

*A Preliminary Assessment of Effects to
Fish Habitat Associated With the Placement
of Dredged Materials at the Alcatraz Disposal Site
San Francisco Bay, California*

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1.0 INTRODUCTION AND OBJECTIVES

1.1 Background

Dredged material disposal in the San Francisco Bay Area is the subject of intensive study by the U. S. Army Corps of Engineers/San Francisco District (USACOE), the U.S. Environmental Protection Agency, Region IX (EPA), the San Francisco Regional Water Quality Control Board (RWQCB), and the San Francisco Bay Conservation and Development Commission (BCDC) under the Long-Term Management Strategy (LTMS). This study has been conducted for the LTMS In-Bay Work Group.

The Alcatraz Dredge Material Disposal Site is situated within the San Francisco Bay between the Hyde Street Pier and Alcatraz Island (Figure 1). The site is designated as a 2000 foot diameter circle with its geographic center at latitude 37° 49' 17" North, longitude 122° 25' 23" West.

The site has been used as a dredged material disposal site since its designation in 1894. The area between Alcatraz Island and the Hyde Street Pier was originally selected because of its depth (formally approximately -165 feet Mean Lower Low Water) and the presence of high current velocities. It was assumed at that time that the high current would carry and disperse the sediments out to sea on the ebb tide, and into other deep regions of the Bay on flood tides. Currents have proved to be insufficient to transport the volume of material that has been placed at the site, and a mound of sediment has accumulated to the extent that it could present a hazard to navigation, a situation currently being addressed by the Corps. There has also been concern that the materials dispersed from the Alcatraz site may be affecting adversely the habitat for commercial and recreational fish species in the Bay. In particular, some local party-boat operators have stated that sediments migrating from the Alcatraz site have degraded prime fishing sites in the Central Bay

including Harding Rock, Shag Rock, Arch Rock, Alcatraz Shoal, and Blossom Rock (R. Tasto, pers. comm., 1993). These operators suspect that fines from sediment disposal may be smothering these rocky habitats and sandy shoals, reducing the available habitat for fishes sought, and subsequently reducing the catch.

Additionally, the National Parks Service on Alcatraz Island suspects that tidepool habitats facing the disposal site (on the south shore of the island) may be silting in because of disposal at the Alcatraz site (Tasto, pers. comm., 1993).

Unfortunately, there are presently no available data to confirm nor refute these statements. The principal objective of this study is to investigate qualitatively the extent to which dredged materials discharged at the Alcatraz Disposal Site has been transported from the site sufficiently to cause degradation of benthic habitat. This objective was approached by a combination of interviews and reviews of scientific literature, review of reports and data pertaining to fish habitat in the Central San Francisco Bay, and reconnaissance field studies. One of the primary goals of the literature search was to determine sediment conditions in the Central Bay existing prior to disposal at Alcatraz so that in combination with a reconnaissance survey, the nature and extent of benthic habitat modification associated with disposal at Alcatraz could be assessed qualitatively.

A secondary objective of this project was to design a quantitative study to delineate in the future, and if desired, more precisely the aerial extent to which material discharged at Alcatraz has migrated beyond the boundaries of the disposal site, and to determine to what extent modification of fish habitat in the Central Bay has affected commercial and recreational fishing in the Central Bay.

Sediment samples were collected and analyzed to estimate the presence and distribution of fine-grained dredged materials within the Central Bay that could be covering fish habitat, and to examine the presence of benthic invertebrate infauna as an additional indicator of modified benthic habitat conditions. This information,

together with reviews of surveys conducted in previous years and with visual observations using an ROV, were used to obtain a general understanding of conditions existing at sandy and rocky habitat in Central San Francisco Bay, as well as the extent of sediment modifications associated with disposal at Alcatraz.

This report summarizes past studies, discusses results of field studies conducted to assess habitat modifications related to disposal activities at Alcatraz, and recommends future work to examine conditions of fish habitat in central San Francisco Bay.

Study Area

The literature search reviewed previous studies pertaining to Central San Francisco Bay. Field reconnaissance focused on the area surrounding the Alcatraz Disposal site, extending from Alcatraz Shoal to the west, to Blossom Rock to the east, north to Alcatraz Island, extending slightly beyond the island to the northeast, and south of the disposal site as depicted in Figure 3. Single samples were also collected near Harding Rock, Shag Rock and Arch Rock.

2.0 REVIEW OF PROPOSED TASKS

There were five tasks in this study of the effects of Alcatraz disposal activities ¹.

The purpose of Task 1 is first to identify and review previous studies in the Bay pertinent to the evaluation of effects of Alcatraz disposal to Central Bay fisheries habitat. Materials of interest included historic records of sediment composition in the Bay prior to disposal at Alcatraz, locations of sediments or rocky outcrops typically identified as fish habitat, and historic collections and surveys focused on fish populations. Second was to prepare a preliminary map locating areas of sensitive fish habitat in the Central Bay. This preliminary map was based on existing literature and discussions and was used to locate all reconnaissance stations reported here. This task also included discussion of methods employed to identify fish habitat.

The first purpose of Task 2 is to use the hydrographic survey results developed by Gahagan & Bryant (G&B) under Delivery Order 0015 to prepare a contour map to overlay the preliminary habitat map developed in Task 1. The G&B hydrographic survey was not intended to cover the entire area of interest in this habitat study. Thus, we obtained from the National Oceanic and Atmospheric Administration additional hydrographic survey data and subsequently were able to prepare a detailed baseline contour map of the Central San Francisco Bay, as well as for terrain surrounding the Bay.

Contour lines within San Francisco Bay below mean lower low tide (MLLT) and outside the G&B surveys were obtained from R. Chang of the USGS, Menlo Park, California, who is using these in unpublished, ongoing modeling studies in the Bay.

¹ The first two tasks were completed and the results submitted in an earlier report, Task 1 and 2, Literature Review and Reconnaissance Field Study Design, to the U.S. Army Corps of Engineers, San Francisco (Corps) in November, 1993. This document reviews the highlights of the Tasks 1 and 2 report, as well as results of Tasks 3, 4, and 5.

Points are derived from NOAA Presidio Tide Station #4290. Elevational data for points above MLLT were obtained from the USGS Digital Elevation Model (DEM), 1984 survey, which are derived from the 7.5 minute USGS quadrangle sheets. Together, these surveys helped delineate the distribution of Alcatraz disposal materials including the extent of the apron of deposited material marking the extremes of deposition, and also clearly link the Bay to land contours above water level.

The second purpose of Task 2 is to design a field reconnaissance study to determine the extent and nature of the movement of discharged material away from the Alcatraz disposal site. During this reconnaissance study, sediments from a wide area of the Central Bay were sampled to assess the areal extent of the Alcatraz sediments.

Task 3 includes two principal purposes. First, is to carry out field studies to delineate the apron of the Alcatraz mound; and second, to assess the potential degradation of Central Bay fisheries habitat.

The principal purpose of Task 4 is to design a quantitative field study to determine the effects of the Alcatraz disposal activities and sediment transfer on sediment characteristics around the margins of the mound including the impact to Central Bay fish habitat.

The purpose of Task 5 is to prepare a report summarizing the results of work on this project. Information included in the earlier Tasks 1 and 2 report submitted to the Corps and which is important to an overall understanding of the work on this project is repeated herein.

3.0 LITERATURE REVIEW

3.1 Background to the Alcatraz Disposal Site and Environment

When the Army Corps of Engineers designated in-Bay disposal sites in the early 1970s, it selected sites from which disposed material would disperse. Some considered that the capacity of the Alcatraz Island site to disperse material was unlimited, and for many years dredged material was disposed in the deep water next to Alcatraz Island. However, in 1982, it was discovered that this site had accumulated enough material to pose a hazard to navigation. The mounding problem at Alcatraz stimulated widespread discussion among scientists, dredgers, and regulators regarding the fate of materials deposited there.

The fate of disposed material that reaches the bottom is determined largely by the direction and strength of the bottom currents (ABAG, 1992). Because the lower portion of the water column in much of San Francisco Bay has a net transport landward, much of the disposed material is carried in that direction, rather than toward the ocean. This landward transport of currents was demonstrated by seabed drifter studies conducted in the late 1960s (Conomos et al., 1970). Studies argue strongly for the net landward transport of currents, especially in Central Bay. Thus, material disposed at the Alcatraz site most likely is dispersed within the estuary, rather than carried westward to the Pacific Ocean. Studies also suggest that some of the material disposed into Central Bay is transported to the estuary's northern reach (Conomos and Peterson, 1977).

Several studies have been completed to optimize current transport of material from the mound and to try to mitigate accumulation of dredged materials (Tetra Tech, 1984; Winzler and Kelly, 1985, Trawle and Johnson, 1986; Trawle, 1986; SAIC, 1986, 1987a, b; Teeter, 1987; Pankow, 1988; and Hauck et al., 1990). However, limited attention has been given to the ultimate depositional area of the current

redistributed dredged materials including the possible adverse effects to biologic habitat resulting from the redistribution of fine clay and silt dredged materials by currents or slide transport. In a report on suspended sediment movement within the Bay (Hauck et al., 1990), it was recommended that detailed mapping of surface sediments be conducted to determine sediment grain size and distribution over an annual cycle. These studies have not yet been conducted.

A brief historical account of research in the San Francisco Bay and a study of human activities effecting general and sedimentological conditions in the Bay is found in Hedgpeth, 1979. In his paper, Hedgpeth makes reference to the study by Gilbert (1917) as "the nearest thing we have to a baseline analysis of the physical characteristic of the San Francisco Bay". Gilbert's report on the hydraulic-mining debris in the Sierra Nevada Mountains also included a study of currents and debris transport into and out of the Bay. In Gilbert's report the general area of the Alcatraz Dredge Disposal Site is shown with a water depth of greater than 20 fathom (approximately -120 feet MLLW). Reference is also made to the volume of material being delivered to the Bay system at that time.

3.2 Sediments Within The Central Bay

San Francisco Bay sediments between the Golden Gate and the area around Alcatraz Island are comprised of primarily coarse to fine sand with minor amounts of silt and clay. East of Alcatraz, sediment particle size generally becomes finer towards the interior of the Bay. Goldman (1967; 1969) provides generalized geologic maps of the San Francisco Bay area which indicate sandy bottom conditions with relatively shallow to exposed bedrock surfaces in some locations.

Sand waves were identified throughout most of the Central Bay area during a hydrographic survey using echo-sounding equipment (Gibson, 1951). A detailed

bathymetric map was contoured for the Alcatraz Shoal area and showed sand waves as high as six feet.

The Wave Research Laboratory of the University of California at Berkeley conducted a core penetration study of sediments in San Francisco Bay in 1953 (Trask, et al., 1953; Trask, 1954²). The study indicated that in the area of strong tidal action between Angel Island, Treasure Island and the Golden Gate, core penetration generally ranged from two to four feet. Cores were collected using a piston core (Kullenberger) sampler. Sediment from nine cores (Sample numbers 139 - 141 and 146 - 151) recovered in the area between Alcatraz Island and the San Francisco shoreline contained primarily fine to medium sands with some shell material. One core (151) on the Alcatraz Shoal contained gravel.

Johnson (1971) conducted some grain size analyses from several cores collected from the 1953 survey. His analyses indicated that sand between Alcatraz Island and the San Francisco Bar is fine to coarse grained (125-1000 microns). A later study by Thompson (1981), using a coring transect from the offshore area through the Golden Gate to the Central Bay, indicated a similar trend with coarse sands in the Golden Gate region fining inward towards the east. Sediment grain size distribution around the Central Bay from available sources are shown in Figure 2.

A detailed study of bedforms within the Central Bay was conducted using side-scanning sonar (Rubin & McCulloch, 1979). Their report shows three types of bedform topography around the disposal site area: 1) a flat bed topography with bedrock and boulders located just south and southwest of Alcatraz Island, 2) a bottom topography with 1 - 3 meter sandwaves located southwest of Alcatraz Island, primarily along the Alcatraz Shoal, and, 3) a bottom topography with sandwaves

² The California state plane coordinates translated from latitude and longitude values presented in Table C-1 of Trask, 1954 unfortunately do not correspond with locations shown on Figure 3 of Trask, et al., 1953. Sample locations from Figure 3 of Trask, et al., 1953 were visually transferred to show the data on the base map of this report.

less than 1 meter located south of Alcatraz Island and east of the Alcatraz Shoal. The junction point of the three bedforms area is in the vicinity of the Alcatraz Dredge Disposal Site.

A general study of dredged materials and natural sediment characteristics within the Alcatraz Dredge Disposal Site area was performed by Farmer (1985). His report included an appendix by Subsurface Consultants which contained boring logs from six holes that were drilled by rotary methods in and around the Alcatraz disposal mound. Some of the significant findings of Farmer's report include:

- The former depth of the dredge disposal site area was approximately -165 feet (MLLW).
- Recent dredged materials are composed of a mixture of ~75% highly plastic clays and ~25% clayey sands. Older dredged materials are predominantly highly plastic clays.
- Recent shoal deposits are comprised of relatively clean dense fine-sands. In some places the shoal deposits have covered the older dredged materials.
- Natural pre-dump site deposits were encountered in one borehole at a 85 feet sub-bottom depth (SBD). Approximately four feet of dense clayey sands were found to overlie a graywacke sandstone bedrock at 89 feet SBD (-129 MLLW).

The results of Farmer's investigation with respect to natural deposits around the site are generally consistent with other reports which indicate sandy-bottom conditions around the area and on the Alcatraz Shoal (Trask, 1954; Goldman, 1969; Johnson, 1971; and Thompson, 1981). The thin sediment cover overlying bedrock also corresponds well with shallow bedrock depths (-100 to -200 feet MLLW) indicated in top of bedrock contours (Goldman, 1967; Carlson and McCulloch, 1970).

An additional study of bedforms and bottom characteristics around the Alcatraz Disposal Site was conducted using side-scanning sonar, piston coring, and bathymetric profiling (SAIC, 1987). Their report shows five types of bedform around the disposal site: 1) long wave length (10 meter) sand waves, south and west of the disposal site; 2) short wave length (1-2 meter) sand waves, south of the disposal site; 3) fine grain deposits characterized by smooth topography (indicated by relatively low reflectance) around the margins of the disposal mound; 4) coarse grained deposits, gravels and clumps of sediments (characterized by relatively high reflectance) around the base of the disposal mound and to the southeast of the disposal site; and 5) extremely coarse dredge deposits characterized by large variations in topography resulting from shadowing effects, located on the disposal mound.

The SAIC also compared the differing methods for material disposal and dispersal along with the effects of the materials in a limited area around the disposal site. This study concluded that it was best to dispose of the material in a fluid matter to achieve the best dispersal and to limit accumulation within the site. They further found that after initial disposal, the more fluid material was eroded by current transport within several months. However, once the material was deposited, the more consolidated material would remain at the site without significant loss of material. The study did not address the ultimate depositional site of the dispersed material, or the effects of the material over a wider area of the Bay.

Bioassay testing and chemical analysis of sediments from cores collected within the disposal site were conducted by EVS Consultants (1988). The EVS report identified locations of contaminated sediment within the pile and included data from biological and chemical testing. Physical descriptions of dredge materials are similar to those reported by Farmer (1985).

The Corps designated in 1987 eight sampling stations (Alcatraz Environs Stations) around the Alcatraz Disposal Site as a reference for determining suitability for dredged materials disposal. These stations have provided a significant volume of data on the area surrounding the disposal site. Grain size data are available for the sites (Corps, 1993); however the sediments have been composited and data for specific sites is not available. Analyses of the sediments indicate 81-98% sand with up to 17% gravel and 0-6% silt and clay. Figures 3 and 4 shows the locations of these sampling stations.

3.3 Distribution of Fishes and Habitat Use Near the Alcatraz Disposal Site

The Bay provides habitat for both marine, estuarine, and anadromous species, each with varying dependencies on substrate conditions. The pelagic anadromous species, such as salmonids and American shad, that move through the Central Bay, either to upstream spawning grounds or as outmigrating juveniles, do not spend a great deal of time near the bottom. In contrast, flatfishes such as halibut, English sole, and starry flounder are demersal species that are in constant contact with the bottom and thus dependent on the benthic resources for food items and cover. The focus of this study is on the demersal species most likely to be directly affected by changes in substrate composition associated with dredged materials placement at the Alcatraz Site.

Other studies have evaluated the effects of substrate quality on fish use. Pearcy (1978) and Pearcy and Hancock (1978) studied the relationship of sediment size and fish species distribution, abundance, and feeding habits of various flatfishes off the coast of Oregon. Deeper mud substrates were dominated by slender sole and shallow sandy bottoms were dominated by Pacific sanddab. Amongst the sanddabs, the small sanddabs predominated at silt-sand stations, whereas the larger sanddabs appeared to prefer sandy sediments (Pearcy, 1978).

In the second 1978 study, Percy and Hancock found slender sole and Pacific sanddab in the same feeding group, which fed primarily on pelagic crustaceans. The other group, comprised of dover sole and rex sole, fed mainly on polychaetes and amphipods. They determined that feeding preferences were associated with mouth and digestive morphology and concluded their study with a quote from Petersen (1918): "It is clear then that the character of the bottom is of fundamental importance for the presence or absence of epifauna. Nevertheless, the succession of the various types of epifauna and of the communities belonging to the level bottom cannot be explained by the character of the bottom alone."

Skinner (1962) described the Alcatraz area as historically supporting a commercial fishery for bottomfish, such as sablefish (*Anoplopoma fimbria*), lingcod (*Ophiodon elongatus*), hake (*Merluccius productus*), and rockfish (*Sebastes* spp.). Later accounts by Aplin (1967) describe the west edge of Treasure Island, which is east of the Alcatraz Disposal Site, as mostly homogeneous sand and mud. Some of the more common fishes noted in the Aplin studies included: Pacific herring (*Clupea harengus harengus*), northern anchovy (*Engraulis mordax*), jacksmelt (*Atherinopsis californiensis*), English sole (*Parophrys vetulus*), tomcod (*Microgadus proximus*), speckled sanddab (*Citharichtys stigmaeus*), shiner perch (*Cymatogaster aggregata*), white croaker (*Genyonemus lineatus*), starry flounder (*Platichthys stellatus*), northern midshipman (*Porichthys notatus*), pile perch (*Rhacochilus [Damalichthys] vacca*), Pacific staghorn sculpin (*Leptocottus armatus*), and tonguefish (*Symphurus atricauda*).

Compendia of fisheries and aquatic resources of San Francisco Bay by Herbold et al. (1992), Monroe et al. (1992), Booth et al. (1989), and WESCO (1988), as well as discussions of turbidity effects to the biota (O'Connor, 1991), provide more current comprehensive descriptions of presence, distribution, and possible causes of population fluctuations of significant fisheries in the Bay. The U.S. Army Corps of Engineers Waterways Experiment Station (WES) also compiled a literature review

of documents providing information on the potential impacts of dredged material disposal on fisheries and contaminant bioavailability in the Central Bay (WES, 1992). However, there is little information cited focusing directly on fish habitat identification or habitat modification as related to changes in Bay substrate. Much of the work that has been reported relates to declines in fish populations and catches, and is directed at water column effects such as changes in flows from rivers entering the Bay and impacts to anadromous fishes caused by alterations of freshwater habitats, turbidity, and levels of pollutants.

The CDFG Bay-Delta Monitoring Program is the only on-going biological monitoring program that has been conducted in the Central Bay (it also includes other stations within the Bay). CDFG has been sampling selected sites since 1980. Otter trawls have been used at stations near the Alcatraz site, although no trawls have been taken at the mound itself. The fish catch data generated by this program are acknowledged to be biased by gear type. Otter trawls tend to capture the slower moving bottom fishes and can be deployed most successfully on even, softer bottoms. Areas of exposed rocks are not satisfactorily sampled by this method, nor by many others for that matter. An examination of the CDFG data suggests that the fishes near the Alcatraz area tend to be more marine than estuarine due to the effects of the sea water entering the Golden Gate. Some of the more common fish encountered include northern anchovy, Pacific herring, longfin smelt (*Spirinchthys thaleichthys*), white croaker, English sole, and marine surfperches.

Between 1984 and 1986, the Corps commissioned a number of biological studies by Kinnetic Laboratories, Inc., to evaluate other potential in-Bay aquatic disposal sites that could provide capacity additional to the Alcatraz site. These sites were located at the South Tower of the Golden Gate Bridge and Bonita Cove (KLI, 1985) and South Tower and "Alcatraz Annex" located east of the present Alcatraz site (WES, 1986). As part of these studies, some data on aquatic resources near the Alcatraz site were collected. In the first study (KLI, 1985) fisheries data were collected from mid-

water and from otter trawl surveys conducted during two seasons. Mid-water catches were mostly comprised of northern anchovy and longfin smelt. The trawl data from the Alcatraz Annex site showed lower fish abundance and number of species (4 species in October; 8 species in February) compared to the South Tower (16 species in October; 11 species in February) and Bonita Cove (23 species in October; 17 species in February). The fishes collected at the Alcatraz Annex site by otter trawl included: shiner perch, plainfin (northern) midshipman, brown rockfish (*Sebastes auriculatus*), longfin smelt, Pacific herring, northern anchovy, white croaker, Pacific staghorn sculpin, English sole, and big skate (*Raja binoculata*).

The Kinnetic Laboratories survey also collected benthic invertebrate data over the same period and in approximately the same locations as the fish sampling. The data showed that variability was very high within the sites as it was between the sites, which would require the collection of far more samples to detect any statistically significant differences in abundance and number of species. The surveys showed seasonal shifts in the composition of dominant taxa, finding for instance that the amphipod *Ampelisca abdita* was numerically dominant at the Alcatraz Annex site during October, but the bivalve *Tellina nuculoides* ranked highest in February.

The second study, conducted by the Waterways Experiment Station (WES, 1986), was performed as part of the decision-making process in the selection of an interim in-Bay disposal site ("Annex Site") immediately east of the main Alcatraz Disposal Site. WES developed the Benthic Resources Assessment Technique (BRAT) for this study to estimate the benthic habitat quality through the collection and analysis of benthic organisms from the sediment and the prey exploitation pattern of demersal fishes collected within the same area. Due to technical difficulties in the field, benthic samples were not collected. The sampler was not adequately equipped to penetrate and retain samples from the sandy/debris (shell fragments) sediments, and the effectiveness of the BRAT procedure was not fully tested.

The study team was able to collect qualitative food habit data for the five species collected at the Annex Site: California halibut, Pacific staghorn sculpin, white croaker, speckled sanddab, and English sole. The report concluded that no unusual feeding patterns for the dominant fish species were observed, but without box-core samples evaluations of the trophic importance of the site for bottom feeders such as white croaker, speckled sanddab, and English sole could not be made. Their data indicated that the species other than these demersal species did not appear to be directly dependent on infaunal organisms for food. From the limited data collected, it appeared that anchovy and pandalid shrimp were important to many of the fish of Central Bay (halibut, sculpin, croaker, rockfish, perch, and sole); however, polychaetes and bivalves could become important on a seasonal basis.

One of the few studies of fishes conducted in the Bay focusing directly on active sediment disposal was a hydroacoustic survey conducted in 1991 at the Alcatraz site immediately before, during, and after a disposal event (MEC, 1991; Bio Sonics, 1991). Survey transects were located around the site and tracked both fish movement and plume dynamics during a flood tide. Fishes were tracked in the water column, and mid-depth trawls deployed to collect fishes and confirm identification of species. The study determined that the plume was dense and sank slowly. Fish in the water column and near the site (herring, Pacific butterfish (*Peprilus simillimus*), and anchovies) left the area during the event. The schools returned two to three hours later. Monitoring of additional disposal events would have been necessary to provide better definition in the tracking system. However, this survey was not repeated. Demersal fishes were not studied in this program.

Anecdotal information also exists that is helpful in determining habitat conditions in the vicinity of Alcatraz. As noted above, it is the suspicion of some local party-boat operators that habitat degradation resulting from sediments migrating from the Alcatraz disposal site has diminished the quality of fishing at sites in the Central Bay. The San Francisco Bay Harbor Pilots Association raised concerns regarding

what they perceived to be recent or increased shoaling of northeast of Alcatraz Island. They attributed this shoaling to off-site migration of dredged material from the disposal site. Some of the operators suspect that fine materials drifting from the Alcatraz disposal site have smothered these rocky habitats, and perhaps sandy shoals, reducing the available habitat preferred by their recreational fisheries, and subsequently reducing their catch. Although the Corps report (USACOE, 1988) concluded that little correlation was evident between sportfishing catch reports and turbidity levels, substrate effects were not evaluated.

Representatives of the National Park Service have also voiced concern related to sediment disposal at the Alcatraz site (Horner, 1994). She believes that disposal activities affect many of the aquatic resources of the Bay, and that wildlife such as sea birds and marine mammals are disturbed and leave the area during disposal events at the Alcatraz site.

Tidepools on Alcatraz have been monitored seasonally as part of a program to assess changes of these habitats, especially as the effects may relate to sediment disposal (Horner, 1994; Hatch, 1994). Much of the data collected are anecdotal, but Park Service biologists have noted die-offs of the intertidal algae *Endocladia* in tidepools facing the Alcatraz Disposal Site. However, no quantitative measurements have been made, nor have attempts been made to link sediments in tide pools with disposal activities at Alcatraz. Although there is insufficient information to substantiate a cause and effect relationship, a COE consultation with UCLA research scientist, Richard Zimmerman, indicates that gross burial by dredged material would likely cause a mass die-off of *Endocladia*, not the patchy one observed. In the latter part of 1993, a natural resource management specialist with the Park Service commented that the *Endocladia* at the tidepools had begun to recover and that die-offs and regeneration of this algae are common at Alcatraz. *Endocladia* is an annual species, and no attempt has yet been made to separate suspected effects of sedimentation and natural seasonal death of this plant.

Exposed subtidal rock surfaces in clean waters of northern California are usually covered with marine organisms (Rickettes, E. F., and J. Calvin, 1968; Johnson, M. E., and H. J. Snook, 1955).

Marine algae communities can be dense in the shallower waters, and hundreds of species of invertebrate animals have been identified from rocks at all depths along the coast. Most of these plants and animals are relatively small, and require rocky substrate relatively clear of muds and sands. Thus, if rock surfaces naturally free of sediments become covered with a layer of sand or mud, the resident organisms die.

The attached plants and animals in clean waters attract feeding fishes and their predators. Rocky surfaces also can provide crevices and caves for refuge and for lurking.

Unfortunately, the subtidal rocky habitat within San Francisco Bay has received little attention (but see Rickettes and Calvin for a general review). Nevertheless, it can be reasonably assumed that clean rocky surfaces, particularly close to the clean marine waters flowing in the Golden Gate, will support a community of surface plants and animals and an associated population of fish predators and grazers. For these reasons, attempts were made in this study to see if evidence of habitat burying was evident. The only technique available within the boundaries of this reconnaissance study to examine deeper waters in the vicinity of the Alcatraz Disposal Site was brief deployment of an ROV.

Rocky outcrops occur around the entire perimeter of Alcatraz Island, and elsewhere in the study area at Arch, Harding, Shag, and Blossom Rocks.

3.4 Demersal Fishes, Dungeness Crab (*Cancer magister*) and Crangon Shrimp (*Crangon spp*) in Central San Francisco Bay

The natural history of demersal fishes of commercial and recreational importance, and of Dungeness crab and Crangon shrimp, that may be commonly found near the Alcatraz disposal site are basically as follows.

California halibut (*Paralichthys californicus*) The California halibut supports an important commercial fishery offshore the Central California coast. This species is primarily marine and spawns pelagic eggs offshore. The eggs and pelagic larvae remain in shallow water in near-shore coastal waters. Young halibut are then transported into the Bay by tidal currents and small juveniles can be found in bays and estuaries and outside the surf zone. Once in the bays and estuaries, juveniles remain in these waters about two to three years and eventually migrate out to shallow open coastal waters.

