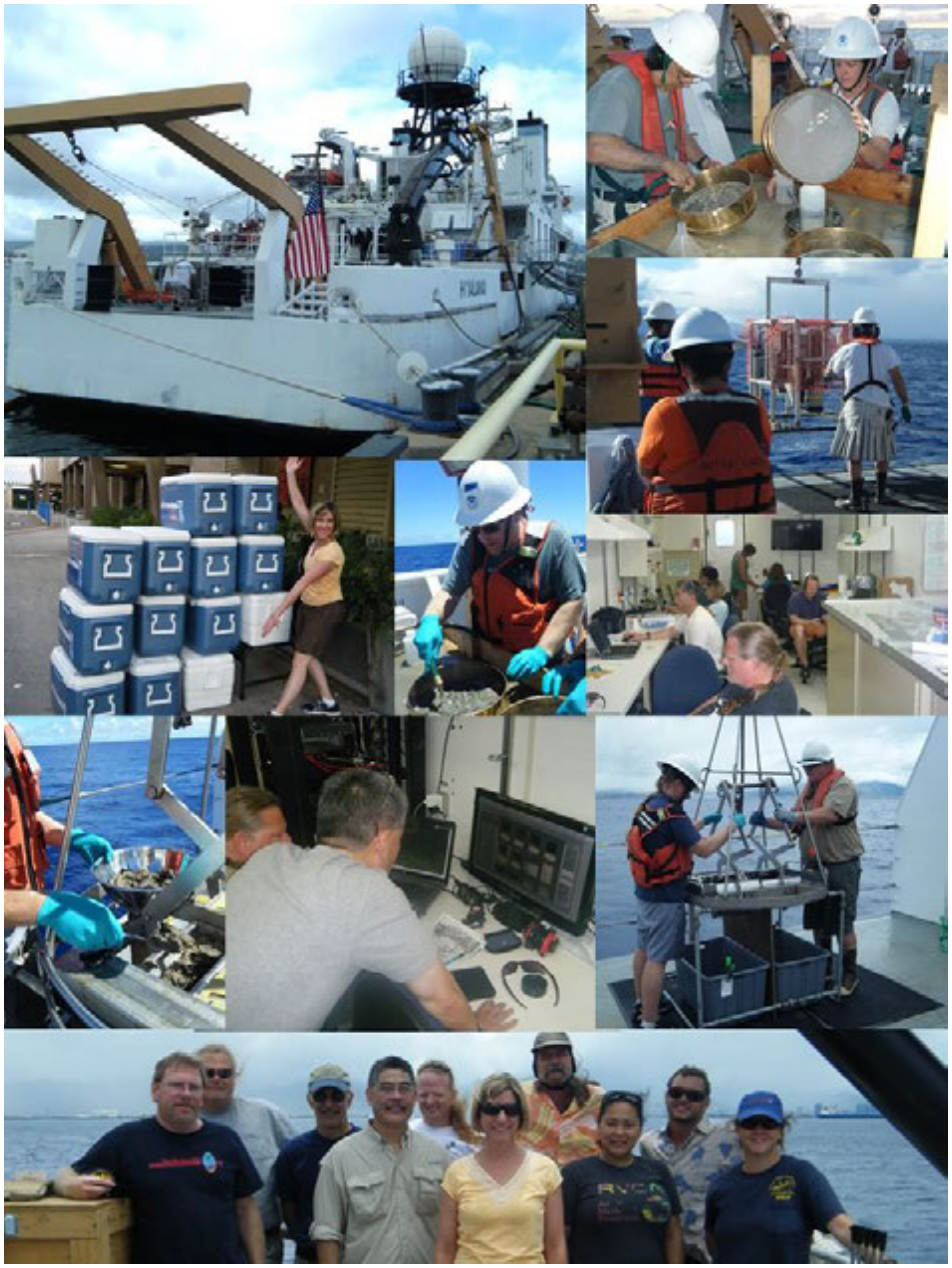
2013 HAWAII OCEAN DISPOSAL SITE MONITORING

SYNTHESIS REPORT



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April 27, 2015

Table of Contents

Executive Summary 1

I. Introduction and Background 1

II. Summary of Site Monitoring Activities 7

2.1. Sediment Profile Imaging (SPI) and Plan View Photography (PVP) 7

2.2. Sediment Sampling for Chemistry and Benthic Communities 13

2.3. Sub-Bottom Profiling Survey of the South Oahu ODMDS 15

III. Survey Results 17

3.1. SPI-PVP Surveys 17
3.1.1 Dredged Material Footprint Mapping 17
3.1.2 Bioturbation Depth 17
3.1.3 Infaunal Successional Stage 24
3.1.4 Plan-View Photography 27
3.1.5 Discussion: SPI-PVP Surveys 30

3.2. Sediment Physical and Chemical Survey Results 30
3.2.1 Physical Results 31
3.2.2 Chemical Results 31

3.3. Benthic Community Analysis Results 34
3.3.1 Abundance of Infauna 34
3.3.2 Diversity of Infauna 35

3.4. Sub-Bottom Profiling Survey (South Oahu Site Only) 36

3.5. Comparison to 1980 Baseline Information 43
3.5.1 South Oahu Disposal Site 43
3.5.2 Hilo Disposal Site 44

IV. Conclusions and Recommendations 46

V. References 47

Appendix: Summary of Planned vs Actual Survey Activities at Hawaii Ocean Dredged Material Disposal Sites, 2013 A-1

List of Figures

Figure 1. Five ocean dredged material disposal sites serve Hawaii ports and harbors. 3
Figure 2. General location of the South Oahu ocean dredged material disposal site. 4
Figure 3. General location of the Hilo ocean dredged material disposal site. 5
Figure 4. SPI-PVP camera system being deployed from the Hi'ialakai. 8
Figure 5. Schematic of deployment and collection of plan view and sediment profile photographs. 9
Figure 6. Soft-bottom benthic community response to physical disturbance (top panel) or organic enrichment (bottom panel). 10
Figure 7. Planned (yellow squares) and actual sample station locations at the South Oahu ODMDS. 11
Figure 8. Planned and actual sample station locations at the Hilo ODMDS. 12
Figure 9. Double Van Veen sediment sampler deployed from the Hi'ialakai. 13
Figure 10. Subsampling from the Van Veen grab for sediment chemistry. 14
Figure 11. Processing a sediment sub-sample for chemical analysis. 14
Figure 12. Processing a sediment sample for benthic community analysis. 15
Figure 13. Sub-bottom profiler equipment – used only at the South Oahu site. 16
Figure 14. Planned transect lines for the sub-bottom profiling survey around the South Oahu ODMDS. 16
Figure 15. Profile images from the ambient bottom at the Hilo ODMDS (left, Station S3) and the South Oahu site (right, Station S6). 18
Figure 16. Plan view images of the dredged material deposit compared to the native seafloor at South Oahu. 19
Figure 17. Profile images from two Hilo Stations showing a surface layer of disposed coarse white dredged sand. 20
Figure 18. Dredged material footprint identified at the South Oahu site. 21
Figure 19. Dredged material footprint identified at the Hilo site. 22
Figure 20. Plan view image from the center station of the Hilo ODMDS shows a high density of small rock and coral rubble. 23
Figure 21. Bioturbation depth at the South Oahu site. 25
Figure 22. Bioturbation depth at the Hilo site. 26
Figure 23. Community structure at the South Oahu site. 28
Figure 24. Community structure at the Hilo site. 29
Figure 25. USGS shaded-relief image showing the boundary of the sub-bottom survey area around the South Oahu disposal site, as well as major bedforms in the vicinity. 37

List of Figures, cont.

Figure 26. USGS sidescan sonar (backscatter) image showing historic dredged material deposits around the sub-bottom survey area and the South Oahu disposal site. 38

Figure 27. Transect lines occupied for the sub-bottom profiling survey of the South Oahu site. 39

Figure 28. Geological (surface) interpretation from the sub-bottom profiling survey superimposed with the SPI-based dredged material footprint map shown in Figure 17. 40

Figure 29. Sub-bottom profile for Diagonal Line 1. 41

Figure 30. Comparison of South Oahu site dredged material volume estimates. 42

List of Tables

Table 1. Disposal volumes (cubic yards) at the 5 Hawaii ODMDS following designation in 1980. 6

Table 2. Summary of sediment chemistry for the South Oahu Ocean Dredged Material Disposal Site and vicinity. 32

Table 3. Summary of sediment chemistry for the Hilo Ocean Dredged Material Disposal Site and vicinity. 33

Table 4. Infaunal species abundances at the South Oahu site. 35

Table 5. Infaunal species abundances at the Hilo site. 35

Table 6. Average Percent Grain Size – South Oahu Site. 43

Table 7. Trace Metal Concentrations – South Oahu Site. 43

Table 8. Percent Abundance – South Oahu Site. 44

Table 9. Average Percent Grain Size – Hilo Site. 44

Table 10. Trace Metal Concentrations – Hilo Site. 45

Table 11. Percent Abundance – Hilo Site. 45

2013 HAWAII OCEAN DISPOSAL SITE MONITORING SYNTHESIS REPORT

EXECUTIVE SUMMARY

In 1981, the US Environmental Protection Agency (EPA) designated five ocean dredged material disposal sites (ODMDS) offshore of Hawaiian Island ports and harbors. In 1997, EPA and the US Army Corps of Engineers (USACE) published a Site Monitoring and Management Plan (SMMP) covering all five of these disposal sites. But since that time, due to lack of available funding, the sites have not been comprehensively monitored and the SMMP has not been updated. Therefore, when funding became available for 2013, EPA identified the Hawaii sites as the highest priority to monitor of all the disposal sites in Region 9. Since only the South Oahu and Hilo sites had received any disposal activity since the late 1990s, EPA conducted surveys at only these two sites. Ship and equipment problems resulted in a reduction in the planned survey scope and in the overall number of samples collected. However, sufficient sampling was completed to provide an adequate basis to confirm environmental conditions at these sites and to update the SMMP. Based on analyses of sub-bottom profiling, sediment profile and plan view imaging, and sediment grain size, chemistry, and benthic community sampling, it appears that the pre-disposal sediment testing program has protected these sites and their environs from any adverse contaminant loading. The bulk of the dredged material disposed in the last decade or more appears to have been deposited properly within the site boundaries. There are minor and localized physical impacts from dredged material disposal, as expected, but no significant adverse impacts are apparent to the benthic environment outside of site boundaries. Continued use of the disposal sites, under an updated SMMP, is recommended.

I. INTRODUCTION AND BACKGROUND

Ocean dredged material disposal sites (ODMDS) around the nation are designated by the Environmental Protection Agency (EPA) under authority of the Marine Protection, Research and Sanctuaries Act (U.S.C. 1401 et seq., 1972) and the Ocean Dumping Regulations at 40 CFR 220-228. Disposal site locations are chosen to minimize cumulative environmental effects of disposal to the area or region in which the site is located, and disposal operations must be conducted in a manner that allows each site to operate without significant adverse impacts to the marine environment. Many ocean disposal sites are located near major ports, harbors, and marinas and are very important for maintaining safe navigation for commercial, military, and private vessels.

EPA and the US Army Corps of Engineers (USACE) share responsibility for managing ocean disposal of dredged sediments. First, there is a pre-disposal sediment testing program that is jointly administered by the agencies to ensure that only clean (non-toxic) sediments are permitted for ocean disposal. EPA must concur that sediments meet ocean dumping suitability requirements before USACE can issue a permit for ocean disposal. Post-disposal site monitoring then allows

EPA and USACE to confirm the environmental protectiveness of the pre-disposal testing. The agencies also jointly manage the ocean disposal sites themselves. All sites are operated under a site management and monitoring plan (SMMP), and the Agencies cooperate on updating the SMMPs if needed, based on the results of periodic site monitoring. EPA is also responsible for enforcement of potential ocean dumping violations at each site.

The site use requirements in SMMPs for each specific ODMDS can be based on any issues of concern identified in the original site designation environmental impact statement (EIS) or environment assessment (EA), and/or on the results of subsequent (post-disposal) monitoring. Each SMMP typically incorporates a compliance monitoring component to ensure that individual disposal operations are conducted properly at the site, as well as a requirement for periodic monitoring surveys to confirm that the site is performing as expected and that long term adverse impacts are not occurring.

EPA designated five ODMDS offshore of Hawaiian Island ports and harbors in 1981 (Figure 1). With the exception of the South Oahu site, these disposal sites are used infrequently (generally only every 5-10 years or so) when USACE conducts maintenance dredging of the federal channels serving each harbor. Baseline surveys were conducted in the 1970s to support the original site designation action, but only limited monitoring work has occurred since then at most of the sites. The USGS, while doing other coastal mapping work in 1994 and 1995, conducted acoustic backscatter surveys at all five sites for EPA, to map dredged material deposits on the sea floor. They also collected sediment chemistry samples at the South Oahu site. Based on the USGS survey results, EPA and USACE published an SMMP in 1997 covering all five Hawaii disposal sites. Since that time, due to lack of available funding, the sites have not been comprehensively monitored and the SMMP has not been updated. When increased funding became available for 2013, EPA therefore identified the Hawaii sites as the highest priority to monitor of all the disposal sites in Region 9. However, because only the South Oahu and Hilo sites had received any disposal at all since 1999 (Table 1), EPA planned comprehensive monitoring at only these two sites.[1]

The South Oahu site (Figure 2) is located approximately 3 nautical miles offshore of Pearl Harbor in water depths ranging from about 1,300 to 1,650 feet (400 to 500 meters). It is a rectangular ocean disposal site 2 kilometers wide (west-east) and 2.6 kilometers long (north-south), and occupies an area of about 5.2 square kilometers on the sea floor. Although the overall site is rectangular, all disposal actions must take place within a 1,000 foot (305 meter) radius Surface Disposal Zone at the center of the site. Its center coordinates are 21 degrees 15.167 minutes North Latitude, 157 degrees 56.833 minutes West Longitude (NAD 83).

The Hilo site (Figure 3) is located approximately 4 nautical miles offshore of Hilo in water depths averaging about 1,150 feet (350 meters). It is a circular ocean disposal site with a radius of 3,000 feet (920 meters) and an area of about 2.7 square kilometers on the sea floor. As at South Oahu, all disposal actions must take place within a 1,000 foot (305 meter) radius Surface Disposal Zone at the center of the site. The center coordinates of the Hilo site are 19 degrees 48.500 minutes North Latitude, 154 degrees 58.500 minutes West Longitude (NAD 83).

[1] USACE is again planning to dredge and dispose at all five Hawaii ODMDS in 2016. Future monitoring of the other sites will be addressed in an updated SMMP for all the Hawaii ODMDS, which is currently in preparation.

Figure 1. **Five ocean dredged material disposal sites serve Hawaii ports and harbors**.

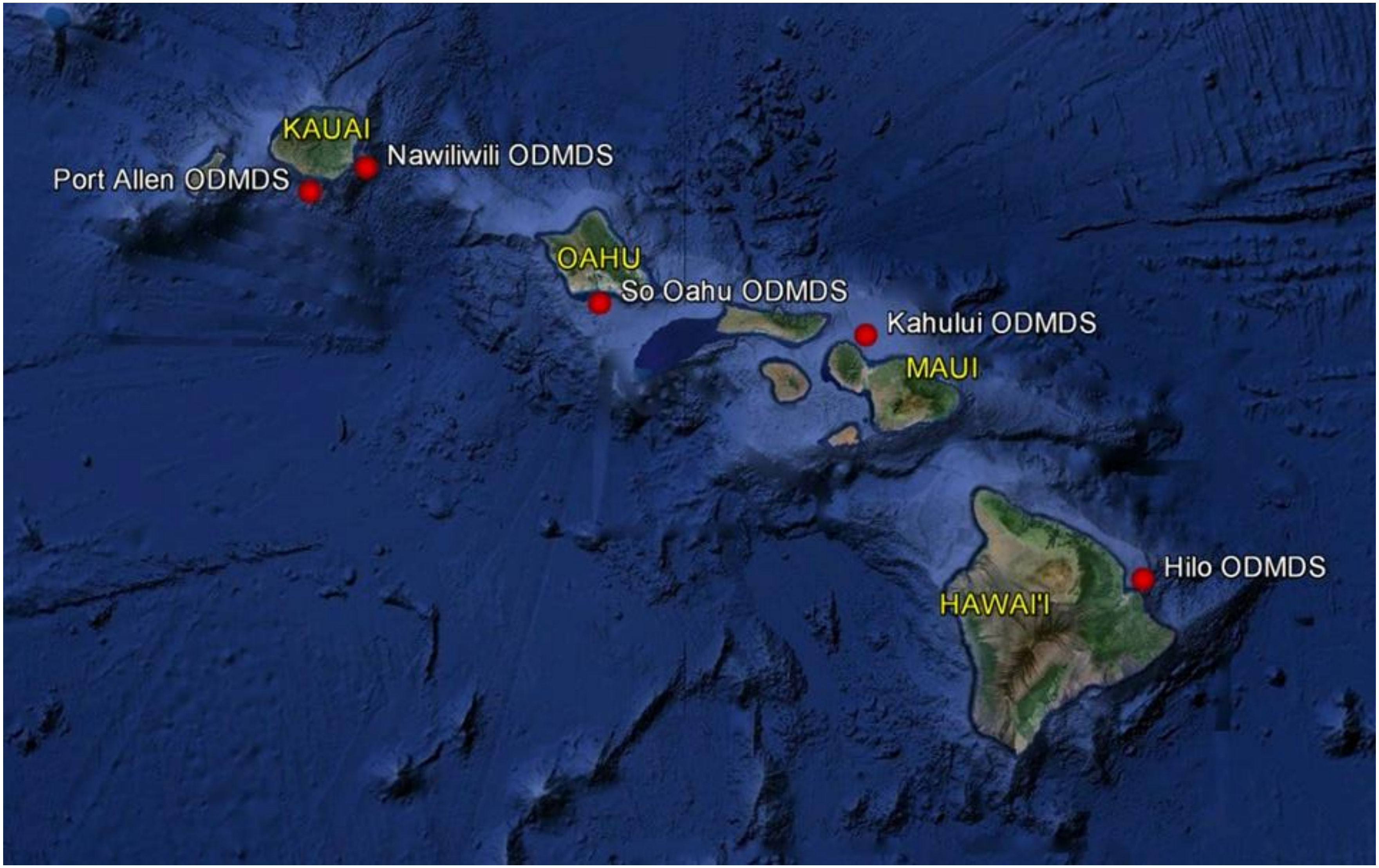


Figure 2. **General location of the South Oahu Ocean Dredged Material Disposal Site**, showing overall site (yellow box) and Surface Disposal Zone (red circle).

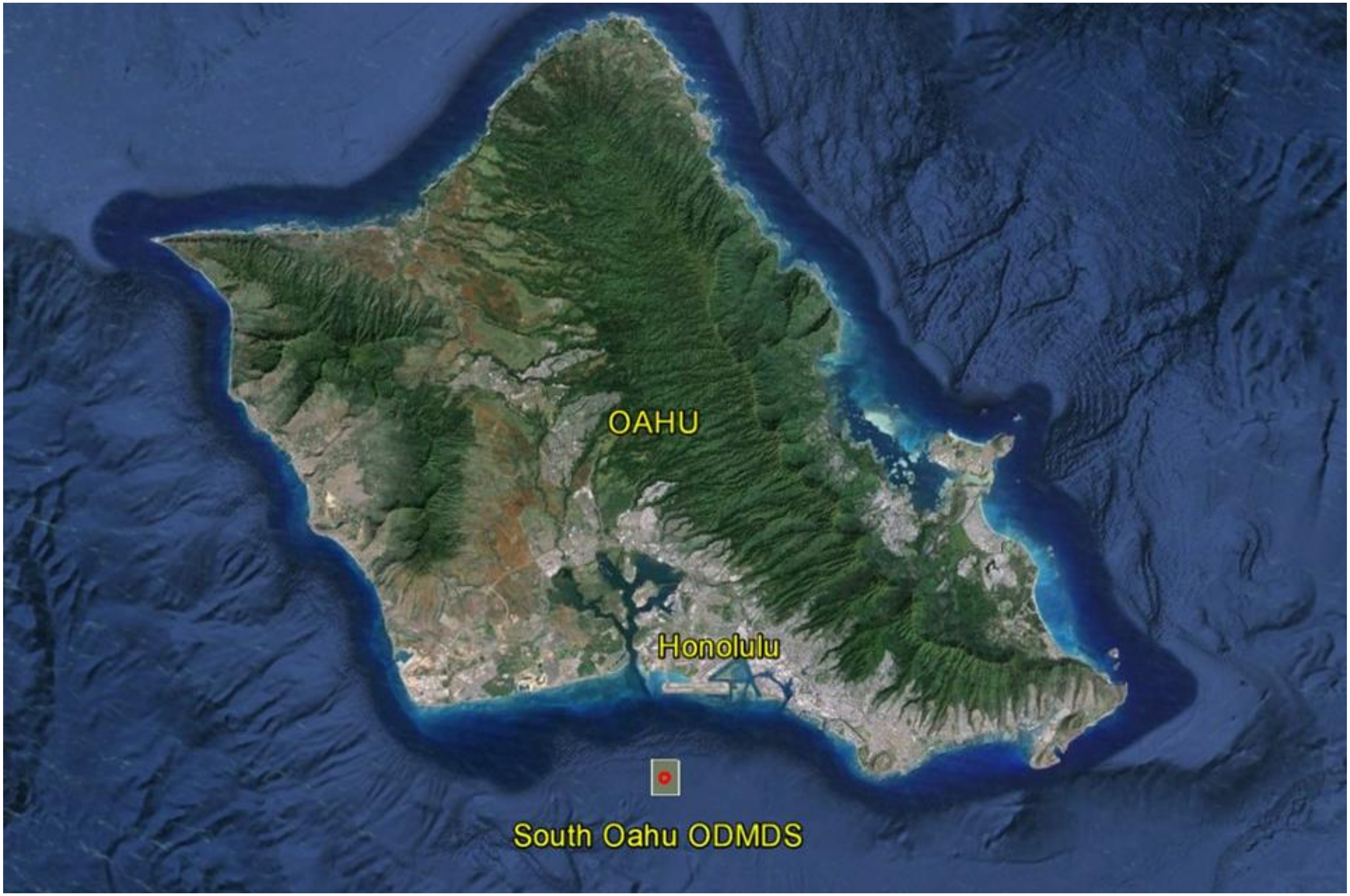
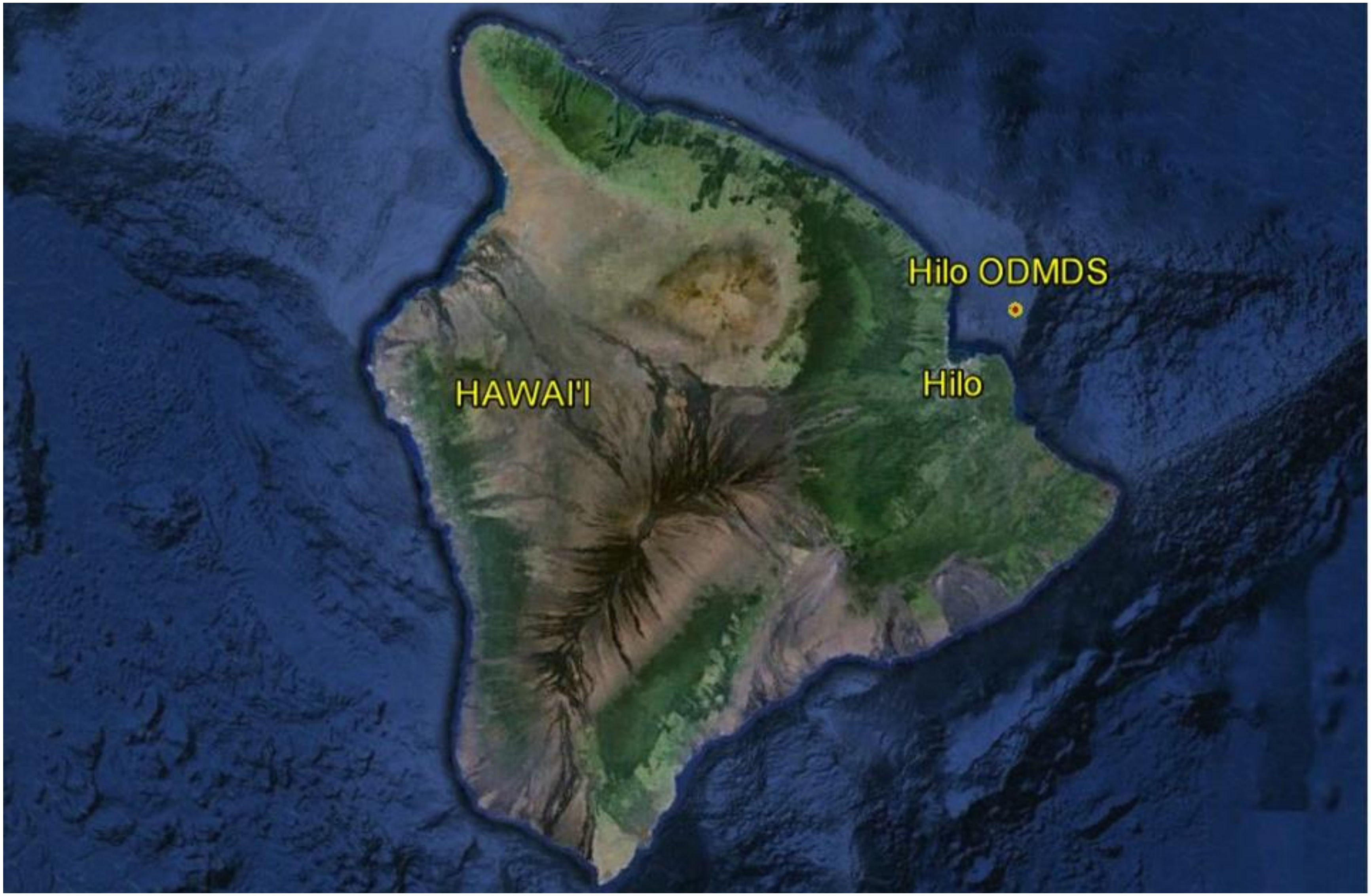


Figure 3. **General location of the Hilo Ocean Dredged Material Disposal Site**, showing overall site (yellow circle) and Surface Disposal Zone (red circle).



