Palos Verdes

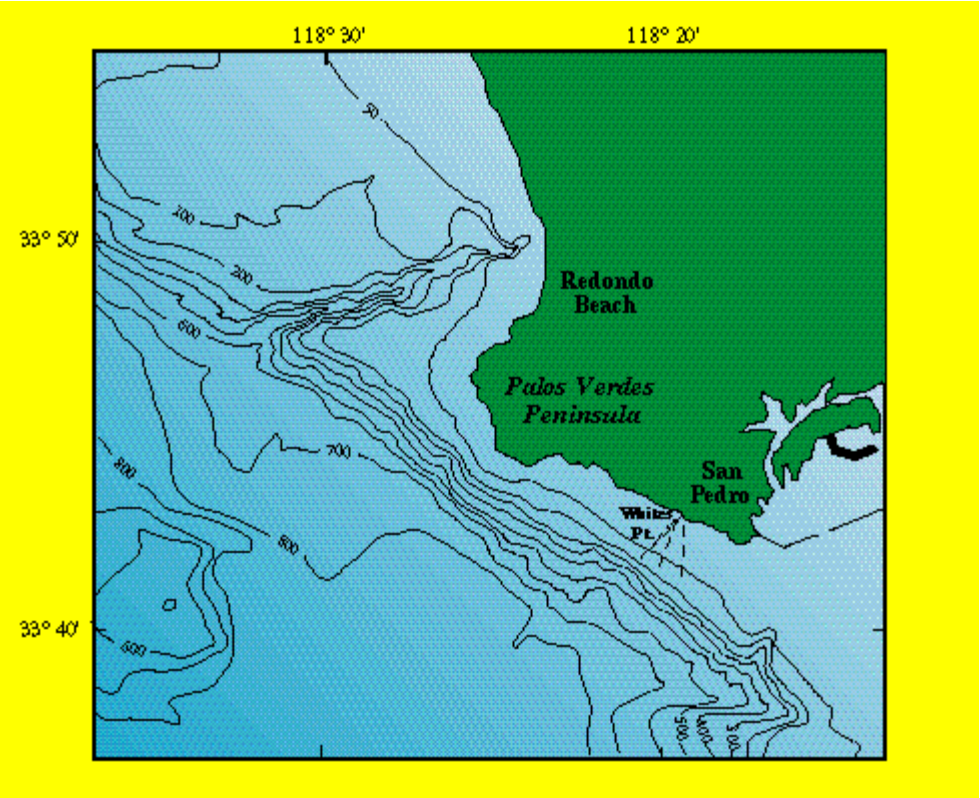
- Sidescan Sonar Survey
- Acoustic Subbottom Profiling
- Camera Survey
  - Images
- Vibracore
- Box Cores
  - Processing a Boxcore
  - Subsamples
- Gravity Core
- Other Samples Collected
- Shelf Circulation Patterns
- Benthic Tripod
- Publications

PCMSC Links

- Southern California Studies
- PCMSC Home Page
- Search PCMSC

Distribution and Fate of Contaminated Seafloor Sediment on the Shelf Offshore Los Angeles

Studies through 1998



Historical background

One of the world's largest producers of DDT was connected to the Los Angeles County sewer system during the 1950's and 1960's. A significant quantity of DDT passed through the sewer system and out the Whites Point outfall into the ocean off the Palos Verdes Peninsula. Several other industries allowed PCBs to pass into the same sewer system, and these substances were also discharged into the marine environment near Palos Verdes.

These contaminants, DDT and PCBs, became associated with organic matter and other solids in the outfall, as well as ordinary sediment particles, to form a contaminated sediment deposit on the continental shelf and slope. These contaminants seriously impacted, and continue to impact, sediment dwelling organisms, fish, and birds.

The largest quantites of DDT discharged to the sewer system by the DDT producer occurred up until the early 1970's, and sediment deposited subsequently is less contaminated with DDT. However, biological and physical mixing processes continue to transfer older, highly contaminated sediment to the sea-floor surface, maintaining a risk to the environment.

Overview

Between 1992 and 1994 the USGS conducted surveys off the southern coast of the Palos Verdes Peninsula. On the Palos Verdes margin, sediment and sediment transport processes are heavily impacted by the Whites Point Outfall of the Los Angeles County Sanitation Districts, which discharges sewage at a water depth of 60 m on the continental shelf. A sediment deposit, derived in part from sewage effluent, has accumulated on the shelf and slope and is contaminated with a number of pollutants, including DDT and PCBs. The purpose of the USGS work was to map the areal and subbottom distribution of DDT and PCBs and to predict the future distribution of these contaminants if no remediation efforts were initiated. A multidisciplinary, multiorganizational project was developed.

Sidescan sonar, high resolution subbottom profiling, and ultra high resolution (chirp) profiling was conducted over a large area in the vicinity of the Palos Verde Peninsula. The area surveyed includes a complete sediment transport cell, extending from near the outfall pipes in the vicinity of Point Fermin, past Point Vicinte, into Redondo Canyon and out onto Redondo Fan within the San Pedro Basin.

