Final Report

Characterization of Benthic Habitat for Saipan Anchorage Commonwealth of the Northern Mariana Islands[1]

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By

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INTRODUCTION

This final report is being submitted in fulfillment of the Scope of Work for Characterization of Benthic Habitat for Saipan Anchorage, Commonwealth of the Northern Mariana Islands, as part of a contract between the Military Sealift Command (MSC) and the Coral Reef Ecosystem Division (CRED) of the National Oceanic and Atmospheric Administration's (NOAA) Pacific Islands Fisheries Science Center (PIFSC). It describes the data collection and processing methods used to complete Tasks 1 and 2, and the results obtained.

Task 1 is defined as Analyze Saipan Bathymetry and Imagery: NOAA/PIFSC shall complete an analysis of the high-resolution bathymetry data, overlain with acoustic backscatter data, that were collected from within the designated anchorage areas off the west coast of Saipan in 2003 during NOAA research cruise OES 0307. NOAA/PIFSC shall develop an interim and final report consisting of both paper and digital maps of the anchorage area. Particular areas of interest may be highlighted with separate maps and three-dimensional views as required.

Task 2 is defined as Collect and analyze optical data in Saipan Anchorage: NOAA/PIFSC shall analyze existing optical (still and video camera) data that were collected from then-accessible areas within the designated anchorage areas off the west coast of Saipan in 2003 during NOAA research cruise OES 0307. NOAA/PIFSC shall assess coverage of the existing 2003 optical data and compare it to locations of specific concern as designated by NAVFAC Pacific. After comparing the location of existing optical data with the designated areas of concern, NOAA/PIFSC shall return to Saipan and collect and analyze any additional optical data as required. NOAA/PIFSC shall analyze the newly collected optical data and develop an interim report. Based upon this interim report, NOAA/PIFSC may provide additional analysis as needed in the final report.

BACKGROUND

The mission of MSC is to provide ocean transport of ammunition, equipment, fuel and supplies to sustain U.S. forces worldwide during peacetime and in war as dictated by operational requirements. As part of the Navy's strategic sealift capability, Maritime Prepositioning Ship (MPS) Squadron Three (COMPSRON THREE) is responsible for tactical control of ships of the MSC Prepositioning Program in the Western Pacific Ocean. In response to the Department of Defense (DoD) Global Forces Program Strategy initiatives, MSC intends to expand the Navy's fleet presence in the Commonwealth of the Northern Mariana Islands (CNMI). In order to meet current operational global forces positioning requirements, the DoD proposes to increase the number of COMPSRON THREE ships on station from 8 to 13. To meet this requirement, MSC has the responsibility for providing these on-station ships. MSC must also increase the operational support in the CNMI region to include increasing the number of anchorage locations.

In the past ten years, the U.S. Federal government has made it a priority to protect and conserve coral reefs, which are being stressed and destroyed by a variety of anthropogenic and environmental factors. All Federal agencies, including the Department of Defense and the Department of Commerce, are mandated to minimize impacts in coral-rich environments. Located at15 degrees north latitude in the warm waters of the western Pacific, Saipan is known to have important coral reef resources; however, no comprehensive maps delineating their locations were available for the Saipan anchorage area. Increasing the number of MSC ships on station in the Saipan anchorage requires the addition of new anchorage sites, which could potentially impact coral-rich environments. A scientific analysis of coral reef resources in the anchorage was needed.

Coincidentally, as part of the NOAA Coral Reef Conservation Program's (CRCP) mission to map all coral reef environments in the U.S.-related Pacific Islands, CRED conducted bathymetric surveys around Saipan between Aug. 23 and Sept. 12, 2003, using their 25-ft survey launch R/V *AHI.* As the first step in mapping benthic habitats, 95% of the Saipan designated anchorage area between depths of 20 and 250m was surveyed with the R/V *AHI's* multibeam echo sounder system. A limited amount of seafloor video was also collected there in August and September 2003 by the NOAA Ship *Oscar E. Sette*, which completed 10 tows with an underwater camera system.

At the time of these surveys, MSC and the U.S. Navy were not aware of NOAA's benthic habitat mapping activities in the Saipan anchorage area. After learning that NOAA had done multibeam mapping around Saipan, Naval Facilities Engineering Command, Pacific (NAVPAC), and MSC contracted CRED to accelerate the analysis of existing bathymetry and imagery data from the anchorage, and to collect additional optical data for further analysis. Processing and analysis of existing data proceeded, and as MSC funds became available, eight CRED personnel and contractors were deployed to Saipan from November 30 to December 17, 2004 to conduct additional bottom videography operations in the Saipan anchorage.

DATA COLLECTION

Multibeam Data Collection

The R/V *AHI* (Figure 1) is equipped with a 240-kHz Reson 8101ER sonar, a POS-MV position and motion sensor, and Science Applications International Corp's (SAIC) ISS-2000 data acquisition software. Both multibeam bathymetric data and backscatter imagery data were logged from the Reson 8101ER sonar. For this survey, data accuracy is estimated at ±5 m horizontal, because no differential GPS was available in Saipan at that time. Vertical accuracy is estimated at ±1 m because: 1) no NOAA-certified tide gauge was available in Saipan (Guam-based tides corrected for offsets to Saipan were used), and 2) these multibeam data for benthic habitat mapping were not required to be collected to International Hydrographic Organization (IHO) Class 1 standards as would be the case with multibeam data collected to update nautical charts.

Figure 1 R/V *AHI*, 25-ft vessel belonging to NOAA, Coral Reef Ecosystem Division. The multibeam bathymetry was collected from this vessel with a 240-kHz Reson 8101ER.

Towed Video Camera Data – 2003

In September and October 2003, the NOAA Ship *Oscar Elton Sette* conducted the first bi-annual Mariana Reef Assessment and Monitoring Program (MARAMP) in the waters of the Commonwealth of the Northern Mariana Islands (CNMI) during cruise OES 0307 and OES 0308. Extensive work was done around all islands of the CNMI chain from Uracus in the north to Guam in the south. As part of this program, routine night operations include videography of the sea floor using CRED's camera sled, the Towed Optical Assessment Device (TOAD). In the Saipan anchorage area, 10 segments of bottom video data were collected on the nights of August 23 and September 9, 2003 (See Figure 3), using the TOAD equipped with a Remote Ocean Systems Multi-Seacam 2050 video camera, two 500 watt Deep Sea Power & Light ML-1050 Multi-Sea Lites, a pressure transducer, and a sonar altimeter. The video signal is relayed by coaxial cable to a topside monitor, enabling the operator to pass commands to deck personnel to pay out or haul in umbilical cable to keep the sled just above the seafloor. A character generator adds the GMT date and time to the video signal, which is recorded on mini-DV tapes using a JVC digital video cassette recorder. The ship's position, depth of the seafloor and camera sled, the sled's altitude above the seafloor and GMT date and time are recorded every 0.5 seconds using Guildline Instrument Group's MiniBAT In-Tow v. 1.1 software and a personal computer running Windows.

Towed Video Camera Data –2004

From December 3-16 2004, CRED personnel and contractors conducted towed video surveys in the Saipan Anchorage, CNMI aboard the 62-ft-long *Carolinian* (Figure 2a), one of the vessels owned and operated by Saipan Crewboats, Inc., and regularly chartered

Figure 2 Survey operations in the Saipan Anchorage, CNMI in December 2004. A) Camera tows were conducted aboard the Saipan Crewboats, Inc. 62-ft vessel *Carolinian* B) CRED personnel on deck during a camera tow as the *Carolinian* approaches one of the US Navy's COMPSRON THREE ships. C) The underwater camera sled. D) The control console, kept below deck housed a digital video recorder, a GPS unit, a laptop for downloading navigation and camera sled location information, and a video screen to monitor the position of the sled relative to the seafloor.

by the U.S. Navy. Operations were conducted (Figure 2b) during daylight hours, with video data collected using a new underwater camera sled (Figure 2c) equipped with a Deep Sea Power & Light Multi SeaCam 2060 color video camera, two 500 watt lights, a sonar altimeter to detect the height of the camera above the seafloor, a pair of parallel lasers to determine the size/scale of viewed objects, a compass to determine the sled heading and orientation, and a depth (pressure) sensor. The camera sled was attached to a control console (Figure 2d) located on board the *Carolinian* via 200 m of 0.5 inch diameter umbilical cable. The camera sled was deployed from the port or starboard side

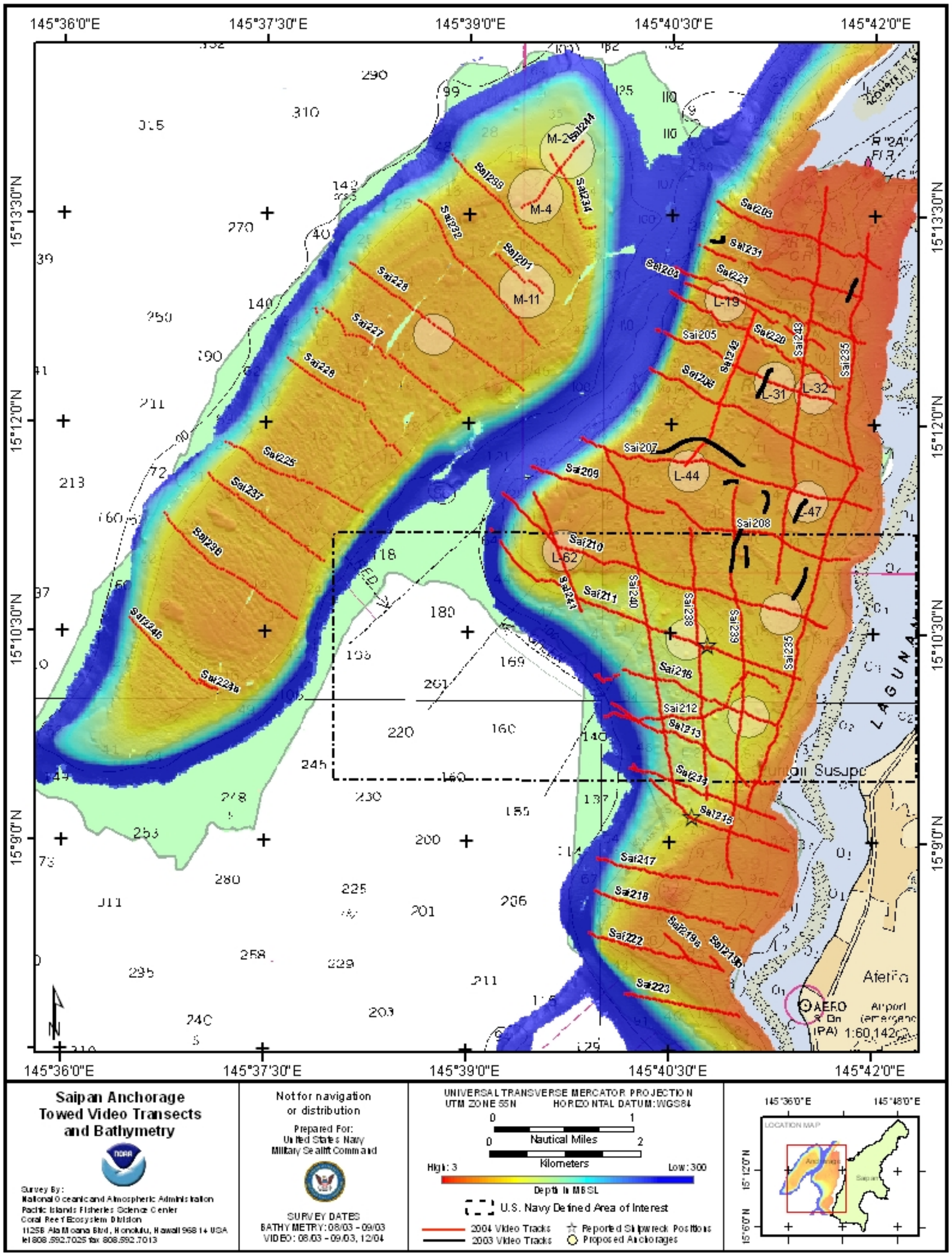

Figure 3 Towed Video Transects and Bathymetry. Bathymetry was collected aboard R/V *AHI* in August/September 2003. Video tows were conducted in August/September 2003 aboard the NOAA Ship, *Oscar Elton Sette*. More extensive towed video data were collected in December 2004 aboard the *Carolinian*.

