C-260

Description of Sludge Field Near the Hyperion 7-mile Outfall

by

Bruce Thompson and Harold Stubbs

Southern California Coastal Water Research Project
646 W. Pacific Coast Highway
Long Beach, California 90806

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Introduction

The location and size of the sludge field remaining near the terminus of the non-operational Hyperion 7-mile outfall was not well documented during the Recovery Study. During that study, measurements of core depths were made five times over four years. An estimate of the approximate size and location of the sludge field was included in that report (SCCWRP 1991). However, those estimates were produced from only 8-10 core samples each time and the sludge depths varied in successive cores from the same sites collected over time. In order to provide a better picture of the sludge field, extensive coring was conducted in August of 1991.

The objective of the 1991 coring study was to provide a more accurate description of the areal extent of the sludge field including its location in the Santa Monica Canyon, the sludge depth on the canyon floor, and its variability. This information will provide a sound basis for following the eventual fate of the sludge field as recovery occurs.

Methods

The cores were collected using the Southern California Coastal Water Research Project (SCCWRP) deep sediment corer (Bascom *et al*. 1982) on the M/V Marine Surveyor, August 20-23, 1991. The corer and methods used are detailed in the Recovery Study report. Loran C was used for navigation, with an accuracy of 30 m. The data obtained at each site was a measurement and description of the thickness of various layers collected by the sediment core, and a photograph of the entire core.

A total of 53 samples were obtained (Figure 1, Appendix 1). A sample usually included an intact core sample, up to 140 cm long. The barrel of the corer is only 1 meter long, but the chamber continues 40 cm into the weight supports, with the overflow on top. In the areas with the most sludge, the corer usually penetrated at least 140 cm into the sludge. If sludge filled the corer and out the overflow, the depth was recorded as 140 + cm. The inability to collect an intact core due to rocks or very sandy sediment was considered a sample as it identified areas where there was no sludge.

Sludge was identified based on its deep black color, typical fibrous texture, and a detectable odor of hydrogen sulfide. Often samples contained "old" sludge which had a similar texture, but was grey in color and had no sulfide odor. Since we wanted to define the extent of the "active" sludge field, samples with old sludge were considered to have no sludge in report. Identification of these areas may indicate that either recovery has occurred, or the existence of past episodes of sludge dispersion during full discharge.

Figure 1. Contours of sludge field in Santa Monica Submarine Canyon . Cross-section at "A" is shown in Figure 2.