In addition to the surveys mentioned previously a seafloor camera-sled survey was conducted on parts of the Palos Verdes continental margin to image the surficial character of effluent-affected sediment deposited on the seafloor near the White's Point outfall.

In addition to the previously mentioned surveys, seventeen 6-meter long vibracores were collected on the shelf between Point Fermin and Redondo Canyon. The cores have been logged for physical properties, split and described. Box cores and gravity cores were taken at 70 sites on the shelf, slope and basin. These cores, which mostly sample contaminated sediment, were logged and tested for contaminants, organic carbon, and texture. Many samples were also taken onshore from beaches on the peninsula.

Prior to this study, there was only a limited amount of information about the likely pathways for transport of the contaminated sediment because historic measurements of environmental influences were limited.

Long-term measurements of currents, wind stress and the associated wave climate were needed so that reliable models that predict the movement, dispersal and eventual fate of contaminated sediment could be developed. Hence, four moorings and an associated benthic tripod were deployed on the shelf and upper slope to measure the vertical and horizontal structure of currents, temperature, salinity, water clarity and wave climate for periods from several months to a year. Predictions of the fate of polluted sediment were developed from numerical models that used these data.

Some of our results:

-
- Acoustic profiling clearly showed a 20- to 60-cm thick low-density sediment layer extending over much of the 3 km by 10 km continental shelf.

Physical property testing of cores confirmed the presence of a 20- to 60-cm thick low-density sediment layer on the shelf and also showed that the layer extended well down the 3 km by 10 km continental slope.
- Chemical analyses confirmed that virtually the entire sediment is contaminated with DDT and PCBs.
- Results indicate that at least 100 tons of DDT are present on the Palos Verdes margin, and that significant amounts of DDT and PCBs will remain near the sediment surface and thus remain biologically available well into the next century.
- The effluent-affected deposit covers an area greater than 40 square kilometers. The volume of the contaminated sediment exceeds 9 million cubic meters.

Other institutions involved:

- University of Virginia
- Woods Hole Oceanographic Institution
- University of Southern California
- Battelle Organization
- Arthur D. Little Company

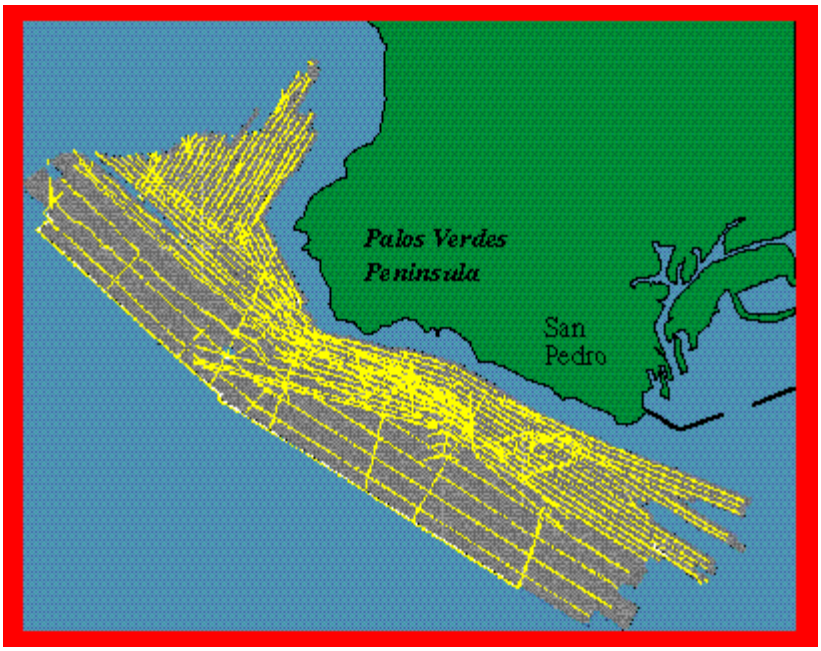
Funding for this study was provided by the National Oceanic and Atmospheric Administration (NOAA).

Several publications are available as a result of this study.

Research Vessel *Farnella* was one of the many vessels used for this project.

Palos Verdes

Sidescan Sonar Survey of the Palos Verdes Shelf and Vicinity



Sidescan sonar tracklines (yellow lines) overlain on mosaic

Sidescan sonar data was collected to provide information about the distribution and fate of an effluent-affected sediment deposit from the White's Point outfall. The data were computer processed to produce a digital sidescan sonar mosaic.

As a result of this investigation, a digital mosaic was constructed of the sidescan data that were collected on the continental shelf and slope.

Background Information

Sidescan-sonar mosaics are acoustic images of the seafloor; acoustic energy transmitted from the sidescan tow vehicle is backscattered from the seafloor. These acoustic data have been computer processed. The shades of gray ranging from black to white that define the features of the seafloor on the mosaic represent varying energy levels of acoustic backscatter. The lighter shades correspond to high backscatter levels. Many complex factors determine how sound is backscattered and reflected from the seafloor. Steep slopes and rough bottom are just two elements that backscatter more acoustic energy. Consequently, other data sets were used to supplement and complement the sonar data so that the sonar images could be interpreted as accurately as possible. In particular, high-resolution seismic-reflection profiles, bottom photographs, and sediment samples were evaluated to verify the images collected by the sidescan sonar survey. By so doing, the sonar image can be verified or "ground-truthed".

