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The purpose of **Coastal Ocean Pollution Assessment** (COPAS) **News** is to provide timely dissemination of information on pollution in coastal waters of the United States — its sources and effects, what is being done to eliminate or mitigate it, and what research and monitoring activities are being conducted to develop more effective strategies to manage it. We publish brief articles describing recent events and activities, new approaches to resolving chronic pollution problems, and early warnings of potential problems. Announcements of cruises, meetings, and investigations will be included.

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In This Issue

Continuity

NOAA, EPA Monitor Radioactive Waste Disposal Site In Massachusetts Bay

During the fall of 1981, an effort to monitor the Massachusetts Bay radioactive waste disposal site was initiated by the Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA). Though NOAA officials have termed the disposed radioactive waste "extremely low-level and non-hazardous", and have found no evidence of a release of radioactivity, the monitoring was begun at the request of the House Subcommittee on Oceanography. There was additional pressure to monitor the site, from the public (accompanied by several editorials in New England publications) and from fishing interests.

Between 1946 and 1960, over 4,000 canisters of radioactive waste were dumped approximately 37 km off Boston by a private firm known as the Crossroads Marine Disposal Corporation. This waste, stated NOAA oceanographer Millington Lockwood, consisted of material from laboratory experiments, such as lab coats and animals. The waste was packaged in cans of 19-, 76-, and 114-liter capacities, and in larger containers surrounded by concrete and wire mesh encasements. The monitoring effort, which took place from 21 September to 9 October, began with a search for these containers.

Two NOAA wire drag vessels, the RV RUDE and RV HECK, scoured the disposal ground in an attempt to bring up a canister. None were encountered, however. The ships were also equipped with side-scan sonar, which located a number of hard objects on the Bay bottom. These were not positively identified as canisters, but a composite plot was made of their locations. Sediment and biota samples were collected and sent to the EPA's Eastern Environmental Radiological Facility in Montgomery, Alabama, for radionuclide analysis. Field work for this stage of the monitoring program was organized by NOAA Commander Melvyn Grunthal, and was overseen by Lockwood and EPA oceanographer William Curtis.

After preliminary analyses, the sediment and biota samples have been returned from the Montgomery lab, and show radioactivity to be at or below background levels. Curtis and Lockwood have followed up these analyses, and the field work that preceded them, by drafting a plan to provide guidelines for future monitoring of radioactivity in the oceans. Called a "generic type of plan" by Curtis, the guidelines contain four major recommendations: (1) monitoring of previously used dumpsites; (2) marketplace sampling; (3) establishing which sites might be used in the future; and (4) support for future monitoring. The plan has been reviewed by NOAA, EPA, and the Food and Drug Administration, and is nearing final draft form. It is expected that the availability of this plan will be announced soon in the *Federal Register*.

The EPA hopes to continue the monitoring of Massachusetts Bay with a multidisciplinary environmental survey to be conducted sometime during the spring or summer of this year. In addition, further radionuclide analyses are planned for commercial fish species to be obtained from the water column and Bay bottom by NOAA personnel.

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Rehabilitation of Commencement Bay (WA) Through Superfund

In 1981 Commencement Bay (WA) was given the dubious accolade of being one of the ten most contaminated waste sites in the nation (Figure 1). As such, Commencement Bay became eligible for consideration for Federal funding of remedial action,