As shown in Table 1, the South Oahu site has received by far the greatest volume of dredged material of all 5 Hawaii sites, both historically and more recently. (Table 1 does not include volume disposed at historic Mamala Bay sites prior to 1981.) This material is generated from construction and maintenance dredging by the U.S. Navy in Pearl Harbor and maintenance dredging of the Honolulu Harbor federal channel by USACE, as well as berth maintenance dredging by Honolulu Harbor and other minor dredging by private marinas. The Hilo site has received lesser volumes of dredged material, which in recent years was generated from US Coast Guard maintenance dredging and from terminal improvement projects in Hilo Harbor.

Table 1. **Disposal volumes (cubic yards) at the 5 Hawaii ODMDS following designation in 1981.** Source: EPA compliance tracking records and USACE Ocean Disposal Database.

Year	South Oahu	Hilo	Kahului	Nawiliwili	Port Allen	Total All Sites
1981						0
1982						0
1983				313,900		313,900
1984	2,554,600					2,554,600
1985	12,000					12,000
1986						0
1987	111,200					111,200
1988	57,400					57,400
1989	75,000					75,000
1990	1,198,000	80,000	58,000	343,000		1,679,000
1991	134,550					134,550
1992	233,000					233,000
1993				322,400		322,400
1994						0
1995						0
1996	27,800					27,800
1997						0
1998						0
1999	27,500		91,000	114,600	20,900	254,000
2000						0
2001						0
2002	53,500					53,500
2003	183,500					183,500
2004	540,000					540,000
2005		3,000				3,000
2006	160,400					160,400
2007	266,500					266,500
2008						0
2009	126,200					126,200
2010						0
2011	18,260	63,879				82,139
2012		70,981				70,981
2013	506,870					506,870
Total 1981-2013	**6,286,280**	**217,860**	**149,000**	**1,093,900**	**20,900**	**7,767,940**
Average/year	**190,493**	**6,602**	**4,515**	**33,148**	**633**	**235,392**
Total 2000-2013	**1,855,230**	**137,860**	**0**	**0**	**0**	**1,993,090**
Average/year 2000-2013	**132,516**	**9,847**	**0**	**0**	**0**	**142,363**

II. SUMMARY OF SITE MONITORING ACTIVITIES

EPA Region 9 developed an overall survey plan and quality assurance project plan (QAPP) for the South Oahu and Hilo ODMDS monitoring (EPA, 2013); supplemental QAPPs were also written by sub-contractors. The surveys were conducted in late June and early July 2013. A summary of the survey design and planned vs actual sampling activities is provided in the Appendix to this report.

The main objective of site monitoring is to support any necessary updates to the SMMP by collecting data and samples adequate to determine whether the sites are performing as expected under existing site management practices. The overall site management goal is that there should be only minor physical impacts inside the disposal site and no adverse impacts outside the disposal site. Consequently, the Hawaii site monitoring surveys were designed to:

1. determine the horizontal extent of the dredged material deposit ("footprint") relative to site boundaries;
2. identify any adverse impacts of disposal of dredged material on or off site; and
3. confirm the protectiveness of pre-disposal sediment testing in avoiding disposal of contaminated sediments.

Specific survey activities specified in the QAPP included: sediment profile and plan-view imaging to map the dredged material footprint; sediment sampling and analyses for chemistry and benthic community structure to identify any chemical or biological effects beyond localized physical impacts; and a geophysical survey (sub-bottom profiling) to determine wide area distribution of native sea bed features and deposits of dredged material. EPA contracted with the National Oceanic and Atmospheric Administration (NOAA) to use its vessel Hi'ialakai, stationed in Pearl Harbor, for the sediment imaging and sampling surveys at both disposal sites, and with Sea Engineering for the separate sub-bottom profiling survey.

The surveys conducted from the Hi'ialakai were originally scheduled to occur over 8 days (plus mobilization and demobilization), but problems associated with readiness of the NOAA ship and its equipment caused some delays. The surveys were ultimately conducted over a 5-day period (not including transit between the South Oahu and Hilo sites and the return transit from Hilo to Pearl Harbor), during which field operations were conducted continuously over a 24-hour period using two scientific crews working 12-hour shifts. Even though not as many stations were sampled as originally planned due to the reduced survey time, sufficient sampling was completed to confirm the performance of each site and to provide an adequate basis to update the SMMP, as described below.

2.1 Sediment Profile Imaging (SPI) and Plan View Photography (PVP)

The SPI-PVP system provides a surface and cross-sectional photographic record of selected locations on the seafloor to allow a general description of conditions both on and off dredged material deposits. Detailed methods for the SPI-PVP survey are provided in the supplemental QAPP prepared by Germano and Associates (2013 a).

SPI-PVP surveys (Figures 4 and 5) were conducted for each ODMDS to delineate the horizontal extent of the dredged material footprint both within and outside the site boundaries, as well as the status of benthic recolonization on the deposited material. With resolution on the order of millimeters, the SPI system is more useful than traditional bathymetric or acoustic mapping approaches for identifying a number of features, including the spatial extent and thickness of the dredged material footprint over the native sediments of the seabed, and the level of disturbance and recolonization as indicated by the depth of bioturbation, the apparent depth of the redox discontinuity, and the presence of certain classes of benthic organisms (Figure 6). PVP is useful for identifying surface features in the vicinity of where the SPI photos are taken, thereby providing important surface context for the vertical profiles at each station. For each station, a minimum of four SPI photos were taken, coupled with at least a single PVP photo.

The SPI-PV camera system was deployed at a total of 86 stations (40 at South Oahu and 46 at Hilo), compared to the planned 98 (49 at each site). The planned vs actual survey stations around the South Oahu ODMDS are shown in Figure 7, while the Hilo ODMDS survey stations are shown in Figure 8. (Specific coordinates for each station are available in the Appendix.)

***Figure 4.* SPI-PVP camera system being deployed from the Hi'ialakai.**

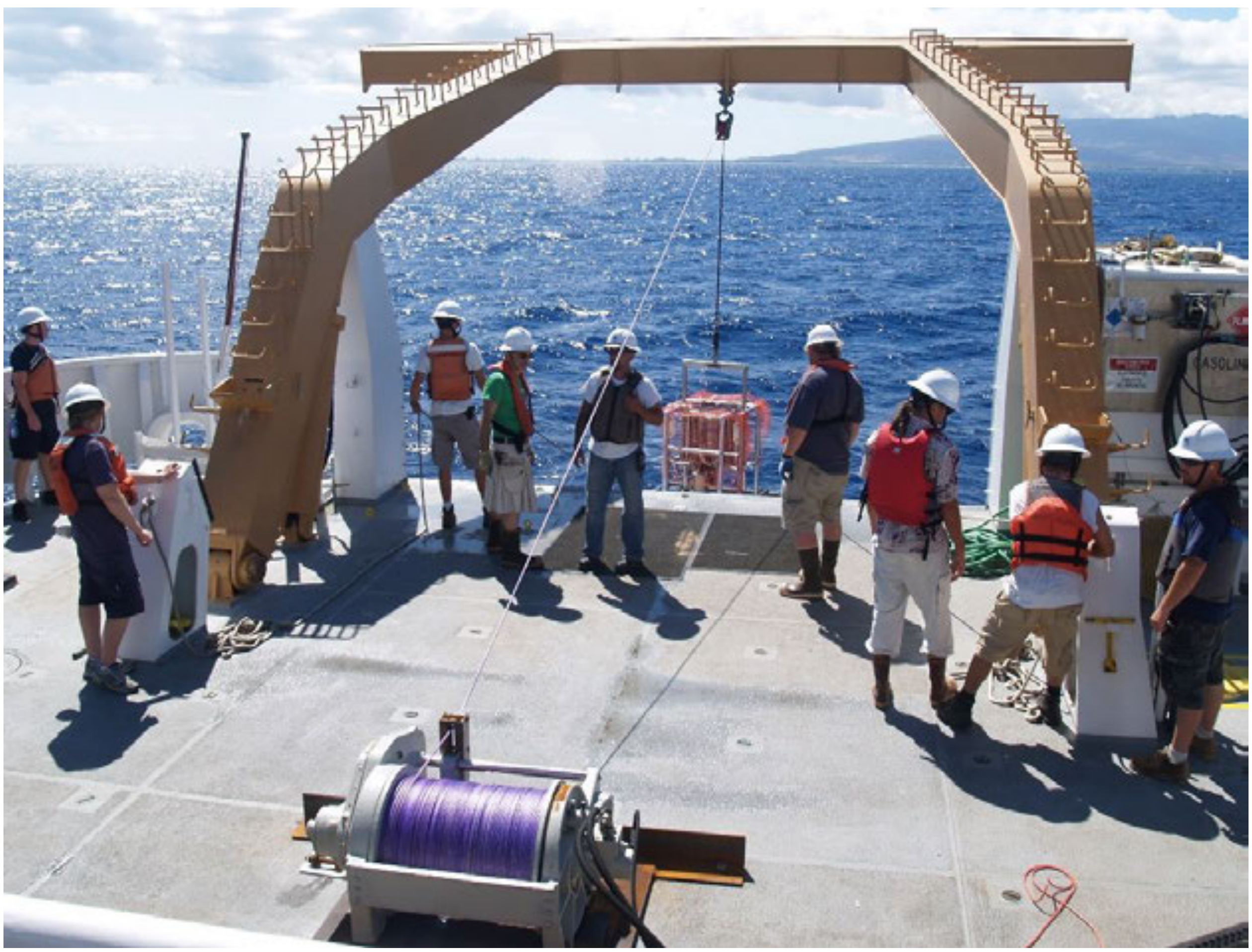


Figure 5. **Schematic of deployment and collection of plan view and sediment profile photographs.** (Germano and Assoc., 2013 b).

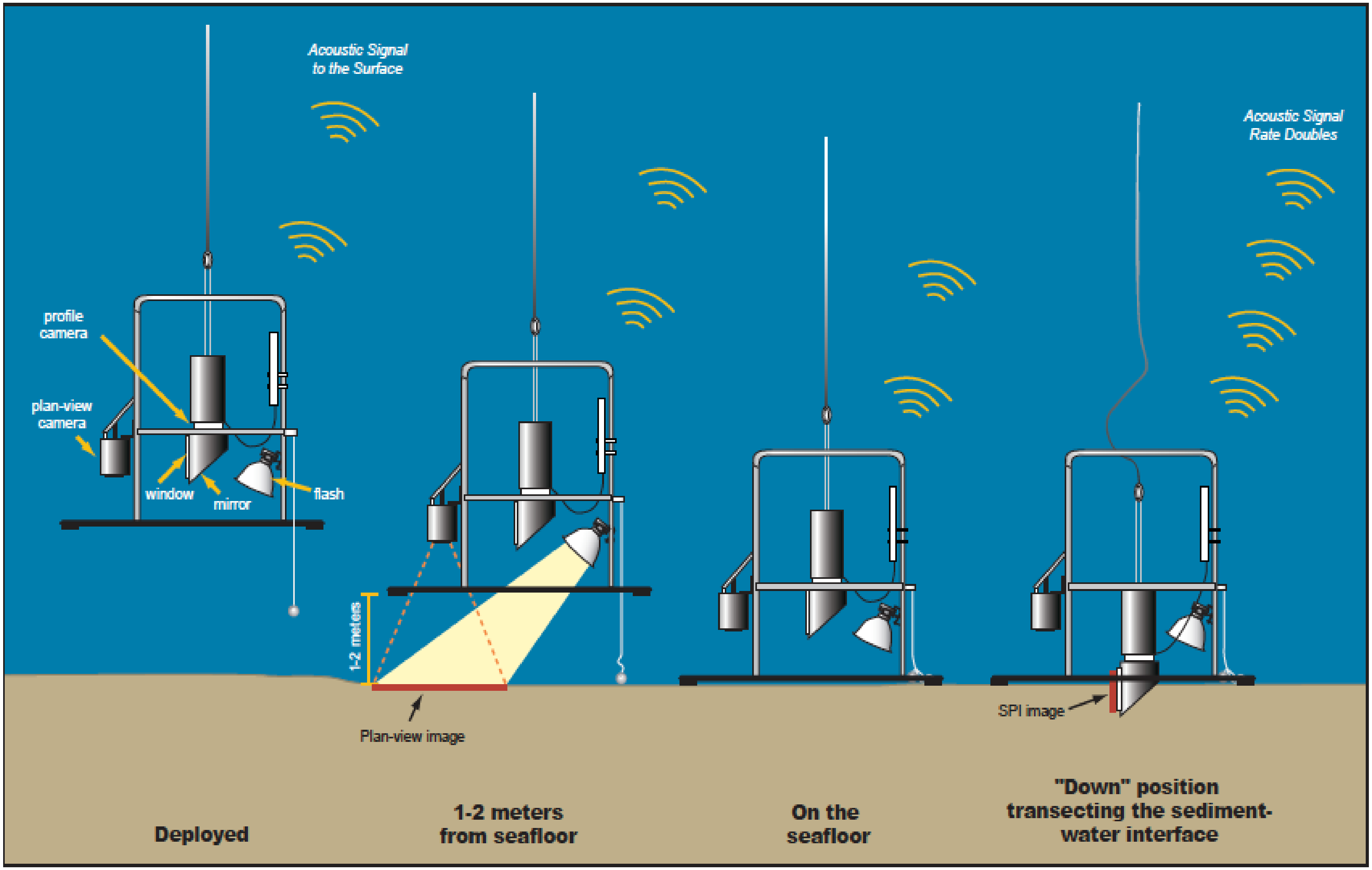


Figure 6. **Soft-bottom benthic community response to physical disturbance (top panel) or organic enrichment (bottom panel).** From Rhoads and Germano (1982).

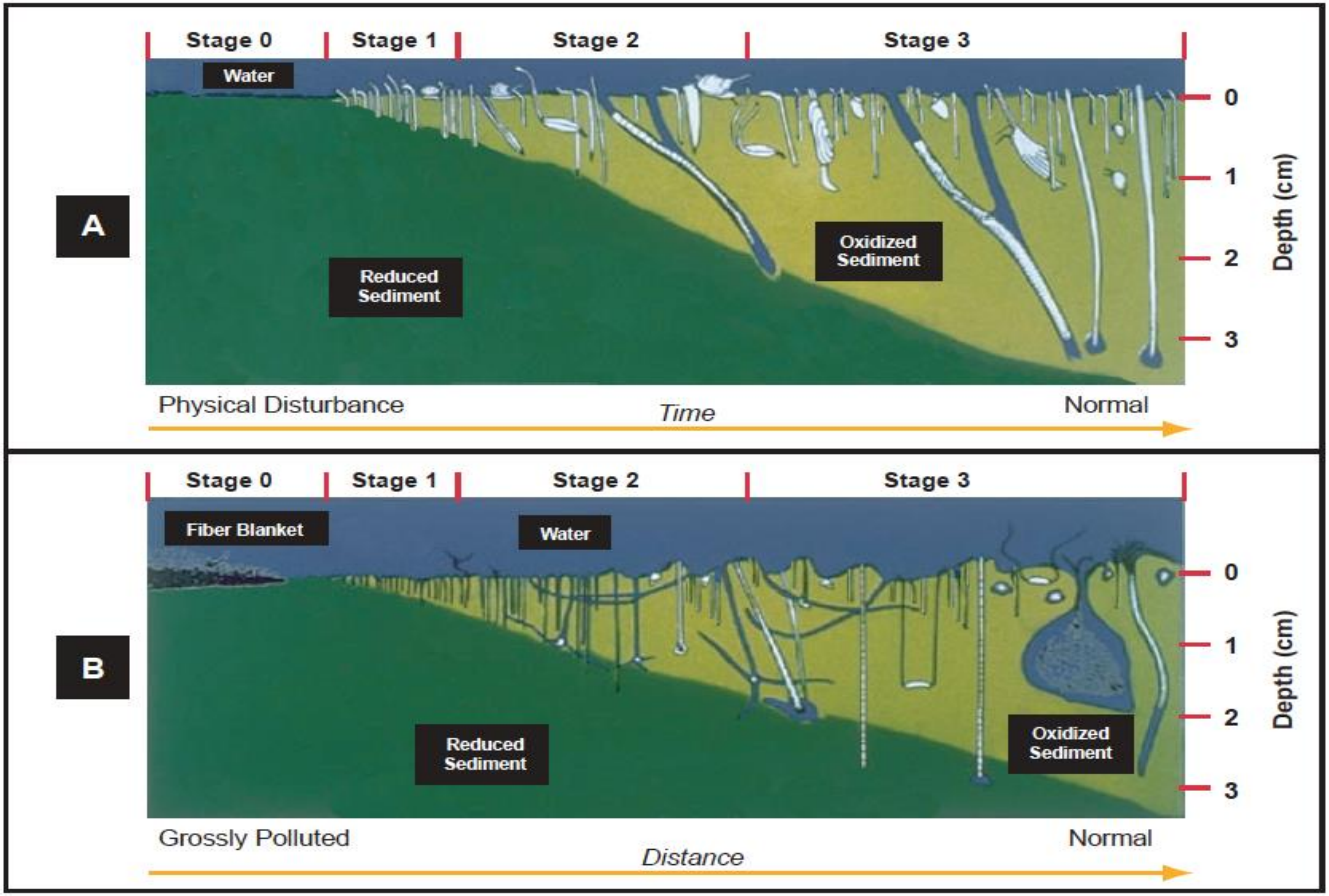


Figure 7. **Planned (yellow squares) and actual sample station locations at the South Oahu ODMDS.** (The circle at the east side of the map shows the location of a historic disposal site used before 1981.)

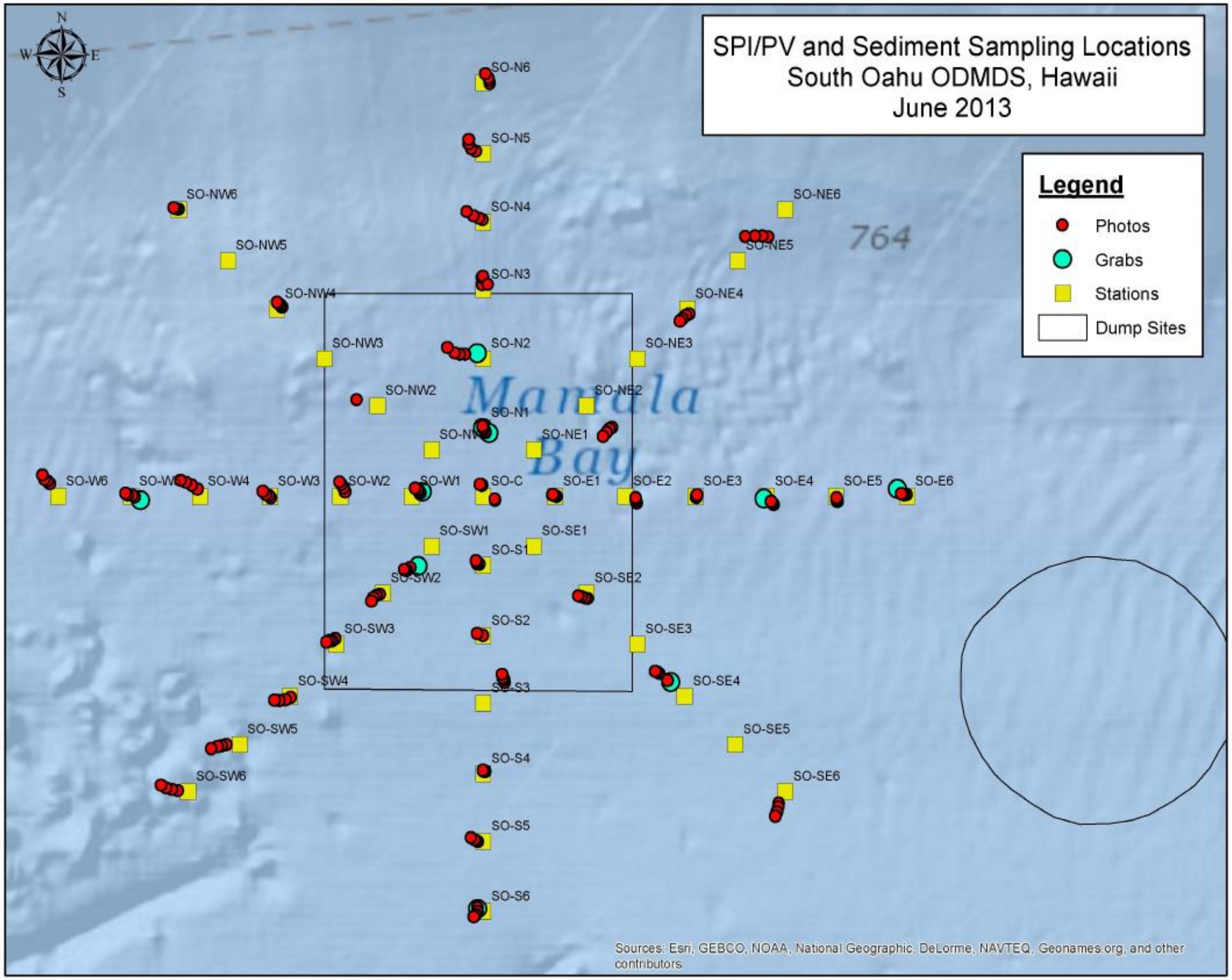
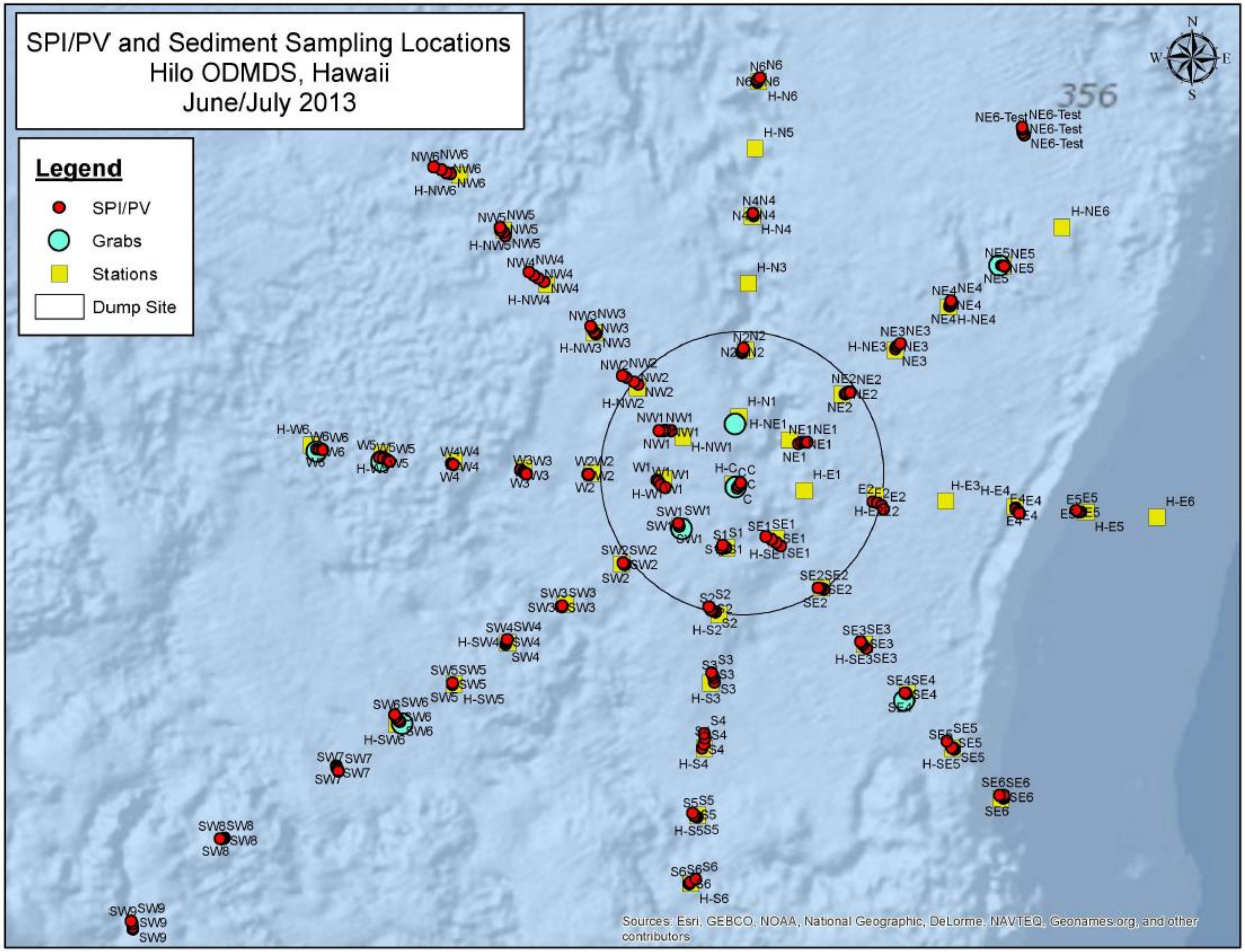


Figure 8. **Planned (yellow squares) and actual sample station locations at the Hilo ODMDS.**



2.2 Sediment Sampling for Chemistry and Benthic Communities

Sediment samples were collected from a subset of stations at each disposal site for sediment grain size, chemistry, and benthic community analysis. Samples were collected using a stainless steel double Van Veen sediment grab (Figure 9, showing side-by-side configuration) capable of penetrating a maximum of 20 centimeters below the sediment surface. Detailed methods for performing the sediment sampling for chemistry and benthic community analyses are described in the QAPP (EPA, 2013 a).