of the *Carolinian* depending on the prevailing current and wind conditions. A video display monitor mounted on the control console was used to monitor the position of the sled relative to the seafloor. Instructions to raise/lower the sled were relayed to CRED personnel on deck to maintain close proximity of the sled to the seafloor and to avoid collisions with seafloor highs. The video data were recorded to digital video cassette

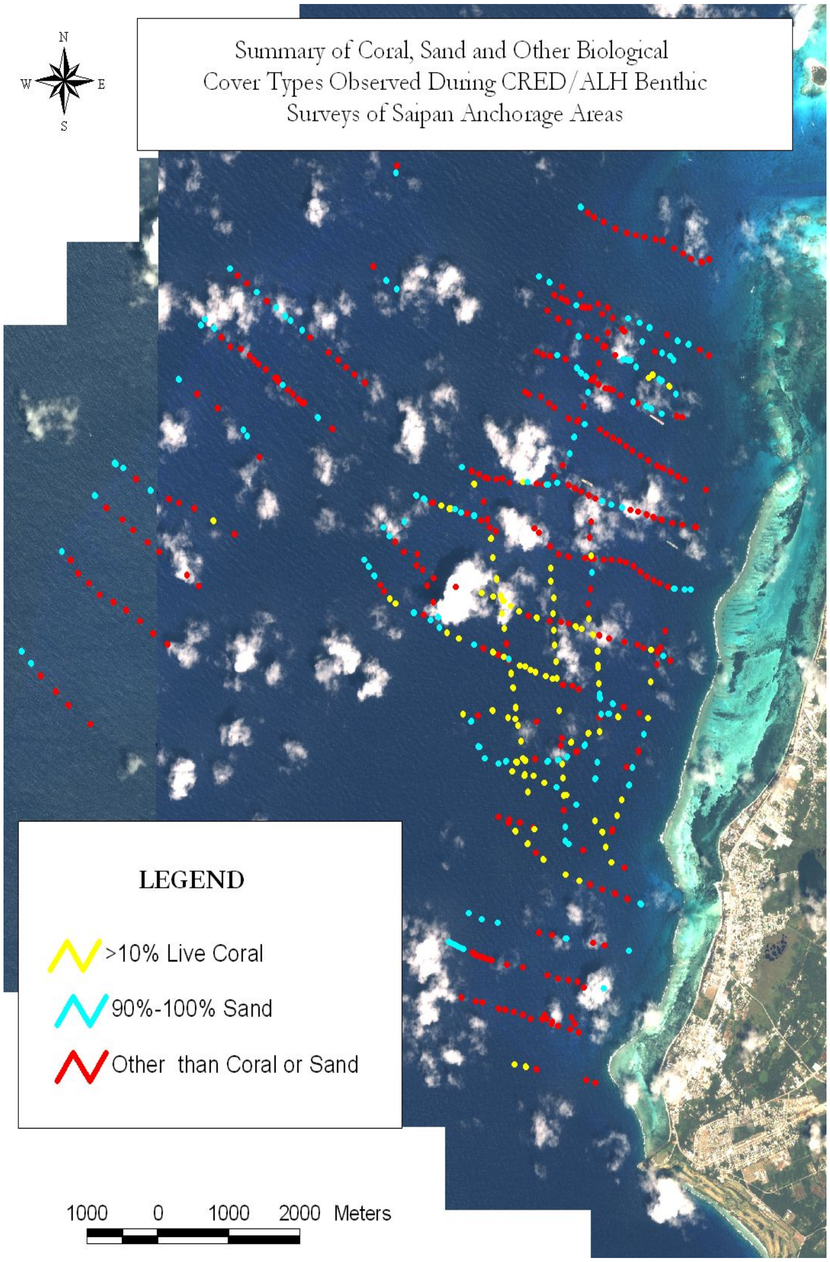

Figure 4 Colored dots show positions of benthic characterizations conducted by ALH. Areas of live coral cover of 10% or greater are highlighted in yellow, 90% or greater sand is highlighted in blue, and sites where neither of these criteria apply are highlighted in red.(ALH 2004).

using a video recorder mounted on the control console. Hypack Max (version 2.12A) hydrographic survey software was used to record GPS data, water depth, length of umbilical cable in the water, and camera sled information (height, heading, etc.), which provide ship and camera sled positions for the duration of individual tows. In total, the video data collected during this operation provide *in situ* optical coverage of 120 linear kilometers of the Saipan Anchorage (Figure 3, and Appendix B).

In addition to CRED personnel, contractors from Analytical Laboratories of Hawaii (ALH) were aboard the *Carolinian* and conducted real-time benthic habitat characterizations (Figure 4). A hand held Trimble Geo Explorer 3 was used to collect the GPS data during benthic habitat characterization intervals and Trimble Pathfinder Office Software was used for all post processing of the raw GPS. Habitat attribute information was collected on site using the GPS data logger with a custom data dictionary designed to reflect the NOS classification scheme for benthic habitats of the Pacific (ALH 2004).

DATA PROCESSING and RESULTS

The multibeam bathymetric data collected in 2003 (Figure 5 and 6 and Appendix A) were processed at CRED's Honolulu processing center, located at the University of Hawaii,

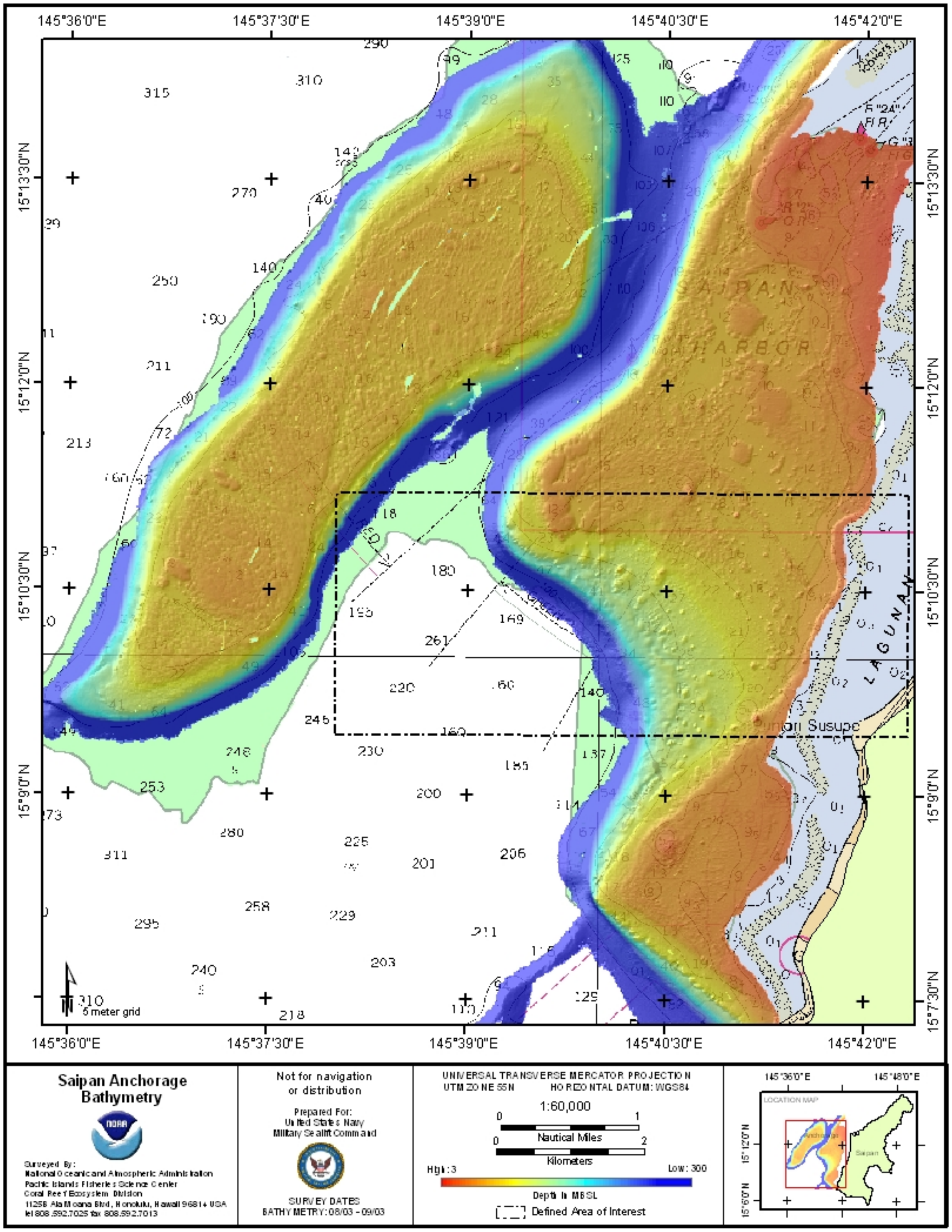

Figure 5 Multibeam bathymetry, with a hillshade underlay to emphasize relief, of the Saipan Anchorage.

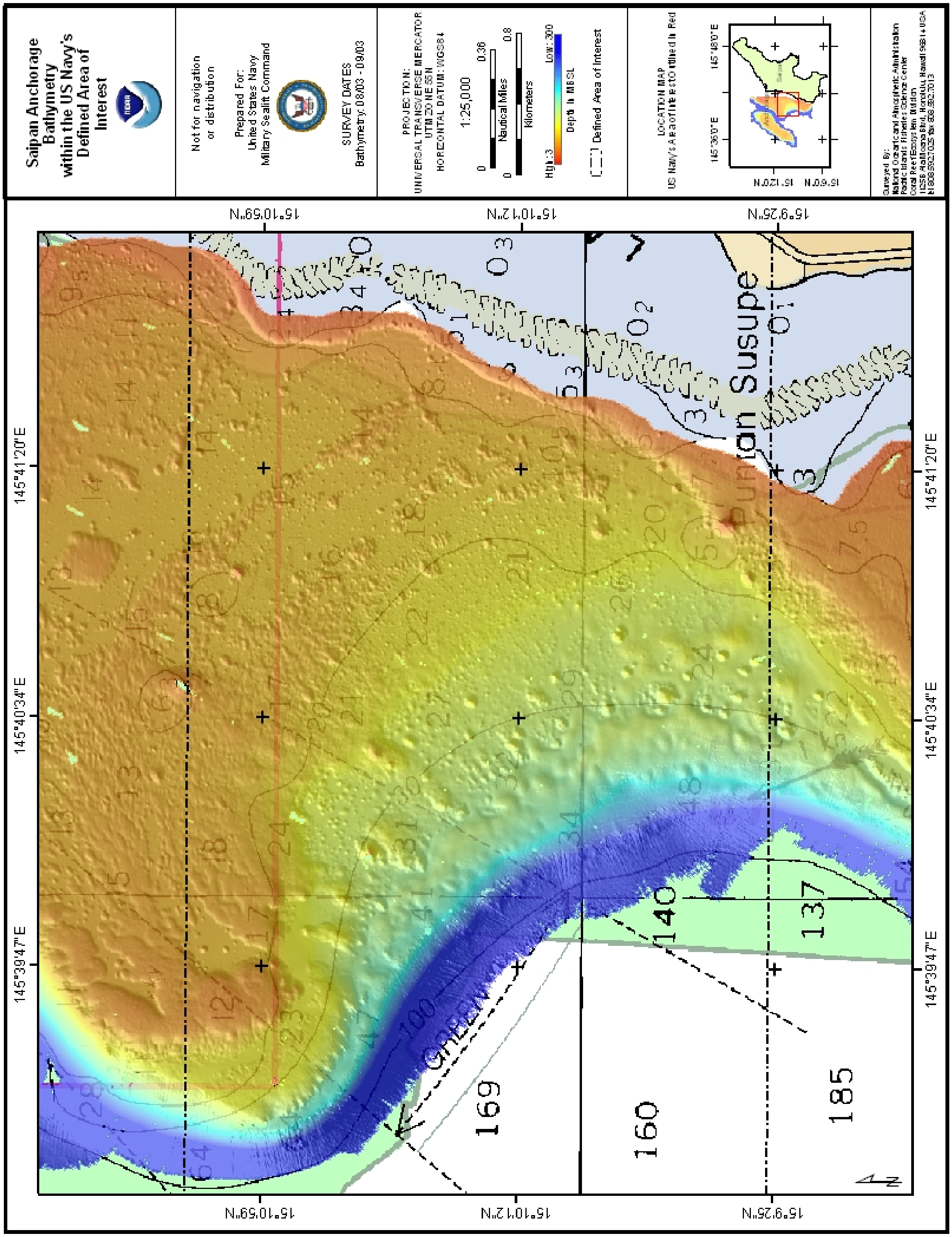

Figure 6 Multibeam bathymetry, with a hillshade underlay to emphasize relief, of the US Navy's defined area of interest for future anchorage locations within the Saipan Anchorage.

using SAIC's SABER software (www.saicnewport.com, Depner et al, 2002), and the publicly available MB-System (Caress and Chayes, 1995) and Generic Mapping Tools (GMT) (Wessel and Smith, 1991) software packages. Bathymetry processing included re-correction for sound velocity and observed tides, and manual editing to remove soundings that were obviously erroneous. Preliminary processing was completed in July 2004.