A few observations

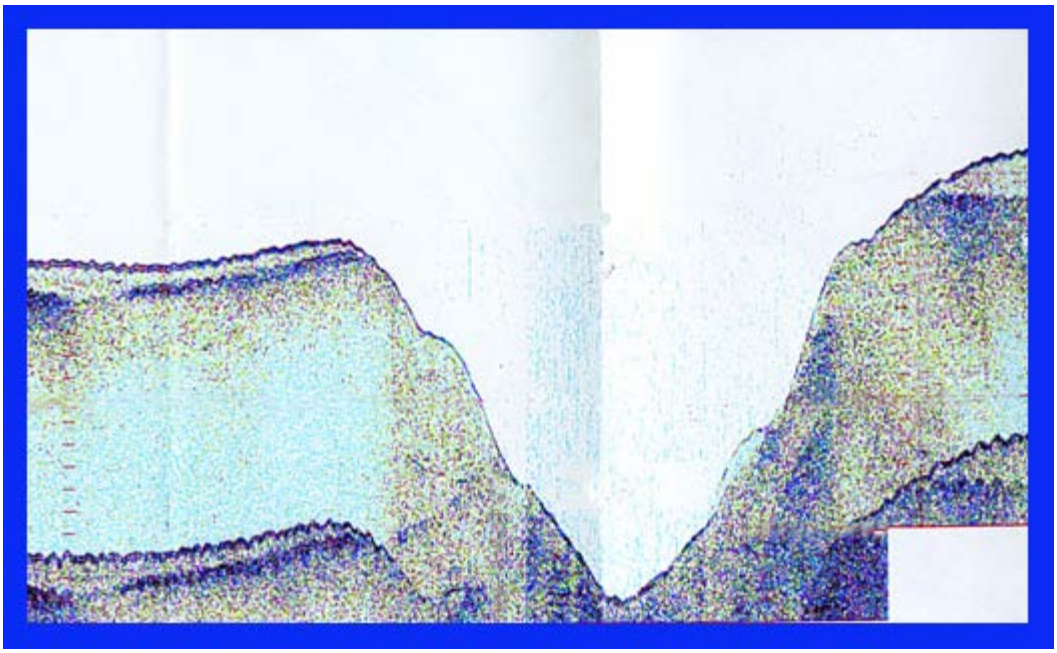
The sidescan sonar imagery provides a plan-view of the seafloor. The most notable aspect of the mosaic in this regard is the uniformity or "smoothness" of the seafloor in the area of the effluent-affected sediment deposit on the shelf between Pt. Vicente and Pt. Fermin. This uniformity is disrupted by bedrock that crops out predominantly east and north of Palos Verdes Point. The outer shelf and upper slope are incised by a series of gullies and small canyons. Numerous circular features that can be described as "pock-mocks" or "boils" occur in the southeastern part of the mosaic. These possibly manifest vents or seeps of hot water that may affect the fate of the sludge deposit.

The mosaic provides valuable information about the distribution of vents of hot, sulfide-rich water, the location of gullies and small canyons on the slope, and the occurrence of bedrock outcrops as well as the prevailing

uniformity of the shelf over the study area.

Palos Verdes

Acoustic Survey of Palos Verdes Shelf and Vicinity



Example of an acoustic record showing a canyon.

An acoustic survey was conducted on the shelf, slope, and basins off the Palos Verdes Peninsula in order to obtain information about the distribution and fate of the deposit from the White's Point diffusers, here called "the effluent-affected sediment deposit". The survey used instruments that profile the strata beneath the seafloor (high-resolution acoustic-reflection profilers) and that image the seafloor in plan view (side scanning sonar). The objectives were to:

- define the distribution of the effluent-affected sediment deposit in three dimensions
- identify pathways and conduits of sediment transport
- identify areas of erosion and deposition
- describe the seafloor morphology

The extent of the effluent-affected sediment deposit was mapped from its appearance in acoustic-reflection profiles. The conclusion that the mapped deposit contains effluent from the White's Point diffusers is based on the deposit's geometry and location (extending from the diffuser pipes and mostly in the direction of regional currents) and on the presence of a low-density surface layer of sediment that contains chemical compounds identified with the effluent, in cores collected from within the mapped extent of the deposit.

The Palos Verdes shelf is a short (12 km), narrow (<3.5 km) section of shallow seafloor off the Palos Verdes Peninsula, situated between the larger San Pedro and Santa Monica Shelves. The shelf seafloor typically is about 75- to 100-m water depth. Steeply sloping seafloor, here termed the "basin slope", lies seaward of the shelf. It descends to the San Pedro Basin where the maximum water depth exceeds 900 m.