After each acceptable grab sample was measured for depth of penetration and photographed, a subsample for chemistry was extracted from one side of the grab sampler with a stainless steel spoon (Figure 10). This subsample was homogenized and divided into separate jars (Figure 11) for chemistry analyses (grain size, metals and organics). After the chemistry subsample was extracted, the entire volume of the other side of the grab was processed to create a benthic community sample for that station (Figure 12). A 500 micron sieve was used to separate organisms from the sediment, and the separated organisms were placed into bottles where they were initially preserved with formalin. A total of 18 sediment grab sample stations were sampled in the two survey areas combined: 10 at South Oahu, and 8 at Hilo (see Figures 7 and 8, respectively). Chemistry subsamples were collected from all 18 stations and benthic community samples were collected at 14 of the 18 stations (the lower number of benthic community samples was due to some grabs being used for field and laboratory chemistry duplicates, and one station where QAPP metrics were not met for an acceptable benthic sample).

***Figure 9.* Double Van Veen sediment sampler deployed from the Hi'ialakai.**

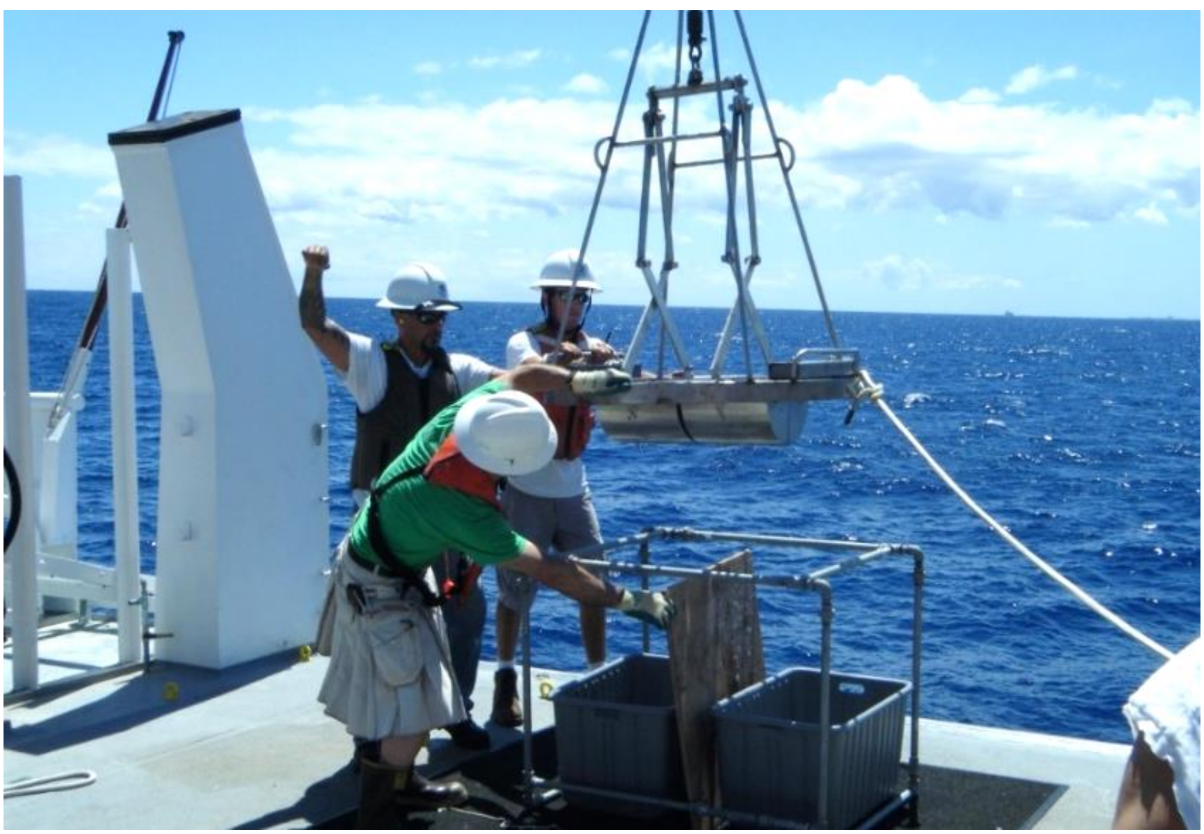


***Figure 10*. Subsampling from the Van Veen grab for sediment chemistry.**

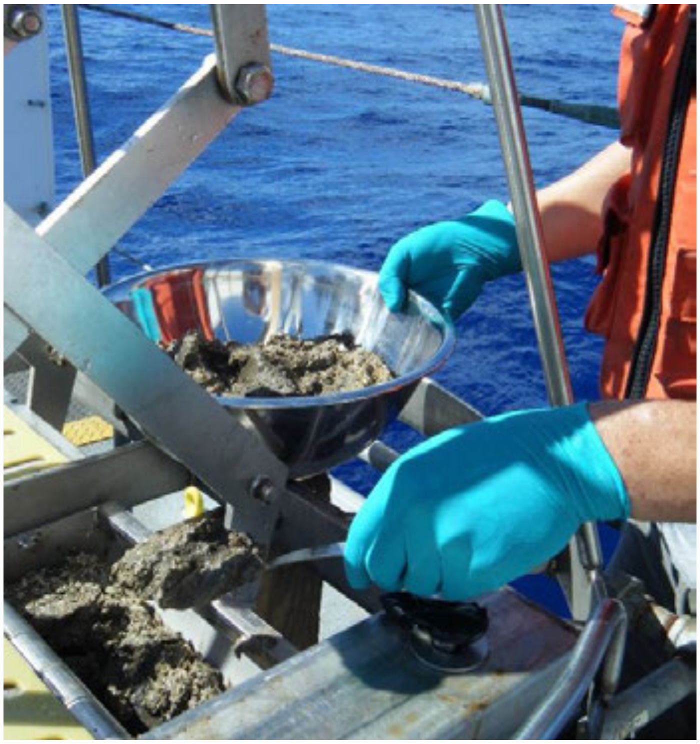


***Figure 11*. Processing a sediment sub-sample for chemical analysis.**

***Figure 12.* Processing a sediment sample for benthic community analysis.**

2.3 Sub-Bottom Profiling Survey of the South Oahu ODMDS

The primary purpose of this survey was to collect cross-sectional images of the native sediment layers and layers indicative of the dredged material deposit across a wide area in the environs of the South Oahu ODMDS. (The Hilo site was not surveyed in this manner during this round of surveys because much smaller volumes of dredged material have been disposed there over time which may not be detectable in terms of thickness and contrast.)

This type of survey allows EPA to separately estimate the cumulative volume of dredged material disposed at the South Oahu site, compared to volumes permitted for disposal. The survey was sub-contracted to Sea Engineering, who conducted the work aboard a separate vessel specially rigged for this type of survey with an acoustic sub-bottom profiler system (Figure 13). Figure 14 shows the grid of transects surveyed. Detailed methods for the sub-bottom survey are provided in the supplemental QAPP prepared by Sea Engineering (2013).

Figure 13. **Sub-bottom profiler equipment – used only at the South Oahu site.**

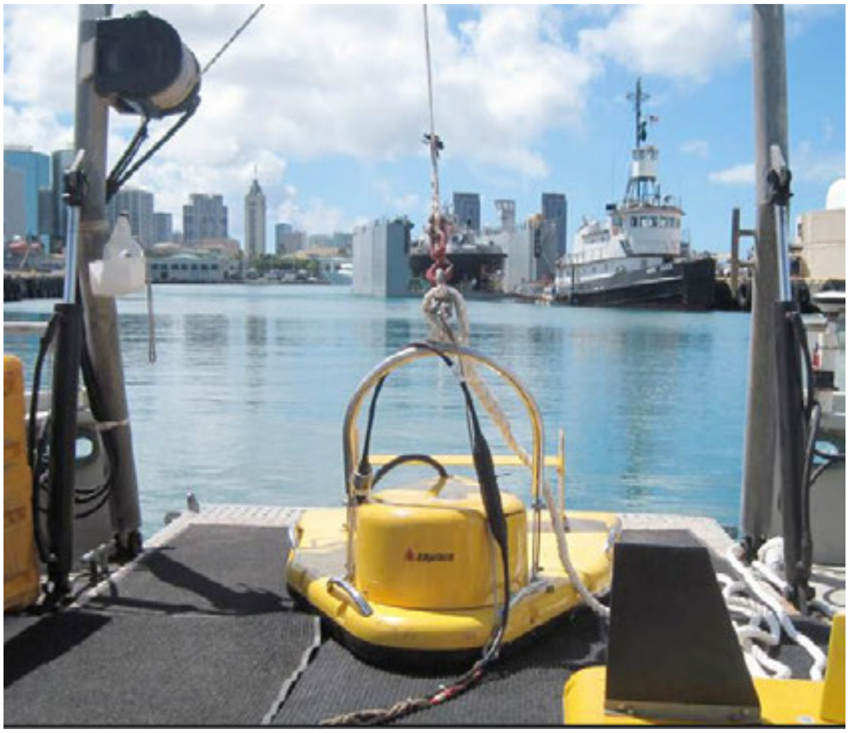
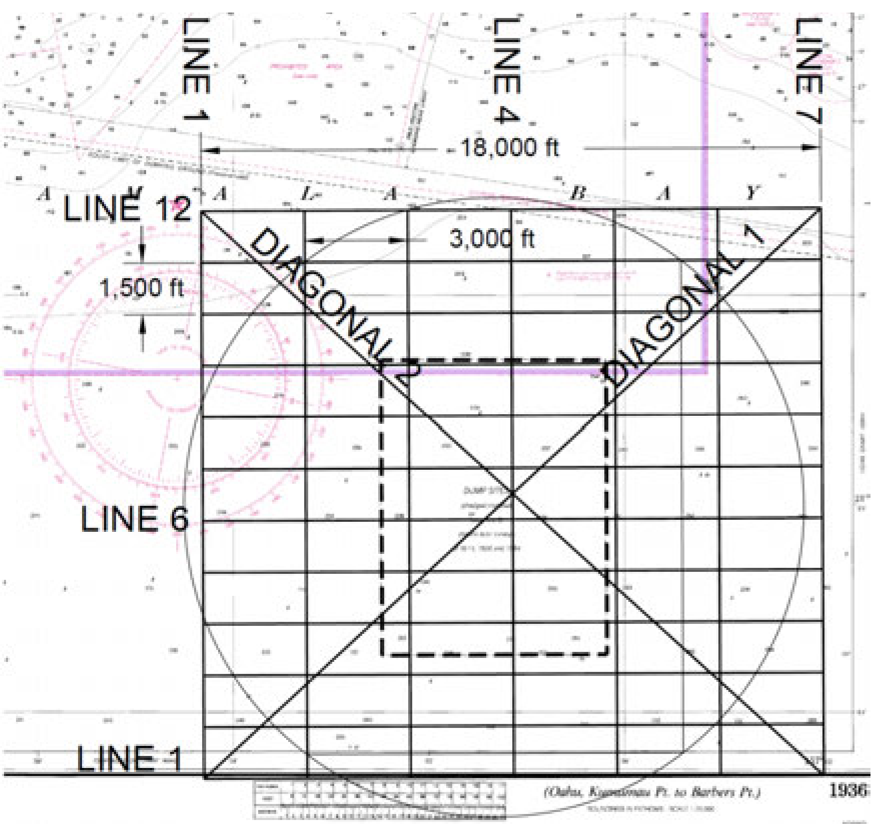


Figure 14. **Planned transect lines for the sub-bottom profiling survey around the South Oahu ODMDS** (from Sea Engineering, Inc., 2014).



III. SURVEY RESULTS

3.1 SPI – PVP Survey Results

3.1.1 Dredged Material Footprint Mapping

The presence and extent of the dredged material footprint was successfully mapped at both Hawaii disposal sites. SPI images of typical native sediments (outside of any dredged material deposit) around the South Oahu and Hilo sites are shown in Figure 15. Dredged material is usually evident because of its unique optical reflectance and/or color relative to the native pre-disposal sediments. The presence of dredged material layers can be determined from both plan view images (Figure 16) and from SPI images (Figure 17). In most cases, the point of contact between the two layers is clearly visible as a textural change in sediment composition, facilitating measurement of the thickness of the newly deposited layer.

Two off-site stations around the South Oahu site had native hard-bottom habitat (N6 and SW5, Figure 7); otherwise the native sediment was fairly uniformly muddy fine sand. The overall dredged material footprint extended well beyond the current disposal site boundary (Figure 18; also see Figure 28). Given the lack of natural fine grained sediment around the South Oahu site, dredged material would be expected to remain visible on the seafloor for a substantial amount of time (decadal scale). Similarly, given the proximity of historic disposal sites to the current designated site in Mamala Bay and the large cumulative volume of disposed sediments over the years (Table 1), it is not surprising that traces of dredged material are found outside of the current designated site boundary. However, the thickest off-site deposits were just north (shoreward) of the site boundary indicating that "short-dumping" (disposal from scows before they reached the Surface Discharge Zone at the middle of the site) probably occurred in the past. EPA has required satellite-based tracking of all disposal scows since the early 2000s, and there have been no "short-dumps" since a single partial mis-dump occurred in 2006. Thus the footprint outside the disposal site boundary would appear to be relic material deposited more than 10 years ago.

Compared to South Oahu, native sediments around the Hilo site were finer. Two off-site stations (E5 and SE6, Figure 8) were on rocky lava outcrops. Even though this area is primarily a silty, very fine to fine sandy bottom, there are periodic lava deposits or rock outcrops creating some topographic diversity. The substantially smaller cumulative volume of dredged material disposed at Hilo appeared to be more fully confined within the designated disposal site boundary (Figure 19). Except at the center of the site where rubble has accumulated (Figure 20), dredged material thickness was only 3 cm or less within the site boundary, and less than 1 cm thick outside the boundary.

3.1.2 Bioturbation Depth

The depth to which sediments are biologically mixed is an important indicator of the status of recovery of the infaunal community following disturbance (e.g., by dredged material disposal). Biogenic particle mixing depths can be estimated by measuring the depths of imaged feeding voids in the sediment column. This parameter represents the particle mixing depths of head-down feeders, mainly polychaetes. This depth is also related to the apparent redox potential discontinuity (aRPD) depth. In the absence of bioturbating organisms, the aRPD (in muds) will

Figure 15. Profile images from the ambient bottom at the Hilo ODMDS (left, Station S3) and the South Oahu site (right, Station S6). The ambient seafloor at Hilo has a higher silt-clay content, allowing greater camera penetration than at South Oahu. Scale: width of each profile image = 14.4 cm. (Germano & Assoc., 2013)

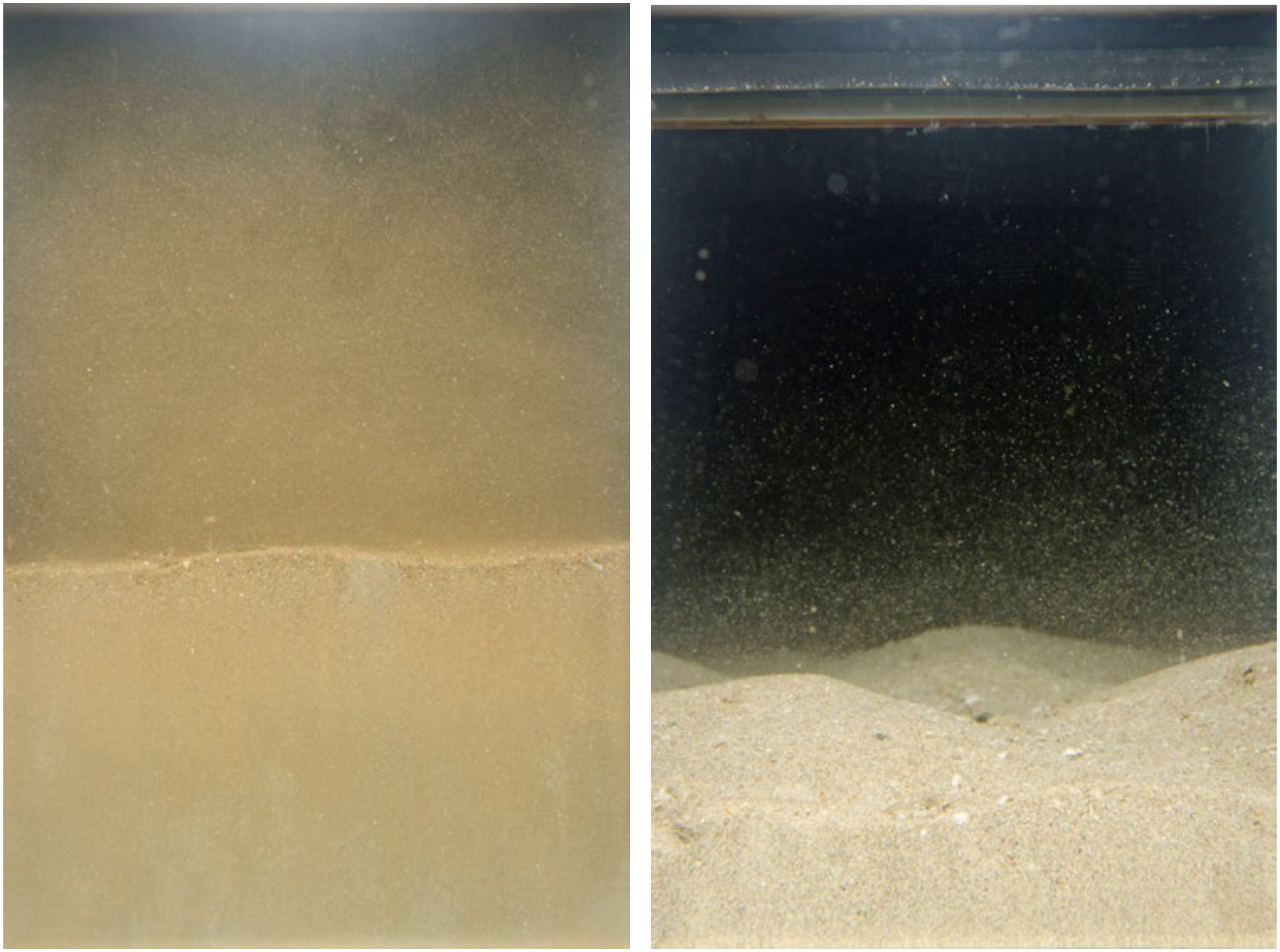


Figure 16. Plan view images of the dredged material deposit compared to the native seafloor at South Oahu. Station C1 on dredged material (top) shows the visual difference in both sediment color and surface texture/features of dredged material compared to the ambient bottom at Station NW6 (bottom). Scale: width of each PV image is approximately 4 m. (Germano & Assoc., 2013)

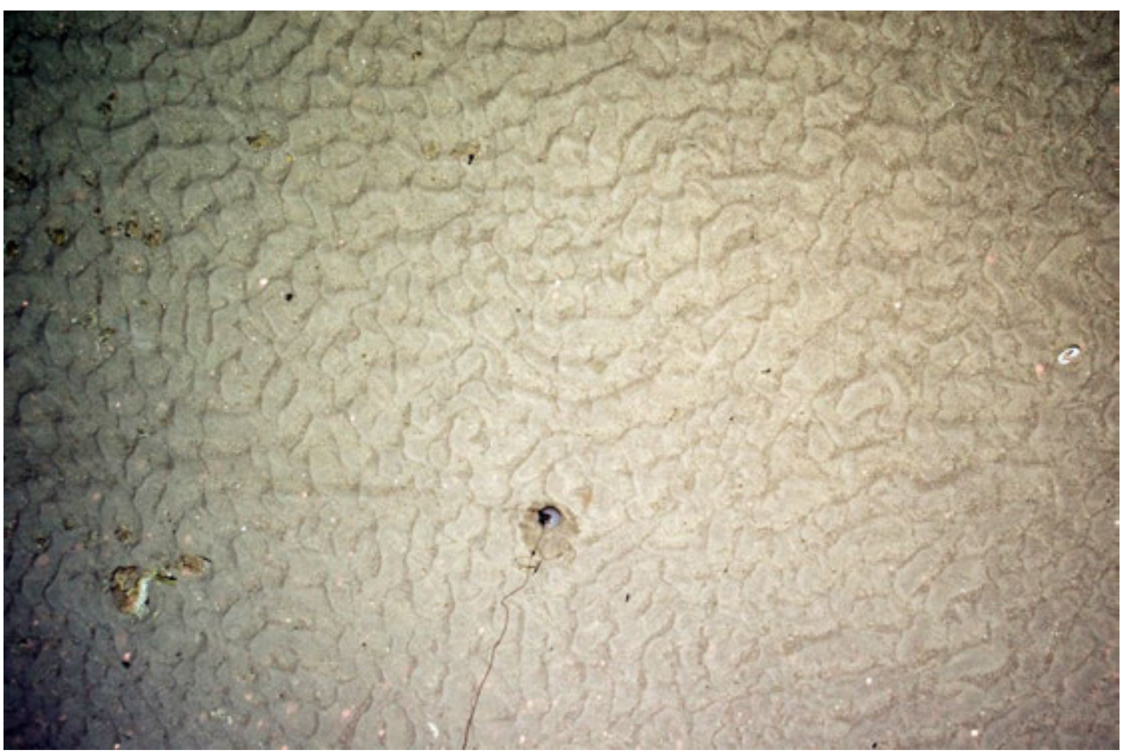


Figure 17. Profile images from two Hilo Stations showing a surface layer of disposed coarse white dredged sand that thins from NW1 (left) near the center of the disposal site to only trace amounts at NW3 (right). Scale: width of each profile image = 14.4 cm. (Germano & Assoc., 2013)