A standard component of CRED's mapping protocol is that multibeam bathymetric data are processed and made available to resource managers and research partners. Gridded 5-m bathymetric data for Saipan and other areas are now available on the PIFSC Web site: http://www.pifsc.noaa.gov/cred/hmapping. Metadata files for the gridded bathymetry were created and have been certified as being Federal Geospatial Data Committee (FGDC) compliant by NOAA's Coral Reef Information System (CoRIS). The metadata file associated with the Saipan anchorage grid is provided with this report and includes full details of bathymetric data collection and processing (Appendix E).

Backscatter imagery was processed using MB-System, an open source software package (http://www.ldeo.columbia.edu/res/pi/MB-System) for the processing and display of bathymetry and backscatter data, and software developed in-house by the Hawaii Mapping Research Group at the University of Hawaii. Each pixel of backscatter imagery displays the measured intensity of acoustic backscattering from the seafloor, which is related to seabed roughness and density differences across the seafloor. Backscatter data aid in distinguishing seabed substrate type (i.e. rock vs. sand) and can be a valuable tool for benthic habitat classification.

To analyze seafloor videography collected by the TOAD camera sled deployments, a series of five small circles extending in a straight horizontal line were marked on a video monitor screen. The type of substrate (sand, rock, etc.) and living cover (macroalgae, scleractinian coral, hydrocorals or other benthic fauna, etc) falling within these circles are identified at 20 m increments along the TOAD track. Other biologically relevant observations were made as well. The full listing of benthic habitat classifications made can be seen in Appendix F. Classification codes for each 20 m increment were entered into spreadsheets for each tow. Tracks of camera sled position for the 2003 and 2004 surveys are shown in Figure 7. The metadata for the 2004 towed video transects are also included with this report and relay details about the video collection and preliminary processing steps used to retrieve and view the data in a format compatible with ArcGIS (Appendix G).

In many instances, although live corals or other organisms can be identified within a video frame, it is difficult to discern the nature of the seafloor under the five circles. The primary cause of this uncertainty is insufficient light, although too high an altitude of the TOAD above the seafloor and slightly blurred imagery resulting from the moving camera not being able to instantaneously adjust focus are also contributing factors. The lack of light was a problem for the 2004 survey and resulted from quartz halogen lamps that turned out to be too fragile for seafloor videography. During the 2003 survey, 500W 120 VAC lamps were used. In 2004 however 500W 240 VAC lamps were used, for reasons described below. After initial discussions with NAVFAC Pacific, CRED was advised that funding for this project would be provided soon, and that the rapid collection and analysis of new data was of paramount importance. Recognizing that the design and construction of camera sleds deployable from small boats would take several months, CRED personnel initiated that process. Rather than waiting for custom umbilical cables to be fabricated, CRED's lead contractor for the sleds recommended using a stock cable available off the shelf. Since conductors in that cable are too thin to support the current associated with 120 VAC lights, he further recommended switching to 240 VAC lamps which would enable the new sleds to still operate two 500W lights. The contractor had used those lamps extensively in a fleet of leased ROVs and did not have problems. However, for the camera sleds to collect data of sufficient resolution to enable the identification of benthic biota, they must be towed very close to the seafloor. This results in occasional inadvertent but inevitable contact with the seafloor. Although the 120VAC lamps are robust enough to handle those shocks, the thinner filaments in the 240VAC lamps repeatedly failed, quickly depleting our stock of spares.

For tow videos collected in 2004 that did not have lights or were not very close to the seafloor, corals, hydrocorals, octocorals, sponges, etc. can only be identified if they have a color that shows up in the videos as being slightly different from the surrounding substrate, or by displaying a distinct branching or lobate morphology. Smaller colonies or those with an encrusting morphology can often not be identified, so percentages reported here of the seafloor covered by living cover coral or other benthic fauna must be assumed to be minimum estimates. Note also that 95% of the benthic fauna reported are corals, with most of the remaining 5% identified as soft corals and a few other organisms.

Analysis of particularly close and clear TOAD video data, in conjunction with diver observations, suggest that hard substrate (rock, rubble, etc) that is not obviously colonized by distinct coral colonies is usually colonized by macroalgae, turf algae or coralline algae. In fact, hard substrate in coral reef ecosystems that is not otherwise colonized is almost always covered by a thin community of algal turf. Accordingly, for situations in which it was not possible to directly distinguish the type of living cover on hard substrate, it was classified as "Unclassified algae," which includes macro, turf, and coralline algae. This assumption was tested using a series of short seafloor video segments taken by scuba divers, over six areas that had been covered by camera tows. Holding a video camera one meter above the seafloor, divers slowly moved along a transect line aiming the camera straight down. Using a high-resolution camera held at an ideal altitude and angle, and by allowing more time for it to focus, these video segments show detail that is usually not discernible in the towed videos. Although the videos collected by hand reveal an occasional sponge, coral, or other encrusting organism that is unlikely to be discernible in the towed videography, they suggest that the living cover identified as unclassified algae is correct for more than 90% of the instances in which it is applied.

For videography collected in 2003, ship's position and time data recorded to data files by the In-Tow software are converted to ArcView shapefiles using ArcView extensions specifically written for that purpose. The actual position of the TOAD is estimated to be not more than 50 m from the reported position. Estimates of camera sled position for the 2004 videos are recorded in Hypack software and exported as text files, which are imported into ArcGIS and converted to shapefiles. The Hypack software used in the 2004

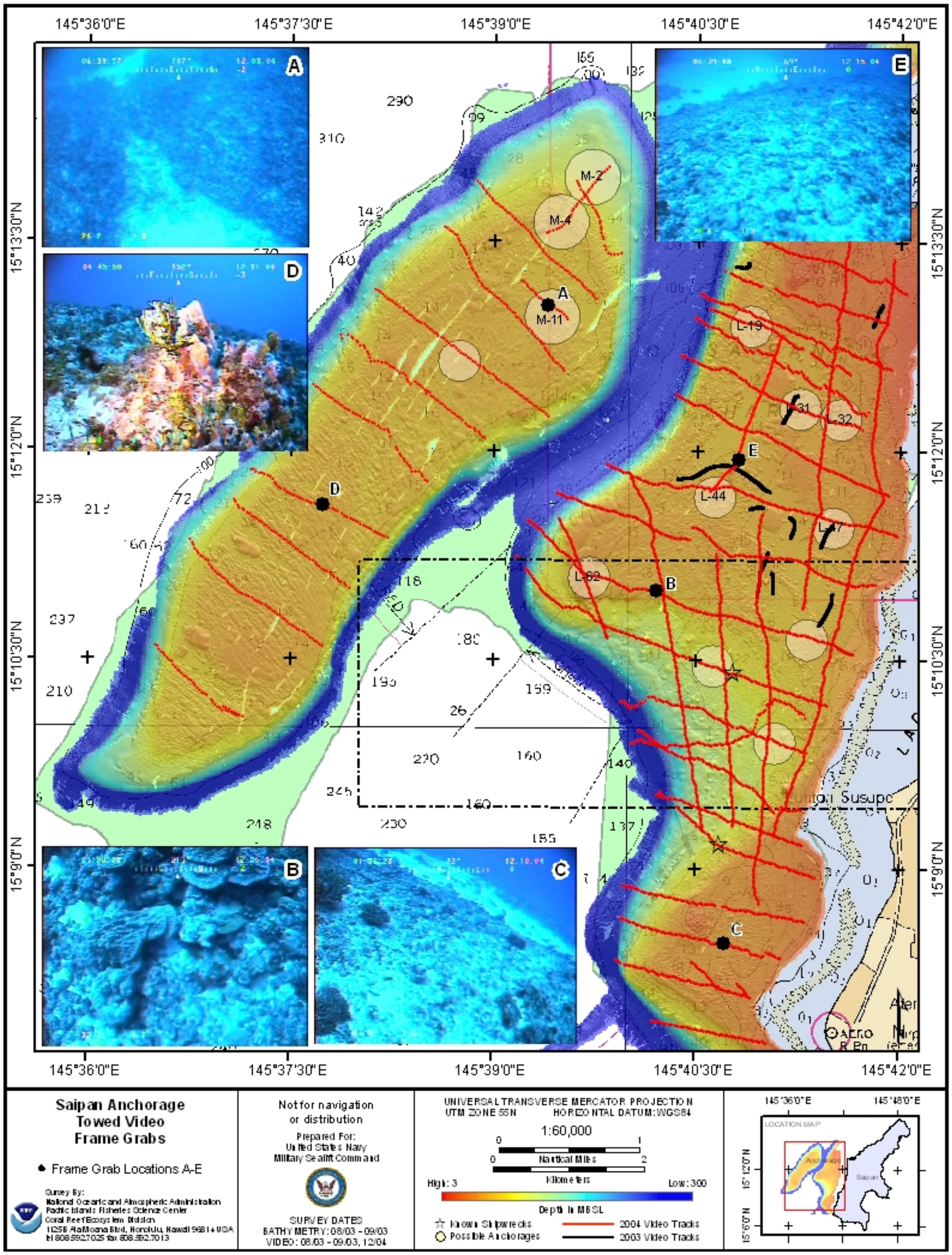

Figure 7 Towed Video Tracks and Frame Grabs. These images of representative benthic environments were extracted from towed video that was collected in December 2004. Note that the video interleaving process yields frame grabs that have half the resolution of moving video.

data collection includes a window for manual entry of the length of camera sled cable paid out, a utility to enter horizontal and vertical offsets between the GPS antenna and sheave over which the camera sled cable passes, and a built-in caternary function. Using these additional data, the Hypack software automatically adjusts the position of the GPS antenna to generate and record an estimate of camera sled position. Analysis of tow data indicate that horizontal positional uncertainty associated with the location of the camera sled recorded in Hypack is ± 13 m. Spreadsheets with benthic classification data from video analysis are attributed to the appropriate tow track shapefile and along-track location. Color coding is then applied to highlight features of interest, such as the percentage of the seafloor covered by living corals or other benthic fauna found at each location (Figure 8) or different types of substrate (Figure 9).

