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A DIRECTORY OF SELECTED RESEARCH SUPPORTED BY NOAA'S OCEAN ASSESSMENTS DIVISION

Mary Baker Matta

Ocean Assessments Division
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ABSTRACT. The purpose of this report is twofold: it is intended to provide both to the general public and to regional waste managers a summary of the research supported by the National Oceanic and Atmospheric Administration's (NOAA) primary marine pollution division, the Ocean Assessments Division (OAD). It is also intended to shape future NOAA efforts by identifying gaps in marine pollution research.

The research areas are presented alphabetically--biological effects, chemical fates, physical transport and processes, and syntheses of polluting events. Appendix I lists all projects, personnel, and locations under those headings. In addition, a subject index, principal investigator index and contract number index are also given.

1. INTRODUCTION

The oceans and coastal zones have been used as a medium for waste disposal for centuries. Only recently, however, has a large effort been made, out of concern for the health of coastal communities and marine resources, to determine the effects of waste disposal in the marine environment through investigation of the effects of these activities in the oceans and in coastal areas. This investigation should provide information on which to base an ocean management program that will minimize the chances of adverse human impacts on the marine environment. The acquisition of such information has been one of the goals of NOAA's marine pollution programs, now represented by the Ocean Assessments Division (OAD) of the Office of Oceanography and Marine Assessment (OOMA).

Development of marine pollution research under NOAA began in 1972 with the passage of Public Law 92-532 (the Marine Protection, Research, and Sanctuaries Act), which directs NOAA to conduct monitoring and research on effects of ocean dumping and on long-range effects of human-induced changes to marine (and Great Lakes) ecosystems. NOAA began reporting to Congress on such research in 1974, although there was no specific program for these matters. In 1976, funding for the ocean dumping section (section 201) of the law became available and research projects were begun. In 1978, Public Law 95-273 (the National Ocean Pollution Planning Act) was passed, which directed NOAA to conduct research necessary to carry out the NOAA five-year ocean pollution plans. In 1979, funds became available to conduct research on the long-range effects of human activities on the marine environment (section 202 of P.L. 92-532).

Guidelines for marine pollution research projects supported by NOAA have taken many forms. Keeping as the overall goal the acquisition of information that allows execution of a management program that will minimize adverse environmental effects, three specific objectives were identified. These were: (1) to determine the ecological consequences of polluting activites, (2) to assess the economic, ecological, and social consequences of polluting activites, and (3) to define management alternatives that will minimize adverse consequences of use of the marine environment.

NOAA's Ocean Assessments Division supports a broad range of research that contributes to fulfilling the objectives of the laws mentioned above. Over $25 million has been used to fund 33 universities, eight private businesses, eight nonprofit groups, and eight other NOAA groups. One hundred forty-six different research projects have been funded between 1979 and 1984.

This report summarizes the objectives and major conclusions of most of the research funded by the Ocean Assessments Division. More information on research methods, results, and conclusions may be obtained by consulting the NOAA contact listed with each description (addresses are presented in Appendix II), and copies of progress reports may be requested from OAD's Rockville, Md, office.

Research projects are presented in four groups. The first group, arranged according to the type of organism studied, deals with biological effects. The second group evaluates chemical fates (arranged by the pollutant studied). The third group deals with physical pollutant transport and processes. The projects covered in the last group evaluate polluting events or situations and the management recommendations that resulted from dealing with them.

2. BIOLOGICAL EFFECTS

Research on biological effects of waste disposal activities constitutes a large part of the research funded by NOAA's Ocean Assessments Division. Projects supported evaluate effects of various wastes (primarily industrial waste, dredged material, and sewage sludge) and pollutants (primarily metals and organic chemicals) on organisms ranging from phytoplankton to sea birds.

Sponsored biological research is conducted both in the field (in the Gulf of Mexico, coastal New England, San Francisco Bay, Puget Sound, Florida, Hawaii, and Alaska), at major dumpsites, and in the laboratories of major research institutions. Major subjects of study include sublethal effects, bioaccumulation, and detoxification mechanisms. Two interesting observations are (1) that there appears to be a southern limit on the East Coast beyond which there is no danger of spreading of paralytic shellfish poisoning (caused by the dinoflagellate Gonyaulax spp. - B-11), and (2) although marine organisms do accumulate metals, metal ions at concentrations that occur in both natural unpolluted and polluted environments are unlikely to affect normal respiratory processes in marine shellfish (B-22).

Forty-two projects were sponsored at 27 institutions. These projects are presented here according to the type of organisms studied.

2.1 Phytoplankton

TITLE: ADAPTIVE BEHAVIOR OF EURYHALINE PHYTOPLANKTON TO STRESS: RESPONSES TO CHRONIC, LOW-LEVEL ADDITIONS OF TRACE METALS
CONTRACT #: NA81RAD00032
NAME: SANDERS, JAMES G.
CONTRACTOR: THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The response of marine phytoplankton communities to chronic input of low levels of trace metals has not been well documented. The purpose of this research is to study sublethal impacts of arsenic and cadmium on natural phytoplankton assemblages by monitoring temporal changes in dominant species and species succession in large-volume, continuous-flow cultures maintained outdoors under natural conditions. Objectives are to monitor species succession (as influenced by low concentrations of trace metals) and to monitor the effect of zooplankton and phytoplankton on arsenic and cadmium geochemistry and their eventual fate. Methods include the use of 1,000-liter cylindrical fiberglass tanks with running seawater. The expected results include determinations of whether estuarine phytoplankton are affected by low metal levels, and if so, whether the community as a whole can readily adapt through a shift in species dominance and species succession.

CONCLUSIONS:
Based on the report dated April 12, 1983.
1. All arsenic doses tested at spring and summer temperatures (up to

15 micrograms/liter) had no effect on phytoplankton biomass or total cell densities. Particulate carbon concentrations and atomic carbon-to-nitrogen ratios were slightly but not significantly depressed. Species succession varied considerably due to arsenic treatments. Centric diatoms declined in treated tanks.

2. Cadmium doses of up to 10 micrograms/liter at summer temperatures did not affect total cell densities, particulate carbon concentrations, or carbon-to- nitrogen ratios; however, biomass estimates declined. There were no significant shifts in dominant species or in species succession. Any shifts would probably not have been measurable due to the biomass decline.

3. Cadmium doses of up to 15 micrograms/liter at fall temperatures depressed cell densities. Production of spores by Chaetocens debile (the dominant species) was significantly depressed at all doses.

4. Survival of adult copepods was reduced by arsenate levels of more than 100 micrograms/liter, but significant reductions required more than 10 mg/li. Juveniles had significant mortality over 15 days at more than 100 micrograms/liter.

5. Algal food type greatly affects copepod life. Those fed small, non-chain-forming centric diatoms had reduced overall success. Maturation was slower, fewer reached maturity, fewer bore young, the number of nauplii produced, and length of life, was lower than those fed larger chain-forming diatoms.

TITLE: LABORATORY PHYTOPLANKTON TOXICITY STUDIES USING OCEAN DUMPED WASTES
CONTRACT #: NA80AAD00037
NAME: BROOKS, JAMES M.
CONTRACTOR: TEXAS A&M UNIVERSITY
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Acid-iron and other industrial wastes are disposed of at the 106-mile dumpsite in the New York Bight. A major concern about dumping is that wastes may adversely affect phytoplankton populations in the area. This research determines acute and sublethal concentrations of industrial wastes that are detrimental to selected species of phytoplankton. Results will help define factors of waste fractions that are most toxic to phytoplankton. This will contribute to the prevention of adverse consequences from ocean dumping of industrial waste.

CONCLUSIONS:
Research is in progress

TITLE: TRACE ELEMENT FLUXES IN HIGH PRODUCTION AREAS
CONTRACT #: NA83AAH00031
NAME: KNAUER, GEORGE
CONTRACTOR: SAN JOSE STATE UNIVERSITY
NOAA CONTACT: M. DEVINE NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Recent independent studies have shown that trace elements can play a significant role in determining rates of primary production. This research investigates interactions of trace elements with marine plankton communities. Objectives include: the determination of the vertical distribution of trace elements in dissolved and suspended particulate form; measurements of fluxes of elements in association with passively sinking particles using freefloating particle traps; estimation of residence times for elements in selected portions of the water column; measurements of primary productivity and relationships with organic carbon fluxes at depth; and the development of water column and trap sampling methodology for common lead measurements. Initial research will be conducted off the coast of Peru. Results will contribute to an understanding of the overall effects of trace metals in marine plankton communities.

CONCLUSIONS:
Research in Progress

TITLE: THE BIOLOGICAL IMPACT OF WASTE METAL DISPOSAL
CONTRACT #: NA79AAD00077
NAME: MOREL, FRANCOIS M.M.
CONTRACTOR: MASSACHUSETTS INSTITUTE OF TECHNOLOGY
NOAA CONTACT: T. O'CONNOR, NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
To be widely applicable and functionally useful, observations about metal toxicity to plankton must be addressed at a mechanistic level where species differences and environmental variables play little role. A key to this problem is to elucidate the mechanism of adaptation of algae to environmental metal concentrations in the marine realm. Freshwater algae adapt to high metal concentrations by lowering their chemical affinity for metals. A similar response may occur for marine phytoplankton. The objectives of this research are: to understand the physiological and biochemical processes through which toxic metals affect the planktonic biota; how these processes depend on the chemistry of the medium; and how organisms respond to metal stress through acclimation, adaptation, or modification of their medium. This may lead to the development of biochemical markers as quantitative indicators of metal stress.

CONCLUSIONS:
Based on the final report dated June 1984.
1. There is a great variability in metal sensitivity among phytoplankton species; therefore, a shift in dominant phytoplankton species is predicted as the major outcome of metal pollution in coastal waters.
2. Iron is taken up through complexation by a membrane protein. The kinetics of the process are markedly enhanced by light due to photoreduction of Iron(III)-organic complexes in solution. A principle locus of the physiological effect of toxic metals on algae now appears to be a simple competitive inhibition of iron uptake. Reduced growth rates are observed only after a few days of exposure to toxic metals (this may be due to use of iron storage). Reversal of metal toxicity can be effected after many days of exposure by simply lowering the toxic metal's activity and supply of adequate iron (presumably allowing resumption of iron uptake).
3. The toxic effect of a trace metal is caused by its interference with uptake, assimilation, or utilization of another essential trace metal. Toxicity occurs when a metal binds competitively to a ligand site involved in the utilization of another metal it cannot emulate. Algal requirements for iron, manganese, and zinc determine metal toxicity in marine phytoplankton. Copper and cobalt are essential, but they are too abundant to be limiting: they are more commonly toxicants. Zinc can be either toxic or limiting within a very narrow concentration range.

TITLE: EFFECTS OF INDUSTRIAL WASTES ON MARINE PHYTOPLANKTON
CONTRACT #: NA80AAD00033
NAME: MURPHY, LYNDA S.
CONTRACTOR: BIGELOW LAB FOR OCEAN SCIENCES
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Industrial waste deposited at deep ocean dumpsites is not distributed uniformly, and the various components of the biota are not affected equally by the waste. Differential sensitivities within the phytoplankton assemblage should lead to an altered community structure, even in the absence of biomass change. Bioassays that are based on analyses for specific chemicals or enzyme activities are needed. Bioassays must be made before death, carnivory, or differential growth can alter the characteristics of the phytoplankton sample being measured. This research evaluates the feasibility of detecting changes in phytoplankton community structure by analysis of fluorescence spectral signatures. This procedure should provide a real-time evaluation of changes in phytoplankton assemblages, as well as a measure of the geographic magnitude of the change, resulting in an improved ability to measure effects of ocean dumping.

CONCLUSIONS:
Based on the final report dated January 30, 1984.
1. An immediate short-term change in population structure was detected at the Puerto Rico dump site after dumping. Dinoflagellates and centric diatoms decreased in abundance, while microflagellates and minute coccoid algae increased in abundance.
2. Two diatom clones became resistant to sublethal concentrations of pharmaceutical wastes over six months of exposure.
3. Bioassays of representative clones with an interacting matrix of iron, manganese, and copper have established that the ratio of chlorophyll-a fluorescence to in vitro chlorophyll-a content is inversely proportional to productivity rate and is a rapid and accurate measure of sublethal physiological stress.
4. Overall, of the several industrial wastes recently disposed of at the deep-ocean dumpsites, pharmaceutical and American Cyanamid wastes were more toxic than the DuPont-Edgemoor waste, which was more toxic than DuPont-Grasselli waste.
5. Changes in the phytoplankton assemblage structure should be detectable by automated procedures. Spectral fluorescence, flow cytometry, and chemosystematics allow a real time evaluation of changes in dominance of phytoplankton assemblages, as well as geographic magnitude of the effect.

TITLE: LABORATORY ALGAL TOXICITY STUDIES OF PHARMACEUTICAL WASTES FROM PUERTO RICO
CONTRACT #: NA80AAD00041
NAME: VAN BAALEN, C.
CONTRACTOR: UNIVERSITY OF TEXAS, PORT ARANSAS MARINE LAB
NOAA CONTACT: T.O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Marine algae are an important facet of the environment of the Puerto Rico dumpsite. The degree of toxicity of seven individual pharmaceutical wastes, and composite mixtures made from them, will be closely screened for their effect on the growth of pure cultures of three very different types of microalgae originally isolated from the marine environment: a blue-green alga; a green alga; and a diatom. Blue-green algae in the form of mats occur extensively in warm, shallow marine environments, while forms such as Trichodesmium spp. are important in the open ocean. The blue-green algae alone can fix nitrogen and therefore help to maintain the combined nitrogen level for other organisms. The green algae, mostly known in marine environments in larger macroforms, often form an important fraction of the phytoplankton population. Various kinds of diatoms can dominate the phytoplankton biomass in many different oceanic regions. This research will evaluate the effect of pharmaceutical waste dumping on this important facet of the marine environment.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. Two of the individual pharmaceutical wastes tested inhibited growth of blue-green algae at a concentration of 2.5 ppm.
2. A composite sample made from seven wastes was toxic at 250 ppm.
3. Effects not reflected in a diminished rate of growth may occur undetected. Therefore, it may not be justifiable to dismiss the algal toxicity of wastes because they are expected to be diluted below levels needed to produce toxic effects in the laboratory.

TITLE: PHYTOPLANKTON RESISTANCE TO TOXIC CHEMICAL POLLUTANTS
CONTRACT #: NA81RAH00002
NAME: WURSTER, CHARLES F.
CONTRACTOR: STATE UNIVERSITY OF NEW YORK
NOAA CONTACT: H. STANFORD NOAA/OAD/STONY BROOK
FUNDING STATUS: COMPLETED

ABSTRACT:
Bacteria are known to develop resistance to many toxic chemicals over relatively short periods of time. It is not known whether phytoplankton can develop resistances that may make them more or less able to withstand the stresses of the natural environment. This research will determine whether phytoplankton groups are capable of developing resistance to PCBs, whether the development of resistance to one toxic chemical confers cross-resistance to other chemicals, and whether development of resistance to toxic chemicals diminishes the ability of these resistant phytoplankton to withstand the natural stresses of an unpolluted environment. Results will evaluate the ability of the low end of the food web to adjust to contamination.

CONCLUSIONS:
Research in progress

2.2 Zooplankton

TITLE: EFFECTS OF SUBLETHAL CONCENTRATIONS OF CRUDE OIL ON THE FEEDING BEHAVIOR AND REPRODUCTIVE SUCCESS OF MARINE ZOOPLANKTON (CRUSTACEA: COPEPODA) IN LABORATORY CONTINUOUS FLOW SYSTEMS
CONTRACT #: NA80RAD00037
NAME: COWLES, TIMOTHY J.
CONTRACTOR: WOODS HOLE OCEANOGRAPHIC INSTITUTION
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Marine organisms are frequently exposed to a range of hydrocarbon concentrations as a result of oil spills, oil seepage, chronic coastal oil pollution from harbors, and, to a small extent, biogenic hydrocarbon production. The purpose of this research is to study the effects of sublethal concentrations of crude oil on the feeding behavior and reproductive success of marine zooplankton (crustacea: copepoda) in laboratory continuous flow systems. The methods of accomplishing this include laboratory experiments. The results of this study will provide needed information about the impact of sublethal concentrations of oil on the productivity of planktonic food chains.

CONCLUSIONS:
Based on the report dated March 26, 1982.
1. Exposure to levels of crude oil in seawater of less than 100 ppb has deleterious effects on feeding rate, health of offspring, and activity level of copepods. Egg production was not affected until concentrations reached 300 ppb. Egg viability was strongly affected by crude oil, with no nauplii surviving from females exposed to concentrations of greater than 10 ppb of dispersed crude oil.
2. Normal swimming and feeding behavior returned after several hours of depuration in clean water.

TITLE: FECUNDITY, GROWTH, AND BEHAVIOR OF ESTUARINE ZOOPLANKTON EXPOSED TO LOW-LEVEL CHRONIC ORGANIC POLLUTANTS
CONTRACT #: NA80RAD00046
NAME: PILSON, MICHAEL E.Q.
CONTRACTOR: UNIVERSITY OF RHODE ISLAND
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
During the past three years the MERL (Marine Ecosystems Research Laboratory) microcosm design has proven to be a powerful tool for the study of chronic, low-level pollution effects in the marine environment. This project investigated the fecundity, growth, and behavior of selected dominant copepod species. The purpose of this study was to evaluate consequences of doses of nutrients to the functioning and stability of an estuary. Specific objectives included determining whether chronic low-level doses of an organic pollutant affect zooplankton productivity. Research utilized MERL microcosms at the University of Rhode Island. The results of this research will improve understanding of pollutant effects on behavior and will improve prediction of toxicant effects on zooplankton, a major component of marine systems.

CONCLUSIONS:
Based on the final report dated March 7, 1983.
1. Nutrient enrichment of two to four times the annual input to Narragansett Bay did not decrease zooplankton growth; larval fish growth and survival were enhanced by these levels.
2. Nutrient enrichment of greater than four times the annual input to Narragansett Bay increased mortality of larval copepods.
3. Zooplankton reproduction, growth, and survival varied greatly over short time periods due to a combination of copepod age, feeding prehistory, and food and water quality.
4. Rates of secondary production can be enhanced by increased food availability (resulting from nutrient additions). Results indicate enhanced potential for secondary production in systems with nutrient levels similar to those in lower Narragansett Bay.
5. The results indicate the importance of determining nutrient loading rates. Changes in species composition, trophic dynamics, and water chemistry may occur even in the absence of particulate carbon or toxic substances.

TITLE: EFFECTS OF COASTAL DEVELOPMENT AND LAND USE ON THE SPREADING OF TOXIC RED TIDES
CONTRACT #: NA81RAD00012
NAME: ANDERSON, DONALD M.
CONTRACTOR: WOODS HOLE OCEANOGRAPHIC INSTITUTION
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Recent histories of toxic dinoflagellate blooms in New England, Washington, and California all support the contention that the phenomenon is spreading and that the associated Paralytic Shellfish Poisoning (PSP) is now a recurrent problem in many previously unaffected areas. This apparent dispersal of the toxic dinoflagellates Gonyaulax tamerensis and Gonyaulax cantennalla within the last 10 years has resulted in the widespread belief that human activities in the coastal zone are somehow involved. The purpose of this study is to examine the mechanisms for accidental dispersal or stimulation of the species responsible for this serious economic and public health problem. Specific objectives include: the study of selected embayments now subject to toxic outbreaks to assess the short- and longterm effects of human physical alteration of coastal zone hydrography in terms of population dispersal; examination of those estuaries where the dormant cysts of the causative organism accumulate in sediments to determine the hydrographic characteristics that are conducive to toxic bloom development following germination; examination of the impact of coastal pollution and eutrophication on the red tide dinoflagellate; and the study of the viability of dormant cysts after ingestion by shellfish as one indication of the potential for accidental introduction of the toxic algae during shellfish seeding. The results of this project should provide information necessary to determine the need for management and regulatory strategies.

CONCLUSIONS:
Based on the report dated October 11, 1983.
1. Gonyaulax tamerensis has an encysted stage in its life cycle that allows it to lie dormant in sediments until conditions are favorable for germination. From 15 to 75 percent of the cysts survive ingestion by shellfish and could be present in the gut of the animals when shellfish are transported to new areas as seed stock.
2. Nine areas of Connecticut and Long Island have dinoflagellate cysts in sediments but no history of paralytic shellfish poisoning. This suggests that red tide dinoflagellates are continuing to spread throughout New England. Over 25 cultures have been analyzed for toxin content and a trend exists with highest levels of toxin per cell in cultures from the northernmost areas and the lowest levels from the southern extreme of Gonyaulax distribution. Although the reasons for this trend are unknown, it suggests that there may be a southern limit beyond which there is no danger of PSP spreading.
3. The copper-complexation capacity of Puget Sound water and sewage effluent is being investigated. At 10 ppb added copper, 50 percent of bacterial carbon uptake is inhibited (unspiked seawater). An addition of 10 percent by volume of sewage effluent increased this copper complexation capacity (50 percent inhibition at 28 ppb added copper).

TITLE: EFFECTS OF TRACE METALS ON THE MICROZOOPLANKTON LINK IN GULF OF MEXICO FOOD WEBS
CONTRACT #: NA81RAD00014
NAME: STOECKER, DIANE K.
CONTRACTOR: WOODS HOLE OCEANOGRAPHIC INSTITUTION
NOAA CONTACT: H. WHITE NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Microzooplankton, as a community, are believed to have an important role in trophic dynamics. The purpose of this work is to investigate indirect and direct effects of copper, zinc, and cadmium on microzooplankton that may be important in food webs leading to larval menhaden and spot. The food habits of phytophagous ciliates will be studied by growing them on cultures of phytoplankton from the Gulf of Mexico. The direct toxic effects of trace metals on microzooplankton will be determined in laboratory experiments. Ciliates will be used in experimental studies on the feeding habits of larval menhaden and spot; the results will further the understanding of how trace metals are transfered through marine food webs.

CONCLUSIONS:
Based on the report dated March 1984.
1. Larval fish eat primarily small zooplankton (tintinnids) whose algal food requirements differ greatly.
2. Different types of algae, though they may be related, differ greatly in their food value, and because tintinnids are specialized eaters, trace metal effects on phytoplankton may affect tintinnids, and therefore larval fish.
3. Some ciliates are even more sensitive than their algal food to trace metal pertubations.

TITLE: THE EFFECTS OF POLLUTANTS ON MARINE ZOOPLANKTON AT DEEP-WATER DUMPSITE 106 AND THE PUERTO RICO DUMP SITE
CONTRACT #: NA79AAD00027
NAME: CAPUZZO, JUDITH
CONTRACTOR: WOODS HOLE OCEANOGRAPHIC INSTITUTION
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Biological effects of waste disposal to plankton populations can be evaluated only with adequate information on the chemical composition of dumped wastes, their persistence in the vicinity of a dumpsite, their bioavailability and bioaccumulation, and their toxicological effects. Through laboratory and field investigations, the response of zooplankton populations to waste additions at the 106 mile dumpsite and the Puerto Rico dumpsite will be compared. Parameters to be investigated include the effects of waste on survival, metabolism, feeding, and egg production of copepod populations, in addition to the bioaccumulation of wastes and the role of copepods in the biogeochemical cycling of waste components. This will allow estimates of the assimilative capacity of a dumpsite area.

