channel fairway and bend are not anticipated to significantly affect sea turtles above existing conditions. Sasa Bay is reported as an area of high concentration for both ESA-listed sea turtle species (NOAA 2005b). Therefore, the alternative actions and associated underwater noise has the potential to affect sea turtle populations, in the area or in transit during aircraft carrier turning basin dredging and wharf construction activities, by temporarily changing their swimming or feeding patterns. Considering the presence of sea turtles in Outer Apra Harbor, the proposed in-water construction action (dredging and pile driving) and associated noise has the potential to affect the ESA-listed green sea turtle by temporarily changing their swimming or feeding patterns.

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, NEA 2005, and Ruggero and Temchin 2002.

As mentioned in Volume 2, Chapter 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 11.1-18): 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 11.1-18.) No nesting activity has occurred at these areas since that time (COMNAV Marianas 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, Chapter 11, for more baseline information on special-status species.

Critical Habitat

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 Clean Water Act (CWA), and Executive Order (EO) 13089, *Coral Reef Protection*. Significant marine biological resources include all special-status species including species that are ESA-listed as threatened and endangered or candidates for listing 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 United States 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 2005).

The Coral Reef Protection Guidelines include a Memorandum of Agreement (MOA) 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. The MOA is specifically limited to the Section 404 regulatory program and does not change substantive Section 404 guidance. The MOA expresses the intent of the Army and USEPA to implement the objective of the CWA 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). They are geographic areas, large or small, possessing special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values. These areas are generally recognized as significantly influencing or positively contributing to the general overall environmental health or vitality of the entire ecosystem of a region.

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 United States."

In regard to dredging activities, the U.S. Army Corps of Engineers (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 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 suitable habitat for a special-status species or permanently lessen designated EFH or HAPC for the sustainment of managed fisheries.

- The extent, if any, that the action would disrupt the normal behavior patterns or habitat of a federally listed species, and substantially impede the Navy's ability to either avoid jeopardizing or to conserve and recover the species.
- The extent, if any, that the action would diminish population sizes or distribution of special status species or designated EFH or HAPC.
- The extent, if any, that the action would be likely to jeopardize the continued existence of any special-status species or result in the destruction or adverse modification of habitat of such species or designated EFH or HAPC.
- The extent, if any, that the action would permanently lessen physical and ecological habitat qualities that special-status species depend upon, and which partly determines the species' prospects for conservation and recovery.
- 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 as Level A or Level B, and these levels are defined uniquely for acts of military readiness such as the proposed action. Public Law (PL) 108-136 (2004) amended the MMPA definition of Level A and Level B harassment for military readiness events, which applies to 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.
- 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.

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 2005). 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). To help identify Navy activities falling within the adverse effect definition, the Navy has determined that 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, as they highlight activities with impacts that are more than minimal and not temporary in nature, opposed to those activities resulting in inconsequential changes to habitat. 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 (Navy 2009c):

- 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, decreased water quality, and/or lighting impacts resulting from construction or operation activities.

Indirect impacts, for the purposes of this evaluation, may include any sedimentation/siltation of coral reef ecosystems resulting from construction or operational activities (i.e., dredging resuspension of sediment), or 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 management 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:

    1. 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.
    2. The degree to which the proposed action affects public health or safety.
    3. 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.
    4. The degree to which the effects on the quality of the human environment are likely to be highly controversial.
    5. The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.

6. 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.
7. 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.
8. 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.
9. 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.
10. 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, and 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). There would be minimal, short-term and localized effects on all marine biological resources; therefore, there would be no significant impacts to marine flora and invertebrates, no adverse effects to fish and EFH, no significant impacts to special-status species (i.e., the action would not "jeopardize" or "take" an ESA-listed species per ESA Sections 7 and 9), and no serious injury or mortality of any marine mammal species is reasonably foreseeable. There would be no adverse effects on the annual rates of recruitment or survival of any of the species or stocks, and no major conduit exists for introduction of non-native species into the marine environment with implementation of Alternative 1.

Therefore, for onshore construction activities, Alternative 1 would result in less than significant impacts to marine biological resources.

Operation

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 (short-term and 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). There would be minimal, short-term and localized effects to all marine biological resources; therefore, there would be no significant impacts to marine flora and invertebrates, no adverse effects to fish and EFH, no significant impacts to special-status species (i.e., the action would not "jeopardize" or "take" an ESA-listed species per ESA Sections 7 and 9), and no serious injury or mortality of any marine mammal species is reasonably foreseeable. There would be no adverse effects on the annual rates of recruitment or survival of any of the species and stocks, and no major conduit exists for introduction of non-native species into the marine environment with implementation of Alternative 1.

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.

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

11.2.2.2 Offshore

<u>Construction</u>

The proposed dredging and fill 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. Construction of the aircraft carrier wharf would involve placing fill material in no more than 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.

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. 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 and coral reef ecosystem 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 BMPs, such as the use of silt containment devices, 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 ROI 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. Sessile organisms such as marine floral communities (macroalgae) have been found to be the predominant benthic community residing within the area to be dredged. Under Alternative 1, dredging and fill activities would have direct and permanent impacts to marine flora and sessile invertebrates in the dredged area through removal. Motile invertebrates would likely vacate the area due to the increased disturbance. Although some mortality would occur to marine flora and sessile invertebrates, new recruits would replenish these populations post-construction. Taylor Engineering, Inc. (TEI) (2009) performed a literature review of effects of beach nourishment, dredging and disposal projects on benthic habitat. The following paragraphs cite the reviewed articles and list the key findings related to benthos effects:

1. NOAA Benthic Habitat Mapping. 2007. Applying Benthic Data: *Dredging and D isposal o f Marine Sediment*.
    a. “Benthic organisms living in shallow water estuarine and nearshore environments are well adapted to frequent physical disturbance”
    b. “Tides, currents, waves, and storms cause sediments to be lifted, deposited, or shifted”
    c. “The resilience of benthic organisms to these environmental changes allows them to recolonize areas of the seafloor affected by dredging”

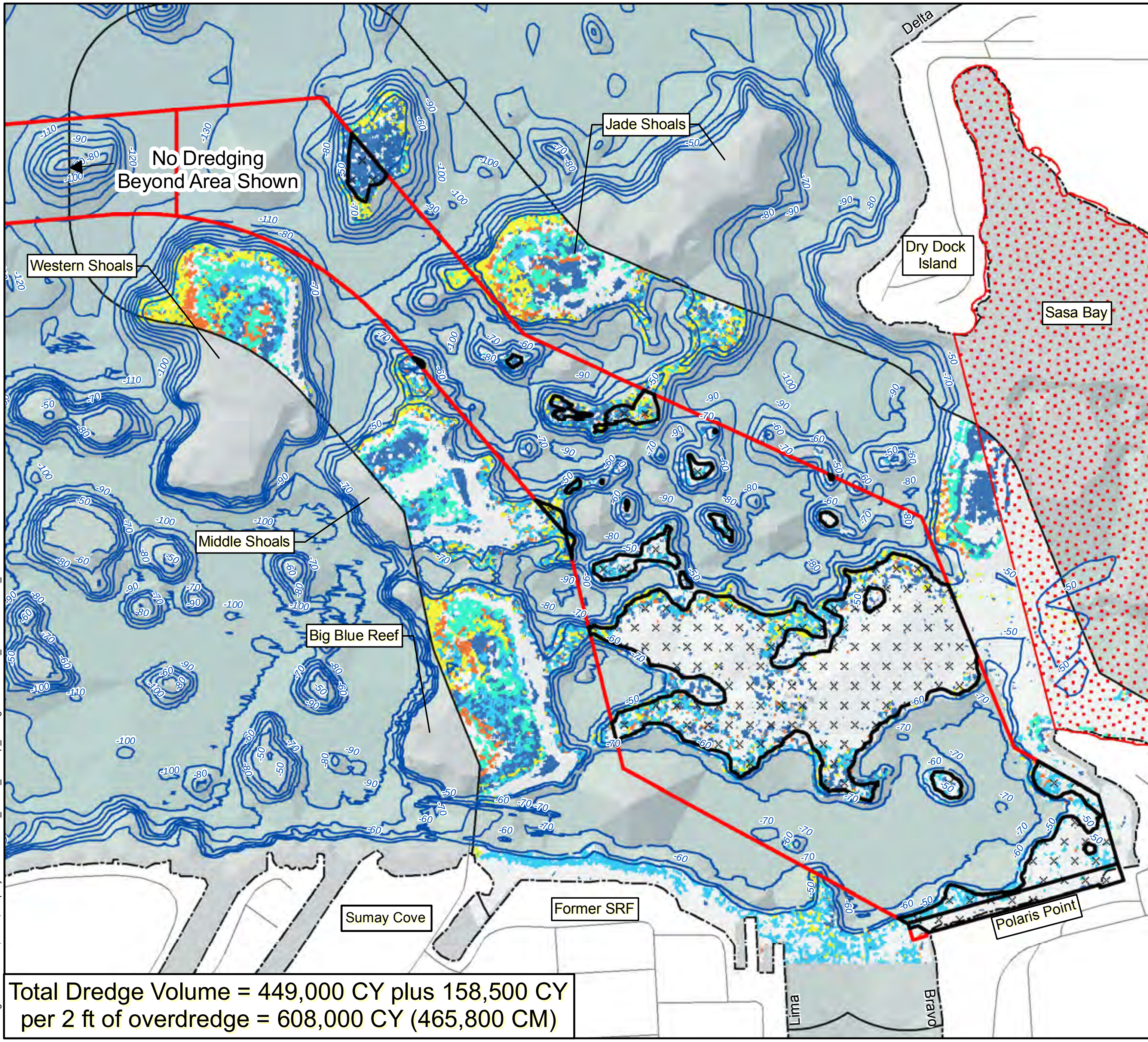


Figure 11.2-1
Coral Abundance and Sensitive Marine Biological Resources Associated with the Proposed Polaris Point Alternative

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

Bathymetry
- -200 to -49.5 (ft MLLW)
- Boundary of Coral Study Area

Coral Cover
- >70%, ≤90%
- >50%, ≤70%
- >30%, ≤50%
- >10%, ≤30%
- >0%, ≤10%
- 0%

Source: Navy 2009a

Printing Date: Oct 26, 2009, M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_4\11.2-1.mxd

2. Dredging Operations and Environmental Research (DOER). 2005. *Sedimentation: P otential Biological Effects of Dredging Operations in Estuarine and Marine Environments.*
   a. "most shallow benthic habitats in estuarine and costal 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."*
   c. "Fill material will bury some benthic organisms."
   d. Most organisms in this turbid environment are adapted for existence in area of considerable substrate movement"
   e. Re-colonization will occur in most cases within one year following construction"
4. Atlantic States Marine Fisheries Commission. 2002. *Review o f th e B iological and Physical Impacts.*
   f. *"Studies from 1985-1996 report short-term declines in infaunal abundance, biomass, and taxa r ichness f ollowing be ach no urishment, w ith r ecovery oc curring be tween 2 and 7 months"*
   g. *"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*.
   h. "animals that spend their entire life cycle in the substrate were not seriously impacted by burying from beach nourishment"
   i. "nourishment destroyed or drove away the inertial macrofauna; but, based in 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 settlement potential provided by the cleared hard surfaces after dredging and the added aircraft carrier wharf armor rip rap and vertical pilings. The development of the pier would provide suitable habitat for species such as benthic invertebrates including sponges, sea urchins, starfish, and mollusks, which are poorly represented within Inner Apra Harbor and the entrance channel areas (COMNAV Marianas 2006).