Although the surface area of the shelf on which the Saipan anchorages are located is only a few tens of square kilometers and was subject to an intensive optical survey effort, only a few percent of the area was videotaped. It is not practical to get complete optical coverage of the seafloor that is useful for benthic habitat classification purposes, for other than extremely small areas, using any technology available today. Given the federal government's mandate to avoid damaging coral rich areas, planning the location of new anchorages is likely to require data coverage more extensive than we were able to collect. However, the distribution of coral reef communities will be controlled by the availability of suitable substrate at appropriate depths, the level of disturbance from natural and anthropogenic causes such as storms and anchor chains, and oceanographic conditions including the current regime and water quality. Although the hydrodynamic study is underway and those data are not yet available, it is reasonable to assume that broad areas within the anchorage will be subject to generally similar environmental conditions, leading to coextensive biological communities. The distribution of living coral and other benthic fauna seen in Figure 8 suggests that this is a valid assumption, and justifies interpolating the type and density of biological communities between survey tracks. However, not all substrates are suitable for coral recruitment and growth. For example, sandy areas can not generally sustain growth of hermatypic (reef forming) corals or other sessile benthic fauna, so a simple interpolation of the percentages they cover is likely to over estimate populations on these substrates. CRED researchers have invested considerable effort in looking for ways to reliably interpolate percentages of live coral reef communities, and to distinguish between different substrates using the bathymetric data and backscatter imagery. CRED personnel originally intended to use some derivative of bathymetry such as a bathymetric position index to generate a gridded surface of numerical values to use in conjunction with an interpolation method to estimate percentages of corals between tow tracks. A number of variations of this and other approaches were tested, with varying degrees of success. However, no method produces results that are free of obvious defects. The technique that produced the best results is described below.

Spatial interpolation allows us to predict values at unsampled locations. First order interpolation methodologies (such as regression or splining) can reliably capture simple trend surfaces if all data measurements are independent. These data do not support such

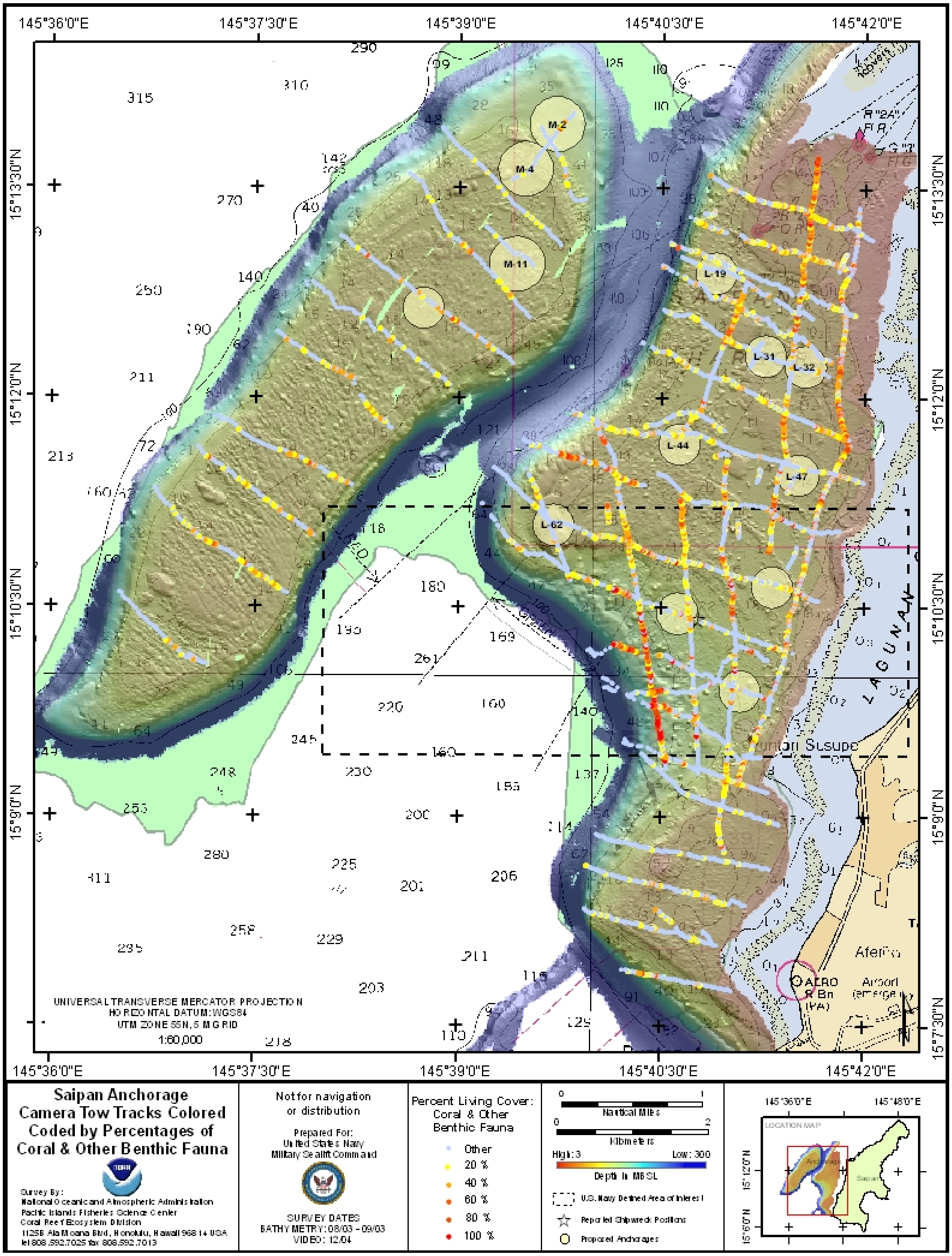

Figure 8 Camera tow tracks from the 2004 fieldwork, classified by the percentage of seafloor covered by corals and other benthic fauna, overlying shaded bathymetry.

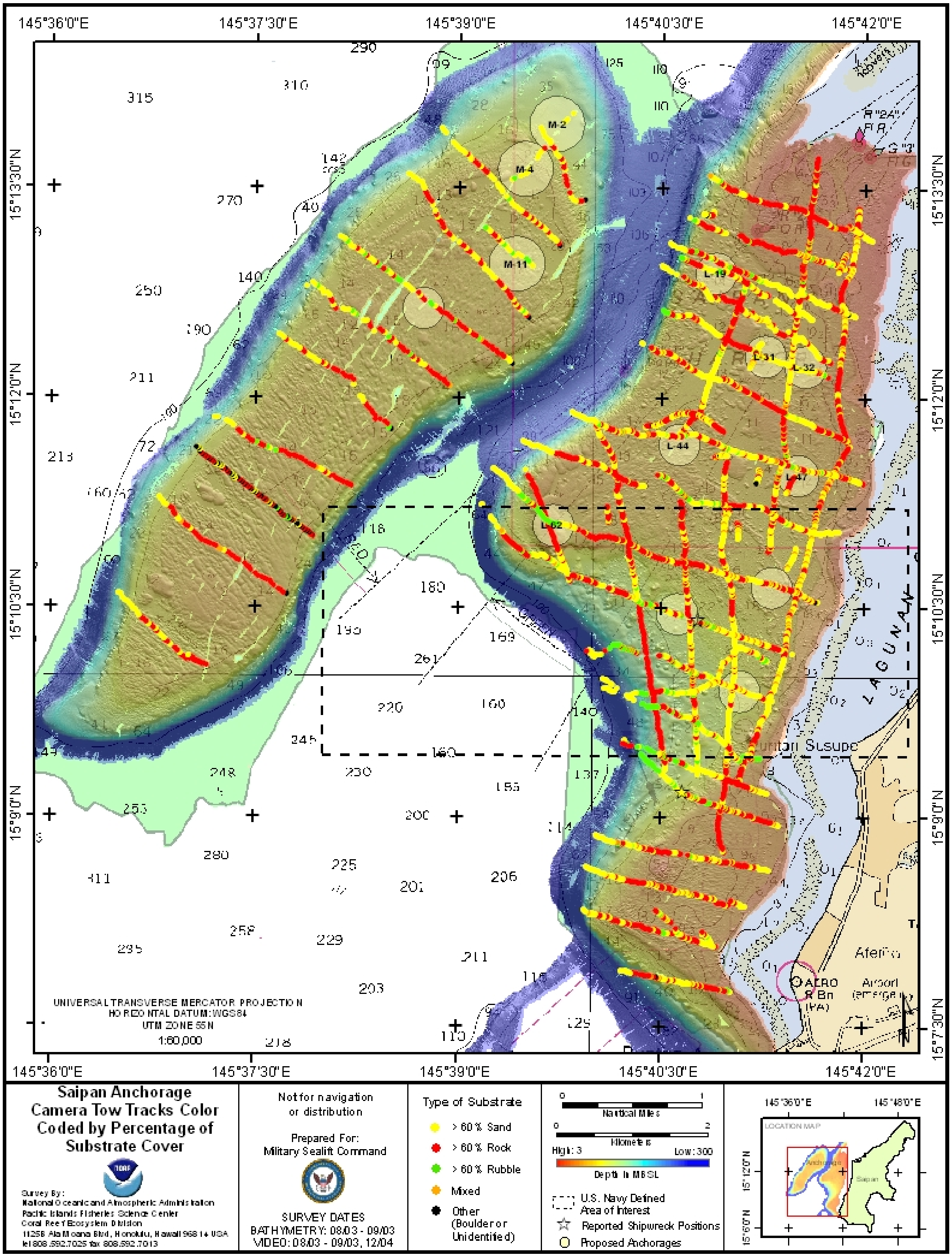

Figure 9 Substrate composition in the Saipan Anchorage area.

an assumption of independence because they are autocorrelated and patchy in distribution. Therefore, the interpolated maps of living cover of corals and other benthic fauna presented here (Figures 10, 11 and 12) are derived using a geostatistical method of interpolation called Kriging. The Kriging method takes into account spatial autocorrelation, the statistical relationship among the measured points based on proximity. Kriging is a robust interpolation method that accounts for spatially correlated distance or directional bias in the data. It assumes that the distance and/or direction between sample points reflect a spatial correlation that can be used to explain variation in the surface (Oliver, 1990). Kriging fits a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location. There are multiple types of Kriging, each of which is most appropriate for a particular data set. Universal Kriging was used for these analyses because this method takes into account certain discernable trends in the data, such as directionality and non-random patchiness (Pawlowsky-Glahn and Olea, 2004). For these surface maps of coral and other benthic faunal cover, a first-order polynomial was used to de-trend the data (identify the degree of patchiness). Using the resulting variogram, a search radius of 15 classified sample points was identified as the most appropriate number of samples needed to best fit the mathematical function, with a minimum of 5 classified neighbors used to determine the output value for the surrounding surface. The maps presented are prediction surfaces, and have a prediction error associated with each interpolated area, as shown in Figure 13. The entire kriging process, with details about the semivariograms, anisotropy values, and neighborhood values used for these interpolations, can be found in the ArcMap project titled “Sai-Krigged-Coral.mxd” on the enclosed DVD.

The map of sand basins was created using a combination of techniques. The 5-meter bathymetry grid was the source of data for all derived bathymetry products, including this map. First, sand areas were derived using a local fourier histogram approach (LFH) (Cutter et al., 2003). This grid was compared and combined with a grid that was created using a first derivative of the slopes from the bathymetry grid. This slope of slopes was then transformed into a focal flow derivative. The basic assumption of the focal flow function is that if the value of a cell in the immediate eight-cell neighborhood is greater than the value of the processing cell, then the neighboring cell will flow into the processing cell. To test whether a particular neighborhood cell will flow into the processing cell, the value of each neighborhood cell is subtracted from the processing cell. If a value is positive, the neighborhood cell does not flow into the processing cell, and if it is negative, it does. If no cells flow into the processing cell, then the location will be assigned a value of '0'. All negative values were designated as receiving basins. All basins that were smaller than 750 m^2 were removed from the final map representation, under the assumption that the resolution of the bathymetry grid was not fine enough to allow for any better spatial discrimination using these methods. Striping that can be seen in the sand basins reflects artifacts from the bathymetry data. The map of sand values was overlain on the map of interpolated benthic faunal cover. Areas covered by sand basins are assumed to be devoid of corals and other sessile benthic fauna.