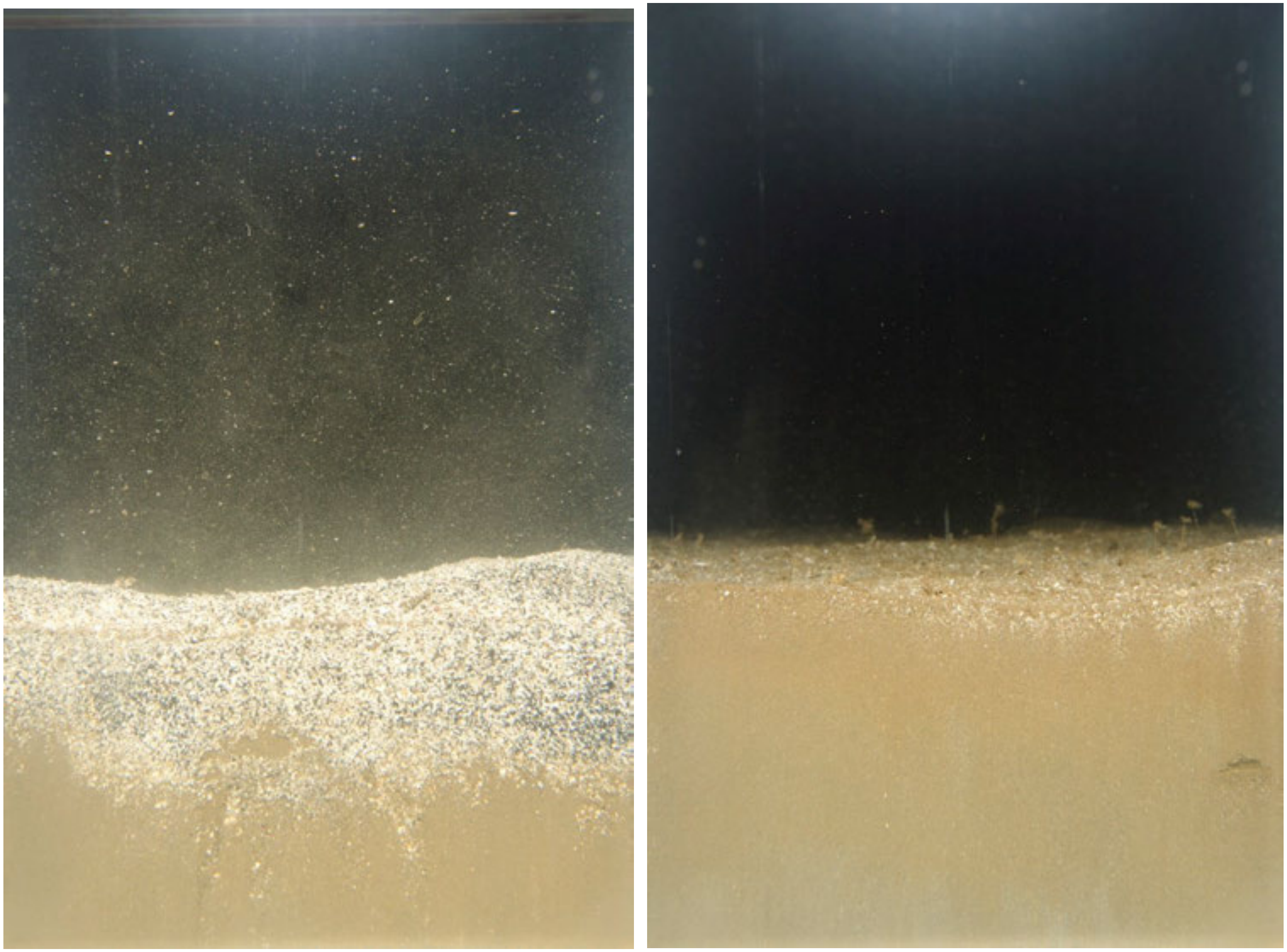


***Figure 18.* Dredged material footprint identified at the South Oahu site.**

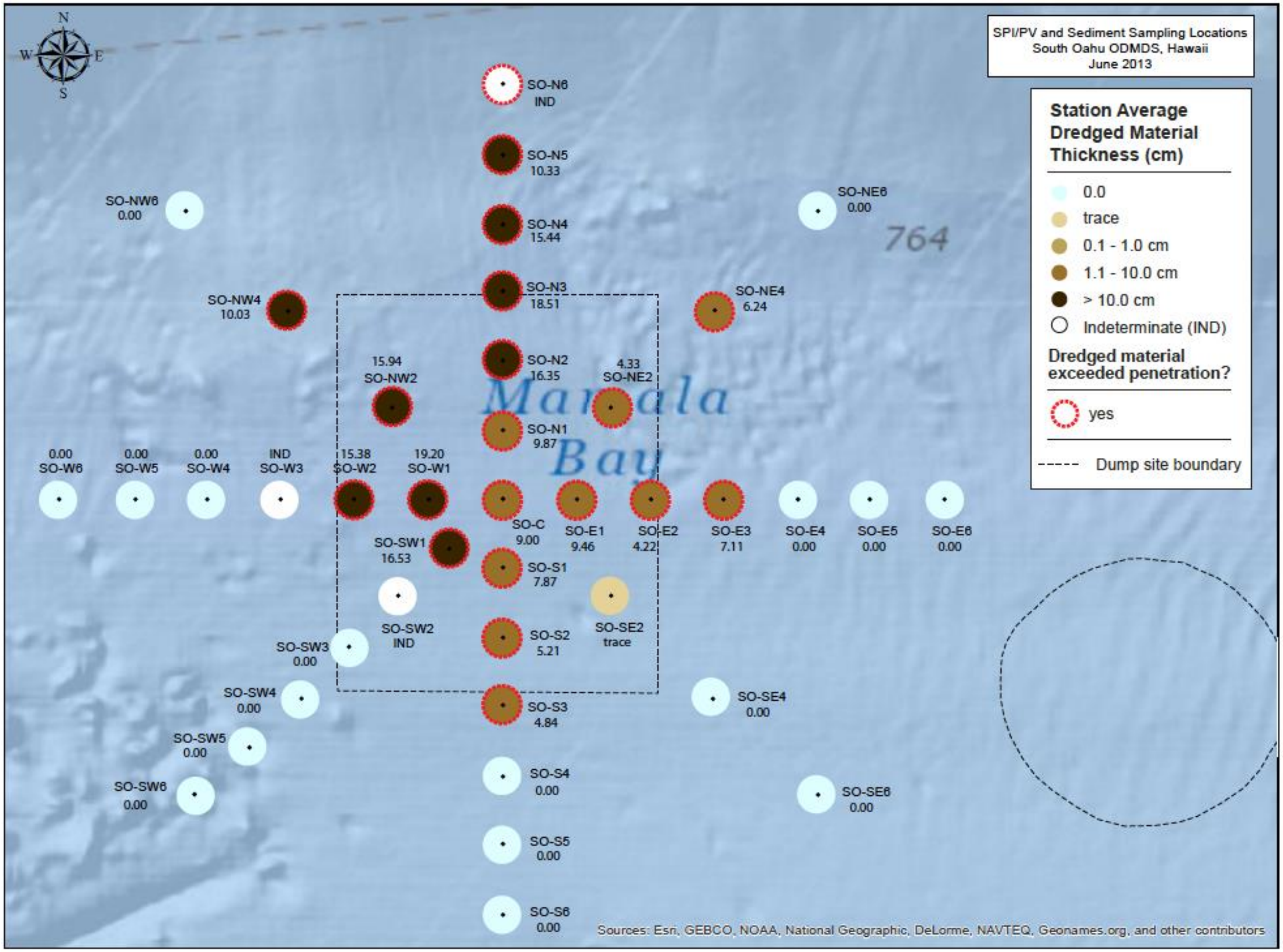


Figure 19. **Dredged material footprint identified at the Hilo site.**

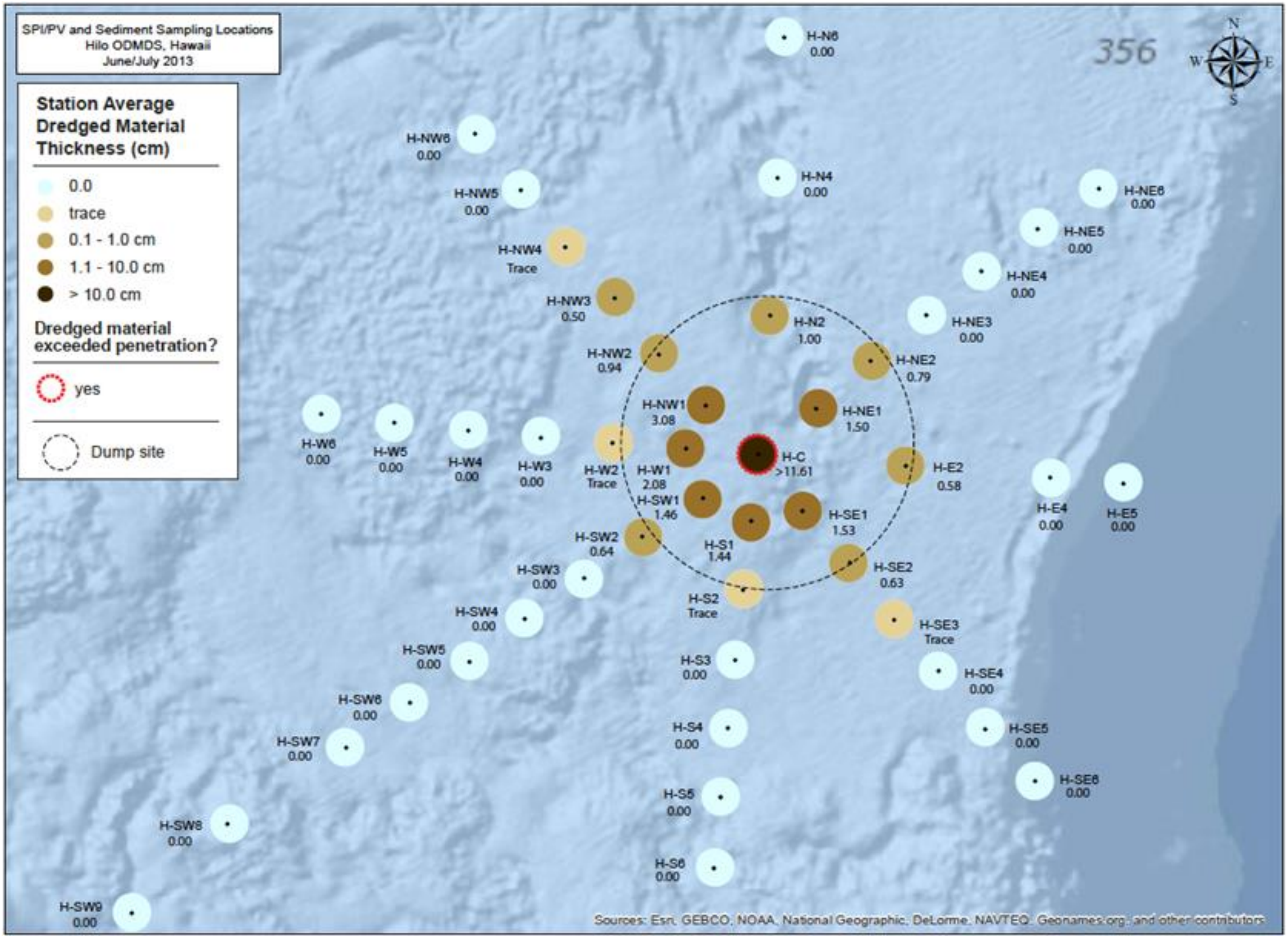
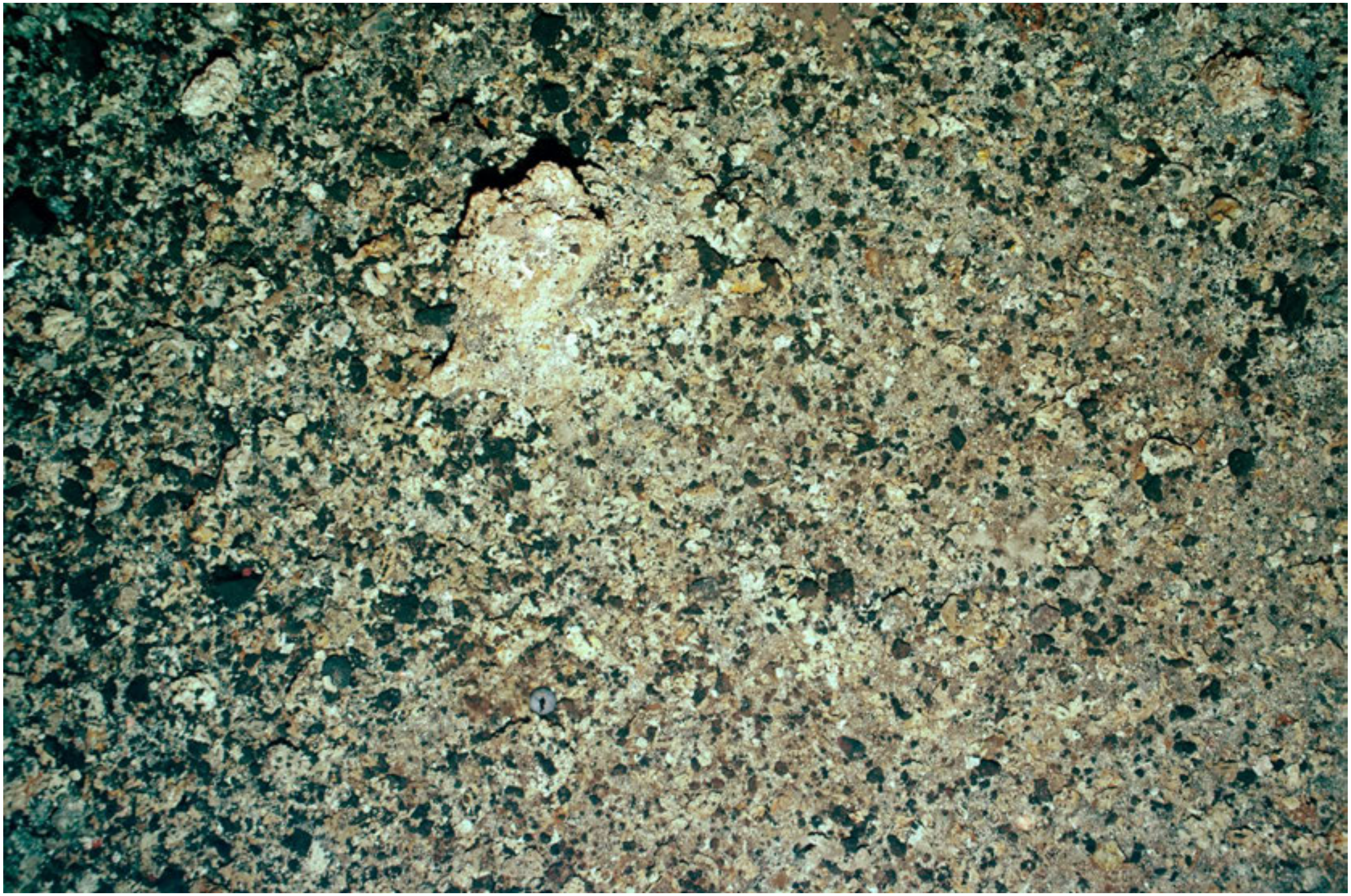


Figure 20. Plan view image from the center station of the Hilo ODMDS shows a high density of small rock and coral rubble. Rubble falls rapidly through the water column with minimal dispersal, and thus has accumulated only at the center of the site. Scale: width of PV image is approximately 4 m. (Germano & Assoc., 2013)



typically reach only 2 mm below the sediment-water interface (Rhoads 1974). However, it is quite common in profile images to see evidence of biological activity (burrows, voids, or actual animals) well below the mean aRPD (Germano and Assoc., 2013 b).

At the South Oahu site, the maximum bioturbation depths (>15 cm) were generally found at the stations that also had the thickest deposits of dredged material (including the off-site stations to the north with relic dredged material deposits) (Figure 21). A similar pattern was seen for average feeding void depth, and for the aRPD depth (see Germano and Assoc., 2013 b). This is to be expected, since dredged material is generally finer, less consolidated, and therefore more conducive to supporting a richer community of burrowing organisms compared to the native, consolidated fine sand around the disposal site. Stations with a native fine sand substrate exhibited lower camera penetration, shallower aRPD depths, and shallower average feeding void depths.

At the Hilo site, where much less dredged material has been discharged and where the native seafloor is more heterogenous, the pattern was different (Figure 22). Although dredged material was thickest at the center of the site, a high concentration of gravel and coral rubble prevented full camera penetration there, so that bioturbation depth and aRPD could not be determined fully. Other on-site stations showed fairly uniform bioturbation depths of 7-10 cm. Many off-site stations also had bioturbation depths in this range, although bioturbation depths of 10-18 cm were also common. Since the native seafloor around the Hilo site is finer-grained than around the South Oahu site, greater bioturbation depths, and less difference between on-site and off-site stations, would be expected.

3.1.3 Infaunal Successional Stage

The mapping of infaunal successional stages is readily accomplished with SPI technology. Mapping of successional stages is based on the theory that organism-sediment interactions in fine-grained sediments follow a predictable sequence after a major seafloor perturbation (Germano and Assoc., 2013). This continuum of change in animal communities after a disturbance (primary succession) has been divided subjectively into four stages: Stage 0, indicative of a sediment column that is largely devoid of macrofauna, occurs immediately following a physical disturbance or in close proximity to an organic enrichment source; Stage 1 is the initial community of tiny, densely populated polychaete assemblages; Stage 2 is the start of the transition to head-down deposit feeders; and Stage 3 is the mature, equilibrium community of deep-dwelling, head-down deposit feeders (see Figure 6).

After an area of bottom is disturbed by natural or anthropogenic events, the first invertebrate assemblage (Stage 1) appears within days after the disturbance. Stage 1 consists of assemblages of tiny tube-dwelling marine polychaetes that reach population densities of 10^4 to 10^6 individuals per m^2. These animals feed at or near the sediment-water interface and physically stabilize or bind the sediment surface by producing a mucous “glue” that they use to build their tubes.

If there are no repeated disturbances to the newly colonized area, then these initial tube dwelling suspension or surface-deposit feeding taxa are followed by burrowing, head-down deposit feeders that rework the sediment deeper and deeper over time and mix oxygen from the overlying water into the sediment. The animals in these later-appearing communities (Stage 2 or 3) are larger, have lower overall population densities (10 to 100 individuals per m^2), and can rework the sediments to depths of 3 to 20 cm or more.

Figure 21. **Bioturbation depth at the South Oahu site** – deeper values here are reflective of an active benthic community reworking deposited dredged material. (Germano & Assoc., 2013)

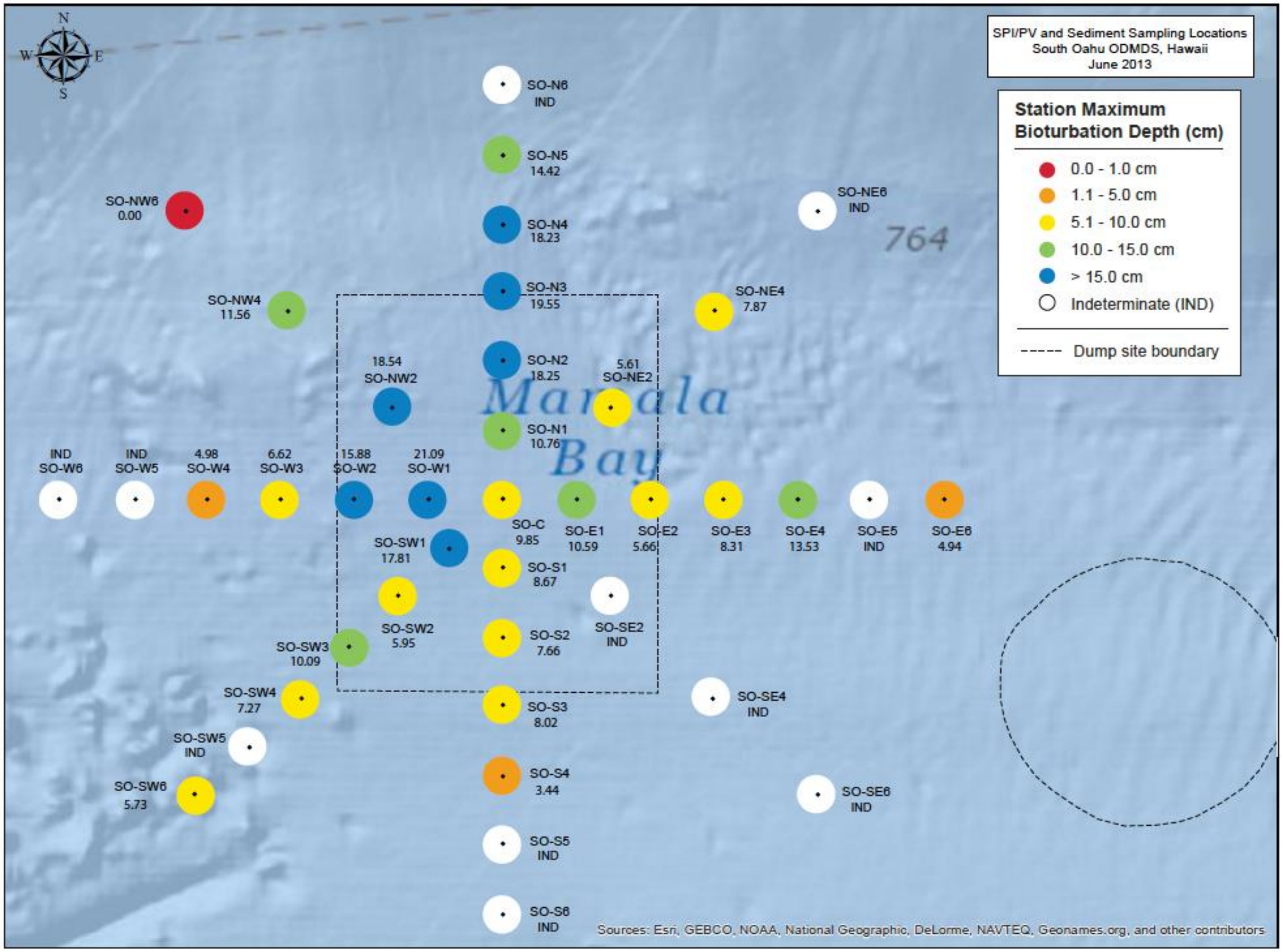
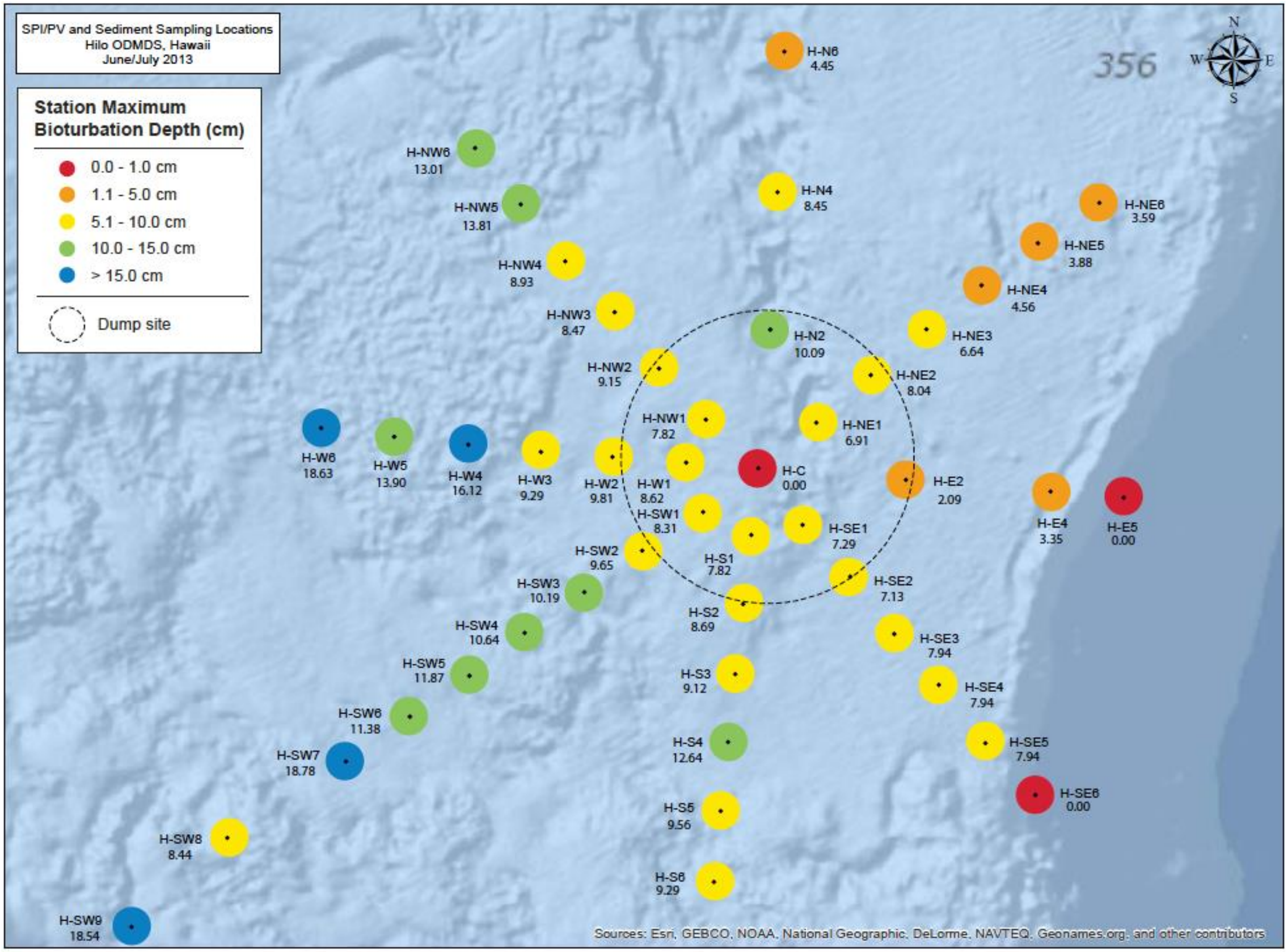


Figure 22. **Bioturbation depth at the Hilo site:** on-site and off-site stations show similar depths (much less material has been disposed here than at South Oahu). (Germano & Assoc., 2013)



Various combinations of these basic successional stages are possible. For example, secondary succession can occur (Horn, 1974) in response to additional labile carbon input to surface sediments, with surface-dwelling Stage 1 or 2 organisms co-existing at the same time and place with Stage 3, resulting in the assignment of a "Stage 1 on 3" or "Stage 2 on 3" designation

The distribution of successional stages in the context of the mapped disturbance gradients is one of the most sensitive indicators of the ecological quality of the seafloor (Rhoads and Germano 1986). The presence of Stage 3 equilibrium taxa (mapped from subsurface feeding voids as observed in profile images) can be a good indication of relatively high benthic habitat stability and quality. A Stage 3 assemblage indicates that the sediment surrounding these organisms has not been disturbed severely in the recent past and that the inventory of bioavailable contaminants is relatively small.

