
SUMMARY OF FINDINGS

WASTES DISCHARGED

The volume of municipal wastewater discharged and the amount of suspended solids have increased somewhat during the last 2 years. This is because of population increases in Los Angeles and because our figures now include SERRA and Encina. Even with those additions, the quantities of BOD, most metals, and DDT have been reduced; PCB has increased.

Quantities discharged

BIOLOGICAL STUDIES

New ideas about bottom sample replication for benthic animals around outfalls are proposed. The statistical requirements for numbers of individuals or abundances of indicator species cannot be satisfied with a reasonable number of samples. Instead, an ecological distance index is suggested. The authors believe it is not efficient to take more than two samples at any point in space or time.

Benthic sample replication

Measurements of bottom chemistry, the benthos, and the fish populations in depths of 100 to 600 m off Newport in Orange County and off Point Dume in Los Angeles County show that these two areas are similar. Thus, if the proposal by Orange County to discharge sewage sludge at the former site is accepted, the latter can serve as a control. This may be the most complete set of data on slope conditions yet collected.

Conditions on the slopes

A unique fishery, in which 2-km-long fishing lines are set from small open dories, operates from the beach next to Newport Pier. Each day the dories are launched through the surf, used to fish for bottom fish in areas that could be affected by a future outfall, and return through the surf to sell fresh fish. The kind of fish and their patterns of distribution were studied to provide background information on this fishery. The sablefish, shortspine thornyheads, and rockfish that

Dory fishing

dominate the catches show no discernable seasonal pattern but a substantial variation in catch from day to day.

A review of the data on fish tumors on the Palos Verdes shelf shows that, between 1971 and 1983, tumors were found in 0.3% of all individuals and in 12% of all species collected. Over 90% of the tumors were on Dover sole less than 2 years old. The presence of tumors appears to be enhanced by proximity to the outfalls. These growths seem to be caused by a parasitic protozoan and thus are not true neoplasms but amoebic pseudotumors.

Fish tumors

The proposed discharge of sludge at depths where the oxygen level is low led us to investigate the metabolic rates of two urchins which are the dominant invertebrates of the upper slope. Laboratory measurements were made of feeding rate and of oxygen consumption. Both species assimilated considerably more food than they could utilize and both seem to regulate respiration. The reasons for this are not yet known.

Urchin metabolism

The flow of lipid-soluble contaminants, including chlorinated hydrocarbons, upward through the marine food web is well established. Sea mammals at the top of the web are likely to accumulate these, but because regulations prevent sampling mammals there is little reliable information about the levels of contaminants in vital organs. With this preliminary investigation, using beached or accidentally killed animals of several species and inadequate statistics, we call attention to the need for a proper study.

DDTs in mammals

Liver cells increase in size as a result of lipid accumulation. This hypertrophy may be a normal part of the reproductive cycle or it may result from exposure to manmade contaminants. Discovery of the widespread existence of hypertrophy accompanied by DDT derivatives led to the detailed investigation of scorpionfish, which is frequently used as an experimental animal. The increase in size of scorpionfish livers significantly correlates with the mass of oxygenated metabolites of DDT, but not with that of parent compounds of DDT as previously believed.

Enlarged liver cells and DDT metabolites

PHYSICAL AND CHEMICAL STUDIES

A numerical simulation model is proposed that can be used to predict the changes in the receiving water environment that will result from a change in wastewater discharge. This model satisfactorily reproduces surface sediment concentrations of total volatile solids and calculates the accumulation of outfall-related volatile solids. It also predicts Infaunal Index values (a measure of the community structure of benthic infauna) in the same areas.

Predicting sediment quality

In order to answer questions relating to sediment transportation and deposition in submarine canyons, currents have been measured continuously for 7 months by pairs of meters at depths of 132 to 500 m. Current speeds averaged 6 to 10 cm/sec and rarely 20 cm/sec, but generally they were weaker than those on the shelf. The net near-bottom flow is down-canyon, but no intense flows (episodic events) were recorded. Sediments with volatile solids contents of over 20% at a depth of 400 m would be resuspended more than 50% of the time by the currents measured.

**Currents
in a
canyon**

Additional steps have been added to the chemical method for determining the quantity of oxygenated metabolites of DDTs and PCBs in sediments and animal tissues. These make it possible to use a conveniently available laboratory instrument (GC/EC) to measure these compounds. We find that 35 to 99% of the total chlorinated hydrocarbons measured are oxy-metabolites and that these, not the primary compounds, correlate best with chronic toxicity in sea animals.