Therefore, negative impacts to marine flora and invertebrates would be short-term and localized, thus there would be less than significant impacts as a result of implementing the offshore component of Alternative 1.

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 2005). EFH for managed fishery resources is designated in the FMPs prepared by the local regional fisheries management council - WPRFMC - and in conjunction with the Guam Division of Aquatic and Wildlife Resources (GDAWR), which manages the fisheries resources in Guam. The WPRFMC is currently converting its FMPs to fishery ecosystem plans (FEPs). In other words, changing from species-based management to place-based management for the Pacific Region. The draft FEPs and Preliminary EIS are being reviewed and the Record of Decision for the associated Programmatic EIS is being prepared.

The Navy is consulting with the National Marine Fisheries Service (NMFS) on proposed activities that may adversely affect EFH. 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/OEIS 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).

Coral Reef Ecosystem and Fish Species. Coral and coral reef ecosystem is arguably one of the most important substrate habitat components of EFH within Apra Harbor. The coral reef ecosystem is highly complex, containing an incredible diversity of invertebrates, fishes, and some other vertebrate animals, such as sea turtles. Although reefs cycle some nutrients to and from other environments, they are to a large extent self-contained systems, and are densely populated with inhabitants. Individuals, both of different species and of the same species, interact with each other in various ways, as predators, prey, competitors, mates or cooperative partners.

Coral reef fish communities are extremely diverse and dense on many tropical reefs, more so than in any other aquatic habitat. Some families of fish, such as butterflyfishes and damselfishes, are adapted to live primarily on coral reefs, while others, such as wrasses, have many members living in other habitats. Coral reef fishes 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 can support so many fish communities because of the diverse lives that the fishes lead, specializing in various foods, and occupying different zones and habitats on and around the reef. The pressures of predation and competition are high and have given rise to immense variety in modes of life and behavioral ploys, and the physical adaptations needed to carry them out.

Coral reef fishes are not all active at the same time. Some feed during the daytime and retire to other sites to sleep at night, while others move out from daytime shelters to feed at night. Only a small minority are active on and off throughout day and night. When they are not feeding or breeding, most reef-dwellers hide from predators. Many fishes use the same refuges at different times of the day, making the most effective use of valuable space. Small fishes, such as blennies and gobies, do not tend to travel far, so their refuges and feeding sites are close together. Some large fishes, however, commute considerable distances--sometimes several kilometers--between resting and feeding places. Many form schools for safety when they are travelling, so that each individual fish runs less risk of being singled out by predators.

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/day; 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 indirect impact areas would be affected at varying degrees from sediment accumulation. The assessment of indirect impacts is a substantial overestimate of the actual indirect impact and based on a 656 ft (200 m) buffer zone. The actual indirect impact area would be a much smaller area than that based on the 40 ft (12 m) cumulative sediment deposition modeling.

During initial meetings with the agencies to determine the extent of the study area, the Navy suggested a 100 m “buffer zone” beyond the dredge footprint. USFWS suggested making it 200 m, which was agreed upon by the Navy. It is important to note that there was no actual basis for this number in terms of indirect impacts; it was simply to define a survey area that could encompass any potential indirect effects. It is in no way connected to the 40 ft (12 m) buffer that comes from the SEI (2009) cumulative plume modeling. It evolved into the "Indirect" impact area only because no one ever suggested that it be anything else, and that it can be stated with high certainty that it is indeed very conservative (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 (69.52 ha), which includes direct and indirect impacts of 72 ac (28.80 ha) and 101 ac (40.71 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 habitat from dredged removal of approximately 25 ac (10.20 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 Polaris Point*					
	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

Indirect impact analysis, as described earlier, assessed a 656 ft (200 m) buffer zone. It important to restate that there is no basis for the 200 m buffer zone in relation to the indirect impact area, which is in no way connected to the 40 ft (12 m) actual indirect impact zone (SEI 2009). However, it can be stated with high certainty that the buffer zone is indeed very conservative (Dollar 2009).

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 2009; 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 with silty sediments being 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.

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. 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 5 milligrams per square centimeter (mg/cm^2) per day to 100 mg/cm^2 per day. 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 FMP species 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 1,000 mg/cm^2 (0.9 in [6 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 0.12 knots (0.61 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 0.17 knots (0.86 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.

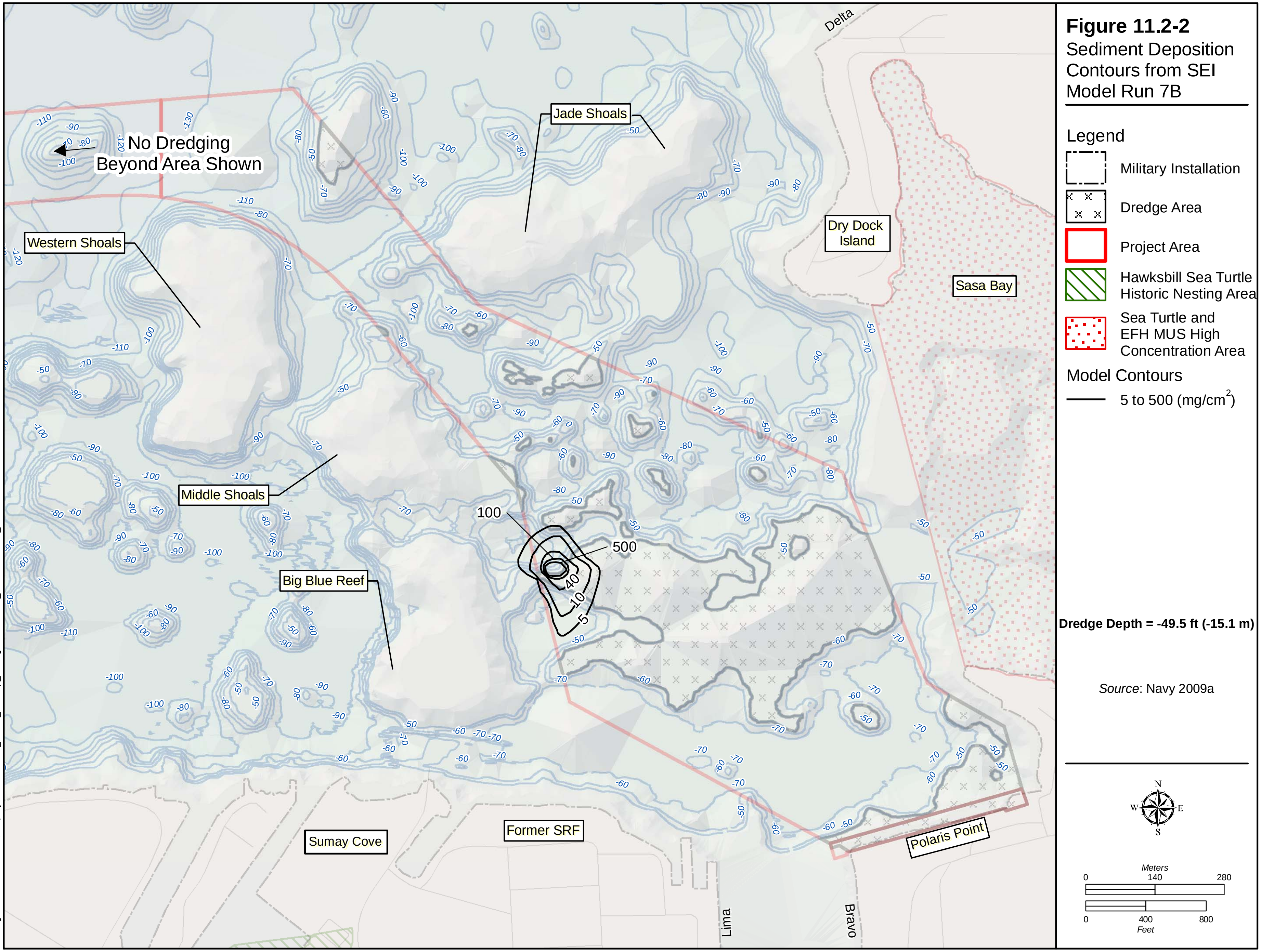
- Tidal effects are small in the harbor basins, but are important in the entrance channel to Inner Apra Harbor, where currents may reverse with the tides.

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.

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 5, 10, 40, 100, 500 mg/cm^2/day and shows that virtually all of the plume at deposition rates of 500 and 100 mg/cm^2/day 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/OEIS). 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 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 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 (greater than 40 mg/cm2 per day) 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.
- Analysis of possible total sediment accumulation during the project indicates that accumulations of greater than 1,000 mg/cm2, or 0.2 in (6 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 (12 m) of the dredge limits in the rest of the project area.



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- 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 2,690 mg/cm2, or 0.6 in (16 mm), and deposition greater than 40 mg/cm2, 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 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 1,000 mg/cm^2, or 0.9 in (6 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 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 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.

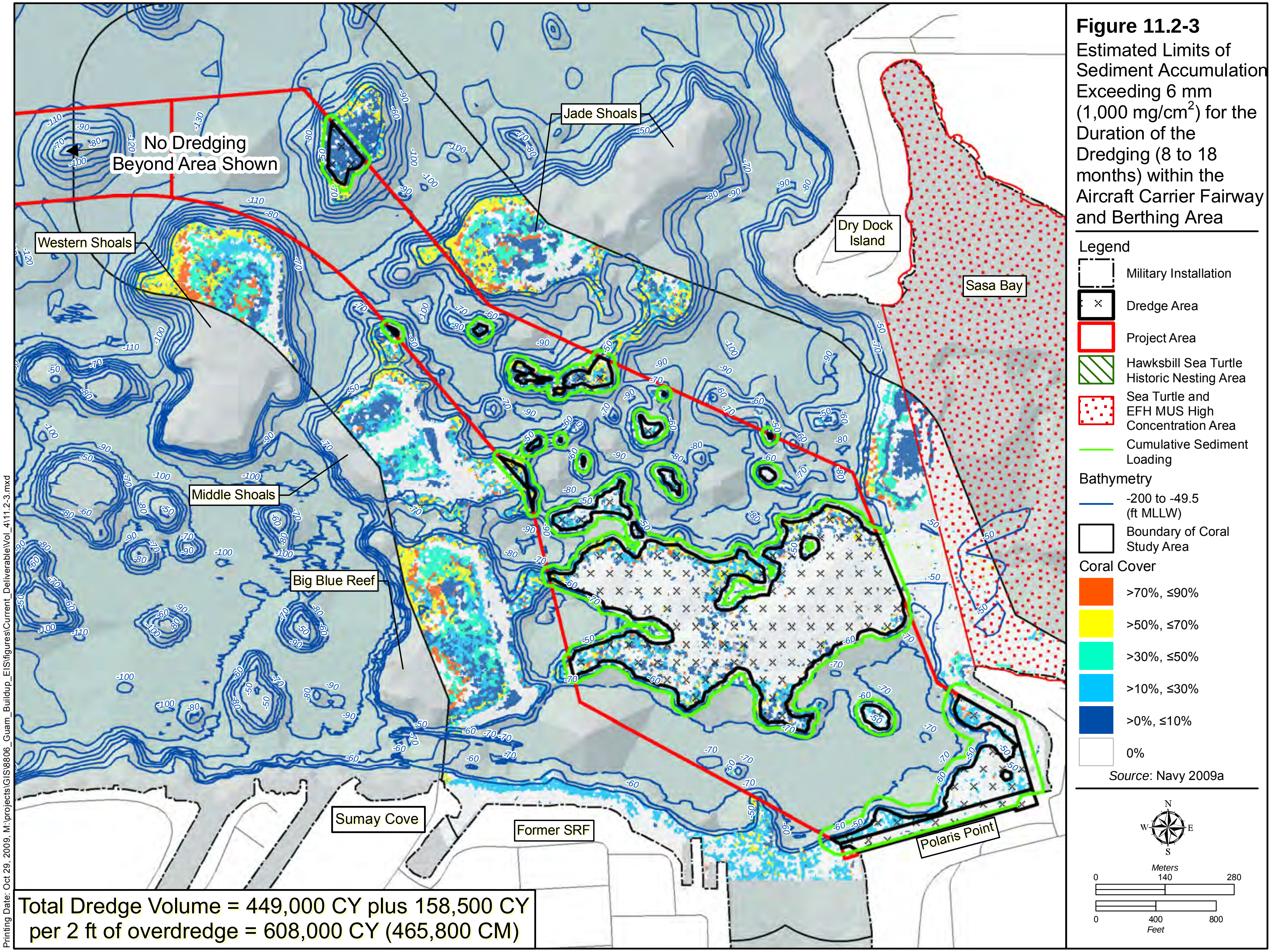

Figure 11.2-3
Estimated Limits of Sediment Accumulation Exceeding 6 mm (1,000 mg/cm^2) for the Duration of the Dredging (8 to 18 months) within the Aircraft Carrier Fairway and Berthing Area

PLUME MODELING SUMMARY. The plume modeling results suggest that cumulative sediment deposition during project construction totaling at least 1,000 mg/cm^2 (approximately 6 mm based on site-specific sediment characteristics) would accumulate up to 39.4 ft (12 m) beyond the area subject to direct 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 2 to 4 cm/second (SEI 2009). Brown et al. (1990) suggest that relatively slow current speeds (<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 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).
3. 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 downgradient flow with little accumulation on the steep reef face (MRC 2009c). 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.