CONCLUSIONS:
Based on the report dated April 20, 1984.
1. In laboratory studies with copepods, acute toxic effects have been detected at concentrations greater than 50-100 ppm of DuPont-Grasselli waste and American Cyanamid waste, and greater than 5-10 ppm of DuPont-Edgemoor waste. Sublethal concentrations reduced feeding, metabolic, and egg production rates.
2. In field studies, copepods suffered the same effects seen in labortory studies within several hours of dumping. Sublethal effects are not reversed when copepods are placed in clean water. Long-term effects seem to be minimal.
3. Waste compounds persist for longer periods at the Puerto Rico dumpsite. Acute toxic effects are seen at concentrations greater than 10 ppm. Sublethal effects (lowered metabolism and sluggish swimming) are seen one and 24 hours after waste dumping, these effects were not reversed after copepods were transferred to clean water.
4. Trace metals are highly concentrated in fecal pellets of copepods exposed to waste. This appears to be an effective depuration mechanism.
5. The methanol and phenol content of waste may inhibit feeding mechanisms, whereas other trace organics may be toxic to oxidative metabolism. Waste exposure mimics starvation stress in its effects on reproduction and metabolism.
6. Production rates of Acartia tonsa, which dominates zooplankton biomass in summer and fall in Buzzards Bay, MA, are reduced at stations heavily contaminated by PCBs.
7. Species with large energy reserves may have a competetive advantage during waste exposure.

TITLE: EFFECTS OF OCEAN-DUMPED PHARMACEUTICAL WASTE ON COPEPOD SURVIVAL, FEEDING AND GROWTH
CONTRACT #: NA80AAD00061
NAME: LEE, W.Y.
CONTRACTOR: UNIVERSITY OF TEXAS PORT ARANSAS MARINE LAB
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The dumping of pharmaceutical wastes off of Puerto Rico is potentially a danger to the living marine resources of the area. This research will examine the effects of ocean-dumped pharmaceutical waste on the survival, growth, and feeding of marine copepods. Experimental concentrations of 0.1, 1.0, and 10.0 ppm will be used which are comparable with levels detected in the field following dumping. The copepod Temora turbinata will be studied with four phytoplankton densities. The effect of wastes on the dinoflagellate Prorocentrum micans will also be investigated.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. Short-term toxic effects to copepods were not observed at waste concentrations of 10 ppm or less.
2. Copepod feeding rates increased with increasing concentrations of pollutants at phytoplankton densities of 120 cells/ml and 2,000 cells per milliliter.
3. Dinoflagellates appeared healthy at waste concentrations below 10 ppm, while at 10 ppm a high percentage of dividing cells occurred in unusual forms. Cells were deformed, formed clumps, or small chains due to incomplete cell fission. Abnormal cell division was rarely observed in normal cultures.

TITLE: ZOOPLANKTON COPEPOD COMMUNITY IN THE PUERTO RICO TRENCH PHARMACEUTICAL DUMPSITE
CONTRACT #: NA79AAD00031
NAME: GEORGE, ROBERT Y.
CONTRACTOR: UNIVERSITY OF NORTH CAROLINA
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
In order to understand the effects of pharmaceutical waste dumping on zooplankton, the community structure of zooplankton at the Puerto Rico dumpsite should be investigated. This research has four objectives: to determine the species composition of calanoid, harpactacoid, and cyclopoid copepod crustaceans in the upper 150 meters of the water column in six locations north of Puerto Rico; evaluate any gradient in biomass and species in the seaward direction; establish the relationship of the oceanic offshore copepod community with the coastal copepod community along the northern coast of Puerto Rico; and delineate night/day vertical migration patterns of the 12 numerically dominant copepod species off Puerto Rico. The study will be based on quantitative zooplankton samples from four depths: 0, 50, 100, and 150 meters. Results will provide an analysis of the community structure of copepods at the Puerto Rico dumpsite.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. Calanoids exhibited the highest species diversity north of Puerto Rico, followed by cyclopoids and harpactacoids.
2. The oceanic copepod community differs substantially from the coastal community.
3. Low chronic concentrations of dumped pharmaceutical and petrochemical wastes has so far not influenced migratory patterns of copepods.

TITLE: INVESTIGATIONS OF THE EFFECTS OF ENVIRONMENTAL STRESSES ON MARINE ZOOPLANKTON DYNAMICS AND SECONDARY PRODUCTION, DEVELOPMENT, AND VALIDATION OF A POPULATION MODEL
CONTRACT #: NA83ABD00010
NAME: DURBIN, ANN
CONTRACTOR: UNIVERSITY OF RHODE ISLAND
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: ENDS 4/30/85

ABSTRACT:
Zooplankton play a major role in determining the fate of primary production by providing a link to higher trophic levels and are central to the functioning of most marine ecosystems. This research will determine how marine zooplankton population dynamics and secondary production rates are affected by stress resulting from eutrophication and increased levels of copper. Objectives include: the development of a model to describe population dynamics of marine zooplankton populations; measurement of the in situ stage-specific recruitment, growth, and mortality rates and the resulting age structure, abundance, and secondary production rates of these populations; comparison of population dynamics of undisturbed and stressed communities; and determination of whether a stress acting upon the community will cause significant changes in population dynamics. Studies will be carried out in the mesoscale marine microcosms at the Marine Ecosystems Research Laboratory (MERL) facility at the University of Rhode Island. Results will contribute to the determination of the effects of stress on marine zooplankton population dynamics and production rates.

CONCLUSIONS:
Based on the report dated July 1984.
1. Three case-studies were conducted with MERL tanks: (a) control tanks containing zooplankton populations from Narragansett Bay, (b) similar tanks to which copper was added in one dose, and (c) tanks enriched with nutrients to levels 16 times higher than control tanks and to which copper was added in a single dose. In the control tank the population of the copepod Acartia tonsa (the dominant species) increased with one population peak. In tanks to which copper was added all juvenile A. tonsa died within four days. Adult zooplankton were reduced in number to a lesser degree. Copper effects include poor growth, high mortality, and large numbers of physical abnormalities. After the addition of copper the A. tonsa population recovered quickly but remained unstable.
2. Other copepod species were also sensitive to copper stress, but the number of polychaetes was not reduced by the addition of copper.

2.3 Finfish

TITLE: EFFECT OF HEAVY METALS ON THE SUSCEPTIBILITY AND IMMUNE RESPONSE OF STRIPED BASS TO BACTERIAL PATHOGENS
CONTRACT #: NA80RAD00042
NAME: HETRICK, FRANK M.
CONTRACTOR: UNIVERSITY OF MARYLAND
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Fish kills have been associated with pollutants introduced into the water through domestic sewage and sludge, agricultural runoff, industrial effluents, and petroleum spills. The subtle effects of low levels of these pollutants on aquatic biota are not well understood. The purpose of this research was to determine if exposure to copper predisposes striped bass to infection with bacterial pathogens. Juvenile striped bass were exposed to copper and were then subjected to various concentrations of bacteria in water for different lengths of time. Results should be of use to agencies charged with controlling the introduction of pollutants into the environment. The experimental method serves as a model for study of effects of other pollutants on fish species exposed to viral and bacterial pathogens.

CONCLUSIONS:
Based on the report dated November 9, 1981.
1. Results suggest that a 24- or 48-hour exposure to copper did increase the susceptibility of striped bass to bacterial infection.
2. Ninety-six hour exposures to copper did not increase the susceptibility of bass to bacterial infection when compared to the control group.
3. The LC-50 for bass at 24-hour exposures was 11.2 mg/li, at 48 hours it was 8.8 mg/li, and at 96 hours it was 8.4 mg/li.

TITLE: FISH-BENTHOS COUPLING IN SEWAGE-ENRICHED MARINE ENVIRONMENTS
CONTRACT #: NA80RAD00050
NAME: CHEW, KENNETH K.
CONTRACTOR: UNIVERSITY OF WASHINGTON
NOAA CONTACT: A. MEARNS NOAA/OAD/SEATTLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Most coastal cities influence their water bodies to a degree through the discharge of treated and untreated sewage. Since sewage is primarily composed of organic material, a major impact that results is organic enrichment of water and sediments. The purpose of this research is to prove or disprove that organic enrichment influences fish communities indirectly through effects on benthic invertebrate communities. Specific objectives are to characterize and compare demersal fish communities in areas influenced by organic enrichment, and to provide explanations for any observed differences in community characteristics. Methods used to attain these objectives include field and laboratory studies., The results of this study will be useful for predicting fish production and community structure in affected areas, identifying potential pathways of contaminants, and developing monitoring strategies.

CONCLUSIONS:
Based on the report dated February 1983.
1. Enriched communities are less diverse than unenriched communities.
2. Enrichment must attain both a critical degree and scale before these differences become substantial.
3. Responses of fish communities are not direct, but are mediated through benthic invertebrate effects of enrichment.
4. Seven of the 11 most abundant fish species in Puget Sound segregate according to sediment character. The dominant nearshore demersal fish in Puget Sound overwinter (a period of starvation) in deep water.
5. Modification of depositional benthic environments can dramatically influence demersal fish. English sole for example, rapidly gain weight while lingering in depositional areas and might be prone to accumulating organic contaminants. Because these compounds are often stored in the lipid reserves of an organism, large amounts of toxicants may be stored for the overwintering and gonad development period and may then be lethally metabolized during the starvation period.

TITLE: INFLUENCE OF WATER QUALITY AND BODY BURDENS ON COMPROMISING THE MOVEMENTS OF FISH: ENVIRONMENTAL CORRELATES OF STRIPED BASS AND SMELT LOCOMOTOR CAPACITY
CONTRACT #: N-NM-NE-001
NAME: CALABRESE, ANTHONY
CONTRACTOR: NOAA/NMFS/NEFC, MILFORD LABORATORIES
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The distribution and abundance of marine organisms is affected by many environmental parameters, man-induced pollution being one of them. The objectives of this research were: to study effects of PCBs and heavy metals on locomotor behaviors and capacities of striped bass and smelt; determine whether water quality compromises locomotor capacity; and determine whether body burdens alter or compromise swimming capacity. Methods included field and laboratory studies. Results of this reseach project provide information of a long-term nature necessary for the development of management capabilities in marine areas.

CONCLUSIONS:
Based on the final report dated May 1983.
1. Both groups of Hudson River fish tested (from mile one and mile 39) had significantly lower swimming capacity (critical swimming speed and burst swimming speed) than animals collected from Eastern Long Island Sound and the Edenton hatchery.
2. PCBs are found in Hudson River fish muscle. Red musculature from Hudson River fish (mile 39) PCB levels ranged from 0.4 to 0.55 ppm (wet weight) and from 0.09 to 0.44 ppm (mile one). In gills PCB levels were 0.08 ppm (mile 39) and from 0.08 to 0.28 ppm (mile one).
3. At the highest levels of added lead (200 ppb over 60 days); a significantly lower critical swimming speed was detected in Edenton Hatchery fish.

TITLE: IMPACT OF ESTUARINE DEGRADATION AND CHRONIC POLLUTION ON POPULATIONS OF ANADROMOUS STRIPED BASS (MORONE SAXITALIS) IN SAN FRANCISCO BAY
CONTRACT #: N-NM-SW-001
NAME: WHIPPLE, JEANETTE A.
CONTRACTOR: NOAA/NMFS/SWFC/TIBURON LAB
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Long-term effects of chronic pollution on declines in fisheries populations is a major topic of concern. The striped bass was selected as a "model species" for such studies because it is the major recreational fishery in the San Francisco Bay-Delta area. This species is also widely distributed on all coasts of the US and is an important commercial and recreational fish elsewhere. The purpose of this research was to examine probable interactions among factors of water diversion, pollution, parasitism, and other variables that appear to be reducing both quality and quantity of striped bass. Field and laboratory studies were used. These studies contribute information helpful in preventing declines of species to catastrophically low levels, as has happened in the past, and in determining the contribution of pollution to this decline. Results should be generally applicable to other chronically polluted estuaries and species.

CONCLUSIONS:
Based on the final report dated May 16, 1984.
1. Field results indicate correlations of pollutants with parasite burdens, body, liver, egg, and gonad condition. Fish from San Francisco Bay have higher and more damaging parasite loads than those from the Coos River, Hudson River, and Lake Mead. Parasitic lesions and infections causes mortality in young fish. These are correlated with the body burden of monocyclic aromatic hydrocarbons.
2. Fish exposed to chronic stress from pollutants (especially monocyclic aromatic hydrocarbons and zinc, but also DDT and PCBs) have significant reductions (50%) in reproductive capacity, fecundity, and gametic viability.
3. Older fish were in poorer condition with reduced fecundity, more parasites, and higher pollutant levels, especially PCBs and metals.
4. Fish from San Francisco Bay had higher tissue levels of petrochemicals (except xylene) than did those from the Coos River or the Hudson River. They also had higher levels of DDT than Hudson River fish. Hudson River fish had higher concentrations of PCBs in gonads and muscle, and higher levels of chlordane and dieldrin in gonads than San Francisco Bay fish.

TITLE: POLLUTANT BODY BURDENS AND REPRODUCTION IN PLATICTHYS STELLATUS IN SAN FRANCISCO BAY
CONTRACT #: NA83ABG00050
NAME: SPIES, ROBERT
CONTRACTOR: LAWRENCE LIVERMORE NATIONAL LAB
NOAA CONTACT: E. LONG NOAA/OAD/SEATTLE
FUNDING STATUS: ENDS 9/14/85

ABSTRACT:
A primary objective of marine pollution research is to understand the effect of pollutants on populations of marine organisms. A direct method of estimating effects of marine pollution on fish reproduction is needed to augment indirect laboratory bioassay studies. This research is investigating the relationship between pollutant body burdens of an estuarine fish and its reproductive capacity. Levels of hydrocarbons, exotic organic molecules, pesticide residues, and heavy metals will be compared to measures of reproductive potential in the starry flounder. Sexually mature fish from San Francisco Bay will be evaluated for pollutant content and gonad index, gamete size, percent successful fertilization, and hatch viability. This will bring our understanding of pollution effects closer to chronically exposed field populations rather than relying on surmised population effects from shorter term laboratory exposures which cannot introduce all of the factors affecting field populations.

CONCLUSIONS:
Based on the report dated April 1983.
1. Sampling locations include San Pablo Bay, off Richmond, CA, and off Berkeley, CA.
2. There is an enhanced oocyte development in San Francisco Bay population, perhaps at the expense of somatic growth.
3. Fish near Berkeley have the highest mean hepatic mixed function oxidases (MFO) activity and the lowest percentage of fertilization success. Fish from San Pablo Bay had the lowest MFO activity and the highest percentage of fertilization success, the lowest hatching success of any of the spawned populations, and the greatest number of abnormal larvae.
4. Monterey Bay populations have high hepatic MFO activity and may be receiving significant exposure to petroleum hydrocarbons or PCBs, since these are the most probable inducers of these enzymes.
5. San Pablo Bay populations (because of their poor hatching success) are probably exposed to pesticides from the Sacramento and San Jaoquin rivers. These may be sequestered in egg yolk and become toxic as developing embryos and larvae draw on yolk reserves.
6. San Francisco Bay females are reproducing far ahead of females in Monterey Bay. The San Francisco Bay population is diverting available energy away from growth and toward reproduction.
7. The capacity of oocytes to be successfully fertilized is greatest in San Pablo fish, Richmond next, then Berkeley.

2.4 Shellfish

TITLE: PHYSIOLOGICAL AND BIOCHEMICAL MECHANISMS OF TRACE METAL DETOXIFICATION IN MARINE ORGANISMS
CONTRACT #: NA80RAD00063
NAME: COSTLOW, JOHN D.
CONTRACTOR: DUKE UNIVERSITY
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
A better understanding of the detoxification process used in normal and metal-stressed environments is necessary for proper interpretation of the consequences to human health of using metal-dosed organisms as part of the human food supply. The purpose of this research is to determine physiological and biochemical processes organisms use to accumulate and detoxify trace metals and how these processes affect survival of organisms and cycling of trace metals. Specific objectives are to determine the extent to which respiratory proteins in crustaceans and molluscs serve as primary targets of carriers for trace metals and to determine the extent to which partitioning is affected by the level of trace metals. Routine methods for the isolation and purification of hemoglobin and hemocyanins of marine organisms will be used. The results of this research will be useful in developing pollutant-specific biochemical and physiological indicators of environmental stress.

CONCLUSIONS:
Based on the report dated October 29, 1982.
1. Hemocyanins are involved in accumulating and detoxifying metals.
2. Zinc partitioning is affected by cadmium accumulation in oysters.
3. Effects of zinc on clams differ from those of cadmium.
4. Cadmium-binding protein in gill and hepatopancreas of crab contain a cadmium-to-zinc ratio of 1:2.6.
5. Oysters have copper-binding proteins with a molecular weight of 7400.
6. Spot hemoglobin posesses at least two mercury binding sites; one to increase and one to decrease hemoglobin oxygen affinity.
7. Cadmium binding proteins in oysters increased with time of exposure and remained constant throughout the depuration period although copper distribution changed during both periods.
8. Spot exposed to cadmium through food or water did not show induction of cadmium-binding protein.
9. Although marine organisms do accumulate metals, metal ions at concentrations that occur in natural unpolluted and polluted environments are unlikely to affect normal hemocyanin-mediated respiratory processes in marine shellfish. This conclusion is based on the capacity of hemocyanin to bind and detoxify relatively large quantities of mercury and other metals.

TITLE: MONITORING THE EFFECTS OF SLUDGE AND ACID-WASTE DUMPING USING THE ANNUAL SHELL INCREMENTS OF THE OCEAN QUAHOG ARCTICA ISLANDICA
CONTRACT #: NA81RAD00023
NAME: THOMPSON, IDA
CONTRACTOR: RUTGERS UNIVERSITY
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
An oceanographically important problem is how dumping of human-generated wastes affects ocean biota. A conspicuous member of the biota under many shelf dumpsites is the large bivalve Arctica islandica, the ocean quahog. If dumping has degraded the benthos, the ocean quahog may reflect this degradation in terms of decreased growth rates, increased mortality, and recruitment failure. This research will compare growth rates of quahogs before, during, and after dumping by observing annual shell layers. Mortality and recruitment of quahogs will be studied by comparing shells from polluted and nonpolluted areas. This information will be used to evaluate the health of the benthic community at the Philadelphia sludge and acid-waste dumping sites.

CONCLUSIONS:
Based on the final report dated January 1984.
1. Ocean quahogs taken from two dumpsites 65-70 km east of Ocean City, Maryland, grew faster after dumping started than in the 12 years before dumping.
2. Clams from areas northeast of the dumpsites, which were relatively free from pollutants, grew more slowly after dumping started.
3. Ocean conditions independent of dumping, for example, cumulative duration of warm-core Gulf Stream rings at the shelf edge, correlate better with growth patterns than does weight of dumped materials.

TITLE: SIGNIFICANCE OF METAL-BINDING PROTEINS AND LYSOSOME-LIKE VESICLES IN MUSSELS IN A METAL-CONTAMINATED ENVIRONMENT: AN EXPERIMENTAL FIELD STUDY
CONTRACT #: NA81RAD00019
NAME: ROESIJADI, G.
CONTRACTOR: BATTELLE, PACIFIC NORTHWEST LABORATORIES
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Metal-binding proteins and lysosome-like vesicles are two subcellular systems involved in binding and sequestering potentially toxic trace metals and may serve as detoxification compartments for trace elements. The toxicity of certain metals seems to be associated with the disruption or saturation of such sequestration mechanisms and the subsequent binding of metal ions to sensitive subcellular sites. This research investigates such systems using mussels in contaminated and clean areas. Mussels will be crossplanted and changes in metal composition and the incorporation of metals into low molecular weight metal-binding proteins and lysosome-like vesicles will be followed. Results of this study will be pertinent to an understanding of marine animals exposed to trace metals in a real-world situation.

CONCLUSIONS:
Based on the report dated November 23, 1982.
1. The site in Tacoma, Washington was highly contaminated with potentially toxic metals. With the exception of cadmium, the tissues of mussels reflected the higher seawater-metal concentrations. Mussels transferred to Tacoma from Sequim, WA (pristine site), accumulated metals rapidly and approached or exceeded metal concentrations in the indigenous Tacoma mussels.
2. Mussels transplanted to Sequim from Tacoma released copper and silver rapidly. Stable background values were approached four weeks after transfer. Zinc and mercury release began after an eight-week lag phase. Zinc concentrations were still high after 24 weeks.
3. It is important to examine individual organs rather than whole animals when studying metal accumulation. Copper in mussels was concentrated by the whole gill and exhibited changes reflective of the external exposure, while cadmium and zinc were relatively stable. There was a highly significant correlation between copper in metal-binding proteins and copper in whole tissues. Changes in copper in subcellular compartments paralleled changes in whole tissues. No evidence for spillover or saturation of the metal-binding proteins was seen despite extremely high copper concentrations.
4. Condition index (used as a measure of mussel health) was reduced in mussels in Tacoma, both indigenous and transplanted. The index was reduced during the time when metal-seawater concentrations were highest.

TITLE: HEAVY METALS AND TISSUE ANOMALIES IN THE ROCK CRAB CANCER IRRORATUS
CONTRACT #: N-NM-NE-003
NAME: SAWYER, THOMAS K.
CONTRACTOR: NOAA/NMFS/NEFC/OXFORD LAB
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Black gill disease in rock crabs has been observed in the New York Bight and Philadelphia-Camden ocean sewage disposal sites. This condition results from the deposition of sediment in gills which become covered by bacterial growth. This research investigates the effect of sewage sludge dumping and heavy metal concentrations in gills on the incidence of black gill disease in rock crabs. Methods used include ultrasound sonication, which dislodges silt (yielding clean gills) and sampling during molting season when the old cuticle and associated silt and sludge are discarded, yielding a clean and apparently healthy animal. When these studies are completed, it should be possible to determine those metal levels in crabs that are physiologically normal and do not reflect bioaccumulation and to provide a valuable tool for monitoring one specific response of crustaceans to changes in the character of sea bottom sediment characteristics.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. Black gills have not been observed in specimens from Maine, Georges Bank, Massachusetts, or North Carolina, but a seasonal incidence of up to 10 percent has been recorded in crabs collected at or near the New York Bight apex and the Philadelphia-Camden ocean sewage disposal sites.
2. In contrast to the geographically limited distribution of black gill disease, internal parasites, tissue lesions, and fouling organisms (bacteria, diatoms, protozoans) may be present throughout the range of the sampling regime.
3. Maximum values of metals in gills of rock crab exceed the tolerable environmental concentrations for three metals proposed by the National Health and Medical Research Council of Australia (copper, lead, and cadmium). The levels in rock crabs also exceeded those found previously in zooplankton and molluscs collected from the New York Bight apex.

2.5 Miscellaneous Organisms

TITLE: TRANSFER OF CADMIUM FROM SEA-SKATERS TO SEABIRDS
CONTRACT #: NA81RAD00018
NAME: CHENG, LANNA
CONTRACTOR: UNIVERSITY OF CALIFORNIA, SAN DIEGO
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The toxic effects of cadmium to humans and other animals are of considerable concern. Although cadmium found in humans and domestic animals can be largely attributed to industrial pollution, sources of cadmium found in wildlife are still largely unknown. A unique set of samples is available for a detailed study involving seabirds breeding on the remote Northwestern Hawaiian Islands and one of their food items, the sea-skater Halobates (Insecta). The purpose of this study is to determine the extent to which cadmium is transferred from sea-skaters to surface-feeding seabirds, and to identify the origin of this heavy metal in this pelagic marine food chain. This will be accomplished by determining the cadmium concentrations in Halobates collected from seabird guts, and comparing these data to those of the seabirds themselves. Halobates collected from an area within the foraging zone of the seabirds will also be analyzed for cadmium, to determine whether there are areas of high cadmium concentrations in nature.