**Oxygenated
metabolite
measure-
ments**

ASSIGNING VALUES TO ASSIMILATIVE CAPACITY

Every animal has some natural capacity for withstanding contamination. Assimilative capacity is its ability to utilize these natural defenses to protect itself from contamination levels between those to which it is normally exposed and those which cause the first damage. Therefore studies of assimilative capacity are essentially searches for the thresholds of damage in the animals of a region. This study looked for (1) spillover of metals into enzymes, (2) spillover of organic chemicals into the metallothionein fraction of cellular cytosol, (3) reduction of reproductive capacity, and (4) histological changes to various tissues at several locations of widely varying contamination. After making the measurements we are still uncertain about the percent of remaining assimilative capacity in the regions studied.

**Concept
and tests**

The relationship between highly contaminated bottom sediments and the bioaccumulation of metals and synthetic organic compounds in the animals that live on and above them was studied. It was found that the degree of contamination of animal tissues by DDTs is roughly proportional to the distance from the JWPCP outfall. The concentrations of metals in the same tissues were inversely proportional to these organic increases. That is, metals decreased in animal tissues as the sediment concentrations increased.

**Contami-
nation and
bioaccumu-
lation**

Bioaccumulation of contaminants and biological effects have been observed in marine organisms, but there has been no direct evidence to show which, if any, of the contaminants cause the effects. The assay described here utilized direct measurements of contaminants found at

**Effects of
oxy-
metabolites**

cellular sites of toxic action. The oxygenated metabolites of both DDTs and PCBs were found to be at least partly responsible for reduced catalase (enzyme) activity and reduced metallothionein metal-binding capacity in some animals.

Two species of fish (longspine combfish and yellowchin sculpin) that live along the three-station contamination gradient have similar reproductive cycles and reaction to contaminants. In both there was 28 to 49% resorption of oocytes in females near the outfall station and 42 to 44% resorption at the reference area. Whole-body lipid content was higher in fish near the outfall. These data are difficult to interpret because of inadequate controls.

Fish reproductive changes

Histological examinations were made of six species of fish taken at nine stations with widely varying contamination. The four species studied at the three assimilative capacity (AsCap) stations showed no differences in hypertrophy, vacuolation, or the number of macrophage centers when the generally accepted subjective rating system was used; however, nearly all had hypertrophy and vacuolation. When objective measurements of scorpionfish livers were used, differences were found for these parameters between the three AsCap stations and Cortes Bank, far offshore.

Quantitative pathology

CADMIUM DETOXIFICATION BY SCORPIONFISH

Bioaccumulation of contaminants does not necessarily mean there will be toxic effects, because organisms can internally detoxify contaminants. The work described in this collection of papers is an investigation into the mechanisms of cadmium detoxification, including its partitioning between cellular sites. It was found that the major portion of the cadmium to which the scorpionfish were exposed was detoxified by being bound to metallothionein, but that this system is not 100% efficient. At the higher levels of exposure (100,000 times sea background) subtle toxic effects were noted.

Detoxification by cellular partitioning

Cadmium, even at the relatively high exposures used, was largely detoxified by metallothionein in four organs of scorpionfish. However, increases were observed in the enzyme pool, especially in gill and intestine (liver and kidney were protected). The increase of cadmium in the metallothionein pool caused a similar increase of zinc and copper there for reasons not yet understood. At concentrations of ionic cadmium that are possible in coastal waters, one would expect complete detoxification.

Effectiveness of detoxification

We wanted to know if detoxification of cadmium by metallothionein caused any biological side effects on enzymes or blood chemistry and if there was a substantial energy cost. Three enzymes were measured, as

Costs of detoxification

were changes in blood plasma composition and energy reserves. It was found that at the lower exposure, calcium levels in the blood increased. High exposure produced changes in the enzyme pool and in enzyme activity of the kidney and intestine. No change in energy levels was detected.

Histopathological examinations were made of gill, intestine, liver, and kidney tissues of scorpionfish exposed to high levels of cadmium. Although various lesions were found, none could be related to cadmium exposure. Lesions ascribed to cadmium by previous investigators were found in the nonexposed animals.

**Histo-
pathology
of cadmium**

W.B.