The general approach to the survey was to collect image and profile records along regularly spaced, straight tracklines approximately parallel to isobaths on the Palos Verdes and Redondo Shelves, the basin slope, and within San Pedro Basin. Tracklines were spaced so that adjacent side-scan images have substantial overlap, enabling construction of an image mosaic portraying the entire area of the seafloor. In shallow water (less than about 200 m), the total swath width of the images typically was 300 m, and tracklines were spaced at 240 m. In deep water, the swath width was increased to 1,000 m along tracklines spaced at 750 m. Subbottom profiles were collected concurrently with the side-scan images along tracklines, using a combination of profilers. A limited number of profiler tracklines were run normal and oblique to the isobath-parallel tracklines, and zig-zag profiler tracklines were run across some canyons and on the shelf.

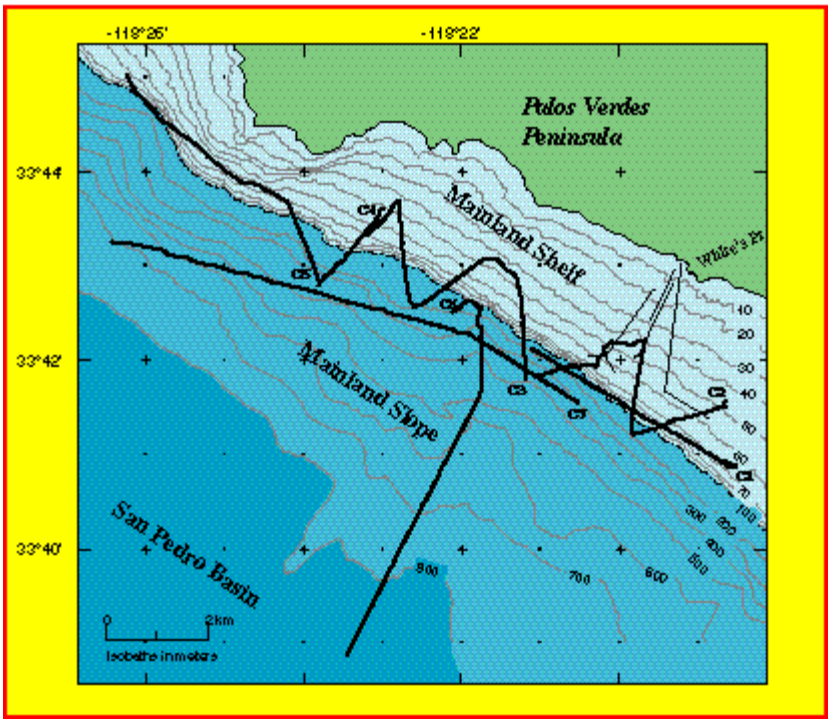
The acoustic instruments used were:

- very high-resolution chirp seismic-reflection profiler
- high-resolution 3.5-kHz seismic-reflection profiler
- 10-kHz bathymetric profiler
- digital high-resolution side-scanning sonar

The ship's position along tracklines was monitored by diffrential GPS, GPS and a shore-based transponder (Del Norte system) navigation system.

Palos Verdes

Camera Survey of the Palos Verdes Shelf and Slope



Map showing camera tracklines

During May 1992, a seafloor camera-sled survey was conducted on parts of the Palos Verdes continental margin to image the surficial character of effluent-affected sediment deposited on the seafloor near the White's Point outfall. A black-and-white silicon-intensified target (SIT) video camera, two Hi-8 mm color video camcorders, and a 35 mm film camera were used to conduct this survey.

The survey consisted of seven camera-sled deployments imaging about 40 trackline--kilometers of seafloor. The lines crossed the middle and outer shelf as well as part of the slope and adjacent San Pedro Basin floor. Surveys

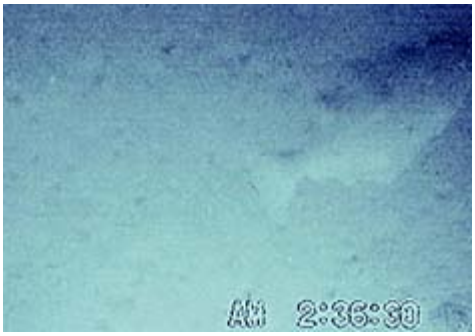
were limited to water depths greater than about 40 meters.

The images show:

- evidence of pervasive disruption of the bed by biogenic activity throughout the study area
- physical reworking in water depths less than 51 meters
- mass-wasting processes on the mainland slope

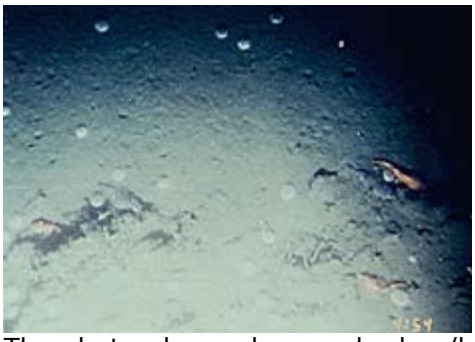
Palos Verdes

A few images from camera survey of the Palos Verdes Shelf and Slope



The photo above shows a California Halibut on the seafloor.