CONCLUSIONS:
Based on the report dated March 1984.
1. In the four major avian predators of the ocean sea-skater, Halobates sericeus, the cadmium concentrations increased from roughly 2 to 8 ug/li dry weight toward the northwest over a linear distance of about 1,500 km.
2. The correlation between Cd levels in insects and in feathers of their predators suggests that Cd is transmitted along the food chain.

TITLE: HISTORIC POLLUTION LEVELS AND ECOLOGICAL RESPONSES IN SUBTROPICAL AND TROPICAL SEAS: THE RECORD CONTAINED IN BANDED CORAL SKELETONS
CONTRACT #: NA80RAD00045
NAME: DODGE, RICHARD E.
CONTRACTOR: NOVA UNIVERSITY
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Long-term changes in marine ecosystems caused by increasing or chronic pollution by heavy metals and other pollutants are difficult to quantify because of both the lack of historical data on pollution levels and lack of precise knowledge of the health of the affected organism through time. The purpose of this research is to develop the means to use coral skeletons as ecological monitors, by determining growth and storage of past chemical pollutants. Specific objectives include the development of a methodology for obtaining historical records of trace metal and metal organic pollutants in tropical waters via chemical analysis of coral skeletons and also the establishment of a program to monitor the long term effects of pollution on benthic communities via coral growth analysis. Methods used to obtain these objectives include field and laboratory studies. The result of this study will serve as a method of "early warning" of harmful effects and will also provide a long-term record of pollution levels from the area of interest.

CONCLUSIONS:
Based on the report dated October 1982.
1. Linear skeleton growth, mass, and density reveal differences perhaps caused by pollution.
2. Skeletons record dredging events through aluminum and cadmium deposits (with a precision of plus or minus two years).
3. Coral growth seems to be lower in areas where dredging and sewage pollution has occurred.
4. Coral skeletons may record environmental chemistry either by direct incorporation of an element into skeletal material (enrichment depends upon the ionic radius of the element), or by occlusion of particles within skeletal pore spaces introduced during major tissue damage.
5. The best indicators of environmental disturbance seem to be copper and zinc.

TITLE: EFFECTS FROM RESIDUAL AND NUMBER TWO FUEL OILS ON INTERTIDAL INFAUNA RECOVERY RATE
CONTRACT #: NA80RAD00048
NAME: VANDERHORST, J.R.
CONTRACTOR: BATTELLE, PACIFIC NORTHWEST LABORATORIES
NOAA CONTACT: E. LONG NOAA/OAD/SEATTLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Field experimental studies are needed to deal with the fate and effects of processed petroleum products in the marine environment. Sediment contamination with these materials, although seldom spectacular, is an insidious problem on and near marine shores. The purpose of this study was to measure persistence of oil, and the effects of oil, on ecosystem recovery. Specific objectives included investigation of the effects of residual and number two fuel on intertidal infauna recovery rate (molluscs, crustaceans, and polychaetes), and measurement of the persistence of these oils in the sediments. Methods employed to obtain these objectives included field studies (in Sequim Bay) and laboratory studies. The results of these studies should provide an initial step in understanding the effects of sediment-borne contaminants and determining recovery rates in the marine ecosystem.

CONCLUSIONS:
Based on the final report dated September 25, 1981.
1. Number two and residual oil is retained to the same degree.
2. Residual oil lost lighter and more aromatic compounds.
3. Up to 70 percent of the number two oil remained in sediments.
4. Number two oil has more serious effects than residual oil on species density.
5. Two species are good pollution indicators: Leptochelia dubia and Exogene lourei.

TITLE: FAUNAL AND BIOGEOCHEMICAL SUCCESSION FOLLOWING DISTURBANCE IN LAKE ERIE
CONTRACT #: NA80RAD00036
NAME: MCCALL, PETER
CONTRACTOR: CASE WESTERN RESERVE UNIVERSITY
NOAA CONTACT: M.B. MATTA NOAA/OAD/SEATTLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Infaunal benthos are the portion of the aquatic ecosystem most directly affected by sediment-associated pollutants. In addition to being an important part of the aquatic food chain, the benthos exerts important controls on the chemical and physical structure of bottom sediments. The purpose of this study is to investigate the pattern of recovery of infaunal benthos of Lake Erie from anthropogenic mortality-producing disturbance, and to examine effects of colonizing benthos on the chemical structure of the sediment, the flux of hazardous materials across the sediment-water interface, and the transport of particulate matter by waves and currents. Methods used include field and laboratory experiments. The results of this research should help predict the effects of various kinds of anthropogenic disturbances, especially disposal of dredged material, on the benthos and the geochemical and geotechnical properties of the bottom of Lake Erie.

CONCLUSIONS:
Based on the report dated June 1983.
1. Recovery of the benthic population after sediment has been defaunated is nearly complete after about one year. Full recovery may take a few years.
2. Early colonizers are near-surface dwellers that colonize in great numbers. They are poor competitors, however, and have high death rates. Larger species and those that burrow deeply into the sediments colonize more slowly, in lower numbers, and have lower death rates.
3. Different types of organisms have differing effects on such sediment properties as erodability, flux of contaminants, oxygenation of sediments, and bacterial growth. For example, clam burrows enhance pollutant exchange between sediment and water by one-third, and the fecal pellets of the tube worms stratify the sediment into two layers, which enhances the flux of ammonium, bicarbonate, and silica from sediments. After the onset of anoxia, tube worms decrease the flux of iron and phosphate. Clams enhance chloride and nitrate flux from sediments and decrease bicarbonate flux. The flux of solutes from pore waters is increased in the presence of irrigated burrows.
4. Bacterial abundance and growth rates at various sediment depths are increased by the presence of the three benthic organisms studied.

TITLE: BIOGEOCHEMISTRY AND PHYSIOLOGIC EFFECTS OF POLYCYCLIC AROMATIC HYDROCARBONS AND THEIR METABOLITES IN CONTROLLED BENTHIC ECOSYSTEMS
CONTRACT #: NA83ABD00012
NAME: TEAL, JOHN M.
CONTRACTOR: WOODS HOLE OCEANOGRAPHIC INSTITUTION
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: ENDS 6/30/85

ABSTRACT:
The coastal benthic environment is rich, and it provides food for many fish species. Contamination of water and sediment by toxic chemicals may harm benthic organisms. Benthic organisms may contribute to the processing of contaminants, affecting their long-term fate. This research will study the biogeochemical fates and physiological effects of polycyclic aromatic hydrocarbons (PAHs) and their oxygenated metabolic products in benthic microcosms in the laboratory. Results will quantify how the presence of these compounds affects the benthos and how the activity of the benthos affects the geochemical fate of these compounds in coastal benthic environments. Fates and effects of these compounds as introduced by different sources will be compared.

CONCLUSIONS:
Research in progress

TITLE: PCBs IN MARINE SEDIMENTS: EFFECTS, UPTAKE, AND METABOLISM IN OPPORTUNISTIC POLYCHAETES
CONTRACT #: NA81RAD00024
NAME: GRASSLE, JUDITH
CONTRACTOR: MARINE BIOLOGICAL LABORATORY
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Polychaetes are abundant in the benthos and provide food for commercial species of fish and crustaceans. There is a need to determine whether polynuclear aromatic hydrocarbons (PAHs) affect polychaetes and whether polychaetes can degrade PAHs. The purpose of this research is to study the effect of deposit-feeding polychaetes (Capitella species) on the transformation of PCBs in New Bedford Harbor sediments. Objectives of the research are: to determine which species of Capitella achieve high population densities in sediments heavily contaminated with PCBs; to provide sediment-free samples of Capitella from heavily contaminated and uncontaminated sediments for chemical analysis for PCBs; and to achieve a better understanding of how environmental factors and pollutants interact to determine the population densities of the different Capitella species. Methods include collection of Capitella species and laboratory bioassays for PCBs.

CONCLUSIONS:
Based on the report dated November 24, 1982.
1. Marine worms are a common food source for many higher organisms in New Bedford Harbor and may act as a transfer mechanism for PCBs from the sediments.
2. Relative proportions of two PCBs in the worms are similar to the proportions of these two PCBs found in harbor sediments.
3. The worms excrete fecal pellets that contain high concentrations of unchanged PCBs that are similar to sediment concentrations (2.7 to 4.0×10^{-6} grams per gram wet weight). By packaging PCBs in fecal pellets, worms may be changing the breakdown rate, and the transport and resuspension properties of PCBs in the harbor sediments.

TITLE: IMPACT OF SEWAGE SLUDGE DISPOSAL AND DREDGING ON THE DISTRIBUTION AND CYCLING OF PATHOGENIC HUMAN ENTERIC VIRUSES IN SHALLOW COASTAL WATERS
CONTRACT #: NA83AAD00050
NAME: GOYAL, SAGAR M.
CONTRACTOR: UNIVERSITY OF MINNESOTA
NOAA CONTACT: H. WHITE NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Contamination of the coastal environment with pathogenic viruses can eliminate the use of valuable coastal recreational and food resources. This research will study the fate and transport of human enteric viruses at the Philadelphia and New York Bight Dumpsites and in Puerto Rico and Lake Superior. The effect of rainfall and dredging on the transport of sediment-associated viruses will be investigated, and the relationship between the presence of viruses in water, sediment, or shellfish and bacterial indicators will be studied. Results of this study will contribute to the protection of coastal waters and shellfish from viral contamination.

CONCLUSIONS:
Based on the report dated December 1983.
1. Human enteric viruses were isolated from five samples of sediments and one sample of water. The number of viruses isolated varied from 12 to 50 plaque-forming units (PFU) per kilogram of sediment and two PFUs per 100 gal of water. Even one PFU of virus is capable of infecting a susceptible host.
2. Stations within the New York Bight have viruses and bacteria in water as deep as 65 meters. Some samples contained viruses but no bacteria, suggesting that indicator bacteria may not be adequate for predicting virological quality of water or sediment. Sediment may act as a reservoir of human enteric viruses following the disposal of sludge in water.
3. Human enteroviruses can survive for over 17 months following sludge disposal in water.

TITLE: MICROBIAL INDICATORS OF ENVIRONMENTAL IMPACT AT DEEP-OCEAN DUMPING SITES
CONTRACT #: NA79AAD00062
NAME: COLWELL, R.R.
CONTRACTOR: UNIVERSITY OF MARYLAND
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Earlier studies provide evidence that suggests ocean disposal of pharmaceutical wastes has caused significant alterations in the bacterial community of the Puerto Rico dumpsite. This study will help elucidate the reasons for shifts in the bacterial community. The goal of this research is to assess the effects of composite pharmaceutical waste on species-defined bacterial communities contained in flask microcosms. Microbial effects of the sewer outfall off Puerto Rico will be investigated and compared with effects observed at the dumpsite.

CONCLUSIONS:
Based on the final report dated August 28, 1984.
1. There has been a shift in the dominant bacteria species from Pseudomonas spp. to Vibrio and Acinetobacter spp. in the area of the Puerto Rico dumpsite and the waste treatment outfall.
2. Bacterial species present in the indigenous flora can multiply in or use waste as a growth substrate. The structure of the bacterial community was altered by waste concentrations of 100-1,000 ppm.
3. In the seawater surrounding the sewage outfall, through which pharmaceutical wastes are now discharged, fecal coliform and streptococci numbers were high. Pathogenic bacteria were found in the seawater and in the waste effluent.
4. Diversion of waste disposal from open ocean to the wastewater treatment plant has not solved the problem of disposing of pharmaceutical wastes. Wastes move through the plant, which provides secondary treatment but no chlorination, and remain relatively unchanged. Presence of the pharmaceutical waste adversely affects the sewage treatment process, especially in the ability to eliminate human pathogens from the sewage. Thus, the toxic pharmaceutical waste materials as well as bacteria potentially pathogenic to humans are carried onshore by tidal currents.

TITLE: UPTAKE, TRANSFORMATION, AND EFFECTS OF WATER BORNE POLLUTANTS ON INTERTIDAL WOODY HALOPHYTES
CONTRACT #: NA81RAD00017
NAME: SNEDAKER, SAMUEL C.
CONTRACTOR: UNIVERSITY OF MIAMI
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Coastal swamp forests are among the most productive ecosystems in the world and are recognized for their supporting role in the maintenance of near-shore fisheries through continuing inputs of detrital organic matter. Due to their coastal position, they are subjected to perpetual inputs of a variety of toxic chemicals. They are occasionally and severely impacted by oil spills. The purpose of this research is (1) to evaluate what happens to pollutants relative to direct uptake into plants versus incorporation into aerobic/anerobic sediments and (2) to determine secondary uptake, translocation, and effects on mangroves. The objective is to experimentally determine the effects, transformations, and/or fates of selected toxic chemicals, including petroleum, in mangroves in subtropical and tropical ecosystems. Methods used to attain this objective are field and laboratory studies and literature searches. This research is expected to fill gaps in the existing literature and lead to the development of a basis for predicting the first- and second-order effects of pollutants in coastal marine environments.

CONCLUSIONS:
Research in progress

TITLE: PERSISTENCE OF PATHOGENIC PROTOZOA IN SEDIMENTS AT THE DISCONTINUED PHILADELPHIA-CAMDEN SEWAGE DISPOSAL SITE
CONTRACT #: N-NM-NE-004
NAME: SAWYER, THOMAS K.
CONTRACTOR: NOAA/NMFS/NEFC/OXFORD LAB
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: ENDS 4/1/85

ABSTRACT:
Small free-living amoebae belonging to the genus Acanthamoeba recently have been implicated as facultative opportunists that may cause disease or death in humans and animals. All known species feed on bacteria, and some can thrive at temperatures equal to or greater than normal mammalian body temperatures. Discovery of pathogenic species of Acanthamoeba in sea bottom sediments from both the New York Bight and Philadelphia-Camden sewage disposal sites has prompted the development of a multidiscipline cooperative research effort. It will determine the influence of the number of bacteria in sewage with the frequency with which the amoebae could be cultured from contaminated sediments, the distribution of amoebae from shore to the open ocean, and the influence of water depth, salinity, temperature, and time of year on the recovery of amoebae from control and test stations.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. Amoebae have been recovered from 20 to 80 percent of the sewage site stations, regardless of differences in salinity, temperature, or water depth. A highly significant correlation exists between bacterial numbers and the frequency with which the amoebae are cultured from sediments.
2. Since the amoebae form resistant cysts that remain viable for several years, it is anticipated that their persistence in the sea bottom will be useful for monitoring habitat improvement when counts of viable bacteria are no longer obtainable.
3. In areas where sewage sludge dumping is not occurring, amoebae were recovered from less than five percent of the test stations. This suggests that a monitoring system based on amoebae may be conducted with a high degree of statistical confidence.

TITLE: THE RESPONSE OF MARINE BACTERIA TO DISPOSAL AT SITE 106
CONTRACT #: NA78AAD00042
NAME: VACCARO, RALPH F.
CONTRACTOR: WOODS HOLE OCEANOGRAPHIC INSTITUTION
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Marine bacterial populations have a unique ability to respond rapidly in a measurable and consistent way to extraneous, sublethal, and substrate changes. They can also react in either a stimulatory or inhibitory fashion depending upon the nature and concentration of a particular perturbant. In addition, they demonstrate remarkable substrate versatility since, as a group, they can respond to all organic molecules synthesized by living matter as well as many of the refractory synthetic molecules that are becoming increasingly prevalent in modern society. This research will utilize microbiological assay techniques to evaluate the impact of industrial waste disposal at the 106-mile dumpsite. Growth and respiration rates, changes in cellular mobility, rates of organic carbon assimilation, and light emission by bioluminescent species will be evaluated. Results will contribute to the evaluation of the effects of waste disposal on bacteria.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. Each behavioral characteristic tested offers potential for a bioassay technique demonstrating extreme sensitivity and short reaction time combined with overall procedural simplicity.
2. None of the tested characteristics have demonstrated long-term toxic consequences associated with 106-mile dumpsite disposal activities.

2.5 Various Organisms

TITLE: EFFECTS OF CONTAMINANTS ON FOOD WEB DYNAMICS IN THE GULF OF MEXICO
CONTRACT #: N-NM-SE-001
NAME: CROSS, FORD
CONTRACTOR: NOAA/NMFS/SEFC/BEAUFORT LAB
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: ENDS 10/1/86

ABSTRACT:
Marine ecosystems display a high degree of temporal and spatial variability and a high capacity for adaptive response to pollution. Pollution impacts are often masked by a high natural variability or compensatory adjustments to a particular pollutant, making it difficult to evaluate ecological effects of pollution over short time scales. Long-term ecological change is evident in many polluted systems, but the information to predict such impacts is lacking. The purpose of this research is to obtain information that can be used to establish criteria by which long range effects of contaminants (especially trace metals) on marine ecosystems can be detected or predicted. Specific objectives include identifying pathways of contaminant and energy transfer through planktonic communities, determining the effects of differences in concentrations and chemical forms of trace metals on planktonic communities, and developing models to estimate the assimilative capacity of planktonic communities for trace metals. This research will be carried out in the Gulf of Mexico (the Mississippi Delta, Cape San Blas, off Galveston, the Gulf Loop Intrusion, in Campeche Bay, and off Yucatan) and in the laboratory. The results of this research will provide environmental managers with the information needed to minimize the impact of trace metal additions to various regions of the Gulf of Mexico.

CONCLUSIONS:
Based on the report dated September 1982.
1. Target fish species feed on copepods.
2. Morphometrics may be valuable in evaluating health of fish larvae at sea.
3. Because of a new use of techniques, secondary production of particulate organic matter by bacteria may be greater than originally thought.
4. Dissolved copper is more complexed in productive waters than in less productive waters, and this affects the degree of toxicity of copper to natural bacteria.
5. Natural communities of bacteria and phytoplankton are extremely sensitive to copper, more so than to cadmium or zinc.
6. Low-production communities are more sensitive than high-production communities (for both chemical and biological reasons).
7. Phytoplankton are highly sensitive to zinc (more so for low-production communities). This condition was reversed by additions of manganese, but not iron. Differences in sensitivity may be due to differences in manganese concentrations.
8. Concentration and speciation of metals may exert natural controls on phytoplankton species composition and primary productivity.

TITLE: LONG-TERM EFFECTS OF PETROLEUM HYDROCARBONS IN SEDIMENT ON REPRODUCTION AND GROWTH OF CRABS AND SHRIMP
CONTRACT #: N-NM-NW-001
NAME: KARINEN, JOHN F.
CONTRACTOR: NOAA/NMFS/NWAFC/AUKE BAY LAB
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Alaska's marine environment is diverse and unique. It is characterized by high fishery productivity (worth over $700 million to United States fishermen in 1979), cold temperatures, vast areas of shallow continental shelf, and more shoreline than all the rest of the United States combined. The most significant difference between Alaska's marine ecosystem and that of the lower 48 states is the pristine condition of the Alaska system, which is now threatened by only one major pollutant--oil. Therefore, it is of national importance to ensure that research is done to evaluate and predict the potential effects of oil pollution in Alaska. The purpose of this research is to determine the lowest concentration of petroleum under cold temperature conditions that allow continued survival of marine species in Alaska. Methods used in this research are field and laboratory studies. The results of this study may be used to aid decisionmakers in the development of oil fields in Alaska; the basis for evaluating environmental impact of these developments should rest on the data base for effects of oil in cold environments rather than for oil impacts in warmer environments.

CONCLUSIONS:
Based on the report dated October 1982.
1. Mussels are very tolerant of oil-water soluble fractions with no mortalities in the first 21 days of exposure.
2. Mussel byssal thread extrusion was stopped or slowed at sublethal exposures of only one to two days.
3. Doses of 60 ppb aromatic hydrocarbons (water-soluble fraction) are lethal to shrimp after one month of exposure. Feeding rates are depressed by dissolved aromatic hydrocarbons at concentrations of 0.09 ppm and greater. Oiled sediments have no effect on feeding rates or behavior.
4. Mortality of gravid Tanner crabs during six months exposure to oiled sediments was not attributable to oil exposure. Short-term exposure (30 days) did not affect egg hatching or production. However, larvae appeared less viable, and their behavior was abnormal.

TITLE: BIOAVAILABILITY OF PARTICLE-ASSOCIATED XENOBIOTICS
CONTRACT #: N-NM-NW-002
NAME: MALINS, DONALD C.
CONTRACTOR: NOAA/NMFS/NWAFC
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: ENDS 9/30/85

ABSTRACT:
Attempts have been made to assess the toxicity of sediments to marine biota and to correlate types and concentrations of chemical contaminants in sediment with toxicity; results have been limited. To improve the lack of knowledge, phylogenetically diverse species will be exposed to sediment from areas of high and low contamination levels, as well as to the associated water. Research results will be used to develop cost-effective procedures for determining toxicity of sewage-contaminated sediment on marine biota.

CONCLUSIONS:
Based on the report dated March 16, 1984.
1. Short-term bioassays using highly contaminated sediments from Puget Sound demonstrated lethal effects on amphipods, surf smelt, and oyster larvae. Sublethal effects included abnormal oyster larvae development, reduction of bacterial bioluminescence, and reproductive impairment (copepod nauplii, sea urchin eggs, and sperm).
2. Short-term bioavailability studies showed that amphipods exposed to contaminated sediment for 10 days accumulated high levels of both aromatic and chlorinated hydrocarbons.
3. In long-term sediment bioassays, no adverse effects were detected in clams or shrimp; however, alterations in liver function were detected in English sole.
4. Sediment-associated aromatic and chlorinated hydrocarbon compounds were taken up by clams, shrimp, and English sole exposed to Duwamish River sediment for periods up to four months.
5. Sediment extract and model mixture bioassays produced no chemically related histopathological changes in English sole exposed to concentrations of aromatic and chlorinated hydrocarbons and metals of 1.7 times environmental levels.
6. Survival of amphipods exposed to model mixtures with levels five times higher than natural was significantly lower than control organisms. No difference was detected between the survival of amphipods exposed to metals at environmental concentrations and the survival of control specimens.

TITLE: MECHANISMS CONTROLLING BIOLOGICAL EFFECTS OF TRACE METALS IN THE OCEAN
CONTRACT #: N-NM-SE-003
NAME: CROSS, FORD
CONTRACTOR: NOAA/NMFS/SEFC/BEAUFORT LAB
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: ENDS 10/1/86

ABSTRACT:
Evaluation of the biological effects of waste dumping in the ocean must include research on basic processes of trace metal accumulation and toxicity. This research investigates the relationship between chemical form and bioavailability of trace metals to marine food webs. It is based on the hypothesis that bioavailability of trace metals is a function of the environmental concentration of metals and factors such as pH, salinity, and dissolved or particulate matter that control the partitioning of the metal into different physical and chemical forms. Experiments will be conducted with marine organisms of different taxa and trophic levels (phytoplankton, bacteria, zooplankton, oysters, and fish) and with trace metals that represent a wide range of toxicity and chemical reactivity (zinc, copper, manganese, cadmium, silver, and nickel).