The juveniles and adults apparently prefer sandy bottoms but may also appear near rocks, sand dollar beds, and channels that enter coastal embayments (Emmett et al., 1991). California halibut are active predators and feed primarily on fish, but when young feed on small invertebrates such as mysids, gammarid amphipods, and harpacticoid copepods. Arrow gobies (*Clevelandia ios*) may also serve as food for juvenile halibut in bays and estuaries. The commercial landings of halibut have declined over time, which has been attributed to overfishing, changes in the marine habitat, changes in estuarine habitat, populations shifts, and pollution (Emmett et al., 1991).

English sole (*Parophrys vetulus*). English sole is another commercially caught flatfish, although it is not a particularly important recreational species. English sole spawn offshore. Eggs and larvae are pelagic, but as the larvae grow, they descend through the water column and are transported into the Bay in the spring and

estuarine, species populations would reflect decreases in the extent of estuarine habitat.

White croaker (*Genyonemus lineatus*). White croaker is very common in the Central Bay. This species is not generally considered to be a prime recreational fish. However, there is an increased popularity among some recent immigrant populations. It is one of the most common native piscivores in the Bay (Herbold et al., 1992) and is commonly caught from piers and nearshore shallow waters. Due to its high fat content, the tissues of this species has a propensity to bioaccumulate contaminants such as PCBs and DDTs and thus has been the subject of number of contaminant studies to assess potential health threats to humans through the ingestion of its flesh. It is also a target species of the National Status and Trends Program (Emmett et al., 1991).

This species spawns in the lower reaches of the estuary or in offshore waters. The pelagic eggs and larvae are released over sand and gravel bottoms (Wang, 1986). They are carried into the upstream portions of the Bay by tidal currents. As larvae and juveniles mature, they tend to descend to the bottom and move towards the Central Bay. At the same time juveniles from the previous year begin to enter the Bay and reside in deeper waters in the South Bay (Herbold et al., 1992). As adults, white croaker may remain in the Bay, but many migrate out. All of these lifestages may be found over mostly sandy bottoms, but may sometimes be found in kelp beds (Emmett et al., 1991). All forms are omnivorous and diets may include mollusks, polychaetes, copepods, crab, shrimp, amphipods, fish, and detritus (Emmett et al., 1991; Wang, 1986).

Shiner perch (*Cymatogaster jaggregata*). Shiner perch is one of the most common of the marine surfperches to be found in the Bay. It does not support a commercial fishery although it is caught recreationally and is used for bait (Emmett et al., 1991; Wang, 1986). The shiner perch apparently uses the estuary for a nursery ground

more than any of the other marine surfperches. This species moves to inshore waters and the Bay in the spring to spawn. It is a live bearer, giving birth to fully-formed young that begin feeding in the same manner as the adults (Herbold et al., 1992). The young and juveniles remain in the Bay for up to two years (Wang, 1986), when they move to deeper waters offshore.

All forms of this species can be found over sandy beaches, rocky areas, piers, and pilings, but the preferred substrate is sandy and muddy bottoms (Emmett et al., 1991). Juveniles and adults are omnivorous and may include in their diets algae, copepods, isopods, amphipods, bivalves and bivalve siphons, mollusks, polychaetes, and detritus (Emmett et al., 1991; Wang, 1986).

Brown rockfish (*Sebastes auriculatus*). Brown rockfish is apparently the most common rockfish to be found in San Francisco Bay, but is not found in the less saline waters (Wang, 1986). It is primarily a marine species with adult forms found generally near rocks, ledges, piers, and other hard substrates. Juvenile and larval rockfish have been found in the Central and San Pablo Bays (Booth et al., 1989). Very little is known about the habitat requirements and behavior of the larval and early juvenile forms of this species. Juveniles can be found near the bottom and their diet may consist of small crustaceans and small fish (Wang, 1986).

Dungeness crab (*Cancer magister*). Dungeness crab historically supported a commercial fishery within San Francisco Bay, but since 1900 commercial landings have all been outside the Golden Gate. This is one of the few benthic organisms of the Bay that has been the subject of research studies (Herbold et al., 1992). The juvenile life stage is the form most commonly found in the Central Bay. Spawning takes place offshore, the juveniles move into the Bay, and return to the ocean after approximately a year. Juveniles found intertidally prefer soft substrate with eelgrass and bivalve shells. Dungeness crab are more common from Richardson Bay to Suisun Bay. Their numbers and distribution appear to be influenced by ocean

changes caused by El Niño events and outflow from the Bay, i.e., fewer juveniles in the Bay during higher outflows (Herbold et al., 1992). Both incoming and outgoing year classes of Dungeness crab use Central San Francisco Bay as a migratory corridor. Juveniles feed on fish, mollusks, and crustaceans and are cannibalistic on smaller Dungeness crabs.

Crangon shrimp. Shrimp are fished commercially in San Francisco Bay by 18 or so boats. Together with the Pacific herring fleet, these constitute the last remaining commercial fisheries operations in the Bay (R. Tasto, pers. comm.). The fishery is dominated by three species: *Crangon nigricauda*, *C. nigromaculata*, and *C. franciscorum* (Smith and Carlton, 1975). A fourth species (*C. alaskensis elongata*) has been reported from the Bay (R. Tasto, pers. comm.), but is readily confused with the larger *C. nigricauda* (Smith and Carlton, 1975). These organisms are found throughout the Central Bay, on mud and sandy bottoms where they feed and seek refuge (Smith and Carlton, 1975). Presumably, conditions that alter the character of the benthic habitat preferred by these species can have effects on one or more of these shrimps, although the extent of these effects in San Francisco Bay has not been studied.

4.0 RECONNAISSANCE FIELD STUDIES:

4.1 Background and Rationale

Based on the literature review and an assessment of Central Bay conditions, the reconnaissance field study was designed and implemented to collect sediment samples from identified fish habitat areas, and to observe, as possible, habitat conditions using a remotely operated vehicle (ROV). The sandy shoals and rocky outcrops that are near the Alcatraz Disposal Site, and that may be subject to deposition of fine particles transported from the disposal site were the focus of these activities. At the level of this reconnaissance study, only the presence of benthic habitat was to be qualitatively evaluated during the single sampling event. For this study, substrate composition and grain size were to be considered to be primary descriptors of "fisheries habitat". This is a fairly restrictive definition of the term in that fish habitat also depends on adequate water quality, water flows, and habitat that provide essential feeding, spawning, and nursery grounds. Also, habitat requirements vary by species and life stage. Details of these habitat requirements are beyond the intended scope of this study, in nature and will have to be addressed in future programs. Specific information sought as evidence for habitat alteration in this study included the following:

- Discontinuities in sediment characteristic within a core sample, especially when evidence exists of freshly deposited materials overlaying historic (previous recorded natural) deposits.
- Evidence of benthic organisms characteristic of disturbed sediments, or present in different quantities than is characteristic of undisturbed sediments in the Bay; variation in species composition among sediment types.

- Surface sediments different from historic descriptions for a locale, i.e. mud where sands were reported, or fine sands where coarse sands or gravels were reported.
- Visual evidence from the ROV study.

4.2 Sampling Methods

The reconnaissance field study was carried out aboard the San Francisco State University Research Vessel "Questuary" from 19 through 21 January, 1994. The vessel was equipped with a 3,000-ton A-frame hoist which was adapted for gravity coring and grab sampling. Sample station positioning was accomplished by means of a dual global positioning system.

A series of general north to south sampling stations was located along the east and west margins of the disposal site (Figures 3 and 4). An east-to-west series of stations was also positioned on both sides of the dredge disposal area as was proposed in the reconnaissance field study design. Additional points were also picked between sediment changes identified during the field study and at selected points around Harding Rock, Shag Rock, Arch Rock, Blossom Rock, and along the Alcatraz Shoal.

The two methods of sediment recovery for this investigation were a gravity core and a box core sampler. A Van Veen core was tested at one station, but it was not so successful for sediment collection as the box corer, and was not used afterwards.

Gravity Corer

The gravity corer designed for collection of sediment samples was fitted with a 4-inch diameter, two-foot or three-foot long core barrel. Approximately 300 lbs of lead weights was used for driving the corer. Before sampling, a plastic liner was inserted

into the corer barrel to retain the sediment sample. A core-catcher device was installed in the cutter nose, which was then threaded onto the corer barrel. The gravity corer was launched by suspending the device from the A-frame on a drop-line and letting out the desired amount of cable from the winch. The drop line was then released at the selected sampling location and the corer was allowed to free-fall to the bottom. The corer was recovered by the winch.

After the coring device was recovered, the core liner was pulled from the corer barrel to expose the bottom of the liner. The liner bottom was then covered with a rubber cap and sealed with duct tape. The liner was then removed from the barrel, labeled with station number and orientation, cut to the length of the sediment retained, and the other end capped and sealed with duct tape. Core samples containing only a minor amount of sediment were transferred to one-gallon size plastic bags, labeled and sealed for later description. All cores and bag samples were transported at the end of the day to a designated storage location for opening and sediment description later.

Box Corer

An approximately two-foot square box corer was used for recovering biological samples. Approximately 400 lbs of lead was bolted to the corer for driving the sampler. The coring device was launched in the same manner as the gravity corer.

A sub-sample of the recovered sediment was retained for geologic logging, determination of particle-size-distribution, and total-organic-carbon analysis. The remaining sediment sample was then passed through a 1 mm sieve and the retained organisms preserved in 10% buffered formalin for identification and enumeration. Organisms were later identified to species when possible.

Upon collection of sediment at each station, the station number, location, water depth, length of recovered volume and initial sediment observations were recorded. Sample location coordinates and water depth data were recorded at the time the coring device reached the sediment surface, as noted by observations of the drop line. Some differences occurred between the desired coordinates and coordinates actually sampled, because of the drift of the ship during the time the sampling device took to free-fall to the bottom. Station locations were recorded for sites actually sampled.

A total of 70 sampling drops were made at 61 collection stations (Table 1). Of these, 57 gravity core stations were attempted for sediment distribution analyzes and 13 box core stations were attempted for biologic analyzes. Nine of the 13 box core stations were attempted as dual stations for sediment and biologic analyzes.

Of the 57 gravity core stations for sediment analyzes, sediment cores with a maximum length of 2.9 feet were recovered from 18 stations, sediment bag samples were recovered from 26 stations, and no sediment samples were recovered at 13 stations whose sediments were either too coarse for retention in the sampler, or where the substrate appeared to be exposed rock. Sediment samples for biological analysis were collected from 12 of the 13 boxes core stations; the thirteenth station, AHS-02B, yielded only a limited amount of sediment and a sample for biological analysis was not collected.

4.3 Sample Analyses

4.3.1 *Sediments*

Cores were cut longitudinally with a power saw, split with a wire and cleaned of cuttings. Sediments were visually described as to sediment type, color, grain size, particle sorting, firmness, lithology, and other miscellaneous characteristics. Grain

Table 1

Table 1

Table1

size characteristics were determined using information presented on Table 2. Geologic logs were prepared for all core samples showing the vertical distribution of different sediment layers. Geologic logs were also prepared for bagged samples. Geologic logs are presented in Appendix A.

Dredged material were visually discernable from natural deposits (sediment type, color, grain size and sorting). Grain-size analyses were performed on the sub-samples from the box core samples and four of the bagged samples. Sediments were not analyzed for physical parameters such as moisture content, density, and plasticity index, because of the limited nature of the vertical recovery, and because of past studies of cores (Farmer, 1984) which indicated only gradual changes in physical characteristic over an extended length of the sediment column.

4.3.2 Infauna

The biological sampling program carried out in this program was not intended to provide sufficient data to permit a detailed and quantitative evaluation of populations of benthic invertebrates (or fishes) in the Central San Francisco Bay: only 12 stations were sampled for benthic invertebrates in the entire Central Bay. Rather, the purpose was to seek biological evidence that Alcatraz disposal activities are associated with benthic habitat degradation or habitat modification. The relative abundances and the species present can be a good indicator of differences between sediments. Although this evidence in itself does not necessarily reveal the suitability of the sediments as benthic fish habitat, variations in numbers and species present can reflect physical or chemical dissimilarities, or both, among locations sampled. Benthic invertebrates are an important part of the diet of a number of fishes, directly or indirectly in the food web. Thus in this study, degradation and modification of the benthic community would be seen as evidence that demersal fish habitat, and thus the presence of these fishes, was being affected as well.

TABLE 2
GRAIN-SIZE CHARACTERISTICS

| Grain size (mm) | Phi (ϕ) scale | Type of sediment |
|--------------------|-------------------------|------------------|
| 256 | -8 | Cobble |
| 64 | -6 | Cobble |
| 16 | -4 | Pebble |
| 4 | -2 | Pebble |
| 2 | -1 | Granule |
| 1 | 0 | Very coarse sand |
| 0.5 | 1.0 | Coarse sand |
| 0.25 | 2.0 | Medium sand |
| 0.125 | 3.0 | Fine sand |
| 0.0625 | 4.0 | Very fine sand |
| 0.031 | 5.0 | Coarse silt |
| 0.0039 | 8.0 | Silt |
| 0.002 | 9.0 | Silt |
| 0.00006 | 14 | Clay |

We had earlier identified natural sediments in the Central Bay that are associated with "good fishing" as reported in the Preliminary Report. It was assumed, for this study, that changes to these sediments could alter their value as fish habitat.

Several techniques were used to compare infaunal communities at the 12 biological sampling locations, including comparisons of species present, and the "evenness" of their representation in the sample. In the context of this report, "evenness" refers to the relative abundance among species within a community: communities in which a few organisms dominate among many present displays "uneven" distribution; communities in which numbers of organisms present in each species gradually diminishes, and where no species is strongly dominant numerically, display "evenness". A graphic technique useful to display both evenness and diversity of a community of organisms is to plot cumulative species abundance (x axis) against percentage abundance of each species (y axis). Data from a community strongly dominated by one or a few species will yield a low, flat slope (Figure 5). Data from a diverse community will produce a strongly convex curve (Figure 6). Although decidedly qualitative, this graphic presentation may provide helpful information on the relative environmental conditions at different locations.

4.4 Remotely Operated Vehicle (ROV) Study

During the course of this study, the opportunity arose to use an ROV to videotape benthic habitat in the Bay. The use of an ROV had not been recommended earlier owing both to the high cost and uncertainties as to the ability of the vehicle to operate effectively under typical Bay conditions of high turbidity and current flow.

The equipment used was a Phantom 500 ROV, equipped with a high-resolution color video camera with adjustable viewing angle and halogen lighting system. Two operators were provided by Deep Ocean Engineering San Leandro, California.

Replicate k Dominance Curve

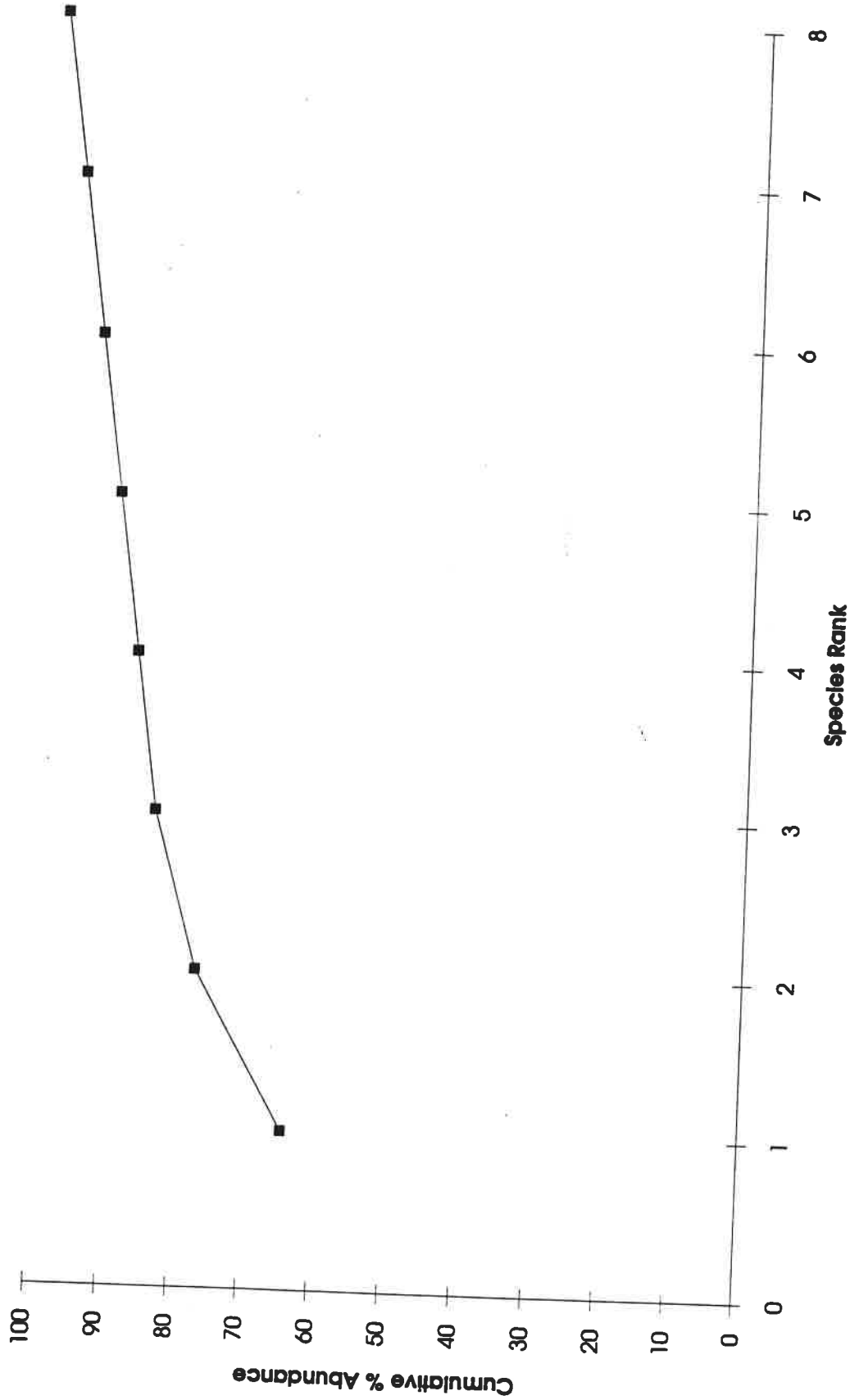


Figure 5. Species Abundance Curve Demonstrating Low Species Number And Relatively Uneven Distribution

Replicate k Dominance Curves

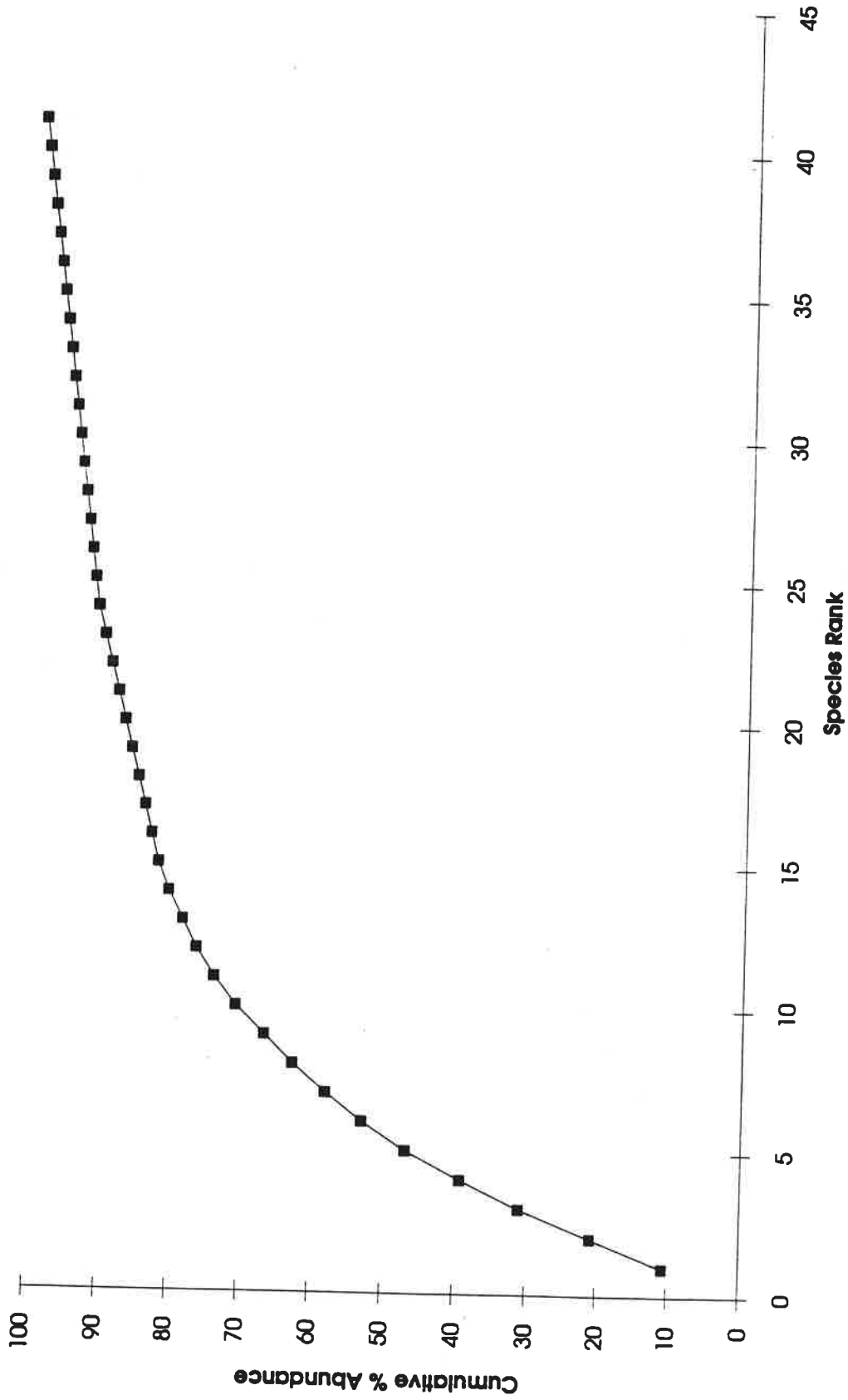


Figure 6. Species Abundance Curve Deviation Demonstration High Species Number And Relatively Even Distribution

recovered to the east (AHS-02B, AHS-03S and AHS-04S) and northeast (AHS-37S, AHS-57S and AHS-39S) of the disposal site. Some fine sand layers were identified interlayered with the mud layers.

5.2.3 Type 3 Sediments (Fine Sands and Minor Mud Deposits)

Type 3 sediments were found around the margins of the disposal site, primarily to the north of the disposal site and on the south slope of Alcatraz Island (AHS-20S, AHS-21S&B, and AHS-60B); to the northeast of the disposal site - east of Alcatraz Island (AHS-38S, AHS-39S, AHS-51S, and AHS-52S); and to the east of the disposal site (AHS-35S and AHS-05S).

5.3 Benthic Invertebrates

Figure 2 depicts the locations of the 12 benthic sampling stations. A summary of the species collected at the stations is presented on Table 3. Lists and enumeration of species identified for each station are attached in Appendix B.

Species Diversity and Abundance

The most species rich-stations were 61B (52 taxa/41 distinct species identified), 37B (43/37), 1B (34 /30), and 23B (23/20). Stations 61B and 1B are dark, muddy sand (Type 3) identified as derived from dredged materials transported by water movement to their present locations. Stations 23B and 37B appear to be natural sands (Type 1) typical of broad areas of the central San Francisco Bay. Four stations were intermediate in species abundance: 60B (10/10), 59B (10/9), 39B (8/6), and 15B (7/7). All four stations are derived from dredged materials (Type 3). Stations with the lowest numbers of benthic infauna collected are 10B (5/5), 58B (5/5), 50B (4/3), and 21B (2/2). Station 10B is Type 3 sediments, but the others are natural Bay sands

Table 3
SPECIES ABUNDANCE IN BENTHIC SAMPLES

| Phylum | Annelida Species/No. of Organisms ¹ | Crustacea Species/No. of Organisms ¹ | Echinodermata Species/No. of Organisms ¹ | Mollusca Species/No. of Organisms ¹ | Other Taxa/ No. of Organisms ² | Station Total Taxa/No. of Organisms ³ |
|----------------|---|--|---|--|---|--|
| Station | | | | | | |
| 1B | <i>Armandia brevis</i> -15 <i>Glycinde picta</i> -8 <i>Sigambra tentaculata</i> -10 17 other species-40 Totals: Species-20 Organisms-65 | <i>Melita dentata</i> -21 <i>Pinnixa franciscana</i> -20 <i>Scleroplax granulata</i> -9 7 other species-11 Totals: Species-10 Organisms-62 | <i>Amphiodia urtica</i> -1 <i>Ophiuroidea</i> sp.-4 Totals: Species-2 Organisms-5 | <i>Gemma gemma</i> -20 <i>Macoma</i> sp.-8 <i>Protothaca staminea</i> -12 3 other species-6 Totals: Species-6 Organisms-46 | Totals: Taxa-4+ Organisms-86 | Totals: Taxa-40 Organisms-264 |
| 10B | <i>Magelona piteikai</i> -3 <i>Hemipodus borealis</i> -1 <i>Mediomastus</i> sp.-1 Totals: Species-3 Organisms-5 | <i>Photis californica</i> -1 Totals: Species-1 Organisms-1 | | | Totals: Taxa-1 Organisms-1 | Totals: Taxa-5 Organisms-7 |
| 15B | <i>Spiophanes missionensis</i> -1 Totals: Species-1 Organisms-1 | <i>Foxiphalus obtusidens</i> -1 Totals: Species-1 Organisms-1 | <i>Amphiodia</i> sp.-1 Totals: Species-1 Organisms-1 | <i>Amygdalum pallidulum</i> -1 <i>Mya arenaria</i> -1 Totals: Species-2 Organisms-2 | Totals: Taxa-2 Organisms-2 | Totals: Taxa-7 Organisms-7 |
| 21B | <i>Mediomastus</i> sp.-1 Totals: Species-1 Organisms-1 | | | <i>Odostomia</i> sp.-1 Totals: Species-1 Organisms-1 | Totals: Taxa-0 Organisms-0 | Totals: Taxa-2 Organisms-2 |

| Station | Phylum | Annelida Species /No. of Organisms | Crustacea Species/No. of Organisms | Echinodermata Species/No. of Organisms | Mollusca Species/ No. of Organisms | Other Taxa/ No. of Organisms | Station Total Taxa/No. of Organisms |
|---------|--------|---|--|--|---|-------------------------------------|---|
| 23B | | <i>Armandia brevis</i> -18 <i>Mediomastus spp</i> -6 9 other species-12 | <i>Melita dentata</i> -6 <i>Cancer anthonyi</i> -2 2 other species-2 | <i>Amphiodia sp</i> -2 | <i>Acanthodoris sp</i> -1 <i>Cephalaspidea</i> -1 <i>Macoma sp</i> -1 | | |
| | | Totals: Species-11+ Organisms-36 | Totals: Species-4 Organisms-10 | Totals: Species-1 Organisms-2 | Totals: Species-3 Organisms-3 | Totals: Taxa-4+ Organisms-8 | Totals: Taxa-23 Organisms-59 |
| 37B | | <i>Armandia brevis</i> -31 <i>Mediomastus spp.</i> -79 <i>Spiophanes missionensis</i> - 207 Tubificidae-17 17 other species-29 | <i>Cancer spp.</i> -2 | <i>Amphiodia digitata</i> -3 | <i>Tellina modesta</i> -4 <i>Transenella tamilla</i> -7800 | | |
| | | Totals: Species-21+ Organisms-363 | Totals: Species-5 Organisms-6 | Totals: Species-1 Organisms-3 | Totals: Species-7 Organisms-7810 | Totals: Taxa-9+ Organisms-105 | Totals: Taxa-43 Organisms-8287 |
| 39B | | <i>Spiophanes missionensis</i> -20 Tubificidae-4 2 other species-2 | | | | | |
| | | Totals: Species-4 Organisms-26 | Totals: 0 | Totals: 0 | Total: 0 | Totals: Taxa-4+ Organisms-5 | Totals: Taxa-8 Organisms-31 |
| 50B | | <i>Saccocirrus spp.</i> -11 <i>Hemipodus borealis</i> -5 2+ other species-12 | | | | | |
| | | Totals: Species-4+ Organisms-23 | Totals: 0 | Totals: 0 | Totals: 0 | Totals: 0 | Totals: Taxa-4+ Organisms-23 |

| Phylum | Annelida Species /No. of Organisms | Crustacea Species/No. of Organisms | Echinodermata Species/No. of Organisms | Mollusca Species/ No. of Organisms | Other Taxa No. of Organisms | Station Total Taxa/No. of Organisms |
|----------------|---|--|--|--|-------------------------------------|---|
| Station | | | | | | |
| 58B | <i>Acmira catherinae</i> -1 Goniadidae-1 <i>Hemipodus borealis</i> -1 <i>Myriochele</i> sp.-1 Totals: Species-4 Organisms-4 | Totals: 0 | Totals: Species-1 Organisms-1 | Totals: 0 | Totals: 0 | Totals: Taxa-5 Organisms-5 |
| 59B | <i>Glycera americana</i> -3 4 other species-4 Totals: Species-5 Organisms-7 | <i>Corophium</i> spp-16 <i>Melita dentata</i> -3 2 other species-2 Totals: Species-4+ Organisms-21 | Totals: 0 | Totals: 0 | Totals: Taxa-1 Organisms-1 | Totals: Taxa-10+ Organisms-20 |
| 60B | <i>Hesionura coineau</i> <i>difficilis</i> -1 <i>Steptosyllis</i> sp.-1 Tubificidae-1 Totals: Species-3 Organisms-3 | <i>Rhepoxynius stenodes</i> -1 <i>Alvania compacta</i> -1 <i>Gemma gemma</i> -1 Totals: Species-1 Organisms-1 | Totals: Species-2 Organisms-2 | Totals: 0 | Totals: Taxa-4 Organisms-4 | Totals: Taxa-10 Organisms-10 |
| 61B | <i>Armandia brevis</i> -171 <i>Eusyllis</i> spp.-7 19 other species-27 Totals: Species-21+ Organisms-205 | <i>Melita dentata</i> -6 <i>Photis brevipes</i> -21 8 other species-18 Totals: Species-10 Organisms-45 | <i>Amphiodia urtica</i> -3 <i>Amphiodia</i> sp-1 <i>Ophiuroidea</i> -7 Totals: Species-3 Organisms-11 | <i>Gemma gemma</i> -12 <i>Alia carinata</i> -6 Mytilidae-7 6+ other species-15 Totals: Species-9+ Organisms-40 | Totals: Taxa-9+ Organisms-170 | Totals: Taxa-52+ Organisms-471 |

Note:

- 1 Only predominant species in the indicated phyla that were present in each sample are identified by name in this table. Other species present (within the indicated phylum) are included in Other Species within that column. Appendix B lists all the species that were collected at the sampling stations.
- 2 "Other Taxa " column refers to organisms collected from the samples that are included in phyla other than annelida, crustacean, ehinodermata, and molluska. In most instances the organisms have been taxonomically identified to family or species and in a few instances, to phyla only. Therefore, these organisms are grouped and numerically counted according to taxa rather than species. The taxa names are listed in Appendix B.
3. "Total Taxa" is the sum of the species identified in the annelida, crustacean, ehinodermata, and molluska columns and the taxa identified in the "Other Taxa " column. Therefore, total species count at these stations is a conservative estimate.