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. In addition, during periods of substantial water motion (e.g., storm waves) and with ship movements in the channel, sand is episodically resuspended at levels that likely exceed the potential from proposed dredging activities (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; Tsutsui et al. 1987; 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 in 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 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 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 2005; MRC 2005; MRC 2009a; Dollar et al. 2009). Hence, these communities support 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. 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 CRE MUS, specifically hard corals, through direct removal that would also 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 of the total live reef area mapped in Apra Harbor. Long-term, localized impacts to coral and coral reef habitats 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.

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 1,000 mg/cm^2, or ¼ in (6 mm), were confined to within 75 ft (23 m) of the dredge limits at Polaris Point, and to within 39 ft (12 m) of the dredge limits in the remainder of the project area. The modeling indicated that sedimentation exceeding 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 sediment deposition would be 656 ft (200 m) wide surrounding the direct impact dredge area. The area of coral within the indirect impact area that is shallower than 60 ft (18 m) is assumed to be temporarily lost due to indirect dredging impacts, including increased sediment in the water column. Compared to the modeled sediment dispersion contours described above, the size of this designated indirect impact area is approximately 16 times larger than the modeled indirect impact. Impacts are further assumed to be permanent.

As the Navy has based its impact conclusion on the 200 m (656 ft) buffer area, Alternative 1 may have initial adverse affects on EFH (25% loss in ecological services based on the HEA [Navy 2009a]). These adverse indirect impacts would be short-term and localized, recovery would be expected within five years, and compensatory mitigation would be provided by the Navy.

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 FMPs, in-water construction activities would result in direct impacts from dredging removal or fill activities, noise (from dredging and impact piling 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 is 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, but 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. Others would be indirectly impacted because of the loss of habitat. Some finfish species occupying habitats that would be temporarily displaced (e.g., habitats disturbed but remaining after dredging) would be expected to eventually return to those habitats or repopulate other habitat areas assuming vacant habitats are available.

Direct impacts from Alternative 1 dredging activities would have an adverse affect on EFH due to the permanent removal of coral 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, may adversely affect EFH. Implementation and enforcement of appropriate BMPs and potential mitigation measures would reduce the effects of dredging, possibly from adverse to no adverse effects. No adverse effects to EFH are expected from indirect impacts of sedimentation to coral habitat (>0% - 90% coral = 46.24 ac [18.71 ha]) and other benthic habitat (0% coral with macroalgae, rubble, sand = 54.36 ac [22.00 ha]) with appropriate implementation of dredging BMPs and potential mitigation measures.

Noise is another potential source of negative impacts associated with in-water construction activities. Noise disturbances would likely cause motile invertebrates and 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 (45.8 m) from in-water construction activities (NMFS 2008c). 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. 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 in the Coral Reef, Bottomfish, Pelagic Fish, and Crustacean FMPs may be impacted by Alternative 1 actions. These life stages typically are weak swimming forms and are carried about by local currents (COMNAV Marianas 2007b). Based on wind and current measurements (SEI 2009), 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). Therefore, the probability of their occurrence in the vicinity of the Alternative 1 action area is small. Nevertheless, the eggs and larvae of these and other FMP species 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 negligible, and therefore, no adverse effects on EFH for planktonic eggs and larvae are anticipated. Potential impacts on EFH and sensitive MUS identified above are expected to be short-term, minimal and/or localized.

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	Direct, permanent and localized removal. Indirect, short-term and localized.
Soft Bottom	Apra Harbor	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction and increased vessel movements	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 Habitat	Outer Apra Harbor Shoal Areas, Entrance Channel	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction Increased vessel movements	Direct, permanent and localized removal. Indirect, short-term and localized increase in underwater noise, localized resuspension of sediments, and potential increase in pollutants. Sessile benthic community is expected to recolonize quickly from adjacent, undisturbed areas. Direct and indirect – short-term, localized resuspension of sediments, increase of noise and potential pollutants
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	Direct and indirect – temporary and localized elevation of turbidity, noise, and potential pollutants Direct and indirect – short-term, localized resuspension of sediments, increase of noise and potential pollutants
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 Short-term, localized increase of noise and resuspension of sediment. Potential increase of pollutants
Submerged Aquatic Vegetation	Apra Harbor, Sasa Bay	Dredging of aircraft carrier channel, turning basin, and berth. Increased vessel movements	Direct and indirect short-term localized removal or filling. Aquatic vegetation is expected to recolonize quickly No effects
Estuarine Water Column	Sasa Bay	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction Increased vessel movements	Direct and indirect – temporary and localized elevation of turbidity, noise, and potential pollutants Direct and indirect – short-term, localized resuspension of sediments, increase of noise and 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 spawning of scalloped hammerhead sharks, although reported to be extremely rare (Navy 2009c), and seasonal high concentrations of adult bigeye scad, may also be temporarily disturbed by increased vessel traffic and dredging activities. EFH for these PHCRT species would not likely be adversely affected with appropriate NMFS-recommended BMPs. The probability of collisions between vessels and adult 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 ROI (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	Spawning (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; WPFMC 2005

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 FMP species. These indirect impacts to EFH would include 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.

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).

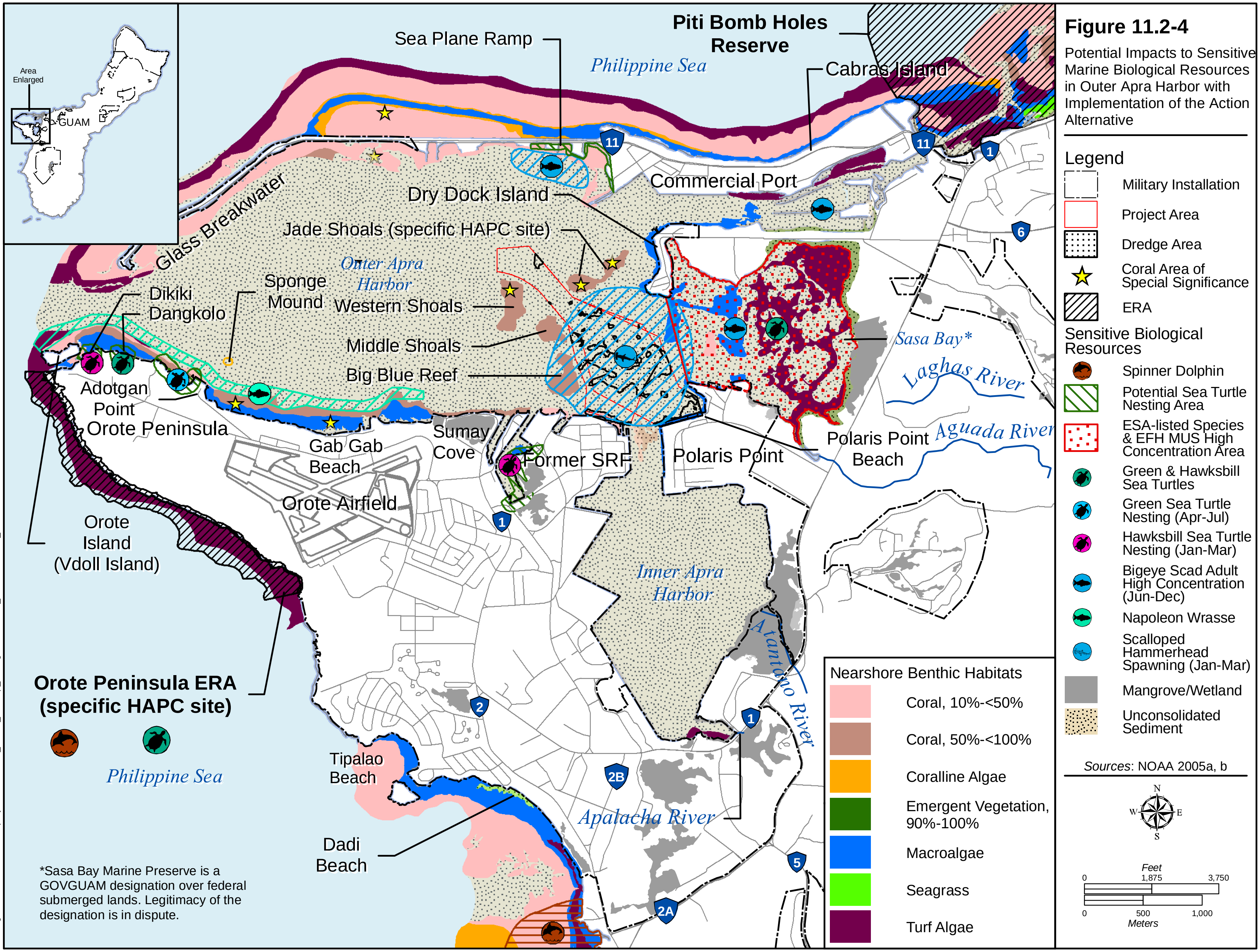

Figure 11.2-4
Potential Impacts to Sensitive Marine Biological Resources in Outer Apra Harbor with Implementation of the Action Alternative

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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 beneficial changes in local community assemblages that would offset any potential short-term, localized negative impacts after the aircraft carrier wharf construction is complete and hard surfaces are populated. This would in essence offset any negative impacts to the currently depauperate (lacking species variety and not fully grown) benthic community.

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%).
- Long-term disruption to coral reef habitat and displacement of species (could take years to recover)
- Permanent loss to some displaced, site-attached finfish species.
- Short-term and localized disturbance and displacement of mobile FMP MUS (fish and some invertebrates).
- Short-term and localized degradation to water quality (i.e., increases of siltation and turbidity).
- Short-term and localized minor indirect impacts to live coral and coral reef habitat (46.24 ac [18.71 ha]) from increased siltation and noise.
- Short-term and localized significant impacts to planktonic forms of eggs and larvae.
- Short-term and localized minor disturbances to coral reef ecosystems from increased vessel movements.
- Short-term seasonal disturbances to potentially spawning scalloped hammerhead sharks and high concentrations of adult bigeye scad.
- Aircraft carrier wharf structure would most likely result in an increase of community assemblages adequately offsetting the short-term, localized effects.