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. For zinc, copper, and cadmium, the free ion is the most toxic dissolved chemical form.
2. A bacterial toxicity bioassay to estimate complexation of copper in seawater has been adapted to shipboard use with natural bacterial populations and used to estimate cupric ion activities in the Gulf of Mexico.
3. Accumulation of cadmium by a marine diatom is controlled by the concentration of the free ion, and accumulation of silver appears to be a function of the neutral complex silver chloride. The more rapid accumulation by silver chloride may be explained by the higher solubility of neutral species in the lipid phase of the cell plasma membrane than that of charged species. The accumulation of dissolved copper by oysters in the absence of food was related to the free cupric ion concentration irrespective of the concentration of total dissolved copper. The free cupric ion may be important in controlling accumulation of dissolved copper in multicellular as well as in unicellular organisms.
4. Food was more important than water as a source of zinc to fish. It accounted for more than 85 percent of the zinc assimilated by fish.

TITLE: OCEAN DUMPING OF DREDGED MATERIAL AND SUBSEQUENT ENVIRONMENTAL MONITORING AT THE BARATARIA BAY DISPOSAL SITE IN THE REGION OF THE MISSISSIPPI DELTA
CONTRACT #: NA80AAD00042
NAME: PEQUEGNAT, WILLIS E.
CONTRACTOR: TERECO CORPORATION
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The fates and effects of toxic metals and organic pollutants will be investigated at the Barataria Bay dredged material disposal site, located in the Mississippi River Delta region. In situ field bioassays will be carried out using pelagic and benthic organisms. These will measure mortality and provide a gauge for measuring potential toxicity and a calibrator for judging the effects of bioaccumulation. Pelagic and benthic organisms will be investigated for effects from several trace metals (cadmium, lead, zinc, iron, copper, manganese, and mercury), total PCBs, selected pesticides, and heavy molecular weight hydrocarbons. A literature search on these subjects will also be done. Results will contribute to the assessment of the effects of dredged material disposal.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. Results from the field bioassay system's enzyme analyses were indicative of a stressed environment.
2. Trace metal concentrations in sediments and organisms are comparable to those of relatively of pristine areas in the Gulf of Mexico.
3. There was no evidence of petroleum contamination. Chlorinated hydrocarbon values are one to two orders of magnitude lower than those found in the New York dredged material dumping area.

TITLE: FATES AND EFFECTS OF NUTRIENTS AND HEAVY METALS ALONG A SIMULATED ESTUARINE NUTRIENT GRADIENT
CONTRACT #: NA83ABD00008
NAME: PILSON, MICHAEL E.Q.
CONTRACTOR: UNIVERSITY OF RHODE ISLAND
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: ENDS 11/15/85

ABSTRACT:
There is considerable evidence that the chemical changes resulting from eutrophication of coastal ecosystems have caused changes in phytoplankton and zooplankton dynamics. This research will investigate the specific causes of zooplankton speciation changes which occur after input of high levels of nutrients to mesoscale microcosms. The interactions between eutrophication and metal availability will be examined. Hypotheses to be tested include whether nutrient-enhanced systems process added metals differently than control systems and whether nutrient-enhanced systems differ from control systems in their sensitivity to added metals. Mesoscale microcosms at the University of Rhode Island will be used for these studies. Results will contribute to a strategy for the management of nutrient-containing wastes so as to maximize positive benefits and minimize the potential for anoxia and damage to critical living resources.

CONCLUSIONS:
Research in Progress

TITLE: DEMOGRAPHIC METHODS FOR THE PREDICTION OF TOXIC SUBSTANCE EFFECTS
CONTRACT #: NA83AAD00058
NAME: CASWELL, HAL
CONTRACTOR: WOODS HOLE OCEANOGRAPHIC INSTITUTION
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: ENDS 7/31/85

ABSTRACT:
Recently developed techniques use population analysis techniques for a variety of purposes. These techniques can be expanded to use life-cycle mortality and reproductive information to evaluate the effect of toxicants on marine populations. In addition to the intrinsic rate of increase, these techniques will reveal toxicant effects on population structure, short-term population fluctuations, stability in the face of environmental fluctuations, and equilibrium population density. A survey of all suitable data sets will be conducted, and the new analytical techniques applied to all of them to produce a review of all population effects.

CONCLUSIONS:
Based on the report dated March 31, 1984.
1. Data has been collected summarizing survivorship and fecundity over a majority of the life cycle of various organisms. Existing demographic studies have been limited to the effects of toxicants on the rate of population increase. Other, more detailed analyses are being conducted, for example, the effects of dieldrin on the copepod Eurytemora affinis were examined with respect to the population age distribution and reproductive value distribution. These can provide measures of the sensitivity of the population growth rate to changes in age-specific survival or fecundity.
2. Analyses indicate that dieldrin reduces both survival and fecundity, particularly for the older age classes. It shifts the age distribution to a dominance by older individuals. It seems that the reproductive value of young individuals increases with dieldrin levels, while the reproductive value of older individuals decreases with increasing dieldrin. Stress from dieldrin reduces the sensitivity of population growth rate to changes in survival.
3. The development of feasible laboratory and field sampling protocols to ensure collection of all information necessary for demographic analysis for the EPA field verification program is underway. This project will study effects of dredged material contaminants on several organisms from Black Rock Harbor.

3. CHEMICAL FATES

The fate of chemicals introduced into the marine environment is a necessary set of information for determining the consequences of waste disposal. NOAA's Ocean Assessments Division (OAD) supports research on the fate of various trace metals and organic pollutants (hydrocarbons, pesticides, PAHs, PCBs, and others) in US coastal waters. Studies are carried out in the Great Lakes, the Gulf of Mexico, along the East and West Coasts, and at major dumpsites. Laboratory studies are also supported. Concentrations of chemicals in various forms, flux between phases, and methods of evaluating chemical toxicity are the major subjects investigated. Some of the more interesting observations resulting from OAD-sponsored research are that salmon are transporting mirex upstream from Lake Ontario (C-10); that Lake Ontario sediments will act as a source of mirex to the water column and that Lake Michigan sediments will act as a source of PCBs to the water column for at least 20 years (C-14); and that trace metal levels in naturally occurring concentrations do affect growth rates and speciation of plankton (C-24). Twenty-two projects were sponsored at 13 institutions. These projects are presented here according to the type of pollutant studied.

3.1 Trace Metals

TITLE: REMOVAL AND FATE OF POLLUTANT TRACE METALS IN COASTAL WATERS
CONTRACT #: NA81RAD00016
NAME: SANTSCHI, PETER
CONTRACTOR: COLUMBIA UNIVERSITY
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
It is imperative for us to understand the pathways and rates by which trace metal pollutants, released to coastal waters, are distributed and retained within the local ecosystem if these environments are to be properly managed and protected. The purpose of this research is to determine the effect of sediment resuspension and the type of sediments present on removal rates of trace metals added to microcosms. Objectives include testing radiotracers as analogs for stable trace metals, testing the degree to which resuspended sediment flux through the water column controls removal rates of trace metals, examining the release of trace metals from sediments under normal and "storm" conditions, and examining remobilization of trace metals under varying water and oxidation-reduction conditions. Methods include the use of MERL tanks at the University of Rhode Island. The accumulated data from metal tracer experiments is to be used to calibrate a comprehensive model for geochemical behavior of metals in an estuary like Narragansett Bay.

CONCLUSIONS:
Based on the final report dated June 1984.
1. During winter, particle flux and temperatures are low. The tank without sediments produced a much lower particle flux than tanks with sediments. Most of the particle flux in the tank with sedient originated from resuspension of bottom sediments. During summer, temperature and

particle flux were high. High resuspension rates were enhanced by intensive benthic fauna activities. High phytoplankton cell concentrations existed at winter temperatures, these concentrations were low in summer due to zooplankton grazing. Half-removal-times for radiolabelled metals were two to eight times faster in tanks with sediments than in those without bottom sediments. Removal rates were two to seven times faster at summer temperatures than at winter temperatures in tanks with sediments, and up to four times faster in tanks without sediments.

2. Distribution ratios for most radiotracers between solid and solution phases of filtered and sediment-trap particles increases with time and reaches a constant value within five or 10 days. The exceptions to this were oxidation/reduction sensitive metals such as Mn, Co, and Cr.

3. Removal of particle-reactive radiotracers from the MERL water column is assumed to be controlled by two counter-acting processes, (a) adsorption of the radiotracer onto suspended particles followed by settling by gravity and (b) the resuspension of settled particles which have been diluted with uncontaminated particles in the sediments by benthic activity.

4. Half-removal-times of radiotracers are inversely related to their partition or distribution ratios between settling particles and solution. For individual radiotracers, the seasonal change in its half-removal-time is mainly controlled by benthic faunal activity which enhances the summer removal by increasing particle flux (by resuspension and bioturbation).

TITLE: MARINE POLLUTION CHEMISTRY ANALYSIS
CONTRACT #: 04-08-MO1-192
NAME: KESTER, DANA R.
CONTRACTOR: UNIVERSITY OF RHODE ISLAND
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
As we endeavor to assess and predict the impact of pollutants in marine systems, it becomes necessary to consider quantitatively the chemical behavior of pollutant substances. This research will develop a series of quantitative chemical models based on thermodynamic and kinetic data that will relate the present chemical knowledge of metals to their behavior as pollutants in marine systems. The solution phase species of copper, manganese, lead, cadmium, and mercury in marine systems will be examined. Heterogeneous phase reactions will also be investigated. This work is primarily an effort to utilize existing data that were obtained primarily for their fundamental value to the problem of marine pollutant chemistry to enhance our ability to predict the chemical behavior of marine pollutants and to help focus future research.

CONCLUSIONS:
Research in Progress

TITLE: TRANSITION AND HEAVY METAL CHEMISTRY ASSOCIATED WITH DEEP-WATER DUMPSITE 106
CONTRACT #: NA79AAD00033
NAME: KESTER, DANA R.
CONTRACTOR: UNIVERSITY OF RHODE ISLAND
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
This study of the chemical behavior of iron, copper, cadmium, and lead at the 106-mile dumpsite is concerned with the consequences of acid-iron industrial waste disposal. These wastes contain high concentrations of acid, iron, chromium, vanadium, copper, and lead. They are discharged in the wake of a moving barge and disperse in the upper mixed surface layer of the ocean. As the acid is neutralized by seawater, the iron precipitates as hydrous ferric oxide, scavenging other constituents from the seawater into a particulate phase. The main objectives of this research are to determine the chemical concentrations that result from acid-iron disposal at sea, the fractionation of metals between particulate and dissolved phases, and the transport and dilution of wastes by oceanic processes. This information is required in order to assess the chemical conditions to which marine biota are exposed and to determine the time period over which the chemical effects persist.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. The concentrations of iron in a plume remain one to two orders of magnitude higher than natural values for periods of up to two to three days. These elevated concentrations are evident in the surface mixed layer of water, which during the summer extends from the sea surface to a pycnocline at about 30 meters in depth.
2. Nearly all of the iron and lead are associated with particles. About half of the copper is particulate, and nearly all the cadmium is dissolved. The particulate phases may be ingested by filter-feeding marine zooplankton or may be removed from the surface waters either by settling or by incorporation into fecal pellets.
3. Waste is diluted 10,000 times within 30 minutes, but a subsequent ten-fold dilution requires about a day. By extrapolating these results, time periods on the order of weeks or months are required to achieve a million-fold dilution of wastes. Other removal or dispersive processes probably become important on these longer time scales.

TITLE: THE BEHAVIOR OF TOXIC METALS IN MISSISSIPPI RIVER DELTA SEDIMENTS
CONTRACT #: NA80AAD00047
NAME: PRESLEY, B.J.
CONTRACTOR: TEXAS A&M UNIVERSITY
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The release of toxins from dredged materials on the seafloor could potentially be more harmful to marine organisms than the toxins released during settling to the seafloor. Because the magnitude of release from the seafloor sediments and the mechanisms that control it are poorly known, a study to investigate the behavior of toxic metals in sediments from the Mississippi River Delta will be undertaken. Benthic flux chambers will be placed over the seafloor of Barataria Bay, sampled, stirred, and oxygenated from the surface. Sediment cores that trap an aliquot of overlying water will also be sampled. Barataria Bay is scheduled for continued maintenance-dredging and is an ideal location for this type of study. Results will contribute to the determination of effects of dumping dredged materials on the marine environment.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. There is a dramatic increase in flux of manganese from sediments to overlying water when oxygen levels are allowed to drop (due to both stagnation and oxygen uptake by sediment).
2. A long-term release of Mn and NH_3 from sediment will occur, possibly affecting organisms.

TITLE: CHEMICAL INVESTIGATION OF WASTE DISPOSAL IN THE NEW YORK BIGHT
CONTRACT #: NA79AAD00086
NAME: KESTER, DANA R.
CONTRACTOR: UNIVERSITY OF RHODE ISLAND
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Dredged material is currently being discharged in the New York Bight. Three types of experiments and observational programs will be conducted through this research, investigating the extent to which dredged material disposal in the New York Bight causes increased concentrations of potentially toxic metals in the waters of this region. The first type is to determine the extent to which dredged material disposal produces elevated water column concentrations in the vicinity of a dump. The second study is to examine the flux of metals from the dredged material mound to the overlying seawater. The third portion of the work is to consider the spatial distribution of metals in the New York Bight apex to determine what effect, if any, is produced by the dumpsites. The metals of principle concern in this investigation are iron, copper, cadmium, and lead. Results of this research will demonstrate whether water quality in the New York Bight is affected by dredged material disposal.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. Chemical modifications to the water column from a single dump of dredged material are of short duration (less than 30 minutes). Accumulations of fine particles at the pycnocline were slight and short-term. Chemical concentrations at the dumpsite were about 10 times higher than offshore.
2. There was a substantial flux of ammonia and cadmium from the sediment and a slight flux of copper. There was no flux of iron or manganese.
3. The Hudson River plume is the major factor in determining metal concentrations in surface waters. Below the pycnocline, elevated concentrations of particulate iron, copper, cadmium, and lead cannot be accounted for by the Hudson River. Either the dredged material or the sewage sludge dumpsite is causing these elevated concentrations.

3.2 Organic Pollutants

3.2.1 Hydrocarbons

TITLE: HYDROCARBONS AND OTHER POLLUTANTS IN URBAN RUNOFF AND COMBINED SEWER OVERFLOWS
CONTRACT #: NA80RAD00047
NAME: HOFFMAN, EVA J.
CONTRACTOR: UNIVERSITY OF RHODE ISLAND
NOAA CONTACT: H. STANFORD NOAA/OAD/STONY BROOK
FUNDING STATUS: COMPLETED

ABSTRACT:
Pollution of the Providence River and upper Narragansett Bay from sewage effluents is Rhode Island's most serious water quality problem. In addition to discharges from sewage treatment facilities and urban runoff, these water bodies also receive effluents from 66 combined sewage overflows (CSOs), which discharge raw sewage along with the storm water runoff directly into the rivers. One of the difficulties in constructing a budget for any pollutant in Narragansett Bay has been a complete lack of data on pollutant levels in urban runoff and on CSO discharges in this region. Data on petroleum hydrocarbon concentrations in this type of effluent are especially scarce. The purpose of this study is to characterize sources, transport, form, and flux of petroleum hydrocarbons in urban runoff and combined sewage overflows to Narragansett Bay. Three specific objectives are: the assessment of the quality and nature of petroleum hydrocarbon inputs; the factors controlling this input; and the examination of the efficiency of treatment of urban runoff effluent. This research should provide information necessary to develop a realistic petroleum hydrocarbon budget for Narragansett Bay.

CONCLUSIONS:
Based on the report dated April 1984.
1. Input of hydrocarbons via urban runoff is a function of rainfall. Only at times of higher amounts of rainfall does the rate of hydrocarbon input decelerate. From industrial areas, discharge was linearly related to rainfall. From other areas the relationship was polynomial.
2. Maximum hydrocarbon discharges are predicted for occurrences of between 2.5 and 4.8 cm of rain, depending on land use. Highest input rates of petroleum hydrocarbons and PAHs are largely (91% and 86% respectively) associated with suspended particulate matter in urban runoff. This suggests that treatment schemes effective for suspended solids will be effective for removing petroleum hydrocarbons from urban runoff or combined sewer overflows.
3. PAHs were enriched on particles smaller than 45 microns.
4. Preliminary sampling indicates that atmospheric fallout rates of PAHs on land surfaces were two to three times the urban runoff discharge rate. This could be the major source to runoff.
5. Metal inputs to runoff were highest for highway, then industrial, commercial, and residential land use. Inputs of hydrocarbons were highest for industrial land, then highways, commercial, and residential land. The bulk of petroleum in urban runoff comes from used crankcase oil on highways.

6. Of the 20 tons of hydrocarbons discharged by combined sewer overflows in Providence, R.I., 80 percent is from urban runoff.
7. Since the concentration of suspended solids in combined sewer overflow effluent is similar to that of treatment plant influent during rainy conditions, the nature of treatment plant influent can be used to predict concentrations of discharges that escape the system through combined sewer overflows. Combined sewer overflows increase loading rate of pollutants to sewage treatment plants and overload the plants causing losses of sludge. Treatment of urban runoff by municipal treatment plants is ineffective.
8. Petroleum hydrocarbons and suspended solids were efficiently removed (46-95% and 26-79% respectively) from runoff effluents of a parking lot by a small retention pond. An average of 53 percent of urban runoff particulates were settlable and could easily be removed by treatment schemes involving sedimentation.

TITLE: THE DISSOLUTION RATES OF HYDROCARBONS FROM CRUDE AND REFINED OILS IN SEAWATER
CONTRACT #: NA80RAD00043
NAME: PANKOW, JAMES F.
CONTRACTOR: OREGON GRADUATE CENTER FOR STUDY AND RESEARCH
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The pollution of seawater by petroleum related materials poses a substantial threat to marine ecosystems. Although dissolution processes play an important role in the weathering and dissipation of petroleum phases in the marine environment, they are only poorly understood. The purpose of this research is to examine the rate of transfer of oil components from the oil-like phase to the aqueous phase. Objectives include: determination of the compounds that dissolve through diffusion-controlled mechanisms; determination of those compounds that tend to be chemically controlled; determination of the nature of the control-rate law governing such chemical control; and the determination of how to use this information to predict dissolution rates. These studies will be carried out in the laboratory. This research will provide rate law information on various study compounds from three petroleum phases. A framework will be developed for understanding dissolution processes.

CONCLUSIONS:
Based on the report dated March 2, 1982.
1. Diffusion is the process that limits and controls the rate of dissolution across an oil-water interface.
2. The coefficients for mass transfer in the aqueous phase from the interface to the bulk seawater for the studied compounds do not exceed 3×10^{-5} m/sec even under the most turbulent of conditions.

3.2.2 Mirex

TITLE: UPSTREAM MIGRATION OF THE LAKE ONTARIO CONTAMINANT, MIREX
CONTRACT #: NA80RAD00058
NAME: MARTIN, KATHRYN H.
CONTRACTOR: STATE UNIVERSITY OF NEW YORK
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The transfer of mirex between species in upstream spawning areas allows an opportunity to study and quantify specific pathways of contaminant transfer. The purpose of this research is to show that migratory lake fish are responsible for the transfer of mirex from Lake Ontario to stream organisms. Specific objectives are: to identify sites of lake fish migration and spawning that prove to be sites of mirex transfer to nonlake species; to determine and quantify mirex in lake organisms; and to demonstrate that in Lake Ontario tributaries devoid of migratory lake fish no such mirex transfer occurs. Tissues of migratory fish, their eggs, and resident brown trout as well as food web intermediates (including blow-fly larvae and crayfish) will be examined for mirex residue levels. The expected result is a diagram describing a stream food web through which mirex flows.

CONCLUSIONS:
Based on the report dated October 28, 1982.
1. Brown trout taken from streams where salmon have not successfully migrated do not contain mirex, while trout taken from streams where salmon have migrated do contain mirex. This suggests that salmon are transporting mirex upstream from Lake Ontario.

TITLE: THE BIOAVAILABILITY OF THE LAKE ONTARIO CONTAMINANT, MIREX
CONTRACT #: NA81RAD00027
NAME: SCRUDATO, R.J.
CONTRACTOR: STATE UNIVERSITY OF NEW YORK
NOAA CONTACT: H. STANFORD NOAA/OAD/STONY BROOK
FUNDING STATUS: COMPLETED

ABSTRACT:
The widespread contamination of Lake Ontario by the persistent chlorinated hydrocarbon mirex poses a significant long-term threat to human health and to the continued economic development of the Lake Ontario sport fishery. Important sport fish such as salmonids and smallmouth bass generally exceed the 0.1 part per million U.S. Food and Drug Administration action level. Studies indicate mirex levels have not declined in recent years. Mirex-contaminated bottom sediments exist in two broad areas in Lake Ontario, offshore of the Oswego and Niagra Rivers; moreover, the two rivers continue to supply mirex-contaminated suspended sediments to the lake. The purpose of this study is to determine if riverine suspended sediments, primarily mobilized in the turbulence and high flow rates of the spring runoff period, are the major source of biologically active mirex to Lake Ontario. Detailed biogeochemical studies will be undertaken in nearshore areas of Lake Ontario to document the impact of the Oswego River plume on Lake Ontario mirex contamination. This investigation will supply information on food chain pathways of mirex contamination important to modeling dispersal and biological uptake of mirex and will also provide a frame of reference for altering harbor dredging and dredged material disposal practices to reduce mirex contamination to Lake Ontario.

CONCLUSIONS:
Based on the report dated October 1983.
1. Brown trout accumulate significant amounts of mirex by direct uptake from water.

3.2.3 Various Organics

TITLE: THE BEHAVIOR OF ORGANIC COMPOUNDS IN INDUSTRIAL WASTES DUMPED AT THE 106-MILE DUMPSITE
CONTRACT #: NA80AAD00045
NAME: BOEHM, PAUL D.
CONTRACTOR: ENERGY RESOURCES CO., INC. (ERCO)
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
In order to evaluate the effect of organic compounds from industrial waste dumping at the 106-mile dumpsite, their behavior must be studied. This research investigates the character, mixing, fate, and bioaccumulation of the nonvolatile or semi-volatile organic compounds present in American Cyanamid and Dupont-Grasselli liquid plant process wastes disposed of at the 106-mile site. Wastes will be characterized by a variety of analytical techniques. Laboratory waste-seawater mixing and waste fate experiments will be conducted, and laboratory bioaccumulation studies will be performed on a set of zooplankton samples obtained after an actual waste dump. Results will provide needed information on the fate and effects of industrial waste at the 106-mile dumpsite.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. American Cyanamid (A.C.) waste contains a variety (50) of low-boiling temperature components (methanol, cyclohexane, two prominent carbamate-type compounds, four phosphorus pesticide residues, and several substituted unsaturated cyclic ketones). These major compounds are present at greater than 10 ppm. Asenes of phenolic residues (more than 1 ppm) dominate the acidic fraction of this waste. Dupont-Graselli waste contains methanol and only minor amounts of nonvolatile organic compounds (for example several phthalic acid esters).
2. Several A.C. waste components undergo total, rapid (less than five minutes) hydrolysis when mixed with seawater. Major changes in waste composition are, in the short term (24 hours), chemically mediated.
3. Several components of the waste are taken up by zooplankton; however, low levels of two waste components were detected in the predump zooplankton samples as well.
4. Cyclohexanone diene sulfide compounds may effectively serve as markers of the A.C. waste during the first 24 hours after waste disposal operations, at which time their seawater concentrations should be 100 nanograms/liter.