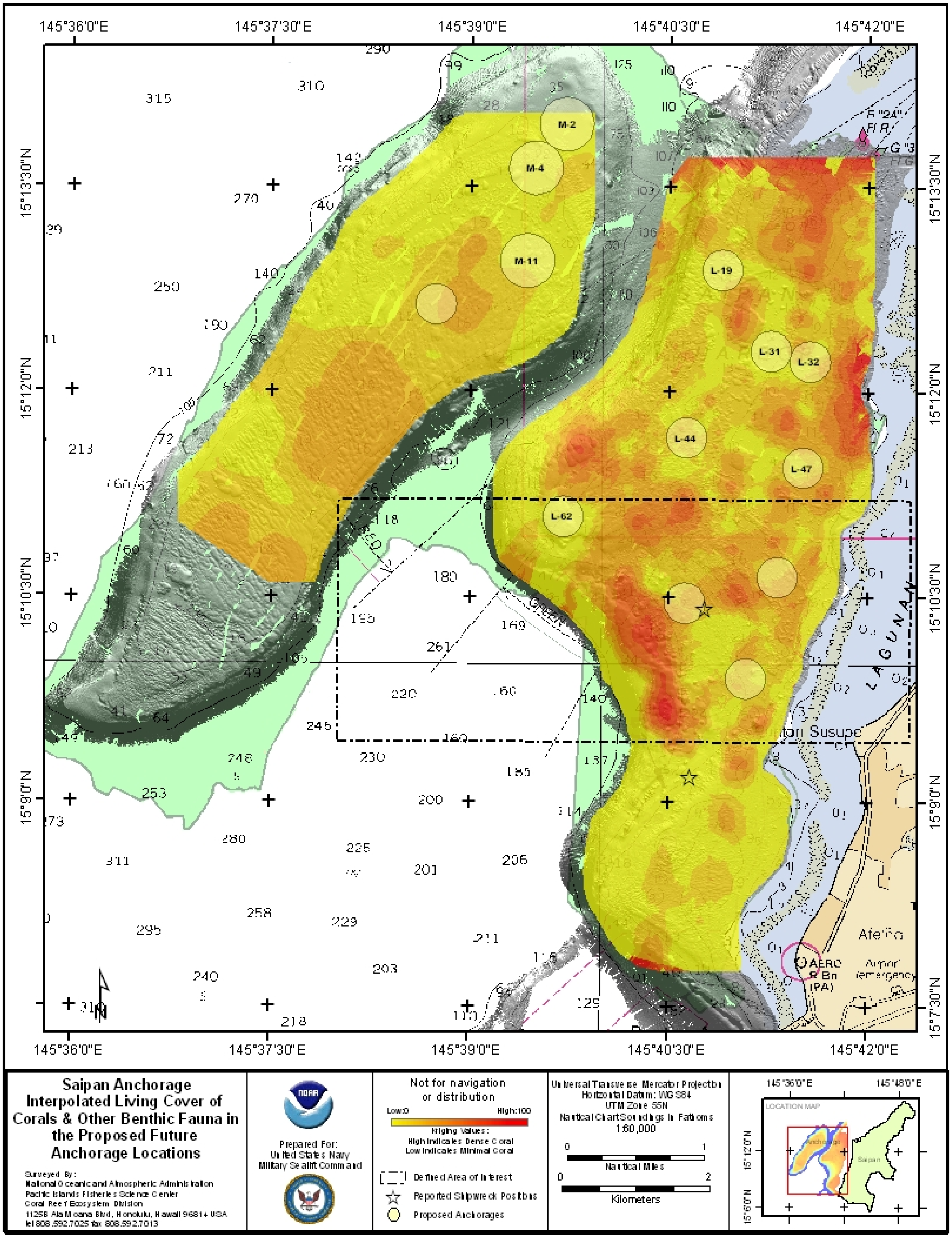

Figure 10 Interpolated values for the percentage of the seafloor covered by corals and other benthic fauna in the Saipan Anchorage area. Interpolated values should be considered markedly less reliable that measured coral cover percentages from tow tracks.

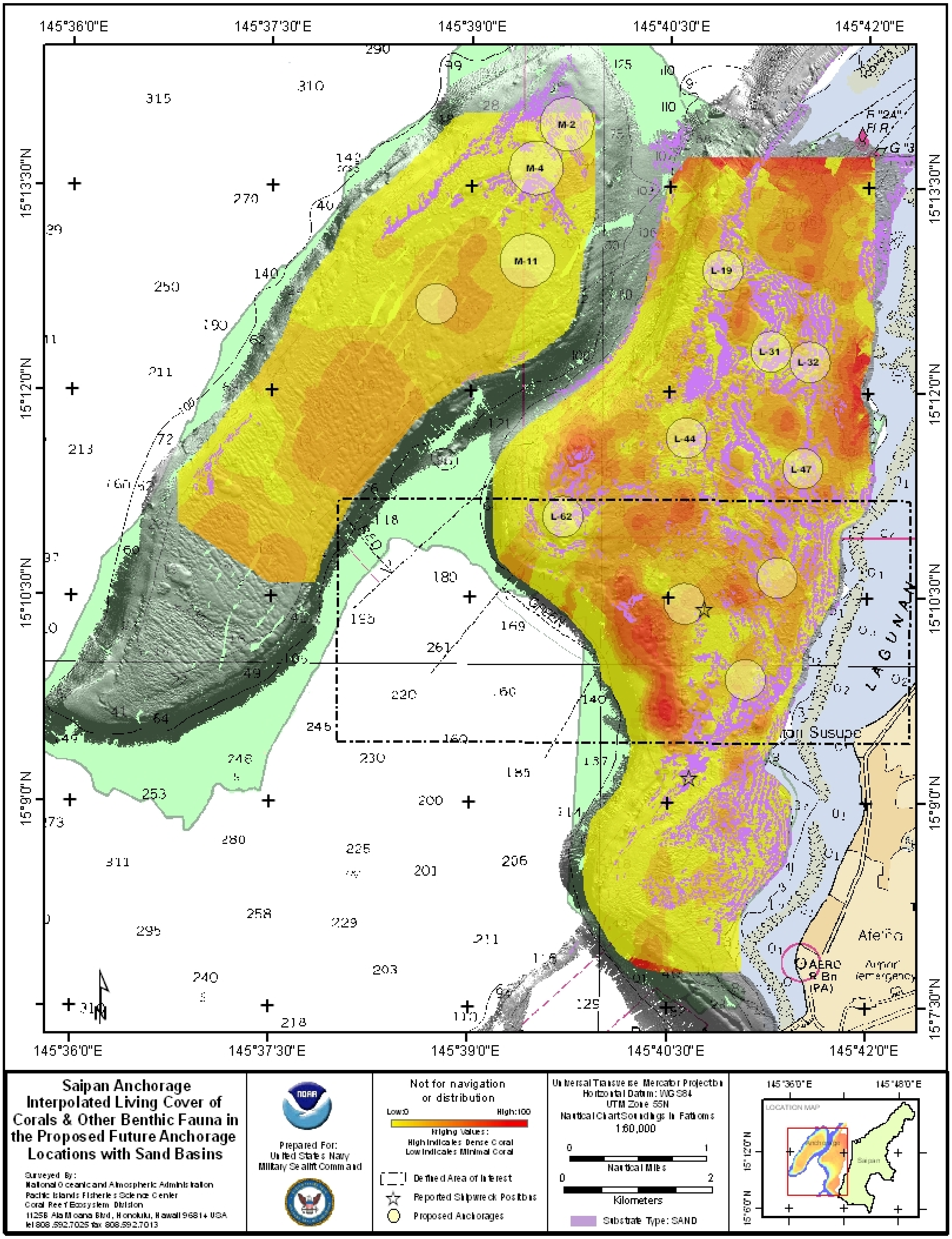

Figure 11 Interpolated percentage of the sea floor covered by living coral and other benthic fauna, and estimated locations of sand basins, in the US Navy's defined area of interest for future anchorage locations. Interpolated values should be considered markedly less reliable that measured percentages from tow tracks.

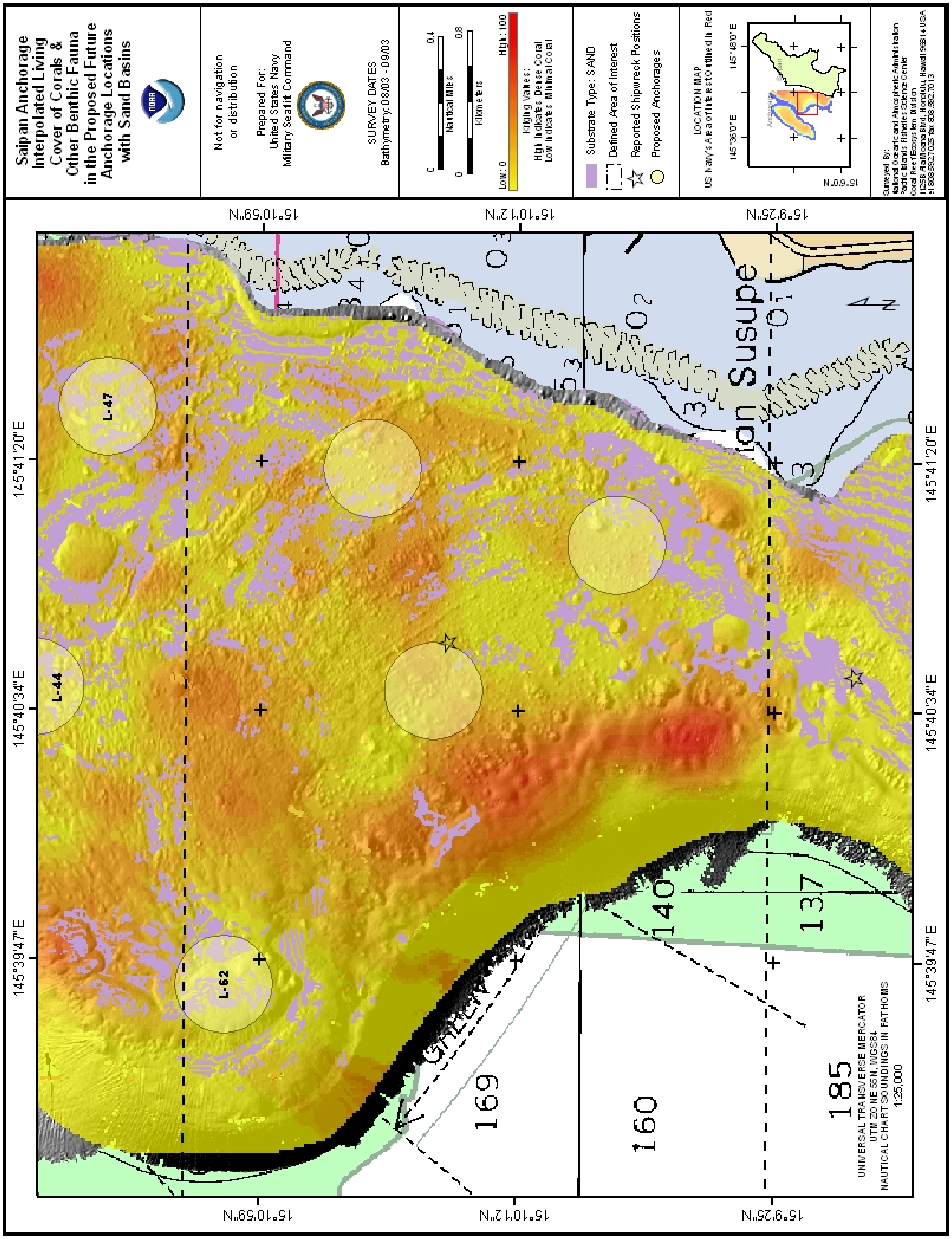

Figure 12 Interpolated percentages of the seafloor covered by living corals and other benthic fauna, and estimated locations of sand basins, in the proposed future anchorage locations in the Saipan anchorage area. Interpolated values should be considered markedly less reliable that measured coral cover percentages from tow tracks.