Based on this assessment, Alternative 1 may adversely affect EFH in Outer Apra Harbor. However, these direct impacts would be either offset or reduced through implementation and management of the BMPs.

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 2009a.

As identified in the affected environment section, no sea turtle density information is available for Apra Harbor. 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 (45.8 m) from in-water construction activities (NMFS 2008c). (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 500 m), 60 (at 320 m), and 80 (at 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 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 mitigation measures in place.

The Navy recognizes that there are many on-going and recent past studies on the subject of potential 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/OEIS. The Navy would continue to research these studies and where appropriate, incorporate and apply methodologies, analysis, 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. The Final

EIS/OEIS would contain revised sea turtle impact analysis as developed through the process described above.

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 following activities:

- Dredging activities for the wharf and turning basin areas anticipated to last 4 to 8 months. 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.
- Pile-driving and wharf construction (approximately 6-18 months).
- A 3.5 year duration has been estimated for all in-water construction activities.

It should be noted that sea turtles have not been observed foraging or resting within the proposed project area during multiple dive surveys performed there; it has been observed to function as a transit area to and from Sasa Bay (Navy 2009d).

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 potential mitigation measures would minimize these potential effects to sea turtles to less than significant. Alternative 1 actions would not "jeopardize" or "take" ESA-listed sea turtles as defined under Sections 7 and 9 of the ESA.

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 nighttime construction operations. However, as mentioned previously, this site has not been active since a reported hawksbill nesting event in 1997.

In summary, 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 DEIS/OEIS. 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. The Final EIS/OEIS will contain revised sea turtle impact analysis as developed through this process.

It is anticipated however, that through the results of consultation with NOAA, including implementation of BMPs and potential mitigation measures, the Alternative 1 proposed actions may affect, but are not likely to adversely affect the ESA-listed green sea turtles in Apra Harbor. The short-term dredging, pile driving activities, and episodic vessel movements associated with Alternative 1 actions may affect, but are not likely to adversely affect ESA-listed sea turtles. Alternative 1 would not “jeopardize” or “take” ESA-listed sea turtles as defined under Section 7 and 9 of ESA. Therefore, Alternative 1 would result in less than significant impacts on special-status species.

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. Approximately 5,500 non-native species were recorded in these surveys, of which most remain 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 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 from the inner harbor area to the new aircraft carrier wharf pilings may be expected. This may enhance the community assemblage and diversity of the area. 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).

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.

<u>Operation</u>

Marine Flora, Invertebrates and Associated EFH

Less than significant impacts would be expected to marine flora and invertebrates. 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. Impacts to marine flora and invertebrates would be long-term, but episodic and minor, considering existing conditions. Therefore, Alternative 1 would result in less than significant impacts to marine flora and invertebrates.

Essential Fish Habitat

There would be long-term, localized and infrequent impacts associated with use of the aircraft carrier wharf at Polaris Point. The tugboats would 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 0.1 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 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/OEIS), 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 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, although localized, increased potential 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 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 would cause decreased turbidity during current operations and would offset the potential increase in turbidity from carrier operations. 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 Summary. Alternative 1 operation activities, including an increase in vessel movements and operational pollutants 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
- 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 potentially spawning scalloped hammerhead sharks and high concentrations of adult bigeye scad

Based on this assessment, there would be no adverse effects to EFH from operation. Therefore, Alternative 1 would result in less than significant impacts to Essential Fish Habitat from 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 and 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. 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 Summary of Overall Potential Impacts

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 and harbor operation	Direct, permanent and localized removal. Indirect, long-term, but periodic and localized.
Soft Bottom	Apra Harbor	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction and increased vessel movements and harbor operation	Direct and indirect, periodic and localized resuspension of sediment. Benthic infaunal community is expected to reestablish themselves quickly from adjacent, undisturbed areas.
Corals/Coral Reef Habitat	Outer Apra Harbor Shoal Areas, Entrance Channel	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction Increased vessel movements and harbor operation	Direct, permanent and localized removal. Indirect, short-term and localized increase in underwater noise, localized resuspension of sediments, and potential increase in pollutants. Sessile benthic community is expected to recolonize quickly from adjacent, undisturbed areas. Direct and indirect – long-term but periodic, localized resuspension of sediments, increase of noise and potential pollutants
Water Column	Apra Harbor	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction Increased vessel movements and harbor operation	Direct and indirect – temporary and localized elevation of turbidity, noise, and potential pollutants Direct and indirect – long-term but periodic, localized resuspension of sediments, increase of noise and potential pollutants
Estuarine Emergent Vegetation	Apra Harbor, Sasa Bay	Dredging of aircraft carrier channel, turning basin, and berth. Increased vessel movements and harbor operation	No effects Long-term, localized potential increase of pollutants
Submerged Aquatic Vegetation	Apra Harbor, Sasa Bay	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction. Increased vessel movements and harbor operation	Direct and indirect short-term localized removal or backfilling. Aquatic vegetation is expected to recolonize quickly from adjacent undisturbed areas. No effects
Estuarine Water Column	Sasa Bay	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction Increased vessel movements and harbor operation	Direct and indirect – temporary and localized elevation of turbidity, noise, and potential pollutants Direct and indirect – long-term but periodic, localized resuspension of sediments, increase of noise and potential pollutants

The long-term, periodic impacts associated with Alternative 1 actions would be likely to affect, but are not likely to adversely affect ESA-listed sea turtles. Alternative 1 would not "jeopardize" or "take" ESA-listed sea turtles as defined under Sections 7 and 9 of ESA. Therefore, Alternative 1 would result in less than significant impacts to special-status species. Nesting sea turtles are addressed in more detail in Volume 2, 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 and especially while in the vicinity of Sasa Bay and during nesting season. 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 Summary

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, if appropriate USCG and Navy ballast water and hull management policies are followed.

BMPs and 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:

- Re-alignment 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 the Polaris Point alternative to avoid removing coral communities.
- Adherence to Navy INRMP measures.

The potential impacts described previously are expected to be minimized by implementation of BMPs. Although a comprehensive list of BMPs is provided in Volume 7, the following are some BMPs specifically related to marine resources.

- Spill Prevention Control and Countermeasures (SPCC) plans are currently in place. Trained personnel would be present that maintain spill control and cleanup materials nearby within Apra Harbor for quick response to spills to be protective of natural resources.
- No in-water blasting would be allowed.
- If a sea turtle is sighted near any project activity, and should that activity have a potential to adversely affect the turtle, the action would be paused or modified to avoid any adverse affects.
- Use of appropriate silt curtains and/or other silt containment BMPs to fully enclose areas (maximum extent practicable and within performance levels of curtains) where in-water

operations are occurring along with frequent monitoring of their effectiveness to contain suspended sediments.

- Water quality would be monitored throughout the construction project.

Relative to impacts to resting and foraging of green and hawksbill turtles, the Navy will consider the following NOAA-recommended lighting and construction BMPs (COMNAV Marianas 2007b) to minimize the potential for adverse effects to sea turtles:

- Employ avoidance and minimization measures, including performance of a visual sweep of the project area prior to commencing in-water activities, if green turtles are seen, in-water activities would not commence until 15 minutes has passed or the animal has moved out of range, a ramping up of increased intensity in noise would be required during pile driving and dredging work allowing undetected animals to voluntarily depart the area.
- Construction personnel would be informed of the protected nature of these animals and procedures that would be employed should a sea turtle enter a construction area. For example, if a dredge-related tug, barge or scow vessel operator sees that the vessel is approaching a sea turtle, the speed would be reduced, the boat would be turned, or other actions would be taken to avoid the turtle.
- Avoid the use of artificial lighting near beaches, where possible, particularly during nesting and hatching seasons.
- Shield or redirect lights to reduce as much as possible the amount of light that can be seen from the nesting beach.
- Where possible, use low-intensity light sources that emit long wavelength light (yellow, red) and avoid sources that emit short wavelengths (ultraviolet, blue, green, white).
- Aboard dredge-related tug, barge or scow vessels at sea, use the minimum lighting necessary to comply with navigation rules and best safety practices.
- Silt curtains would be employed as part of the turbidity BMPs during dredging operations; however, precautions would be taken to ensure that curtains do not encircle turtles when put in place. If a turtle should enter the silt curtain area, work would be halted and the curtain lowered until the turtle voluntarily leaves the area.
- Observers would be present during dredging operations specifically for sea turtle identification. If a sea turtle is sighted near any project activity and deemed that the activity could potentially adversely affect the sea turtle, the action would be suspended or modified to avoid any adverse effect.
- Construction-related materials that may pose an entanglement hazard would be removed from the project site if not actively being used.
- Anchor lines from construction vessels would be deployed with appropriate tension to avoid entanglement with sea turtles.
- All in-water work would be postponed when turtles are within 100 yd (91 m), or other protected species are within 50 yd (46 m). Activity would commence only after the animal(s) depart the area.

Additionally, the Navy maintains the following general protective measures for marine resources in Apra Harbor including:

- Constant vigilance shall be kept for the presence of ESA-listed species.
- When piloting vessels, vessel operators shall alter course to remain at least 100 yards (yd) (91 m) from sea turtles and at least 50 yd (46 m) from other protected species.

- Reduce vessel speed to 10 knots or less when piloting vessels in the proximity of marine mammals.
- Reduce vessel speed to 5 knots or less when piloting vessels in areas of known or suspected turtle activity.
- Marine mammals and sea turtles should not be encircled or trapped between multiple vessels or between vessels and the shore.
- Do not attempt to feed, touch, ride, or otherwise intentionally interact with any protected species.
- 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 returned to ambient conditions.
- Anchors, anchor chain, wire rope and associated anchor rigging would be restricted to designated anchoring areas, the sandy harbor bottom or within the area that would be permanently impacted.
- All construction-associated equipment would be operated and anchored to avoid contacting coral reef resources during construction activities or extreme weather conditions.

<u>Invasive Species Control</u>

The Navy is preparing a Regional Biosecurity Plan including a risk analysis with the overall goal to identify marine biosecurity risks associated with Department of Defense (DoD) build-up and training activities on Guam and the Commonwealth of the Northern Mariana Islands (CNMI). The Regional Biosecurity Plan will document measures for prevention, control and treatment measures for military operations. Volume 7 includes a more detailed description of a Regional Biosecurity Plan.

11.2.2.3 Summary of Alternative 1 Impacts

Table 11.2-6 summarizes Alternative 1 impacts.

11.2.2.4 Alternative 1 Potential Mitigation Measures

Potential avoidance and minimization measures that would be discussed during required consultations and permitting actions include the following. The results of consultations and permit discussions would form the basis of mitigation measures included by the Navy in its ROD implementing the proposed actions.

- Incorporate seasonal dredging prohibitions similar to those EPA suggested for the Kilo Wharf dredging activities.
  - Cessation of dredging operations during the period of peak coral spawning (7-10 days after the full moon in July) in consultation with the Guam Department of Water Resources (GDAWR).
  - Dredging or filling of tidal waters would not occur during hard coral spawning periods, usually around the full moons of June, July, and August.
- No ships would be allowed to enter Sasa Bay at night.
- Provide marine biological resources education and training on EFH, ESA, and MMPA. This may include Base Orders, natural resource educational training (i.e., watching of short Haputo Ecological Reserve Area 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.