(Type 1). The cumulative abundance curves (Appendix C) corroborate the species counts of the biological collection stations.

High Species Abundance Stations. The species abundance data thus indicate the general pattern of approximately equally high abundance among the four stations east of the Alcatraz disposal site (1B, 23B, 37B, and 61B). Two of the stations are derived from Type 1 native sands (23B, 37B), the other two from Type 3 redistributed dredge sands (1B, 61B). Annelid species predominated in samples from these four locations. The annelid *Armandia brevis* was the only species that was present in samples from all four stations, ranging from 15 animals at Station 1B to 171 animals at Station 61B. *Mediomastus* spp. was present in samples from two of the four stations (23B, 37B) and *Spiophanes missionensis* was present at three of the stations (1B, 23B, 37B). Various species of the echinoderm *Amphiodia* were found in samples from all four stations. Ophiuroidea sp. was present at two of the stations (1B, 61B). The crustacean *Melita dentata* was found at Stations 1B, 23B, and 61B. The mollusk *Gemma gemma* was present at Stations 1B, 37B, and 61B. *Macoma* spp. was present in samples from three stations, 1B, 23B, and 37B.

The species found in greatest abundance was the mollusk *Transenella tantilla*, with a count of 7800 in the one sample from Station 37B (Type 1 sediment). This mollusk was not found in any of the other samples.

Intermediate Species Abundance Station. Intermediate species abundance was found at the four dredged materials stations, (all are Type 3 sediments), three stations on the periphery of the disposal area to the south (59B), west (15B), and north (60B) of the disposal site, and the single site to the northeast of Alcatraz Island (39B). Annelid species predominated at Station 39B with greater representation from other phyla evident at the other three stations. The species found in the highest abundance from these four stations was *Spiophanes missionensis*, with a count of 20 animals from the Station 39 B. None of the species present in the

samples were found at all four stations. Species present in samples from intermediate abundance stations that were also found in samples from the high abundance stations include *Spiophanes missionensis* (Stations 15B and 39B), *Melita dentata* (Station 39B) and *Amphiodia* sp. (Station 15B).

Low Species Abundance Stations. Low species abundances occurred at one Type 1 station about one kilometer west of the disposal area on Alcatraz shoal (50B), one Type 1 station south of the disposal area (58B), and another Type 1 station several hundred meters north of the disposal site (21B). Sediments at all these stations are consistent with descriptions of "natural sands" in Central San Francisco Bay. Station 10B, presumably derived from dredged materials and several hundred meters west of the disposal site also had a low number of species. Most of the animals collected from these above stations were annelids. The annelid *Mediomastus* sp. was present in very low numbers in two of the four samples (Stations 10B and 21B). This species was also found at some of the intermediate and high abundance stations in far greater numbers, as high as 79 animals at Station 37B. The annelid *Hemipodus borealis* was found at Stations 10B and 50B (one at each station). This annelid was not present in any samples from the other 10 stations. One echinoderm (*Holothuroidea*) was present in the sample from Station 58B and one mollusk (*Osdostomia* sp.) was present in the sample from Station 21B. No crustaceans nor other phylas were represented in these four samples.

A preliminary examination of the organic carbon data (presented in Appendix D) reveals no strong correlation of numbers of species at a station and the levels of organic carbon present in the sediments. For instance, Station 59B, with the highest portion of organic carbon at 1.347%, had 10 taxa (8 species identified) present. Station 60B, with the lowest portion of organic carbon at .024%, also had 10 taxa (8 species identified) present. There appears to be only a slight correlation between the amount of organic carbon and decreasing grain size.

5.4 ROV Survey

On January 6, 1994, an in-situ reconnaissance survey of the Alcatraz environs was completed by means of an ROV. The ROV was deployed at six locations in central San Francisco Bay: four around the periphery of Alcatraz Island, one along the western shore of Angel Island, and one at Arch Rock. Throughout the survey, visibility was limited due to high levels of suspended material that scattered and diffused the light. Maximum visibility near Alcatraz and Arch Rock was approximately 1 foot; visibility offshore of Angel Island increased to as much as several feet. In addition, the sub-surface currents, which were sometimes greater than 2 knots, exceeded the optimum operating limits of the ROV and made it difficult to remain on station.

ROV observation Stations 1 through 13 were located along a linear transect trending north to south from the mid-point of the southern side of Alcatraz Island towards the Alcatraz Disposal Site. When the ROV was in contact with the bottom, which was between 40 and 59 feet on this transect, the substrate was seen to consist of large boulders, rock rubble, and cobble embedded in a dark sediment. Pieces of algae were seen floating through the water column, and coverage of organisms on hard surfaces was sparse.

When the ROV was positioned next to the southern wall of Alcatraz Island, an orange starfish (*Patiria miniata*) and a crab (*Cancer* sp.) were observed. What appeared to be either red or orange bryozoans or sponges were common on rocks. This position was held only briefly because ebb currents were rising and the boat could not be kept on station for prolonged periods. The decision was made to relocate to a calmer portion of the central Bay until tidal currents decreased.

Observations at Station 14, a cove on the west-southwest shore of Angel Island revealed rocks, boulders, and outcrops in the deeper substrate (17 feet and above)

and what appeared to be muddy sand in the shallower areas. Visibility was approximately 2 feet. *Patiria miniata* were common, as were red and orange incrusting organisms. Red (possibly *Halosaccion* and others), brown, and green (possibly *Ulva*) algae were also present. A fish, probably a sculpin, and a yellow nudibranch with brown spots was observed.

The substrate and organisms appeared to be covered with a very fine flocculent easily resuspended. From approximately 40 feet up to 1 foot depth, sea pens (*Pennatulacea*) were visible. These are anthozoans that in the Bay are characteristic of areas of low current velocities and deep sediments. Sea pens were observed at any of the other study locations.

Several *Patiria miniata*, purple sea stars (*Pisaster ochraceus*), and bryozoans or sponges were seen between 30 and 60 feet at Arch Rock. Nothing was visible in the water column while the ROV was operated between locations on the bottom.

On the northwest side of Alcatraz, incrusting red bryozoans or sponges were observed. One *Patiria miniata* and an unidentified pink sea anemone (Anthozoa) were also seen.

At the southern point of Alcatraz Island currents were high (approximately 4 knots) and consequently the ROV was operated as the vessel drifted with the current. The survey revealed the presence of *Patiria miniata* and the ubiquitous red or orange incrusting organisms.

The next cluster of observations were performed along approximately the same transect as Stations 1 through 13. Clean rocks were observed at 30 feet. No significant biological material other than small incrusting organisms was observed. This area has the appearance more of a river bottom than of a marine habitat, and few sediments were seen among the cobbles and boulders. This could be a result of

the high currents passing through the depression between the disposal mound and Alcatraz Island. To the east of the previous transect at Stations 21, 21' and 22, an increase in the red and orange incrusting material was noted. A crab (*Cancer* sp.) was seen.

Blossom Rock, to the southeast of Alcatraz Island, was to be the last station surveyed. Surveys could not be conducted at Blossom Rock as the currents exceeded the ability to safely operate the ROV.

Although qualitative, the ROV observations reveal that none of the areas examined around Alcatraz Island were blanketed in sediments, dredged or otherwise. On the contrary, rock surfaces near Alcatraz were relatively clear of sands and mud, probably the result of the high current velocities through the area.

6.0 CONCLUSIONS

6.1 Sediment Characteristics

Natural deposits were visually discernable from dredged materials. The characteristics of the sediments recovered in cores from this investigations are as follows:

- Observed native sands (Type 1 materials) which appear unaffected by dredge materials (Type 2 materials) are generally:
 - 1) shades of brown with some red and pink;
 - 2) between a grain size of upper-medium sand (>350 um) and very-coarse sand (<2000 um) with some gravel;
 - 3) moderately sorted; and
 - 4) with less than 5% clay and silt content.
- Dredge materials (Type 2 materials) recovered around the Alcatraz disposal mound are primarily:
 - 1) black to grayish black;
 - 2) muds with some interlayered black to dark gray fine sands.
 - 3) comprised primarily of clay and silt with minor amounts of fine sand.

6.3 Biological Characteristics

No distinct and quantitative correlations were intended to be drawn between benthic invertebrate species abundance and species composition and habitat alteration from either disposal of dredged sediments or redistribution of dredged sediments as stated previously. However, the findings of the study indicate the following:

- Benthic sediments outside the disposal area that receive Type 3 sediments (transported dredged materials) appear for the most part to have more diverse infaunal populations than exist at undisturbed Alcatraz Shoal (although only one sample was collected on the shore for comparison). It is not known if these modified sediments are suitable habitat for commercial and recreational species.
- Benthic species abundance within the study area appears to be highest east of the Alcatraz Disposal Site; this is the case both for Type 1 (natural materials) and Type 3 (redeposited dredged materials) stations.
- Species abundance appears lowest at Type 1 (natural sands) stations located north, south, and west of the Alcatraz Disposal Site.
- The species *Armandia brevis*, *Melita dentata*, and *Amphiodia* spp. were present in both natural sediments and modified sediments indicating either that 1) these species may be tolerant of varying sediment conditions, and or 2) the sediments may not be sufficiently altered to exclude these species.
- Although the limited biological sampling conducted in this reconnaissance study indicates that some of the benthic invertebrates present in the modified

sediment may not also be present in the natural sediment, there is insufficient data to conclude that the former group includes any "indicator species" or those species tolerant of severely polluted conditions.

Benthic sediments over a portion of the Central San Francisco Bay outside the Alcatraz Disposal Area appear to be modified by redistributed dredged materials placed within or in proximity to the disposal site. This conclusion is based on physical observations of cored surface sediments and on qualitative observations of the benthic invertebrates community at a relatively small number of collection stations in the Central Bay.

The affected benthic sediments appear to cover an area estimated to be 3 square miles, an area approximately three times that of the disposal site itself. Thus, an estimated 4 square miles of Central Bay has been affected by these estimates.

Exposed rocky substrate in proximity to the disposal site observed with an ROV appeared to support a community of organisms similar in density and composition to similar substrate observed well away from the disposal site. Suitability of these sites for fish habitat was not determined.

7.0 RECOMMENDED QUANTITATIVE FIELD STUDY PROGRAM

7.1 Introduction and Purpose

The following recommended field study provides the framework for a quantitative evaluation of habitat utilization of demersal fishes in the vicinity of the Alcatraz Disposal Site. One of the primary goals of this study, as part of the program of the LTMS In-Bay Work Group, is to contribute to the generation of data and information on demersal fishes in the vicinity of the study area that will allow for improved management of the Alcatraz Disposal Site. This data, in combination with existing information and ongoing studies, will contribute to the:

- Prediction of dredged material dispersion;
- Evaluation of ecological impacts and consequences of dredged material disposal, and
- Recommendations of changes for site use, disposal amounts, or seasonal usage.

An assessment of habitat utilization by demersal fishes, such as English sole, starry flounder, shiner perch, and rockfish near the Alcatraz Disposal Site may be accomplished through the collection and analysis of data specifically for determining habitat characteristics for those species. The data that will be collected to evaluate the utilization of target demersal fishes in the vicinity of the Alcatraz Disposal Site includes collection of fishes, macroinvertebrates of commercial importance (Dungeness crab, Crangon shrimp) and benthic sediment and biological samples. Methods for evaluating fish habitat use and preference have been developed over the years for the Instream Flow Incremental Methodology, which is a habitat-based approach for evaluating environmental changes in streams and

rivers (Bovee, 1986). The general approach to fish habitat use and preference as presented in this plan is based on these guidelines, as the overall concepts are applicable to other aquatic systems, such as the Bay.

Habitat availability is also important to establish because habitat availability determines preference. It is not within the scope of this plan, however, to assess the availability of all habitat types within the San Francisco Bay system.

Analyses of sediment will include physical, chemical, and biological evaluations. An important part of sediment chemistry is the possible presence of contaminants in the sediments and the risk to biological resources that these contaminants may pose. Constituents of interest in the Bay waters include heavy metals and polynuclear aromatic hydrocarbons (PAHs) (ABAG, 1992). Some of these constituents can become highly concentrated in sediments and can remain in the environments indefinitely. Sediments that may be toxic to biological resources do not provide good habitat. Low species richness in benthic infauna or in fishes can indicate stressful conditions. As part of the chemical evaluation this study, the sediments will be analyzed for heavy metals and PAHs.

The scope of work for this field study will incorporate spacial and temporal variations, and a larger sample size than that achieved with the reconnaissance study. Therefore, some of the analyses pertaining to habitat degradation that were intended in the reconnaissance study, but were not feasible, will be incorporated into this study. These analyses will provide comparative information between the benthic communities in disturbed sediments (sediments with dredged materials) and local reference benthic communities in natural sediment. These analyses are discussed further in Section 7.3.

7.2 Background

7.2.1 *Habitat Utilization*

Habitat utilization can be based on a frequency analysis of habitat characteristics at specific locations within the study area, in this case, the Alcatraz Disposal Site. Data are collected to evaluate habitat utilization, which is represented by the presence of one or more individuals of target species at a fixed location, which can be defined as a focal point or as a part of the species home range. Because data are only collected where target species or organisms are found, these data represent the probability of occurrence of a particular environment given the presence of a species. It also represents, in part, the habitat characteristics available to the species at the time of sampling.

Habitat preference is related to the habitat utilization concept. A species found in a high proportion in a particular environment, compared to the availability of those conditions, has actively selected that set of conditions. If the species' frequency distribution is identical to the distribution of environmental conditions, then it is randomly distributed; all measured conditions are equally suitable for the species (Bovee, 1986). More simply stated, a particular species may be frequently observed associated with a specific habitat type because that habitat is more readily available or accessible to the target organisms than their preferred habitat. However, this does not imply that the target prefers the particular habitat type on which it is found. It is utilizing what is available. In contrast, if suitable or preferred habitat is readily available in a number of different locations within the species or organisms home range, then the one habitat occurrence where the organism is most commonly found is the one that has been actively sought out and is preferred.

7.2.2 Methods for Collection of Fish

The dynamics of the Bay system prevent the use of the more unobtrusive methods of collecting fish habitat use data, such as through direct observation or the use of gill or fyke nets. The use of direct observation is limited due to visibility in the area being confined to within a few inches or feet due to high levels of suspended materials. The Bay environment near Alcatraz would make difficult the use of nets due to the high current velocities, and endangerment to non-target organisms by entanglement in the equipment. Other methods of collecting fish use data, such as electrofishing and biotelemetry, are not logistically feasible, again due to the in-Bay environment.

Hydroacoustic surveys have been used successfully to monitor the distribution of fish in the vicinity of Alcatraz (Bio Sonics, Inc., 1991). When combined with trawling, good data can be collected on the presence of various species. These techniques are best for identification of fishes in mid-water, and not particularly effective for demersal species. For this reason, hydroacoustic techniques are not recommended in studies to determine the presence of fishes associated with specific sediments and other benthic habitat.

Among the few choices available for scientists to collect this type of data is the careful use of trawls. Otter trawls are effective in catching fish; however they have limitations which must be considered: 1) they are species and size selection; 2) they are not particularly useful around cover substrates, such as boulders and rock outcroppings, because the nets may snag on these objects and become a safety hazard during sampling; 3) the deployment of the nets is highly disruptive and the more highly mobile fish are able to avoid capture; and 4) the actual trawling distance may inadvertently cover more than one substrate type. However, because some of these limitations can be remedied to an extent, trawls are the preferred choice for collection of fish for this study.

7.3 *Sampling Program*

A vessel with a large working area and equipped with an A-frame hoist which can be adapted for vibra-coring or use of drilling equipment will be used for this study. The vessel will be equipped with a differential GPS, recording bathometer, trawling gear, and appropriate hydraulics.

A series of sampling points will be made along margins of the disposal site (as defined from the reconnaissance study) to evaluate the vertical extent of the mound around the margins and to study the effects of sediment armoring over time. A more detailed east-to-west transect will be made on the east side of the dredge disposal area to assess the impact between the disposal site and Blossom Rock and the area around Blossom Rock.

Sediment sampling will be conducted to assess and better define the horizontal and vertical distribution of fine-grained dredged materials material that are covering or changing fish habitat within the proximity of the disposal site and around Alcatraz Island. The boundaries of disposed sediments will be further evaluated and the information will be used to develop more comprehensive recommendations to minimize habitat impacts in the area of the disposal site. Benthic invertebrates will be collected from selected sediment stations and identified to genus and, if possible, species.

Habitat utilization will be determined by conducting a series of otter trawls along pre-determined transects that are in the same locations as the sediment collection. Since otter trawls are species and size selective, the use of two otter trawls of two different mesh sizes will increase the catch of various sized fish.

7.3.1 Sampling Methods

The effect of natural variability, both temporal and spacial is an important consideration for all habitat analyses. Although time is not a material part of the habitat it does relate to the daily and seasonal habitat changes. The distribution and amount of the physio-chemical components vary in both time and space, and in turn influence the distribution and abundance of the biotic components. The amount of information that can be generated on seasonal or daily patterns of distribution in a community is limited by the number of sampling occurrences and the timing of each sampling event. The biological field study will be carried out over a sufficient period of time to allow for incorporation of temporal variation in sampling occurrences. Although field sampling during different portions of the day can provide important information on fish and invertebrates that are diurnal, nocturnal, and crepuscular (daytime, nighttime, and dawn and/or dusk, respectively), such a program would involve an extensive sampling effort; thus this study will be limited to an evaluation of seasonal patterns. Recorded spacial information should include specific locality, topography, and physical conditions. A description of the physical factors affecting the site such as substrate, currents, and turbidity, will be recorded. This is further discussed in the following sections.

Core samples will be collected using a vibra-core device or drilling equipment capable of approximately 10 to 20 feet of sub-bottom penetration, depending on sediment type. These deeper core samples (as compared to those collected in the reconnaissance study) will enable greater penetration of the dredge materials to establish the thickness of the redistributed sediment. Gravity coring and box-core sampling may also be used in selected location for further surface habitat studies. Samples from the core barrel will be recovered within an acrylic liner or another suitable liner material. Limited recovery or grab samples will be transferred to 1-gallon plastic bags or containers as appropriate. After sediments are collected, the station number, location, water depth, and length of recovered volume will be

recorded. Shipboard logs will be maintained and any geologic and biologic notes made on board will be recorded. The core liners and bag samples will be sealed after initial observations are made and the samples will be transported to the laboratory for further study and analyses. The core samples will be sectioned in the laboratory after shipboard procedures are completed and detailed sediment logs will be generated. The number of samples for sediment-size and biologic testing will be determined at that time.

Biological samples will be collected by surface grab at some of the sediment stations. Sediments will be passed through a 1 mm sieve and retained organisms preserved in 10% buffered formalin and identified to genus, and to species when possible. A sub-sample will be retained for particle-size-distribution and total-organic-carbon analysis.

Trawls will be used for collection of demersal fish as the net drags across the substrate along the transect. Based on the results of the sediment surveys, a minimum of five trawling stations will be established. Each station, with two additional replicate stations per grain size category, will be in an area previously sampled for substrate analysis and represented by different grain sizes (categories). For example, one station will be in mud, perhaps at the edge of the active disposal pile; one station in the mud/sand interface, possibly between Stations 58 and 59 south of the disposal site; one in fine "muddy sands", as typified by Stations 37 or 61; one in fine "clean sands", such as Station 44S; and one station in clean coarse sands such as those observed on the Alcatraz Shoal or near Arch and Harding Rocks. The total number of trawling stations will be 15, 3 in each of the grain size categories.

To account for the seasonal use of the study area, trawls will be conducted once a month. Each trawling survey will consist of one ten-minute trawl performed at each station. Date, station coordinates, weather, distance traveled by the trawl, water quality (temperature, pH, dissolved oxygen, conductivity/salinity), depth, and

current speed will be recorded for each trawl. The four latter parameters and grain size will be used to generally define habitat type within the sampling stations. The fish captured from each trawl will be identified to genus and species, and length and weight determined, any gross anomalies (e.g., tumors, fin necrosis) noted, and released. If more than twenty individuals of one species are captured, only twenty fish will be measured and weighed. Any incidental catches of macroinvertebrates will be recorded and identification will be to genus and species if possible.

7.3.2 Sample Analyses

Sediment will be analyzed for physical and chemical characterization. Physical parameters will include grain-size, color, density, consolidation, and sorting. Chemical analyses of selected samples will include total organic carbon, heavy metals and polynuclear aromatic hydrocarbons (PAHs). The sediments will be analyzed using the appropriate EPA procedures, and appropriate QA/QC (quality assurance and quality control).

Biological samples will be evaluated qualitatively and a description of the benthic invertebrate assemblage described. Difference in physical, chemical, and biological characteristics will be considered. Directional trends and changes will be discussed and compared in an attempt to correlate benthic community structure with changes associated with transport of sediments from the Alcatraz site.

Potential habitat degradation or habitat modification that may be associated with Alcatraz disposal activities will be considered during this study. As discussed in the reconnaissance study, degradation and modification of the benthic community would be seen as evidence that demersal fish habitat, and thus the presence of these fishes would be affected. Biological evidence of habitat degradation may include the following:

- ❑ Reduced numbers of species when compared to local undisturbed reference communities: Certain species are more tolerant of degraded conditions and can tend to dominate the community (Kennish, 1991; Clark, 1986; Widdows, 1985).
- ❑ The presence of species commonly associated with severely polluted habitats: Some species appear to be universally favored by degraded conditions. For instance, the polychaete worm *Capitella capitata* is commonly with sediments with very high levels of organic material (Kennish, 1991; Gray, 1981).
- ❑ Presence of a different assemblage of species (“community”) than is typical of an undisturbed local reference community natural sediments in the area: Conditions favoring one assemblage of species over another include a large suite of physical and chemical environmental factors, including organic content of the sediments, pH, grain size and distribution, temperature, levels of suspended materials, depth, and patterns of water flow, to name a few (Kennish, 1991; Cobb, 1993; Eckman, 1983).
- ❑ The dominance of the community by one or a few species, evidence of recent changes in sediment particle size distribution, organic content, or chemistry: These differences can occur even as a result of the deposition of non-polluted sediments, or from current changes associated with deposition of and accumulation new materials (Gray, 1981).

7.3.3 Data Analysis

For each of the target species, trawl data will be compiled by month, size class, and grain size category. The mean and 95 percent confidence intervals for the number of

fish captured within the stations will be calculated and graphed. It is possible that the trawls may actually cover more than one grain size category and the catch may reflect fish presence over more than one substrate, therefore caution must be taken in formulating firm conclusions on this dataset. Any general trends of occurrence over particular substrates that are observed will be assessed.

7.4 Reporting and Conclusions

All observations made and data generated during this study will be combined in a final report. The data will be compared to existing studies and will be used to generate recommendations for future management of the disposal site.

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Sustar, J.F., 1982. *Sediment Circulation in San Francisco Bay*. US Army Corps Engineers. (no specific reference to Alcatraz site, general bay sediment study with reference to chemical pollutant).

Treasher, RC, 1963. *Geology of the Sediment Deposits in San Francisco Bay, CA*. CA Div. M&G SR-82. (contains general geologic information of the bay with bay mud formation contours in main regions of the bay).

US Army Corps Eng., 1985. *Analysis of Sediments, Alcatraz Cores*. (little discussion on sediment characteristic, limited chemical data on dredged materials).

Appendix A: Geologic Logs



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-01B

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Disposal Site, San Francisco Bay

SAMPLE DATE

1-21-94

VESSEL

R.V. Questuary

COORDINATES

N 2,127,013 E 6,006,894

ELEVATION (below MLLW)

-76

SAMPLE LENGTH

1.0

SAMPLER WEIGHT

~400 lbs

BARREL SIZE

24" sq.

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|
| BX | 2.0' | -1.0' | -76.0 | | | |
| | | | -76.3 | 0.5 | | |
| | | | -77.0 | 1.0 | | |

Lithologic Description

Box core sample: Muddy SAND over MUD, Dark gray to Black, sand is fine grained, some shell fragments.

(Template: SEA)

Remarks

Box core dropped from water surface and allowed to free-fall to bottom.

Grain-size analysis performed from surface sub-sample:

- 10% gravel (shells)
- 2% coarse-vc sand
- 12% medium sand
- 37% fine sand
- 4% very-fine sand
- 20% silt
- 15% clay

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Disposal Site San Francisco Bay

HOLE NO.