The photo above shows a depression-dominated seafloor.

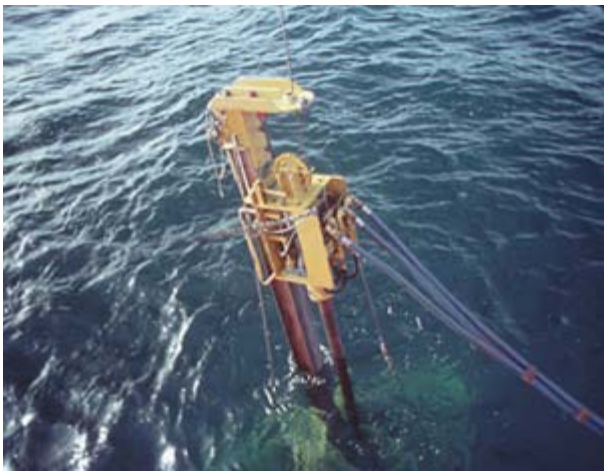

The photo above shows a broken/blocky sediment mass on the seafloor.

Palos Verdes

Vibracore

An Alpine vibracore was used to collect cores on the shelf (shelf here is defined as no deeper then 70-90 meters). An Alpine vibracore is used to collect long cores (approximately 6 meters in length) from a sandy and/or gravelly sea floor. A longer core might provide information on sediment conditons before human occupation. The vibracore is lowered to the sea floor and the core is "vibrated" into the sea floor by an air driven pneumatic motor on top of the corer. The compressed air is provided by an air compressor on deck.

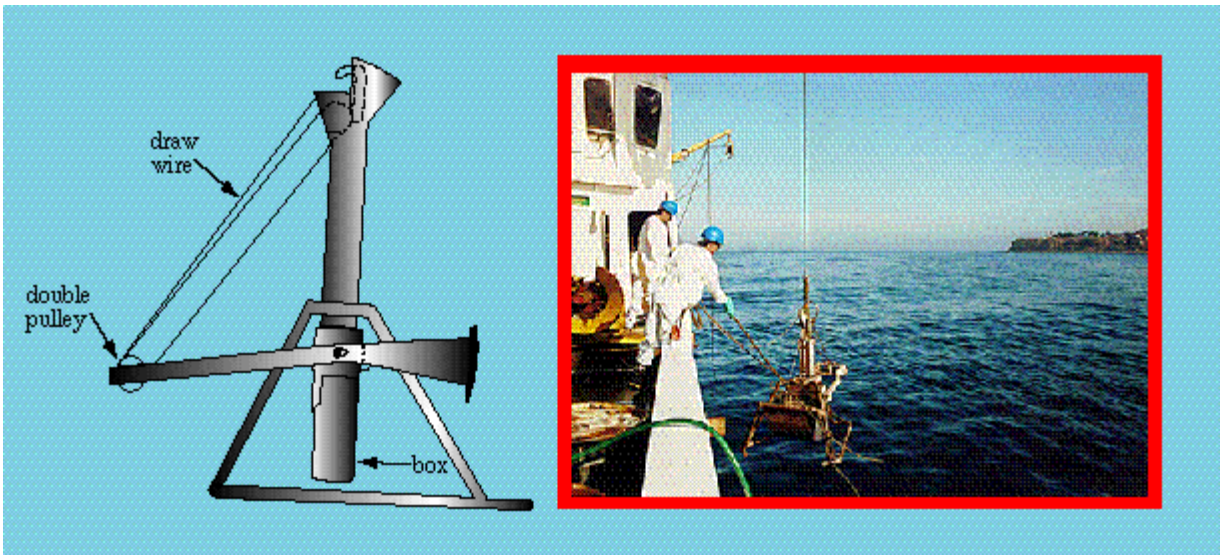
In the photos above the vibracore is being lowered to the sea floor from the deck of the research vessel Farnella. The blue hoses are providing compressed air to the pneumatic motor on top of the corer. The photo below shows the vibracore on the bottom.