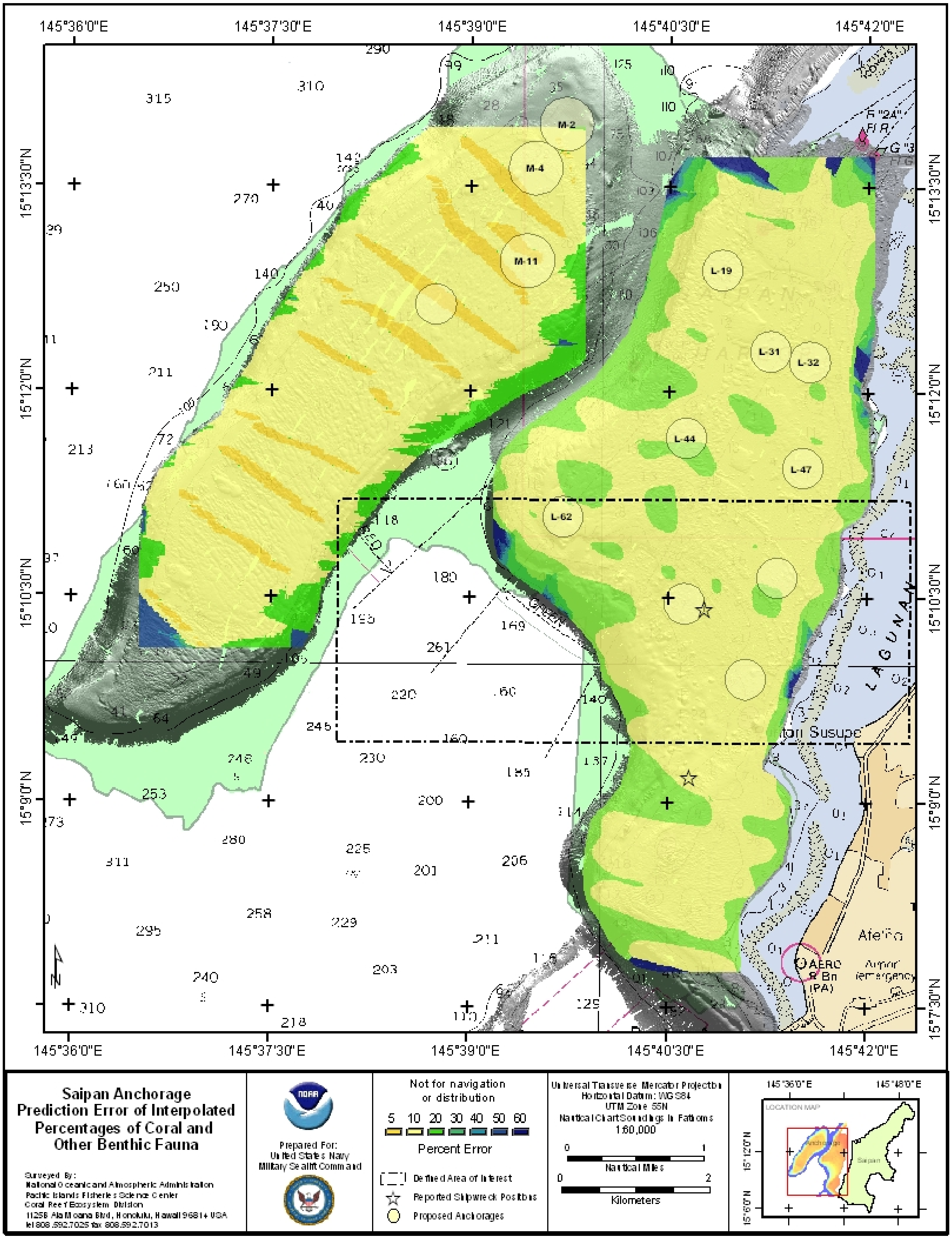

Figure 13 Prediction error for interpolated percentages of the seafloor covered by living corals and other benthic fauna in the Saipan anchorage area. Values are shown as percent of possible error.

CONCLUSIONS AND RECOMMENDATIONS

Given the mandate to avoid rich coral reef communities, this study and data collection was designed to detect and quantify live cover of coral and other benthic fauna using imagery from towed camera sleds. Although large and distinctively shaped colonies were reliably detected, where video image quality was poor it was difficult to identify smaller colonies or those with encrusting morphologies. Consequently, living cover was probably underestimated. Although some soft corals, sponges and a few other organisms were found, 95% of the benthic fauna were identified as hard corals. Video quality may have been degraded by a number of factors including insufficient light, camera sled altitude or camera angle that results in too great a distance between the camera and seafloor, turbidity in the water column, etc.

Living benthic faunal cover between tow tracks was estimated using an approach based on Universal Kriging. Although the method appears to generally correctly identify areas that are known to have significant live coral reef, it also produces obvious artifacts related to the tow track pattern that may over or under estimate quantities of reef organisms in some areas. Interpolated values of living fauna cover are markedly less reliable than measured values from tow tracks. It appears from our observations that natural distribution patterns of coral reef communities in the anchorage are patchy to begin with, making it difficult to predict the community structure in unsurveyed areas. The natural pattern has been further confused by decades of anchor chain damage which has devastated large areas, further precluding our ability to provide better estimates of coral communities between camera sled tracks. It is important to note also that although we show the entire gradient of percentages, most classification schemes identify areas with coral communities covering of 10% to 20% or more as being coral rich. Given the mandate to avoid rich coral reef communities, those should be avoided in planning future anchorage sites.

Areas with high percentages of living coral and other benthic fauna, and/or high relief and rugosity which can provide cover for other invertebrates and fish, can be considered "biologically significant areas." Some of these have been identified, as the increasingly reddish or dark areas, in Figures 8, 10, 11 and 12. Although the interpolated maps fit the existing data reasonably well, the patchy distribution of benthic communities in the Saipan Anchorage preclude the positive identification of all biologically significant areas. There are many pinnacles and mounds throughout this area that were not covered by tow tracks, some of which are likely to have high concentrations of corals, fish, and marine invertebrates.

The U.S. Navy's defined area of interest for locating additional anchorages contains the most coral-rich community on the entire shelf, as well as numerous other biologically significant areas. However, the shelf south of the defined area and the outer shelf contain fewer rich coral reef communities and biologically significant areas. These are much more appropriate sites for anchorages from an environmental perspective. Although it is particularly important to avoid anchoring in biologically sensitive areas, it must be pointed out that unlimited anchoring anywhere in the anchorage will have a deleterious effect on coral communities.

Another possible alternative may be for the new anchorages to utilize an anchoring system that impacts a smaller area (e.g., permanent moorings). Given the long scope of anchor chain paid out by COMPSRON THREE vessels, it is difficult to pick out anchorage locations within the defined area that do not include biologically significant sites. During both the 2003 and 2004 field surveys we observed COMPSRON THREE ships that had strayed outside of their designated anchor circles. To the best of our knowledge, the ships typically pay out about as much scope of anchor chain as the diameter of the designated anchor circles and some were observed to swing in an approximately 60 degree arc depending on the state of the winds and currents, so it is not surprising that they will occasionally drift outside the bounds of an anchorage. Given the multiple times that we observed vessels outside their designated anchor circles over the short durations of our surveying, it would be unrealistic to not assume that that will also occur in the future. Accordingly, we recommend that a buffer wider than the existing anchor circles be considered when planning the location of new anchorages relative to biologically significant areas.

We strongly recommend that any sites selected as new anchorage locations be more intensively surveyed to ensure that coral-rich and biologically significant areas are not present. The size and depths of the proposed anchorage circles precludes their effective coverage by traditional scuba diving surveys. A better approach would be towboard surveying. In this method, pairs of divers are towed behind a boat while holding onto towboards on which are mounted digital still and video camera systems, various other instruments, and a signaling telegraph to communicate with the towing vessel. Towboard surveying can cover up to several linear kilometers per hour and has been used extensively for surveying around many Pacific Islands. Typically limited to depths of approximately 30 m, use of oxygen enriched air (nitrox) breathing gas would enable towboard teams to safely survey at depths of up to approximately 40 m. Towboarding would be an effective means for collecting several linear kilometers of optical imagery within a single anchorage circle, following pre-planned tracks on a handheld GPS receiver. For deeper anchorage circles however, towed camera systems would still be required. Track lines would have to be spaced much closer together than was the case for the surveying reported here, but that would be feasible given the much smaller areas that would need to be covered. High intensity discharge lights and slower towing speeds would enhance the quality of imagery collected by towed camera sleds for these surveys.

To date, efforts to infer with the occurrence of coral-rich communities in the Saipan anchorage area have relied on the location of optical imagery, and used a range of statistical techniques to estimate coverage between imaged areas. However, strong and apparently tidally-influenced currents have been observed in the anchorage and may influence where corals and other benthic fauna are likely to grow. Occasional storm waves or long period swell may also have an effect. Results of hydrodynamic studies may indicate areas of the seafloor subject to concussive impacts of breaking waves large enough to physically break corals, or areas of shear stress sufficient to or scour away coral communities during storm conditions. They may also provide insights on the strength and direction of currents over the anchorage that may encourage or inhibit the successful recruitment and growth of corals and other reef organisms. Accordingly, results from the ongoing hydrodynamic study may provide insights that would be useful for future efforts to refine models of coral community distribution in the anchorage.

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APPENDICES

Appendix A. Multibeam Bathymetry (Large format plot folded in pocket)

Appendix B. Bathymetry Percentages of Live Coral and Other Benthic Fauna along Tow Tracks (Large format plot folded in pocket)

Appendix C. Interpolated Percentages of Living Cover of Corals and Other Benthic Fauna (Large format plot folded in pocket)

Appendix D. Interpolated Percentages of Living Cover of Corals and Other Benthic Fauna Overlain by Sand Fields (Large format plot folded in pocket)

Appendix E. Interpolated Percentages of Living Cover of Corals and Other Benthic Fauna Overlain by Sand Fields in the Proposed Future Anchorage Locations (Large format plot folded in pocket)

Appendix F Digital Version of Final Report, Maps, Figures, and GIS Layers (DVD)

Appendix G Metadata for Multibeam Bathymetry – Available online at http://www.pifsc.noaa.gov/cred/hmapping/datadownload.html

Identification_Information:

Citation:

Citation_Information:

Originator: Benthic Habitat Mapping Group, CRED, PIFSC, NOAA

Publication_Date: 20040504

Title: saipan_anc_5

Geospatial_Data_Presentation_Form: raster digital data

Online_Linkage:

\\ahi10.soest.hawaii.edu\GIS\GIS_Data\CNMI\Saipan\Bathymetry\saipan_anc-5\saipan_anc_5

Description:

Abstract:

Gridded bathymetry of Garapan Anchorage off Saipan Harbor, Commonwealth of Northern Mariana Islands. Almost complete bottom coverage was achieved on these extensive banks in depths between 20 and 250 meters.

Purpose:

This grid was created using data gathered from multibeam soundings for use as a planning and reference document. Refer to supplemental information for description of instrument and survey.

Supplemental_Information:

Data were collected aboard the R/V AHI (Acoustic Habitat Investigator), a 25 survey launch owned and operated by the NOAA Pacific Islands Fisheries Science Center in Honolulu, HI. The R/V AHIs survey sensors include a 240 kHz RESON 8101-ER sonar providing bathymetry and imagery data, a TSS/Applanix

POS/MV Model 320 which measures position, velocity, attitude and heading, and a Seabird SBE 19 CTD used to measure sound velocity profiles.

Equipment serial numbers and software versions are as follows:

RESON 8101-ER multibeam echosounder DOC inventory #: CD0000537418 Firmware, dry: 8101-2.07-2D4D Firmware, wet: 8101-1.06-2F6B

POS/MV Model 320, version 3 DOC inventory #: CD0000476647 PCS serial #: 474 IMU serial #: 203 Controller software: v 1.0.5.0

Seabird SBE19 CTD: Serial #: 3029

R/V AHI Lever Arm Distances and Alignment Offsets The R/V AHI Reference Point (RP) is defined to be the intersection of the vessel's centerline, the cabin deck and the bulkhead immediately aft of the transducer. This is marked by a punch in the deck weld at that location. Positive X means the point is forward of the RP, positive Y means the point is to starboard of the RP, positive Z means the point is below the RP. The loaded waterline is defined as the intersection of the vessels performance wing with the hull at the transom.