AHS-01B



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-01S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

SE of Disposal Site, San Francisco Bay

SAMPLE DATE

1-19-94

VESSEL

R.V. Questuary

COORDINATES

N 2,125,796 E 6,007,029

ELEVATION (below MLLW)

-70

SAMPLE LENGTH

0.1

SAMPLER WEIGHT

~200 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|--|--|
| GC | 3.0' | bag sample | -70.1 | | | | <p>Bag sample: Shelly SAND, Moderate brown to Moderate yellowish brown, medium to coarse grained, with shell fragments up to 0.5".</p> | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>First core drop had no recovery, second core drop yielded -0.1' of sample which was bagged.</p> <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

SE of Disposal Site San Francisco Bay

HOLE NO.

AHS-01S



GEOLOGIC LOG

PROJECT and JOB NUMBER
Alcatraz Habitat Study **21845-004**

HOLE NO.
AHS-02B
 SHEET NO. 1 OF 1

SAMPLER
MEC, Inc.

SITE and LOCATION
East of Disposal Site, San Francisco Bay

SAMPLE DATE
1-21-94

VESSEL
R.V. Questuary

COORDINATES ELEVATION (below MLLW)
N 2,126,998 E 6,007,616 **-81**

SAMPLE LENGTH
0.1

SAMPLER WEIGHT BARREL SIZE
~400 lbs **24" sq.**

LOGGED BY
Stephen Knuttel

UPDATE
3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|
| BX | 2.0' | -0.1' | -81.1 | | | |

Lithologic Description

Box core sample: Coarse Sand, Gravel, and Shell fragments.

(Template: SEA)

Remarks

Box core dropped from water surface and allowed to free-fall to bottom.

Little recovery, sample washed with box core retrieval.

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION
East of Disposal Site San Francisco Bay

HOLE NO.
AHS-02B



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-02S

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Disposal Site, San Francisco Bay

SHEET NO. 1 OF 1

SAMPLE DATE

1-19-94

VESSEL

R.V. Questuary

COORDINATES

N 2,125,796 E 6,007,029

ELEVATION (below MLLW)

-70

SAMPLE LENGTH

2.9

SAMPLER WEIGHT

~200 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|-----------------------------------|----------------|---------------|----------------------|---------------|-----------|---|---|--|
| GC | 3.0' | 2.9' | -70.0 | | | | | (Template: SEA) |
| | | | -70.2 | 0.0 | | | 0.0 - 0.2 ft: Muddy SAND, Black, fine grained, moderately sorted, common white shell fragments, gradational contact. | Gravity core dropped from water surface and allowed to free-fall to bottom. |
| | | | | 0.5 | | | 0.2 - 1.2 ft: Sandy MUD, Black to Greenish gray, moderately soft, sand is fine grained, sharp contact. | Torvane reading at 0.3' = 0.9 tons/sq.ft. |
| | | | -71.2 | 1.0 | | | | Torvane reading at 1.0' = 0.5 tons/sq.ft. |
| | | | | 1.5 | | | 1.2 - 2.9 ft: MUD, Grayish black to Black, mottled in areas with Dark greenish gray, changing to Light olive gray with exposure to air; moderately firm, minor shell fragments. | |
| | | | | 2.0 | | | | Torvane reading at 2.0' = 1.5 tons/sq.ft. |
| | | | | 2.5 | | | | |
| | | | -72.9 | | | | | Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |
| GC = GRAVITY CORE; BX = BOX CORE. | | | | | | SITE and LOCATION | | HOLE NO. |
| | | | | | | East of Disposal Site San Francisco Bay | | AHS-02S |



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-03S

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Disposal Site, San Francisco Bay

SHEET NO. 1 OF 1

SAMPLE DATE
1-19-94

VESSEL

R.V. Questuary

COORDINATES

N 2,127,081 E 6,008,500

ELEVATION (below MLLW)

-77

SAMPLE LENGTH

0.1

SAMPLER WEIGHT

~200 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|--|--|
| GC | 3.0' | bag sample | -77.1 | | | | Bag sample: MUD, Light olive gray, soft, with shell fragments up to 0.25". | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>First core drop had no recovery, second core drop yielded -0.1' of sample which was bagged.</p> <p>Core cutter dented on second drop.</p> <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Disposal Site San Francisco Bay

HOLE NO.

AHS-03S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-04S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Disposal Site, San Francisco Bay

SAMPLE DATE

1-19-94

VESSEL

R.V. Questuary

COORDINATES

N 2,126,868 E 6,009,058

ELEVATION (below MLLW)

-77

SAMPLE LENGTH

1.1

SAMPLER WEIGHT

~200 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|--|--|
| GC | 3.0' | 1.1' | -77.0 | | | | 0.0 - 1.1 ft: MUD, Grayish black mottled with Greenish gray changing to Grayish green at 0.5', soft to moderately soft, sandy layer between 0.5 - 0.6', abundant shell fragments between 0.9 - 1.1'. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Torvane reading at 0.4' = 0.5 tons/sq.ft. Torvane reading at 0.9' = 0.5 tons/sq.ft. Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |
| | | | -77.5 | 0.5 | | | | |
| | | | -77.6 | | | | | |
| | | | | 1.0 | | | | |
| | | | -78.1 | | | | | |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Disposal Site San Francisco Bay

HOLE NO.

AHS-04S



GEOLOGIC LOG

PROJECT and JOB NUMBER
Alcatraz Habitat Study 21845-004

HOLE NO.
AHS-06S
 SHEET NO. 1 OF 1

SAMPLER
MEC, Inc.

SITE and LOCATION
Blossom Rock area, San Francisco Bay

SAMPLE DATE
1-19-94

VESSEL
R.V. Questuary

COORDINATES ELEVATION (below MLLW)
N 2,125,817 E 6,010,962 -100

SAMPLE LENGTH
0.1

SAMPLER WEIGHT BARREL SIZE
~200 lbs 4"

LOGGED BY
Stephen Knuttel

UPDATE
3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|------------------|---|--|
| GC | 3.0' | bag sample | -100.1 | | | <p>Bag sample: Gravel, Olive gray, with sand, minor mud content, gravel is primarily medium-grained sandstone, some shell fragments up to 0.5".</p> | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>First core drop had no recovery, second core drop yielded -0.1' of sample which was bagged.</p> <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION
Blossom Rock area San Francisco Bay

HOLE NO.
AHS-06S



GEOLOGIC LOG

PROJECT and JOB NUMBER

*Alcatraz Habitat Study***21845-004**

HOLE NO.

AHS-07S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

Blossom Rock area, San Francisco Bay

SAMPLE DATE

1-19-94

VESSEL

R.V. Questuary

COORDINATES

N 2,125,892 E 6,012,248

ELEVATION (below MLLW)

-80

SAMPLE LENGTH

0.0

SAMPLER WEIGHT

~200 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

Sampler Type

Sampler Length

Recovery (ft)

Elevation below MLLW

Depth in Feet

Lithology

Sample

Lithologic Description

(Template: SEA)

Remarks

GC

3.0'

0.0'

no sample recovery.

Gravity core dropped from water surface and allowed to free-fall to bottom.

Two core drops attempted - no recovery.

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

Blossom Rock area San Francisco Bay

HOLE NO.

AHS-07S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-08S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

West of Disposal Site, San Francisco Bay

SAMPLE DATE

1-19-94

VESSEL

R.V. Questuary

COORDINATES

N 2,126,960 E 6,004,565

ELEVATION (below MLLW)

-47

SAMPLE LENGTH

1.3

SAMPLER WEIGHT

~200 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|--|
| GC | 3.0' | 1.3' | -47.0 | | | | | (Template: SEA) |
| | | | -47.2 | | | | 0.0 - 0.2 ft: SAND, Olive black, fine to medium grained, moderately sorted, minor mud, 2" rounded pebble with encrusted barnacles. | Gravity core dropped from water surface and allowed to free-fall to bottom. |
| | | | -47.5 | 0.5 | | | 0.2 - 0.8 ft: MUD, Greenish gray to Grayish black, mottled, soft; sandy layer with shell fragments between 0.5 - 0.6'. | Torvane reading at 0.3' = 0.7 tons/sq.ft. |
| | | | -47.6 | | | | | |
| | | | -47.8 | | | | | |
| | | | -48.0 | 1.0 | | | 0.8 - 1.0 ft: SAND, Olive black, fine to medium grained, moderately sorted, shell fragments up to 0.5", 3.0 x 1.5 x 1.5" black piece of wood. | |
| | | | -48.3 | | | | 1.0 - 1.3 ft: MUD, Greenish gray to Grayish black, mottled, soft. | Torvane reading at 1.2' = 0.7 tons/sq.ft. |
| | | | | | | | | Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

West of Disposal Site San Francisco Bay

HOLE NO.

AHS-08S



GEOLOGIC LOG

PROJECT and JOB NUMBER
Alcatraz Habitat Study 21845-004

HOLE NO.
AHS-09S
SHEET NO. 1 OF 1

SAMPLER
MEC, Inc.

SITE and LOCATION
West of Disposal Site, San Francisco Bay

SAMPLE DATE
1-19-94

VESSEL
R.V. Questuary

COORDINATES ELEVATION (below MLLW)
N 2,126,972 E 6,004,004 -67

SAMPLE LENGTH
0.1

SAMPLER WEIGHT BARREL SIZE
~200 lbs 4"

LOGGED BY
Stephen Knuttel

UPDATE
3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth In Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|--|
| GC | 3.0' | bag sample | -67.1 | | | | <p>Bag sample: Sandy MUD, Olive black, changing to Grayish brown with exposure to air, soft, sand is very fine to fine grained.</p> | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>Core drop yielded -0.1' of sample which was bagged.</p> <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION
West of Disposal Site San Francisco Bay

HOLE NO.
AHS-09S



GEOLOGIC LOG

PROJECT and JOB NUMBER
Alcatraz Habitat Study 21845-004

HOLE NO.
AHS-10B
SHEET NO. 1 OF 1

SAMPLER
MEC, Inc.

SITE and LOCATION
West of Disposal Site, San Francisco Bay

SAMPLE DATE
1-21-94

VESSEL
R.V. Questuary

COORDINATES ELEVATION (below MLLW)
N 2,127,079 E 6,003,685 **-74**

SAMPLE LENGTH
1.0

SAMPLER WEIGHT BARREL SIZE
~400 lbs **24" sq.**

LOGGED BY
Stephen Knuttel

UPDATE
3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|--|---|--|
| | | | | | | | | | (Template: SEA) |
| BX | 2.0' | -1.0' | -74.0 | 0.5 | | | Box core sample: SAND, Olive gray, fine to medium grained, well sorted, minor fines. | Box core dropped from water surface and allowed to free-fall to bottom. | Grain-size analysis performed from surface sub-sample: 0% gravel <1% coarse-vc sand 47% medium sand 46% fine sand 2% very-fine sand 3% silt 2% clay |
| | | | -75.0 | 1.0 | | | | | Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION
West of Disposal Site San Francisco Bay

HOLE NO.
AHS-10B



GEOLOGIC LOG

PROJECT and JOB NUMBER
Alcatraz Habitat Study 21845-004

HOLE NO.
AHS-10S
SHEET NO. 1 OF 1

SAMPLER
MEC, Inc.

SITE and LOCATION
West of Disposal Site, San Francisco Bay

SAMPLE DATE
1-19-94

VESSEL
R.V. Questuary

COORDINATES ELEVATION (below MLLW)
N 2,127,079 E 6,003,685 **-75**

SAMPLE LENGTH
0.1

SAMPLER WEIGHT BARREL SIZE
~200 lbs **4"**

LOGGED BY
Stephen Knuttel

UPDATE
3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|

(Template: SEA)
Remarks

| | | | | | | |
|----|------|------------|-------|--|--|---|
| GC | 3.0' | bag sample | -75.1 | | | <p>Bag sample: Sandy MUD, Olive black, changing to Grayish brown with exposure to air, soft, sand is very fine to fine grained.</p> |
|----|------|------------|-------|--|--|---|

Gravity core dropped from water surface and allowed to free-fall to bottom.

First core drop yielded -0.1' of sample which was bagged.

Two additional core drops were made which had no recovery.

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION
West of Disposal Site San Francisco Bay

HOLE NO.
AHS-10S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-11S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

West of Disposal Site, San Francisco Bay

SAMPLE DATE

1-19-94

VESSEL

R.V. Questuary

COORDINATES

N 2,127,093 E 6,003,043

ELEVATION (below MLLW)

-74

SAMPLE LENGTH

0.0

SAMPLER WEIGHT

~200 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|------------------------|---|
| GC | 3.0' | 0.0' | -74.0 | | | | no sample recovery. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Two core drops attempted - no recovery. |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

West of Disposal Site San Francisco Bay

HOLE NO.

AHS-11S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-12S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

West of Disposal Site, San Francisco Bay

SAMPLE DATE

1-19-94

VESSEL

R.V. Questuary

COORDINATES

N 2,127,109 E 6,002,241

ELEVATION (below MLLW)

-67

SAMPLE LENGTH

0.0

SAMPLER WEIGHT

~200 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ff) | Elevation below MLLW -67.0 | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks (Template: SEA) |
|--------------|----------------|---------------|-------------------------------|---------------|-----------|--------|------------------------|--|
| GC | 3.0' | 0.0' | | | | | no sample recovery. | Gravity core dropped from water surface and allowed to free-fall to bottom. Two core drops attempted - no recovery. |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

West of Disposal Site San Francisco Bay

HOLE NO.

AHS-12S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-13S

SAMPLER

MEC, Inc.

SITE and LOCATION

West of Disposal Site, San Francisco Bay

SHEET NO. 1 OF 1

SAMPLE DATE

1-19-94

VESSEL

R.V. Questuary

COORDINATES

N 2,127,608 E 6,002,573

ELEVATION (below MLLW)

-60

SAMPLE LENGTH

0.1

SAMPLER WEIGHT

~200 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|--|--|
| GC | 3.0' | bag sample | -60.1 | | | | <p>Bag sample: SAND, Moderate brown, medium grained, some pebbles up to 0.25".</p> | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>Core drop yielded -0.1' of sample which was bagged.</p> <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

West of Disposal Site San Francisco Bay

HOLE NO.

AHS-13S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-14S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

West of Disposal Site, San Francisco Bay

SAMPLE DATE

1-19-94

VESSEL

R.V. Questuary

COORDINATES

N 2,127,595 E 6,003,214

ELEVATION (below MLLW)

-72

SAMPLE LENGTH

0.0

SAMPLER WEIGHT

~200 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW -72.0 | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|-------------------------------|---------------|-----------|--------|------------------------|--|
| GC | 3.0' | 0.0' | | | | | no sample recovery. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Core drop had no recovery. |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

West of Disposal Site San Francisco Bay

HOLE NO.

AHS-14S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-15B

SAMPLER

MEC, Inc.

SITE and LOCATION

West of Disposal Site, San Francisco Bay

SHEET NO. 1 OF 1

VESSEL

R.V. Questuary

COORDINATES

N 2,127,577 E 6,004,097

ELEVATION (below MLLW)

-58

SAMPLE DATE

1-21-94

SAMPLER WEIGHT

-400 lbs

BARREL SIZE

24" sq.

LOGGED BY

Stephen Knuttel

SAMPLE LENGTH

1.0

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks | |
|--------------------------------|----------------|---------------|----------------------|---------------|-----------|--------|--|---|----------------------------|
| BX | 2.0' | -1.0' | -58.1 | 0.5 | | | Box core sample: SAND, Grayish brown, fine to medium grained; over MUD, Black, soft. | (Template: SEA) | |
| | | | -59.0 | 1.0 | | | | Box core dropped from water surface and allowed to free-fall to bottom. Grain-size analysis performed from sub-sample (mixed): 5% gravel and shells 2% coarse-vc sand 28% medium sand 15% fine sand 2% very-fine sand 21% silt 27% clay | |
| | | | | | | | | Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). | |
| = GRAVITY CORE; BX = BOX CORE. | | | | | | | SITE and LOCATION | West of Disposal Site San Francisco Bay | HOLE NO. AHS-15B |



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-15S

SAMPLER

MEC, Inc.

SITE and LOCATION

West of Disposal Site, San Francisco Bay

SHEET NO. 1 OF 1

VESSEL

R.V. Questuary

COORDINATES

N 2,127,577 E 6,004,097

ELEVATION (below MLLW)

-72

SAMPLE DATE

1-19-94

SAMPLER WEIGHT

~200 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

SAMPLE LENGTH

1.6

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|--|---|
| GC | 3.0' | 1.6' | -72.0 | | | | | (Template: SEA) |
| | | | -72.4 | 0.5 | | | 0.0 - 0.4 ft: SAND, Moderate olive brown, fine to coarse grained, moderately well sorted, abundant shell fragments, sharp contact. | Gravity core dropped from water surface and allowed to free-fall to bottom. |
| | | | -73.3 | 1.0 | | | 0.4 - 1.3 ft: MUD, Grayish black mottled with Dark greenish gray, soft, sharp contact. | |
| | | | -73.5 | 1.5 | | | 1.3 - 1.5 ft: SAND, Greenish gray, fine grained, well sorted, sharp contact. | Torvane reading at 0.7' = 0.7 tons/sq.ft. |
| | | | -73.6 | | | | 1.5 - 1.6 ft: MUD, similar to 0.4 - 1.3'. | Torvane reading at 1.5' = 0.7 tons/sq.ft. |

= GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

West of Disposal Site San Francisco Bay

HOLE NO.

AHS-15S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-16S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

West of Disposal Site, San Francisco Bay

SAMPLE DATE

1-19-94

VESSEL

R.V. Questuary

COORDINATES

N 2,127,567 E 6,004,578

ELEVATION (below MLLW)

-56

SAMPLE LENGTH

1.9

SAMPLER WEIGHT

~200 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|--|
| GC | 3.0' | 1.9' | -56.0 | | | | | (Template: SEA) |
| | | | -56.3 | 0.5 | | | 0.0 - 0.3 ft: Muddy SAND, Greenish gray, fine grained, moderately sorted, 2" white shell fragment, gradational contact. | Gravity core dropped from water surface and allowed to free-fall to bottom. |
| | | | -56.7 | | | | 0.3 - 0.7 ft: MUD, Grayish black, soft, minor fine sand, common shell fragments, sharp contact. | |
| | | | -57.0 | 1.0 | | | 0.7 - 1.0 ft: SAND, Olive brown to Grayish green, fine to medium grained, well sorted, abundant white shell fragments up to 0.25", sharp contact. | |
| | | | -57.9 | 1.5 | | | 1.0 - 1.9 ft: MUD, Grayish black mottled with Greenish gray, soft; -0.25" layer of sandy mud between 1.8 - 1.9'. | |
| | | | | | | | | Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

= GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

West of Disposal Site San Francisco Bay

HOLE NO.

AHS-16S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-17S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

NW of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,128,183 E 6,004,109

ELEVATION (below MLLW)

-60

SAMPLE LENGTH

0.1

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|--|--|
| GC | 2.0' | bag sample | -60.1 | | | | <p>Bag sample: Shelly SAND, Moderate brown to Moderate yellowish brown, fine to coarse grained, with shell fragments up to 0.5".</p> | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>Core drop yielded -0.1' of sample which was bagged.</p> <p>Grain-size analysis performed from bagged sample:</p> <ul style="list-style-type: none"> 20% gravel and shells 15% coarse-vc sand 44% medium sand 15% fine sand <1% very-fine sand 2% silt 4% clay <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

NW of Disposal Site San Francisco Bay

HOLE NO.

AHS-17S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-18S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

NW of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,128,177 E 6,004,430

ELEVATION (below MLLW)

-62

SAMPLE LENGTH

0.9

SAMPLER WEIGHT

-300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|--|--|
| GC | 2.0' | 0.9' | -62.0 | | | | | (Template: SEA) |
| | | | -62.3 | | | | 0.0 - 0.3 ft: MUD, Grayish black, soft, sharp contact. | Gravity core dropped from water surface and allowed to free-fall to bottom. |
| | | | -62.9 | 0.5 | | | 0.3 - 0.9 ft: SAND, Dark greenish gray, fine to medium grained, moderately sorted, abundant shell fragments up to 0.75". | |
| | | | | | | | | Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

NW of Disposal Site San Francisco Bay

HOLE NO.

AHS-18S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-19S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

NW of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,128,580 E 6,004,519

ELEVATION (below MLLW)

-42

SAMPLE LENGTH

0.1

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|---|
| GC | 2.0' | bag sample | -42.1 | | | | <p>Bag sample: Sandy SHELL HASH, Very pale orange, shell fragments up to 1.5"; sand is Moderate brown, fine to coarse grained, with some pebbles up to 0.25".</p> | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>Core drop yielded -0.1' of sample which was bagged.</p> <p>Grain-size analysis performed from bagged sample:</p> <ul style="list-style-type: none"> 41% gravel and shells 15% coarse-vc sand 31% medium sand 8% fine sand 1% very-fine sand 2% silt 2% clay <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

NW of Disposal Site San Francisco Bay

HOLE NO.

AHS-19S



GEOLOGIC LOG

PROJECT and JOB NUMBER
Alcatraz Habitat Study **21845-004**

HOLE NO.
AHS-20S
 SHEET NO. 1 OF 1

SAMPLER
MEC, Inc.

SITE and LOCATION
NW of Disposal Site, San Francisco Bay

SAMPLE DATE
1-20-94

VESSEL
R.V. Questuary

COORDINATES ELEVATION (below MLLW)
N 2,128,672 E 6,004,922 **-40**

SAMPLE LENGTH
0.1

SAMPLER WEIGHT BARREL SIZE
~300 lbs **4"**

LOGGED BY
Stephen Knuttel

UPDATE
3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|--|--|
| GC | 2.0' | bag sample | -40.1 | | | | <p>Bag sample: SAND, Olive gray, fine to medium grained, with shell fragments up to 0.25".</p> | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>Core drop yielded -0.1' of sample which was bagged.</p> <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

C = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION
NW of Disposal Site San Francisco Bay

HOLE NO.
AHS-20S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-21S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

NW of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,128,563 E 6,005,321

ELEVATION (below MLLW)

-45

SAMPLE LENGTH

0.9

SAMPLER WEIGHT

-300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|--|--|-----------------|
| | | | | | | | | | (Template: SEA) |
| GC | 2.0' | 0.9' | -45.0 | 0.5 | | | 0.0 - 0.9 ft: SAND, Olive gray, fine to medium grained, moderately well sorted, some shell fragments up to 0.5"; 2" clast of black mud between 0.7 - 0.9'. | Gravity core dropped from water surface and allowed to free-fall to bottom. | |
| | | | -45.9 | | | | | Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). | |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

NW of Disposal Site San Francisco Bay

HOLE NO.

AHS-21S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-22S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

NE of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,128,126 E 6,006,917

ELEVATION (below MLLW)

-114

SAMPLE LENGTH

1.7

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth In Feet | Lithology Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|------------------|--|--|
| GC | 2.0' | 1.7' | -114.0 | 0.0 - 1.7 | | 0.0 - 1.7 ft: MUD, Grayish black slightly mottled with Greenish gray, soft, some white shell fragments, minor sand content between 0.0 - 0.2'. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. |

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

NE of Disposal Site San Francisco Bay

HOLE NO.

AHS-22S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-23B

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Disposal Site, San Francisco Bay

SAMPLE DATE

1-21-94

VESSEL

R.V. Questuary

COORDINATES

N 2,127,519 E 6,006,904

ELEVATION (below MLLW)

-64

SAMPLE LENGTH

1.0

SAMPLER WEIGHT

~400 lbs

BARREL SIZE

24" sq.

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|------------------------|---------|
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|------------------------|---------|

(Template: SEA)

Remarks

| | | | | | | | | |
|----|------|-------|-------|-----|--|--|--|---|
| BX | 2.0' | -1.0' | -64.0 | | | | Box core sample: Muddy SAND over MUD, Dark gray to Black, some gravel and shell fragments. | Box core dropped from water surface and allowed to free-fall to bottom. |
| | | | -64.3 | 0.5 | | | | Grain-size analysis performed from sub-sample: 18% gravel and shells 10% coarse-vc sand 19% medium sand 28% fine sand 3% very-fine sand 9% silt 13% clay |
| | | | -65.0 | 1.0 | | | | |

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Disposal Site San Francisco Bay

HOLE NO.

AHS-23B



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-23S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,127,623 E 6,006,746

ELEVATION (below MLLW)

-77

SAMPLE LENGTH

1.4

SAMPLER WEIGHT

~300 lbs

BARREL SIZE





4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|--|---|--|
| GC | 2.0' | 1.4' | -77.0 | 0.5 |  | 0.0 - 0.9 ft: MUD, Greenish black to Black, very soft, minor sand; layer of sandy mud with shell fragments between 0.7 - 0.8'; gradational contact. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. |
| | | | -77.7 | |  | | |
| | | | -77.8 | |  | | |
| | | | -77.9 | 1.0 |  | 0.9 - 1.4 ft: MUD, Black changing to Greenish black at 1.0', soft, -0.2' very light gray shell fragments between 1.1 - 1.3'. | |
| | | | -78.4 | | | | Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Disposal Site San Francisco Bay

HOLE NO.

AHS-23S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-24S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,126,615 E 6,006,565

ELEVATION (below MLLW)

-94

SAMPLE LENGTH

1.6

SAMPLER WEIGHT

~300 lbs

BARREL SIZE


4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|--------------------------|--|---|--|
| GC | 2.0' | 1.6' | -94.0 | 0.0 0.5 1.0 1.5 |  | 0.0 - 1.6 ft: MUD, Black slightly mottled with Greenish gray, soft, 2" x 3" metamorphic rock fragment between 0.3 - 0.6'; sandy between 0.0 - 0.3'. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Torvane reading at 0.8' = <0.5 tons/sq.ft. Torvane reading at 1.4' = <0.5 tons/sq.ft. Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Disposal Site San Francisco Bay

HOLE NO.

AHS-24S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-26S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

SE of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,125,488 E 6,007,264

ELEVATION (below MLLW)

-72

SAMPLE LENGTH

0.1

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|--|
| GC | 2.0' | bag sample | -72.1 | | | | Bag sample: SAND, Moderate brown to Grayish brown, medium grained with some coarse grains, with shell fragments up to 1.0". | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>Core drop yielded -0.1' of sample which was bagged.</p> <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

SE of Disposal Site San Francisco Bay

HOLE NO.

AHS-26S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-27S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

SE of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,126,088 E 6,007,597

ELEVATION (below MLLW)

-70

SAMPLE LENGTH

0.0

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

Sampler Type

Sampler Length

Recovery (ft)

Elevation below MLLW
-70.0

Depth in Feet

Lithology

Sample

Lithologic Description

(Template: SEA)

Remarks

GC

2.0'

0.0'

no sample recovery.

Gravity core dropped from water surface and allowed to free-fall to bottom.

Core drop attempted - no recovery; core cutter dented.

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

SE of Disposal Site San Francisco Bay

HOLE NO.

AHS-27S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-41S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Alcatraz Island, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,130,029 E 6,007,838

ELEVATION (below MLLW)

-52

SAMPLE LENGTH

0.1

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW -52.0 | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|-------------------------------|---------------|-----------|--------|---|---|
| GC | 2.0' | bag sample | -52.1 | | | | Bag sample: SAND, Moderate brown, fine to coarse grained, with shell fragments up to 0.25". | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Core drop yielded -0.1' of sample which was bagged. Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Alcatraz Island San Francisco Bay

HOLE NO.

AHS-41S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-42S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

Arch Rock area, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,129,655 E 6,001,411

ELEVATION (below MLLW)

-74

SAMPLE LENGTH

0.1

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|---|
| GC | 2.0' | bag sample | -74.1 | | | | Bag sample: SAND, Moderate brown to Grayish red, medium to very coarse grained. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Core drop yielded -0.1' of sample which was bagged. |

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

Arch Rock area San Francisco Bay

HOLE NO.

