Recovery of Santa Monica Bay After Termination of Sludge Discharge

This progress report prepared by Bruce Thompson describes the environmental changes in Santa Monica Bay after the termination of sludge discharge at the City of Los Angeles Hyperion Treatment Plant's seven-mile outfall in November 1987. Pre-termination sampling began in February 1986 during full sludge discharge and the research methods and results of those studies were summarized in the 1986 and 1987 SCCWRP annual reports.

This report summarizes the progress of recovery in the bay documented during 1988 after sludge discharge was terminated. The results of some data analyses have been completed and the changes in those parameters are described in this progress report; analysis of other samples collected are proceeding in the SCCWRP laboratories. Semi-annual sampling will continue in 1989 and 1990.

Methods

Quarterly sampling in Santa Monica Bay was conducted in January, April, August, and November 1988. Sampling of Santa Monica Bay was conducted in three pre-termination areas of impact: (1) the contaminated area nearest to the old sludge outfall, (2) the transition area, and (3) a reference area representing "normal" Santa Monica Bay conditions (Figure 1). In addition, five sludge field sites were sampled in the Santa Monica submarine canyon. Sampling methods included deep coring of sediment, Van Veen grabs for sediment chemistry and infauna analysis, and otter trawls at 100 m and 200 m depths for

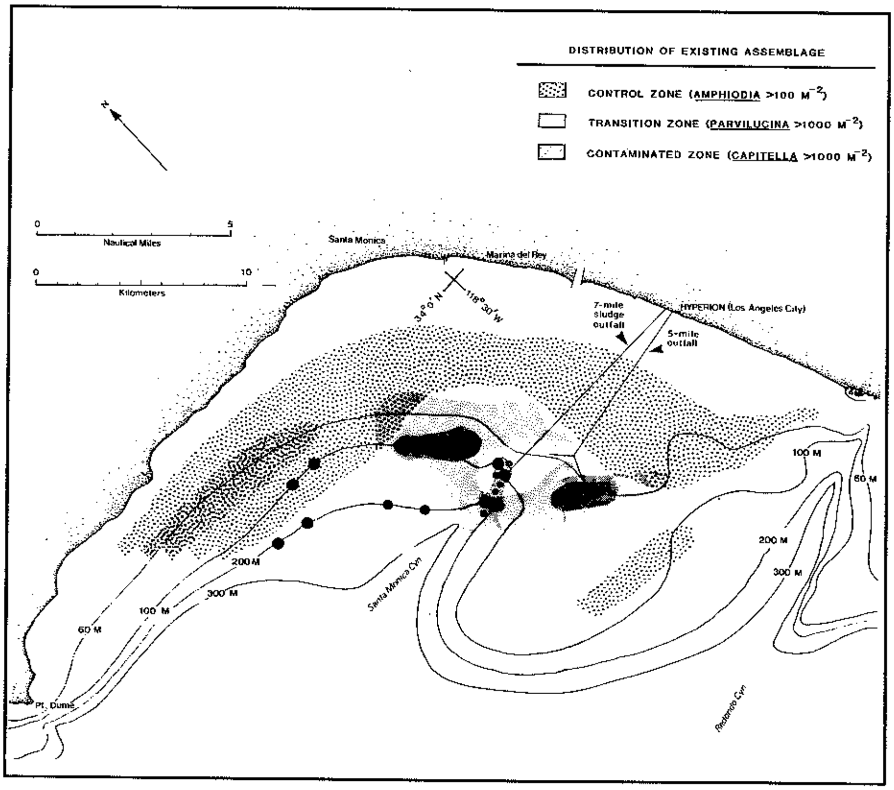

Figure 1. Santa Monica Bay study area.

megafauna and fish.

Tissue samples were collected each summer (August) and analyzed for trace contaminants in two target species: The ridge-backed prawn (*Sicyonia ingentis*) and the Dover sole (*Microstomus pacificus*).