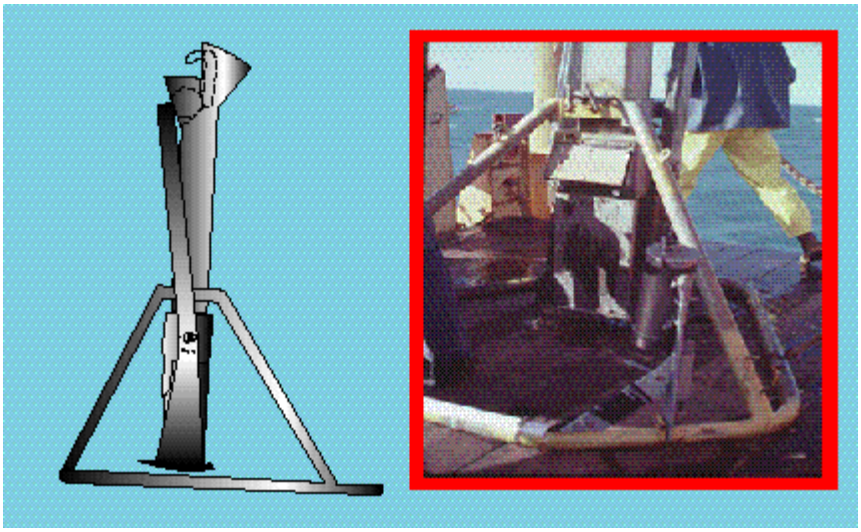
Palos Verdes

Box Cores

Numerous box cores were taken on both the shelf and slope. Box cores are generally much shorter in length then gravity or vibracores but can provide a good undisturbed look at both the geologic and biologic structure of the sediment. It can also preserve the surface layer of the sample and provide valuable information about what the sea floor looks like. Each core is processed and a detailed written description is kept for later use in laboratory analysis. Subsamples were also taken for geochemical and biologic analysis.



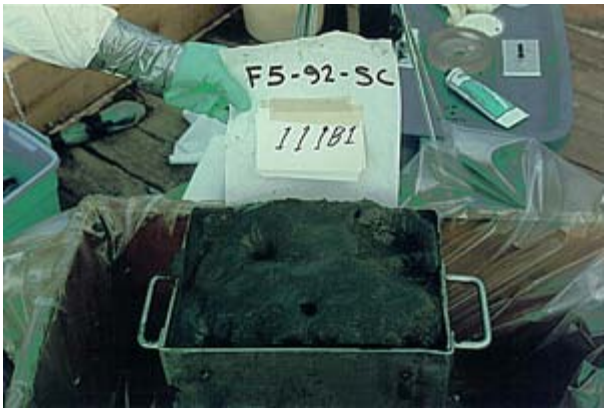
The above diagram shows the box core as it would look on deck before being lowered to the sea floor, notice the "shovel arm" is in a horizontal position. The diagram below shows the box core as it would look with a sample inside after being lowered to the sea floor, notice the "shovel arm" is now vertical which is what keeps the sample in the box.



Palos Verdes

Processing a boxcore

Many photos of the boxcores are taken and a detailed description is written about each core.



The photos above show the top of the boxcore and the "front" of the boxcore once the face plate of the box is removed.

The photo below shows a plexi-glass tray with a "slab" of the boxcore. The "slab" is basically just a thin slice of the boxcore and is kept for later use in analysis back onshore, one of the uses for this kind of sample is for x-ray analysis.

Palos Verdes

Geochemical and biologic subsamples

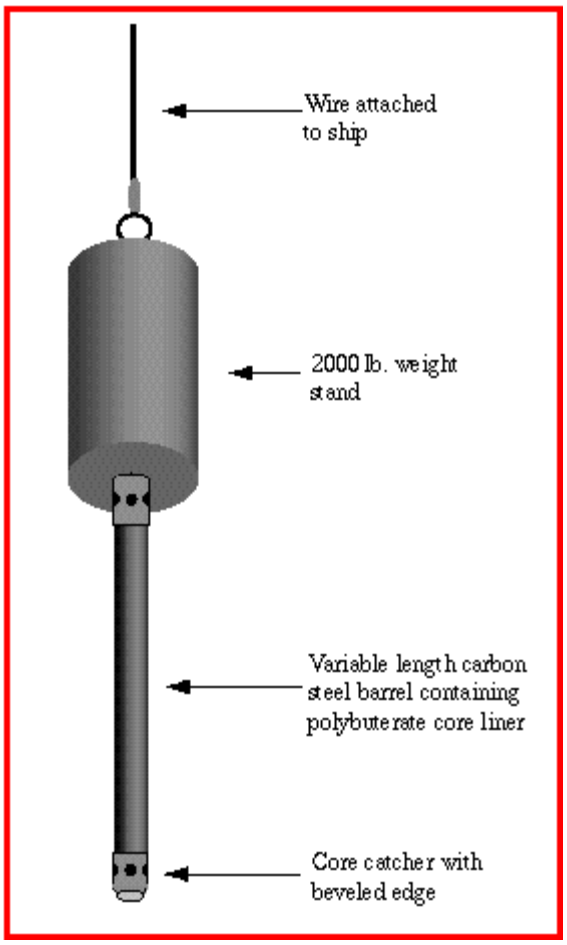
The photo above shows subsamples (tubes with white spots) for geochemical analysis being taken from the boxcore. The photo below shows biologists organizing samples taken for biologic analysis.

Palos Verdes

Gravity core

The gravity core is lowered from the ship to the sea floor. The weight of the weight stand drives the carbon steel barrel into the sea floor. Inside the carbon steel barrel is a clear polybuterate core liner which, when brought back aboard, is pulled out of the carbon steel barrel and capped at both ends. The cores recovered are variable in length depending on the sediment at a particular site.