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, mitigated to less than significant impacts from direct and indirect effects associated with in-water construction (i.e., dredging and impact pile driving) activities on Essential Fish Habitat. Marine Flora, Invertebrates and Associated EFH: Less than significant direct and indirect impacts to marine flora and non-coral invertebrates. Injury and/or mortality to marine flora and sessile invertebrates from physical removal would occur within the dredged footprint. These organisms are anticipated to quickly reestablish themselves from adjacent areas after construction. 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 25 ac (10 ha) of coral habitat (>0% to ≤ 90%) and 46 ac (19 ha) of benthic habitat (0% coral). Short-term and localized adverse indirect impacts from sediment accumulation on a portion of an additional 46 ac (19 ha) of coral habitat (>0% to ≤ 90%) and 54 ac (22 ha) of benthic habitat (0% coral) adjacent to, but outside of, the dredge footprint. 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 potential 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: Less than significant impact on special-status species from in-water construction activities. Short-term and localized effects on sea turtle behavior during the dredging and impact pile driving periods are expected, for example, temporarily altering their swimming, resting or feeding behaviors could be anticipated from elevated noise levels. However, there are many alternate sea turtle foraging and resting sites throughout Apra Harbor unassociated with the proposed action and potential mitigation measures would postpone operations if sea turtles approach the area. Through Section 7 consultation and the implementation of identified BMPs and potential mitigation measures, including USACE permit conditions, sea turtles would be affected, but not adversely affected by the proposed action. Non-native Species: Less than significant impacts are expected from introduction 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 Regional Biosecurity Plan with risk analysis (see Volume 7 for more details).

Area	*Project Activities*	*Project Specific Impacts*
	Operation	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 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, potential 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 Regional Biosecurity Plan with risk analysis (see Volume 7 for more details).

11.2.2.5 Potential Mitigation Projects for Coral Reefs

The proposed action would result in unavoidable impacts to coral communities and compensatory mitigation would be required. 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 the CWA, through the Section 404/10 permit requirements (USACE, USEPA, USFWS, and NOAA 2000).

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.

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 in other Navy dredging projects in Apra Harbor, including Kilo Wharf.

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/OEIS. 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/OEIS.

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 (-15.1 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.

Although the indirect impacts were modeled and indicated that sedimentation exceeding 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 (and the HEA) assumes an indirect impact distance of 656 ft (200 m) distance 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 39 ft (12 m) beyond the direct dredge impact area as anticipated to receive cumulative sedimentation totaling at least 0.2 inches (in) (6 millimeters [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 Polaris Point - Alternative 1 is 71 ac (29 ha) and 61 ac (25 ha) for Former SRF - Alternative 2. As discussed above, this total dredged area assumes a 60 ft (18 m) depth. This is an overestimate of the proposed project's dredge footprint (-49.5 ft [-15.1 m] MLLW, plus 2 ft. (0.6) 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:

1. 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.
2. 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 the Polaris Point Alternative and 23.74 ac (9.60 ha) for the Former SRF Alternative 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.

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 Polaris Point, and approximately 32 ac (13 ha) for Alternative 2 Former SRF.

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 Former SRF Alternative 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.

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 (*Porites rus* and *Porites 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 described earlier in the EFH indirect impacts subsection above.

The shape of the recovery curve, the period over which losses are calculated, expected project timing and an appropriate discount rate.

<u>Restoration Calculation (Step 2)</u>

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) [4.5 m (w) x 4.5 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 habitat 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 (HDAR 2007).

Applying the algorithm used to assign injuries to Habitat Index Categories, an 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.

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	2012 (a)	0% (b)	None (c)	No Recovery (c)	N/A (c)	0% (c)	Perpetuity (d)	303.93
	Category 2								243.99
	Category 3								179.40
	Category 4								163.39
	Category 5								71.23
	Category 6								26.92
	Category 7								7.17
	Category 8								0.35
	Category 9								0.00
	Category 10								0.00
	Subtotal								**996.37**
Former SRF	Category 1	2012 (a)	0% (b)	None (c)	No Recovery (c)	N/A (c)	0% (c)	Perpetuity (d)	288.95
	Category 2								232.69
	Category 3								178.32
	Category 4								166.13
	Category 5								70.06
	Category 6								26.15
	Category 7								5.88
	Category 8								0.18
	Category 9								0.00
	Category 10								0.00
	Subtotal								**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	2012 (a)	75% (b)	2013 (c)	5 (d)	Linear (e)	100% (f)	10.31
	Category 2							9.46
	Category 3							11.75
	Category 4							7.79
	Category 5							5.09
	Category 6							3.82
	Category 7							2.42
	Category 8							0.80
	Category 9							0.21
	Category 10							0.13
	Subtotal							**51.79**
Former SRF	Category 1	2012 (a)	75% (b)	2013 (c)	**5** (d)	Linear (e)	100% (f)	10.70
	Category 2							9.48
	Category 3							12.04
	Category 4							8.28
	Category 5							5.45
	Category 6							4.24
	Category 7							2.80
	Category 8							0.97
	Category 9							0.23
	Category 10							0.13
	Subtotal							**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

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 due to 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 the Polaris Point Alternative. 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.

11.2.2.6 Implementation of Coral Restoration

Within DoD, regulatory agencies and the Military Civilian Task Force on Guam there is 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. These programs are not yet established on Guam and would have to 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 potential 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

11.2.2.7 Development of Potential 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 potential 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 property 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.

Potential Mitigation Options

The Navy is considering a suite of potential options for compensatory mitigation for the loss of coral in Outer Apra Harbor as shown below and discussed in more detail in the text.

Compensatory mitigation for unavoidable coral community impacts includes the following options:

Option 1: Artificial Reefs within Apra Harbor or Other Locations

Option 2: Watershed Restoration and Management

- *Aforestation*
- *Apra Harbor and/or Philippine Sea Riparian Enhancement*
- *Stream bank stabilization component*

Option 3: Coastal Water Resource Management

- *Shallow Water Reef Enhancement*
- *Upgrade Wastewater Management Systems*

Option 4: In-Lieu Fee or Mitigation Banking Program

The final conceptual determination would not be made until the Record of Decision on this EIS/OEIS. More detailed identification of potential mitigation would be done during the USACE permit process. Both artificial reefs and watershed management projects would be considered as potential compensatory mitigation, and it is possible that a combination of those potential mitigation efforts that are listed below would be appropriate. 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 artificial reefs or upland watershed management 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 options.

Option 1: Artificial Reefs within Apra Harbor or Other Locations

Description: 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 surfaces to which algae and invertebrates attach, which in turn attracts fish species providing food habitat for fish assemblages. Car and Hixon (1997) 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.

This option 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 potential 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.

Option 2: Watershed Restoration and Management

Description: 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 watershed restoration/conservation is to address reef degradation from discharge of eroded sediments from upland sources. Restoring vegetation to barren areas to reduce soil runoff and subsequent discharge into coastal waters is a major step in watershed restoration and improvement of coastal waters. Most potential watershed restoration projects would involve planting 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.

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 (EPA 2008)

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

Aforestation. 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/OEIS. Resource agencies have recommended coastal marine waters and associated rivers and watersheds as restoration candidates for potential compensatory mitigation for coral reef impacts. USFWS has recently provided the following potential sites for a watershed aforestation coral reef restoration option (USFWS 2009). 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 potential mitigation. These watersheds are associated with reefs that are degraded by sedimentation, but were healthy a few decades ago (USFWS 2009).

Additional restoration/enhancement projects as recommended in 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 watershed area on the figures is approximately 4,694,980 ac (1,900,000 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.

The Talofofo watershed associated with the Ordnance Annex is located on Navy-owned land. The watershed currently suffers from soil erosion which manifests itself in sediment transfer to various streams that feed into Talofolo Bay. The Ordnance Annex 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.

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 Cetti Bay watershed restoration project was attempted as compensatory mitigation for coral loss at Kilo Wharf. Because land use was not totally controlled and management agreements could not be concluded, the project has not been successful. It may be possible, however, to have a combination of reforestation/aforestation on some smaller scale when done in conjunction with watershed restoration project on Navy-owned lands, artificial reef installation within Apra Harbor or other areas, and/or riparian enhancement that would benefit fish, corals, and other marine organisms.

Apra Harbor and/or Philippine Sea Riparian Enhancement. This option would include mangrove and/or wetlands enhancement in the Apra Harbor area. This may be based on BSPs 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.