TITLE: THE DEVELOPMENT AND APPLICATION OF SCREENING METHODS FOR THE DETERMINATION OF NITROSAMINES AT THE PARTS PER BILLION LEVEL IN THE MARINE ENVIRONMENT
CONTRACT #: NA80RAD00044
NAME: GARSIDE, CHRISTOPHER
CONTRACTOR: BIGELOW LABORATORY FOR OCEAN SCIENCES
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Nitrosamines in the environment present a potential human health hazard because these compounds are known to be carcinogenic, teratogenic, and mutagenic. That their distribution in the environment is not well known can be attributed to the lack of fast economical analytical techniques for this general group of compounds. The purpose of this research is to develop and apply screening methods for the determination of nitrosamines at the parts per billion level in the marine environment. The Cox method for nitrosamine analysis will be tested and applied. This work will be done in the laboratory. Nitrosamines include a large number of components that may be present in as yet unknown concentrations. This technique will allow estimates of the total presence of nitrosamines in the environment, without the need for preconcentration.

CONCLUSIONS:
Based on the report dated February 12, 1982.
1. Analysis in aqueous solution is quantitative for six of eight nitrosamines tested with 100 percent yield of the N-nitroso group.
2. Nitrosamines were present in sewage effluent at close to the detection limit (8-20 ± 4 ppb) and three orders of magnitude higher in the sludge (18-77 ppm).

TITLE: CYCLING OF TOXIC ORGANIC SUBSTANCES IN THE GREAT LAKES ECOSYSTEM
CONTRACT #: N-ER-GL-001
NAME: EADIE, BRIAN
CONTRACTOR: NOAA/ERL/GLERL
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: ENDS 9/30/85

ABSTRACT:
The leakage of synthetic toxic organic compounds into the environment is a recognized critical problem and one that appears to be greater in the Great Lakes than in most other regions of the world, due to a high population density and a concentration of heavy industry compounded by slow flushing rates in the Lakes. The purpose and objectives of this research are to determine various parameters of synthetic organic contaminants including their location, their residence time, their decomposition rates and products, and their final sinks after long-term leakage or high concentration loading. There are twelve different research projects within this package, and they will be handled through a cooperative program with the University of Michigan. Short-term goals are to estimate future concentrations of polynuclear aromatic hydrocarbons (PAH) in the Great Lakes, to address specific problems identified in previous polychlorinated biphenyl (PCB) research, and to upgrade the existing PCB model.

CONCLUSIONS:
Based on the report dated April 1983.
1. There is a significant enhancement of particulate-phase PCBs in the surface microlayer of Lake Michigan, probably from atmospheric deposition. These particles will preferentially accumulate in high sedimentation basins.
2. Photodecomposition rates for PCBs are inversely related to their degree of chlorination. More highly chlorinated PCBs have slower breakdown rates which are increased by algae. Sunlight decreases the degradation rate of napthalene in lake water. $CaCO_3$ increases degradation with sunlight; humic acids decrease degradation with sunlight.
3. The capacity of the liquid phase to accomodate pollutants depends on the concentration of solids in the system. There seems to be a microparticle phase that is partly organic and has a higher affinity for PCBs than water does. There is less interaction between humics and compounds having low water solubility. The aqueous solubility of compounds determines binding to humics. Uptake of PAHs is reduced when small molecules are present in sufficient concentrations, especially when the PAHs have low solubility. Uptake is especially reduced with aromatics rather than aliphatics or alicyclics of the same solubility.
4. The presence of natural sediment increases pollutant uptake and elimination by benthic organisms. They also decrease biotransformation and metabolite binding. Worms rework sediments and redistribute compounds to the surface, making them more available to the rest of the food web. Bioavailability of PAHs will be reduced in the short term by presence of other compounds; however, stabilization of PAHs by other compounds will enhance distribution of PAHs and will prolong exposure of organisms to low levels of PAHs.
5. The fate of PCBs in Lake Michigan was modeled. Sediment will probably be a source of PCBs for several decades.

6. The transport and fate of mirex in Lake Ontario was modeled. It is highly associated with particles, and the sediments will be a source of mirex for at least 20 years. Mirex will move around the eastern end of the lake and out into the deep central basins. Little mirex will end up at the north end of the lake. This transport will take a few decades from the time of input.
7. The process of resuspension of particles is important because it increases pollutant residence times. Particles seem to move in a series of hops, temporarily deposited and resuspended on their way to permanent deposition.
8. Uptake of several PAHs by Pontoporeia hoyi increases with temperature. Most compounds had increased elimination rates with increasing temperature. Simulation results indicate that trophic uptake of PCBs by alewife is very important. More than 80 percent of the total accumulated PCBs will be from this source. More than half of the accumulated PCBs comes from the amphipod Pontoporeia spp. Spawning is a major PCB loss mechanism.

TITLE: VOLATILE ORGANIC STUDIES IN GULF OF MEXICO ESTUARINE AND COASTAL ECOSYSTEMS
CONTRACT #: NA80RAD00039
NAME: BROOKS, JAMES M.
CONTRACTOR: TEXAS A&M UNIVERSITY
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Many volatile halocarbons and hydrocarbons have great potential for impacting coastal ecosystems due to both large production volumes and their high toxicity. Although over 29 volatile halocarbons and 7 volatile aromatic hydrocarbons are on the EPA's priority pollutant list, little information is available on the transport mechanisms and concentrations of these compounds in estuarine or coastal marine waters. The purpose of this research is to study the sources, sinks, and concentrations of purgeable halocarbons and aromatic hydrocarbons in estuarine ecosystems along the Gulf of Mexico. Objectives include improving analytical capability, determining the concentrations, sources, sinks, and transport of volatile organics in two estuaries, and developing a technique to examine organic content of sediments. Samples will be collected in the field and analyzed in the laboratory. This research will provide important information on the cycling and transport of volatile organic compounds through marine ecosystems.

CONCLUSIONS:
Based on the final report dated June 1984.
1. A wide variety of volatile organic compounds were detected in Gulf of Mexico estuaries. These concentrations decrease around river mouths.
2. Benzene and toluene are the most often detected aromatics. These form a major percentage of all volatile organics detected. Their source is petroleum-related activities.
3. Concentrations of individual components of volatile organics are highly variable.
5. Centrally located bay stations are dominated by chloroform and methylchloride (industrial solvents) and tetrachloroethylene (a component of dry-cleaning solution).
6. Concentrations of volatile organics are initially controlled by the input concentration. Steady-state concentrations are controlled by the rate of exchange with the atmosphere. Adsorption becomes more important with increasing carbon content of volatile organic compounds.
7. The residence time of most volatile compounds in bays is over the scale of days while in rivers it is on the order of hours. Biodegredation and photodecomposition are minor processes in determining the fate of volatile compounds because of limited light penetration in estuaries and rapid loss of volatile compounds to the atmosphere.
8. Observed distributions of organic pollutants are indicative of oil pollution. Resuspension of sediments is the most likely source of organic pollutants to the study areas.
9. Results from the lower Mississippi River delta indicate input of petrogenic hydrocarbons is occurring. Compounds present in the sediment were low level n-alkanes up to normal pentadecanes. Levels of these compounds in the water column were very low indicating the importance of evaporation and adsorption.

TITLE: THE FATE AND TRANSFER OF ORGANIC POLLUTANTS IN BENTHIC SYSTEMS
CONTRACT #: NA81RAD00029
NAME: KLUMP, J. VAL
CONTRACTOR: UNIVERSITY OF WISCONSIN
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Because of the widespread introduction and ubiquitous occurrence of organic pollutants in marine environments, the importance of sediments as sinks in aquatic systems, and because of the unknown influence of benthic organisms on pollutant cycling, there is a need to understand the processes and rates controlling the fate and transfer of organic pollutants in detritus-based benthic systems. The purpose of this research is to determine rates and processes controlling major marine pollutant transforms in the detrital food chain. Objectives are: to develop a methodology for determining assimilation and transfer mechanisms for organic pollutants by particle-feeding organisms; to investigate rates of pollutant transfer between particles and organics; assess the potential for food chain transfer; and to develop methods for assessing rates of microbially mediated degradation. Radionuclides will be applied to Lake Michigan sediments as tracers to measure the transfer of materials in aquatic food chains in the laboratory. The expected result of this work is the determination of the efficiency with which organisms assimilate contaminants associated with their food.

CONCLUSIONS:
Based on the final report dated May 1984.
1. A dual radiotracer methodology to measure mineralization of particle-bound organic pollutants by deposit-feeding organisms was developed. A defecation chamber technique was developed to measure oligochaete defecation rates.
2. Uptake kinetics of particle-bound pollutants greatly exceed feeding or defecation rates. Uptake of hexachlorobiphenyl (HCBP) by oligochaetes, amphipods, and mysids reaches equilibrium in less than 24 hours.
3. Initial assimilation efficiencies of HCBP were 30 percent for oligochaetes, 74 percent for pontos, and 57 percent for mysids. Assimilation efficiencies decreased over the 10-day experiment due to reduced residence time of food within the gut. Changing grain size distributions as the organisms preferentially fed on small particles also played a role.
4. Transintegumentary uptake of trichlorophenol (TCP) by worms resulted in concentration factors of 140 within 24 hours. Integumentary adsorption from solution and respiratory assimilation may be more important than assimilation from the gut from feeding for compounds that are soluble.
5. Biodegradation is a significant sink for organic pollutants. However, at $4^{o}C$, which is the normal year-round temperature of Lake Michigan sediments, no remineralization occurred. At $20^{o}C$ remineralization was significant. More than twice as much remineralization occurred in sediment that had been freshly reworked.

TITLE: FATE AND PERSISTENCE OF VOLATILE ORGANIC COMPOUNDS IN ESTUARINE AND COASTAL SEAWATER: MICROCOSM EXPERIMENTS USING RADIOLABELED MODEL COMPOUNDS
CONTRACT #: NA81RAD00015
NAME: WAKEHAM, STUART G.
CONTRACTOR: WOODS HOLE OCEANOGRAPHIC INSTITUTION
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Little is known about the toxic effects of low levels of volatile organic hydrocarbon compounds on marine organisms. However, there is considerable concern about pollutant halogenated hydrocarbons as products of chlorination in human drinking water supplies, and low-molecular-weight aromatic hydorcarbons are often thought to be among the more toxic components of petrolem. Even less is known about the behavior of volatile organic compounds in the coastal zone, how these chemicals are transported, how they are removed from the water column, or how long they persist. The purpose of this research is to examine the fate and persistence of volatile organic compounds in estuarine and coastal waters. A series of short-term microcosm experiments using additions of a variety of radiocarbon-labeled volatile organic compounds will be be conducted. Direct measurements of the partitioning of volatiles between dissolved and particulate phases and biological degradation will be obtained as indicated by $C^{14}O_2$ production. Detailed studies of microbial degradation of tracer chemicals will also be conducted. The results of this study should show how volatile compounds are distributed between compartments in coastal ecosystems and allow the estimation of mass balances. This information is essential in predicting the fate and persistence of these compounds in coastal waters.

CONCLUSIONS:
Based on the final report dated March 31, 1984.
1. Levels of volatile organic compounds in coastal seawater depend on the molecular structure of the compounds. Toluene, naphthalene, and alkanes are rapidly remineralized while tetrachloroethylene and chlorobenzenes are resistant to microbial degradation.
2. Microbial incorporation and remineralization occur much faster in summer (half-lives are often less than one day) than in winter. For compounds not readily degraded, volatilization is the major fate. Volatilization half-lives are two to three weeks and are strongly influenced by wind-driven turbulence.
3. A combination of volatilization and remineralization are the major fates of benzene in the summer in coastal seawater.
4. Removal of aromatic hydrocarbons and chlorinated volatile organic compounds by sorption onto particles is not significant. Aliphatic hydrocarbons are quickly sorbed and remineralized.

TITLE: DYNAMICS OF POLYNUCLEAR AROMATIC HYDROCARBONS (PAHs) IN AN ESTUARINE ENVIRONMENT NEAR AN URBAN CENTER
CONTRACT #: NA80RAD00052
NAME: DEWALLE, FOPPE B.
CONTRACTOR: UNIVERSITY OF WASHINGTON
NOAA CONTACT: E. LONG NOAA/OAD/SEATTLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Polynuclear aromatic hydrocarbons (PAHs) occur widely in surface waters and sediment, and there is widespread concern regarding the health implications of these potentially carcinogenic compounds. The purpose of this research is to quantify the routes of PAH transport to sediments and the potential for accumulation of PAHs in benthic food chains. The specific objectives are to quantify the type and rate of PAH deposition at the sediment-water interface as influenced by urban runoff and organic particulate deposition, and to quantify the degree of microbial and infaunal degradation of the deposited PAHs. Methods used to obtain these objectives include literature searches, and field and laboratory studies. Results to date indicate that substantial quantities of PAHs are entering Puget Sound and are being deposited in bottom sediments. Further studies will focus on the bacterial degradation processes affecting the adsorbed PAH and polychaete-sediment interactions.

CONCLUSIONS:
Based on the report dated November 1982.
1. Commercial areas, the major source of lead to runoff contributed four times the lead input of residential areas and 10 times that of highway runoff.
2. Although residential runoff contained high concentrations of total organic carbon and extractable organics, there were actually fewer different compounds present. Thus, total organic carbon levels cannot be used to predict the presence of polynuclear aromatic hydrocarbons. The only PAHs detected in this study came from commercial areas, suggesting that containment and treatment of these runoffs may be warranted.

TITLE: ORGANIC:AQUEOUS PARTITION COEFFICIENT AS A PREDICTOR OF TRACE ORGANIC ACCUMULATION
CONTRACT #: NA80RAD00040
NAME: BROWN, DAVID A.
CONTRACTOR: SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
NOAA CONTACT: A. MEARNS NOAA/OAD/SEATTLE
FUNDING STATUS: COMPLETED

ABSTRACT:
A cost-effective screening survey is needed for testing organic pollutants. The purpose of this research is to apply the "n-octanol:water partitioning coefficient" as a predictor of the fate of an organic compound. Objectives include: identifying and quantifying trace organics discharged from sewage; estimating organic-aqueous partitioning coefficients for the measurable organics; using these coefficients to predict relative concentrations of organic contaminants in bottom sediments; testing these coefficients by sampling sediment and lower trophic organisms for organic compounds; and sampling higher biota for bioaccumulation effects. Methods include the use of electron capture gas chromotography for the analysis of PCBs. The expected result is the ability to compare the developmental analytic results for yet to be selected target organics.

CONCLUSIONS:
Based on the final report dated March 30, 1984.
1. The accumulation of compounds into sediments and organisms is predictable at log k(ow) (n-octanol-water partition coefficient) values of three or greater.
2. Rates of uptake and loss of contaminants in scorpionfish could not be determined by caging fish near an outfall. Natural variations in contaminant concentrations, lipid content, and metabolism, combined with the stress of caging had greater effects than exposure level on contaminant concentrations.
3. Metabolism of trace organic contaminants affects bioaccumulation and equilibrium of contaminants by conversion of parent compounds into oxygenated metabolites, which need special extraction techniques and which have not been yet reported to any extent in the literature. Modes of toxicity and detoxification of metabolites differ from those of parent compounds. The majority of oxy-metabolites in white croaker and California mussels were conjugated in the low-molecular-weight cystolic pool containing glutathione, which sequesters them away from sensitive cellular sites.
4. In some liver samples from white croaker, oxy-metabolites were detectable in all cytosolic pools, which suggests that spillover had occurred. Compounds would then be exposed to DNA and enzymes which could result in chronic contaminant effects.

TITLE: CHEMICAL STUDIES AT THE PUERTO RICO DUMPSITE
CONTRACT #: 04-8-MO1-55
NAME: BROOKS, JAMES M.
CONTRACTOR: TEXAS A&M UNIVERSITY
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Volatile organic material constitutes the major nonaqueous portion (30 percent) of waste materials dumped at the Puerto Rico dumpsite. Analysis of waste samples discharged at different times indicates significant changes in the composition of wastes. Despite these compositional changes, unique fingerprints of volatile organics may be identified and used to track and measure the dispersion of wastes from the discharge plume into the surrounding waters, employing currently available gas chromatographic techniques. This research will analyze waste fingerprints at the Puerto Rico dumpsite. This information will assist in evaluating environmental consequences of ocean dumping.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. Several alkyl-substituted aromatic compounds (for example, three- and four-carbon benzenes) persist throughout the dumpsite area. The distribution of these compounds (the fingerprint) indicates a dispersion of wastes throughout the water column and surrounding areas that could not be predicted from the hydrographic regime or routinely detected by other chemical methodologies. While major current patterns indicate a rapid westward flow, the volatile organic waste was observed as far away as 103 km to the northeast of the dumpsite. Distributions of the organics north of Puerto Rico do not indicate a rapid flushing from the dumping area, as the fingerprint was detected throughout 23,000 km^2.
2. Contrary to expectations of inhibited vertical mixing based on salinity, temperature, and depth profiles, the waste fingerprint was found to have penetrated the thermocline to as deep as 200 meters. It is postulated then that transport may be accomplished by attachment to more dense particulate material.

TITLE: ORGANIC POLLUTANT TRANSFORMS AND BIOACCUMULATION OF POLLUTANTS IN THE BENTHOS FROM WASTE DISPOSAL ASSOCIATED SEDIMENTS
CONTRACT #: NA81RAD00020
NAME: BOEHM, PAUL D.
CONTRACTOR: ENERGY RESOURCES CO., INC. (ERCO)
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
After release into the marine environment either through waste outfalls or barged waste disposal, the accessibility of pollutant compounds to benthic marine organisms is dictated by the pollutant's association with the substrate, its transformation from the sorbed to the colloidal state, and its flux rate out of the sediment into the benthic boundary layer. This research will examine the detailed physical-chemical transformation of selected organic pollutants (polynuclear aromatic hydrocarbons, polychlorinated biphenyls, and phthalate acid esters) in the upper one meter of waste sediment and the bioconcentration of these pollutants from the individual physical-chemical forms. Specific biogeochemically relevant relationships between key organic pollutant levels and forms, their bioavailability, and their assimilation by marine organisms will be derived to assess bioaccumulation potential.

CONCLUSIONS:
Research in Progress

TITLE: INVESTIGATIONS ON THE SOURCES, DISTRIBUTION, AND TRANSPORT OF ORGANIC POLLUTANT-BEARING WATER COLUMN PARTICULATES IN THE HUDSON RIVER ESTUARY AND NEW YORK BIGHT REGION
CONTRACT #: NA80AAD00062
NAME: BOEHM, PAUL D.
CONTRACTOR: ENERGY RESOURCES CO., INC. (ERCO)
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
A research program designed to examine the sources and transport of organic pollutants (polychlorinated biphenyls, polynuclear aromatic hydrocarbons, and fecal steroids) out of the Hudson River estuary and into the adjacent New York Bight region will be undertaken. The relationship between the organic pollutants found in the New York Bight water column (suspended particulates) and sources from the estuary as well as from the dredge spoil and sewage sludge disposal sites in the bight will be examined to determine the relative importance of each source in contributing to the water column's pollutant load. Results of this study will have great significance in evaluating the chronic inputs of organic pollutants from normal riverine inputs in relation to waste disposal deposits.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. Sewage sludge disposal sites have much different sediment chemistries than dredge spoil disposal sites.
2. Within the waste deposits there exist marked differences in the chemical composition of various size fractions of sediment.
3. Normal Hudson River/shelf fluxes mix with particles associated with waste deposits to constitute the total organic pollutant loading in the New York Bight water column.
4. The vertical distribution of PCB- and PAH-bearing particles can be used to distinguish waste deposits from riverine inputs.

TITLE: CHEMICAL EFFECTS ON PRODUCTIVITY OF THE SEA
CONTRACT #: N-ER-AO-001
NAME: ATWOOD, DONALD K.
CONTRACTOR: NOAA/ERL/AOML/OCEAN CHEMISTRY AND BIOLOGY LAB
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The concept that undefined dissolved "organic matter" influences the quality or productivity of seawater has often been invoked to explain observed conditions. However, there has been no clear demonstration that specific consequences to an ecosystem result from the degree to which trace metals are complexed by dissolved organics. The purpose of this research is to understand basic processes by which natural and pollutant organic materials affect the availability and toxicity of trace metals in marine ecosystems. Specific objectives include quantification of the dependence of plankton and bacterial growth rates and net ecological efficiency on trace metal/organic interactions, and the development of recommendations for disposal of waste metals or organic materials based on new knowledge of the ability of the Gulf of Mexico to assimilate them. This research will take place in the Gulf of Mexico (off Galveston, the Mississippi River Delta, and near Cape San Blas) and in the laboratory. The research will generate information on the distribution, nature, and amounts of metalcomplexing organic matter in the Gulf of Mexico that will correlate with the observed productivity, assimilative capacity, and pollution at the particular study areas. This information will be applicable to other regions of the U.S. coastal zone and will be fundamental for making management decisions on uses of the coastal ocean.

CONCLUSIONS:
Based on the report dated September 1982.
1. Fulvic acids interact strongly with zinc but not with cadmium or copper.
2. Zinc-fulvic acid interaction probably occurs as part of a steady state cycle of less than 40 hours; the duration is controlled by photo-oxidation and bacterial processes.
3. Fulvic acids do not significantly detoxify copper for bacteria (no appreciable copper bonding occurs).
4. There are strong indications that copper toxicity is reduced by humic acids, and there is some indication that zinc toxicity is reduced by fulvic acids.
5. Survival and growth of larval fish are coupled to species composition and productivity of plankton.
6. Trace metal levels in naturally occurring concentrations do affect growth rates and speciation of plankton.
7. Copper apparently affects membrane integrity causing leakage of metabolites, and cadmium seems to interfere with calcification of some plankton.
8. Trace metal speciation is controlled by biologically produced organic matter through chelation and light-activated reduction. It may be possible to minimize the disruption of normal trace metal metabolism by blending organic and inorganic wastes to an innocuous mixture.
9. Coastal plankton are less sensitive than oceanic plankton to metals suggesting that coastal areas should be used for waste disposal. However, production is higher in coastal areas, requiring that coastal waste disposal be accompanied by monitoring of larval fish health.

TITLE: IN VITRO TESTING OF TOXIC ENVIRONMENTAL SUBSTANCES USING MARINE FISH EGGS
CONTRACT #: NA80RAD00053
NAME: KOCAN, RICHARD
CONTRACTOR: UNIVERSITY OF WASHINGTON
NOAA CONTACT: E. LONG NOAA/OAD/SEATTLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Fish cell cultures are adaptable to toxicity screening and mutation detection. The purpose of this research is to develop systems to test marine fish cells to assess in them toxic effects of environmental substances. Cells will be exposed to varying concentrations of known chemicals. After exposure, cells will be counted and from these counts, cell mortality will be evaluated. Expected results include a list of those compounds that are excessively toxic to fish cells at environmental levels, and also an indication of potential mutagenicity.

CONCLUSIONS:
Based on the report dated October 26, 1982.
1. Every class of genotoxic chemicals tested produces overt forward mutations in some fish cells employed.
2. Five classes of mutagenic compounds induce anaphase abberations.
3. Hexachlorobutadiene is toxic but not mutagenic.
4. Fish cells have been cultured that can be used to directly detect mutagens and toxic agents that do not require metabolic activation to produce a toxic response. By measuring DNA content of cell nuclei, past and chronic exposure to mutagens can be detected.
5. Fish embryos exposed to PAHs after organ development has begun can metabolize and excrete PAHs. If the embryos are exposed before organ development, they never develop a fully functioning oxygenase enzyme system that allows them to process steroids.