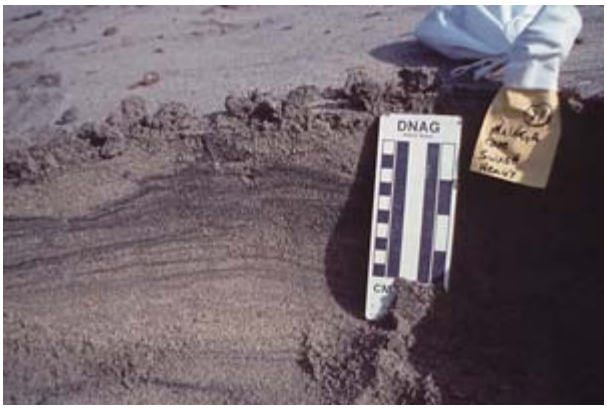
A core from the gravity core would be less disturbed then a vibracore while still preserving the stratigraphy. The gravity core was used at sites where a mud-like bottom was expected.



Palos Verdes

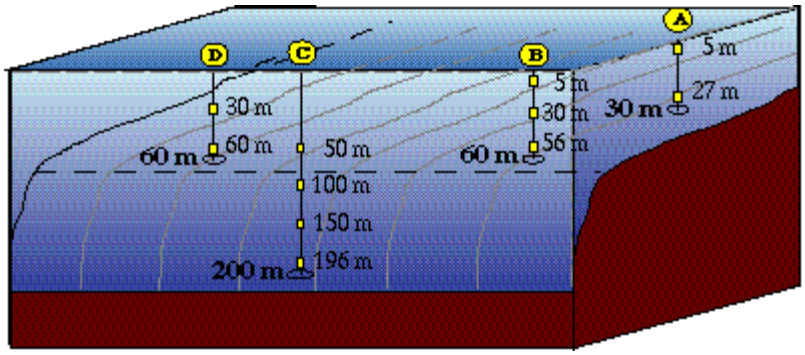
Other samples collected

In addition to the samples taken offshore, samples were taken from beaches on the Palos Verdes Peninsula.



Palos Verdes

Circulation patterns on the Palos Verdes Shelf



A year-long study of the processes that resuspend and transport sediment on the Palos Verdes shelf was begun in May, 1992. A detailed description of current speed and direction in the region and how these current patterns change with location and time was needed as part of this study. For this program, four moorings that measure current, temperature, salinity and water clarity were deployed on the shelf and upper slope for an extended period of time. The information gathered by this array of moorings was designed to provide both a basic description of the circulation patterns in the region and an understanding of important physical processes, especially those processes that control the resuspension and transport of sediment and associated pollutants.

The exact design of each mooring was specific to each measurement site, although there were many features common to each:

- All instruments at a site were attached to a single mooring.
- Either a single or dual acoustic release package was used to connect the mooring to the anchor.
- Each had a surface buoy to mark the measurement site.
- Near-surface instrumentation was attached 4 m below the buoy and elastic tethers below the surface instruments were used to stop the mid-depth and near-bottom instruments from being moved around the by surface waves.

The types of current meters used were vector-averaging current meters (VACM) and vector-averaging current meters with attached transmissometer (VTCT) to record water clarity data. The meters measured the average current direction and speed every 3.75 minutes.

These instruments not only measured currents, but the individual meters were outfitted with different sensors to measure several variables at each site. These additional data types were collected:

- Water clarity (transmission)was measured using transmissometers with a 25-cm path length. The clear water reading for each transmissometer was recorded before each deployment. The sample rate was the same as for the associated current meter.
- Conductivity, which tells us how salty the water is, was measured using conductivity cells. Each conductivity cell was calibrated before each deployment. The sample rate was the same as for the associated current meter.
- Water temperature was measured with temperature sensors installed in the VACM's and VTCT's or data loggers. All temperature sensors were calibrated before deployment. The sample rate was the same as for the associated current meter.