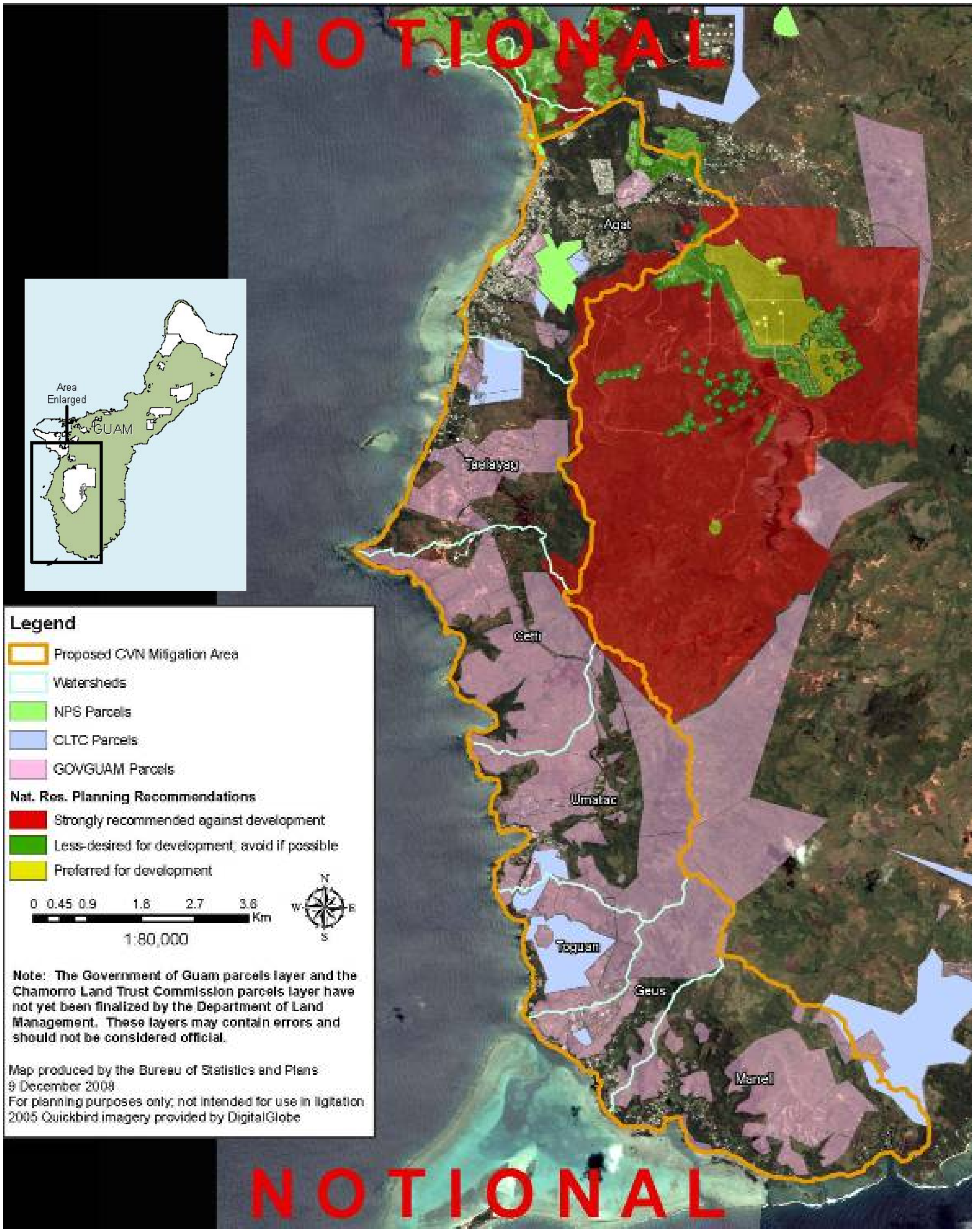

Figure 11.2-5. Boundary of Guam Agency Proposed CVN Potential Mitigation Area

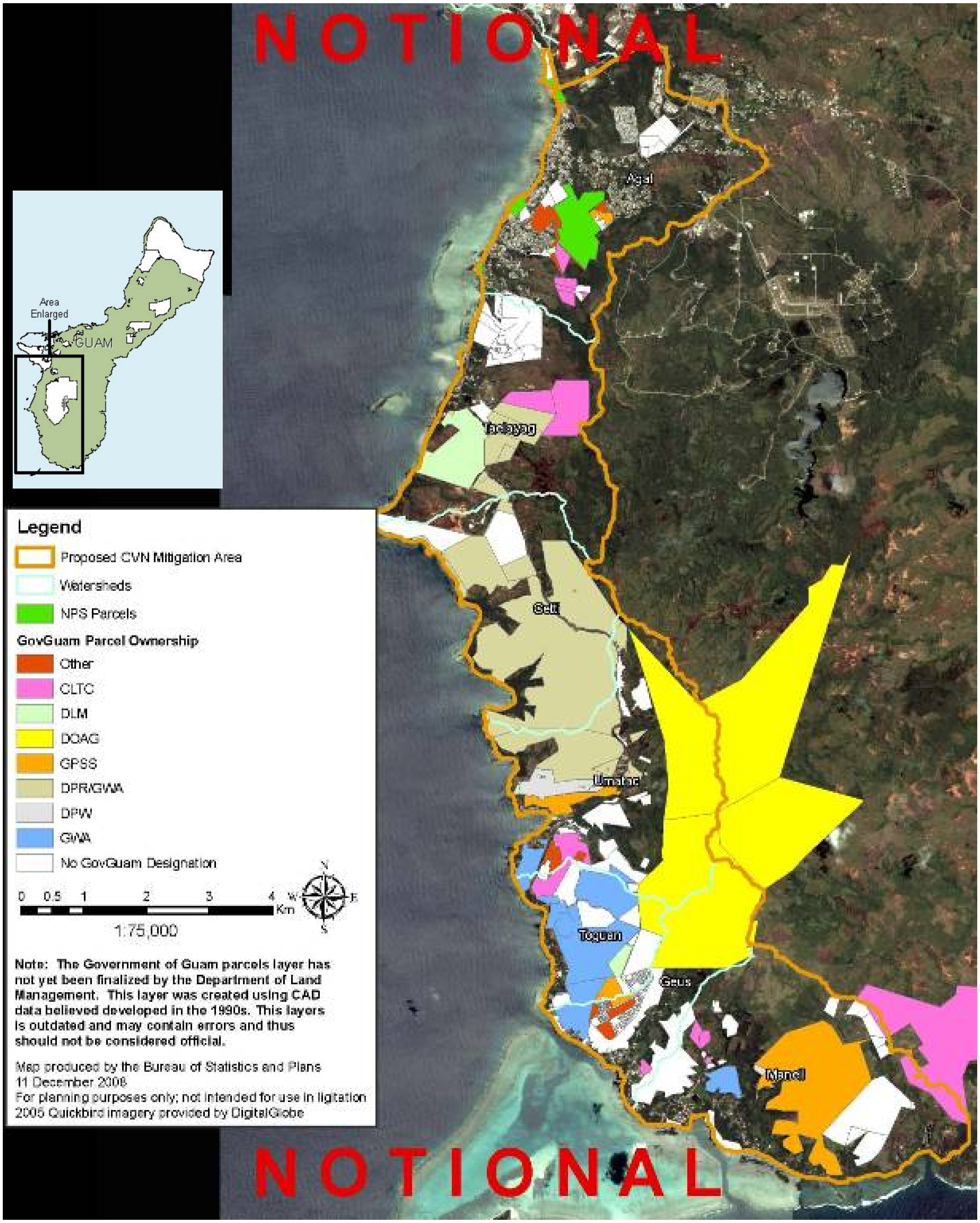

Figure 11.2-6. Potential Mitigation Area, GOVGUAM Parcel Ownership

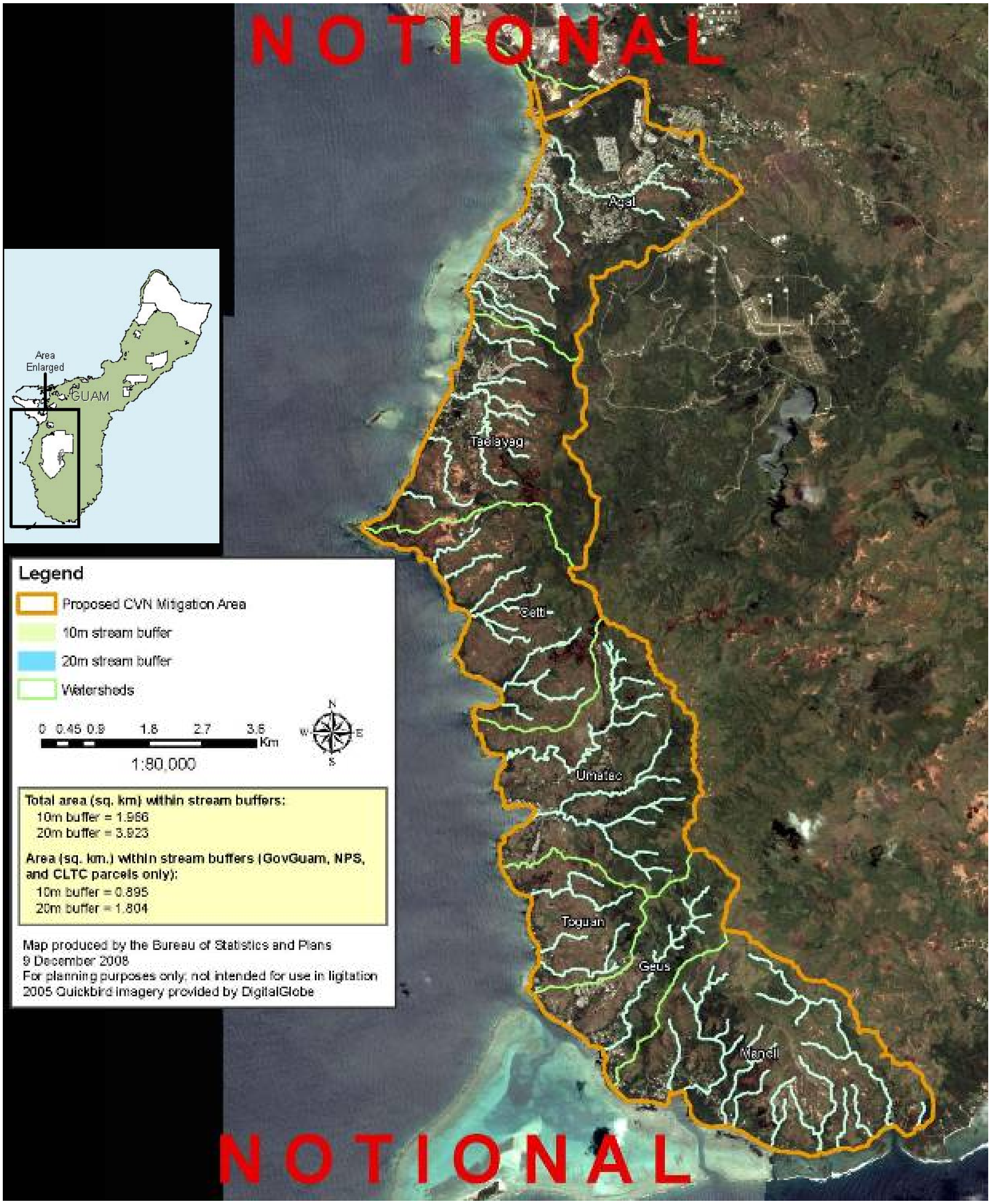

Figure 11.2-7. Potential Mitigation Area, Riparian Buffers for Stream

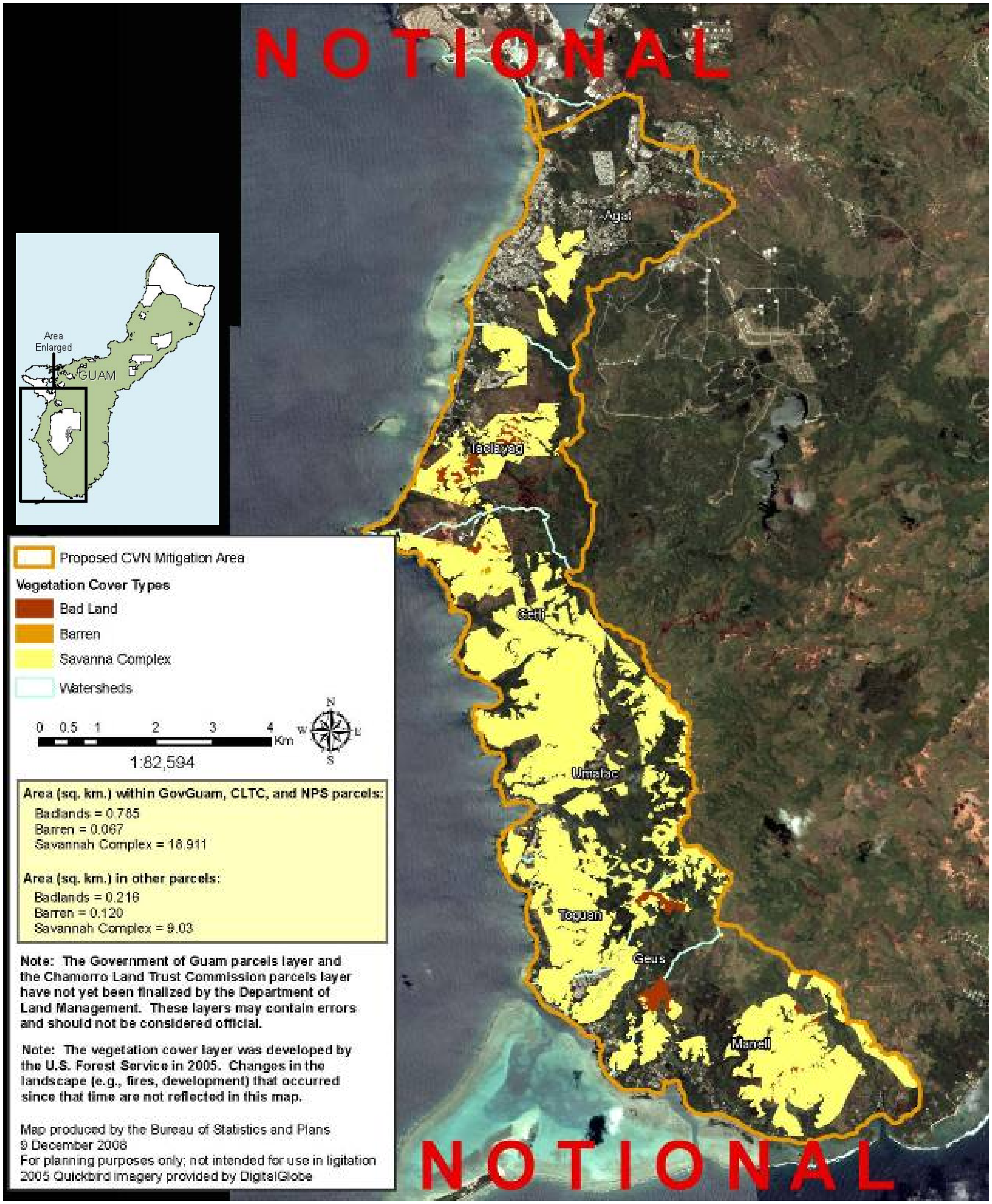

Figure 11.2-8. Potential Mitigation Area Vegetation Types

Stream bank stabilization component. This option would involve stabilization of stream banks within watersheds that would involve the placement of vegetative 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 would include major factors including: 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.