Oceanographic parameters were also measured as a part of this study, including currents, conductivity, temperature, depth, and dissolved oxygen profiles, and will be discussed in detail in future reports.

Standard format graphs, referred to herein as "recovery graphs", were prepared to show the change in the parameters measured over time in each the three zones of impact. The recovery graphs show a recovery threshold - the reference area 95% confidence interval for each parameter. Recovery graph data from the contaminated area sites are expected to converge on this confidence interval as recovery proceeds, and recovery will be considered complete when the parameters measured in the contaminated area are similar to those in the reference area.

Results

Core collections indicate that the sludge field has slumped down Santa Monica Canyon about 0.5 km (Figure 2). Additionally, core collections indicate a thin layer of clean sediment, probably entrained into the canyon from the adjacent shelf of the bay, has been deposited on the surface of the old sludge. Current meters installed in the area of the canyon have measured very high current velocities near the bottom of the

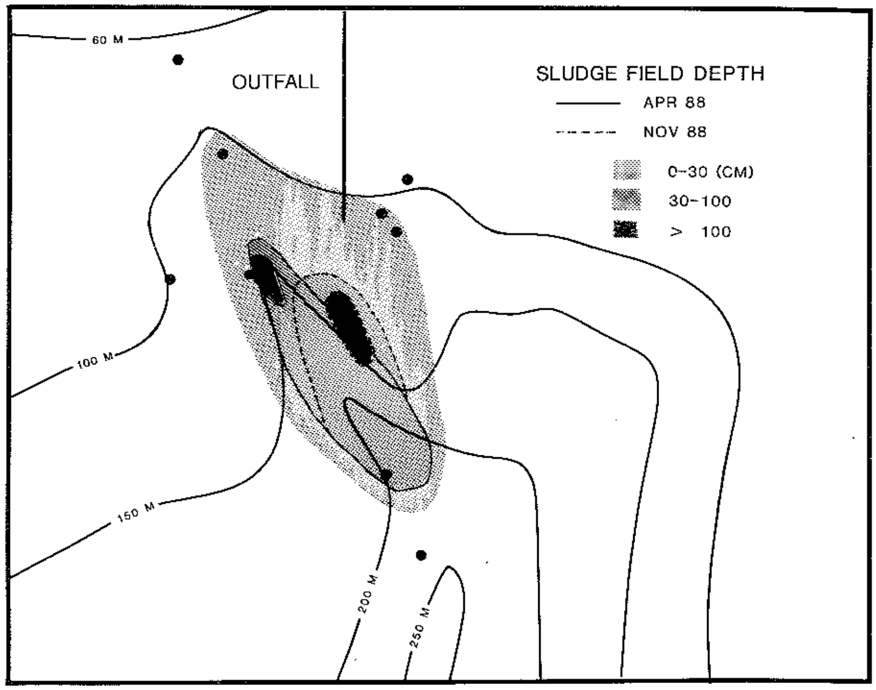

Figure 2. Santa Monica Bay sludge field depth.

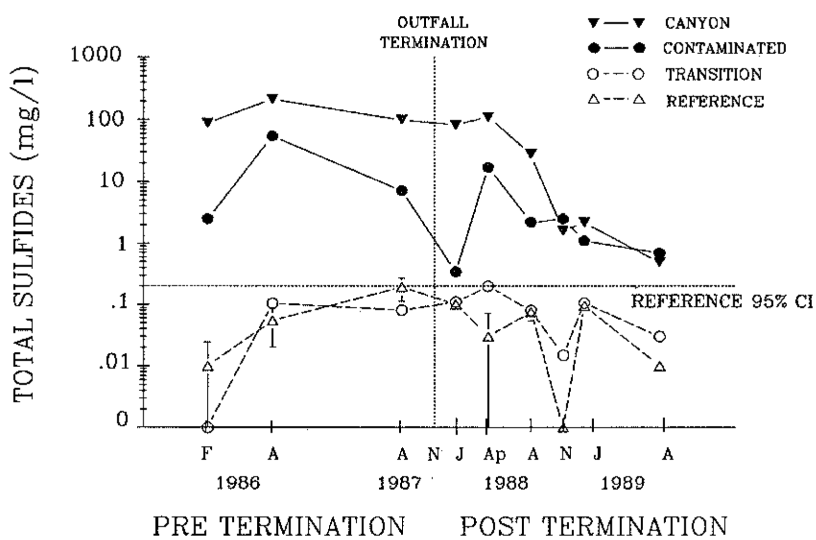

Figure 3. Concentrations of sulfides in sediment.