4. PHYSICAL TRANSPORT AND PROCESSES

The physical transport and transformation of waste associated with particles provide the background information for evaluating effects of waste disposal. NOAA's Ocean Assessments Division supports the modeling of waste transport at dumpsites and from outfalls and runoff into US waters. Physical processes that change waste, particularly those associated with particles, are also studied. Coagulation, adsorption, desorption, and partitioning are the major processes investigated. Laboratory research is a major fraction of sponsored work; field research is conducted in the Great Lakes, Puget Sound, southern California, and at major waste dumpsites. An interesting observation is that agricultural pesticides are found during storm runoff in waters from the Sandusky River and Sandusky Bay in sufficiently high concentrations to be a serious problem. Also, finished drinking water taken from the bay shows pesticide concentrations similar to those of untreated bay water (P-4). Nineteen projects were sponsored at fifteen institutions. Projects describing waste transport are presented before projects dealing with physical processes.

4.1 Pollutant Transport

TITLE: ESTUARINE AND COASTAL POLLUTANT TRANSPORT AND TRANSFORMATION: THE ROLE OF PARTICULATES
CONTRACT #: N-ER-PM-001
NAME: CURL, HERBERT
CONTRACTOR: NOAA/ERL/AOML AND PMEL
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: ENDS 9/30/85

ABSTRACT:
Environmental pressure on the quality of the coastal and estuarine hydrosphere will continue to increase through the 1980s. Society's use of these waters as a dumping ground, as a conduit for waste material, and as sites for resource exploitation will aggravate the problems already apparent today. The purpose of this project is to determine the budgets, residence times, and fates of selected pollutant compounds principally associated with particulates in large estuaries and to correlate these processes with physical forcing and chemical transformations. Methods used to achieve specific objectives include various field (several areas of Puget Sound including the Duwamish River, Elliott Bay, and the main basin) and laboratory studies and experiments. Because this project addresses the general processes of estuarine and coastal pollutant transport, it is anticipated that the results will have specific applicability wherever the field work is conducted and will also aid in providing information on particulate pollution and assimilative capacity.

CONCLUSIONS:
Based on the report dated December 1982.
1. Near bottom sediment accumulations are strongly dependent on changes in bottom flow.
2. Upper water sediment accumulations are steady with time.

3. An suspended particulate matter (SPM) minimum zone is centered at 50 meters or shallower and there is a persistant though variable bottom nepheloid layer.
4. Highest concentrations of sediment exist in the central portion of the main basin.
5. The location of the SPM minimum zone is generally centered around the shear zone between the surface and deep flow.
6. Water in this zone presumably has a longer residence time than surface water.
7. Local resuspension of bottom sediments is a principal contributor to the total sedimentation rates.
8. The PAH and unresolved complex mixture decrease with depth, resulting from either hydrocarbon decomposition or dilution from resuspending bottom sediments.
9. The sum of the water patterns in Puget Sound is to retain water and entrained material within the estuary. Poverty Bay is the area most likely to be the ultimate sink of particulate-bound pollutants.
10. Most river-borne surface particles are deposited from plumes flowing along the shoreline, except during maximum flow when the plumes expand horizontally.
11. The self-cleansing action of Puget Sound appears to be limited.

TITLE: MODELING OF TRANSPORT AND FATE OF POLLUTANTS FROM OCEAN WASTEWATER DISCHARGES
CONTRACT #: NA80RAD00055
NAME: KOH, ROBERT C.Y.
CONTRACTOR: CALIFORNIA INSTITUTE OF TECHNOLOGY
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Existing models for estimating initial dilution, transport, and fate of pollutants from ocean wastewater outfalls are inadequate for use in other than very simple cases. They exhibit in deficiencies such as the assumption of simple geometries, lack of consideration for the finite thickness of the sewage field and currents and for the finite length of diffusers. The purpose of this study is to develop mathematical models, encorporating all relevant new findings from laboratory experiments, and to estimate near-field initial dilution observed in ocean wastewater discharges from multiple-port diffusers. The model will allow prediction of dilution in situations (a) with no ambient current and (b) with ambient current as determined from field measurements. The model will be designed so that the output will include not only typical instantaneous representative values of dilution (as function of time), but also its probability distribution. The results of this work should permit better definition of the source characteristics of the introduced contaminants so their effects (both short- and long-term) can be assessed.

CONCLUSIONS:
Based on the report dated March 1984.
1. The model developed to calculate transport and mixing processes occurring near the discharge for the case of long, multiple-port diffusers with various possible port configurations, arbitrary ocean-density stratification, and no ocean current, shows that multiple-port diffusers mix wastewater and seawater in a ratio of one to several hundred, allowing waste to remain submerged.
2. Following plume rise, the diluted wastewater drifts with the existing ocean current. This current is composed of a subtidal, a tidal, and a supertidal factor.
3. The results of numerical models were consistent with laboratory results of settling experiments with short settling columns, but not with results from taller columns. It is concluded that coagulation and settling processes may be different in a tall column than in a short one.

TITLE: ASSIMILATION AND FLUX OF SEDIMENTS AND POLLUTANTS IN THE SANDUSKY RIVER ESTUARY, SANDUSKY BAY, AND THE ADJACENT NEARSHORE ZONE OF LAKE ERIE
CONTRACT #: NA80RAD00038
NAME: RICHARDS, R. PETER
CONTRACTOR: HEIDELBERG COLLEGE
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Recent studies of Lake Erie tributaries have shown that a large portion of the annual sediment load and the load of many pollutants result from short time intervals during runoff from storm events and spring snow melt. These studies suggest that loadings to the open-lake ecosystem will be largely of non-point-source origin and that these loadings will occur in a pulsed fashion associated with runoff events. They will involve forms of pollutants that are relatively bioavailable, because the short time of travel to the lake allows little time for processing and assimilation in the river, estuary, and bay, and will be largely assimilated in these systems and the nearshore zone. Only a small portion of low-flow loadings will reach the open lake. The lack of studies that have sampled both the river system and the lake during runoff events and low-flow conditions has prevented testing this model. The purpose of this study is to examine the movement of pollutants and related material through Sandusky Bay into Lake Erie (during runoff) from major storms and from times when the river is at low flow. It will also provide loading estimates for the estuary, bay, and adjacent Lake Erie. If the results of the study support the model, increased emphasis on the management of non-point sources of pollution will probably be indicated.

CONCLUSIONS:
Based on the report dated September 1982.
1. More than half the total annual export of phosphorous, sediments, and sediment-related pollutants from Lake Erie occurred in runoff from two storms.
2. Runoff is recognized by low conductivity, high turbidity, and by its sediment composition--predominantly suspended matter.
3. Storms cause nitrate washout of the soil, but nitrate concentration depends on the rainfall history.
4. Ground cover minimizes erosion.
5. Major storms have sufficient discharge to more than displace the volume of Sandusky Bay (1.35 times).
6. Major storms may transport dissolved materials through Sandusky Bay and into Lake Erie without substantial transformation (except by dilution).
7. Less intense storms push some Bay water into the Lake but direct effects may well be confined to the upper Bay.
8. Much of the particulate material settles in the upper Bay.
9. Important longer term mechanisms for nutrient transport may include: seiche-driven transport; regeneration of nutrients from the sediments, and incorporation into algae following wave resuspension; and vertical circulation in the deeper part of the lower Bay.
10. Agricultural pesticides are found in the river and bay in sufficiently high concentrations during storm runoff for long enough periods to be a serious problem.

11. Concentrations of these pesticides with time are unlikely to be predicted from standard water quality data.
12. Finished drinking water from the bay has pesticide concentrations similar to those of untreated Bay water.

TITLE: FLUID TURBULENCE AND PARTICLE SIZE DISTRIBUTIONS IN COASTAL OCEAN WATERS
CONTRACT #: NA82RAD00004
NAME: LIST, E. JOHN
CONTRACTOR: CALIFORNIA INSTITUTE OF TECHNOLOGY
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Evidence indicates that 75 to 90 percent of pollutants in water are particles or are associated with particles. Although the fate of particulate matter discharged to the coastal waters of the Southern California bight is not well understood, comprehending it is essential to understanding the fate of the associated pollutants. This research will investigate the physical and chemical properties of particulate matter discharged to coastal waters. Oxidation/reduction reactions of colloidal particles and collision mechanisms will be studied. Laboratory and field work will allow the development of computer simulation models of the fate of suspended particles after discharge.

CONCLUSIONS:
Based on the report dated January 1983.
1. The rate of production of iron oxide particles in the coastal ocean is found to be significantly affected by sulfate and chloride complexes. It is rapid at a pH value of eight (half-time for oxidation is two minutes). Oxidation time for reduced manganese is dependent on the presence of suitable surfaces for catalysis. MnOOH will contribute to the particle size distribution on the order of days. Loss of manganese compounds by reduction will proceed over several hours to several days. Light catalyses the reaction of manganese oxide with fulvic acids.
2. Results support two hypotheses: (a) that particles of one size range would have a predominant collision mechanism and (b) that an equilibrium would be established in which a uniform mass flux through the particle size distribution would exist.

TITLE: ANALYSIS AND INTERPRETATION OF EXISTING SLOPE CURRENT DATA
CONTRACT #: NA82RAD00006
NAME: FRYE, DANIEL E.
CONTRACTOR: EG&G ENVIRONMENTAL CONSULTANTS
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Deep-water dumpsite 106 (DWD 106) is located in slope waters of an oceanographically distinct region off the U.S. East Coast, bounded by the Gulf Stream and the shelf/slope front. In order to determine the volume and composition of wastes that should be dumped at DWD 106, an understanding of water circulation in the area is needed. This research involves the analysis of existing current data from the DWD 106 area by investigating subtidal- frequency currents after the occurrence of warm-core eddy events. Statistical and time series analyses will provide information on important forcing mechanisms, storm effects, Gulf Stream eddies, and stagnant conditions. This research will allow improved and more supportable conclusions concerning the intermediate and long-term fate of wastes discharged in the continental slope waters off the U.S. East Coast.

CONCLUSIONS:
Based on the report dated May 1984.
1. The general pattern of slope circulation consists of a downcoast drift directed parallel to the isobaths. The drift is strongest in the near-surface layer above the main thermocline (200 meters). Mean current speeds are variable at these shallow depths but are typically in excess of 10 cm/sec. Current direction near the surface is also variable and this should provide effective dilution of dumped wastes.
2. The major source of current variability in the slope water is the occurrence of warm-core eddies cast into the region by the Gulf Stream. Currents within the eddies rotate clockwise with a period of six weeks and at speeds over 100 cm/sec. Eddy effects are observed to 1,000 m.
3. Considerable variability is seen in speed and direction of background currents on time scales shorter than one month. Typical residence time for near-surface waters (and associated waste) is estimated to be one to five days.
4. Suspended or dissolved wastes dumped at DWD 106 are eventually entrained by the Gulf Stream at points east of Cape Hatteras. The mean residence time within slope water for wastes dumped at DWD 106 is approximately one month.

TITLE: DYE STUDIES AT THE PUERTO RICO DUMPSITE
CONTRACT #: 04-8-MO1-55
NAME: ICHIYE, TAKAHASHI
CONTRACTOR: TEXAS A&M UNIVERSITY
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Discovery in previous cruises of waste products east of the Puerto Rico dumpsite casts a doubt about the concept of an almost uniform eastward flow of the North Equatorial current off Puerto Rico. To explore the actual pattern of waste movement, a series of dumpsite monitoring cruises will be conducted. A physical oceanography program will include salinity and temperature measurements with depth, drifter tracking, and fluorometric measurements of the waste plumes dyed with Rhodamine WT. Salinity and temperature data will be used to determine the typical fall pattern of the geostrophic current north of Puerto Rico. This information will provide a clearer picture of the fate of wastes from the Puerto Rico dumpsite.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. Surface dynamic topography shows southward flow around the dumpsite and northward flow west of it with a cyclonic gyre of a zonal length of about 50 km. This flow pattern has a mean speed of about 0.3 m/sec. If this type of circulation is common, wastes may reach coastal areas.
2. Liquid wastes did not reach below 15 meters from the surface within 24 hours after dumping. Horizontal dispersion seemed to be within one km during the same period.
3. Hydrodynamic measurements showed a sharp temperature inversion at the bottom of the upper mixed layer. This suggests that the intense upper layer stirring does not penetrate below a certain depth.

TITLE: TRACKING OF RADIOSONDE DROGUES AT THE PUERTO RICO DUMPSITE
CONTRACT #: NA79AAD00078
NAME: HERNANDEZ-AVILA, MANUEL L.
CONTRACTOR: UNIVERSITY OF PUERTO RICO
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The fate of material dumped at the Puerto Rico dumpsite has not been well documented in the past. This research will provide a picture of water movement around the dumpsite in order to evaluate the effects of waste disposal. Drift direction patterns and average velocities of surface and subsurface waters will be observed by tracking 12 drogue drifters. Drifters will be deployed at six depths above 150 m. Because of the inherent difficulties in the interpretation of Lagrangian field measurements made using drifters, several data reduction analytical methods will be employed for correlation. Results of this research will allow increased accuracy in predicting the fate of wastes disposed of at the Puerto Rico dumpsite.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. The wind regime seems to be the dominant forcing factor for net drift at all levels.
2. Drift patterns suggest the presence of eddies in the area.
3. Wastes dumped at the site will remain enclosed in the area from one to more than 15 days, depending on season or type of drift pattern.
4. The predominant westward flow of the Antilles current does change direction consonant to the relative strength of forcing factors: wind and tidal regimes; inertial-eddy effects; and possibly through currents (jets) lateral shear.

TITLE: DISPERSION AND FATE OF DUMPED, DREDGED MATERIAL IN THE NEW YORK BIGHT
CONTRACT #: N-ER-AO-002
NAME: PRONI, JOHN R.
CONTRACTOR: NOAA/ERL/AOML
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Dredged material is routinely disposed of by dumping at sea. Hydrographic and biological variability of dumpsites in the New York Bight must be determined before effects can be evaluated. This research utilizes acoustic backscatter intensity data, chemical and biological samples, and measurements of suspended particulate matter concentrations to provide a picture of the dispersion and fate of dredged material dumped in the New York Bight.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. The downward momentum of dumped material can generate bottom surges as high as eight meters above the bottom.
2. Background suspended particulate matter concentrations are so high that dumped material can be detected for 40 minutes after disposal at a dumpsite in this region.
3. The water column of the dumpsite is stratified into four layers.
4. Calculated particulate matter concentrations demonstrate a two phase dispersion process, each with a different diffusion velocity at any given time.

TITLE: TRAJECTORY AND DISPERSION OF A WASTE CLOUD IN THE SEA
CONTRACT #: 04-8-MO1-62
NAME: CSANADY, G.T.
CONTRACTOR: WOODS HOLE OCEANOGRAPHIC INSTITUTION
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
In order to evaluate the effects of waste dumped at the 106-mile dumpsite, a determination of the fate of the wastes must be made. The trajectory and dispersion of a waste cloud at the 106-mile dumpsite will be investigated through this research. Dispersal rates will be extrapolated from experiments with dye and other tracers and the relative importance of advection and intermittent mixing processes will be evaluated. This research will allow evaluation of the long-term fate of wastes in slope waters.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. The long-term dispersal of wastes released into slope water is controlled by large-scale advection which provides a "flushing" mechanism, and a highly intermittent mixing process is hindered by density gradients in rings, boluses, and lenses.
2. Neither advection nor mixing processes are well explored or understood.

TITLE: THREE-DIMENSIONAL NUMERICAL DISPERSION MODEL OF ACID IRON WASTE DISPOSAL
CONTRACT #: NA80AAD00058
NAME: SPAULDING, M.L.
CONTRACTOR: UNIVERSITY OF RHODE ISLAND
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
In order to predict the effects of acid iron waste disposal, an evaluation of the dispersion of the waste must be made. This research will develop a three-dimensional model to predict the dispersion of suspended and particulate iron acid waste. The model will be validated using conditions at the 106-mile dumpsite. Simulations of sensitivity and dilution for waste discharged in the center of a stationary warm-core ring will be performed. Results will be useful for predicting biological and chemical effects of waste disposal.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. The model assumes a 10-km-long, 10-m-thick, and 40-m-wide plume as the initial waste configuration. Vertical current shear coupled with vertical diffusion seem to be more important in predicting dilution than horizontal diffusion.
2. Stationary warm-core rings induce current shears in both the horizontal and vertical directions and substantially increase dilution over the unsheared flow fields.
3. Dilution of the waste to background levels is estimated at a minimum of 15 days for the ring simulation.

4.2 Physical Processes

TITLE: FIELD CONFIRMATION OF PARTICLE COAGULATION MECHANISMS IN SEAWATER
CONTRACT #: NA80RAD00054
NAME: LIST, E.J.
CONTRACTOR: CALIFORNIA INSTITUTE OF TECHNOLOGY
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The assessment of proposed and actual wastewater treatment and discharge practices requires a better understanding of the fate of sewage particulates and their associated trace metals after discharge to coastal ocean waters. The rate of deposition of such particulate matter on the seafloor is strongly dependent on the rates of coagulation of the particulate matter. The purpose of this research is to develop models of particle collision processes to view coagulation as time dependent and to measure fluid-shearing motions in turbulent coastal waters as model input. The models will be tested by field measurement and analysis using a recently developed laser-Doppler velocimetry system, which will provide the necessary small-scale ocean turbulence information required by the theoretical development. It is anticipated that the results obtained will enable the size distributions of particulate matter discharged from ocean outfalls to be predicted. The data obtained will indicate mean fluid shear rates in the coastal ocean and their relationship to vertical density distribution and particle size distributions. This data, when incorporated into existing particle size distribution theories, will aid in the determination of the fate of particulate matter discharged from ocean outfalls.

CONCLUSIONS:
Based on annual report dated October 13, 1981.
1. Two models were completed that simulate Brownian motion and laminar fluid-shearing collision processes.

TITLE: PARTICULATE-DISSOLVED PARTITIONING AND THE FATE OF TOXIC ORGANICS IN ESTUARINE ENVIRONMENTS
CONTRACT #: NA81RAD00025
NAME: PFAENDER, FREDERICK
CONTRACTOR: UNIVERSITY OF NORTH CAROLINA
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Information on partitioning of pollutants between soluble and particulate fractions of the environment is essential to assessing the effects and fate of organic pollutants. The purpose of this study is to examine partitioning of pollutants between soluble and particulate fractions and the effects of the two phases on biodegradation by combining techniques of radio-label distribution assay, biodegradation rate measurements, and microautoradiography. These investigations will reveal the quantitative distribution of the labeled compound between particulate-bound and dissolved fractions, the biodegradation rates of the pollutants by particle-associated and free-living microorganisms, and the mechanism involved in uptake by particles (whether biotic or abiotic). These methods will be used in the Newport River estuary to examine the partitioning and biodegradation process in environments of different particle and nutrient concentrations over tidal and annual, seasonal cycles. Measurements of pertinent physical/chemical characteristics of the water column will also be conducted and correlated with the partitioning/ biodegradation assessments. The results should reveal the quantitative significance and mechanism of particle uptake of pollutants, how particle association influences biodegradation, and how these processes are influenced by environmental factors.

CONCLUSIONS:
Based on the report dated May 1983.
1. Adsorption of all organic compounds tested appears to be greater (per milligram of suspended particulate matter) at freshwater sites than at estuarine or marine sites.
2. Temperature seems to be the key in controlling degradation rates of organic pollutants. Degradation is very slow at temperatures of less than $10^{\circ}C$.
3. Spring blooms in the estuary may, due to the increase in bacterioplankton, play a role in the increased degradation rate in the spring. The species responsible for the bloom was probably Heterocapso triquetra.
4. Data from the Gulf of Mexico is consistent with results from the Newport River; therefore, the preceding results may have general applications.
5. Smaller organisms (less than five microns) are responsible for the majority of degradation in all three environments.
6. One group of larger organisms was capable of taking up Nitrilo Triacetic Acid (dinoflaggelates).

TITLE: POLLUTANT PARTICLE COAGULATION IN SEA WATER
CONTRACT #: NA81RAD00035
NAME: HUNT, JAMES R.
CONTRACTOR: UNIVERSITY OF CALIFORNIA
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The fate of suspended particles is a principal concern in evaluating the impact of the disposal of anthropogenic wastes. Suspended particles often have organic matter and pollutants associated with them and can decrease photosynthetic activity through increased scattering of light. This research conducts a quantitative analysis of particle coagulation under conditions encountered in natural waters. Experiments are proposed to investigate the coagulation characteristics of various particles in seawater after initial mixing is complete, then to measure the rate of particle coagulation within the inital mixing zone of a waste effluent discharged into seawater. The results will quantify the importance of coagulation in controlling the rate of particle accumulation in sediments following discharge.

CONCLUSIONS:
Based on the report dated May 1984.
1. Experiments performed with the fine fraction of sewage sludge indicate that the coagulation rate constant is a function of fluid shear rate.
2. A model that incorporates coagulation rate predicts bottom sediment accumulation rates under various fluid shear rates. The fluid shear rate determines coagulation rate, aggregate settling velocity, and the turbulent dispersion coefficient.
3. Experiments using partially chemically destabilized artificial particles (through the addition of salts to the water) demonstrated overall behavior similar to that observed in sewage sludge experiments, but a quasi-steady size distribution was not established.
4. The time required to establish a removal rate similar to that observed in sewage sludge experiments was found to depend on particle stability and the density difference between particles and solutions.

TITLE: PARTICLE DYNAMICS OF SEWAGE SLUDGE DUMPING IN THE OCEAN
CONTRACT #: NA81RAD00033
NAME: GIBBS, RONALD
CONTRACTOR: UNIVERSITY OF DELAWARE
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Ocean dumping of sewage sludge may be less harmful to the marine environment if particles can be widely dispersed. The processes responsible for the transport of sludge after dumping must be understood in order to disperse sludge effectively through dumping techniques. This research is aimed at understanding the effect of flocculation on the transport and deposition of ocean-dumped sewage sludge. Laboratory and field research will investigate equilibrium size distributions, flocculation rates, and settling velocities. A computer model will be developed for the dispersion and sedimentation of ocean-dumped sludge based on laboratory and field data. This information should permit modifying dumping techniques to obtain the desired sludge dispersion.

CONCLUSIONS:
Research in Progress

TITLE: TOXIC SUBSTANCE SEGREGATION BY COAGULATION
CONTRACT #: NA82RAD00009
NAME: GIBBS, RONALD
CONTRACTOR: UNIVERSITY OF DELAWARE
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: ENDS 9/14/85

ABSTRACT:
Knowlege of material segregation in the ocean is required to understand the processes that cause coagulation of dumped material. Sewage sludge is a complex mixture of organic and inorganic material with a wide variety of particle surface charges, which can cause different materials to coagulate at different rates, and as such is an ideal material to investigate coagulation. Sludge has varying amounts of toxic substances associated with it, and segregation of toxic substances can occur through differential floc settling velocities or differential coagulation rates. This research will investigate types and degrees of toxic substance segregation when sewage sludge coagulates in seawater. Flocs of various settling rates and times of formation will be analyzed for heavy metals and toxic organic substances. Leachability, release into solution, and uptake by biota will also be investigated. This information will contribute to the understanding of coagulation of dumped material.