AHS-42S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-28S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,126,584 E 6,008,089

ELEVATION (below MLLW)

-72

SAMPLE LENGTH

0.4

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|---|
| GC | 2.0' | bag sample | -72.0 | | | | <p>Bag sample: SAND, Olive gray to Moderate brown, fine to very coarse grained, with pebbles up to 1.2", abundant shell fragments up to 1.0"; -1/16" thick piece of green plastic on top of core barrel sample.</p> | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>Core drop yielded -0.4' of sample which was bagged.</p> <p>Grain-size analysis performed from bagged sample:</p> <ul style="list-style-type: none"> 29% gravel and shells 22% coarse-vc sand 41% medium sand 6% fine sand <1% very-fine sand <1% silt 1% clay <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Disposal Site San Francisco Bay

HOLE NO.

AHS-28S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-29S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,126,599 E 6,007,367

ELEVATION (below MLLW)

-80

SAMPLE LENGTH

1.0

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|--|
| GC | 2.0' | 1.0' | -80.0 | | | | | (Template: SEA) |
| | | | -80.2 | | | | 0.0 - 0.2 ft: Sandy MUD, Greenish gray, soft, sand is fine to medium grained, abundant shells fragments, gradational contact. | Gravity core dropped from water surface and allowed to free-fall to bottom. |
| | | | -80.4 | | | | 0.2 - 0.4 ft: MUD, Black, moderately stiff, sharp contact. | |
| | | | -80.7 | 0.5 | | | 0.4 - 0.7 ft: Muddy SAND, Black, fine to medium grained, moderately well sorted, sharp irregular contact. | |
| | | | -81.0 | 1.0 | | | 0.7 - 1.0 ft: MUD, Black, moderately stiff. | |
| | | | | | | | | Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Disposal Site San Francisco Bay

HOLE NO.

AHS-29S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-30S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,126,594 E 6,007,608

ELEVATION (below MLLW)

-77

SAMPLE LENGTH

0.1

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ff) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|--|
| GC | 2.0' | bag sample | -77.1 | | | | <p>Bag sample: Sandy SHELL HASH, Moderate brown to Very pale orange, some sandstone gravel, gravel and shell fragments up to 1.0"; sand is fine to very-coarse grained.</p> | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>Core drop yielded -0.1' of sample which was bagged.</p> <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Disposal Site San Francisco Bay

HOLE NO.

AHS-30S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-31S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

SW of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,126,153 E 6,004,469

ELEVATION (below MLLW)

-84

SAMPLE LENGTH

0.6

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|--|
| GC | 2.0' | bag sample | -84.0 | 0.5 | | | <p>Bag sample: SAND, Moderate brown to Grayish brown, fine to medium grained with some coarse grains, abundant shell fragments up to 0.25".</p> | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>Core drop yielded -0.6' of sample which was bagged.</p> <p>Grain-size analysis performed from bagged sample:</p> <ul style="list-style-type: none"> 20% gravel and shells 12% coarse-vc sand 45% medium sand 10% fine sand <1% very-fine sand 2% silt 2% clay <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

SW of Disposal Site San Francisco Bay

HOLE NO.

AHS-31S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-32S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

SW of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,126,555 E 6,004,557

ELEVATION (below MLLW)

-75

SAMPLE LENGTH

1.1

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|
| GC | 2.0' | 1.1' | -75.0 | | | |
| | | | -75.4 | | | |
| | | | -75.5 | 0.5 | | |
| | | | -75.6 | | | |
| | | | -76.0 | 1.0 | | |
| | | | -76.1 | | | |

Lithologic Description

(Template: SEA)

Remarks

0.0 - 0.4 ft: SAND, Olive brown, fine to coarse grained, moderately sorted, some gravel up to 0.5", abundant shell fragments up to 0.5", sharp contact.

0.4 - 0.5 ft: MUD, Grayish black, soft; minor fine sand content, sharp contact.

0.5 - 0.6 ft: SAND, Olive brown, fine grained, some shell fragments up to 0.5", sharp contact.

0.6 - 1.0 ft: MUD, Greenish gray to Grayish black, mottled, soft.

1.0 - 1.1 ft (Core Catcher): Sandy MUD, Olive black changing to Light olive gray with exposure to air, soft, sand is fine grained.

Gravity core dropped from water surface and allowed to free-fall to bottom.

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

SW of Disposal Site San Francisco Bay

HOLE NO.

AHS-32S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-33S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

SW of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,126,565 E 6,004,076

ELEVATION (below MLLW)

-80

SAMPLE LENGTH

0.0

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

Sampler Type

Sampler Length

Recovery (ft)

Elevation below MLLW

Depth in Feet

Lithology

Sample

Lithologic Description

(Template: SEA)

Remarks

GC

2.0'

0.0'

-80.0

no sample recovery.

Gravity core dropped from water surface and allowed to free-fall to bottom.

Core drop attempted - no recovery.

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

SW of Disposal Site San Francisco Bay

HOLE NO.

AHS-33S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-34S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,127,509 E 6,007,386

ELEVATION (below MLLW)

-94

SAMPLE LENGTH

1.3

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|---|
| GC | 2.0' | 1.3' | -94.0 | 0.5 | | | 0.0 - 1.0 ft: Muddy SAND, Black, fine grained, moderately well sorted, common black shell fragments, gradational contact. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Torvane reading at 0.3' = 0.5 tons/sq.ft. |
| | | | -95.0 | 1.0 | | | 1.0 - 1.3 ft: Sandy MUD, Black, soft, sand is fine grained. | Torvane reading at 1.2' = 0.7 tons/sq.ft. |
| | | | -95.3 | | | | | Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Disposal Site San Francisco Bay

HOLE NO.

AHS-34S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-35S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,127,393 E 6,008,105

ELEVATION (below MLLW)

-90

SAMPLE LENGTH

0.2

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|--|---|
| GC | 2.0' | bag sample | -90.0 -90.2 | | | | Bag sample: Muddy SAND, Olive gray to Moderate brown, fine to coarse grained, with shell fragments up to 1.5". | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Core drop yielded -0.2' of sample which was bagged. |

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Disposal Site San Francisco Bay

HOLE NO.

AHS-35S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-36S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

NE of Disposal Site, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,128,209 E 6,007,801

ELEVATION (below MLLW)

-94

SAMPLE LENGTH

0.0

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|------------------------|--|
| GC | 2.0' | 0.0' | -94.0 | | | | no sample recovery. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Core drop attempted - no recovery. |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

NE of Disposal Site San Francisco Bay

HOLE NO.

AHS-36S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-37B

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

NE of Disposal Site, San Francisco Bay

SAMPLE DATE

1-21-94

VESSEL

R.V. Questuary

COORDINATES

N 2,128,215 E 6,007,480

ELEVATION (below MLLW)

-100

SAMPLE LENGTH

1.0

SAMPLER WEIGHT

~400 lbs

BARREL SIZE

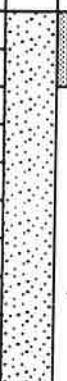
24" sq.

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ff) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|---|--------|---|--|
| BX | 2.0' | -1.0' | -100.0 | 0.5 |  | | Box core sample: SAND, Dark gray to Grayish brown, fine grained, well sorted, minor fines; some mud clast, Grayish black, with organic material and wood fragments. | <p>(Template: SEA)</p> <p>Box core dropped from water surface and allowed to free-fall to bottom.</p> <p>Grain-size analysis performed from sub-sample:</p> <ul style="list-style-type: none"> <1% gravel and shells 1% coarse-vc sand 3% medium sand 75% fine sand 11% very-fine sand 5% silt 5% clay <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |
| | | | -101.0 | 1.0 | | | | |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

NE of Disposal Site San Francisco Bay

HOLE NO.

AHS-37B



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-38S

SAMPLER

MEC, Inc.

SITE and LOCATION

NE of Disposal Site, San Francisco Bay

SHEET NO. 1 OF 1

VESSEL

R.V. Questuary

COORDINATES

N 2,128,520 E 6,007,406

ELEVATION (below MLLW)

-82

SAMPLE DATE

1-20-94

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

SAMPLE LENGTH

1.2

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Remarks |
|--------------|----------------|---------------|----------------------|---------------|--|--------|---|
| GC | 2.0' | 1.2' | -82.0 | 0.0 - 1.2 | Muddy SAND, Grayish black, fine to medium grained, moderately well sorted, some black shell fragments, abundant organic material between 0.0 - 0.5' with sea grass on top of core. | | Gravity core dropped from water surface and allowed to free-fall to bottom. |

Lithologic Description

(Template: SEA)

Remarks

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

NE of Disposal Site San Francisco Bay

HOLE NO.

AHS-38S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-39B

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Alcatraz Island, San Francisco Bay

SHEET NO. 1 OF 1

SAMPLE DATE

1-21-94

VESSEL

R.V. Questuary

COORDINATES

N 2,129,535 E 6,007,267

ELEVATION (below MLLW)

-53

SAMPLE LENGTH

1.0

SAMPLER WEIGHT

-400 lbs

BARREL SIZE

24" sq.

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|
| BX | 2.0' | -1.0' | -53.0 | | | |
| | | | -53.5 | 0.5 | | |
| | | | -54.0 | 1.0 | | |

Lithologic Description

Box core sample: SAND, Grayish brown, fine grained; over Sandy MUD, Grayish black, silty sand to sandy silt.

(Template: SEA)

Remarks

Box core dropped from water surface and allowed to free-fall to bottom.

Grain-size analysis performed from surface sub-sample:

- <1% gravel and shells
- <1% coarse-vc sand
- 10% medium sand
- 80% fine sand
- 4% very-fine sand
- 2% silt
- 4% clay

Description and classification by visual examination of sample.

Colors from "Rock-Color Chart" (GSA, 1948).

C = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Alcatraz Island San Francisco Bay

HOLE NO.

AHS-39B



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-39S

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Alcatraz Island, San Francisco Bay

SHEET NO. 1 OF 1

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,129,432 E 6,007,345

ELEVATION (below MLLW)

-50

SAMPLE LENGTH

0.6

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|--|
| GC | 2.0' | 0.6' | -50.0 | 0.5 | | | 0.0 - 0.6 ft: SAND, Olive gray, fine grained, well sorted, few shell fragments. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. |

Description and classification by visual examination of sample.
Colors from "Rock-Color Chart" (GSA, 1948).

C = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Alcatraz Island San Francisco Bay

HOLE NO.

AHS-39S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-40S

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Alcatraz Island, San Francisco Bay

SHEET NO. 1 OF 1

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,129,515 E 6,008,229

ELEVATION (below MLLW)

-47

SAMPLE LENGTH

0.0

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|------------------------|--|
| GC | 2.0' | 0.0' | -47.0 | | | | no sample recovery. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Core drop attempted - no recovery. |

= GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Alcatraz Island San Francisco Bay

HOLE NO.

AHS-40S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-43S

SAMPLER

MEC, Inc.

SITE and LOCATION

Arch Rock area, San Francisco Bay

SHEET NO. 1 OF 1

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,129,573 E 6,000,527

ELEVATION (below MLLW)

-80

SAMPLE LENGTH

0.1

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|---|
| GC | 2.0' | bag sample | -80.1 | | | | Bag sample: SAND, Moderate brown to Grayish red, medium to very coarse grained. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Core drop yielded -0.1' of sample which was bagged. |

Description and classification by visual examination of sample.
Colors from "Rock-Color Chart" (GSA, 1948).

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

Arch Rock area San Francisco Bay

HOLE NO.

AHS-43S



GEOLOGIC LOG

PROJECT and JOB NUMBER
Alcatraz Habitat Study 21845-004

HOLE NO.
AHS-44S
 SHEET NO. 1 OF 1

SAMPLER
MEC, Inc.

SITE and LOCATION
Shag Rock area, San Francisco Bay

SAMPLE DATE
1-20-94

VESSEL
R.V. Questuary

COORDINATES ELEVATION (below MLLW)
N 2,130,700 E 5,999,828 -84

SAMPLE LENGTH
0.1

SAMPLER WEIGHT BARREL SIZE
~300 lbs 4"

LOGGED BY
Stephen Knuttel

UPDATE
3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|
| GC | 2.0' | bag sample | -84.1 | | | |

Lithologic Description

(Template: SEA)

Remarks

| | | | | | | |
|----|------|------------|-------|--|--|--|
| GC | 2.0' | bag sample | -84.1 | | | |
|----|------|------------|-------|--|--|--|

Bag sample: SAND, Moderate brown to Grayish red, medium to very coarse grained.

Gravity core dropped from water surface and allowed to free-fall to bottom.

 Core drop yielded -0.1' of sample which was bagged.

Description and classification by visual examination of sample.
 Colors from "Rock-Color Chart" (GSA, 1948).

C = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION
Shag Rock area San Francisco Bay

HOLE NO.
AHS-44S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-45S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

Shag Rock area, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,131,694 E 6,000,651

ELEVATION (below MLLW)

-77

SAMPLE LENGTH

0.0

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|------------------------|--|
| GC | 2.0' | 0.0' | -77.0 | | | | no sample recovery. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Core drop attempted - no recovery; core cutter dented. |

C = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

Shag Rock area San Francisco Bay

HOLE NO.

AHS-45S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-46S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

Shag Rock area, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,132,706 E 6,000,672

ELEVATION (below MLLW)

-89

SAMPLE LENGTH

0.1

SAMPLER WEIGHT

-300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|--|--|
| GC | 2.0' | bag sample | -89.1 | | | | <p>Bag sample: SAND, Moderate brown to Grayish red, medium to very coarse grained.</p> | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>Core drop yielded -0.1' of sample which was bagged.</p> <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

Shag Rock area San Francisco Bay

HOLE NO.

AHS-46S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-47S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

Harding Rock area, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,132,739 E 5,999,068

ELEVATION (below MLLW)

-89

SAMPLE LENGTH

0.1

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|---|
| GC | 2.0' | bag sample | -89.1 | | | | Bag sample: SAND, Moderate brown to Grayish red, medium to very coarse grained. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Core drop yielded -0.1' of sample which was bagged. |

Description and classification by visual examination of sample.
Colors from "Rock-Color Chart" (GSA, 1948).

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

Harding Rock area San Francisco Bay

HOLE NO.

AHS-47S



GEOLOGIC LOG

PROJECT and JOB NUMBER
Alcatraz Habitat Study 21845-004

HOLE NO.
AHS-48S
 SHEET NO. 1 OF 1

SAMPLER
MEC, Inc.

SITE and LOCATION
Harding Rock area, San Francisco Bay

SAMPLE DATE
1-20-94

VESSEL
R.V. Questuary

COORDINATES ELEVATION (below MLLW)
N 2,133,749 E 5,999,169 -73

SAMPLE LENGTH
0.1

SAMPLER WEIGHT BARREL SIZE
~300 lbs 4"

LOGGED BY
Stephen Knuttel

UPDATE
3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|---|
| GC | 2.0' | bag sample | -73.1 | | | | <p>Bag sample: SAND, Moderate brown to Grayish red, fine to coarse grained.</p> | <p>(Template: SEA)</p> <p>Remarks</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>Core drop yielded -0.1' of sample which was bagged.</p> <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION
Harding Rock area San Francisco Bay

HOLE NO.
AHS-48S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-49S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

Harding Rock area, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,133,228 E 5,999,881

ELEVATION (below MLLW)

-50

SAMPLE LENGTH

0.0

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|------------------------|--|
| GC | 2.0' | 0.0' | -50.0 | | | | no sample recovery. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Core drop attempted - no recovery. |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

Harding Rock area San Francisco Bay

HOLE NO.

AHS-49S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-50B

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

Alcatraz Shoal, San Francisco Bay

SAMPLE DATE
1-21-94

VESSEL

R.V. Questuary

COORDINATES

N 2,128,619 E 6,002,593

ELEVATION (below MLLW)

-57

SAMPLE LENGTH

1.0

SAMPLER WEIGHT

~400 lbs

BARREL SIZE

24" sq.

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|------------------|------------------|--|---|
| BX | 2.0' | -1.0' | -57.0 | 0.5 1.0 | [Dotted pattern] | [Dotted pattern] | Box core sample: SAND, Moderate brown, coarse to very coarse grained, with pebbles up to 1.0", with abundant shell fragments (naah), little fines (clean). | (Template: SEA) Box core dropped from water surface and allowed to free-fall to bottom. Grain-size analysis performed from sub-sample: 30% gravel and shells 57% coarse-vc sand 11% medium sand 1% fine sand <1% very-fine sand <1% silt 1% clay Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

Alcatraz Shoal San Francisco Bay

HOLE NO.

AHS-50B



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-50S

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

Alcatraz Shoal, San Francisco Bay

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,128,618 E 6,002,674

ELEVATION (below MLLW)

-60

SAMPLE LENGTH

0.1

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|---|
| GC | 3.0' | bag sample | -60.1 | | | | Bag sample: SAND, Moderate brown to Grayish red, coarse to very coarse grained, with some fine to medium grains, some pebbles up to 0.5". | (Template: SEA) Gravimetric core dropped from water surface and allowed to free-fall to bottom. Core drop yielded -0.1' of sample which was bagged. Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

Alcatraz Shoal San Francisco Bay

HOLE NO.

AHS-50S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-52S

SAMPLER

MEC, Inc.

SITE and LOCATION

NE of Disposal Site, San Francisco Bay

SHEET NO. 1 OF 1

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,128,504 E 6,008,208

ELEVATION (below MLLW)

-64

SAMPLE LENGTH

1.5

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|---|
| GC | 3.0' | 1.5' | -64.0 | 0.0 - 1.5 | | | 0.0 - 1.3 ft: SAND, Greenish black, fine grained, well sorted, -10% mud content, gradational contact. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Torvane reading at 0.1' = <0.5 tons/sq.ft. Torvane reading at 0.5' = <0.5 tons/sq.ft. |
| | | | -65.3 | 1.3 - 1.5 | | | 1.3 - 1.5 ft: Muddy Sand, Grayish black, fine grained, 0.5 x 3" x 1/8" thick black wood fragment. | Torvane reading at 1.4' = 1.0 tons/sq.ft. |
| | | | -65.5 | 1.5 | | | | Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

NE of Disposal Site San Francisco Bay

HOLE NO.

AHS-52S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-53S

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Alcatraz Island, San Francisco Bay

SHEET NO. 1 OF 1

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,128,915 E 6,007,896

ELEVATION (below MLLW)

-54

SAMPLE LENGTH

0.0

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|
| GC | 3.0' | 0.0' | -54.0 | | | |

Lithologic Description

no sample recovery.

(Template: SEA)

Remarks

Gravity core dropped from water surface and allowed to free-fall to bottom.

Core drop attempted - no recovery.

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Alcatraz Island San Francisco Bay

HOLE NO.

AHS-53S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-54S

SAMPLER

MEC, Inc.

SITE and LOCATION

East of Alcatraz Island, San Francisco Bay

SHEET NO. 1 OF 1

SAMPLE DATE

1-20-94

VESSEL

R.V. Questuary

COORDINATES

N 2,129,034 E 6,007,016

ELEVATION (below MLLW)

-114

SAMPLE LENGTH

0.0

SAMPLER WEIGHT

~300 lbs

BARREL SIZE

4"

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|
| GC | 3.0' | 0.0' | -114.0 | | | |

Lithologic Description

no sample recovery.

(Template: SEA)

Remarks

Gravity core dropped from water surface and allowed to free-fall to bottom.

Core drop attempted - no recovery; core cutter dented.

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

East of Alcatraz Island San Francisco Bay

HOLE NO.

AHS-54S



GEOLOGIC LOG

PROJECT and JOB NUMBER
Alcatraz Habitat Study 21845-004

HOLE NO.
AHS-55S
 SHEET NO. 1 OF 1

SAMPLER
MEC, Inc.

SITE and LOCATION
NE of Disposal Site, San Francisco Bay

SAMPLE DATE
1-20-94

VESSEL
R.V. Questuary

COORDINATES ELEVATION (below MLLW)
N 2,128,528 E 6,007,005 **-104**

SAMPLE LENGTH
0.1

SAMPLER WEIGHT BARREL SIZE
~300 lbs **4"**

LOGGED BY
Stephen Knuttel

UPDATE
3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|--|--|
| GC | 3.0' | bag sample | -104.1 | | | | <p>Bag sample: Gravel, mixed colors, brown to gray; with fine sand, Olive gray, and some shell fragments up to 0.5".</p> | <p>(Template: SEA)</p> <p>Gravity core dropped from water surface and allowed to free-fall to bottom.</p> <p>Core drop yielded -0.1' of sample which was bagged.</p> <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION
NE of Disposal Site San Francisco Bay

HOLE NO.
AHS-55S



GEOLOGIC LOG

PROJECT and JOB NUMBER
Alcatraz Habitat Study 21845-004

HOLE NO.
AHS-56S
SHEET NO. 1 OF 1

SAMPLER
MEC, Inc.

SITE and LOCATION
NE of Disposal Site, San Francisco Bay

SAMPLE DATE
1-20-94

VESSEL
R.V. Questuary

COORDINATES ELEVATION (below MLLW)
N 2,127,996 E 6,008,278 -82

SAMPLE LENGTH
0.0

SAMPLER WEIGHT BARREL SIZE
~300 lbs 4"

LOGGED BY
Stephen Knuttel

UPDATE
3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|------------------------|--|
| GC | 3.0' | 0.0' | -82.0 | | | | no sample recovery. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. Core drop attempted - no recovery. |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION
NE of Disposal Site San Francisco Bay

HOLE NO.
AHS-56S



GEOLOGIC LOG

PROJECT and JOB NUMBER
Alcatraz Habitat Study 21845-004

HOLE NO.
AHS-57S
SHEET NO. 1 OF 1

SAMPLER
MEC, Inc.

SITE and LOCATION
NE of Disposal Site, San Francisco Bay

SAMPLE DATE
1-20-94

VESSEL
R.V. Questuary

COORDINATES ELEVATION (below MLLW)
N 2,128,323 E 6,007,162 -100

SAMPLE LENGTH
2.1

SAMPLER WEIGHT BARREL SIZE
-300 lbs 4"

LOGGED BY
Stephen Knuttel

UPDATE
3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|------------------|---|--|
| GC | 3.0' | 2.1' | -100.0 | 0.0 | | 0.0 - 1.4 ft: Muddy SAND, Dark greenish gray, fine grained, well sorted, mud content -20-25%. | (Template: SEA) Gravity core dropped from water surface and allowed to free-fall to bottom. |
| | | | -101.4 | 1.4 | | 1.4 - 2.1 ft: MUD, Grayish black to Black, soft, abundant shell fragments between 1.4 - 1.7', minor fine sand between 1.4 - 1.8'. | |
| | | | -102.1 | 2.1 | | | Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION
NE of Disposal Site San Francisco Bay

HOLE NO.
AHS-57S



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-58B

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

South of Disposal Site, San Francisco Bay

SAMPLE DATE

1-21-94

VESSEL

R.V. Questuary

COORDINATES

N 2,125,621 E 6,005,742

ELEVATION (below MLLW)

-65

SAMPLE LENGTH

1.0

SAMPLER WEIGHT

~400 lbs

BARREL SIZE

24" sq.

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|--------|---|---|
| BX | 2.0' | -1.0' | -66.0 | 1.0 | | | Box core sample: SAND, Moderate brown, medium to coarse grained, little fines (clean), with gravel and shell fragments. | (Template: SEA) Box core dropped from water surface and allowed to free-fall to bottom. Grain-size analysis performed from sub-sample: 4% gravel and shells 47% coarse-vc sand 45% medium sand 2% fine sand <1% very-fine sand 1% silt 1% clay Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

GC = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

South of Disposal Site San Francisco Bay

HOLE NO.

AHS-58B



GEOLOGIC LOG

PROJECT and JOB NUMBER

Alcatraz Habitat Study

21845-004

HOLE NO.

AHS-59B

SHEET NO. 1 OF 1

SAMPLER

MEC, Inc.

SITE and LOCATION

South of Disposal Site, San Francisco Bay

SAMPLE DATE

1-21-94

VESSEL

R.V. Questuary

COORDINATES

N 2,126,027 E 6,005,670

ELEVATION (below MLLW)

-89

SAMPLE LENGTH

1.0

SAMPLER WEIGHT

~400 lbs

BARREL SIZE

24" sq.

LOGGED BY

Stephen Knuttel

UPDATE

3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW -89.0 | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|-------------------------------|---------------|-----------|--------|---|--|
| BX | 2.0' | -1.0' | | 0.5 1.0 | | | Box core sample: Sandy MUD, Black, soft, sand is very fine to very coarse grained, some shell fragments and gravel. | (Template: SEA) Box core dropped from water surface and allowed to free-fall to bottom. Grain-size analysis performed from sub-sample: 9% gravel and shells 6% coarse-vc sand 5% medium sand 5% fine sand 3% very-fine sand 24% silt 48% clay Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

= GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION

South of Disposal Site San Francisco Bay

HOLE NO.

AHS-59B



GEOLOGIC LOG

PROJECT and JOB NUMBER
Alcatraz Habitat Study 21845-004

HOLE NO.
AHS-60B
SHEET NO. 1 OF 1

SAMPLER
MEC, Inc.

SITE and LOCATION
NW of Disposal Site, San Francisco Bay

SAMPLE DATE
1-21-94

VESSEL
R.V. Questuary

COORDINATES ELEVATION (below MLLW)
N 2,129,075 E 6,005,010 -18

SAMPLE LENGTH
1.0

SAMPLER WEIGHT BARREL SIZE
~400 lbs 24" sq.

LOGGED BY
Stephen Knuttel

UPDATE
3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Sample | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|------------------|--------|--|---|
| BX | 2.0' | -1.0' | -18.0 | 0.5 1.0 | [Dotted pattern] | | Box core sample: SAND, Olive gray, fine to medium grained, well sorted, minor fines. | (Template: SEA) Box core dropped from water surface and allowed to free-fall to bottom. Grain-size analysis performed from sub-sample: <1% gravel and shells 1% coarse-vc sand 30% medium sand 59% fine sand 3% very-fine sand 3% silt 4% clay Description and classification by visual examination of sample. Colors from "Rock-Color Chart" (GSA, 1948). |

□ = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION
NW of Disposal Site San Francisco Bay

HOLE NO.
AHS-60B



GEOLOGIC LOG

PROJECT and JOB NUMBER
Alcatraz Habitat Study 21845-004

HOLE NO.
AHS-61B
SHEET NO. 1 OF 1

SAMPLER
MEC, Inc.

SITE and LOCATION
East of Disposal Site, San Francisco Bay

SAMPLE DATE
1-21-94

VESSEL
R.V. Questuary

COORDINATES ELEVATION (below MLLW)
N 2,127,002 E 6,007,455 -84

SAMPLE LENGTH
1.0

SAMPLER WEIGHT BARREL SIZE
~400 lbs 24" sq.

LOGGED BY
Stephen Knuttel

UPDATE
3-24-94

| Sampler Type | Sampler Length | Recovery (ft) | Elevation below MLLW | Depth in Feet | Lithology | Lithologic Description | Remarks |
|--------------|----------------|---------------|----------------------|---------------|-----------|---|---|
| BX | 2.0' | -1.0' | -84.0 | 1.0 | | <p>Box core sample: Gravelly SAND, Olive gray, fine to medium grained, mud -10%, gravel and shell fragments up to 1.5".</p> | <p>(Template: SEA)</p> <p>Box core dropped from water surface and allowed to free-fall to bottom.</p> <p>Grain-size analysis performed from sub-sample:</p> <ul style="list-style-type: none"> 33% gravel and shells 7% coarse-vc sand 21% medium sand 28% fine sand 2% very-fine sand 4% silt 5% clay <p>Description and classification by visual examination of sample.</p> <p>Colors from "Rock-Color Chart" (GSA, 1948).</p> |

C = GRAVITY CORE; BX = BOX CORE.