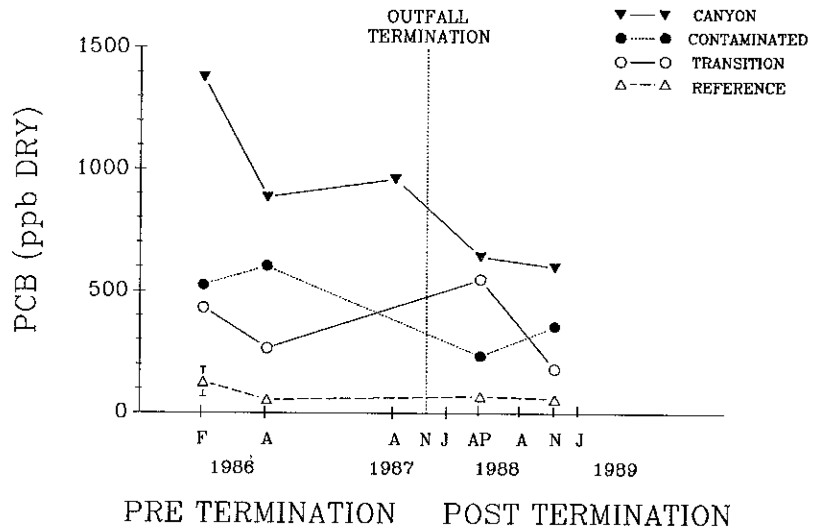

Figure 4. Concentrations of PCBs in sediment.

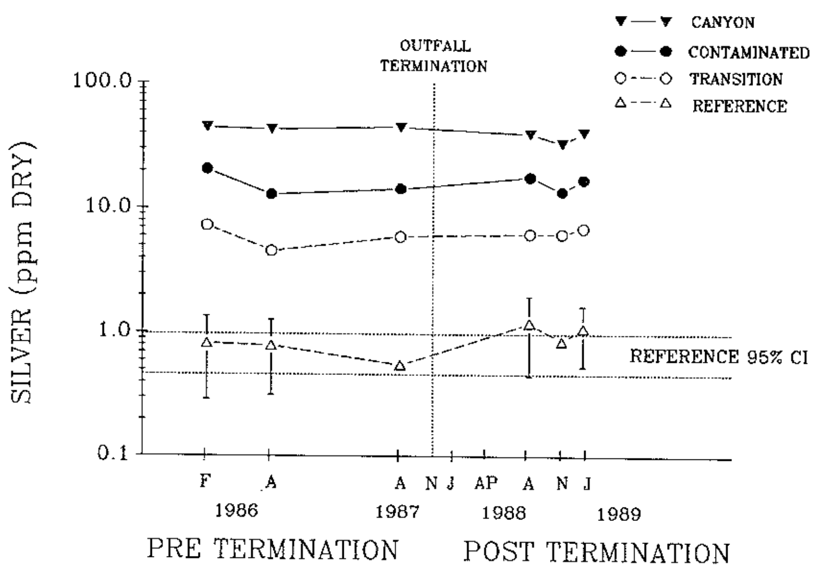

Figure 5. Silver concentrations in sediment samples (100 m and 200 m).

canyon that flow both up and down the canyon axis. This information suggests that recovery may proceed through a combination of down-canyon transport of sediments and burial of sludge-contaminated sediment by clean shelf sediment.