At the South Oahu site, infaunal community successional stage was readily apparent on the dredged material deposit, but was generally unmeasurable (indeterminate) on the native sandy sediments off-site (Figure 23). Successional stage on the dredged material mound, including the relic off-site material to the north, was fairly uniformly Stage 1 on 3. While this indicates relatively rapid recolonization and a well-established infaunal community in the finer, more carbon-rich dredged sediments, it is clearly a different community than would be supported by the native fine sand at this location in the absence of dredged material disposal.

At the Hilo site, differences between stations with and without dredged material were less apparent (Figure 24). Since far less dredged material has been discharged at this site than at the South Oahu site, less disturbance to the native sediments around the site has occurred. Both on-site and off-site stations were dominated by Stage 1 on 3 communities, but more heterogenous communities were present to the east and northeast of the site as well. These stations had either no apparent dredged material, or only trace thicknesses of dredged material; therefore the different community structure at these stations may reflect natural heterogeneity of benthic habitat types in this area rather than any particular effect from dredged material deposition.

3.1.4 Plan-View Photography

Unusual surface sediment textures or structures detected in any of the sediment profile images can be interpreted in light of the larger context of surface sediment features (for example, is a surface layer or topographic feature a regularly occurring feature and typical of the bottom in this general vicinity or just an isolated anomaly?). The scale information provided by the underwater lasers allows accurate density counts (number per square meter) of attached epifaunal colonies, sediment burrow openings, or larger macrofauna or fish which may be missed in the sediment profile cross-sections.

Except for the two stations on hard bottom, the native seafloor around the South Oahu site is a muddy carbonate sand with rippled bedforms and relatively low abundance of epifauna. Other than the occasional hermit crab or other decapods such as shrimp or Brachyurans, the presence and abundance of epifauna was directly proportional to the amount of rock/rubble/outcrop present on the flat sandy bottom. Anything that provided a hard surface or additional vertical relief for niche/topographic diversity became a suitable substratum to which organisms could attach (tunicates, cnidarians, bryozoans) or hide within (echinoderms), which subsequently attracted more fish to that particular location.

Figure 23. **Community structure at the South Oahu site:** presence of Stage 3 organisms is indicative of healthy benthic community. (Germano & Assoc., 2013)

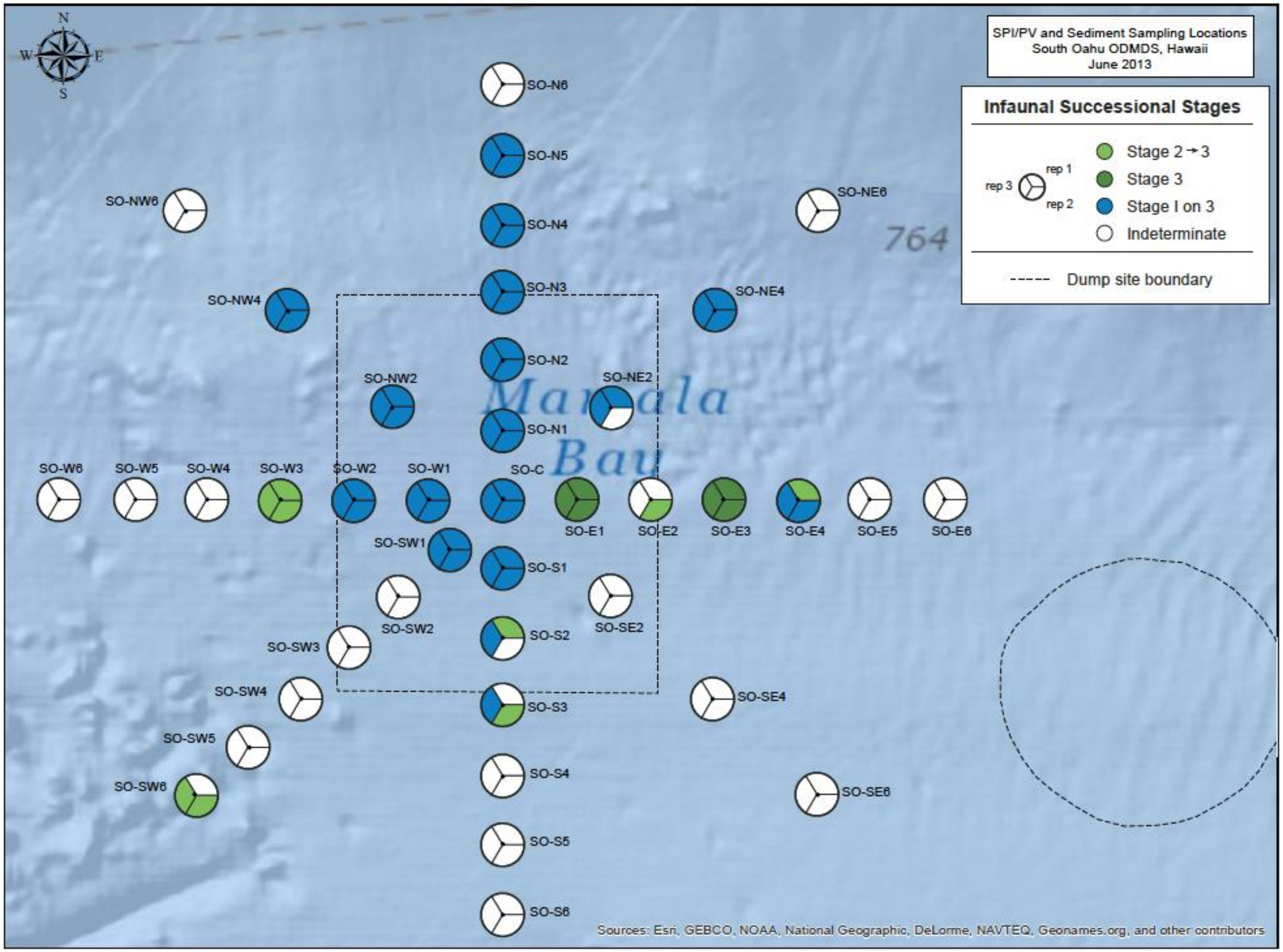
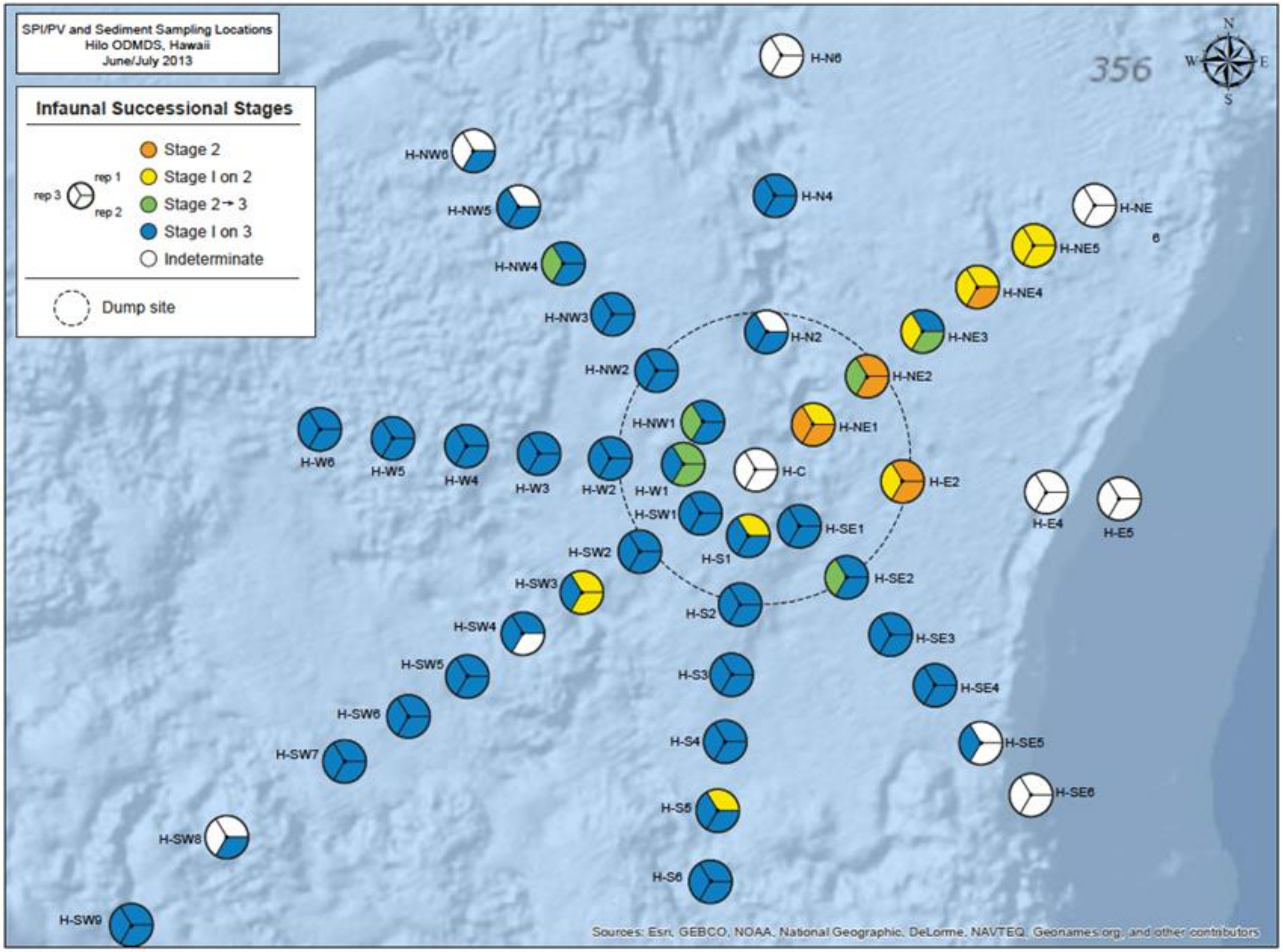


Figure 24. **Community structure at the Hilo site:** presence of Stage 3 organisms is indicative of healthy benthic community. (Germano & Assoc., 2013)



In contrast, the native Hilo sediments had a higher percentage of fine sediments (attracting higher densities of small prey, evidenced by burrow holes in plan view images) along with more frequent occurrence of rocky outcrops (creating habitat heterogeneity) both inside and outside the site boundaries. These characteristics attracted a generally more abundant and varied epifauna and fish assemblage. Unlike the South Oahu site, the areas of the highest accumulation of dredged material (near the site center where the surface was a continuous cover of rubble) appeared to have the lowest faunal attractiveness. But higher densities of fish and anthozoans as well as more frequent evidence of burrowing infauna were seen throughout the area as a whole, compared to South Oahu.

3.1.5 Discussion: SPI – PVP Surveys

Minor and localized physical impacts are expected within the site as a result of disposal operations. However, historical and more recent disposal activity appear to have had little lasting adverse impact on benthic infauna, or epibenthic organisms, at either site. With the exception of the center station at the Hilo site where an accumulation of disposed rubble has most likely altered the resident infaunal community on a localized scale, the disposal of dredged material, in general, has not impeded benthic recolonization or the re-establishment of mature successional stages. At the South Oahu site, it appears the larger cumulative volume of fine grained, higher carbon content dredged material deposited over the native coarser grain carbonate sands may have actually enhanced the secondary benthic production by promoting the settlement and persistence of subsurface deposit feeders that would not normally exist in the native carbonate sand bottom here.

The prediction in the original EIS (EPA 1980) that disposal of dredged material at both the Hilo and South Oahu ODMDS will have no lasting adverse impact on the benthic community inside or outside of site boundaries is supported by the results of the SPI-PVP survey. Stage 3 taxa have successfully recolonized all but the center station at the Hilo ODMDS, and secondary production appears to be enhanced at the South Oahu ODMDS within the dredged material footprint. Also epifauna, in general, are similar on-site and off-site (though different between South Oahu and Hilo overall.

Based on the results of the SPI-PVP surveys, the authors predicted that the traditional benthic sampling results would also show a higher species diversity and infaunal abundance in samples from the Hilo site versus those from the South Oahu site, because of the increased amount of fines and evidence of increased subsurface burrowing in the images from the Hilo site. (See discussion of Benthic Community Analysis Results, below.)

3.2 Sediment Physical and Chemical Survey Results

Full physical and chemical analytical results are provided in ALS Environmental (2013) and EPA (2013 b). Due to vessel and equipment problems, less than half the originally-targeted benthic grab stations were sampled. But by using the SPI survey results to help select the chemistry (and benthic community) stations at each site, a sufficient number of samples were collected within and outside of site boundaries and the dredged material footprints to characterize the native (ambient) seafloor compared to seafloor areas physically impacted by dredged material disposal. Nevertheless, only qualitative (vs statistical) analysis of the physical and chemical results was conducted given that only four “on site” and five “offsite” stations were ultimately sampled at South Oahu, and only three “on site” and four “offsite” stations were sampled at Hilo.

3.2.1 Physical Results

Minor and localized physical impacts are expected within the site boundary as a result of disposal operations. Tables 2 (South Oahu) and 3 (Hilo) compare areas within the disposal sites that have dredged material deposits (indicated as "Inside") and off site areas without any dredged material deposits (indicated as "Outside"). Physical on-site differences are most apparent at the South Oahu site, which has received an order of magnitude more dredged material over the years than the Hilo site. At South Oahu (Table 2), "inside" stations have substantially more gravel, more fines (silt and clay), and higher organic carbon content than the "outside" stations that represent ambient or native seafloor conditions. This reflects the character of dredged material typically disposed at this site, which often includes grave-size coral rubble, and fines from land-side runoff that settles in harbors, berths, and navigation channels. In contrast, native sediments around the South Oahu site are uniformly sandier, with lower carbon. These on-site physical changes are expected to be persistent, but are not considered to be a significant or adverse impact.

Physical characteristics of the off-site ambient or native sediments around the Hilo site are more variable (Table 3) reflecting the more heterogeneous nature of the seafloor in the area, which includes a mixture of hard bottom features (submerged reef and terraces) coupled with areas of accumulated finer grained sediments (USGS, 2000). The dredged material disposed at the Hilo site has not substantially altered the physical nature of the disposal site in part due to this natural variability, and in part because only a relatively small volume of material has been disposed at Hilo (especially compared to disposal volumes at South Oahu).

3.2.2 Chemical Results

Although physical differences are expected as a result of disposal operations, pre-disposal sediment testing is intended to minimize any degradation to the site which might be caused by introduction of contaminants which are bioavailable and/or pose a toxicity risk to the marine environment. The bulk chemistry data show low but variable concentrations of most chemical constituents at both sites (Tables 2 and 3). At both "inside" and "outside" stations, four to six metals were at concentrations above NOAA's effects-based 10th percentile screening value (ER-L), below which adverse effect are predicted to rarely occur (NOAA, 2008). Of these metals, only chromium, copper, and mercury were slightly higher at "inside" stations compared to "outside" stations, and only at the South Oahu site. At Hilo, the metals concentrations were virtually indistinguishable between "inside" and "outside" stations.

Only nickel exceeded its 50th percentile screening value (ER-M), above which adverse effects are expected to frequently occur (NOAA, 2008). It was most elevated at Hilo, but was at similar elevated concentrations at both "inside" and "outside" stations there. Nickel is often naturally elevated in certain sediments, including volcanic sediments.

Organic constituents were also low at both sites. Only two constituents exceeded NOAA ER-L screening levels, and again only at the South Oahu site. PCBs and DDTs each slightly exceeded their respective ER-Ls at one "inside" station and one "outside" station. PCBs were generally higher at the "inside" stations, even when not exceeding the ER-L. There were no exceedances of ER-Ls for organics at either "inside" or "outside" stations at the Hilo site.

***Table 2.* Summary of sediment chemistry for the South Oahu Ocean Dredged Material Disposal site and vicinity.**

South Oahu site		Survey Station: "Inside"					"Outside"					NOAA Screening	
Analyte	Units (dw)	SO-N1	SO-N1 dup*	SO-N2	SO-SW1	SO-W1	SO-SE4**	SO-W5	SO-S6	SO-E6	SO-E4	ER-L	ER-M
Gravel	%	21	3	69	3	12	1	1	0	1	11	--	--
Sand	%	43	53	29	47	50	78	79	82	83	64	--	--
Silt	%	21	24	11	25	24	16	12	12	10	20	--	--
Clay	%	14	17	4	15	11	5	4	5	5	7	--	--
Total Organic Carbon	%	1.25	1.78	1.25	1.02	1.48	0.58	0.53	0.43	0.41	0.81	--	--
Arsenic	mg/kg	20	13	24	33	19	40	39	27	30	27	8.2	70
Cadmium	mg/kg	0.6	0.69	0.39	ND	0.43	ND	0.42	ND	ND	ND	1.2	9.6
Chromium	mg/kg	100	160	100	110	120	68	100	47	45	73	81	370
Copper	mg/kg	65	84	47	43	56	22	36	11	13	37	34	270
Lead	mg/kg	25	31	22	15	95	19	37	10	15	23	46.7	218
Mercury	mg/kg	0.2	0.13	0.13	0.1	0.38	0.09	0.1	0.02	0.05	0.19	0.15	0.71
Nickel	mg/kg	68	140	68	71	92	37	63	24	30	53	20.9	51.6
Selenium	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--
Silver	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	3.7
Zinc	mg/kg	78	130	76	75	86	52	79	34	35	69	150	410
Dioxins - Total TEQ	ng/kg	6.33	3.88	4.49	1.27	4.12	1.06	0.91	0.07	0.95	4.01	--	--
Total DDTs	ug/kg	ND	2.1	ND	ND	ND	ND	ND	ND	ND	2.6	1.58	46.1
Total Organotins	ug/kg	1.73	4.67	4	1.46	2.21	0.71	5.83	ND	4.1	2.09	--	--
Total PAHs	ug/kg	741	264	274	182	160	344	153.8	ND	263	1501	4022	44792
Total PCB Congeners	ug/kg	21.43	17.49	35.98	8.87	14.11	6.07	7.16	0.09	2.7	23.15	22.7	180

"Inside" stations are both within the disposal site boundary AND on the dredged material deposit as determined by the SPI-PVP survey.

"Outside" stations are both outside the site boundary AND off the dredged material deposit.

* Field duplicate sample from a separate grab taken at a different time at the same station

** This station was chosen for full OTM testing on upcoming dredging project(s) as a possible new reference site for future Hawaii projects.

Table 3. **Summary of sediment chemistry for the Hilo Ocean Dredged Material Disposal site and vicinity.**

		Survey Station:									
Hilo site		"Inside"				"Outside"				NOAA Screening	
Analyte	**Units (dw)**	**H-W1**	**H-W1 dup***	**H-N1**	**H-SW1**	**H-SE4**	**H-NE5**	**H-SW6**	**H-W6**	**ER-L**	**ER-M**
Gravel	%	2	3	2	0	0	0	0	0	--	--
Sand	%	62	61	47	69	72	85	26	14	--	--
Silt	%	25	24	21	26	21	16	61	70	--	--
Clay	%	5	8	7	5	7	5	11	17	--	--
Total Organic Carbon	%	0.83	0.98	0.81	0.81	0.69	0.57	2.43	3.27	--	--
Arsenic	mg/kg	36	36	32	36	26	28	48	55	8.2	70
Cadmium	mg/kg	0.4	ND	0.5	0.6	0.72	0.5	0.71	0.62	1.2	9.6
Chromium	mg/kg	110	120	140	130	140	140	150	160	81	370
Copper	mg/kg	30	35	31	31	30	31	51	56	34	270
Lead	mg/kg	11	11	11	12	9.6	11	19	21	46.7	218
Mercury	mg/kg	0.05	0.06	0.05	0.06	0.04	0.04	0.14	0.17	0.15	0.71
Nickel	mg/kg	160	200	290	230	320	290	88	82	20.9	51.6
Selenium	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	--	--
Silver	mg/kg	ND	ND	ND	ND	0.75	ND	1.1	1.2	1	3.7
Zinc	mg/kg	70	81	83	78	87	83	91	95	150	410
Dioxins - Total TEQ	ng/kg	3.02	1.99	2.19	1.96	1.58	0.831	4.84	7.65	--	--
Total DDTs	ug/kg	ND	ND	ND	ND	ND	ND	ND	ND	1.58	46.1
Total Organotins	ug/kg	ND	ND	0.86	ND	ND	ND	ND	ND	--	--
Total PAHs	ug/kg	2.2	2.3	10.2	1.8	ND	ND	3	17.4	4022	44792
Total PCB Congeners	ug/kg	0.3	0.5	ND	ND	ND	ND	0.25	0.28	22.7	180

"Inside" stations are both within the disposal site boundary and ON the dredged material deposit as determined by the SPI-PVP survey.
"Outside" stations are both outside the site boundary and OFF the dredged material deposit.

* Field duplicate sample from a separate grab taken at a different time at the same station

The screening level exceedances were relatively minor in magnitude and, in many cases, were seen at both “inside” and “outside” stations. The few constituents that were at higher concentrations within the disposal sites reflect the contaminant levels in the dredged material approved for discharge. All sediments discharged at ocean disposal sites are fully characterized before approval for ocean disposal is granted. Sediments that contain toxic pollutants in toxic amounts, or that contain elevated levels of compounds that will readily bioaccumulate into tissues of organisms exposed to them on the seafloor, are prohibited from being discharged. Thus the chemical concentrations identified are not considered to represent a risk of environmental impacts in and of themselves; also, these low concentrations indicate that the pre-dredge sediment testing regime is adequately protecting the environment of the disposal sites by identifying and excluding more highly contaminated sediments from being disposed.

3.3 Benthic Community Analysis Results

Less than half of the original targeted stations were sampled for sediment grab sampling due to ship and equipment problems. Nevertheless, by selecting stations based on the results of the SPI-PVP surveys, sufficient samples were collected within and outside of site boundaries and the dredged material deposit footprint to provide general characterization of benthic communities occupying native (ambient) seafloor and seafloor physically impacted by dredged material disposal.

3.3.1 Abundance of Infauna

As noted earlier, some physical changes (e.g., grain size and organic carbon content) were apparent at stations with dredged material, especially at the South Oahu site. However, overall abundances of different organism classes, while low, were not statistically different between “inside” and “outside” stations at either disposal site (Tables 4 and 5) (EcoAnalysts, Inc., 2014).