SITE and LOCATION
East of Disposal Site San Francisco Bay

HOLE NO.
AHS-61B

Appendix B: Species Collected At Biological Sampling Stations

| STATION 1B | |
|---------------------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| ANNELIDA | |
| <i>Ampharete labrops</i> | 2 |
| <i>Armandia brevis</i> | 15 |
| <i>Autolytus</i> sp. | 1 |
| <i>Capitella capitata</i> | 6 |
| <i>Caulleriella</i> nr. <i>hamata</i> | 1 |
| <i>Chone minuta</i> | 2 |
| <i>Cossura</i> sp. | 1 |
| <i>Eunoe</i> sp. | 1 |
| <i>Glycera americana</i> | 3 |
| <i>Glycera robusta</i> | 1 |
| <i>Glycinde picta</i> | 8 |
| <i>Heteromastus</i> sp. | 1 |
| <i>Lumbrineris inflata</i> | 1 |
| <i>Lumbrineris</i> sp. | 1 |
| <i>Mediomastus</i> spp. | 5 |
| <i>Sabaco elongata</i> | 2 |
| <i>Sigambra tentaculata</i> | 10 |
| <i>Sphaerosyllis californiensis</i> | 1 |
| <i>Spiophanes missionensis</i> | 2 |
| Tubificidae | 1 |
| CRUSTACEA | |
| <i>Balanus</i> spp. | 2 |
| <i>Callianassa (Neotrypaea)</i> sp. | 1 |
| <i>Corophium</i> sp. | 1 |
| <i>Foxiphalus obtusidens</i> | 2 |
| <i>Leptochelia</i> spp. | 4 |
| <i>Melita dentata</i> | 21 |
| <i>Pinnixa franciscana</i> | 20 |
| <i>Scleroplax granulata</i> | 9 |
| <i>Sphaeroma pentodon</i> | 1 |
| <i>Upogebia</i> sp. | 1 |
| ECHINODERMATA | |
| <i>Amphiodia urtica</i> | 1 |
| Ophiuroidea | 4 |
| MOLLUSCA | |
| <i>Cryptomya californica</i> | 2 |
| <i>Gemma gemma</i> | 20 |

| STATION 1B | |
|----------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| MOLLUSCA | |
| <i>Macoma</i> spp. | 8 |
| Mytilidae | 2 |
| <i>Petricola</i> spp. | 2 |
| <i>Protothaca staminea</i> | 12 |
| OTHERS | |
| <i>Carinoma mutabilis</i> | 1 |
| Ctenostomata | 1 |
| Lineidae | 16 |
| Nematoda | 68 |

| STATION 10B | |
|---------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| ANNELIDA | |
| <i>Hemipodus borealis</i> | 1 |
| <i>Magelona pitelkai</i> | 3 |
| <i>Mediomastus</i> sp. | 1 |
| CRUSTACEA | |
| <i>Photis californica</i> | 1 |
| OTHERS | |
| Lineidae | 1 |

| STATION 15B | |
|--------------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| ANNELIDA | |
| <i>Spiophanes missionensis</i> | 1 |
| CRUSTACEA | |
| <i>Foxiphalus obtusidens</i> | 1 |
| ECHINODERMATA | |
| <i>Amphiodia</i> sp. | 1 |

| STATION 15B | |
|-----------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| MOLLUSCA | |
| <i>Amygdalum pallidulum</i> | 1 |
| <i>Mya arenaria</i> | 1 |
| OTHERS | |
| Nemertea | 1 |
| <i>Scrupocellaria sp.</i> | 1 |

| STATION 21B | |
|------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| ANNELIDA | |
| <i>Mediomastus sp.</i> | 1 |
| MOLLUSCA | |
| <i>Odostomia sp.</i> | 1 |

| STATION 23B | |
|------------------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| ANNELIDA | |
| <i>Ampharete labrops</i> | 1 |
| <i>Armandia brevis</i> | 18 |
| <i>Eusyllis spp.</i> | 1 |
| <i>Glycinde picta</i> | 2 |
| <i>Lumbrineris spp.</i> | 1 |
| <i>Mediomastus spp.</i> | 6 |
| <i>Phyllodoce longipes</i> | 2 |
| <i>Sabellaria cementarium</i> | 2 |
| <i>Schistomeringos longicornis</i> | 1 |
| <i>Spiophanes missionensis</i> | 1 |
| <i>Streptosyllis sp. B</i> | 1 |

| STATION 23B | |
|------------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| CRUSTACEA | |
| <i>Balanus</i> sp. | 1 |
| <i>Cancer anthonyi</i> | 2 |
| <i>Foxiphalus obtusidens</i> | 1 |
| <i>Melita dentata</i> | 6 |
| ECHINODERMATA | |
| <i>Amphiodia</i> spp. | 2 |
| MOLLUSCA | |
| <i>Acanthodoris</i> sp. | 1 |
| Cephalaspidea | 1 |
| <i>Macoma</i> sp. | 1 |
| OTHERS | |
| <i>Carinoma mutabilis</i> | 1 |
| <i>Epiactis prolifera</i> | 1 |
| Lineidae | 5 |
| <i>Tubulanus polymorphus</i> | 1 |

| STATION 37B | |
|------------------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| ANNELIDA | |
| <i>Amaeana occidentalis</i> | 2 |
| <i>Apoprionospio pygmaea</i> | 2 |
| <i>Armandia brevis</i> | 31 |
| <i>Cirriformia spirabranca</i> | 1 |
| <i>Eteone leptotes</i> | 2 |
| <i>Euchone limnicola</i> | 2 |
| <i>Glycinde picta</i> | 4 |
| <i>Leitoscoloplos pugettensis</i> | 1 |
| <i>Lumbrineris tetraura</i> | 2 |
| <i>Mediomastus</i> spp. | 79 |
| <i>Nephtys caecoides</i> | 1 |
| <i>Nephtys cornuta franciscana</i> | 4 |
| <i>Notomastus</i> sp. | 1 |

| STATION 37B | |
|--------------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| ANNELIDA | |
| <i>Onuphis</i> sp. A | 1 |
| <i>Pholoe minuta</i> | 1 |
| <i>Prionospio</i> sp. A | 1 |
| <i>Sigambra tentaculata</i> | 1 |
| <i>Spiophanes missionensis</i> | 207 |
| <i>Streptosyllis</i> sp. B | 2 |
| <i>Tharyx</i> sp. | 1 |
| Tubificidae | 17 |
| CRUSTACEA | |
| Calanoida | 1 |
| <i>Cancer gracilis</i> | 1 |
| <i>Cancer</i> spp. | 2 |
| <i>Foxiphalus obtusidens</i> | 1 |
| <i>Photis</i> sp. | 1 |
| ECHINODERMATA | |
| <i>Amphiodia digitata</i> | 3 |
| MOLLUSCA | |
| <i>Gemma gemma</i> | 1 |
| <i>Nassarius mendicus</i> | 1 |
| <i>Philine</i> spp. | 2 |
| <i>Protothaca staminea</i> | 2 |
| <i>Tellina modesta</i> | 4 |
| <i>Transennella tantilla</i> | 7,800 |
| OTHERS | |
| <i>Aglaophenia</i> sp. | 1 |
| <i>Anquinella palmata</i> | 1 |
| <i>Carinoma mutabilis</i> | 1 |
| Ctenostomata | 1 |
| <i>Glottidia albida</i> | 1 |
| Lineidae | 7 |
| Nemotoda | 91 |
| <i>Tubulanus polymorphus</i> | 1 |
| <i>Watersipora cucullata</i> | 1 |

| STATION 39B | |
|--------------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| ANNELIDA | |
| <i>Notomastus</i> sp. | 1 |
| <i>Sigambra tentaculata</i> | 1 |
| <i>Spiophanes missionensis</i> | 20 |
| Tubificidae | 4 |
| OTHERS | |
| Ctenostomata | 1 |
| Lineidae | 1 |
| Phoronida | 2 |
| <i>Watersipora cucullata</i> | 1 |

| STATION 50B | |
|--------------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| ANNELIDA | |
| <i>Hemipodus borealis</i> | 5 |
| <i>Pisione remota</i> | 6 |
| <i>Saccocirrus</i> spp. | 11 |
| <i>Spiophanes missionensis</i> | 1 |

| STATION 58B | |
|---------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| ANNELIDA | |
| <i>Acmira catherinae</i> | 1 |
| Goniadidae | 1 |
| <i>Hemipodus borealis</i> | 1 |
| <i>Myriochele</i> sp. M | 1 |
| ECHINODERMATA | |
| Holothuroidea | 1 |

| STATION 61B | |
|---------------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| ANNELIDA | |
| <i>Ampharete labrops</i> | 2 |
| <i>Armandia brevis</i> | 171 |
| <i>Cauelleriella nr. hamata</i> | 2 |
| <i>Chone minuta</i> | 2 |
| Cirratulidae | 1 |
| <i>Diopatra ornata</i> | 1 |
| <i>Eusyllis</i> spp. | 7 |
| <i>Exogone lourei</i> | 1 |
| <i>Glycera americana</i> | 2 |
| <i>Harmothoe imbricata</i> | 1 |
| <i>Lumbrineris</i> spp. | 2 |
| <i>Lumbrineris tetraura</i> | 1 |
| Nereidae | 1 |
| <i>Nereis latescens</i> | 1 |
| <i>Notomastus</i> spp. | 2 |
| <i>Paleanotus bellis</i> | 3 |
| <i>Phyllodoce longipes</i> | 1 |
| <i>Polydora</i> sp. | 1 |
| <i>Sabellaria alcocki</i> | 1 |
| Sabellidae | 1 |
| <i>Streptosyllis</i> sp. B | 1 |
| CRUSTACEA | |
| <i>Caprella californica</i> | 1 |
| <i>Dulichia</i> sp. | 1 |
| <i>Ericthonius</i> sp. | 1 |
| <i>Gammaropsis thompsoni</i> | 5 |
| <i>Jaeropsis dubia</i> | 1 |
| <i>Leptochelia</i> spp. | 4 |
| <i>Melita dentata</i> | 6 |
| <i>Photis brevipes</i> | 21 |
| <i>Pinnixa franciscana</i> | 1 |
| <i>Pycnogonum rickettsi</i> | 4 |
| ECHINODERMATA | |
| <i>Amphiodia</i> sp. | 1 |
| <i>Amphiodia urtica</i> | 3 |
| Ophiuroidea | 7 |

| STATION 61B | |
|------------------------------|----------------------|
| SPECIES | ABUNDANCE PER SAMPLE |
| MOLLUSCA | |
| <i>Acanthodoris</i> sp. | 1 |
| <i>Alia carinata</i> | 6 |
| <i>Gemma gemma</i> | 12 |
| <i>Macoma</i> spp. | 4 |
| <i>Mysella</i> sp. A | 2 |
| Mytilidae | 7 |
| <i>Nitidiscala</i> spp. | 2 |
| <i>Okenia plana</i> | 2 |
| <i>Protothaca staminea</i> | 3 |
| OTHERS | |
| <i>Anquinella palmata</i> | 1 |
| Ctenostomata | 1 |
| <i>Emplectonema gracile</i> | 1 |
| <i>Epiactis prolifera</i> | 7 |
| Lineidae | 10 |
| Nematoda | 139 |
| <i>Nephasoma</i> spp. | 5 |
| <i>Tubulanus polymorphus</i> | 6 |
| <i>Watersipora cucullata</i> | 1 |

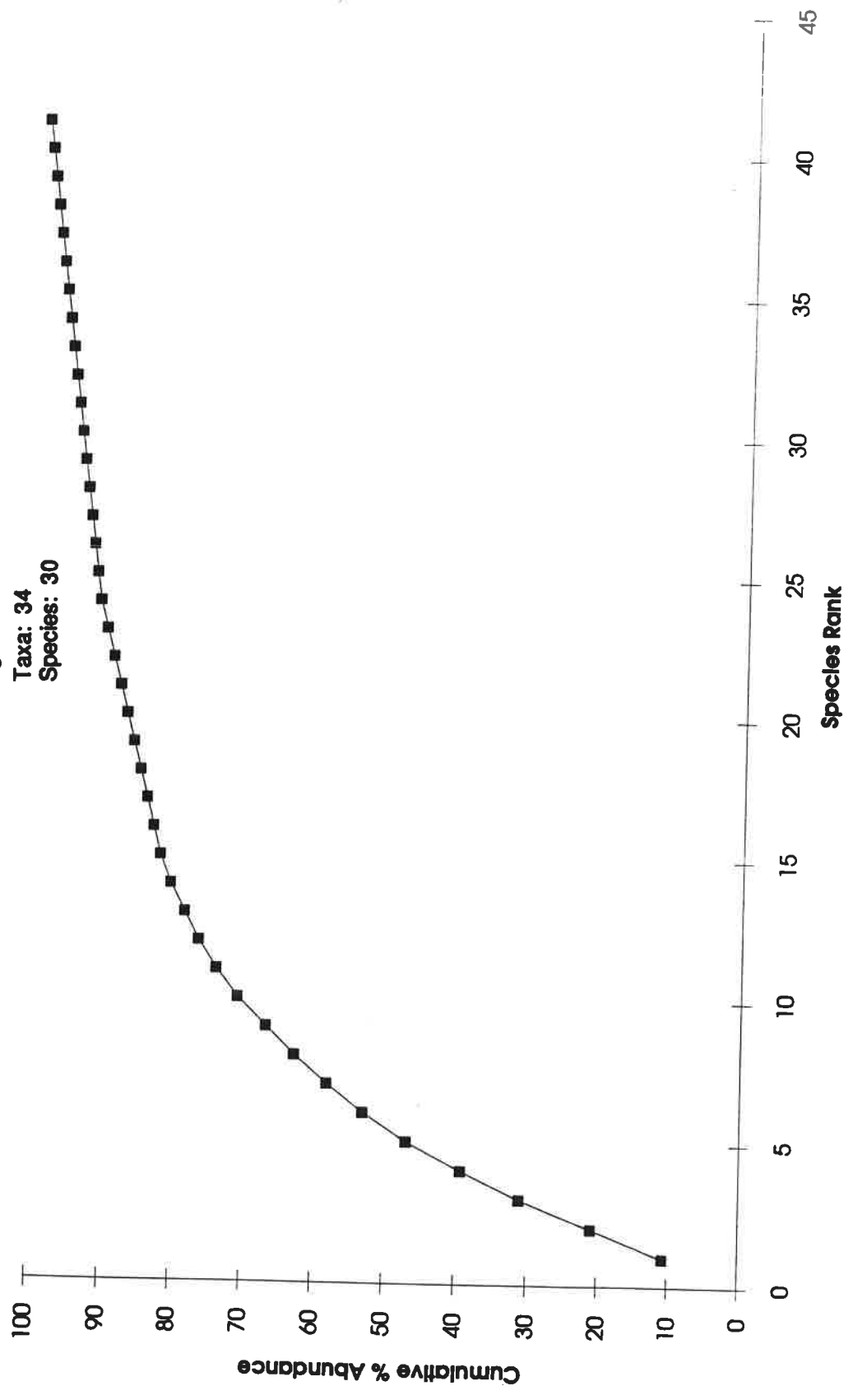
Appendix C: Cumulative Abundance Curve

Replicate k Dominance Curves: Station 1B

Dredged Material.