CONCLUSIONS:
Based on the report dated February 9, 1984.
1. The coagulation rate of anaerobically treated sludge in seawater is almost equally influenced by turbulence and sludge concentration. The equilibrium floc time increases with concentration. The maximum floc diameter occurs at intermediate turbulence shear values of 13/sec to 17/sec for all sludge concentrations.
2. Aerobic sludge behaves differently in coagulation. Coagulation rates are slower and maximum floc size is smaller.
3. Floc breakage by turbulence has been modeled. Floc density decreases with increasing size of the floc.

TITLE: RESISTANT AND REVERSIBLE COMPONENTS OF TOXIC ORGANIC CHEMICAL AND HEAVY METAL PARTITIONING IN THE MARINE ENVIRONMENT
CONTRACT #: NA82RAD00007
NAME: DITORO, DOMINIC
CONTRACTOR: MANHATTAN COLLEGE
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: ENDS 9/14/85

ABSTRACT:
The principal route by which toxic chemicals associated with marine disposal enter the marine environment is desorption from the particulates with which they are associated. Present regulations for ocean disposal of wastes are based upon total chemical content and not only that portion available for desorption. This research will investigate the adsorption and desorption of toxic organic chemicals and heavy metals from digested sewage sludge and sediments from dredged materials in the marine environment. The basis for this research is a model describing the lack of complete reversibility of PCB adsorption and desorption for a wide range of types of suspended sediments over a range of realistic concentrations. This research will involve laboratory and theoretical work to provide a manageable description of adsorption and desorption that can be applied to marine waste disposal problems within the context of mass balance models for toxic chemicals.

CONCLUSIONS:
Based on the report dated October 1984.
1. Experiments with nickel and montmorillonite indicate that metal sorption and desorption are rapid and no substantial changes occur with time. No major pH effects were noted in studies with Ni and Co. Non-reversibility of metal sorption persisted throughout the pH range tested.
2. An inverse relationship between particle concentration and partition coefficients was discovered. As particle concentrations increase Ni desorbs, increasing Ni concentrations. It appears to be the presence of the particles themselves that is causing this.
3. There seem to be two desorption mechanisms affecting the reversible component. The effect of particle concentration decreases as ionic strength increases.
4. These results appear to be applicable to sludge dumping.
5. The reversible component partition coefficient expression derived from desorption experiments fits experimental data over seven orders of magnitude in partition coefficients. Isotherm parameters can be predicted from chemical (octanol-water partition coefficients) and physical properties (particle concentration and fraction organic carbon). For neutral hydrophobic chemicals and suspensions of particles the desorption partitioning problem is essentially solved.

TITLE: SCAVENGING OF REACTIVE ELEMENTS IN COASTAL WATERS
CONTRACT #: NA83AAD00032
NAME: MURRAY, JAMES
CONTRACTOR: UNIVERSITY OF WASHINGTON
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: ENDS 3/31/86

ABSTRACT:
Reactive pollutants adsorb readily onto particles in the coastal environment. In order to make correct decisions in the regulation of pollutant discharge to coastal waters, the geochemical behavior of pollutants must be thoroughly understood. This research will determine the adsorption equilibrium constants and residence times of reactive elements and natural marine particles in the water column. The importance of resuspension of bottom sediments and particle inputs from river runoff will also be evaluated. Studies will be conducted in the laboratory with field data for thorium-234, thorium-228, lead-210, and polonium-210. The initial hypothesis is that the scavenging residence time is a function of primary productivity in coastal regions like Puget Sound. Results will contribute to the understanding of the short- and long-term effects of coastal pollution.

CONCLUSIONS:
Based on the report dated October 1984.
1. Initial results indicate that the production rate of Th^{234} from its dissolved parent U^{234} is equal to its radioactive decay plus removal by particle scavenging.
2. The relationship appears to be

$$Lc = L2\ ((1-A2/A1)/(A2/A1))$$

Where Lc = removal rate constant or the fraction removal per unit time
L2 = decay constant of Th^{234}
A2 = activity of Th^{234}
A1 = activity of U^{234}

3. The total residence time for thorium at 45 m in Puget Sound in September is 7.5 days. This includes the time for adsorption of dissolved thorium plus the residence time of the particles. In February, 60 percent of the Th^{234} is dissolved, and 40 percent is in particulate form. The scavenging residence time for February at 45 m is 32 days. Since biological activity is slower in February than in September, this suggests that biological removal processes are the dominant factors. In July, the removal residence time is from 8.9-16.6 days.
4. In a study to determine the distribution coefficients of various metals added to seawater containing suspended sediment collected from Puget Sound, most metals reached equilibrium conditions within five days. Distribution coefficients ranged from 100(Cd) to 10,000,000(Fe). Values of the distribution coefficients for any metal decrease with increasing particle concentration.

TITLE: A NUMERICAL MODEL OF SEDIMENT QUALITY NEAR AN OCEAN OUTFALL
CONTRACT #: NA80RAD00041
NAME: HENDRICKS, TAREAH J.
CONTRACTOR: SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
NOAA CONTACT: A.J. MEARNS NOAA/OAD/SEATTLE
FUNDING STATUS: COMPLETED

ABSTRACT:
A successful numerical model of sediment quality for an area around two ocean outfalls in California has recently been developed. This study expands and generalizes that model to allow the prediction of changes in sediments that will occur due to initiation or cessation of a discharge or as a result of modification of an existing discharge in other locations along our coasts. Sediment characteristics predicted by the model are the areal sedimentation rates, concentration of organic carbon/volatile solids in the sediments, some trace constituent concentrations, and the gross changes in the benthic biota (as characterized by their predominant type of feeding behavior). The processes to be considered in the model are sedimentation, resuspension, the "decay" of organic material, and the stirring of the sediments by the benthic biota (bioturbation). The model will be tested for validity at the Orange County outfall sites and at one additional test location.

CONCLUSIONS:
Based on final report dated October 28, 1983.
1. Sediments around sewer outfalls have enhanced levels of organic matter and trace metals. Changes in the abundance and composition of benthic communities are also observed.
2. A model developed from analysis of current observations was used to estimate the characteristics, rates, and patterns of effluent particle sedimentation. The model gives good agreement with net accumulation and concentrations of organic material around the Palos Verdes outfall. Between 15 and 20 percent of discharged particles settle along a 16 km section of the coast.
3. Predicted concentrations of volatile solids in surface sediments around the Whites Point outfall were in excellent agreement with measurements. Sediments around the Oceanside outfall have surprisingly high concentrations of volatile solids, comparable to levels near the Newport Beach outfall, which has a mass emission rate of 130 times that of the Oceanside outfall. The reasons for this are unknown.

TITLE: POLLUTANT PARTICLE REACTIONS IN THE MARINE ENVIRONMENT (P-PRIME); INCLUDING ANALYSIS OF CHLORINATED ORGANICS
CONTRACT #: N-ER-AO-002
NAME: ATWOOD, DONALD
CONTRACTOR: NOAA/ERL/AOML
NOAA CONTACT: H.M. STANFORD NOAA/OAD/STONY BROOK
FUNDING STATUS: ENDS 9/30/85

ABSTRACT:
Interactions between particles and contaminants could control the fate of wastes discharged into coastal waters. Environments rich in suspended particles, such as river deltas, are ideal for the investigation of such interactions. This research examines a major river and its delta to test the following hypothesis: that river deltas act as irreversible sinks for pollutants scrubbed from the river outflow by inorganic and biogenic particles. Testing of this hypothesis consists of a physiochemical investigation of the dynamics of pollutant-particle relationships in a system that includes a riverine source area, a freshwater mixing zone, and a delta/shelf environment. A model will be constructed from which an effective waste disposal management scheme can evolve.

CONCLUSIONS:
Based on the report dated April 11, 1984.
1. Mississippi River suspended load varies on an hourly to seasonal scale and is composed of three distinct suites: a dominant lithogenic portion and two subordinate, distinct and seasonally variable phytoplankton suites.
2. Offshore transport of particulate matter is effected dominantly by the bottom nepheloid layer, then by the surface turbid layer; particulate transport also occurs in the midwater region. In the nearshore and mid-shelf region, rapid removal of river-derived (lithogenic) particles from the water column to the underlying sediments may be driven by biopackaging.
3. The sediment accumulation data for lead ^{210} support the rapid removal and accumulation of river-derived sediments very near the river mouth. Sediment is rapidly buried in the nearshore zone with no loss of pollutant lead from the particles.
4. The disposition of river-derived particles can be used to predict the pathways and sinks of pollutants that are primarily associated with such particles.

5. SYNTHESES OF POLLUTING EVENTS

NOAA's Ocean Assessments Division sponsors a number of research projects that do not fit into the categories of biological effects, chemical fates, or physical processes. These projects primarily describe specific polluting events such as oil spills or red tides, or deliberate waste disposal activities. In addition, several management-oriented projects take an holistic approach to an area or an activity. These studies are also difficult to categorize, yet fill a need for comprehensive, synthesis studies of problem areas. Unintentional polluting events studied include eutrophication, red tides, and oil spills. Deliberate waste disposal activities studied include the disposal of dredged material, industrial waste, and fish processing waste. Management-oriented studies include economic evaluations of fisheries, ocean dumping, and assessments of viral pollution and pollutionmonitoring systems. Twenty-two projects were sponsored at 17 institutions. Syntheses of polluting events or problem areas are presented first; studies that provide management alternatives follow.

5.1 Syntheses of Situations and Polluting Events

TITLE: THE EFFECT OF PERSISTENT POLLUTANTS ON MICROBIAL BIOMASS AND ACTIVITY IN SALT MARSH AND ESTUARINE SEDIMENTS
CONTRACT #: NA80RAD00057
NAME: CAPONE, DOUGLAS G.
CONTRACTOR: STATE UNIVERSITY OF NEW YORK
NOAA CONTACT: H. STANFORD NOAA/OAD/STONY BROOK
FUNDING STATUS: COMPLETED

ABSTRACT:
Microorganisms that participate in aspects of several important material cycles (carbon, nitrogen, sulfur) reside in the upper strata of marine sediments. Marine sediments are also the repository of an increasing load of persistent pollutants, such as chlorinated hydrocarbons and heavy metals. The purpose of this research is to investigate effects of common contaminants on microbial viability and selected microbial activities in estuarine and salt marsh sediments. Microbial biomass will be determined using adenosine triphosphate (ATP) as an index as well as epifluorescence. Nitrogen fixation and denitrification will be determined by using applicable technologies. The short-term effects of selected environmentally significant compounds upon sediment microbial biomass and metabolic activities will be determined.

CONCLUSIONS:
Based on the report dated October 28, 1982.
1. Microbial biomass (measured as ATP biomass) is sensitive to and inhibited by additions of mercury and lead.
2. Direct bacterial counts are a more variable biomass parameter than ATP measurements and are not affected by mercury addition.
3. Nickel produces slight inhibition, whereas chromium and cadium produce short-term inhibition followed by stimulation.
4. Carbon dioxide production appears to be less sensitive to mercury and lead additions.

5. Several metals appear to be toxic to bacteria that reduce sulfates and also those that produce methane. These include mercury, chromium, iron, arsenic, nickel, and cadmium.
6. Loading of these metals might induce a shift in the normal, predominating metabolic pathway of anaerobic marine sediments (sulfate reduction) to methane production. Because methane-producing bacteria are less efficient at degrading organic material than are sulfate-reducing bacteria, this could reduce the capacity of marsh systems for processing pollutants. Methane-producing bacteria may also produce methylated metals, which are more mobile and more soluble than inorganic forms and can more easily enter food webs.

TITLE: THE DETERMINATION OF FATE OF OIL FROM SEVERAL OIL SPILLS IN COASTAL AND OFFSHORE WATERS
CONTRACT #: NA80RAD00060
NAME: GUNDLACH, ERICH R.
CONTRACTOR: RESEARCH PLANNING INSTITUTE, INC.
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
A major goal of research on oil spills is to account for oil once it is released into the environment. Analysis of existing information derived from oil spills indicates that many questions remain regarding the relative quantities of oil incorporated in the water column and sediments. The purpose of this research was to determine the fate of oil from several oil spills in coastal and offshore waters and to calculate a mass balance denoting major pathways for dispersion of the spilled oil. This was done for six oil spills. Methods used to produce a mass-balance model included literature searches and laboratory studies. This study will provide an increased understanding of the major pathways of natural oil dispersion and degradation. Suggestions for future research to improve tracking of the dispersion pathways of spilled oil will also be made.

CONCLUSIONS:
Based on the final report dated December 1981.
1. Data was difficult to place into a mass-balance format since sampling was inadequate. A maximum of 50 percent of the total oil spilled was accounted for using existing data.
2. Evaporation (from lab studies) accounts for 20 to 40 percent. Derived amounts for oil incorporated into the water column range from 0.02 to 9 percent, from 0.1 to 8 percent for oil deposited in bottom sediments, from 0 to 28 percent for oil stranded on the shoreline, and from 0 to 4.5 percent for water column microbial degradation.

TITLE: A RESURVEY OF THE METULA OIL SPILL SITE TO DETERMINE RESIDENCE TIME OF OIL WITHIN A SUBTEMPERATE ENVIRONMENT
CONTRACT #: NA80RAD00061
NAME: GUNDLACH, ERICH R.
CONTRACTOR: RESEARCH PLANNING INSTITUTE, INC.
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The supertanker METULA grounded in 1974 and resulted in one of the largest oil tanker spills in history (approximately 54,000 tons of oil were lost). The purpose of this study was to examine the persistence of the oil in the Straits of Magellan after 6.5 years of weathering. Objectives included determining if effects of the spill were still obvious and whether heavily oiled marshes have recovered. These objectives were attained through observational beach profiles. The results of this study will greatly add to the understanding of the long-term fate of oil spilled in a subtemperate environment.

CONCLUSIONS:
Based on the final report dated September 30, 1981.
1. On beaches with moderate wave energy and mixed sand and gravel, some oil is still buried along the upper beach face.
2. On beaches with low wave energy, a thick pavement of asphalt up to 100 m wide rests on the low-tide terrace.
3. Tidal flats and marshes remain unchanged since the spill, showing pronounced damage, with only minor growth. Here damage will persist for more than 100 years.
4. The "let nature take its course" approach will not work for oil spills.

TITLE: MEASURING THE TOXIC EFFECTS OF LONG-BURIED CHEMICAL WASTES IN MARINE AND ESTUARINE SEDIMENTS
CONTRACT #: NA81RAD00028
NAME: PAMATMAT, MARIO M.
CONTRACTOR: SAN FRANCISCO STATE UNIVERSITY
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Many different pollutants are buried in the sediments of San Francisco bay, and many species and metabolic types of organisms normally inhabit the bay bottom. The purpose of this research is to test the hypothesis that the accumulation of many pollutants in San Francisco Bay sediments has depressed the overall biological activity of the benthic community, thus lowering the capacity of the bay to mineralize domestic sewage and other organic effluents discharged into the bay. This hypothesis will be tested by determining the vertical profiles of heat production in polluted and unpolluted sediments, conducting enrichment experiments with sediments, and conducting toxicity experiments with polluted sediments and burrowing infauna. These studies will be carried out in the laboratory with sediment samples collected in the field. The results of this research will show whether the activity of anaerobic microorganisms is diminished, if not destroyed, by buried toxicants, and will provide a basis for evaluating the appropriateness of using marine waters as a receptacle for organic and industrial waste.

CONCLUSIONS:
Based on the report dated November 5, 1982.
1. Preliminary results indicate two advantages of calorimetry techniques over the usual methods of determining stress as a function of metabolic rates. First, the organisms are maintained in an environment that closely resembles the natural habitat to which they readily acclimate. This eliminates the problem of the hyperactive/quiescent cycle associated with usual techniques that require the use of abnormal, artificial test environments. Second, the results thus obtained reflect the response of a normally functioning organism and can be extrapolated directly from the laboratory to field situations.

TITLE: ASSESSMENT OF THE OCEAN DISPOSAL ALTERNATIVE FOR MANAGEMENT OF FISH-PROCESSING WASTE
CONTRACT #: NA81RAD00009
NAME: SOULE, DOROTHY F.
CONTRACTOR: UNIVERSITY OF SOUTHERN CALIFORNIA
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Ocean disposal of nontoxic biodegradable wastes could provide the best alternative for management of certain fish-processing-industry wastes. Strategies must be developed for determining the effects of such wastes and generating criteria under which management can be effective. The purpose of this study is to evaluate case histories, design tests, carry out field and laboratory research on solid and liquid waste disposal in the warm temperate Southern California Bight and tropical American Samoa. Chemical and physical changes will be measured using electronic-probe field measurements and laboratory analyses. Biological effects will be evaluated in southern California by means of fish surveys, fish-locating sonar, and bioassay techniques. The wastes must be evaluated to determine whether organic load and potential toxicity, if any, can be managed. Potential bioassay organisms appropriate to actual ocean disposal site conditions will be investigated. Review of case histories, published and unpublished information, and on-site observations will help to identify the potential for adverse impacts or beneficial effects. Results will be directed toward developing appropriate criteria for revising regulations for ocean disposal of nontoxic, biodegradable wastes, and identifying strategies for carrying out waste management in an environmentally sound and cost-effective manner.

CONCLUSIONS:
Based on the final report dated October 1984.
1. Los Angeles harbor fish waste effluent has been completely routed through the Terminal Island Sewage Treatment Plant since January of 1978. Since treatment of wastes began in 1973, biological quality has severely declined suggesting that effluent treatment has not improved water quality.
2. Ocean dumping of fish-processing sludge in American Samoa produces no measurable environmental stress. Conditions of turbidity, BOD, ammonia, and dissolved oxygen were elevated by dumping but returned to normal within several hours. Short-term effects included the development of a surface slick (composed of bubbles, fine particles, and an oily film) visible for up to six hours, but only different in measurable parameters for two hours. The plume can be tracked inexpensively through its ammonia content.
3. Ocean dumping of fish processing sludge off Los Angeles produced results similar to those in American Samoa, with environmental quality parameters returning to normal within several hours. Anchovy and mackerel were attracted to the waste plume, which attracted seabirds, porpoises, and occasionally whales. There was, coincidentally, an increase in commercial gill netting and lobstering at the site. Fish were not attracted to the American Samoa dumpsite, apparently because there is limited shallow water habitat nearby and limited numbers of forage fish.
4. Socioeconomic impacts of regulation of the fish processing industry have been, or could be severe for both large and small scale processors. Ocean dumping of processing wastes should be allowed on a case-by-case basis where no deleterious effects can be shown through adequate sampling.

TITLE: ELUCIDATION OF LONG-TERM CHANGES OCCURRING IN A COASTAL MARINE ECOSYSTEM: NARRAGANSETT BAY
CONTRACT #: NA80RAD00064
NAME: SMAYDA, THEODORE
CONTRACTOR: UNIVERSITY OF RHODE ISLAND
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Natural variation is the essential baseline against which any effects of man-induced changes in the ocean are to be detected, measured, and predicted. Natural variability is among the several basic principles that must be understood in order to evaluate both the short-term and long-range effects of pollution, overfishing, and other human-induced changes in ocean ecosystems. The purpose of this research is to investigate the nature, causes, and future course of long-term ecosystem changes in lower Narragansett Bay. Specific objectives include determination of whether the recent trend suggestive of increasing fertility is a natural effect resulting from (or causing) observed alterations in phytoplankton cycles, or whether this trend is attributable to subtle pollution effects. Methods to achieve this objective include field and laboratory experimentation, mathematical modeling, and surveillance. The results of this study can be expected to increase our understanding of the nature of long-term variability and change characterizing a representative ecosystem.

CONCLUSIONS:
Based on the report dated September 1982.
1. Environmental conditions can produce a phytoplankton standing stock in excess of that utilized by zooplankton. This surplus sinks to the benthos, perhaps supporting a dense, benthic, filter-feeding community.
2. Phytoplankton in Narragansett Bay have been found to cycle naturally in five-year units.
3. Most of the annual variability in phytoplankton composition and response was due to variations in the less abundant species. Interannual variability in local plankton dynamics exhibit a pattern that can be linked to environmental variables such as light, temperature, and nutrient fields, which can, in turn, be modified by anthropogenic activities.
4. There is evidence that increased phytoplankton and zooplankton populations have occurred in the last decade accompanying increased riverine input of phosphorous, without a concommitant detectable rise in dissolved phosphorous levels. There is also evidence suggesting that temperature regulates phytoplankton abundance, but not species composition and occurrence. Together, these suggest that traditional monitoring programs that evaluate anthropogenic effects must be supplemented with process-oriented studies to establish cause and effect relationships.

TITLE: RECOVERY PROCESSES IN A EUTROPHIC ESTUARY
CONTRACT #: NA80RAD00062
NAME: CARPENTER, EDWARD J.
CONTRACTOR: STATE UNIVERSITY OF NEW YORK
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Nutrients introduced into an estuary from Long Island duck farms have led to very dense growths of small chlorophyte algae. The fecal input of the past duck population represents the fecal output of a city of several thousand people. It is important to investigate both input and cycling of nitrogen and phosphorous in the estuary in order to determine the ability of a highly eutrophic estuary to recover after decades of high nutrient loading. The methods used will be field and laboratory studies. This research is highly significant in that it parallels the situation faced by many cities located on estuarine sites today when they are required to install sewage systems. This research will have direct application to the importance of installing these systems.

CONCLUSIONS:
Based on the report dated December 1982.
1. Within the relatively short length of estuary examined, radically different distributions of phytoplankton were seen.
2. Phytoplankton removal of nitrate and ammonium was so extensive that by the time water reached the mouth of the estuary almost all nitrate and ammonium had been taken up.
3. Nitrogen excretion by zooplankton is dependent on temperature variation.
4. The major input of nitrogen is in the form of nitrate entering through freshwater runoff. Sediments release a significant amount of ammonium, which also provides a major source of nitrogen to the estuary. It is possible that the growth of small forms in the estuary may not diminish for many years, since bottom sediments still release large amounts of nitrogen.

TITLE: MODELLING THE EFFECT OF WASTES DUMPED IN DEEP-OCEAN GYRES
CONTRACT #: NA82RAD00001
NAME: FLIERL, GLENN R.
CONTRACTOR: MASSACHUSETTS INSTITUTE OF TECHNOLOGY
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Understanding and predicting the effects of waste disposal in the ocean requires simultaneous study of the physics, chemistry, and biology of the ocean. Simple conceptual models are needed to illustrate possible impacts of ocean dumping, to suggest which measurements or laboratory experiments would be particularly useful in predicting pollution impacts, and to explore various dumping and monitoring strategies. The dumpsite can be assumed to be contained in a section of a recirculating gyre. This gyre may be infinitely long, representing a river flow, or it may be considered to represent the periodic nature of tidal flows. The waste can be assumed to decompose due to a slow chemical decay and a more rapid biochemical process. Biologically, the effect of the waste will be modeled as if it were causing an increase in the death rate of a population, which would otherwise reach some steady, food-limited value.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. When biologically induced decay is significant and the dumping rate is increased slowly, the population remains fairly high but then crashes suddenly with only a slight further increase in the rate. From this state, a large decrease in the dumping rate is necessary before the population can recover.
2. The impact of dumping is most severe when the circulation is slow, the populations are long lived, and dumping is concentrated into a small section of the gyre.
3. Pollutants ahead of warm-core rings will be displaced by several hundred kilometers in a direction opposite to the eddy's translation. Those placed several hundred kilometers to the right of an eddy's path will be displaced in the direction of the eddy's translation. Rings are an important element of the transport of material across slope water. Certain strategies may be effective in minimizing the probability of dumped waste impinging upon the shelf. When a ring is near the dumpsite, waste should be placed within the ring or several hundred kilometers southeast of the track.