Option 3: Coastal Water Resources Management

Shallow Water Reef Enhancement. This option 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 in outer Apra Harbor. 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 potential mitigation options are under consideration at this time.

Coastal Water Resource Management – Upgrade Wastewater Management Systems. This option would involve upgrading Guam treatment plants and ocean outfalls to have secondary treated effluent to improve coastal water quality that would in turn enhance coral health in the coastal zone of Guam. This option is an alternative for the Northern District Wastewater Treatment Plant under consideration within this EIS/OEIS.

Option 4: In-Lieu Fee or Mitigation Banking Program

Within the HEA Administrative Working Group, DoD, and the Military Civilian Task Force on Guam, there is 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 would be included in this 2008 compensatory mitigation rule as endorsed Federal programs. These programs have not yet 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. The Sponsor is responsible for implementing the project according to an approved work plan.

Development of Compensatory Mitigation Plan

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 would be the vehicle through which compensatory mitigation would be implemented. The project would be designed to avoid coral reef impacts and to minimize any unavoidable impacts. Unavoidable impacts would be mitigated through implementation and/or funding of mitigating measures to compensate for the resulting loss of ecological functions and/or services. Selection, scaling, and implementation of appropriate compensatory mitigation actions are being carried out in consultation with USACE, NOAA, USFWS, USEPA and GOVGUAM resource agencies. The HEA presented is a tool designed to equate impact habitat services to potential mitigation habitat services. The financial aspect does not come into consideration until after the mitigation project has been selected (e.g., execution costs of the mitigation project). 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-EPA 2008 Compensatory Mitigation Rule.

11.2.3 Alternative 2 Former SRF

11.2.3.1 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.

11.2.3.2 Offshore

Offshore activities associated with Alternative 2 would be similar to those of Alternative 1. Volume 4, Section 2.6 describes this Alternative.

<u>Construction</u>

Marine Flora, Invertebrates and Associated EFH

The anticipated impacts to these resources resulting from implementation of Alternative 2 are similar to the those described for Alternative 1. Under Alternative 2, dredging activities would have direct and permanent impacts to marine flora and invertebrates (not including coral and coral reefs which are discussed in more detail under EFH), particularly to sessile organisms. Motile invertebrates would likely vacate the area due to the increased disturbance. Although some mortality would occur to marine flora and sessile invertebrates, these organisms would be anticipated to quickly reestablish once project activities cease. Therefore, impacts to marine flora and invertebrates would be less than significant as a result of implementing the offshore component of Alternative 2.

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. There are minor differences in the location of dredging activities and in coral removal acreages and percent removals. 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 11.2-9) would require the dredging of approximately 61 ac (25 ha) as compared to 71 ac (29 ha) for the Polaris Point Alternative (Table 11.2-10). 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. This equates to a percent coral cover impact of 46%, 39% direct and 50% indirect impacts of the total area affected, respectively. The indirect area extends 656 ft (200 m) from the direct area boundary as was described for the Polaris Point Alternative.

Table 11.2-9 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 <u><</u> 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 11.2-10. Estimated Coral Area and Percentages Impacted by Proposed Dredging Activities with Implementation of Alternative 2

Coral Level	*Alternative 2 Former SRF*					
	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.

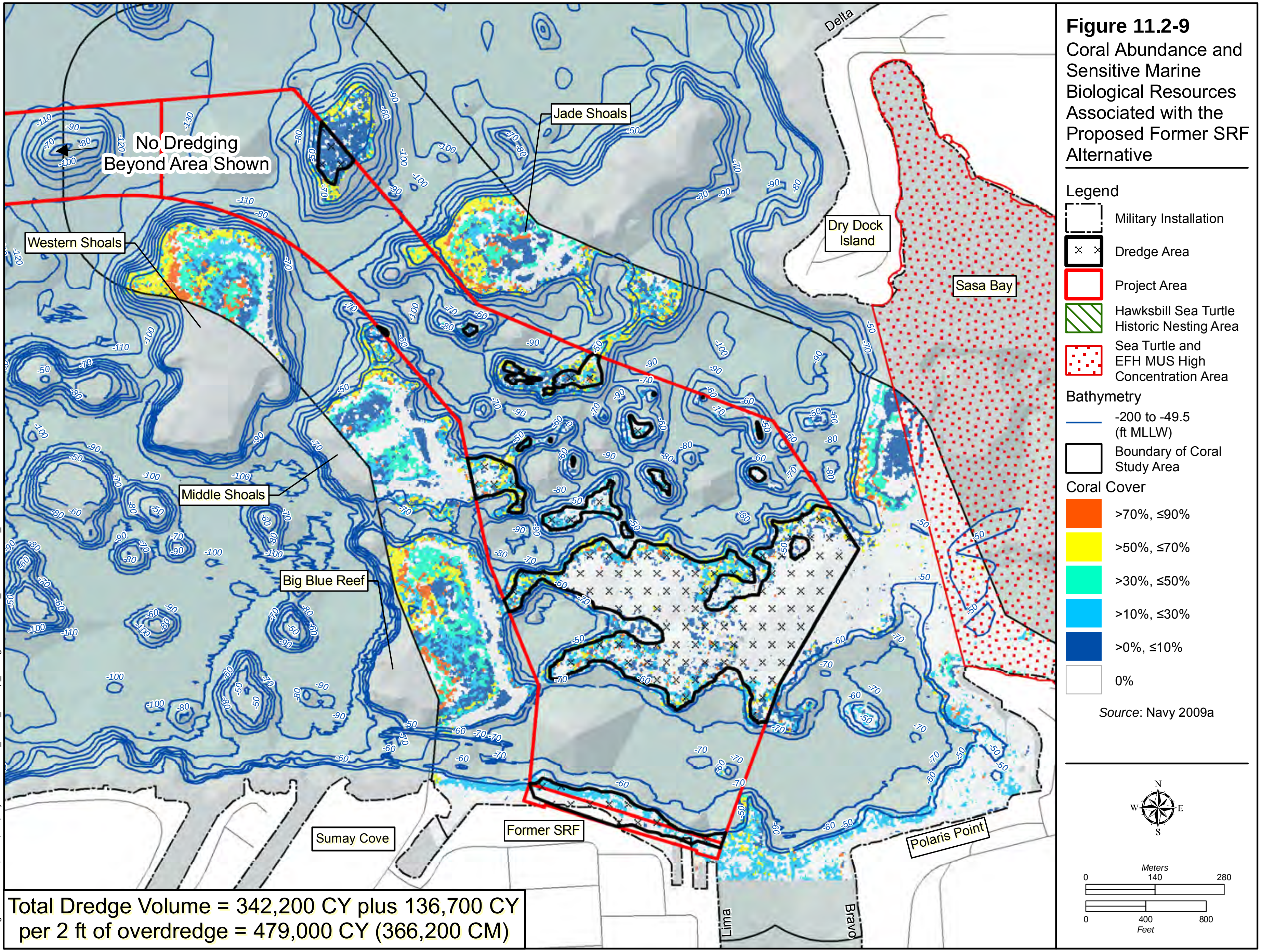

Figure 11.2-9
Coral Abundance and Sensitive Marine Biological Resources Associated with the Proposed Former SRF Alternative

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Adverse affects to EFH for reef fish MUS may occur due to the direct removal of coral 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 to EFH.

Short-term adverse effects to 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 (i.e., *Porites rus* and *Porities cylindrica*) to such levels of sedimentation.

Alternative 2 impacts to Essential Fish Habitat would be similar to those described for Alternate 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 parish 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 therefore may adversely affect essential fish habitat. Implementation and enforcement of appropriate BMPs and mitigation measures would reduce effects, possibly from adverse to no adverse affects. Indirect impacts from Alternative 2 actions would be similar to those described under Alternative 1. Therefore, potential indirect effects on EFH and sensitive MUS are expected to be adverse, however short-term and localized; therefore, implementation of Alternative 2 may adversely affect EFH.

Table 11.2-11 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 11.2-11. 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 Increased vessel movements	Direct, permanent and localized removal. Indirect, short-term and localized.
Soft Bottom	Apra Harbor	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction and increased vessel movements	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 Habitat	Outer Apra Harbor Shoal Areas, Entrance Channel	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction	Direct, permanent and localized removal. Indirect, short-term and localized increase in underwater noise, localized resuspension of sediments, and potential increase in pollutants. Sessile benthic community is expected to recolonize quickly from adjacent,

Habitat	*Area of Occurrence*	*Associated Activity*	*Effect*
		Increased vessel movements	undisturbed areas. Direct and indirect – short-term, localized resuspension of sediments, increase of noise and potential pollutants
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	Direct and indirect – temporary and localized elevation of turbidity, noise, and potential pollutants Direct and indirect – short-term, localized resuspension of sediments, increase of noise and potential pollutants
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 short-term, localized increase of noise and resuspension of sediment. Potential increase of pollutants
Submerged Aquatic Vegetation	Apra Harbor, Sasa Bay	Dredging of aircraft carrier channel, turning basin, and berth. Increased vessel movements	Direct and indirect short-term localized removal or filling. Aquatic vegetation is expected to recolonize quickly No effects
Estuarine Water Column	Sasa Bay	Dredging of aircraft carrier channel, turning basin, and berth. Backfill and pile driving for wharf construction Increased vessel movements	Direct and indirect – temporary and localized elevation of turbidity, noise, and potential pollutants Direct and indirect – short-term, localized resuspension of sediments, increase of noise and potential pollutants

Under Alternative 2, 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. The EFHA prepared for Alternative 2 construction-related actions found 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%).
- Long-term disruption to coral reef habitat and displacement of species (could take years to recover)
- Permanent loss to some displaced, site-attached finfish species.
- Short-term and localized disturbance and displacement of mobile FMP MUS (fish and some invertebrates).
- Short-term and localized degradation to water quality (i.e., increase in siltation and turbidity).

- Short-term and localized indirect impacts to live coral and coral reef habitat (47 ac [19 ha]) from increased siltation and noise.
- Short-term and localized significant impacts to eggs and larvae.
- Short-term and localized disturbances to coral reef ecosystems from increased vessel movement.
- Short-term seasonal disturbances to potentially spawning scalloped hammerhead sharks and high concentrations of adult bigeye scad.
- Total coral coverage impacted (direct and indirect) is 71 ac (29 ha).

Based on this assessment, Alternative 2 may adversely affect EFH. However, these impacts would be offset and mitigable to no adverse affect through implementation and management of the BMPs and 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. Green sea turtles would be affected, however not adversely affected through appropriate NOAA consultation and implementation of avoidance and minimization BMPs and mitigation measures. Less than significant impacts to special-status species, specifically sea turtles, would occur with implementation of Alternative 2.

Non-Native Species

The anticipated impacts of non-native species 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.

<u>Operation</u>

Marine Flora, Invertebrates, and Associated EFH

Alternative 2 impacts to these resources would be similar to those described under Alternative 1.