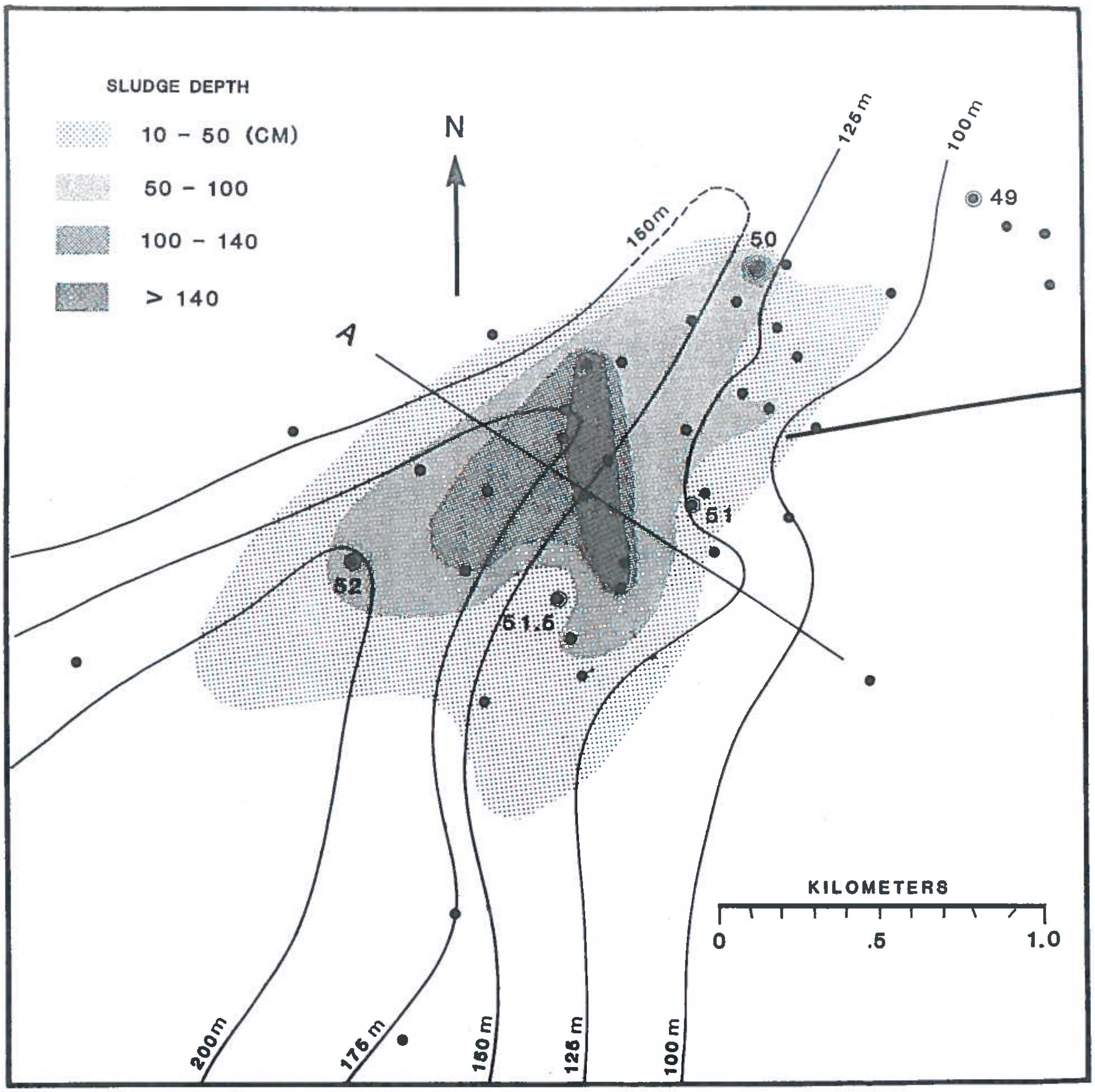
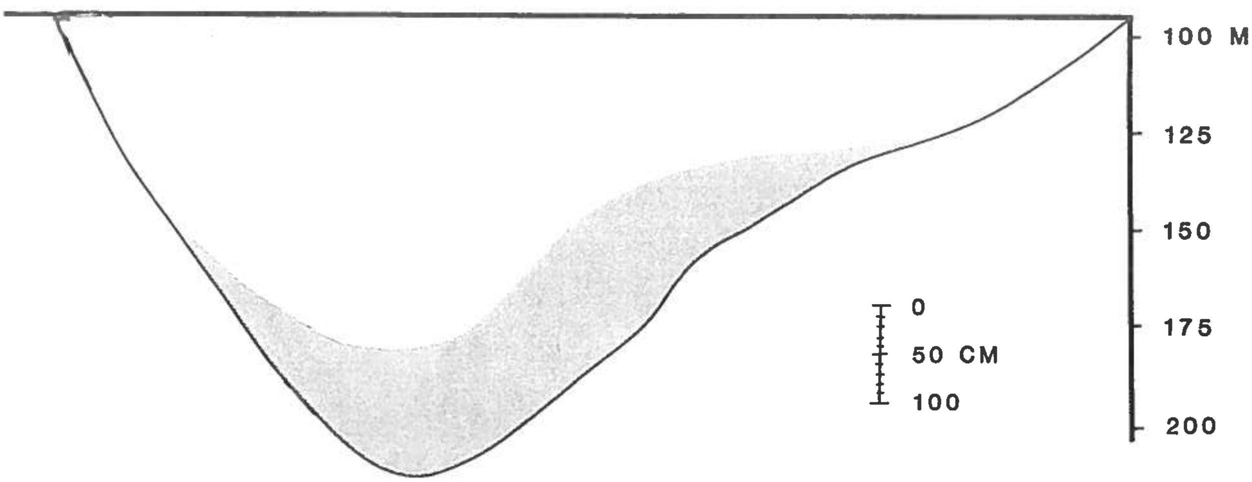


Table 1. Sludge field depths (cm) at three sites sampled at different times. Small scale spatial variation (~50 m) among five replicate cores was sampled August 1991. $\bar{X}$=mean, CV= coefficient of variation.

Date	HR-50	HR-51	HR-51.5
October 1986	50	-	-
April 1988	140+	16	47
November 1988	23	115	106
November 1989	140+	140+	6
September 1990	25	140+	34
August 1991 $\bar{X}$=	120	49	10
CV=	24%	22%	130%

Figure 2. Cross-section profile at "A" on Figure 1.



Results

The sludge field currently covers an area of 1.9 km^2 at the head of the Santa Monica Submarine Canyon. However, only 0.23 km^2 contain sludge in excess of 100 cm deep.

The deepest part of the sludge field is located in the apex of the canyon and along its eastern flank adjacent to the sludge field. This deepest part probably forms an arc between Station HR50 and the other area where sludge was > 140 + as shown on Figure 1. However, not enough cores were collected along the northern edge to adequately define an arc. The main lobe of the sludge field extends down the axis of the canyon 1.8 km to a water depth of about 250 m. Another smaller lobe exists on a small plateau on the eastern canyon flank. A transect across the canyon shows that more sludge exists on the eastern side of the canyon than on the western side (Figure 2).

Almost all of the core samples, except those 140 + that overflowed the corer, had a 1-2 cm layer of clean sediment overlaying the sludge layer. This layer tended to be thicker at the deeper sites; HR52 had a surface layer of 3-5 cm of clean sediment. This sediment was probably entrained into the canyon from the adjacent shelf. Sediment transport into canyons from shelf areas is well documented in other areas off southern California and is a dominant mechanism of sediment transport to deeper areas (Karl *et al.* 1980). This observation demonstrates that burial by clean sediment from the shelf may be an important mechanism for recovery.