Taxa: 34

Species: 30

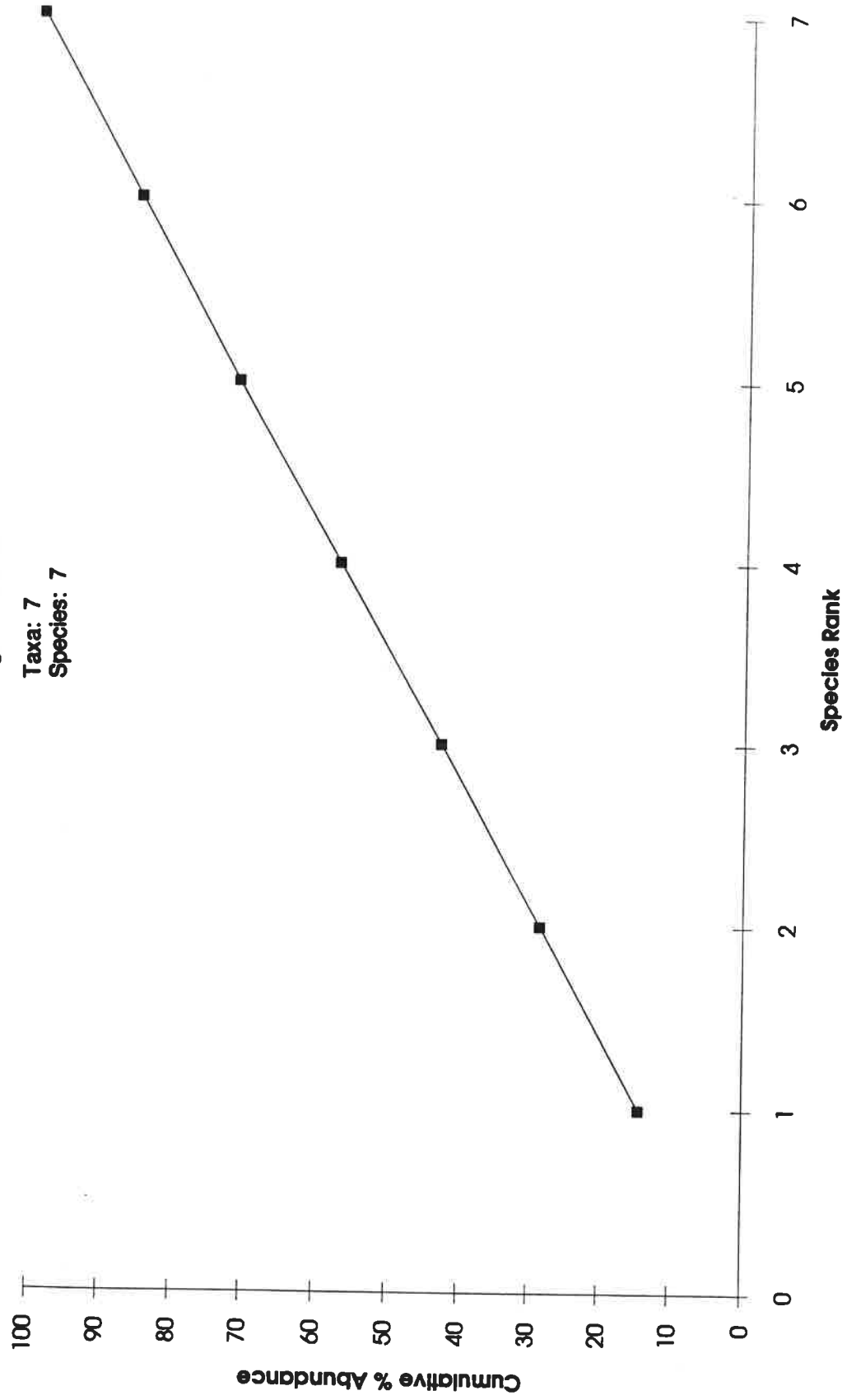


Replicate k Dominance Curve: Station 158

Dredged Material

Taxa: 7

Species: 7

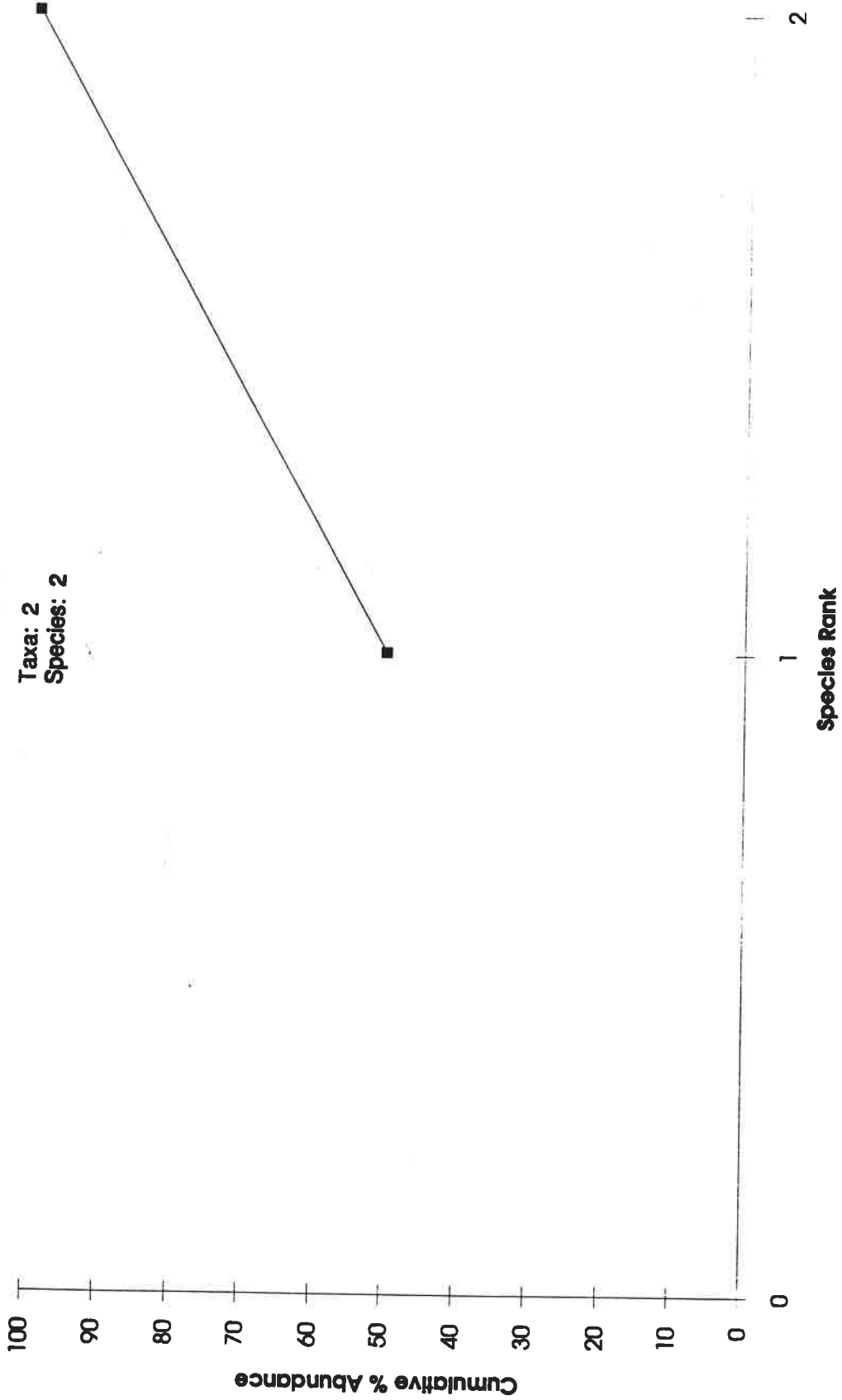


Replicate k Dominance Curve: Station 21B

Native Sands

Taxa: 2

Species: 2

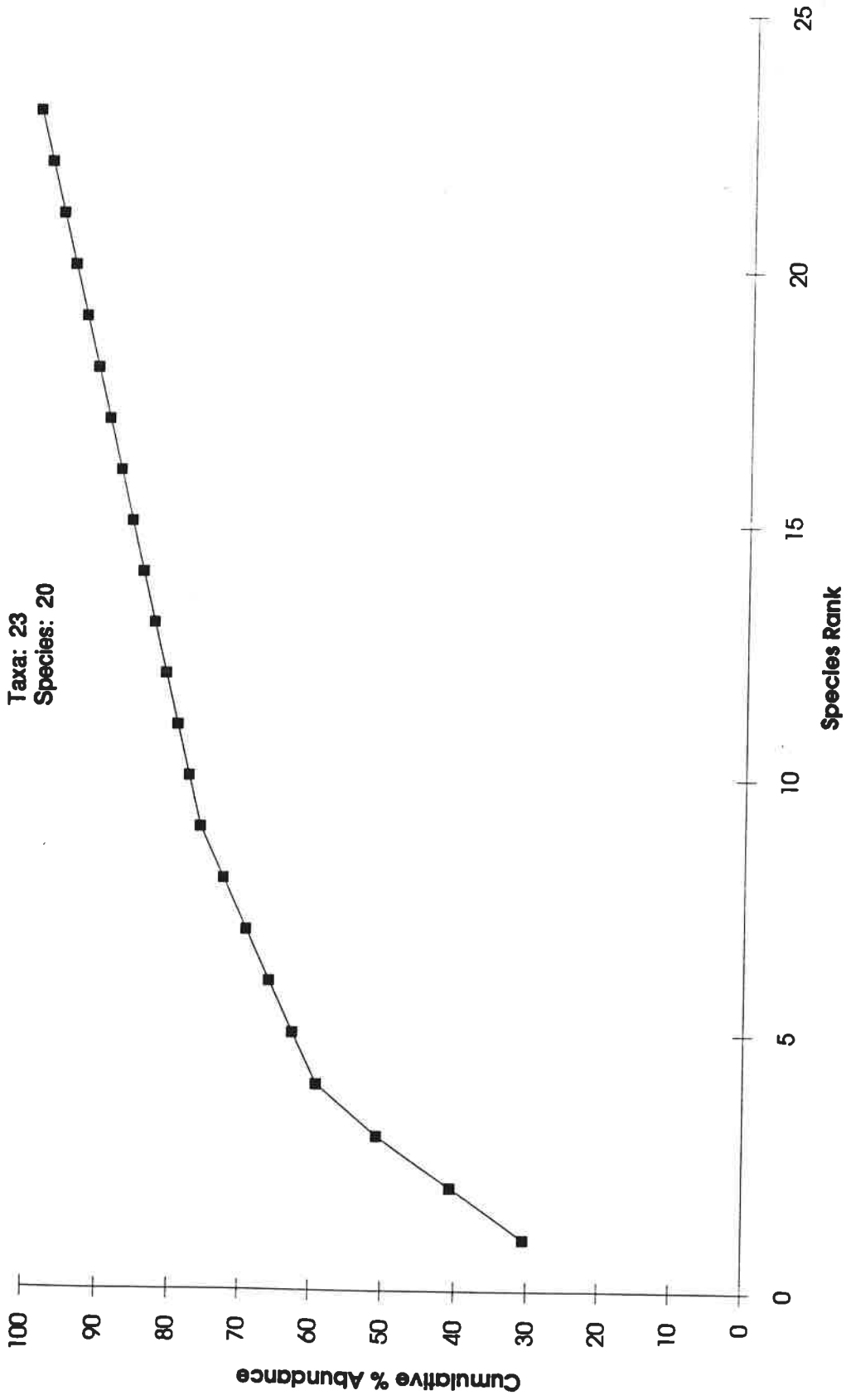


Replicate k Dominance Curve: Station 23B

Native Sands

Taxa: 23

Species: 20

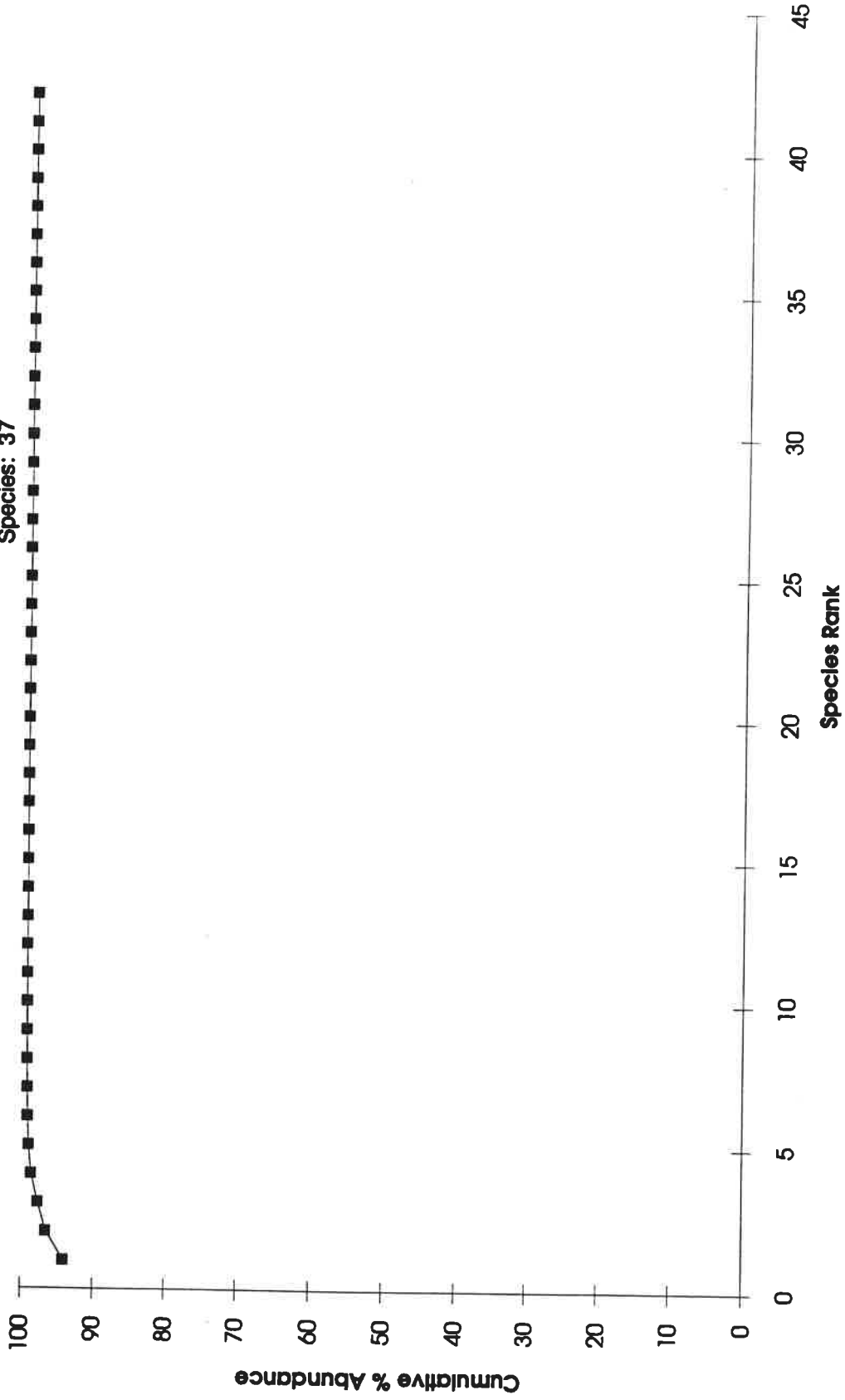


Replicate k Dominance Curve: Station 37B

Native Sands

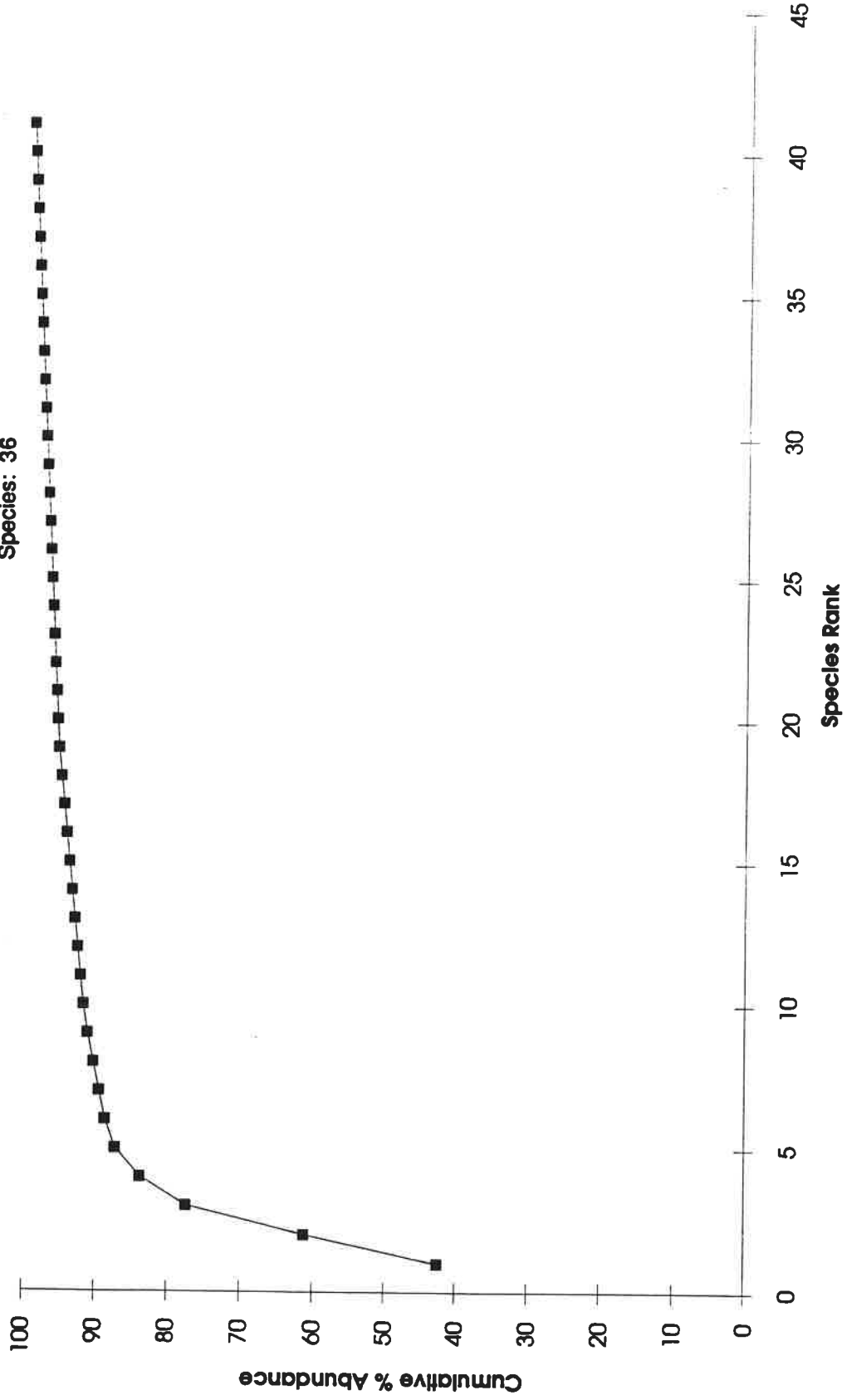
Taxa: 43

Species: 37



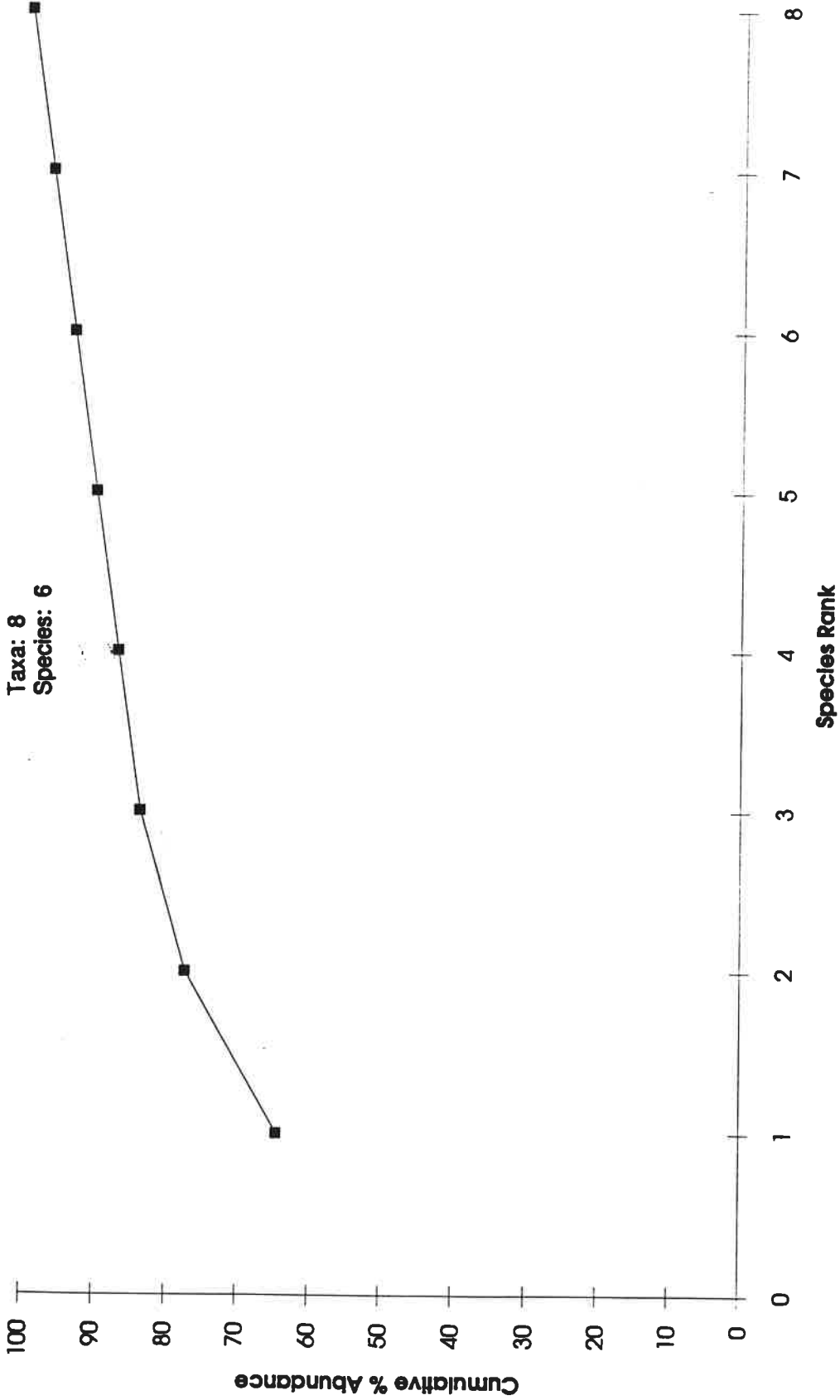
Replicate k Dominance Curve: Station 37B (All)

**Native Sand Taxa: 42
Species: 36**



Replicate k Dominance Curve: Station 39B

Dredged Material

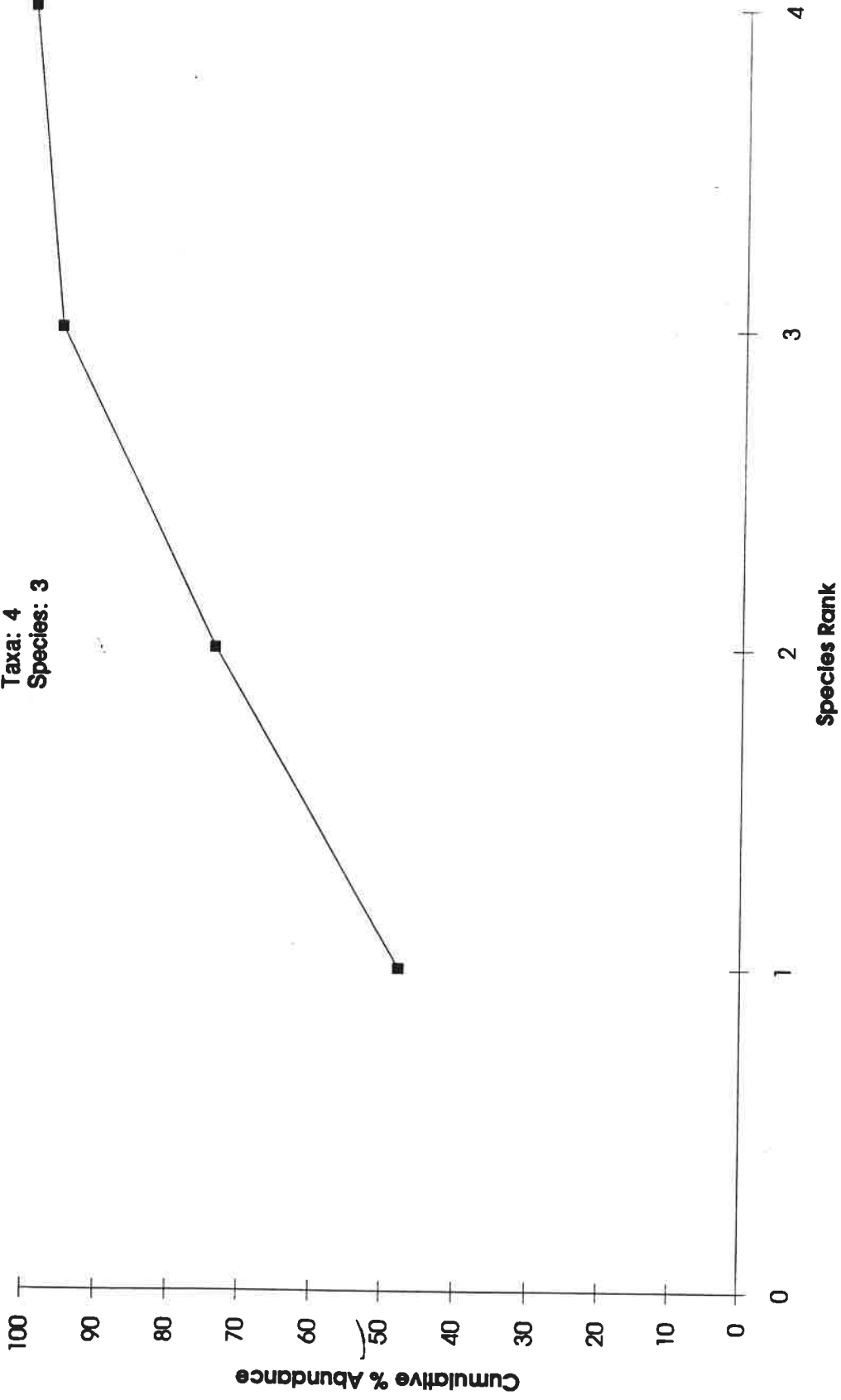


Replicate k Dominance Curve: Station 50B

Native Sands

Taxa: 4

Species: 3

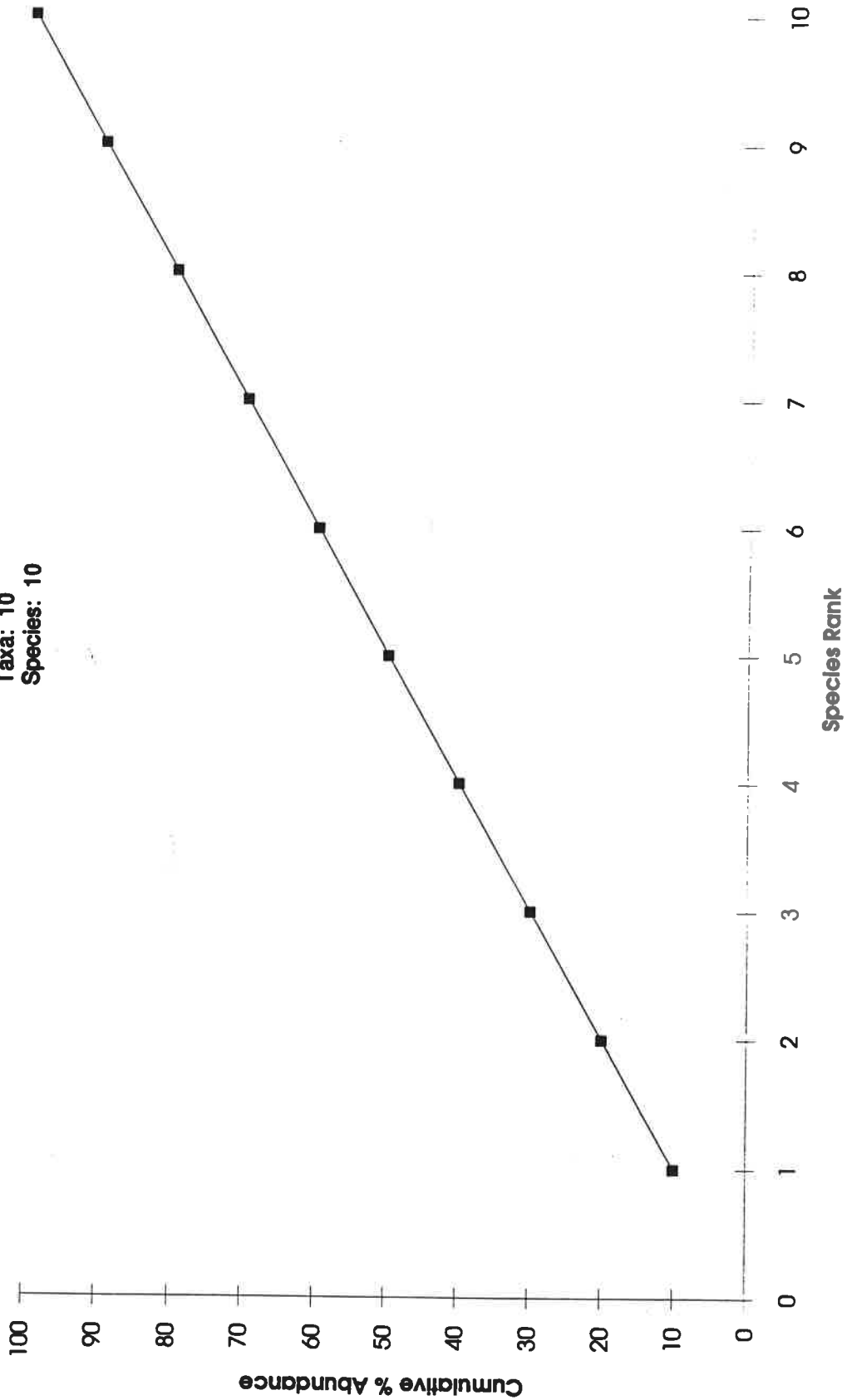


Replicate k Dominance Curve: Station 60B

Native Sands

Taxa: 10

Species: 10

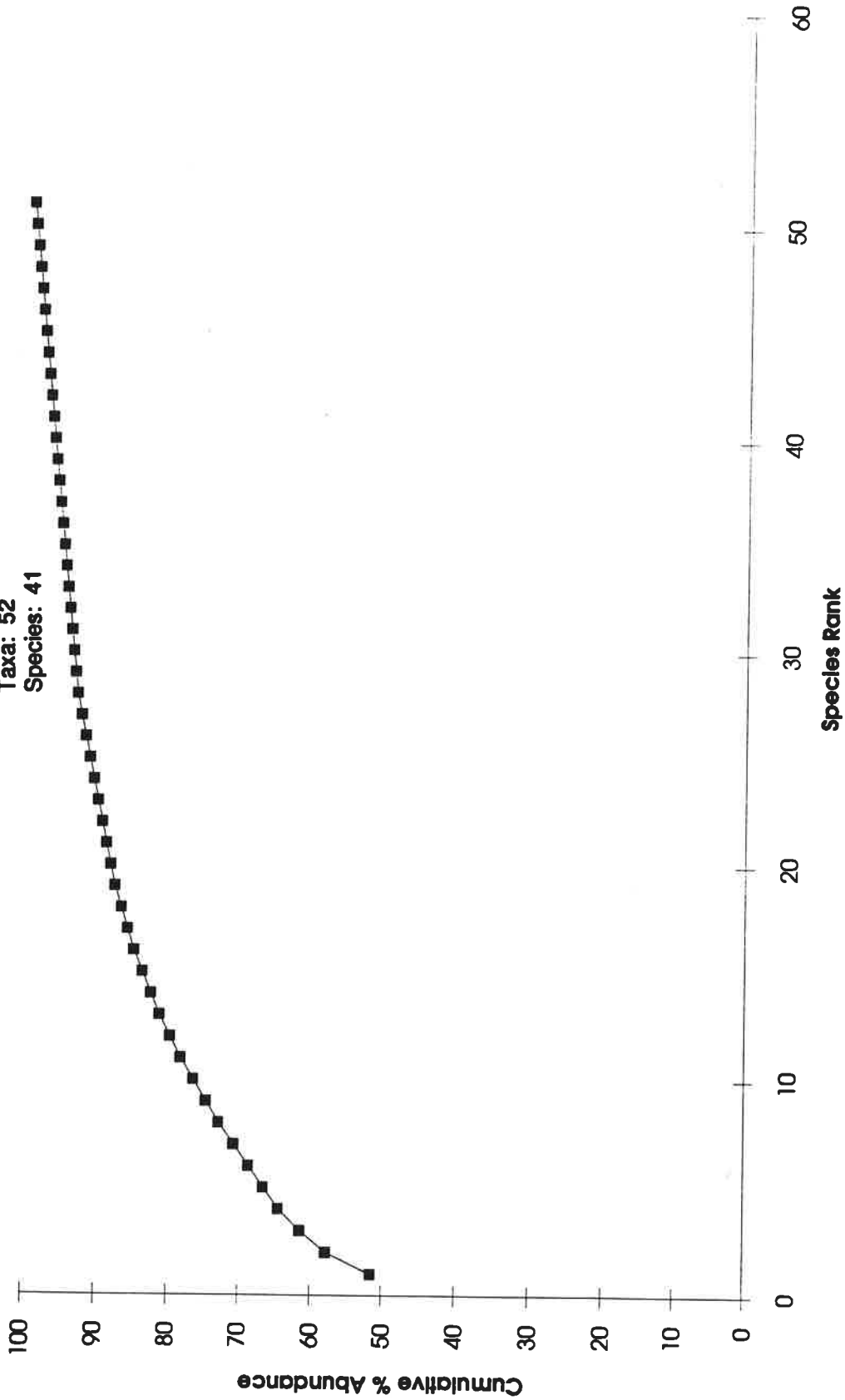


Replicate k Dominance: Station 61B

Dredged Material

Taxa: 52

Species: 41



Appendix D: Organic Carbon Analysis

ORGANIC CARBON ANALYSIS

Contract: ALCATRAZ
Contact person: Dr. William Muellenhof
Date of analysis: 9Mar94
Date of report: 10Mar94
Analysis method: Persulfate wet oxidation (Menzel and Vaccaro, 1964)

----- Carbon Values -----

| Sample ID | % Carbon |
|-----------|----------|
| 10B | 0.038 |
| 15B | 0.556 |
| 1B | 0.354 |
| 21B | 0.036 |
| 23B | 0.430 |
| 37B | 0.377 |
| 39B | 0.072 |
| 50B | 0.060 |
| 58B | 0.028 |
| 59B | 1.347 |
| 60B | 0.024 |
| 61B | 0.275 |

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ORGANIC CARBON ANALYSIS

| ----- Sample Calibration ----- | | | | |
|--------------------------------|-------------|---------|---------|-----------|
| Sample number | Weight (gm) | ugC | %Carbon | Sample ID |
| 44 | 0.01880 | 66.569 | 0.354 | 1B |
| 45 | 0.01825 | 6.982 | 0.038 | 10B |
| 46 | 0.01856 | 106.414 | 0.573 | 15B |
| 47 | 0.01825 | 98.266 | 0.538 | 15B |
| 48 | 0.02023 | 7.310 | 0.036 | 21B |
| 49 | 0.01831 | 78.740 | 0.430 | 23B |
| 50 | 0.01891 | 71.206 | 0.377 | 37B |
| 51 | 0.01809 | 13.097 | 0.072 | 39B |
| 52 | 0.01973 | 11.744 | 0.060 | 50B |
| 53 | 0.01857 | 5.189 | 0.028 | 58B |
| 54 | 0.01604 | 216.138 | 1.347 | 59B |
| 55 | 0.01843 | 4.354 | 0.024 | 60B |
| 56 | 0.01823 | 50.178 | 0.275 | 61B |

A
B

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ORGANIC CARBON ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhof
 Date of analysis: 9Mar94
 Date of report: 10Mar94
 Analysis method: Persulfate wet oxidation (Menzel and Vaccaro, 1964)

----- Standard Curve Fit -----

| Standard X | Standard Y | Predicted Y |
|------------|------------|-------------|
| 4463.00 | 0.00 | 1.3503 |
| 2399.00 | 0.00 | -2.5220 |
| 2643.00 | 0.00 | -2.0787 |
| 9438.00 | 9.90 | 11.8925 |
| 10704.00 | 9.90 | 14.8663 |
| 14304.00 | 24.90 | 24.0158 |
| 14313.00 | 24.90 | 24.0400 |
| 23796.00 | 49.90 | 53.5565 |
| 23461.00 | 49.90 | 52.3693 |
| 28415.00 | 74.90 | 71.0948 |
| 28551.00 | 74.90 | 71.6451 |
| 34811.00 | 99.90 | 99.2025 |
| 34331.00 | 99.90 | 96.9307 |
| 44911.00 | 149.90 | 153.6088 |
| 43970.00 | 149.90 | 147.9841 |
| 52783.00 | 199.90 | 205.4848 |
| 50189.00 | 199.90 | 187.4151 |
| 66323.00 | 299.80 | 316.6714 |
| 65375.00 | 299.80 | 307.9144 |
| 79892.00 | 499.80 | 459.5484 |
| 85036.00 | 499.80 | 522.8100 |

Product moment correlation=0.9969751

Coefficient of determination (R square)=0.9939594

Polynomial curve fit: $y = a + b \cdot x + c \cdot x^2 + d \cdot x^3$

a=-6.68137

b=0.0016603

c=2.99669e-08

d=2.79086e-13

----- Blank Calibration -----

| | |
|--------------------|----------------------|
| Blank X(1)= 7811 | Blank Y(1)= 8.2486 |
| Blank X(2)= 5437 | Blank Y(2)= 3.2764 |
| Blank X(3)= 7011 | Blank Y(3)= 6.5282 |
| Blank X(4)= 6593 | Blank Y(4)= 5.6476 |
| Blank X(5)= 4580 | Blank Y(5)= 1.5782 |

Mean Blank = 5.0558

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Appendix E: Grain Size Analysis

GRAIN SIZE ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhoff
 Date of analysis: 9Feb94
 Date of report: 15Feb94
 Analysis method: Sieve/pipette (Plumb, 1981)
 Sample Identification: Station 1B
 Total sample weight: 26.726 grams

| Size | Phi | Weight | Percent | Cumulative |
|----------|-------|--------|---------|------------|
| Microns | | grams | | Percent |
| 2000.000 | -1.0 | 2.650 | 9.916 | 9.916 |
| 1414.214 | -0.5 | 0.230 | 0.861 | 10.776 |
| 1000.000 | 0.0 | 0.104 | 0.389 | 11.165 |
| 707.107 | 0.5 | 0.158 | 0.591 | 11.756 |
| 500.000 | 1.0 | 0.130 | 0.486 | 12.243 |
| 353.553 | 1.5 | 1.083 | 4.052 | 16.295 |
| 250.000 | 2.0 | 2.100 | 7.858 | 24.153 |
| 176.777 | 2.5 | 5.566 | 20.826 | 44.979 |
| 125.000 | 3.0 | 4.269 | 15.973 | 60.953 |
| 88.388 | 3.5 | 0.723 | 2.705 | 63.658 |
| 62.500 | 4.0 | 0.254 | 0.950 | 64.608 |
| 31.250 | 5.0 | 1.501 | 5.617 | 70.225 |
| 15.625 | 6.0 | 1.704 | 6.376 | 76.600 |
| 7.812 | 7.0 | 1.055 | 3.947 | 80.547 |
| 3.906 | 8.0 | 1.014 | 3.795 | 84.342 |
| 1.953 | 9.0 | 0.568 | 2.125 | 86.468 |
| < 1.953 | > 9.0 | 3.617 | 13.532 | 100.000 |

% < 4 phi = 35.392
 % > 1 phi = 11.756
 % gravel = 9.916
 % sand = 54.693
 % silt = 19.734
 % clay = 15.658

Sample Statistics

| Median | Mean | Dispersion | Skewness |
|--------------|-------------|------------|----------|
| phi microns | phi microns | | |
| 2.657 158.53 | 4.687 38.83 | 3.223 | 0.630 |

5th percentile =
 16th percentile = 1.464
 50th percentile = 2.657
 84th percentile = 7.910
 95th percentile =
 *** 5th percentile not obtainable ***
 *** 95th percentile not reached ***