At South Oahu, where both disposal volume and physical changes were greatest, crustaceans were similarly abundant at “inside” and “outside” stations; annelids appeared to be somewhat less abundant at “inside” stations; while mollusks and other miscellaneous taxa appeared to be somewhat more abundant at “inside” stations. But considering all infauna classes, overall abundance was very similar on-site and off-site.

At Hilo, crustacea appeared to be somewhat more abundant at “inside” stations, but annelids, mollusks and other miscellaneous taxa appeared to be somewhat more abundant at “outside” stations. Overall abundance of infaunal organisms appeared to be slightly greater off-site than on-site but these results were not statistically significant, perhaps due in part to the small sample size. As predicted from the SPI-PVP survey results, overall infaunal abundance appeared to be slightly greater at Hilo than at South Oahu.

Dredged material had been fairly recently deposited at both sites, and these infaunal abundance results are consistent with relatively rapid recolonization following disposal.

***Table 4.* Infaunal species abundances at the South Oahu site.**

	"Inside"				"Outside"				
Category	**SO-N1**	**SO-N2**	**SO-W1**	**SO-SW1**	**SO-W5**	**SO-S6**	**SO-SE4**	**SO-E4**	**SO-E6**
Annelida	390	540	700	400	1190	120	50	660	670
Annelida Average	507.5				538				
Crustacea	0	10	10	10	20	0	0	10	10
Crustacea Average	7.5				8				
Mollusca	10	40	20	20	0	30	0	10	0
Mollusca Average	22.5				8				
Miscellaneous Taxa	30	50	130	40	20	10	0	110	60
Miscellaneous Taxa Average	62.5				40				
Totals	430	640	860	470	1230	160	50	790	740
Overall Averages	600				594				

***Table 5.* Infaunal species abundances at the Hilo site.**

	"Inside"		"Outside"		
Category	**H-N1**	**H-SW1**	**H-NE5**	**H-SW6**	**H-SE4**
Annelida	900	320	490	930	650
Annelida Average	610		690		
Crustacea	20	20	10	0	10
Crustacea Average	20		6.7		
Mollusca	50	10	10	260	10
Mollusca Average	30		93.3		
Miscellaneous Taxa	50	50	50	80	100
Miscellaneous Taxa Average	50		76.7		
Totals	1020	400	560	1270	770
Overall Averages	710		866.7		

3.3.2 Diversity of Infauna

Based on species lists and statistics presented in EcoAnalysts, Inc. (2014), the overall benthic community at the South Oahu site was shown to be different from the assemblage at the Hilo site. This finding is not surprising given that the Hilo site is located in a relatively heterogeneous area containing a mixture of hard bottom features (submerged reef and terraces) coupled with areas of accumulated finer grained sediments (USGS, 2000), while the South Oahu site is located on a more homogeneous sandy seafloor with some scattered hard bottom features. However, as is expected of deep-sea benthic habitats overall, both sites have well developed benthic communities with high diversity and relatively low abundances, and presence of several undescribed taxa.

For both sites combined, there were 126 taxa found. A total of 85 infaunal taxa were identified from the South Oahu ODMDS sampled locations and a total of 79 taxa were identified from the Hilo ODMDS sampled stations. Within the polychaetes identified from both locations, 24 of 89 species were determined to likely be undescribed (EcoAnalysts, Inc., 2014).

At the South Oahu site, diversity was high and abundances tended to be low at all stations. Stations located inside the disposal site were not statistically different in terms of diversity, abundances, or species richness when compared to stations located outside the disposal site. Thus there is no evidence that dredge material is negatively impacting the benthic communities at the South Oahu ODMDS sites sampled.

Similarly at the Hilo site, there were no significant differences in diversity between inside and outside stations. As at South Oahu, diversity was high while abundances were relatively low, which was expected of deep-sea benthic habitats. Based on these results there is no evidence that dredge material is negatively impacting the benthic communities at the Hilo ODMDS stations sampled, other than the expected reduction of abundances due to physical impacts from rubble disposed at the center of the site.

3.4 Sub-Bottom Profile Survey (South Oahu site only)

The survey area, approximately 8 square nautical miles, covered the current designated site and surrounding abyssal plain seafloor areas, including existing hard bottom features (such as relic reefs and other outcrops) (Figure 25). The contrast between high reflectance native bottom bed forms and lower reflectance non-native deposited sediments allowed for identification of dredged material deposits throughout the study area.

While dredged material was identified within the current disposal site boundary, deposits of dredged material were still identifiable outside the site boundaries as well (Figure 26), probably due to past (pre-1981) disposal at historic disposal sites as well as mis-dumping before the 2000's (when satellite tracking systems began being required to help ensure proper disposal within site boundaries). Transects lines for the survey are shown on Figure 27. Figure 28 superimposes an area-wide surface geological map from the sub-bottom profiling survey with the SPI-based mapping of the dredged material footprint, showing excellent concordance between the two methods. Sub-surface results for a typical transect are shown on Figure 29, which presents a cross-section through the center of the disposal site looking down through both the dredged material deposit and the native sediment underlying it.

The analysis of the full sub-bottom data set (Sea Engineering, Inc., 2014) suggests that the dredged material deposits in and around the South Oahu site generally vary between 3 and 12 feet (1- 4 m) in thickness. An order of magnitude approximation of the total amount of dredged material within the study area was calculated using an average thickness of 6 feet (2 meters). The total volume of dredged material mapped throughout the entire study area, including historic disposal outside the current site boundaries, was thus calculated to be 27,885,600 cubic yards (21,320,000 cubic meters). However, the total volume of dredged material mapped within the current South Oahu site boundary was calculated to be 1,736,000 cubic yards (1,327,350 cubic meters). This compares quite favorably with the recorded volume of 1,855,230 cubic yards of material known to have been disposed from 2000 through 2013 (Table 1, and Figure 30).

Figure 25. USGS shaded-relief image showing the boundary of the sub-bottom survey area around the South Oahu disposal site, as well as major bedforms in the vicinity (shaded relief imagery from USGS, 2000). (Sea Engineering, 2014)

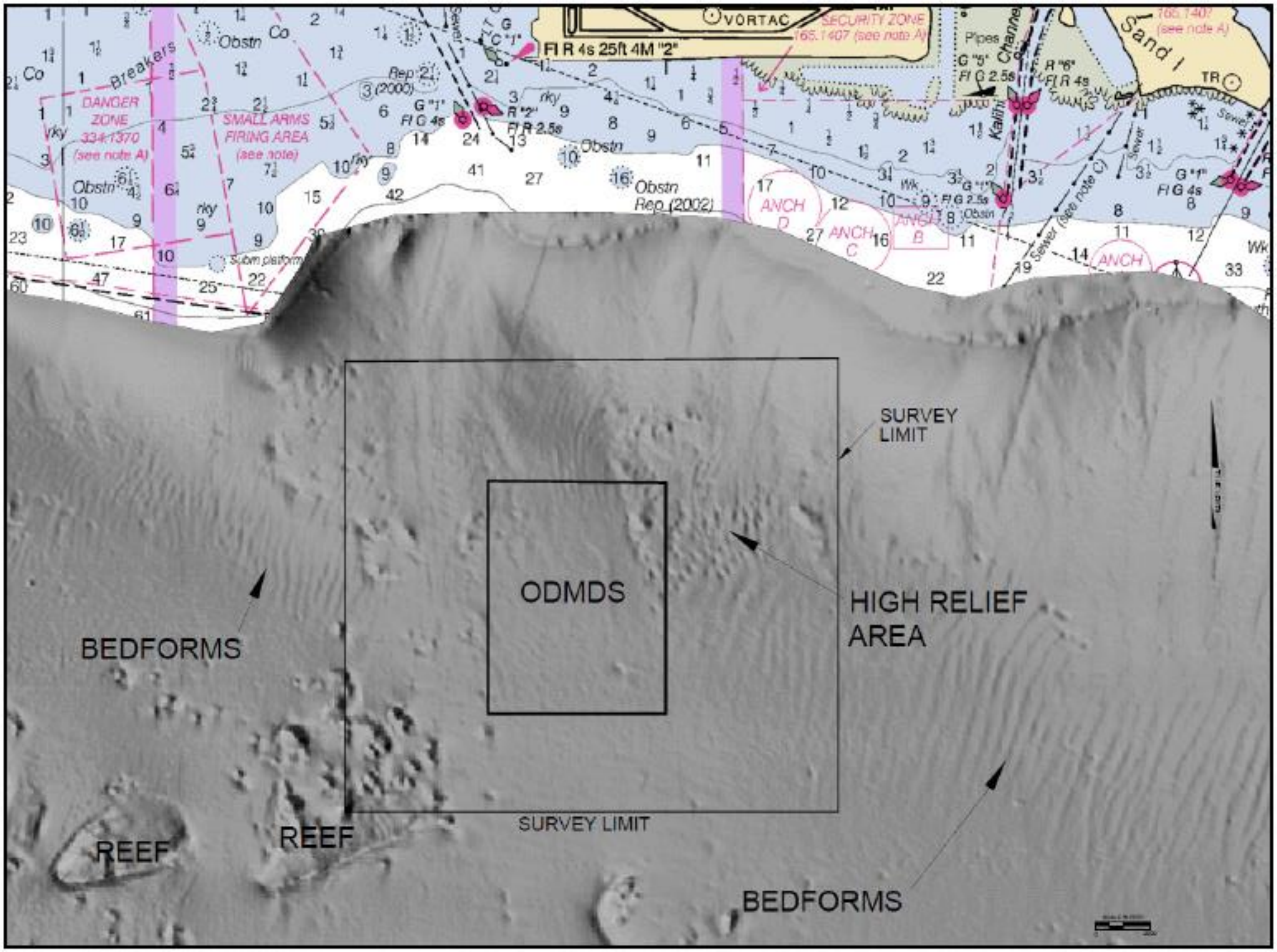


Figure 26. USGS sidescan sonar (backscatter) image showing historic dredged material deposits around the sub-bottom survey area and the South Oahu disposal site (sidescan imagery from USGS, 2000). (Sea Engineering, 2014)

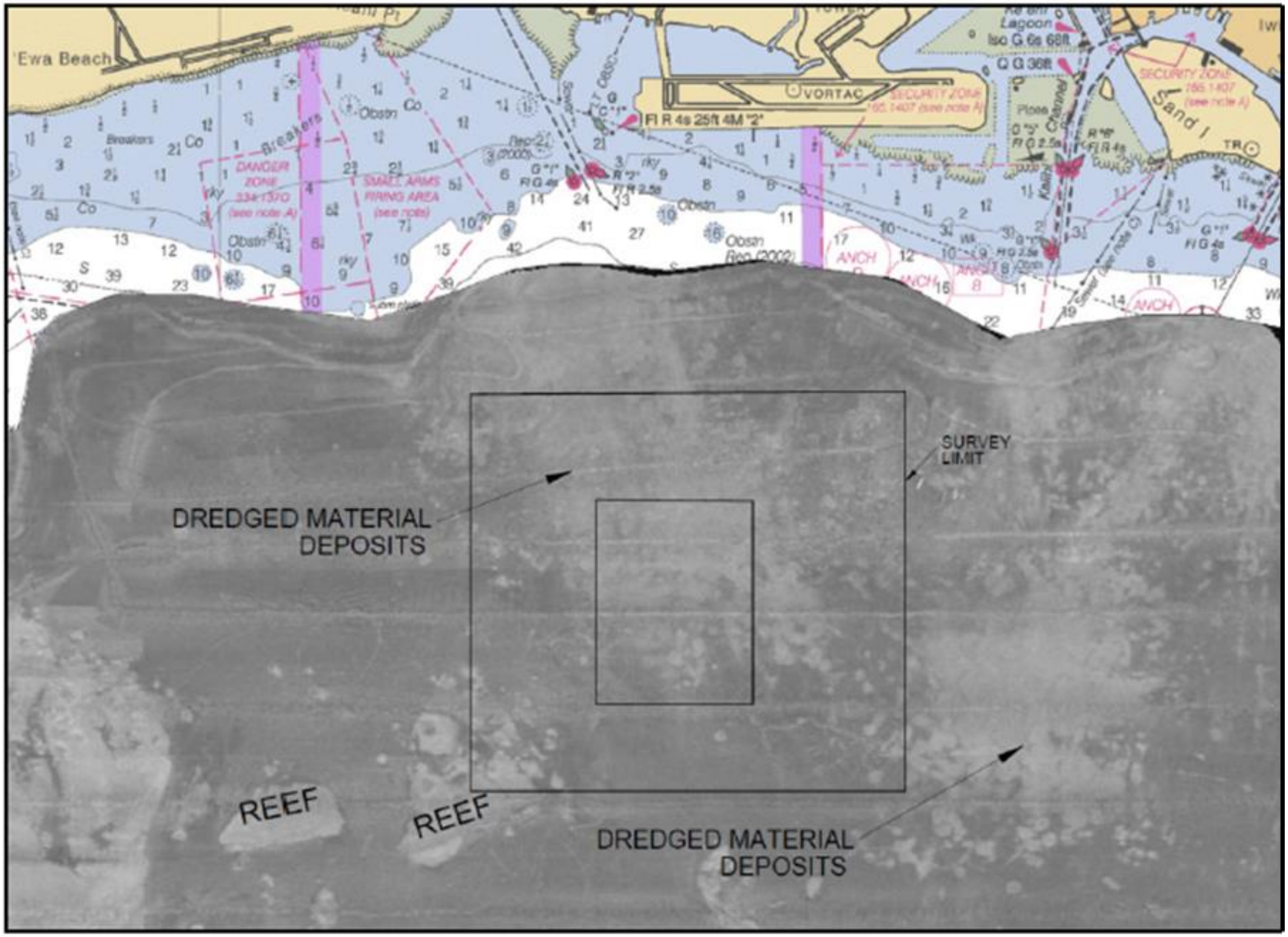


Figure 27. Transect lines for the sub-bottom profiling survey of the South Oahu site. Results for Diagonal line 1 through the center of the disposal site (arrows) are given in Figure 29. (Sea Engineering, 2014)

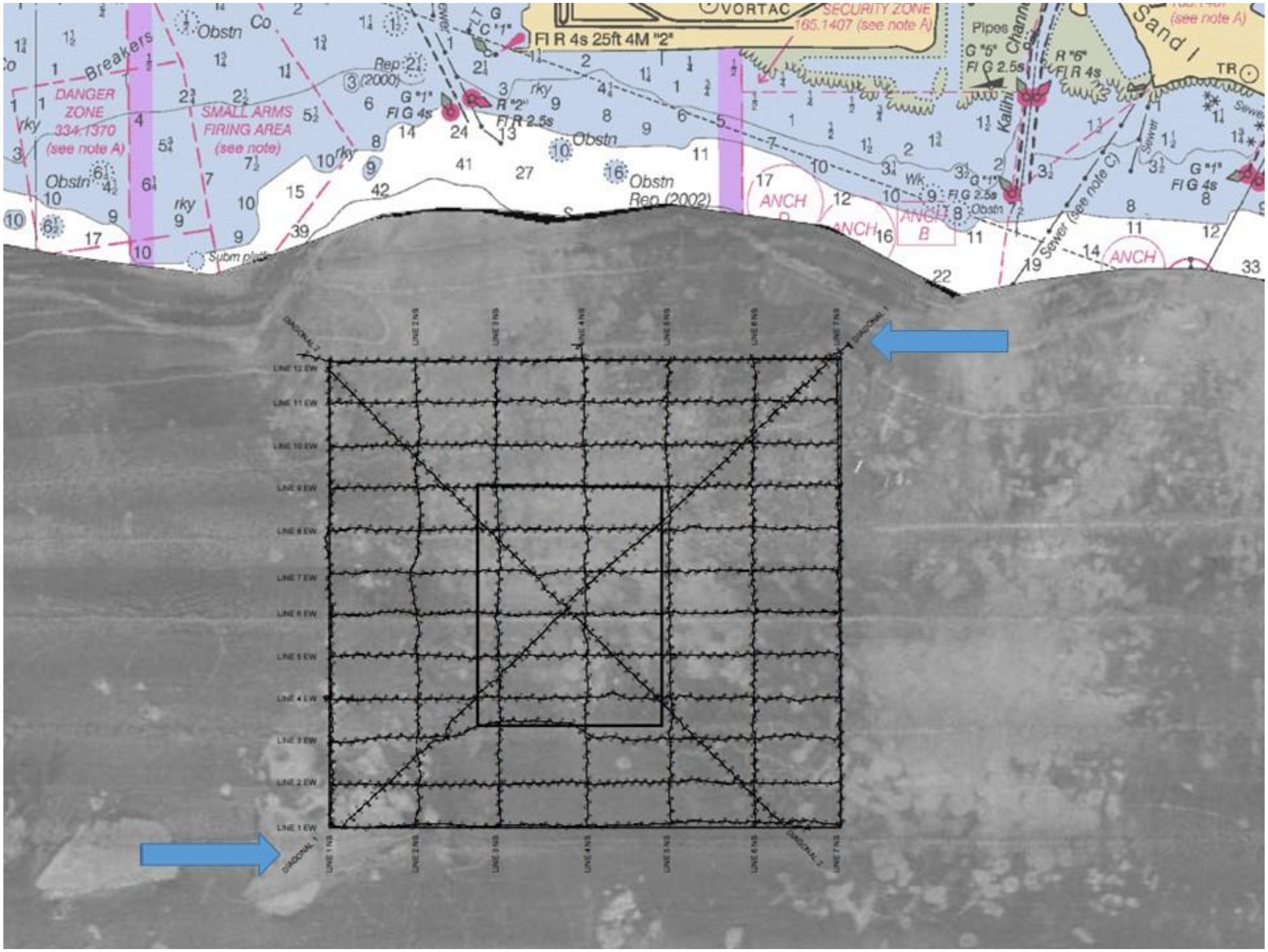


Figure 28. Geological (surface) interpretation from the sub-bottom profiling survey superimposed with the SPI-based dredged material footprint map shown in Figure 17. (DM = dredged material; HSL = hard sand layer; HR/DM = high-relief terrain with dredged material.) (Sea Engineering, 2014)

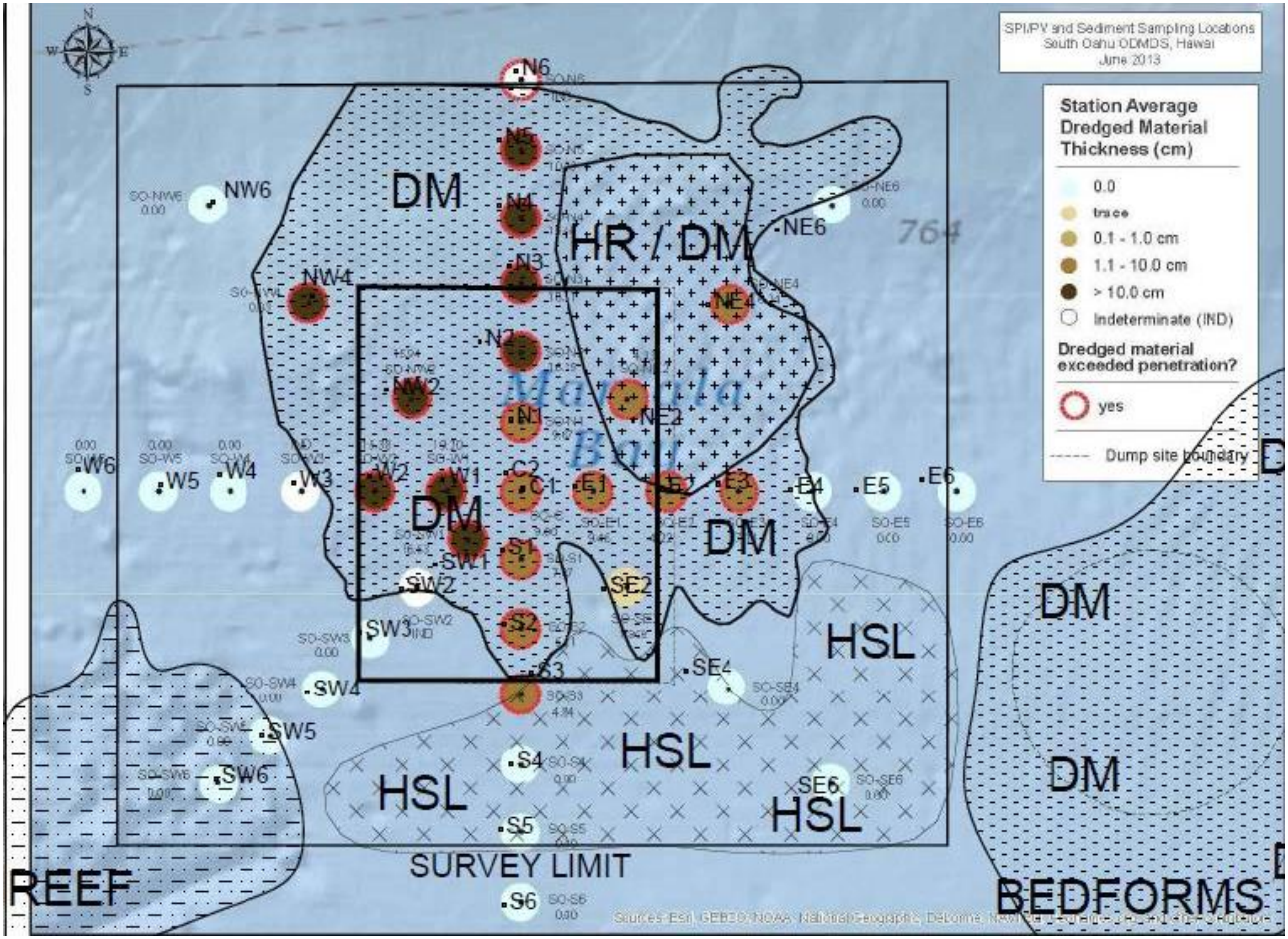


Figure 29A. Sub-bottom profile – NE portion of Diagonal Line 1. (Sea Engineering, 2014)

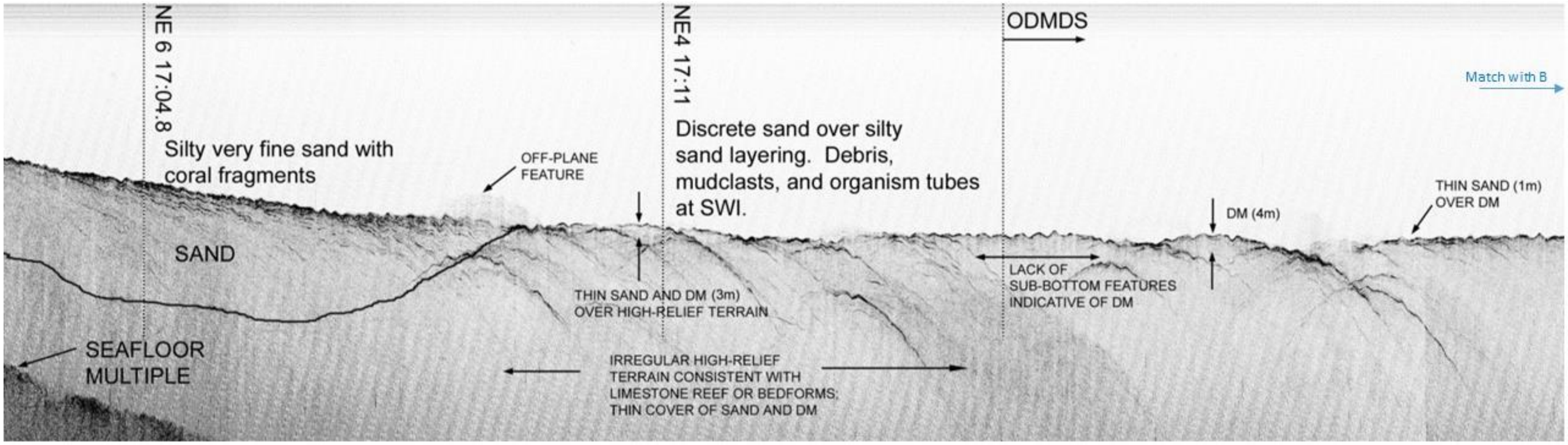


Figure 29B. Sub-bottom profile – SW portion of Diagonal Line 1. (Sea Engineering, 2014)

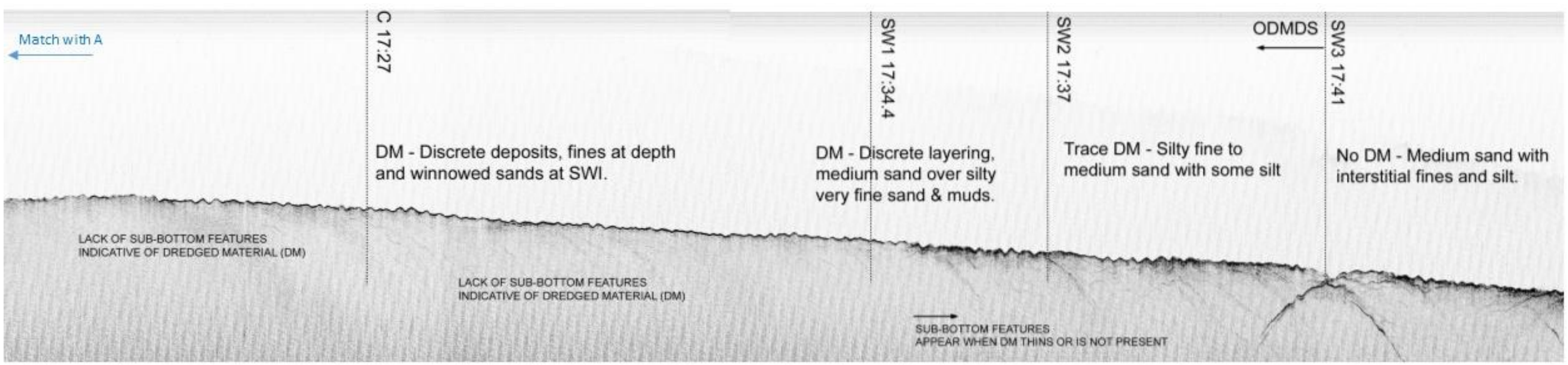


Figure 30. Comparison of South Oahu site dredged material volume estimates: from sub-bottom mapping versus recorded disposal volumes for 2000-2013 (see Table 1).