TITLE: INVESTIGATIONS OF TWO OCEAN DUMPSITES
CONTRACT #: NA80AAC03105
NAME: LEAR, DONALD W.
CONTRACTOR: US ENVIRONMENTAL PROTECTION AGENCY
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Two ocean dumpsites are located on the mid-continental shelf of the mid-Atlantic Bight, approximately 74 kilometers east of the Delaware-Maryland coast. An industrial acid waste dumpsite was used from 1968 to 1977, and a sewage sludge dumpsite was used from 1973 to 1980. More than five billion kilograms of acid wastes and 3.7 billion kilograms of sewage sludge were dumped at these sites. This research undertakes for both sites complete field investigations including baseline surveys, circulation studies, mathematical hydraulic models, bathymetry, sediment studies, metals analyses in sediments and metals uptake by commercial shellfish, organic compounds in sediments and shellfish, occurrence and distribution of sewage bacteria, viruses, and pathogenic amoebae in surface sediments, faunal surveys, benthic population assessments, and comparisons of diseases in marine animals near to and far from the waste release areas. These studies will lead to plausible mechanisms of contamination and response which will be analyzed and documented statistically into an overall ecological assessment.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. Tidal currents, storm-induced currents, and large-scale geostrophic flows act concurrently to distribute dumped wastes. In addition, with a stratified warm surface layer in summer, wastes can be transported from the sites before settling to the bottom. Most dumped materials at the sludge site are deposited immediately to the south of the release area, but with occasional transport 28 km north or south of the release area.
2. Bacteria from sewage sludge dumping were recovered from surface sediments in an area of approximately 1,160 km^2. Viruses and potentially pathogenic amoebae were also found and highly correlated with sludge dumping.
3. Contamination of surficial sediments by toxic heavy metals, notably lead, copper, and mercury, were associated with ocean-dumping activity by increased concentrations and ratios of metals. PCBs are prevalent on the entire shelf and locally increased by sewage-sludge dumping.
4. Unusual mortalities of the ocean quahog, Arctica islandica were associated with ocean dumping. Metal concentrations, especially of vanadium, copper, silver, and nickel, were statistically higher in shellfish from areas affected by dumping.
5. Topographic bottom features are an effective factor in the locations of accumulating contaminants and distributions of certain bottom-dwelling organisms; and the size of the sediment particles closely correlates with chemical and biological parameters.

TITLE: AN ASSESSMENT OF THE ECOLOGICAL IMPACT OF OPEN-OCEAN DISPOSAL OF MATERIALS DREDGED FROM A HIGHLY INDUSTRIALIZED ESTUARY
CONTRACT #: NA79AAD00026
NAME: ALDEN, RAYMOND, W.
CONTRACTOR: OLD DOMINION UNIVERSITY
NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The current sites for disposal of dredged material from Chesapeake Bay are rapidly approaching either their capacity or their permit expiration dates. The use of a disposal site located in the coastal waters off the mouth of Chesapeake Bay for disposal of dredged material will be investigated for feasibility as an alternative to the present land and temporary nearshore disposal sites. The study will fulfill permit requirement guidelines for ocean disposal operations and will provide basic research data required for the understanding of the potential acute and chronic effects of disposal operations on the coastal ecosystems in the vicinity of the proposed Norfolk dumpsite.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. Water quality of the Norfolk site is good, with concentrations of nutrients and 11 metals being well below Federal and state water quality criteria levels, and often below detection levels.
2. Only manganese and ammonia were released from dredged materials to the degree that water quality reference levels would be exceeded. However, mixing models have indicated that these parameters will be diluted from one to two orders of magnitude below the limiting permissible EPA/COE concentration during the first four hours following disposal operations.
3. Lethal effects were mainly associated with fine suspended solid materials of a few dredged materials. Solid phase bioassays indicated that the heaviest fractions of wastes that would reach the bottom of the disposal site produced moderately low mortalities even in the worst cases.
4. Only iron, zinc, and manganese were significantly accumulated by test organisms following exposure to sediments from the most contaminated areas. However, concentrations and toxicities of these metals are expected to be low.
5. The disposal area is extremely dynamic and almost all sediments potentially disposed in the area may be transported and dissipated by tidal current or storm activity.

TITLE: MODIFICATION OF THE AIR/SEA INTERFACE FROM OCEAN DUMPING
CONTRACT #: RD-0-8003
NAME: GOUPIL, DENNIS W.
CONTRACTOR: CALSPAN ADVANCED TECHNOLOGY CENTER
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
In order to assess current ocean-dumping practices and impact of future waste disposal, questions involving waste characterization, waste dynamics, and potential biological effects must be answered. This research will assess the kinetics of waste plume dispersion and the activities of zooplankton and phytoplankton at the 106-mile dumpsite. Based on field cruises, results will determine if modifications of the air-sea interface have occurred from ocean dumping.

CONCLUSIONS:
Based on the report dated December 14, 1981.
1. The sea surface in the 106-mile site is virtually devoid of the natural surfactants that exist in nonpolluted locales in both the Atlantic and Pacific Oceans.
2. The waste material dispersed during the cruise period did not alter the sea surface state acutely but may have long-term effects.
3. Waste dumping activities have probably depleted the normal, biologically spawned, interfacial films by a combination of displacement, digestion, and adsorption processes.
4. Both the number of biological organisms and their diversity subjacent to the sea surface may be different from unaffected oceanic sites. Local marine aerosol characteristics may be different from those over unperturbed oceanic areas.

5.2 Projects Offering Management Recommendations and Alternatives

TITLE: BIOECONOMIC CONSEQUENCES FOR A FISHERY DEPENDENT UPON A BENTHIC COMMUNITY PERTURBED BY PETROLEUM
CONTRACT #: NA80RAD00051
NAME: BROWN, GARDNER M.
CONTRACTOR: UNIVERSITY OF WASHINGTON
NOAA CONTACT: C. EHLER NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Benthic feeders (flatfish) depend on polychaetes, bivalves, and crustaceans for existence. When an oil spill disrupts biological production by reducing clams and worms, the cost of the reduction in species to the flatfish populations can be estimated. The purpose of this research was to evaluate the long-range economic impacts of petroleum contamination. Specific objectives include placing dollar values on the benthos as it applies to flatfish, developing a model predicting the time to economic and ecological recovery of a flatfish operation, and applying this methodology to other systems. Methods included literature searches and mathematical modeling. This study will provide an economically defensible way to value species that have no direct commercial or sport value. It is a step toward estimating the value of essential prey resources.

CONCLUSIONS:
Based on the final report dated June 30, 1982.
1. An economic analysis based on predator-prey relationships has been completed.
2. Estimates of benthic biological recovery have been determined.
3. Results showed a much lower mortality rate for bottom-dwelling species than had previously been estimated, and showed that as a part of recovery, many groups of benthic species undergo a population explosion of as much as 10 times their steady value one to four years after a spill.
4. The model predicts that subsequent to a spill it is often optimal to harvest more commercial fish than normally in order to bring about a more stable relationship between those commercial species and the bottomdwelling species (which are most directly affected by a spill) on which they feed.

TITLE: DEVELOPMENT OF MANAGEMENT STRATEGIES FOR THE ASSESSMENT AND CONTROL OF VIRAL POLLUTION OF COASTAL WATERS
CONTRACT #: NA80RAD00056
NAME: GOYAL, SAGAR M.
CONTRACTOR: BAYLOR COLLEGE OF MEDICINE
NOAA CONTACT: M.B. MATTA NOAA/OAD/SEATTLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The presence of human pathogenic enteric viruses in the marine environment has been shown to be a public health hazard. No attempts have been made to organize and systematically assimilate the current body of information in a format that can be utilized for the assessment and control of viral pollution of marine waters. The purpose of this research was to develop strategies to assess and control viral pollution in coastal waters. Specific objectives included the identification of wastes that contribute viruses, factors that influence virus fate, development of a model of virus fate and transport, and the organization of a conference on viruses in coastal waters. Methods used to attain these objectives include literature searches, laboratory and field studies, and mathematical modeling. The results of this study should provide a tool for assessing the impact of waste discharges on the virological quality of marine waters. This tool could then be used in the development of management strategies for the control of such pollution.

CONCLUSIONS:
Based on the final report dated January 20, 1982.
1. A preliminary model has been developed to evaluate the effects of various factors on the distribution of human viruses discharged into confined coastal areas. It incorporates rates of input, inactivation in water, sediment, and shellfish, as well as rates of uptake and release by sediments and shellfish. The model provides predictions of virus concentrations in water, sediment, and oysters.
2. Simulation runs using the initial model have indicated that fluctuations in the input rate are the overriding factor in determining the expected level of virus in the sediment, water, and shellfish.

TITLE: A BIOECONOMIC EVALUATION OF ALTERNATIVE STRATEGIES TO MANAGE A FISHERY RECOVERING FROM A CATASTROPHE
CONTRACT #: NA81RAD00030
NAME: BROWN, GARDNER M.
CONTRACTOR: UNIVERSITY OF WASHINGTON
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The health and survival of fisheries rely on stable benthic systems, which contain some long-lived dominant and subdominant invertebrate species. If such systems are poisoned and populations destroyed, the recovery period will be prolonged. The purpose of this research was to examine economic and biological losses associated with different management strategies applied during recovery of a commercial flatfish enterprise previously curtailed or destroyed by the loss of its benthic food base. Specific objectives included the examination of strategies employed to manage fisheries recovery and to determine the consequences of these strategies. These objectives were attained through literature surveys and mathematical models. This research documents patterns of recovery from oil spills and provides a decisionconsequence matrix to allow considerations of decisions, constraints, and consequences in the management of ocean pollution.

CONCLUSIONS:
Based on the final report dated November 1983.
1. A mesocosm of an English sole nursery was constructed. Reduction of Macoma nasuta food items by one-half of the normal density found in a bay would reduce the growth of an individual fish by an average of 35 percent of the expected natural growth. The reduction of Macoma density to one-fourth (or less) effected reduced growth of fish to seven percent of that expected in a natural environment.
2. Bivalve growth is dependent on population density, not on grazing pressure. Bivalves, not fish, control colonization of small crustacea. Thus, events that interfere with sediment surface colonization would also affect bivalves, and through them, year-class strength in the commercial fishery on English sole.

TITLE: MARINE ECOSYSTEM MONITORING: INTEGRATED IMPACT ASSESSMENT
CONTRACT #: NA81RAD00026
NAME: FLINT, R. WARREN
CONTRACTOR: UNIVERSITY OF TEXAS
NOAA CONTACT: G.G. LAUENSTEIN NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
The dispersal of pollutants into aquatic ecosystems has had far-reaching effects and continues to present risks to the environment. Available methodology for measuring the effects of pollutants no longer meets the demand of scientific inquiry or the legal mandates imposed upon environmental managers. This research will answer those demands by developing a reliable monitoring methodology with repeatable data on the response of experimental benthic communities to pollution stress and will validate laboratory responses and demonstrate the methodology using sewage disposal. This research will be carried out in the field and in the laboratory. Results from field and laboratory studies will be compared and contrasted. This methodology is based on assumptions that disturbances to the benthos interfere with the regulation of processes related to total ecosystem functioning. Field validation of these results will indicate that a monitoring methodology exists that is able to act as an integrative means of detecting subtle and sensitive ecosystem changes.

CONCLUSIONS:
Based on the final report dated December 1983.
1. Colonization experiments with defaunated sediment trays placed in Corpus Christi and Oso Bay indicate that after chlorine treatment, distribution of dominant fauna changed. Functional measures returned to normal after 85 days. Most measures returned to normal between 44 and 85 days after disturbance.
2. In evaluations of different benthic communities by metabolic measures, it is clear that communities can be equally productive although their community structures vary greatly. Of two sites in the Corpus Christi Bay estuary located away from the sewage outfall, one recycles sediment nutrients at a much greater rate than the other, whose sediments act as a nutrient sink.
3. The classical approach to environmental assessment (identifying, counting, and weighing benthic organisms) would not have correctly evaluated the health of benthic communities as well as functional measurements did.

TITLE: THE DEVELOPMENT OF STRATEGIES FOR MANAGING THE SOCIAL, ECONOMIC, AND ENVIRONMENTAL IMPACTS OF OCEAN DUMPING IN A REGION
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FUNDING STATUS: COMPLETED

ABSTRACT:
There have been a number of stages in the evolution of US policy concerning the oceanic disposal of hazardous wastes. In the first stage, ocean disposal evolved in a climate of minimal regulation in the belief that coastal waters had limitless capacity to absorb wastes placed in them. The second stage saw the passage of legislation to end ocean dumping practices considered to be environmentally unacceptable. This research is directed at defining a position that can be thought of as a third stage in the evolution of ocean disposal policy for US coastal waters. Methodologies will be developed and tested to describe the outcomes of policy options for the disposal of wastes in the ocean. Strategies for waste disposal will also be developed to satisfy a variety of society's needs considering social, economic, and environmental constraints. This will be accomplished through a combination of mathematical analysis of marine systems, social and economic impact identification, and optimization techniques developed to deal with decisionmaking under conditions of uncertainty in the face of conflicting objectives. The project will analyze waste disposal in the New York Bight and at Deep Water Dumpsite 106.

CONCLUSIONS:
Based on the report dated June 26, 1983.
1. The New York Bight sludge management problem was reviewed to suggest optimal management policy. Quantitative policy analysis combined with mediation should be utilized to manage waste disposal.
2. Economic factors associated with regulating sludge disposal were reviewed. In order to reduce external cost inequities dumping authorities should consider a simple "distance-from-shore" requirement.
3. The creation of a system of charging for ocean dumping was explored. This system could act as an effective regulatory tool and provide alternative funding for ocean dumping research.
4. The process of decision modeling was evaluated for application to ocean dumping management.

TITLE: DEVELOPMENT OF A STOCHASTIC RISK ASSESSMENT MODEL OF THE FATES AND EFFECTS OF PETROLEUM IN MARINE ECOSYSTEMS
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FUNDING STATUS: COMPLETED

ABSTRACT:
The release of petroleum and its products into the oceans has been a matter of concern for a number of years. A large body of literature exists to document the study of the distribution, fate, and effects of petroleum in the marine environment. This information was used to develop a stochastic risk assessment model of the fates and effects of petroleum in marine ecosystems. Specific objectives included the development of a hydrocarbon physicalbiological model, the determination of the fate of petroleum hydrocarbons in marine food webs, and the elucidation of the mechanisms of cause and effect between petroleum and the biota. These objectives were attained through literature searches and mathmatical modeling. These models form the basis of a risk assessment instrument to aid in the decisionmaking process. They allow development of new ways to look at petroleum hydrocarbons, the marine biotic system, and man as an interconnected ecosystem.

CONCLUSIONS:
Based on the final report dated September 7, 1983.
1. A model system was developed and used to estimate an equilibrium description of the Buccaneer oil field off of Galveston Island, Texas. Effects of oil on biota were also modeled over 30 days.
2. Results indicate that exposure to acute toxic levels result in sharp declines of biomass within 10 days. The model uses the ratio between the toxic threshold and ambient hydrocarbon concentrations.

TITLE: SYMPOSIA FOR OCEAN DUMPING RESEARCH
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FUNDING STATUS: ENDS 6/30/85

ABSTRACT:
The purpose of this work is to organize a series of international symposia to focus scientific interest on the problems related to waste disposal in the ocean. The work also includes the preparation of published papers resulting from the symposia in order to disseminate the information gained from this area of research and to make the results available for considerations of waste disposal management in the marine environment. This activity provides a means of involving a large number of technical experts in the consideration of waste disposal in the marine environment. It brings together the available knowledge of the behavior and impacts of waste in marine systems, thereby providing a basis for future decisions concerning the role of the oceans in assimilating wastes.

CONCLUSIONS:
Based on the report dated Februrary 1984.
1. The fourth International Ocean Disposal Symposium was held from April 11-15, 1983, in Plymouth, England, and was attended by 150 scientists from 22 countries.
2. The Ocean Waste Management Symposium was held from May 2-6, 1983, at the University of Rhode Island, Greenwich. Presentations emphasized the development and evaluation of criteria for site selection, techniques for assessing hazards and risks, protocol for monitoring, legislative frameworks, and national and international regulations.
3. The fifth International Ocean Disposal Symposium is scheduled for September 10-14, 1984, at Oregon State University in Corvallis. Presentations will emphasize processes associated with waste disposal in the marine environment.

TITLE: A QUALITATIVE APPROACH TO CAUSE AND EFFECT IN EVALUATING MARINE POLLUTION
CONTRACT #: NA82RAD00002
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FUNDING STATUS: COMPLETED

ABSTRACT:
At present, ecologists do not have a satisfactory method of anticipating and predicting the impacts of human intervention in ecosystems. This study focuses on developing a better methodology through a study of the role of nutrient enrichment as a natural driving function and source of pollution in marine ecosystems. In the past, experimental and theoretical studies have led to contradictory results because there has not been an adequate understanding of cause-and-effect relationships. Qualitative (loop) analysis provides the structure of the ecological network, the elucidation of the causal pathways, identification of perturbations, predictions of the changes in standing crops, turnover rates and their correlations for all components, and patterns of variability and several stability measures. The purpose of this work is to construct loop models of Narragansett Bay and test their validity using phytoplankton communities at MERL (Marine Ecology Research Laboratory) at the University of Rhode Island. These microcosms have been a successful research tool used to trace the fate of pollutants in complex marine systems. The work will also include the development of a procedural manual for ecological managers who would like to apply the quantitative methodology. This manual will detail the application of loop analysis directly for pollution specialists needing to resolve today's environmental problems.

CONCLUSIONS:
Based on the report dated March 1984.
1. Generation of 153 three layered system models has been accomplished. Each system has an average of 14 to 16 variables used to predict changes in plankton abundances resulting from eutrophication experiments in MERL tanks. Ninety-three percent of the predictions were verified. Driving forces were identified.
2. Total biomass does not correlate with enrichment but total metabolic activity (oxygen production and uptake) does.
3. Enrichment produces greater changes in the nutrient levels than in organisms, although ciliate populations do change as much as nutrient levels.

TITLE: DETERMINATION OF ASSIMILATIVE CAPACITY
CONTRACT #: NA82RAD00003
NAME: BASCOM, WILLARD
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NOAA CONTACT: T. O'CONNOR NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
It is generally accepted that animals in open coastal waters have some capacity for withstanding contamination. Exactly how large that capacity is has never been specified. This research will result in the development of a method that can be used to determine the assimilative capacity of a body of water by specifying the threshold of change to animals that live in it. The threshold of assimilative capacity will be measured using four criteria: the reproductive capacity, the spill over of metals into the enzyme fraction of liver tissue, the spill over of hydrocarbons into the metallothionein fraction of liver tissue, and histopathological examination of appropriate tissues.

CONCLUSIONS:
Based on the report dated March 1984.
1. At sediment concentrations of 0.07-6.3 ppm DDTs, fish livers accumulated from 12-610 ppm DDT and invertebrates accumulated from 5-49 ppm DDT (wet weight). Oxygenated metabolites of DDTs were present at concentrations of 0.48-26 ppm in sediments, 0-263 ppm in fish livers, and 49-140 ppm in invertebrate hepatopancreases.
2. PCB levels were about one order of magnitude lower than those of DDTs but oxygenated PCB metabolite levels were present at concentrations similar to DDT metabolite levels.
3. As metal levels increase in sediments they decrease in fish livers and invertebrate hepatopancreases. This is correlated with increases of oxygenated metabolites of DDTs and PCBs due to their impact on metallothionein metal binding.
4. Reproductive capacity of longspine combfish was reduced at the station that showed the largest decrease in liver tissue metal levels (but no gonad metal decrease). As levels of organic compounds increase in fish livers, levels of trace metals decrease. The correlation is with levels of oxygenated metabolites of DDTs and PCBs.
5. Results indicate that at present, levels of environmental contamination in Southern California coastal waters, the detoxification capacity for metals has not been exceeded. However, this capacity may have been exceeded for organics. Organic contamination may be causing nutrient metal depletion and liver hypertrophy and vacuolation.

TITLE: THE USE OF ENVIRONMENTAL AND RESOURCE VALUATION TECHNIQUES IN LEGAL AND LEGISLATIVE/REGULATORY PROCEEDINGS: A CASE STUDY OF HAZARDOUS SUBSTANCES DAMAGES
CONTRACT #: NA80RAD00035
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NOAA CONTACT: C. EHLER NOAA/OAD/ROCKVILLE
FUNDING STATUS: COMPLETED

ABSTRACT:
Hazardous substance spills, leakages, and discharges are depleting the nation's coastal and estuarine environmental resources by damaging their supporting ecosystems. Regulatory and judiciary processes have been used to rehabilitate damaged resources. One of the key elements in these processes is the evaluation of environmental damages. Often, courts do not provide full compensation because of inadequate resource valuation. The purpose of this research was to examine the use of environmental and resource valuation techniques in legal and legislative/regulatory proceedings as applied to hazardous materials. Specific objectives included examining existing valuation methodologies, analyzing obstacles to their effective use, and developing means to improve their applicability. These were accomplished through literature searches. This research will allow more effective use of resource estimation methods.

CONCLUSIONS:
Based on the final report dated February 26 1983.
1. Economic theory is the recommended approach to natural resource valuation. It offers a logical and testable framework for damage valuation, it is consistent with how other goods are valued, and allows for consistent comparison with services of other resources and goods. Damage valuation is the estimation of the dollar change in the surpluses due to a change in the resource service flow. The reduction in the willingness of the users to pay for or sell the amount of the lost service must be identified. This can be calculated as long as there is a relationship between willingness to pay and the amount of service consumed.
2. Various valuation methods were evaluated for private and public uses. These include changes in property value and lost business opportunities (the most common private methods), replacement cost (the most commonly used public method), energy analysis, travel cost, contingent valuation (the most versatile method), and the hedonic price approach.
3. The preceding methods and "simplified damage assessment schemes" were evaluated for their regulatory implications.
4. For the assessment of damage from major spills a decision making guideline should be developed to determine how to choose the appropriate valuation method(s). More than one method should be used concurrently to provide a range of estimates.

TITLE: INVENTORY OF MONITORING PROGRAMS
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FUNDING STATUS: COMPLETED

ABSTRACT:
Many federal, state, and local organizations are involved in monitoring coastal and estuarine water quality. In order to more effectively monitor coastal water quality, these efforts should be coordinated. This research will identify coastal and estuarine waters organizations that are committed to monitoring on a long-term basis (more than two years) and acquire information about the types of data they collect. The scope, characteristics, and comprehensiveness of the distinct data sets will be evaluated, those parts of existing data sets that can augment NOAA's abilities in assessing the status and trends of pollution conditions will be identified. Results will improve marine water quality monitoring efforts.

CONCLUSIONS:
Based on the report dated Februrary 15, 1984.
1. Development of a data sheet for monitoring program inventory is complete.
2. Telephone interviews were used to identify organizations that have conducted monitoring programs and to complete data sheets.
3. Two hundred eighty monitoring/research programs have been identified.

ACKNOWLEDGEMENTS.

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Appendix I

Supported Projects
(as they appear in this document)

PHYSICAL TRANSPORT AND PROCESSES

Appendix II

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