Sulfide concentrations measured in the top 2 cm of the grab samples collected in both the contaminated area and Santa Monica Canyon have decreased by more than two orders of magnitude to near reference levels (Figure 3), and PCB concentrations have decreased by about 48% (Figure 4). However, trace metal concentrations (eg. silver) have not changed since outfall termination (Figure 5).

The most abundant benthic infauna species in the reference area was the brittlestar *Amphiodia urtica*, which occurs in densities of 620/m^2. No *A. urtica* were collected in the contaminated area or canyon sites during pre-termination sampling, and this species has exhibited no evidence of returning to these areas (Figure 6).

The polychaete *Capitella capitata* was most abundant in the contaminated area in densities of 2,818/m^2, but it was found in greatly in reduced abundances (28/m^2) in the sludge field (canyon sites), indicating an intolerance for the severe conditions of the sludge field. This species has decreased two orders of magnitude, to 10/m^2 at the contaminated sites since sludge discharge was terminated, but they have increased at the canyon sites, which is, ironically, a good indication that the sludge field is recovering (Figure 7).

Megafauna species collected during otter trawling were similar at the 200 m deep sites and exhibited no evidence of sludge impact even under full discharge. However, megafauna species collected at the 100 m sites differed when the contaminated sites and the reference sites were compared. The most abundant megafaunal species collected at the contaminated sites in 1986-87

Bruce Thompson and Jimmy Laughlin sorting invertebrates captured during trawls.

during full sludge discharge was the starfish *Astropecten verrilli*, which averaged a mean of 154/trawl. Following termination of discharge, this species decreased in abundance to below reference levels (Figure 8), however, there was considerable variation in the population's response to the environmental changes over time. Abundances of *A. verrilli* at the reference sites have increased, suggesting some natural

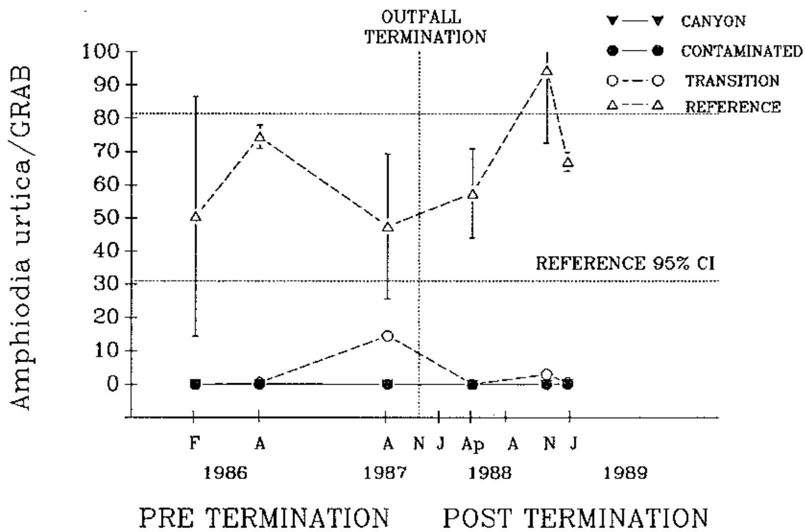

Figure 6. Abundance of *Amphiodia urtica* per grab (100 m).