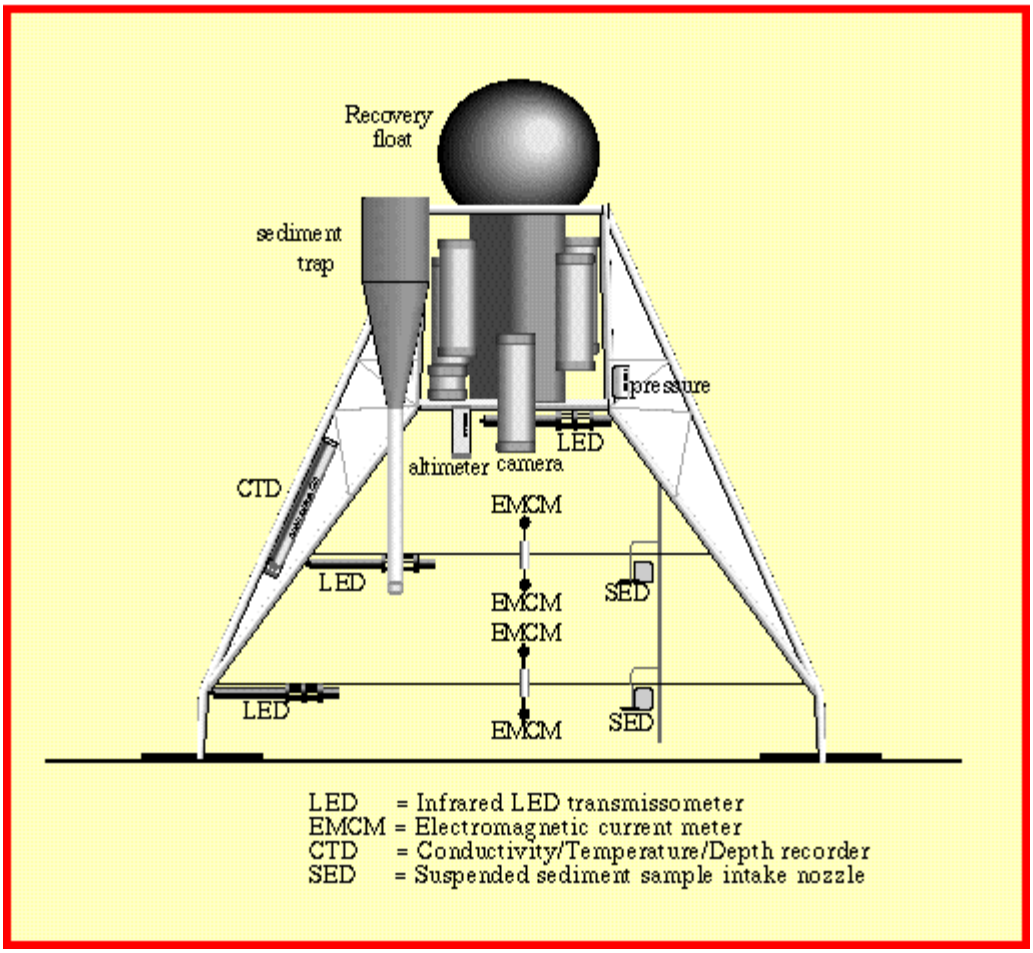
An Anderson sediment trap 0.5-m in diameter was used to collect the resuspended sediment at each site. Intervalometers that dispense discrete layers of Teflon beads at a specified interval were used in many of the sediment traps to generate a time base for when a particular layer of sediment was collected in the trap. The traps were poisoned to inhibit biological mixing and modification of the successive layers in the captured sediment.

All the moorings for this study were designed and prepared by the Sediment Transport Support Team at the Woods Hole Field Center, a part of the USGS Marine and Coastal Geology Program.

The NOAA research vessel *Vickers* was one of the vessels used for deployment/recovery of the moorings.

Palos Verdes

Benthic Tripod



Drawing of benthic tripod set-up used in Palos Verdes study.

Palos Verdes

Publications

- Drake, D. E., 1996,Fecal Pellets in Effluent-Affected Sediment on the Palos Verdes Margin (abstract from poster): EOS Trans. AGU, 76(3), Ocean Sciences Meeting Supplement OS1, 1996
- Edwards, B. D. and Chezar, H., 1996, Camera Surveys of Effluent-Affected Sediment on the Continental Margin near Los Angeles, California (abstract from poster): EOS Trans. AGU, 76(3), Ocean Sciences Meeting Supplement OS1, 1996
- Kayen, R. E., Lee, H. J., and Drake, D. E., 1996, Geotechnical Properties of Effluent-Affected Sediment, Palos Verdes Margin, Southern California (abstract from talk): EOS Trans. AGU, 76(3), Ocean Sciences Meeting Supplement OS1, 1996
- Lee, H. J., Drake, D. E., Edwards, B. D., Hamer, M. R., Hampton, M. A., Karl, H., Kayen, R. E., Wong, F. L., and Murray, C. J., 1996, Contaminated, Effluent-Affected Sediment on the Continental Margin near Los Angeles, California (abstract from talk): EOS Trans. AGU, 76(3), Ocean Sciences Meeting Supplement OS1, 1996
- Lee, Homa J. and Weisberg, Stephen, Guest eds., 2003, Integrated Assessment of an Urban Water Body: Santa Monica Bay, California: Marine Environmental Research Special Issue 56 (1-2)
- Lee, H.J. and Wiberg, P.L., eds., 2002, Sedimentation Processes, DDT, and the Palos Verdes Margin, Southern California: Continental Shelf Research, 22(6-7), p. 835-1115 (April - May 2002)
- Noble, M. A., Harris, C. K., Wiberg, P. L., and C. Sherwood, 1996, Statistical Characterizasions of Current and Wave Patterns on the Southern California Shelf off Palos Verdes for use in Sediment-Transport Models (abstract from poster): EOS Trans. AGU, 76(3), Ocean Sciences Meeting Supplement OS1, 1996
- Wong, F. L. , 1996, Heavy Mineralogy of Effluent-Affected Sediment and Other Deposits, Palos Verdes Shelf, Southern California (abstract from poster): EOS Trans. AGU, 76(3), Ocean Sciences Meeting Supplement OS1, 1996