Antenna Baseline Distance, m: 1.229 Transducer depth below waterline, m 0.62

RP to IMU 0.80 0.00 0.08 RP to Primary GPS Antenna -3.55 -0.61 -1.88 RP to Vessel 0.16 0.00 0.77 RP to Sensor 1(MB transducer) 0.16 0.00 0.77 RP to Sensor 2 0 0 0 RP to Aux. GPS Antenna 0 0 0 RP to Heave lever arm(deg) -0.67 0.00 0.00 IMU rotation Ref. Frame, deg 0 0 0 Sensor 1 rotation Ref. Frame, deg 0 0 0 Sensor 2 rotation Ref. Frame, deg 0 0 0

Roll offset: +0.5 deg Pitch offset: 0.0 deg Gyro offset: 0.0 deg

Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date:
REQUIRED: The year (and optionally month, or month and day) for which the data set corresponds to the ground.
Range_of_Dates/Times:
Beginning_Date: 20030823
Ending_Date: 20030912
Currentness_Reference: ground condition
Status:
Progress: Complete
Maintenance_and_Update_Frequency: As needed
Spatial_Domain:
Bounding_Coordinates:

West_Bounding_Coordinate: 145.595186
East_Bounding_Coordinate: 145.706872
North_Bounding_Coordinate: 15.251413
South_Bounding_Coordinate: 15.118877
Keywords:
Theme:
Theme_Keyword_Thesaurus: None
Theme_Keyword: Gridded bathymetry
Place:
Place_Keyword_Thesaurus: None
Place_Keyword: Garapan Anchorage
Place_Keyword: Saipan
Place_Keyword: Commonwealth of the Northern Mariana Islands
Access_Constraints: None
Use_Constraints:
These data are not to be used for navigation purposes. Please acknowledge the NOAA Coral Reef Ecosystem Division, Pacific Islands Fisheries Science Center as the source of this information.
Point_of_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization:
Benthic Habitat Mapping Group, Coral Reef Ecosystem Division, PIFSC,NOAA
Contact_Person: Joyce Miller
Contact_Address:
Address_Type: mailing and physical address
Address: 1125B Ala Moana Blvd
City: Honolulu
State_or_Province: HI
Postal_Code: 96814
Country: USA
Contact_Voice_Telephone: 808-592-8303
Contact_Electronic_Mail_Address: joyce.miller@noaa.gov
Browse_Graphic:
Browse_Graphic_File_Name: saipan_anc-5.jpg
Browse_Graphic_File_Description: Gridded Bathymetry
Browse_Graphic_File_Type: JPEG
Data_Set_Credit:
Benthic Habitat Mapping Group, Coral Reef Ecosystem Division (CRED), Pacific Islands Fisheries Science Center (PIFSC), NOAA
Native_Data_Set_Environment:
Microsoft Windows XP Version 5.1 (Build 2600) Service Pack 2; ESRI ArcCatalog 9.0.0.535

Data_Quality_Information:
Attribute_Accuracy:

Attribute_Accuracy_Report:
Data are collected for resource management and research purposes and are tested for internal consistency; however, no effort is made to compare these data to external references or to other published data.
Logical_Consistency_Report: Unspecified
Completeness_Report: Complete
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report:
Horizontal positioning system: GPS SPS Horizontal position accuracy: 5
Vertical_Positional_Accuracy:
Vertical_Positional_Accuracy_Report:
Range resolution of sonar ~ 1.25 cm Raw sounding resolution: 1 cm Vertical accuracy of gridded product ~ 1 meter
Lineage:
Process_Step:
Process_Description:
Science Applications International Corporations (SAIC) ISS-2000 acquires, processes and records data, provides survey control and underway quality control displays. SAICs SABER processing software is used to process the raw soundings, analyze the results, manually edit the sounding data to remove outliers and derive average gridded data values. GMT was then used to reformat the grid into final form. Interactive Visualization Systems Fledermaus and ESRI ArcGIS were used for viewing results and creating browse objects.

The data have been corrected for observed tides from Guam tide gauge 1630000 with a time corrector of 18 minutes and a tide height multiplier of 0.94 using SABER postprocessing software. The data were also recorrected for observed sound velocities in postprocessing.

Software used: SAIC ISS-2000 Acquisition Software, v 3.4 (20030610) SAIC SABER Processing Software, v 2.0.2 (20030610) GMT Generic Mapping Tools, v 3.4.2 (20021002)

Process_Step:
Process_Description: Metadata imported.
Source_Used_Citation_Abbreviation:
C:\DOCUME~1\ELUNDB~1\LOCALS~1\Temp\xml141.tmp

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Raster
Raster_Object_Information:
Raster_Object_Type: Grid Cell
Row_Count: 2918
Column_Count: 2382
Vertical_Count: 1

Spatial_Reference_Information:

Horizontal_Coordinate_System_Definition:
Planar:
Grid_Coordinate_System:
Grid_Coordinate_System_Name: Universal Transverse Mercator
Universal_Transverse_Mercator:
UTM_Zone_Number: 55
Transverse_Mercator:
Scale_Factor_at_Central_Meridian: 0.999600
Longitude_of_Central_Meridian: 147.000000
Latitude_of_Projection_Origin: 0.000000
False_Easting: 500000.000000
False_Northing: 0.000000
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: row and column
Coordinate_Representation:
Abscissa_Resolution: 5.000000
Ordinate_Resolution: 5.000000
Planar_Distance_Units: meters
Geodetic_Model:
Horizontal_Datum_Name: D_WGS_1984
Ellipsoid_Name: WGS_1984
Semi-major_Axis: 6378137.000000
Denominator_of_Flattening_Ratio: 298.257224
Vertical_Coordinate_System_Definition:
Depth_System_Definition:
Depth_Datum_Name: mean lower low water
Depth_Resolution: 0.01 meters
Depth_Distance_Units: meters
Depth_Encoding_Method: Attribute values

Entity_and_Attribute_Information:

Overview_Description:
Entity_and_Attribute_Overview:
Depth values are real values based on the average of the soundings that fell within the extracted grid cells. Number of soundings per grid cell range from >1000 soundings in shallow depths to as few as 20 soundings in deeper areas. A total error budget for this survey has not been developed, therefore the accuracy of depth measurements should be considered to be within 1 meter.
Entity_and_Attribute_Detail_Citation: none

Distribution_Information:

Distributor:
Contact_Information:
Contact_Organization_Primary:

Contact_Organization: Benthic Habitat Mapping Group, CRED, PIFSC, NOAA
Contact_Person: Joyce E. Miller
Contact_Position: Oceanographer
Contact_Address:
Address_Type: mailing and physical address
Address: 1125 'B' Ala Moana Blvd
City: Honolulu
State_or_Province: Hawaii
Postal_Code: 96814
Country: USA
Contact_Voice_Telephone: 808-592-8303
Contact_Electronic_Mail_Address: joyce.miller@noaa.gov
Resource_Description: Downloadable Data
Distribution_Liability:
These data are not to be used for navigational purposes. NOAA makes no warranty regarding these data, expressed or implied, nor does the fact of distribution constitute such a warranty. NOAA cannot assume liability for any damages caused by any errors or omissions in these data, nor as a result of the failure of these data to function on a particular system.
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: ASCII ARC/INFO Grid
Format_Information_Content:
ASCII ARC/INFO grid Files of this type can be imported with ArcToolbox 8.3 using the following path: Conversion Tools;Import to Raster;ASCII to Grid (Float).

These data as having the following header format and description

NCOLS xxx NROWS xxx XLLCORNER xxx YLLCORNER xxx CELLSIZE xxx NODATA_VALUE xxx ROW 1 ROW 2 . . . ROW n where:

NCOLS is the number of columns in the ASCII file. NROWS is the number of rows in the ASCII file. XLLCORNER is the x coordinate for lower left corner of the lower left most cell in the grid. YLLCORNER is the x coordinate for the lower left corner of the lower left most cell in the grid. CELLSIZE is the length of a cells edge. NODATA_VALUE is the value in the ASCII file representing unknown values. xxx are numbers, and the cell values are space delimited

File_Decompression_Technique: Zip file
Transfer_Size: 26.627
Digital_Transfer_Option:
Online_Option:
Computer_Contact_Information:
Network_Address:

Network_Resource_Name:
<ftp://ftp.soest.hawaii.edu/pibhmc/data/marianas/saipan_anc-5.asc.zip>
Fees: None

Metadata_Reference_Information:
Metadata_Date: 20050124
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Benthic Habitat Mapping Group, CRED, PIFSC, NOAA
Contact_Person: Dr. Michael Parke
Contact_Position: Research Biologist
Contact_Address:
Address_Type: mailing and physical address
Address: 1125 'B' Ala Moana Blvd
City: Honolulu
State_or_Province: Hawaii
Postal_Code: 96814
Country: USA
Contact_Voice_Telephone: 808-592-7025
Contact_Electronic_Mail_Address: michael.parke@noaa.gov
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time
Metadata_Access_Constraints: None
Metadata_Use_Constraints: None
Metadata_Extensions:
Online_Linkage: <http://www.esri.com/metadata/esriprof80.html>
Profile_Name: ESRI Metadata Profile

Appendix H

BENTHIC VIDEO CLASSIFICATION CODES

Percentage of Substrate		Living Cover	
Unconsolidated		Seagrass	1
Mud	1	Macroalgae	2
Sand	2	Non-scleractinian Fauna	3
	3	Scleractinian Coral	4
	4	Coralline Algae (CA)	5
Hardbottom		Coral or CA	6
Rubble	6	Emergent Vegetation	7
Boulder	7	None	8
Rock	8	Unclassified Algae	9
Man-Made Structure	9		
	10		
Unclassified	20	Unclassified	20

Relief		Holes	
≤ 0.5 m	1	No Cavities	1
> 0.5 m, ≤ 1.0 m	2	Few Small Cavities	2
> 1.0 m, ≤ 2.0 m	3	Many Small Cavities	3
> 2.0 m, ≤ 3.0 m	4	Few Large Cavities	4
> 3.0 m	5	Many Large Cavities	5
		Few Sml & Lrg Cavities	6
		Many Sml & Lrg Cavities	7
		Many Sml & Few Lrg Cavities	8
Unclassified	20	Unclassified	20

Appendix I

Metadata for Towed Video Transects

Identification_Information:

Citation:

Citation_Information:

Originator: NOAA, PIFSC, Coral Reef Ecosystem Division

Title: Towed Video - Saipan Anchorage

Geospatial_Data_Presentation_Form: vector digital data

Online_Linkage: Q:\GIS_Data\CNMI\Saipan\Bathymetry\saipan_anc-5

Description:

Abstract:

Towed video transects. Collected on the Carolinian, 62 ft vessel contracted by US Navy, in Saipan in December 04. Collected with a Deep Sea Power & Light Multi SeaCam 2060 color video camera, two 500 watt lights, a sonar altimeter to detect the height of the camera above the seafloor, a pair of parallel lasers to determine the size/scale of viewed objects, a compass to determine the sled heading and orientation, and a depth sensor. The video data were recorded to digital video cassette using a video recorder mounted on the control console. Hypack Max (version 2.12A) hydrographic survey software was used to record GPS data, water depth, and camera sled information (height, heading, etc.), which provide ship and camera sled positions for the duration of individual tows

Purpose:

Environmental assessment for US Navy. The videos will be analyzed and classified in post processing to provide an assessment that the US Navy can use to plan potential anchorage sites. The videos will also serve as a ground truthing data that will be combined with multibeam bathymetry and backscatter imagery and other data to produce benthic habitat maps.