Comparison of Disposal Volumes: Sub-Bottom Profile Survey versus Disposal Records

Estimated Volume of Dredged Material Disposed at the South Oahu ODMDS Based on Sub-Bottom Profile Results:

- Volume estimated in overall Study Area: 27,885,600 cy (21,320,000 m³)
- Volume estimated within ODMDS limits only: **1,736,000 cy** (1,327,350 m³)

Disposal Records:	
Year	Cubic Yards
2000	0
2001	0
2002	53,500
2003	183,500
2004	540,000
2005	0
2006	160,400
2007	266,500
2008	0
2009	126,200
2010	0
2011	18,260
2012	0
2013	506,870
Total:	**1,855,230**

Although the volume of dredged material estimated by the sub-bottom profiling survey to be within the South Oahu disposal site boundary (1.74 million cy) compares well with the actual disposal records since 2000 (1.85 million cy), Table 1 shows that a total of 6.3 million cy has actually been disposed since the site was designated in 1981. It is likely that some substantial portion of the total 6.3 million cy disposed at the South Oahu site since 1981 is actually represented within the approximately 26 million cy of historic material estimated to be *outside* the site boundaries. Prior to the early 2000s, automatic satellite-based tracking and recording of disposal scow position was not required [2], and "short-dumping" (resulting in material depositing outside site boundaries) probably occurred fairly frequently. Still, it is highly likely that much of the material disposed between 1981 and 2000 was nevertheless deposited on-site, so more than 1.8 million cy should be present. It is to be expected that physical consolidation of any dredged material deposit would occur over time, reducing its apparent volume compared to disposal records. For all these reasons, the sub-bottom profiling survey's rough estimate is certainly low. However, it is also certainly within an order of magnitude, and is an interesting cross-check on other disposal site monitoring results.

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[2] The 1997 SMMP (USEPA and USACE, 1997) required a navigation system capable of 30 m accuracy, but did not specify that the system show the position of the disposal scow itself (as opposed to the tug or towing vessel). Similarly, the 1997 SMMP did not require "black box" recording of the actual disposal location, so independent confirmation that disposal only occurred at the center of the disposal site (as required) was difficult. But beginning in the 2000s, as both commercial GPS accuracy and vessel sensor technology advanced, and EPA and USACE began requiring sophisticated automatic tracking systems as conditions for all individual project's ocean disposal permits.

3.5 Comparison to 1980 Baseline Information

3.5.1 South Oahu Disposal Site

Comparison of the data contained in the 1980 EIS to the data collected from the 2013 survey shows that the grain size proportions in the disposal site have shifted to a higher percentage of silt and clay, as well as higher percentage of sediments coarser than sand (Table 6). This is not surprising because maintenance dredged material tends to be finer grained in comparison to the native bottom sediments which contain a higher percentage of sand, as described in the 1980 EIS. New work (deepening) dredging projects in areas such as Pearl Harbor have likely removed deeper layers of reef formation material, thus contributing to the gravel-sized fraction. This much coarser material is expected to sink rapidly to the bottom, without dispersing and drifting outside of the site boundary, in contrast to fine grained dredged material.

Table 6. **Average Percent Grain Size – South Oahu Site**

Grain Size Category	1980 EIS (Pre-Disposal)	2013 - Disposal Site only	2013 - Outside of Disposal Site	2013 – Entire Survey Area
Gravel	12.0	21.6	2.8	12.2
Sand	75.0	44.4	77.2	60.8
Silt & Clay	13.0	33.2	19.2	26.2

Comparison to baseline sediment chemistry is limited to the trace metal concentrations shown in the 1980 EIS. When comparing the 1980 trace metal data to the data collected from the 2013 survey, it is apparent that dredged material disposal operations generally have not appreciably increased contaminant loading on-site, or relative to the surrounding environs, except for copper (Table 7). The slightly elevated on-site copper concentration is higher than the NOAA ER-L screening level, but is much lower than the ER-M screening level where toxicity effects are more likely to occur. As discussed in Section 3.2, all sediments discharged at ocean disposal sites are fully characterized before approval for ocean disposal is granted. Sediments that contain toxic pollutants in toxic amounts are prohibited from being discharged. Thus the slightly elevated concentration of copper compared to the 1980 baseline is not considered to represent a risk of environmental impact.

Table 7. **Trace Metal Concentrations – South Oahu Site**

Analyte	1980 EIS (Pre-Disposal)		2013 - Disposal Site only		2013 - Outside of Disposal Site		2013 – Entire Survey Area		ER-L	ER-M
	Range (ppm)	Ave. (ppm)	Range (ppm)	Ave. (ppm)	Range (ppm)	Ave. (ppm)	Range (ppm)	Ave. (ppm)		
Cadmium	4.0-6.3	5.2	0.0-0.69	0.4	0.0-0.42	0.08	0.0-0.69	0.25	1.2	9.6
Mercury	0.5-0.9	0.7	0.10-0.38	0.18	0.02-0.19	0.09	0.02-0.38	0.14	0.15	0.71
Copper	17.6-45.5	31.0	43.0-84.0	59.0	11.0-37.0	23.8	11.0-84.0	41.4	34	270
Lead	38.1-59.0	48.6	15.0-95.0	37.6	10.0-37.0	20.8	10.0-95.0	29.2	46.7	218

The 1980 EIS characterized the benthic community as typical for abyssal depths, with low infaunal abundance relative to shallow depth communities. Infaunal abundances were similar in the 2013 surveys, although on-site percent abundances of crustaceans and other miscellaneous taxa appeared to be slightly lower than in 1980 (Table 8). Nevertheless, even these minor differences are most likely attributable to natural variability across the study area rather than to disposal activities. This conclusion is supported by abundances of crustaceans and other miscellaneous taxa in 2013 being *greater* inside the disposal site compared to outside it.

Table 8. **Percent Abundance – South Oahu Site**

Taxonomic Group	1980 EIS (Pre-Disposal)	2013 – Disposal Site only	2013 – Outside of Disposal Site	2013 – Entire Survey Area
Annelida (includes polychaetes)	82.9	84.6	90.6	87.9
Crustacea	2.9	1.3	1.3	1.3
Mollusca	0.8	3.8	1.3	2.4
Miscellaneous taxa	13.3	10.4	6.7	8.4

3.5.2 Hilo Disposal Site

Comparison of the data contained in the 1980 EIS to the data collected from the 2013 survey shows that the grain size character has shifted to a somewhat higher percentage of silt and clay (Table 9). This is not surprising because maintenance dredged material tends to be finer grained in comparison to the native bottom sediments which contain a higher percentage of sand, as described in the 1980 EIS. But these physical changes are less obvious and widespread than at the South Oahu site, where much more dredged material has been disposed. Also in contrast to the South Oahu site, new work (deepening) dredging projects have not placed such a high volume of much coarser reef formation material, and as a result, the gravel-sized fraction has not increased significantly.

Table 9. **Average Percent Grain Size – Hilo Site**

Grain Size Category	1980 EIS (Pre-Disposal)	2013 - Disposal Site only	2013 - Outside of Disposal Site	2013 – Entire Study Area
Gravel	1.0	1.75	0.0	0.9
Sand	77.0	59.8	49.3	54.5
Silt & Clay	22.0	30.3	52.0	41.1

Comparison to baseline sediment chemistry is limited to the trace metal concentrations shown in the 1980 EIS. When comparing the 1980 trace metal data to the data collected from the 2013 survey, it is apparent that dredged material disposal operations at the Hilo site have not caused any significant increase in contaminant loading, except for copper (Table 10.). The slightly elevated copper concentration is higher than the NOAA ER-L screening level, but is much lower than the ER-M screening level, where toxicity effects are more likely to occur; therefore the slightly elevated copper is not considered to represent a risk of environmental impact. In addition, the copper elevation is shoreward and *outside* the disposal site. Possible explanations include contaminants from other shore-side source, or historic short-dumping from disposal scows (prior to the early 2000's, after which "black box" compliance monitoring was required).

Table 10. **Trace Metal Concentrations – Hilo Site**

Analyte	1980 EIS (Pre-Disposal)		2013 - Disposal Site only		2013 - Outside of Disposal Site		2013 – Entire Survey Area		ER-L	ER-M
	Range (ppm)	Ave. (ppm)	Range (ppm)	Ave. (ppm)	Range (ppm)	Ave. (ppm)	Range (ppm)	Ave. (ppm)		
Cadmium	---	3.4	0.0-0.6	0.4	0.50-0.72	0.64	0.0-0.72	0.51	1.2	9.6
Mercury	0.10-0.59	0.35	0.05-0.06	0.06	0.04-0.17	0.10	0.04-0.17	0.08	0.15	0.71
Copper	33.9-38.1	36.0	30.0-35.0	31.8	30.0-56.0	42.0	30.0-56.0	36.9	34	270
Lead	19.5-29.0	24.3	11.0-12.0	11.2	9.6-21.0	15.2	9.6-21.0	13.2	46.7	218

The 1980 EIS characterized the benthic community at the Hilo site as typical for abyssal depths, with low infaunal abundances relative to shallow depth communities. Compared to data presented in the site designation EIS, some minor differences in percent abundance appear to have occurred (Table 10). Mollusks and miscellaneous taxa appear to be very slightly lower on-site compared to off-site in 2013 (though not statistically significantly so), and miscellaneous taxa appear to be less abundant in 2013 than they were in 1980. However, in 2013 miscellaneous taxa were lower both inside and outside the disposal site, while mollusks were *more* abundant region-wide than in 1980. As noted earlier, the native benthic environment around the Hilo site is more heterogeneous than around the South Oahu site to begin with. These minor differences may in infaunal abundances therefore are at least substantially attributable to natural variability across the study area rather than to disposal activities.

Table 11. **Percent Abundance – Hilo Site**

Taxonomic Group	1980 EIS (Pre-Disposal)	2013 – Disposal Site only	2013 – Outside of Disposal Site	2013 – Entire Survey Area
Annelida (includes polychaetes)	80.0	85.9	79.6	81.8
Crustacea	2.2	2.8	1.0	1.5
Mollusca	1.1	4.2	10.8	8.5
Miscellaneous taxa	16.7	7.0	8.8	8.2

IV. CONCLUSIONS AND RECOMMENDATIONS

Multiple survey activities were conducted in 2013 to assess the condition and performance of the EPA-designated South Oahu and Hilo ocean dredged material disposal sites. Over the past two decades, South Oahu and Hilo have been the most heavily used of the five disposal sites that serve the ports and harbors of the Hawaiian Islands. The survey results are intended to identify whether any adverse impacts of dredged material disposal are occurring compared to baseline conditions, to confirm the protectiveness of the pre-disposal sediment testing required by EPA and USACE, and to serve as a basis for updating the Site Management and Monitoring Plan (SMMP) as appropriate.

The dredged material deposit (footprint) was mapped at each site. Significant deposits of dredged material are apparent outside the South Oahu site boundaries, but this likely resulted from short-dumping prior to the early 2000s when EPA and USACE began requiring "black box" tracking systems. Since that time, virtually all material disposed at South Oahu is documented as having been discharged properly within the Surface Disposal Zone at the center of the site. At the Hilo site, almost all of the dredged material footprint is contained within the site boundary.

Sediment sampling confirms that there have been no significant adverse impacts as a result of dredged material disposal operations at either of the disposal sites monitored. Only minor physical effects (grain size and organic carbon content changes) have occurred at either site, despite the order-of-magnitude greater volume that has been disposed at the South Oahu site over the last 15 years. Chemical analysis of both on-site and off-site stations indicated only low concentrations of chemicals of concern, both on-site and off-site. Benthic community analyses showed that recolonization occurs after dredged material is deposited, and similar infaunal and epifaunal communities occupy both on-site and off-site areas. Taken together, these results also provide support that the pre-disposal sediment testing program is effective in not allowing highly contaminated sediments to be discharged at either site.

The 2013 monitoring results also indicate a lack of significant adverse impacts compared to 1980 baseline conditions. Only minor and localized physical changes are apparent as a result of disposal operations at either site.

Overall, these findings suggest that ongoing use of the South Oahu and Hilo ocean dredged material disposal sites, under testing and management conditions at least as stringent as have been applied over the past 15 years, should similarly result no significant adverse effects. Permit conditions should be updated in the revised SMMP, and a more specific site monitoring schedule should be established for the future. But based on all the monitoring results, no significant changes to sediment testing or to the overall site management framework appear to be warranted for these sites.

Continued use of the other three Hawaii ocean dredged material disposal sites that were not monitored in 2013 is also supported by inference. These sites have received far less frequent dredged material disposal than South Oahu or even Hilo, and impacts can be expected to be negligible there as well. Nevertheless, the other Hawaii sites should be considered for confirmatory monitoring after the next round of disposal operations, currently expected to occur in 2016.

V. REFERENCES

ALS Environmental, 2013. South Oahu Ocean Sediments. (Analytical chemistry results for grain size, total solids, TOC, PCBs, Dioxins/Furans, and butyltins.) Prepared under EPA contract EP-C-09-020 for ERG Inc., Chantilly, VA.

EcoAnalysts, Inc., 2014. Final Report for Benthic Community Analysis for Site Monitoring of EPA-Designated Ocean Disposal Sites in Region 9: South Oahu and Hilo Sites (EPA Contract EP-C-09-020, Work Assignment 4-27). Woods Hole, MA.

Germano & Associates, 2013 a. Confirmatory Site Monitoring of the South Oahu and Hilo Ocean Dredged Material Disposal Sites Utilizing Sediment Profile and Plan View Imaging: Quality Assurance Project Plan. Prepared under EPA contract EP-C-09-020 for ERG Inc., Chantilly, VA.

Germano & Associates, 2013 b. Monitoring Survey of the EPA-Designated South Oahu and Hilo Ocean Dredged Material Disposal Sites: Sediment Profile & Plan View Imaging Results, 2013 (Project No. 0268.04.027/2, EPA Contract EP-C-09-020, Work Assignment 4-27). Bellevue, WA.

NOAA, 2008. Sediment Quick Reference Tables (SQuiRT), NOAA OR&R Report 08-1, Office of Response and Restoration Division, Seattle, WA.

Rhoads, 1974. Organism-sediment relations on the muddy seafloor. Oceanography and Marine Biology: An Annual Review; 12:263-300.

Rhoads and Germano. 1982. Characterization of benthic processes using sediment profile imaging: An efficient method of remote ecological monitoring of the seafloor (REMOTS™ System). Mar. Ecol. Prog. Ser. 8:115-128.

Sea Engineering Inc., 2013. Quality Assurance Project Plan: Sub-Bottom Profiler Survey for Confirmatory Site Monitoring of the South Oahu Ocean Dredged Material Disposal Sites. Prepared under EPA contract EP-C-09-020 for ERG Inc., Chantilly, VA

Sea Engineering Inc., 2014. South Oahu Ocean Dredged Material Dump Site Sub-Bottom Survey, Honolulu, HI (EPA Contract No. EP-C-09-020, Work Assignment 4-27; Subcontract 0268.04.027/1). Waimanalo, HI.

Torresan and Gardner, 2000. Acoustic Mapping of the Regional Seafloor Geology in and Around Hawaiian Dredged Material Disposal Sites (USGS Open File Report 00-124).

USACE. Ocean Disposal Database. http://el.erdc.usace.army.mil/odd/ODMDSSearch.cfm.

USEPA, 1980. Final Environmental Impact Statement for Hawaii Dredged Material Disposal Site Designation, US Environmental Protection Agency, Oil and Special Materials Control Branch, Marine Protection Branch. Washington, D.C.

USEPA, 2013 a. Work Plan QAPP (EPA Contract No. EP-C-09-020, Work Assignment 4-27); EPA Region 9, San Francisco, CA.

USEPA, 2013 b. Analytical Testing Results, Project R13W07, SDG 13189B. EPA Region 9 Laboratory, Richmond, CA.

USEPA and USACE, 1977. Site Management Plan (SMP) for the Hawaii Ocean Dredged Material Disposal Sites. Special Joint Public Notice, April 7, 1997.

APPENDIX

SUMMARY OF PLANNED VS ACTUAL SURVEY ACTIVITIES AT HAWAII OCEAN DREDGED MATERIAL DISPOSAL SITES, 2013

APPENDIX
SUMMARY OF PLANNED VS ACTUAL SURVEY ACTIVITIES AT HAWAII OCEAN DREDGED MATERIAL DISPOSAL SITES, 2013

General Survey Information:

Site Name (Region): South Oahu and Hilo Ocean Dredged Material Disposal Sites (Region 9)
Survey Chief Scientist/Organization: Allan Ota (EPA Region 9)
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Science Crew/Organization:
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Leslie Robinson (US Navy, HI)
Sean Hanser (US Navy, HI)
Thomas Smith (USACE, HI)
Robert O'Connor (NOAA, HI)
Joseph Germano (Germano & Assoc., WA)
David Browning (Germano & Assoc., WA)
Christine Smith (ANAMAR, FL)

Schedule of Operations:
Number of survey days: 8 planned, 5 actual (plus 2 for mobilization/demobilization)
Mobilization date (Location): 24-25 June 2013 (Ford Island, Pearl Harbor, Oahu)
Demobilization date (Location): 03 July 2013 (Ford Island, Pearl Harbor, Oahu)

Original Problem Definitions/Task Descriptions (from Quality Assurance Project Plan)

1. Using the Hi'ialakai, collect MBES images to confirm overall bathymetry and identify any features of interest to adjust sediment sampling locations as appropriate:
   a. Is the overall bathymetry different from the standard NOAA charts?
   b. Are there unusual or unique features that suggest that adjustment of planned sampling station locations is necessary to improve interpretation of site monitoring data?
2. Using the Hi'ialakai, collect SPI and PVP images at up to 49 stations covering each EPA ODMDS and adjacent areas outside of site boundaries to address the following management questions:
   a. Is the footprint of recently deposited dredged material contained within site boundaries? Are dredged materials in a single mound feature or contained in multiple mounds?

   b. Are the sediments within the dredged material deposit footprint visually similar or dissimilar from ambient bottom sediments?
   c. Are there indications of disposal of materials other than dredged materials?
   d. Are there indications of an undisturbed or disturbed environment (adverse impacts)?
3. Using the Hi'ialakai, collect up to 20 sediment grab samples at each EPA ODMDS and adjacent areas outside of site boundaries to address the following management questions:
   a. Are sediment contamination levels at the sites within the range predicted by pre-disposal sediment testing of dredged material approved for disposal?
   b. Are levels of contaminants at historic disposal sites (>10 years since used) adjacent to the active South Oahu site similar to or below ambient levels (undisturbed native sediments – outside of deposit footprint or site boundaries)?
   c. How do the biological communities compare, between within the site and outside of site boundaries?
   d. How do the biological communities compare to what existed when these permanent sites were designated?
4. Using a contracted (Sea Engineering) vessel, collect high resolution sub-bottom seismic profiles within selected basin locations to address the following management questions:
   a. Based on the acoustic signal contrast between native bottom sediments and dredged material layer, what is the horizontal extent of the dredged material deposit footprint relative to the site boundaries? – i.e., does the dredged material deposit appear to reside mostly or completely within site boundaries, suggesting site is performing as expected?
   b. Based on the acoustic signal contrast between native bottom sediments and dredged material layer, what is the apparent thickness of the dredged material deposit footprint? – i.e., does the bulk of the dredged material volume appear to reside mostly or completely within site boundaries, suggesting site is performing as expected?
   c. How does the calculated volume of the dredged material identified by this survey compare with dredging records for projects using the site? – i.e., comparison of volumes from compiled disposal records to the calculated volume using information from (a) and (b) above.

Actual Sequence of Tasks/Events

The surveys were originally scheduled to occur over 8 days (plus mobilization and demobilization), but problems associated with readiness of the NOAA ship and its equipment caused some delays. The surveys were ultimately conducted over a 5-day period (not including transit between the South Oahu site and the Hilo site, and the return transit to Pearl Harbor from the Hilo site). Field operations were conducted continuously over a 24-hour period (two scientific crews working12-hour shifts).

The survey sampling objectives were not fully accomplished due to the following problems:

1. Departure was delayed by one day, due to:
   a. Hole/rupture in the NOAA ship's bilge tank which had to be repaired.

   b. The original contracted marine winch, which was installed during the previous week, was not working properly and its hydraulic unit had to be replaced.
2. The replacement winch operated at a slower rate (about 20 meters per minute, instead of 40-60 meters per minute) than what was expected when the survey plan was conceived, resulting in less than half of the planned sediment grab sampling stations being occupied in the time remaining for survey work.
3. Hard bottom features were encountered and multiple attempts were needed at several stations to obtain acceptable samples, as judged by QAPP metrics (i.e., adequate penetration and undisturbed appearance).

4. The multi-beam echo sounder (MBES) survey initially planned for both sites was not executed due to the equipment on the NOAA vessel not functioning properly at the beginning of the first survey leg. As a result, no MBES data was collected at either site. In the absence of the MBES survey data, the combination of SPI and PVP photography and analysis of the SPI visual parameters provided information on the horizontal and vertical extent of the dredged material footprint, and context for the other (sediment) sampling results.

Survey Activities/Operations Conducted to Address Problem Definitions:

The following are the survey activities executed at both sites:

1. <u>Sediment Profile Imaging (SPI) and Plan View Photography (PVP)</u>
   SPI-PVP surveys were conducted for each ODMDS to delineate the horizontal extent of the dredged material deposit footprint within the site, and outside of site boundaries if any deposits exist (Figure 2). A total of 86 stations were occupied with the SPI/PV camera system (40 at South Oahu and 46 at Hilo), compared to the planned 98 (49 at each site). With optimal resolution on the order of millimeters, the SPI system is particularly useful for identifying a number of features, including the edges of the footprint as they overlay native sediments of the seabed, identifying dredged material layers relative to native sediments, and the level of disturbance as indicated by presence of certain classes of benthic organisms (Figures 3 and 4). PVP is useful for identifying surface features where the SPI photos are taken, thereby providing surface context for the vertical profiles at each station. For each station, a minimum of four SPI photos were taken, coupled with a single PVP photo.
2. <u>Sediment Sampling for Chemistry and Benthic Communities:</u>
   Sediment samples were collected for sediment grain size, chemistry, and benthic community analysis with a stainless steel double Van Veen sediment grab (Figure 5) capable of penetrating a maximum of 20 centimeters of depth below the sediment surface. Sediment grab samples were judged acceptable based on approved QAPP metrics. After each acceptable grab sample was measured for depth of penetration and photographed, sufficient volume of chemistry subsample were extracted from one of the two grabs with a stainless steel spoon for further processing (Figure 6). The chemistry subsample was then homogenized and divided into the different chemistry analysis jars (i.e., grain size, metals and organics). After the chemistry subsample was extracted, the entire volume of the other grab was processed (Figure 7) to create a benthic community sample for that station. A 500 micron sieve was used to separate organisms from the sediment, and the separated organisms were then initially preserved

with formalin. A total of 18 sediment grab sample stations were occupied in the two survey areas combined, relative to the original targeted 40 locations. 18 chemistry samples were processed (10 at South Oahu, and 8 at Hilo), 3 of which were field or laboratory duplicates. A total of 14 benthic community samples were collected; the lower number than the chemistry samples was due to some grabs being used for field and laboratory chemistry duplicates, and one station where QAPP metrics were not met for an acceptable benthic sample (lack of time to re-deploy).