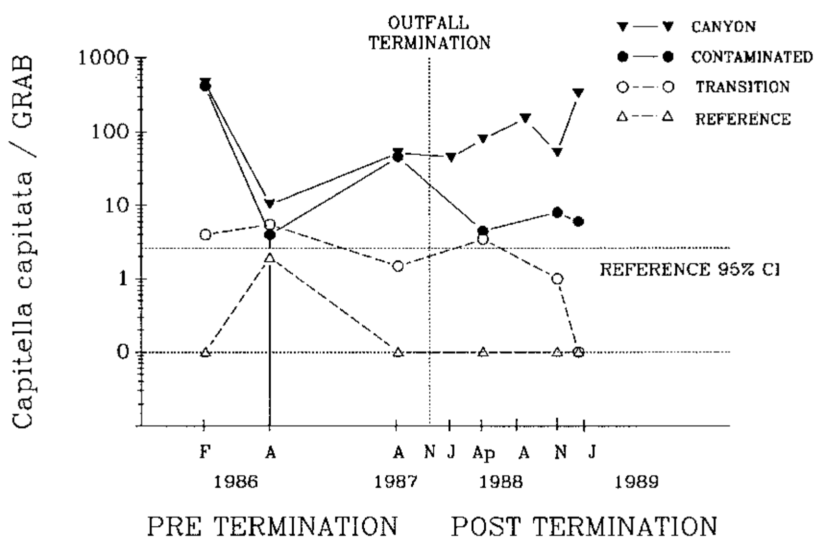

Figure 7. Abundance of *Capitella capitata* per grab.

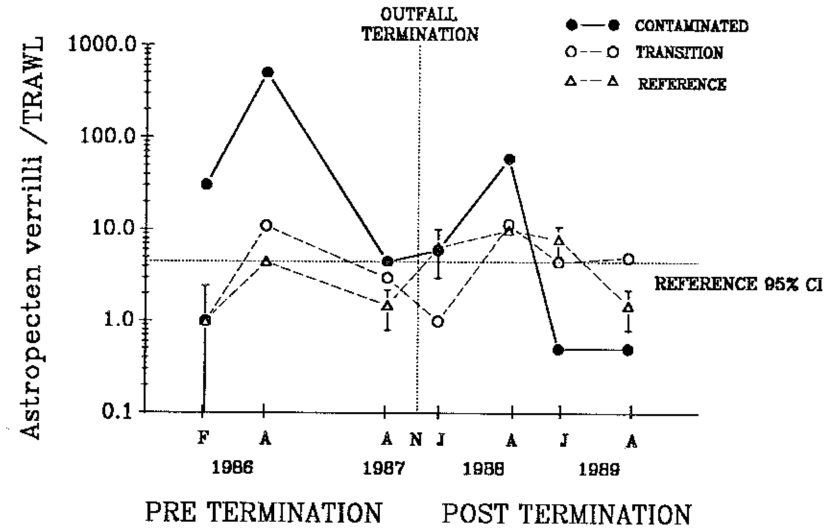

Figure 8. Abundance of *Astropecten verrilli* per trawl.

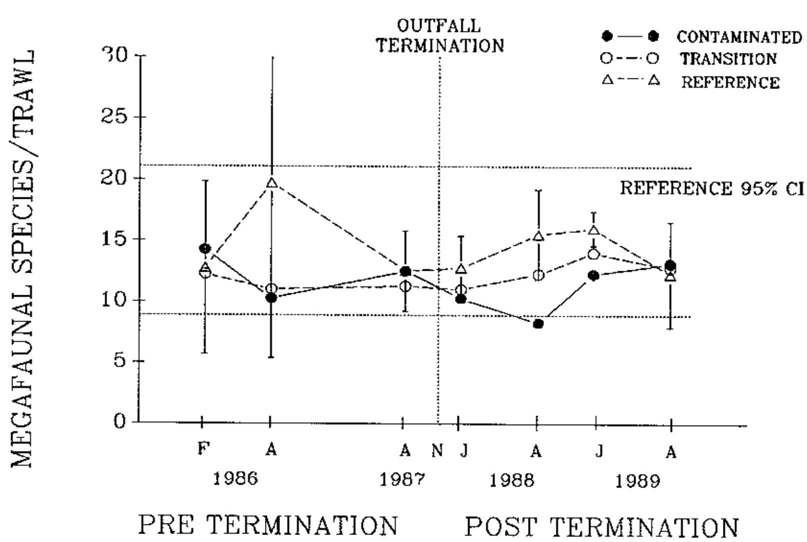

Figure 9. Abundance of megafaunal species per trawl.

variation may have taken place at the contaminated sites. Similar responses were observed in populations of *S. ingentis*.