Cores collected since October 1986 indicate that the depth of the sludge field is quite variable over time (Table 1). At Station HR50, samples collected in successive years ranged from 23-140 + cm deep. HR50 still contains some of the deepest sludge deposits. Samples at HR51 usually contained deep sludge deposits, over 100 cm deep. However, as of 1991, the replicates ranged between 38-66 cm of sludge, possibly demonstrating that sludge is being transported down canyon. Station HR49 had 22-37 cm of sludge in past samples, but contained no sludge in August 1991. Similar variation was observed at the other sites. Because of this large amount of temporal variation, definite trends in decreasing sludge field size cannot yet be identified. It is not known whether this variation is due to resuspension by strong currents, thus episodic, or whether more constant sediment transport by waves, tides, and gravity down the canyon is responsible.

In addition to the variation over time, there is considerable variation over small spatial scales of about 30 m. Five replicate samples were collected at three sites during the August 1991 cruise. A buoy was deployed at the site so that the Marine Surveyor could be held on station. Post plots of the sample positions indicated that all five replicates were collected within 30 m of each other. The core depths obtained showed variation of about 22-24% at Stations HR50 and 51, where sludge depths were deepest. Variation at Station HR51.5 was higher (130 %), but sludge depths were less with a smaller range. Those samples ranged from areas with rock and cobble and no sludge to more silty sediments with up to 36 cm of sludge. This suggests that the sea-floor at that site is heterogeneous on a scale of less than 30 m containing some rocky areas interspersed by pockets of silty sediments.

Discussion and Conclusions

The tremendous amount of variation in sludge field depths over both time (five years) and space (30 m) precludes a precise estimate of actual sludge field boundaries and volume. Temporal variation is generally greater than small scale variation. Due to this temporal variation and the small number of cores collected before 1991, it is difficult to observe changes in the size of the sludge field since discharge termination. Additionally, the actual depth of sludge in the deepest areas remains unknown. Several cores exceeded the penetration depth of the SCCWRP corer without reaching base sediment.

The 1991 samples will provide a good baseline for evaluation of sludge field recovery in the future. Similar sampling should be conducted annually to evaluate the physical recovery of the sludge fields. One improvement would be to use a 3.5 Khz high resolution acoustic profiler to plot the sludge field area.

Stations HR50 and 51 in the sludge field were sampled continuously during the Recovery Study and have shown considerable recovery in terms of sediment contamination and improved biological conditions (see Recovery Report). It will be important to continue to sample those sites as recovery proceeds. Burial and mixing with clean sediment has apparently facilitated recolonization, but another severe storm or resuspension episode could remove the clean layers of surface sediment exposing the remaining deep layer of sludge. This may cause occasional "relapses" in recovery. Eventually, the processes of resuspension, down-canyon transport, mixing, and burial should remove the sludge, but which processes are most important and how long it will take is not know.

Acknowledgments

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References

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Karl, D.M., D.A. Cacchione, and D.E. Drake. 1980. Erosion and transport of sediments and pollutants in the benthic boundary layer on the San Pedro Shelf, southern California. U.S. Dept. of Interior, Geol. Surv. Open File Report. p. 80-386.

Appendix 1. Stations and Sludge depths

August 20-24, 1991

Station HR		Water Depth (m)	Sludge Depth (cm)
49	28159.9-41137.3	91	0
491E	28159.9-41137.1	85	0
492E	28160.2-41137.2	72	0
50	28158.9-41138.9	140	140 +
501E	28159.1-41138.8	110	0
501N	28159.0-41138.6	133	69
502N	28159.2-41138.0	123	33
503N	28159.4-41138.1	114	10.5
501S	28158.7-41139.0	152	64
502S	28158.3-41139.3	160	64
503S	28158.1-41139.5	175	100
50.5	28158.5-41138.9	136	89
50.51S	28158.9-41138.4	106	39
51	28158.4-41138.1	118	48.7
51-1N	28158.2-41139.5	130	140 +
51-2N	28158.0-41139.0	150	140 +
51-3N	28157.7-41139.7	183	100
51-1S	28158.5-41137.5	102	0
51-2S	28158.5-41137.0	130	0
51-3S	28159.0-41136.2	89	0
51.25E	28158.1-41138.4	132	140 +
51.25N	28158.3-41139.0	151	140 +
51.25S	28158.1-41138.5	133	140 +
51.5N	28158.4-41139.3	168	140 +
51.5	28158.1-41138.8	131	17.2
51.5-S1	28158.0-41138.6	130	61
51.5-S2	28157.8-41138.4	127	37
51.5-S3	28157.3-41138.7	148	25

51.5-N1	28158.7-41138.3	110	34
51.5-N2	28158.8-41138.0	104	62
51.5-N3	28159.0-41137.6	85	0
51.75	28157.6-41139.6	179	100
52	28157.0-41140.4	208	59
52.5	28155.9-41141.9	185	0
51.5.4-S	28156.7-41137.8	171	0-10
51.5.3-S	28157.0-41138.1	194	0
51.4N	28157.4-41140.3	176	83 +
51.5N	28157.0-41141.4	148	0
50.4N	28160.2-41136.6	73	0
50.4S	28157.8-41140.4	127	0