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GRAIN SIZE ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhoff
 Date of analysis: 9Feb94
 Date of report: 15Feb94
 Analysis method: Sieve/pipette (Plumb, 1981)
 Sample Identification: Station 10B
 Total sample weight: 31.639 grams

| Size | Phi | Weight grams | Percent | Cumulative Percent |
|----------|-------|-----------------|---------|-----------------------|
| 2000.000 | -1.0 | 0.000 | 0.000 | 0.000 |
| 1414.214 | -0.5 | 0.000 | 0.000 | 0.000 |
| 1000.000 | 0.0 | 0.005 | 0.016 | 0.016 |
| 707.107 | 0.5 | 0.035 | 0.111 | 0.126 |
| 500.000 | 1.0 | 0.119 | 0.376 | 0.503 |
| 353.553 | 1.5 | 1.858 | 5.872 | 6.375 |
| 250.000 | 2.0 | 13.107 | 41.427 | 47.802 |
| 176.777 | 2.5 | 10.054 | 31.777 | 79.579 |
| 125.000 | 3.0 | 4.334 | 13.698 | 93.277 |
| 88.388 | 3.5 | 0.398 | 1.258 | 94.535 |
| 62.500 | 4.0 | 0.141 | 0.446 | 94.980 |
| 31.250 | 5.0 | 0.365 | 1.154 | 96.135 |
| 15.625 | 6.0 | 0.203 | 0.641 | 96.776 |
| 7.812 | 7.0 | 0.041 | 0.128 | 96.904 |
| 3.906 | 8.0 | 0.243 | 0.769 | 97.673 |
| 1.953 | 9.0 | 0.203 | 0.641 | 98.314 |
| < 1.953 | > 9.0 | 0.533 | 1.686 | 100.000 |

% < 4 phi = 5.020
 % > 1 phi = 0.126
 % gravel = 0.000
 % sand = 94.980
 % silt = 2.693
 % clay = 2.327

Sample Statistics

| Median | Mean | Dispersion | Skewness |
|-----------------|-----------------|------------|----------|
| phi microns | phi microns | | |
| 2.035 244.08 | 2.139 227.07 | 0.523 | 0.199 |

5th percentile = 1.383
 16th percentile = 1.616
 50th percentile = 2.035
 84th percentile = 2.661
 95th percentile = 4.017

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GRAIN SIZE ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhoff
 Date of analysis: 9Feb94
 Date of report: 15Feb94
 Analysis method: Sieve/pipette (Plumb, 1981)
 Sample Identification: Station 15B
 Total sample weight: 25.493 grams

| Size | Phi | Weight | Percent | Cumulative |
|----------|-------|--------|---------|------------|
| Microns | | grams | | Percent |
| 2000.000 | -1.0 | 1.308 | 5.131 | 5.131 |
| 1414.214 | -0.5 | 0.152 | 0.596 | 5.727 |
| 1000.000 | 0.0 | 0.111 | 0.435 | 6.162 |
| 707.107 | 0.5 | 0.108 | 0.424 | 6.586 |
| 500.000 | 1.0 | 0.210 | 0.824 | 7.410 |
| 353.553 | 1.5 | 3.674 | 14.412 | 21.822 |
| 250.000 | 2.0 | 3.586 | 14.067 | 35.888 |
| 176.777 | 2.5 | 2.891 | 11.340 | 47.229 |
| 125.000 | 3.0 | 0.859 | 3.370 | 50.598 |
| 88.388 | 3.5 | 0.190 | 0.745 | 51.344 |
| 62.500 | 4.0 | 0.227 | 0.890 | 52.234 |
| 31.250 | 5.0 | 0.974 | 3.819 | 56.054 |
| 15.625 | 6.0 | 1.826 | 7.161 | 63.215 |
| 7.812 | 7.0 | 1.095 | 4.297 | 67.512 |
| 3.906 | 8.0 | 1.379 | 5.411 | 72.923 |
| 1.953 | 9.0 | 0.893 | 3.501 | 76.424 |
| < 1.953 | > 9.0 | 6.010 | 23.576 | 100.000 |

% < 4 phi = 47.766
 % > 1 phi = 6.586
 % gravel = 5.131
 % sand = 47.103
 % silt = 20.688
 % clay = 27.077

Sample Statistics

| Median | | Mean | | Dispersion | Skewness |
|--------|---------|-------|---------|------------|----------|
| phi | microns | phi | microns | | |
| 2.911 | 132.93 | 6.022 | 15.39 | 4.724 | 0.659 |

5th percentile = .
 16th percentile = 1.298
 50th percentile = 2.911
 84th percentile = 10.746
 95th percentile = .
 *** 5th percentile not obtainable ***
 *** 84th percentile extrapolated ***
 *** 95th percentile not reached ***

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GRAIN SIZE ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhoff
 Date of analysis: 9Feb94
 Date of report: 15Feb94
 Analysis method: Sieve/pipette (Plumb, 1981)
 Sample Identification: Station 15B QA
 Total sample weight: 26.176 grams

| Size | Phi | Weight | Percent | Cumulative |
|----------|-------|--------|---------|------------|
| Microns | | grams | | Percent |
| 2000.000 | -1.0 | 1.551 | 5.925 | 5.925 |
| 1414.214 | -0.5 | 0.190 | 0.726 | 6.651 |
| 1000.000 | 0.0 | 0.128 | 0.489 | 7.140 |
| 707.107 | 0.5 | 0.087 | 0.332 | 7.472 |
| 500.000 | 1.0 | 0.221 | 0.844 | 8.317 |
| 353.553 | 1.5 | 1.423 | 5.436 | 13.753 |
| 250.000 | 2.0 | 5.797 | 22.146 | 35.899 |
| 176.777 | 2.5 | 2.638 | 10.078 | 45.977 |
| 125.000 | 3.0 | 1.033 | 3.946 | 49.923 |
| 88.388 | 3.5 | 0.169 | 0.646 | 50.569 |
| 62.500 | 4.0 | 0.235 | 0.898 | 51.466 |
| 31.250 | 5.0 | 1.623 | 6.199 | 57.666 |
| 15.625 | 6.0 | 1.907 | 7.284 | 64.950 |
| 7.812 | 7.0 | 1.663 | 6.354 | 71.305 |
| 3.906 | 8.0 | 1.014 | 3.875 | 75.179 |
| 1.953 | 9.0 | 1.014 | 3.875 | 79.054 |
| < 1.953 | > 9.0 | 5.483 | 20.946 | 100.000 |

% < 4 phi = 48.534
 % > 1 phi = 7.472
 % gravel = 5.925
 % sand = 45.541
 % silt = 23.713
 % clay = 24.821

Sample Statistics

| Median | Mean | Dispersion | Skewness |
|--------------|-------------|------------|----------|
| phi microns | phi microns | | |
| 3.060 119.94 | 5.781 18.19 | 4.230 | 0.643 |

5th percentile =
 16th percentile = 1.551
 50th percentile = 3.060
 84th percentile = 10.011
 95th percentile =
 *** 5th percentile not obtainable ***
 *** 84th percentile extrapolated ***
 *** 95th percentile not reached ***

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GRAIN SIZE ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhoff
 Date of analysis: 9Feb94
 Date of report: 15Feb94
 Analysis method: Sieve/pipette (Plumb, 1981)
 Sample Identification: Station 21B
 Total sample weight: 33.201 grams

| Size | Phi | Weight | Percent | Cumulative |
|----------|-------|--------|---------|------------|
| Microns | | grams | | Percent |
| 2000.000 | -1.0 | 0.020 | 0.060 | 0.060 |
| 1414.214 | -0.5 | 0.018 | 0.054 | 0.114 |
| 1000.000 | 0.0 | 0.037 | 0.111 | 0.226 |
| 707.107 | 0.5 | 0.060 | 0.181 | 0.407 |
| 500.000 | 1.0 | 0.168 | 0.506 | 0.913 |
| 353.553 | 1.5 | 7.359 | 22.165 | 23.078 |
| 250.000 | 2.0 | 8.725 | 26.279 | 49.357 |
| 176.777 | 2.5 | 11.362 | 34.222 | 83.579 |
| 125.000 | 3.0 | 3.234 | 9.741 | 93.320 |
| 88.388 | 3.5 | 0.199 | 0.599 | 93.919 |
| 62.500 | 4.0 | 0.025 | 0.075 | 93.995 |
| 31.250 | 5.0 | 0.041 | 0.122 | 94.117 |
| 15.625 | 6.0 | 0.162 | 0.489 | 94.606 |
| 7.812 | 7.0 | 0.081 | 0.244 | 94.850 |
| 3.906 | 8.0 | 0.041 | 0.122 | 94.972 |
| 1.953 | 9.0 | 0.041 | 0.122 | 95.094 |
| < 1.953 | > 9.0 | 1.629 | 4.906 | 100.000 |

% < 4 phi = 6.005
 % > 1 phi = 0.407
 % gravel = 0.060
 % sand = 93.934
 % silt = 0.978
 % clay = 5.028

Sample Statistics

| Median | Mean | Dispersion | Skewness |
|--------------|--------------|------------|----------|
| phi microns | phi microns | | |
| 2.009 248.38 | 1.931 262.25 | 0.591 | -0.133 |

5th percentile = 1.092
 16th percentile = 1.340
 50th percentile = 2.009
 84th percentile = 2.522
 95th percentile = 8.228

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 2433 Impala Dr.
 Carlsbad, CA 92008

GRAIN SIZE ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhoff
 Date of analysis: 9Feb94
 Date of report: 15Feb94
 Analysis method: Sieve/pipette (Plumb, 1981)
 Sample Identification: Station 23B
 Total sample weight: 29.976 grams

| Size | Phi | Weight grams | Percent | Cumulative Percent |
|----------|-------|-----------------|---------|-----------------------|
| 2000.000 | -1.0 | 5.525 | 18.432 | 18.432 |
| 1414.214 | -0.5 | 0.910 | 3.036 | 21.467 |
| 1000.000 | 0.0 | 0.727 | 2.425 | 23.893 |
| 707.107 | 0.5 | 0.446 | 1.488 | 25.380 |
| 500.000 | 1.0 | 0.594 | 1.982 | 27.362 |
| 353.553 | 1.5 | 1.566 | 5.224 | 32.586 |
| 250.000 | 2.0 | 4.226 | 14.098 | 46.684 |
| 176.777 | 2.5 | 4.592 | 15.319 | 62.003 |
| 125.000 | 3.0 | 3.761 | 12.547 | 74.550 |
| 88.388 | 3.5 | 0.610 | 2.035 | 76.585 |
| 62.500 | 4.0 | 0.400 | 1.334 | 77.919 |
| 31.250 | 5.0 | 0.974 | 3.248 | 81.168 |
| 15.625 | 6.0 | 0.730 | 2.436 | 83.604 |
| 7.812 | 7.0 | 0.365 | 1.218 | 84.822 |
| 3.906 | 8.0 | 0.527 | 1.759 | 86.581 |
| 1.953 | 9.0 | 0.730 | 2.436 | 89.018 |
| < 1.953 | > 9.0 | 3.292 | 10.982 | 100.000 |

% < 4 phi = 22.081
 % > 1 phi = 25.380
 % gravel = 18.432
 % sand = 59.488
 % silt = 8.662
 % clay = 13.419

Sample Statistics

| Median | Mean | Dispersion | Skewness |
|--------------|--------------|------------|----------|
| phi microns | phi microns | | |
| 2.108 231.93 | 2.462 181.45 | 3.863 | 0.092 |

5th percentile = .
 16th percentile = -1.400
 50th percentile = 2.108
 84th percentile = 6.325
 95th percentile = .

*** 5th percentile not obtainable ***
 *** 16th percentile extrapolated ***
 *** 95th percentile not reached ***

MEC Analytical Systems, Inc.
 2433 Impala Dr.
 Carlsbad, CA 92008

GRAIN SIZE ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhoff
 Date of analysis: 9Feb94
 Date of report: 15Feb94
 Analysis method: Sieve/pipette (Plumb, 1981)
 Sample Identification: Station 37B
 Total sample weight: 28.807 grams

| Size | Phi | Weight grams | Percent | Cumulative Percent |
|----------|-------|--------------|---------|--------------------|
| 2000.000 | -1.0 | 0.145 | 0.503 | 0.503 |
| 1414.214 | -0.5 | 0.074 | 0.257 | 0.760 |
| 1000.000 | 0.0 | 0.026 | 0.090 | 0.850 |
| 707.107 | 0.5 | 0.050 | 0.174 | 1.024 |
| 500.000 | 1.0 | 0.073 | 0.253 | 1.277 |
| 353.553 | 1.5 | 0.307 | 1.066 | 2.343 |
| 250.000 | 2.0 | 0.486 | 1.687 | 4.030 |
| 176.777 | 2.5 | 7.524 | 26.119 | 30.149 |
| 125.000 | 3.0 | 14.049 | 48.769 | 78.918 |
| 88.388 | 3.5 | 2.395 | 8.314 | 87.232 |
| 62.500 | 4.0 | 0.670 | 2.326 | 89.558 |
| 31.250 | 5.0 | 0.893 | 3.098 | 92.656 |
| 15.625 | 6.0 | 0.122 | 0.423 | 93.079 |
| 7.812 | 7.0 | 0.325 | 1.127 | 94.205 |
| 3.906 | 8.0 | 0.162 | 0.563 | 94.769 |
| 1.953 | 9.0 | 0.162 | 0.563 | 95.332 |
| < 1.953 | > 9.0 | 1.345 | 4.668 | 100.000 |

% < 4 phi = 10.442
 % > 1 phi = 1.024
 % gravel = 0.503
 % sand = 89.054
 % silt = 5.211
 % clay = 5.231

Sample Statistics

| Median | Mean | Dispersion | Skewness |
|--------------|--------------|------------|----------|
| phi microns | phi microns | | |
| 2.704 153.52 | 2.767 146.87 | 0.538 | 0.119 |

5th percentile = 2.019
 16th percentile = 2.229
 50th percentile = 2.704
 84th percentile = 3.306
 95th percentile = 8.411

MEC Analytical Systems, Inc.
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GRAIN SIZE ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhoff
 Date of analysis: 9Feb94
 Date of report: 15Feb94
 Analysis method: Sieve/pipette (Plumb, 1981)
 Sample Identification: Station 39B
 Total sample weight: 32.252 grams

| ----- Size ----- | | Weight | | Cumulative |
|------------------|-------|--------|---------|------------|
| Microns | Phi | grams | Percent | Percent |
| 2000.000 | -1.0 | 0.009 | 0.028 | 0.028 |
| 1414.214 | -0.5 | 0.004 | 0.012 | 0.040 |
| 1000.000 | 0.0 | 0.004 | 0.012 | 0.053 |
| 707.107 | 0.5 | 0.011 | 0.034 | 0.087 |
| 500.000 | 1.0 | 0.042 | 0.130 | 0.217 |
| 353.553 | 1.5 | 0.782 | 2.425 | 2.642 |
| 250.000 | 2.0 | 2.415 | 7.488 | 10.130 |
| 176.777 | 2.5 | 14.308 | 44.363 | 54.493 |
| 125.000 | 3.0 | 11.604 | 35.979 | 90.472 |
| 88.388 | 3.5 | 1.061 | 3.290 | 93.761 |
| 62.500 | 4.0 | 0.140 | 0.434 | 94.195 |
| 31.250 | 5.0 | 0.081 | 0.252 | 94.447 |
| 15.625 | 6.0 | 0.162 | 0.503 | 94.950 |
| 7.812 | 7.0 | 0.041 | 0.126 | 95.076 |
| 3.906 | 8.0 | 0.203 | 0.629 | 95.705 |
| 1.953 | 9.0 | 0.041 | 0.126 | 95.831 |
| < 1.953 | > 9.0 | 1.345 | 4.169 | 100.000 |

% < 4 phi = 5.805
 % > 1 phi = 0.087
 % gravel = 0.028
 % sand = 94.167
 % silt = 1.509
 % clay = 4.295

Sample Statistics

| Median | | Mean | | Dispersion | Skewness |
|--------|---------|-------|---------|------------|----------|
| phi | microns | phi | microns | | |
| 2.449 | 183.09 | 2.488 | 178.24 | 0.422 | 0.092 |

5th percentile = 1.657
 16th percentile = 2.066
 50th percentile = 2.449
 84th percentile = 2.910
 95th percentile = 6.397

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GRAIN SIZE ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhoff
 Date of analysis: 9Feb94
 Date of report: 15Feb94
 Analysis method: Sieve/pipette (Plumb, 1981)
 Sample Identification: Station 50B
 Total sample weight: 34.779 grams

| Size | Phi | Weight grams | Percent | Cumulative Percent |
|----------|-------|-----------------|---------|-----------------------|
| 2000.000 | -1.0 | 10.379 | 29.842 | 29.842 |
| 1414.214 | -0.5 | 3.795 | 10.912 | 40.754 |
| 1000.000 | 0.0 | 6.084 | 17.493 | 58.247 |
| 707.107 | 0.5 | 5.023 | 14.442 | 72.690 |
| 500.000 | 1.0 | 4.900 | 14.089 | 86.779 |
| 353.553 | 1.5 | 2.812 | 8.085 | 94.864 |
| 250.000 | 2.0 | 0.992 | 2.852 | 97.716 |
| 176.777 | 2.5 | 0.187 | 0.538 | 98.254 |
| 125.000 | 3.0 | 0.061 | 0.175 | 98.429 |
| 88.388 | 3.5 | 0.010 | 0.029 | 98.458 |
| 62.500 | 4.0 | 0.003 | 0.009 | 98.467 |
| 31.250 | 5.0 | 0.041 | 0.117 | 98.583 |
| 15.625 | 6.0 | 0.041 | 0.117 | 98.700 |
| 7.812 | 7.0 | 0.041 | 0.117 | 98.817 |
| 3.906 | 8.0 | 0.041 | 0.117 | 98.933 |
| 1.953 | 9.0 | 0.041 | 0.117 | 99.050 |
| < 1.953 | > 9.0 | 0.330 | 0.950 | 100.000 |

% < 4 phi = 1.533
 % > 1 phi = 72.690
 % gravel = 29.842
 % sand = 68.624
 % silt = 0.467
 % clay = 1.067

Sample Statistics

| Median phi microns | Mean phi microns | Dispersion | Skewness |
|-----------------------|---------------------|------------|----------|
| 0 1178 | 0 1289 | 1.268 | -0.103 |

5th percentile = .
 16th percentile = -1.634
 50th percentile = -0.236
 84th percentile = 0.901
 95th percentile = 1.524
 *** 5th percentile not obtainable ***
 *** 16th percentile extrapolated ***

MEC Analytical Systems, Inc.
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GRAIN SIZE ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhoff
 Date of analysis: 9Feb94
 Date of report: 15Feb94
 Analysis method: Sieve/pipette (Plumb, 1981)
 Sample Identification: Station 58B
 Total sample weight: 32.914 grams

| Size | Phi | Weight | Percent | Cumulative |
|----------|-------|--------|---------|------------|
| Microns | | grams | | Percent |
| 2000.000 | -1.0 | 1.172 | 3.561 | 3.561 |
| 1414.214 | -0.5 | 0.521 | 1.583 | 5.144 |
| 1000.000 | 0.0 | 1.007 | 3.059 | 8.203 |
| 707.107 | 0.5 | 3.300 | 10.026 | 18.229 |
| 500.000 | 1.0 | 10.764 | 32.703 | 50.932 |
| 353.553 | 1.5 | 13.507 | 41.037 | 91.969 |
| 250.000 | 2.0 | 1.367 | 4.153 | 96.123 |
| 176.777 | 2.5 | 0.577 | 1.753 | 97.876 |
| 125.000 | 3.0 | 0.207 | 0.629 | 98.505 |
| 88.388 | 3.5 | 0.034 | 0.103 | 98.608 |
| 62.500 | 4.0 | 0.006 | 0.018 | 98.626 |
| 31.250 | 5.0 | 0.041 | 0.123 | 98.749 |
| 15.625 | 6.0 | 0.041 | 0.123 | 98.873 |
| 7.812 | 7.0 | 0.041 | 0.123 | 98.996 |
| 3.906 | 8.0 | 0.081 | 0.247 | 99.242 |
| 1.953 | 9.0 | 0.041 | 0.123 | 99.366 |
| < 1.953 | > 9.0 | 0.209 | 0.634 | 100.000 |

% < 4 phi = 1.374
 % > 1 phi = 18.229
 % gravel = 3.561
 % sand = 95.065
 % silt = 0.616
 % clay = 0.758

Sample Statistics

| Median | Mean | Dispersion | Skewness |
|--------------|--------------|------------|----------|
| phi microns | phi microns | | |
| 0.986 504.97 | 0.896 537.43 | 0.507 | -0.177 |

5th percentile = -0.545
 16th percentile = 0.389
 50th percentile = 0.986
 84th percentile = 1.403
 95th percentile = 1.865

MEC Analytical Systems, Inc.
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GRAIN SIZE ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhoff
 Date of analysis: 9Feb94
 Date of report: 15Feb94
 Analysis method: Sieve/pipette (Plumb, 1981)
 Sample Identification: Station 59B
 Total sample weight: 18.775 grams

| Microns | Size | Phi | Weight grams | Percent | Cumulative Percent |
|----------|------|-------|--------------|---------|--------------------|
| 2000.000 | | -1.0 | 1.646 | 8.767 | 8.767 |
| 1414.214 | | -0.5 | 0.273 | 1.454 | 10.221 |
| 1000.000 | | 0.0 | 0.308 | 1.640 | 11.861 |
| 707.107 | | 0.5 | 0.252 | 1.342 | 13.204 |
| 500.000 | | 1.0 | 0.304 | 1.619 | 14.823 |
| 353.553 | | 1.5 | 0.352 | 1.875 | 16.697 |
| 250.000 | | 2.0 | 0.614 | 3.270 | 19.968 |
| 176.777 | | 2.5 | 0.543 | 2.892 | 22.860 |
| 125.000 | | 3.0 | 0.463 | 2.466 | 25.326 |
| 88.388 | | 3.5 | 0.251 | 1.337 | 26.663 |
| 62.500 | | 4.0 | 0.213 | 1.134 | 27.797 |
| 31.250 | | 5.0 | 0.811 | 4.322 | 32.119 |
| 15.625 | | 6.0 | 0.893 | 4.754 | 36.873 |
| 7.812 | | 7.0 | 2.799 | 14.910 | 51.782 |
| 3.906 | | 8.0 | 0.041 | 0.216 | 51.998 |
| 1.953 | | 9.0 | 8.073 | 43.000 | 94.999 |
| < 1.953 | > | > 9.0 | 0.939 | 5.001 | 100.000 |

% < 4 phi = 72.203
 % > 1 phi = 13.204
 % gravel = 8.767
 % sand = 19.030
 % silt = 24.201
 % clay = 48.002

Sample Statistics

| Median | | Mean | | Dispersion | Skewness |
|--------|---------|-------|---------|------------|----------|
| phi | microns | phi | microns | | |
| 6.880 | 8.49 | 5.029 | 30.63 | 3.715 | -0.498 |

5th percentile = .
 16th percentile = 1.314
 50th percentile = 6.880
 84th percentile = 8.744
 95th percentile = .
 *** 5th percentile not obtainable ***
 *** 95th percentile not reached ***

MEC Analytical Systems, Inc.
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GRAIN SIZE ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhoff
 Date of analysis: 9Feb94
 Date of report: 15Feb94
 Analysis method: Sieve/pipette (Plumb, 1981)
 Sample Identification: Station 60B
 Total sample weight: 30.049 grams

| Size | Phi | Weight grams | Percent | Cumulative Percent |
|----------|-------|-----------------|---------|-----------------------|
| 2000.000 | -1.0 | 0.029 | 0.097 | 0.097 |
| 1414.214 | -0.5 | 0.021 | 0.070 | 0.166 |
| 1000.000 | 0.0 | 0.061 | 0.203 | 0.369 |
| 707.107 | 0.5 | 0.119 | 0.396 | 0.765 |
| 500.000 | 1.0 | 0.265 | 0.882 | 1.647 |
| 353.553 | 1.5 | 3.568 | 11.874 | 13.521 |
| 250.000 | 2.0 | 5.330 | 17.738 | 31.259 |
| 176.777 | 2.5 | 12.194 | 40.580 | 71.839 |
| 125.000 | 3.0 | 5.617 | 18.693 | 90.532 |
| 88.388 | 3.5 | 0.605 | 2.013 | 92.546 |
| 62.500 | 4.0 | 0.165 | 0.549 | 93.095 |
| 31.250 | 5.0 | 0.243 | 0.810 | 93.905 |
| 15.625 | 6.0 | 0.122 | 0.405 | 94.310 |
| 7.812 | 7.0 | 0.527 | 1.755 | 96.065 |
| 3.906 | 8.0 | 0.041 | 0.135 | 96.200 |
| 1.953 | 9.0 | 0.081 | 0.270 | 96.470 |
| < 1.953 | > 9.0 | 1.061 | 3.530 | 100.000 |

% < 4 phi = 6.905
 % > 1 phi = 0.765
 % gravel = 0.097
 % sand = 92.998
 % silt = 3.105
 % clay = 3.800

Sample Statistics

| Median phi microns | Mean phi microns | Dispersion | Skewness |
|-----------------------|---------------------|------------|----------|
| 2.231 213.02 | 2.198 218.00 | 0.628 | -0.053 |

5th percentile = 1.141
 16th percentile = 1.570
 50th percentile = 2.231
 84th percentile = 2.825
 95th percentile = 6.393

MEC Analytical Systems, Inc.
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 Carlsbad, CA 92008

GRAIN SIZE ANALYSIS

Contract: ALCATRAZ
 Contact person: Dr. William Muellenhoff
 Date of analysis: 9Feb94
 Date of report: 15Feb94
 Analysis method: Sieve/pipette (Plumb, 1981)
 Sample Identification: Station 61B
 Total sample weight: 32.849 grams

| Size | | Weight | | Cumulative | |
|----------|-------|--------|---------|------------|---------|
| Microns | Phi | grams | Percent | Percent | Percent |
| 2000.000 | -1.0 | 10.729 | 32.661 | 32.661 | 32.661 |
| 1414.214 | -0.5 | 0.766 | 2.332 | 34.993 | 34.993 |
| 1000.000 | 0.0 | 0.549 | 1.671 | 36.665 | 36.665 |
| 707.107 | 0.5 | 0.346 | 1.053 | 37.718 | 37.718 |
| 500.000 | 1.0 | 0.523 | 1.592 | 39.310 | 39.310 |
| 353.553 | 1.5 | 1.592 | 4.846 | 44.156 | 44.156 |
| 250.000 | 2.0 | 5.336 | 16.244 | 60.400 | 60.400 |
| 176.777 | 2.5 | 5.427 | 16.521 | 76.921 | 76.921 |
| 125.000 | 3.0 | 3.903 | 11.882 | 88.803 | 88.803 |
| 88.388 | 3.5 | 0.472 | 1.437 | 90.240 | 90.240 |
| 62.500 | 4.0 | 0.198 | 0.603 | 90.843 | 90.843 |
| 31.250 | 5.0 | 0.162 | 0.494 | 91.337 | 91.337 |
| 15.625 | 6.0 | 0.609 | 1.853 | 93.189 | 93.189 |
| 7.812 | 7.0 | 0.284 | 0.865 | 94.054 | 94.054 |
| 3.906 | 8.0 | 0.122 | 0.371 | 94.424 | 94.424 |
| 1.953 | 9.0 | 0.365 | 1.112 | 95.536 | 95.536 |
| < 1.953 | > 9.0 | 1.466 | 4.464 | 100.000 | 100.000 |

% < 4 phi = 9.157
 % > 1 phi = 37.718
 % gravel = 32.661
 % sand = 58.181
 % silt = 3.582
 % clay = 5.576

Sample Statistics

| Median | Mean | Dispersion | Skewness |
|--------------|-------------|------------|----------|
| phi microns | phi microns | | |
| 1.680 312.11 | * | | |

5th percentile =
 16th percentile =
 50th percentile = 1.680
 84th percentile = 2.798
 95th percentile = 8.518
 *** 5th percentile not obtainable ***
 *** 16th percentile not obtainable ***
 *** 16th percentile extrapolated ***

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