Time_Period_of_Content:

Time_Period_Information:

Single_Date/Time:

Calendar_Date: December 2004

Currentness_Reference: December 2004

Status:

Progress: Complete

Maintenance_and_Update_Frequency: None planned

Spatial_Domain:

Bounding_Coordinates:

West_Bounding_Coordinate: 145.658268

East_Bounding_Coordinate: 145.669310

North_Bounding_Coordinate: 15.224189

South_Bounding_Coordinate: 15.216201

Keywords:

Theme:

Theme_Keyword: Video
Theme_Keyword: Towed
Theme_Keyword: Saipan Anchorage
Theme_Keyword: classifications
Theme_Keyword: in situ
Theme_Keyword: benthic habitat
Theme_Keyword: IGOR
Theme_Keyword: Optical
Use_Constraints: NOT FOR NAVIGATION!
Point_of_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization:
NOAA, Pacific Islands Fisheries Science Center, Coral Reef Ecosystem Division
Contact_Person: Michael Parke
Contact_Address:
Address_Type: mailing address
Address: 1125B Ala Moana Blvd.
City: Honolulu
State_or_Province: Hawaii
Postal_Code: 96822
Country: USA
Contact_Voice_Telephone: (808) 592-7025
Contact_Facsimile_Telephone: (808) 592-7013
Contact_Electronic_Mail_Address: Michael.Parke@noaa.gov
Native_Data_Set_Environment:
Microsoft Windows XP Version 5.1 (Build 2600) Service Pack 2; ESRI ArcCatalog 9.0.0.535
Cross_Reference:
Citation_Information:
Title:
Task 1 Report and Task 2 Field Report - Characterization of Benthic Habitat for Saipan Anchorage - Commonwealth of the Northern Mariana Islands

---

Data_Quality_Information:
Lineage:
Source_Information:
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: December 2004
Source_Currentness_Reference: Collection Date
Process_Step:
Process_Description:
Exported 2004CA3380708.edt from Hypack Saved as text 04CA3380708 Added XY Data Event theme to ArcMap Exported Data as shapefile CONVERSION

INSTRUCTIONS BELOW: --- December 11, 2004 Updated INSTRUCTIONS FOR CONVERTING HYPACK RAW FILES TO ARC FILES (from .TXT to .SHP)

1. Hypack Max ' Insert the Hypack Lite dongle on your laptop ' Open Hypack Max 02.12A (happy whale) ' When the project opens, make sure the tracks you want to export are displayed on the navigation chart. If not, right click on the Raw Data Files folder and add the appropriate .log file (i.e. raw1204.log) ' Note the name of the track you want to export Labeled on the map (i.e. 2004ca3400406.raw) ' Processing ' Single Beam Editor ' SB Max ' File ' Open ' RAWFILE.RAW (i.e. 2004CA3400406.RAW) View all file types to see the individual .RAW files ' Corrections ' OK ' Read Parameters ' Selections and Survey Info tabs should be filled in from set up ' Offsets ' fill in with offsets used for the survey ' Presort ' Yes, All Data ' Distance Along Line ' Increment = 10 ' SB Max ' View ' Spreadsheet & ' Survey Window

In your Spreadsheet the columns should be Record, Longitude, Latitude, X, Y, Time, Raw Depth, Corr Depth1. If these columns are not present, right-click in the spreadsheet, and go to View Options. Now you can change the column values.

' Spreadsheet ' Export ' Single File, Comma Separated Fields ' OK ' file name

The above steps will output a .TXT file that can be imported to ArcGIS. However, you must first open the .TXT file in Notepad and remove the spaces between the header values.

2. ArcGIS Tools ' Add XY Data ' Browse to text file you just saved with headings Make sure X Field is looking at X and Y Field is looking at Y Define the Coordinate System: ' Edit ' Select ' Projected Coordinate Systems folder ' Utm ' Wgs 1984 ' Browse to WGS 1984 UTM Zone 55N.prj ' Add ' OK ' OK An Event theme will appear in your Table of Contents in ArcGIS Right-click the theme ' Data ' Export Data Use defaults (Export: All features and Use same Coord. Sys. As the layer's source data) Name shapefile (with file path which should already be filled in) in browse box (save in same place as the text file you used to make it) ' OK Add the shapefile to your ArcGIS project

----

Process_Date: 120504
Process_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: NOAA Fisheries - CRED
Contact_Person: Emily Lundblad
Contact_Position: GIS Specialist

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information:
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: Entity point
Point_and_Vector_Object_Count: 980

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Grid_Coordinate_System:
Grid_Coordinate_System_Name: Universal Transverse Mercator
Universal_Transverse_Mercator:
UTM_Zone_Number: 55
Transverse_Mercator:
Scale_Factor_at_Central_Meridian: 0.999600
Longitude_of_Central_Meridian: 147.000000
Latitude_of_Projection_Origin: 0.000000
False_Easting: 500000.000000
False_Northing: 0.000000
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: coordinate pair
Coordinate_Representation:
Abscissa_Resolution: 0.000001
Ordinate_Resolution: 0.000001
Planar_Distance_Units: meters
Geodetic_Model:
Horizontal_Datum_Name: D_WGS_1984
Ellipsoid_Name: WGS_1984
Semi-major_Axis: 6378137.000000
Denominator_of_Flattening_Ratio: 298.257224

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Detailed_Description:
Entity_Type:
Entity_Type_Label: SaiTransectNo
Attribute:
Attribute_Label: FID
Attribute_Definition: Internal feature number.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain:
Sequential unique whole numbers that are automatically generated.
Attribute:
Attribute_Label: Shape
Attribute_Definition: Feature geometry.

Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain: Coordinates defining the features.
Attribute:
Attribute_Label: Fix_No
Attribute:
Attribute_Label: X
Attribute:
Attribute_Label: Y
Attribute:
Attribute_Label: Date_
Attribute:
Attribute_Label: Time
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Attribute_Label: CorDepth1
Attribute:
Attribute_Label: CorDepth2
Attribute:
Attribute_Label: RawDepth1
Attribute:
Attribute_Label: RawDepth2
Attribute:
Attribute_Label: temp
Attribute:
Attribute_Label: Record_No
Attribute:
Attribute_Label: NoName

Distribution_Information:
Resource_Description: Downloadable Data
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Transfer_Size: 0.025

Metadata_Reference_Information:
Metadata_Date: 20050124
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: NOAA Fisheries - CRED
Contact_Person: Emily Lundblad
Contact_Position: GIS Specialist
Contact_Address:
Address_Type: mailing address
Address: 1125B Ala Moana Blvd.

City: Honolulu
State_or_Province: Hawaii
Postal_Code: 96822
Country: USA
Contact_Voice_Telephone: (808) 956-5239
Contact_Facsimile_Telephone: (808) 956-6530
Contact_Electronic_Mail_Address: Emily.Lundblad@noaa.gov
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time
Metadata_Extensions:
Online_Linkage: <http://www.esri.com/metadata/esriprof80.html>
Profile_Name: ESRI Metadata Profile
Metadata_Extensions:
Online_Linkage: <http://www.esri.com/metadata/esriprof80.html>
Profile_Name: ESRI Metadata Profile
Metadata_Extensions:
Online_Linkage: <http://www.esri.com/metadata/esriprof80.html>
Profile_Name: ESRI Metadata Profile

Appendix J

DVD Contents:

- Documents
  - Final Report: Characterization of Benthic Habitat for Saipan Anchorage: Commonwealth of the Northern Mariana Islands
  - ReadMe – DVD Contents.doc

- Figures
  (includes .pdf & .jpg of each layout)
  1. Towed Video Transects and Bathymetry
     - Fig3-Sai-Bathy-Tracks-A
  2. Multibeam Bathymetry of the Saipan Anchorage Area
     - Fig5-Sai-Bathy-A
  3. Multibeam Bathymetry Within Defined Area of Interest
     - Fig6-Sai-Bathy-box-A
  4. Towed Video Frame Grabs
     - Fig7-Sai-Bathy-Tracks-FrameGrabs-A
  5. Camera Tow Tracks Colored Coded by the Percentages of Live Coral and Other Benthic Fauna
     - Fig8-Sai_PercentCoral
  6. Camera Tow Tracks Colored Coded by Substrate Type
     - Fig9-Sai_Sand_Rock_Rubble
  7. Interpolated Percentages of Living Cover of Corals and Other Benthic Fauna in the Saipan Anchorage Area
     - Fig10-Sai-Krigged-Coral
  8. Interpolated Percentages of Living Cover of Corals and Other Benthic Fauna Overlain by Sand Fields in the Saipan Anchorage Area
     - Fig11-Sai-Krigged-Coral-w-Sand
  9. Interpolated Percentages of Living Cover of Corals and Other Benthic Fauna Overlain by Sand Fields in the Proposed Future Anchorage Locations
     - Fig12-Sai-Krigged-Coral-w-Sand-box
  10. Prediction Error for Interpolated Percentages of The Seafloor Covered by Living Corals and Other Benthic Fauna in the Saipan Anchorage Area
     - Fig13-Sai-Krigged-Coral-Error

- Appendices
  (includes .pdf & .jpg of each layout)
  A. Multibeam Bathymetry
     - AppA-Sai-Bathy-C

B. Bathymetry and Percentages of Live Coral and Other Benthic Fauna along Tow Tracks
    - AppB-Sai-PercentCoral-C
C. Interpolated Percentages of Living Cover of Corals and Other Benthic Fauna
    - AppC-Sai-Krigged-Coral-C
D. Interpolated Percentages of Living Cover of Corals and Other Benthic Fauna Overlain by Sand Fields
    - AppD-Sai-Krigged-Coral-w-Sand-C
E. Interpolated Percentages of Living Cover of Corals and Other Benthic Fauna Overlain by Sand Fields in the Proposed Future Anchorage Locations
    - AppE-Sai-Krigged-Coral-w-Sand-box-C

- GIS Data
    - Note: Raster Grids are included as interchange files (.e00) and shapefiles are included with all related files need to add the shapefiles to a project. For this report, these data were used in ArcGIS 9.0. These data are projected in UTM, WGS84 zone 55N or are undefined, but viewed and mapped with the UTM, WGS84 zone 55N data.
        - Bathymetry (saipan_anc_5.e00)
        - Hillshade (sai_anc_hs15x2.e00)
        - Slope (slope.e00)
        - Nautical Chart (SAI2TIN05_81067_1.KAP and SAI-Harbor05_81076_1.KAP)
        - Saipan Shoreline (saipan_shore.shp)
        - Box – Defined Area of Interest (box.shp)
        - Reported Shipwrecks (Sai_Shipwrck.shp)
        - Proposed Anchorage Circles (anchbuffutm2.shp)
        - Sand Basins – (finalsand+1000.shp)
    - Classified-Towed-Videos
        - Towed Video Tracks (sai201_clean_lyr.shp – sai244_clean_lyr.shp)
        - Merged Towed Video Tracks
            - Inner Anchorage including 2003 and 2004 Video Tow Tracks (merge03-04utm.shp)
            - 2003 Video Tow Tracks (merge2003towutm.shp)
    - Interpolations (includes .shp and .lyr)
        - Outer Anchorage (Outer-Krig)
        - Inner Anchorage (Inner-Krig)
    - Interpolation Prediction Error
        - Outer Anchorage (reclassoerr.shp, krig-error-outer.lyr)
        - Inner Anchorage (reclassierr.shp, krig-error-inner.lyr)

- GIS ArcMap Projects (.mxd)
  - For Figure 3: Sai-Bathy-Tracks-A.mxd
  - For Figure 5: Sai-Bathy-A.mxd
  - For Figure 6: Sai-Bathy-box-A.mxd
  - For Figure 7: Sai-Bathy-Tracks-FrameGrabs-A.mxd
  - For Figure 8: Sai_PercentCoral.mxd
  - For Figure 9: Sai_Sand_Rock_Rubble.mxd
  - For Figure 10: Sai-Krigged-Coral.mxd
  - For Figure 11: Sai-Krigged-Coral-w-Sand.mxd
  - For Figure 12: Sai-Krigged-Coral-w-Sand-box.mxd
  - For Figure 13: Sai-Krigged-Coral-Error-A.mxd
  - For AppendixA: Sai-Bathy-C.mxd
  - For AppendixB: Sai_PercentCoral-C.mxd
  - For AppendixC: Sai-Krigged-Coral-C.mxd
  - For AppendixD: Sai-Krigged-Coral-w-Sand-C.mxd
  - For AppendixE: Sai-Krigged-Coral-w-Sand-box-C.mxd

- 3D Visualization
  - Note: Simply download IView3D and run the executable file to install the viewer. Then, in IView3D, go to File → Load the .sd or .scene file included in this folder. You'll be able to zoom in/out and pan around to view the bathymetry around Saipan. The data here have a vertical exaggeration of 4 to provide more descriptive visualization.
    - Bathymetry as 3D scientific data
    - 3D Viewer – IView3D