Essential Fish Habitat

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

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
- 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 potentially spawning scalloped hammerhead sharks and high concentrations of adult bigeye scad

Based on this assessment, there would be no adverse effects to EFH from operation. 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 would be similar to those described under Alternative 1.

11.2.3.3 Summary of Alternative 2 Impacts

Table 11.2-12 summarizes Alternative 2 impacts, which would be similar to those of Alternative 1.

Table 11.2-12. 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, mitigated to less than significant impacts from direct and indirect effects associated with in-water construction (i.e., dredging and impact pile driving) activities. Marine Flora, Invertebrates and Associated EFH: Less than significant direct impacts to marine flora and non-coral invertebrates. Injury or mortality to these resources from physical removal would occur within the dredge footprint, but reestablishment is anticipated to be quick after construction. Motile invertebrates would likely vacate the area due to the increased disturbance. Essential Fish Habitat: Unavoidable, long-term significant direct impacts from dredged removal of 24 ac (10 ha) of marine benthic 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 habitat (all coverage classes) and 46 ac (19 ha) of 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 potential mitigation efforts, there would still 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: Similar to Alternative 1, except short-term construction

Area	*Project Activities*	*Project Specific Impacts*
		operation would be closer to Big Blue Reef. Less than significant impact. Short-term and localized effects on sea turtle behavior during the dredging and impact pile driving periods would be expected, but turtle foraging and resting sites would not be impacted. Potential mitigation measures would postpone operation if sea turtles approach the construction area. Through Section 7 consultation and the implementation of identified BMPs and potential mitigation measures, including USACE permit conditions, sea turtles would be affected, but not adversely affected by 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.
	Operation	Same as Alternative 1 impacts, except long-term operational activities would be closer to Big Blue Reef. 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, potential 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).

11.2.3.4 Alternative 2 Potential Mitigation Measures

Proposed potential mitigation measures for Alternative 2 would be the same as for Alternative 1. As part of the potential 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.

11.2.4 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.

11.2.5 Summary of Alternative 1 and Alternative 2 Impacts

Table 11.2-13 summarizes the potential impacts of each action alternative and the no-action alternative. A text summary is provided below.

11.2.5.1 Summary of EFH Assessment

The EFHA, comparing Alternative 1 and 2, is summarized in Table 11.2-14 and brief text description of coral reef impacts follows. Table 11.2-15 shows the estimated coral area and percentages impacted with 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.

The following is a summary of direct and indirect impacts to coral and coral reef habitat:

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

- Permanent localized destruction to live coral reef benthos
- Long-term disruption to coral reef habitat (recovery could take years)

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

- Short-term and localized disturbance and displacement of mobile FMP 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 live coral reefs from siltation

There are other considerations when assessing the scale of the 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 overall coral community composition within the dredge area are of marginal to modest ecological value, based upon eight criteria (i.e., 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).

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.

Table 11.2-13. Summary of Impacts

Alternative 1	*Alternative 2*	*No-Action Alternative*
Marine Flora, Invertebrates and Associated EFH		
LSI • Insignificant adverse impacts due to localized removal of non-unique species and habitat during construction activities. Species are expected to re-populate quickly. • Long-term, localized and infrequent minor impacts from increased vessel movements.	LSI • Insignificant adverse impacts due to localized removal of non-unique species and habitat during construction activities. Species are expected to re-populate quickly. • Long-term, localized and infrequent minor impacts from increased vessel movements. Long-term operational activities would be closer to Big Blue Reef and may have increased indirect impacts from turning basin maneuvers.	• NI
Essential Fish Habitat		
SI-M • Significant, long-term direct adverse effects to coral and coral reef ecosystems, mitigated to less than significant. • Short-term and localized potential indirect less than significant impacts from sediment accumulation during dredging activities. • 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 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.	SI-M • Significant, long-term direct adverse effects to coral and coral reef ecosystems, mitigated to less than significant. Short-term and localized potential indirect less than significant impacts from sediment accumulation during dredging activities. Dredging operations would be closer to Big Blue Reef and may have increased indirect impacts on coral and coral reef ecosystem. • 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 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.	• NI
Special-Status Species		
SI-M • Significant adverse effect from in-water construction and operation activities, mitigated (including dredging and impact pile driving BMPs) to less than significant.	SI-M • Significant adverse effect from in-water construction and operation activities, mitigated (including dredging and impact pile driving BMPs) to less than significant.	• NI
Non-native Species		
LSI	LSI	• NI

Alternative 1	*Alternative 2*	*No-Action Alternative*
• Expected because vessels would comply with USCG and Navy requirements for ballast water and hull management policies.	• Expected because vessels would comply with USCG and Navy requirements for ballast water and hull management policies	

Legend: SI = Significant impact, SI-M = Significant impact mitigable to less than significant, LSI = Less than significant impact, NI = No impact, BI = Beneficial impact

Table 11.2-14. EFHA Summary for Alternative 1 and Alternative 2 Proposed Actions

Project Activities	*Alternative 1- Polaris Point*	*Alternative 2 – Former SRF*
Construction	The proposed action would have direct and indirect impacts from noise, turbidity, decreased water quality, and other disturbances on EFH and FMP species during dredging and in-water construction activities, including dredged spoils tug and scow movements through Outer Apra Harbor to the ocean disposal site. Direct and Indirect Impacts from dredging activities, which are shown in Table 11.2-14, include: • Removal of approximately 46 ac (19 ha) of benthic substrate (0% coral) with a no adverse affects to EFH. • Unavoidable permanent significant direct impacts to coral reefs from removal of approximately 25 ac (10 ha) of live coral (all classes [>0% to ≤90%]), which may adversely affect EFH and coral MUS. Compensatory mitigation is being implemented to offset this impact. • Unavoidable permanent direct impacts to benthic habitat (0% coral) from removal of approximately 46 ac (19 ha), resulting in no adverse affect to EFH. No compensatory mitigation would be implemented to offset this impact. • Unavoidable short-term and localized indirect impacts to coral 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. This equates to a percent coral cover impacted of 42%, which includes direct and indirect impacts accounting for 35% and 46% of the total area affected, respectively. • Approximately 35% of the proposed dredge area contains some coral coverage and virtually all of the area consists of reefs that were dredged	The proposed action would have direct and indirect impacts from noise, turbidity, decreased water quality, and other disturbances on EFH and FMP species during dredging and in-water construction activities, including dredged spoils tug and scow movements through Outer Apra Harbor to the ocean disposal site. Direct and Indirect Impacts from dredging activities, which are shown in Table 11.2-14, include: • Removal of approximately 37 ac (15 ha) of benthic substrate (0% coral) with a no adverse affects to EFH. • Unavoidable permanent significant direct impacts to coral reefs 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 MUS. Compensatory mitigation is being implemented to offset this impact. • Unavoidable permanent direct impacts to benthic habitat (0% coral) from removal of approximately 37.03 ac (14.98 ha), resulting in no adverse affect to EFH. No compensatory mitigation would be implemented to offset this impact. • Unavoidable short-term and localized indirect impacts to coral 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. This equates to a percent coral cover impacted of 46%, which includes direct and indirect impacts accounting for 39% and 50% of the total area affected, respectively. • Approximately 39% of the proposed dredge area contains some coral coverage and virtually all of the area consists of reefs that were

Project Activities	*Alternative 1- Polaris Point*	*Alternative 2 – Former SRF*
	60 years ago during the creation of Inner Apra Harbor. 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. • Short-term and localized disturbances and displacement of motile species during dredging activities and in-water work. 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. • 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 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. However, with the implementation of BMPs and potential mitigation measures (including compensatory) these impacts would be decreased to no adverse affects to EFH.	dredged 60 years ago during the creation of Inner Apra Harbor. 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. • Short-term and localized disturbances and displacement of motile species during dredging activities and in-water work. 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. • 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 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 already depauperate community. Based on this assessment, the Navy has determined that these long-term impacts associated with Alternative 2 may adversely affect EFH. However, with the implementation of BMPs and potential mitigation measures (including compensatory) these impacts would be decreased to no adverse affects to 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 FMP species due to increased vessel movements in Outer Apra Harbor.	The proposed action would have direct, indirect and cumulative impacts from noise, resuspension of sediment, decreased water quality, and other disturbances on EFH FMP species due to increased vessel movements in Outer Apra Harbor.

Project Activities	*Alternative 1- Polaris Point*	*Alternative 2 – Former SRF*
	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. • 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 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 effects on EFH with the implementation of BMPs and potential mitigation measures.	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. • 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 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 effects on EFH with the implementation of BMPs and potential mitigation measures.

Table 11.2-15. Estimated Coral Area and Percentages Impacted with Implementation of Alternative 1 and 2 Proposed Dredging Activities

Coral Level	*Alternative 1 Polaris Point*					
	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 Former SRF*					
	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.

Essential Fish Habitat for all FMP species, 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 FMP species would be present in the area impacted by the proposed activity. Both alternatives would result in significant impacts to hard corals under EFH-PHCRT. However, these impacts would be mitigated to less than significant through the identified BMPs and through compensatory mitigation measures. Both alternatives would result in less than significant impacts to all other EFH and FMP species.

11.2.5.2 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 ft2 [92 m2]
- 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 associated coral 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.

11.2.6 Summary of Potential Mitigation Measures

Table 11.2-16 summarizes the potential mitigation measures.

Table 11.2-16. Summary of Potential Mitigation Measures

Alternative 1	*Alternative 2*
Construction Activities	
Potential avoidance and minimization measures that would be discussed during required consultations and permitting actions include the following. The results of consultations and permit discussions would form the basis of potential mitigation measures included by the Navy in its ROD implementing the proposed actions. • Incorporate seasonal dredging prohibitions similar to those EPA suggested for the Kilo Wharf dredging activities. o Cessation of dredging operations during the period of peak coral spawning (7-10 days after the full moon in July) in consultation with the Guam Department of Water Resources. o Dredging or filling of tidal waters would not occur during hard coral spawning periods, usually around the full moons of June, July, and August. • No ships would be allowed to enter Sasa Bay at night. An additional potential measure that could be implemented includes: • Provide marine biological resources education and training on EFH, ESA, and MMPA: this may include Base Orders, natural resource educational training (i.e., watching of short Haputo Ecological Reserve Area (ERA) video required before entering reserve areas [e.g., Hanauma Bay]) and documentation (i.e., preparation of *Military Environmental/ N atural R esource Handbook, distribution of natural resource educational materials to dive boat operators*), or a combination of all. The Navy is proposing a suite of potential mitigation option for impacts to coral reefs. Both artificial reefs and watershed management projects are being considered as potential compensatory mitigation, and the final determination may not be made until after the ROD on this EIS/OEIS and during the USACE regulatory process. It is possible that a combination of the mitigation efforts would be appropriate. The various options are listed below. Option 1: Artificial Reefs within Apra Harbor or Other Locations Option 2: Watershed Restoration and Management • Aforestation • Apra Harbor and/or Philippine Sea Riparian Enhancement • Stream bank stabilization component. Option 3: Coastal Water Resource Management • Shallow Water Reef Enhancement • Upgrade Wastewater Management Systems Option 4 : In-Lieu Fee or Mitigation Banking Program Within DoD, regulatory agencies and the Military Civilian Task Force on Guam there is 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	The same potential mitigation measures identified for Alternative 1 would apply to Alternative 2.

Alternative 1	*Alternative 2*
Guam. These programs are not yet established on Guam and would have to 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 potential 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 • Comparison of Artificial Reef and Watershed Management Mitigation Projects.	
Operational Activities	
No potential mitigation measures have been identified in addition to the existing federal, Guam, and military orders, laws, BMPs, and regulations.	Same as Alternative 1.

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