The urchin *Lytechinus pictus* was most abundant at the reference sites and does not usually occur at the contaminated sites. Since sludge discharge was terminated, there is no evidence of this species returning to the contaminated zone. The number of megafaunal species collected per trawl was similar at all sites, although the species collected were different (Figure 9), therefore this parameter will not be used in evaluating recovery.

The number of fish collected per trawl in the contaminated zone are still below the reference level (Figure 10). Like the megafaunal invertebrates, the fish species collected at all 200 m sample sites were similar and showed no evidence of sludge impact. At the 100 m sites, the fish collected differed when contaminated and reference sites were compared. At the contaminated sites, white croaker (*Genyonemus lineatus*) and Dover sole were the most abundant fish collected. Fewer white croaker were collected at the contaminated sites immediately after termination of sludge discharge (Figure 11). The reduction in the number of white croaker collected after termination may be due to feeding habits; white croaker may feed on suspended particles (among other foods) and termination of sludge discharge may have reduced the food supply of this fish. Dover sole have decreased in abundances since sludge discharge termination, but this species exhibits considerable variation in abundance, and they may be exhibiting a seasonal response similar to that observed for *A. verrilli*. As with the megafaunal invertebrates, the number of fish species caught per trawl were similar at all sampling sites and numbers of fish per trawl have not indicated any trends toward recovery.

Trace metals including silver, cadmium, copper, and zinc were measured in tissue samples from Dover sole livers and *S. ingentis* hepatopancreas. Since sludge discharge was terminated, silver concentrations have decreased to reference levels, but zinc concentrations have not (Figure 12). Levels of cadmium and zinc found in *S. ingentis* and levels of all four trace metals in Dover sole were equal to or less than reference levels measured during full sludge discharge. This information and the fact that *S. ingentis* apparently accumulates silver in their hepatopancreas in high concentrations naturally dictate that these data will not be used to evaluate recovery.

Discussion

The data that have been analyzed one year after termination of the sludge discharge in Santa Monica Bay indicates that some parameters have apparently recovered (eg. decreases in white croaker and *A. verrilli* abundances) and others are still in the process of recovery (eg. sulfide levels and *C. capitata* abundances). Some parameters appear to be changing, but they may be confounded by apparently natural fluctuations (eg. Dover sole and *S. ingentis* responses).

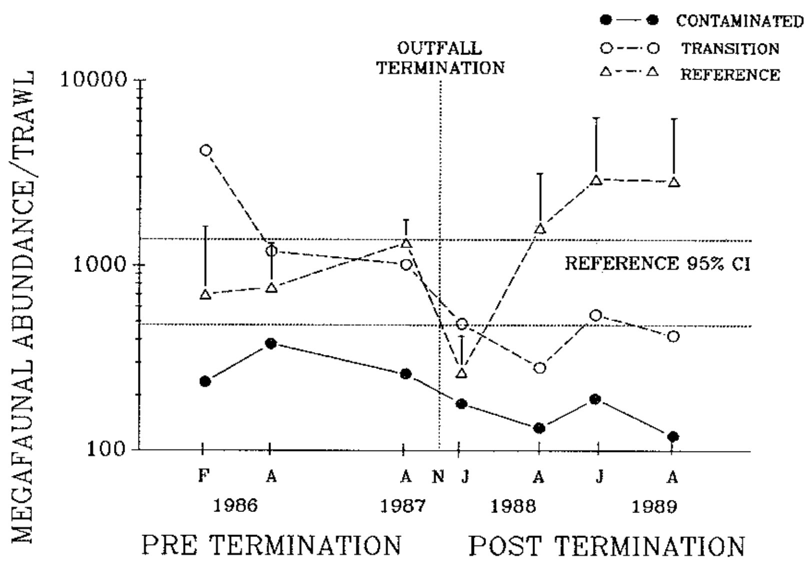

Figure 10. Megafauna abundance per trawl.