The following survey activity was executed only at the South Oahu site:

3. Collection of high-resolution sub-bottom seismic-reflection profiles:
   The primary purpose of this survey was to collect cross-sectional images of the native sediment layers and identify layers indicative of the dredged material deposit footprint in the environs of the South Oahu ODMDS. (The Hilo site was not surveyed in this manner during this round of surveys, primarily due to the much smaller volumes of dredged material which may not be detectable in terms of thickness and contrast.) The survey was contracted to Sea Engineering, who conducted the work aboard a separate vessel specially rigged for this type of survey with an acoustic sub-bottom profiler system (Figure 8), which was more cost effective than attempting to install the equipment on the NOAA vessel. The results of this survey allowed EPA to calculate an estimate of cumulative volume of dredged material in the South Oahu site.

The study areas are depicted in Figures 9 and 10 (South Oahu) and 11, and 12 (Hilo) The target sampling station coordinates are listed in Tables 2 (South Oahu) and 3 (Hilo).

Figure 9. General location of the South Oahu ODMDS

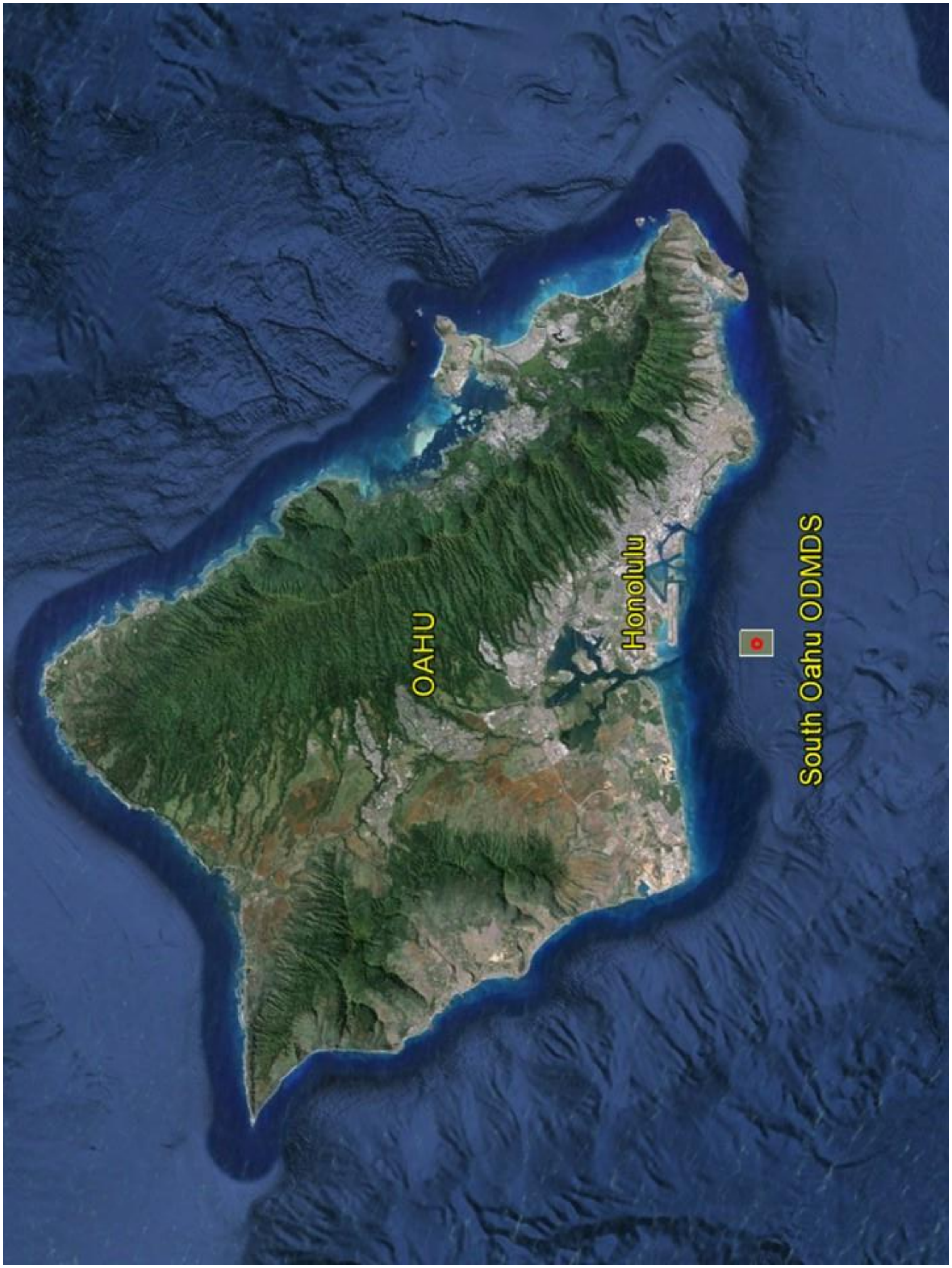

Figure 10. Planned and actual sample station locations at the South Oahu ODMDS:

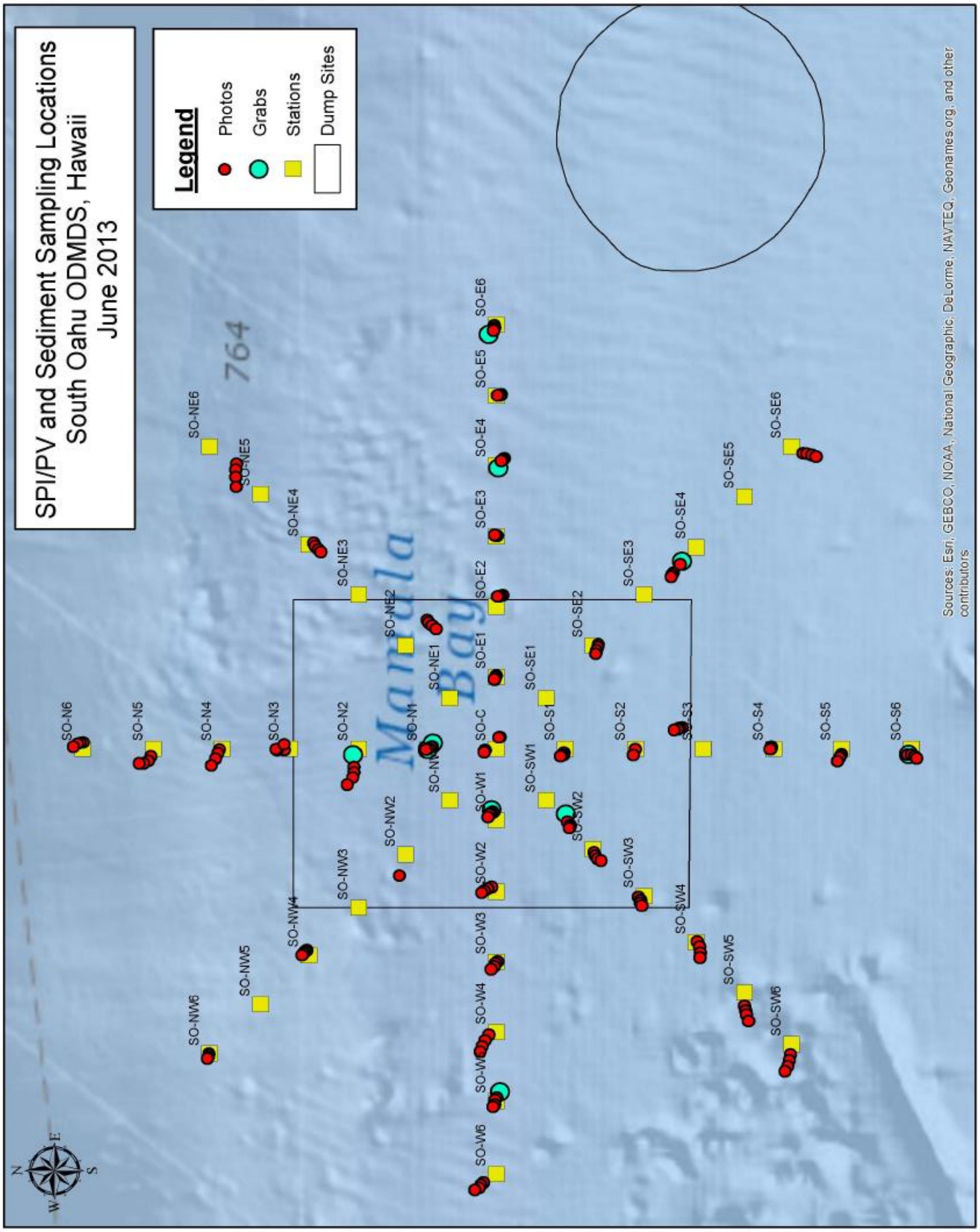

Table 2. **South Oahu ODMDS Sampling Station Coordinates (NAD83). SPI and PVP photographic samples at all stations; sediment grab samples at highlighted stations.**

Station ID	Latitude	Longitude	Sampling Notes
C	21 14.970 N	157 56.670 W	SPI-PV only
N1	21 15.220 N	157 56.670 W	SPI-PV and sediment grab
N1-A	21 15.199 N	157 56.647 W	SPI-PV and sediment grab (field dupe)
N2	21 15.470 N	157 56.670 W	SPI-PV and sediment grab
N3	21 15.720 N	157 56.670 W	SPI-PV only
N4	21 15.965 N	157 56.670 W	SPI-PV only
N5	21 16.215 N	157 56.670 W	SPI-PV only
N6	21 16.470 N	157 56.670 W	SPI-PV only
S1	21 14.720 N	157 56.670 W	SPI-PV only
S2	21 14.465 N	157 56.670 W	SPI-PV only
S3	21 14.220 N	157 56.670 W	SPI-PV only
S4	21 13.965 N	157 56.670 W	SPI-PV only
S5	21 13.720 N	157 56.670 W	SPI-PV only
S6	21 13.465 N	157 56.670 W	SPI-PV and sediment grab
W1	21 14.970 N	157 56.940 W	SPI-PV and sediment grab
W2	21 14.970 N	157 57.210 W	SPI-PV only
W3	21 14.970 N	157 57.475 W	SPI-PV only
W4	21 14.970 N	157 57.740 W	SPI-PV only
W5	21 14.970 N	157 58.000 W	SPI-PV and sediment grab
W6	21 14.970 N	157 58.275 W	SPI-PV only
E1	21 14.970 N	157 56.400 W	SPI-PV only
E2	21 14.970 N	157 56.135 W	SPI-PV only
E3	21 14.970 N	157 55.870 W	SPI-PV only
E4	21 14.970 N	157 55.600 W	SPI-PV and sediment grab
E5	21 14.970 N	157 55.340 W	SPI-PV only
E6	21 14.970 N	157 55.070 W	SPI-PV and sediment grab
NW1	21 15.140 N	157 56.865 W	Station not occupied
NW2	21 15.300 N	157 57.070 W	SPI-PV only
NW3	21 15.470 N	157 57.270 W	Station not occupied
NW4	21 15.650 N	157 57.450 W	SPI-PV only
NW5	21 15.825 N	157 57.635 W	Station not occupied
NW6	21 16.010 N	157 57.820 W	SPI-PV only

***Table 2, continued.* South Oahu ODMDS Sampling Station Coordinates (NAD83). SPI and PVP photographic samples at all stations; sediment grab samples at highlighted stations.**

NE1	21 15.140 N	157 56.480 W	Station not occupied
NE2	21 15.300 N	157 56.280 W	SPI-PV only
NE3	21 15.470 N	157 56.090 W	Station not occupied
NE4	21 15.650 N	157 55.900 W	SPI-PV only
NE5	21 15.825 N	157 55.710 W	Station not occupied
NE6	21 16.010 N	157 55.530 W	SPI-PV only
SW1	21 14.790 N	157 56.865 W	SPI-PV only
SW2	21 14.620 N	157 57.050 W	SPI-PV and sediment grab
SW3	21 14.435 N	157 57.225 W	SPI-PV only
SW4	21 14.245 N	157 57.400 W	SPI-PV only
SW5	21 14.070 N	157 57.590 W	SPI-PV only
SW6	21 13.900 N	157 57.785 W	SPI-PV only
SE1	21 14.790 N	157 56.480 W	Station not occupied
SE2	21 14.620 N	157 56.280 W	SPI-PV only
SE3	21 14.435 N	157 56.090 W	Station not occupied
SE4	21 14.245 N	157 55.910 W	SPI-PV and sediment grab
SE5	21 14.070 N	157 55.720 W	Station not occupied
SE6	21 13.900 N	157 55.530 W	SPI-PV only

Figure 11. General location of the Hilo ODMDS:

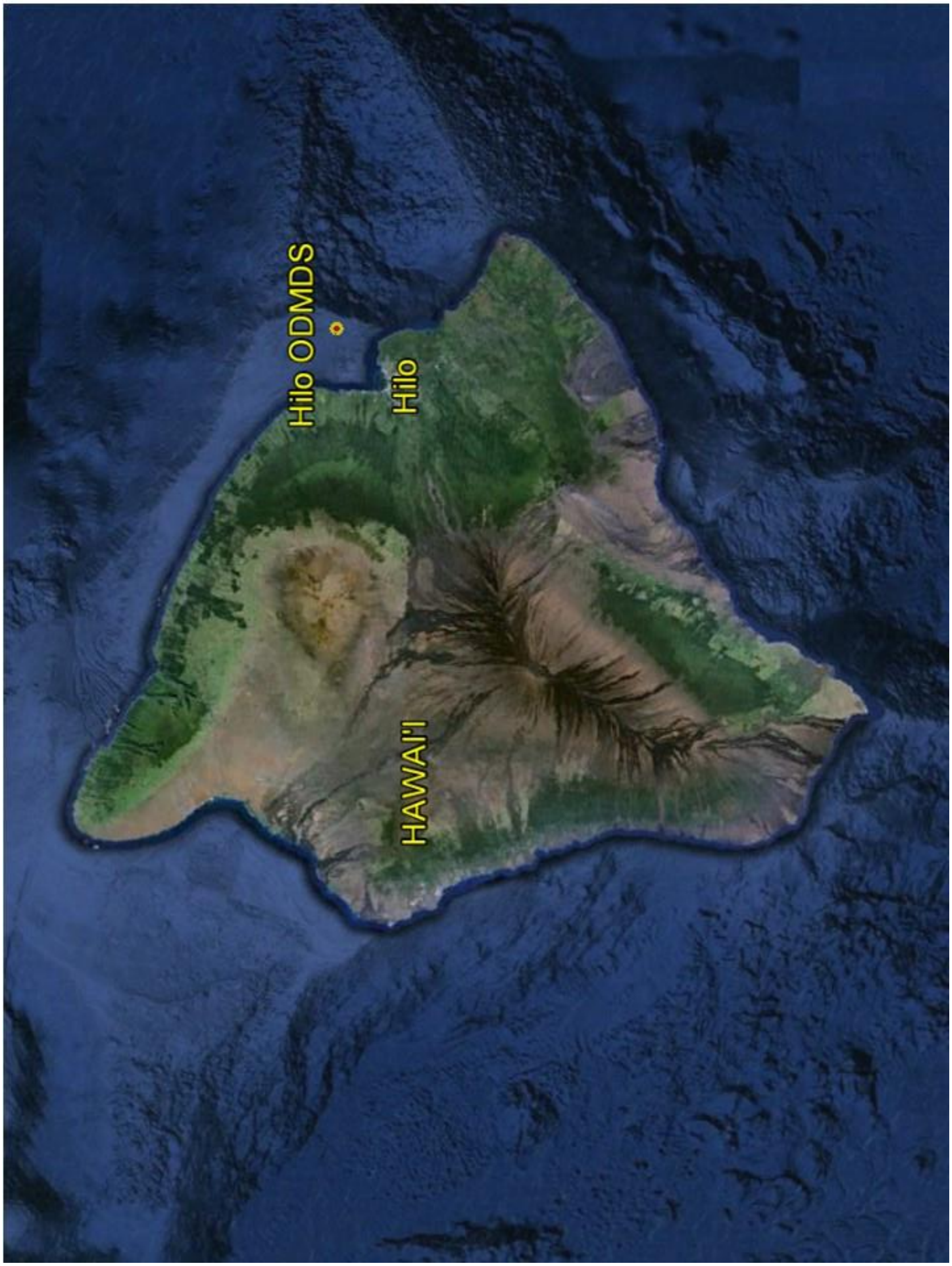

Figure 12. Planned and actual sample station locations at the Hilo ODMDS:

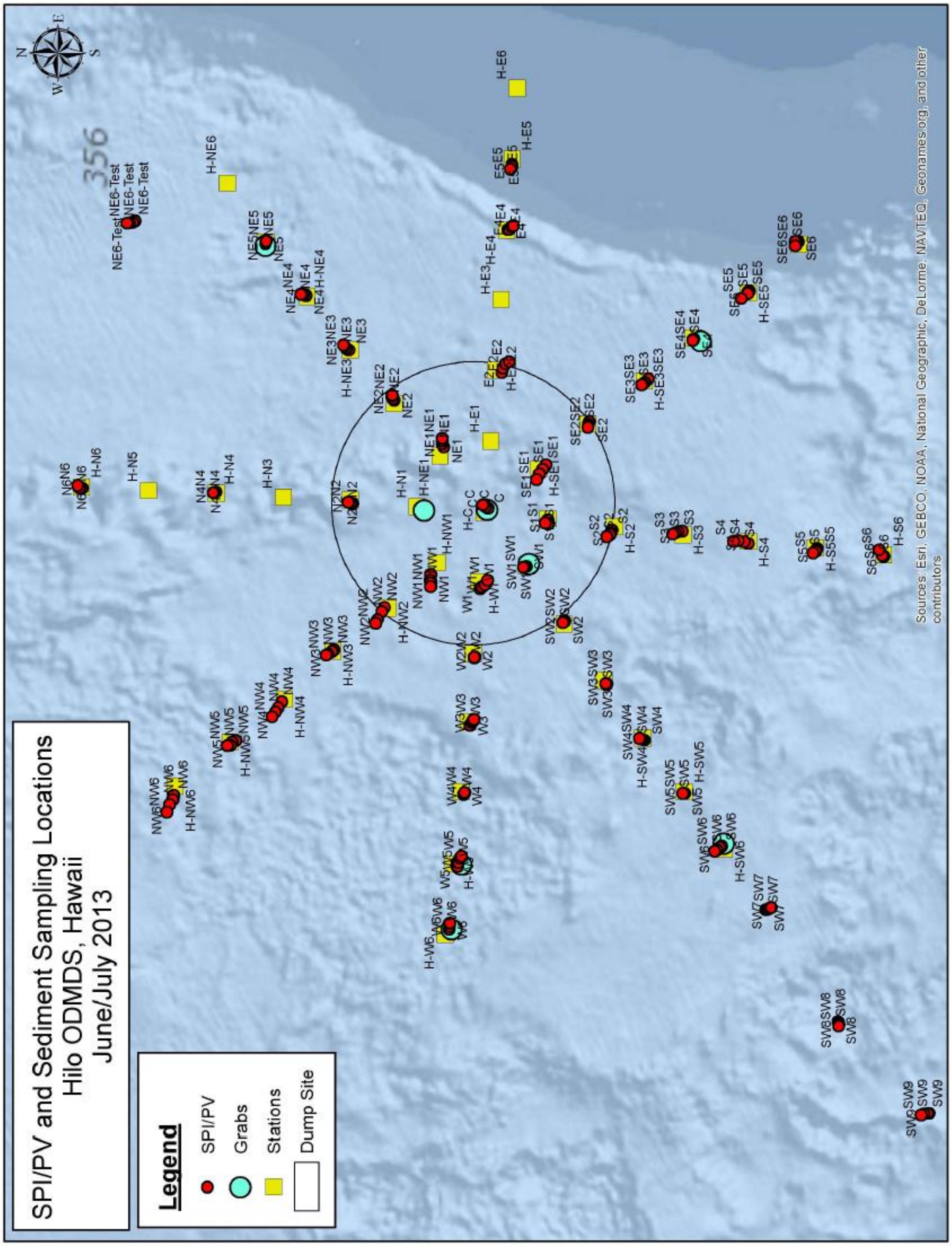

***Table 3.* Hilo ODMDS Sampling Station Coordinates (NAD83). SPI and PVP photographic samples at all stations; sediment grab samples at highlighted stations.**

Station ID	Latitude	Longitude	Notes
C	19 48.315 N	154 58.340 W	SPI-PV only (grab failed)
N1	19 48.565 N	154 58.320 W	SPI-PV and sediment grab
N2	19 48.815 N	154 58.295 W	SPI-PV only
N3	19 49.065 N	154 58.285 W	Station not occupied
N4	19 49.315 N	154 58.270 W	SPI-PV only
N5	19 49.570 N	154 58.260 W	Station not occupied
N6	19 49.820 N	154 58.245 W	SPI-PV only
S1	19 48.075 N	154 58.365 W	SPI-PV only
S2	19 47.825 N	154 58.395 W	SPI-PV only
S3	19 47.570 N	154 58.425 W	SPI-PV only
S4	19 47.325 N	154 58.450 W	SPI-PV only
S5	19 47.075 N	154 58.475 W	SPI-PV only
S6	19 46.820 N	154 58.500 W	SPI-PV only
W1	19 48.335 N	154 58.600 W	SPI-PV only
W2	19 48.355 N	154 58.870 W	SPI-PV only
W3	19 48.375 N	154 59.125 W	SPI-PV only
W4	19 48.400 N	154 59.385 W	SPI-PV only
W5	19 48.430 N	154 59.655 W	SPI-PV only (grab failed)
W6	19 48.460 N	154 59.920 W	SPI-PV and sediment grab
E1	19 48.290 N	154 58.075 W	Station not occupied
E2	19 48.270 N	154 57.810 W	SPI-PV only
E3	19 48.250 N	154 57.545 W	Station not occupied
E4	19 48.230 N	154 57.285 W	SPI-PV only
E5	19 48.210 N	154 57.020 W	SPI-PV only
E6	19 48.190 N	154 56.755 W	Station not occupied
NW1	19 48.490 N	154 58.530 W	SPI-PV only
NW2	19 48.675 N	154 58.700 W	SPI-PV only
NW3	19 48.880 N	154 58.860 W	SPI-PV only
NW4	19 49.060 N	154 59.040 W	SPI-PV only
NW5	19 49.265 N	154 59.200 W	SPI-PV only
NW6	19 49.470 N	154 59.365 W	SPI-PV only
NE1	19 48.480 N	154 58.130 W	SPI-PV only
NE2	19 48.650 N	154 57.935 W	SPI-PV only

Table 3, continued. **Hilo ODMDS Sampling Station Coordinates (NAD83). SPI and PVP photographic samples at all stations; sediment grab samples at highlighted stations**.

NE3	19 48.815 N	154 57.735 W	SPI-PV only
NE4	19 48.975 N	154 57.535 W	SPI-PV only
NE5	19 49.130 N	154 57.330 W	SPI-PV and sediment grab
NE6	19 49.275 N	154 57.110 W	Station not occupied
SW1	19 48.155 N	154 58.540 W	SPI-PV and sediment grab
SW2	19 48.015 N	154 58.760 W	SPI-PV only
SW3	19 47.865 N	154 58.970 W	SPI-PV only
SW4	19 47.720 N	154 59.185 W	SPI-PV only
SW5	19 47.565 N	154 59.385 W	SPI-PV only
SW6	19 47.415 N	154 59.600 W	SPI-PV and sediment grab
SW7	19 47.257 N	154 59.827 W	SPI-PV only (station added in field)
SW8	19 46.989 N	155 00.245 W	SPI-PV only (station added in field)
SW9	19 46.648 N	155 00.587 W	SPI-PV only (station added in field)
SE1	19 48.110 N	154 58.180 W	SPI-PV only
SE2	19 47.925 N	154 58.010 W	SPI-PV only
SE3	19 47.715 N	154 57.850 W	SPI-PV only
SE4	19 47.530 N	154 57.690 W	SPI-PV and sediment grab
SE5	19 47.325 N	154 57.520 W	SPI-PV only
SE6	19 47.135 N	154 57.340 W	SPI-PV only