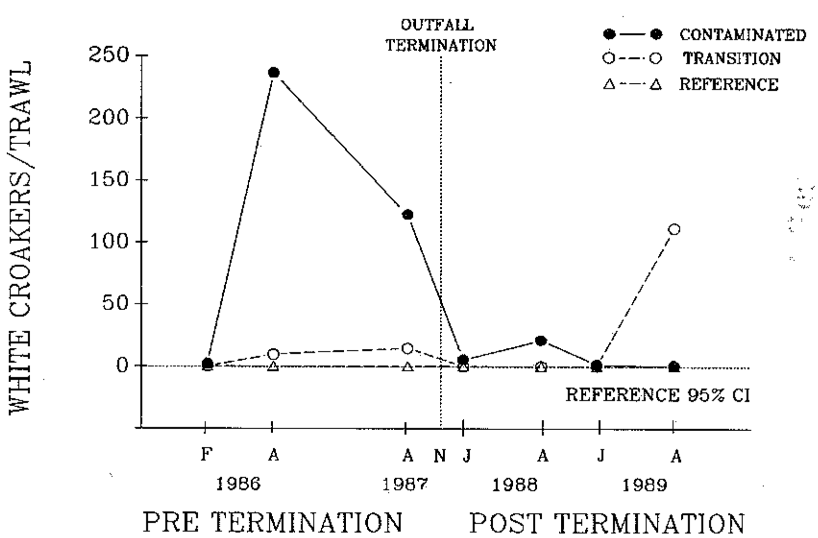

Figure 11. Abundance of white croaker per trawl.

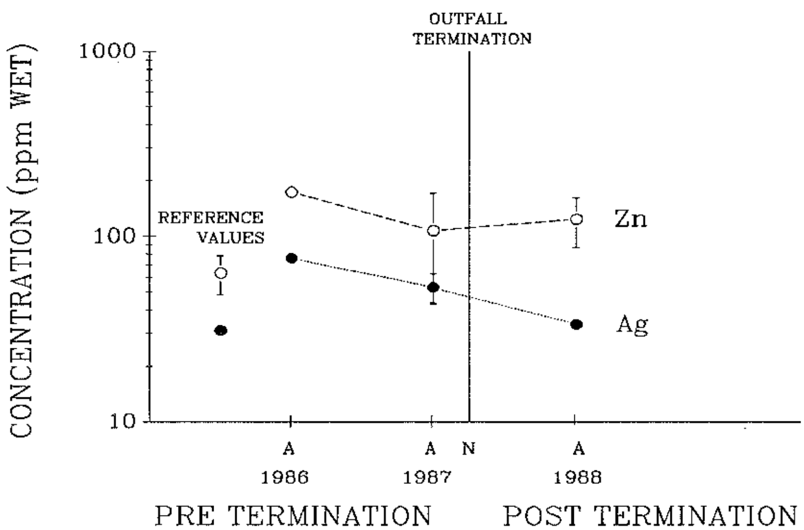

Figure 12. Concentrations of trace metals (zinc and silver) accumulated in *Sicyonia* hepatopancreas collected at contaminated sites.

Diane O'Donahue screens sediment samples for infauna.

Other parameters have exhibited no sign of change (eg. *A. urtica* and *L. pictus* abundances).

Observed recovery for each parameter appears to be related to different events. White croaker may be affected by the loss of suspended sludge particles, and *C. capitata* appears to have responded to the reduction in sulfide levels found in sediments in Santa Monica Canyon. The lack of response by *A. urtica* and *L. pictus* to the reduced sulfide levels are more reflective of the trends of metals that have not decreased in concentrations in the sediments.

Differential rates of recovery of sediment quality and contaminants will hopefully correlate with biological events that will help us understand which sediment factors are keys to biological responses. However, these analyses are incomplete, and correlations of recovery events are premature before all the data have been collected and analyzed.

Acknowledgements

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