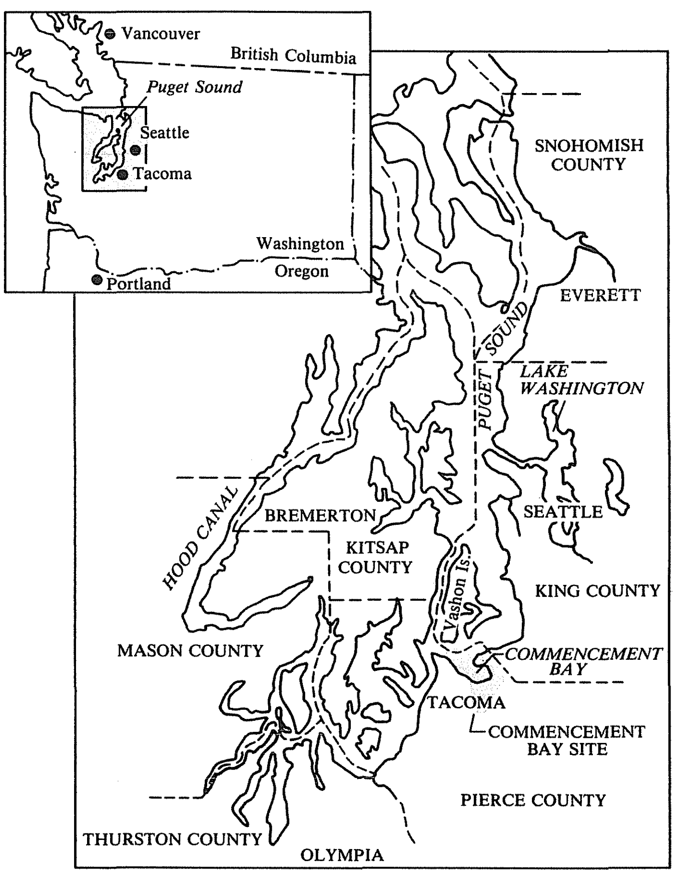

Figure 1. Vicinity Map.

under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), better known as "Superfund." Located about 53 km south of Seattle, the roughly 20 square kilometer embayment and its dredged and filled harbor and tideflats have been used intensively by several hundred commercial and industrial enterprises since about 1910. The Bay also supports an extensive sport and Indian salmon fishery for more than 155,000 City of Tacoma and Pierce County residents. Among active industries in the area are a copper smelter, kraft pulp mill, primary aluminum producer, and oil refineries, pole treating facilities, electroplaters, and numerous chemical manufacturing and transportation companies. The problems of Commencement Bay are compounded further by documented past and present waste management practices which include active landfilling, open dumping, chemical recycling and reclamation, open water disposal of dredged material and industrial wastes, and on-site storage and treatment facilities. Before the 1950s, there were few regulations and little enforcement of disposal of wastes on land or in water. From 1945 through the 1970s, chemical manufacturing wastes were shipped by barge and dumped into Commencement Bay.

Prior to 1980, the waters of Puget Sound (with its numerous inlets and embayments) were considered relatively pristine, and, like today, aesthetically pleasing. Unlike the heavily impacted New York Bight region, Puget Sound was perceived as being in a state of transition, for there was no evidence of an "environmental problem" except for an occasional isolated water quality problem. The "problem" perceived in Puget Sound was the protection of a healthy environment against degradation caused by increasing stresses associated with projected economic growth and industrial expansion. Beginning in 1978, the Marine EcoSystems Analysis (MESA) Puget Sound Project, within the Office of Marine Pollution Assessment (OMPA) of the National Oceanic and Atmospheric Administration (NOAA), began a study to answer the basic question: "What contaminants, if any, are there in Puget Sound that are or could be detrimental to the Sound's ecosystem?" The results were reported in the three NOAA Technical Memoranda (Malins et al., 1980; Riley et al., 1980; Riley et al., 1981) and summarized in part by Long (1981).

Charged by NOAA's disclosure of potential chemical hazards of Commencement Bay and its waterways, the Environmental Protection Agency (EPA) Region X, working with the Washington State Department of Ecology, and the Tacoma-Pierce County Health Department, initiated further studies. To date, over 1,000 organic compounds and metals have been detected in the marine sediments and biota of the Commencement Bay area, but only about 250 of those compounds have been identified. Recent EPA-initiated site investigations also revealed chemical contamination of both surface water and of a groundwater aquifer which provides a portion of the drinking water supply for the City of Tacoma. Preliminary investigations have identified 117 sites in the tide-flat area alone where past waste disposal practices may be posing a water pollution problem (WDOE, 1982, Fig. 2).

The Commencement Bay site is unique amoung the 115 "high priority" sites considered the most dangerous toxic waste sites in the country. It is the only marine shoreline site on the list representing a large industrial complex bounded by a large urban area highly dependent upon water quality for fishing, recreation, and aesthetic values. The site includes significant portions of the nearshore and deepwater marine environments of Commencement Bay proper, and the industrialized and port areas of former tide flats and river delta superimposed on a confusing structure of glacial material (Fig. 3). The shoreline has been dredged, shaped, and oftentimes extended and filled with industrial wastes leaching into the Bay. The site also includes upland areas which may be supplying contaminants to the Bay.

The extent and severity of the problem of hazardous wastes at the Commencement Bay site is unknown. Sufficient data are available, however, to warrant serious concern that major source(s) of contamination either from the past or present may exist. So far, these concerns have resulted in a number of regulatory and enforcement actions. One action led to the voluntary removal by private industry of contaminated soils from a solvent plant. Another resulted in the removal and clean-up of an upland hazardous material storage site. A public health advisory was issued recommending caution in the consumption of locally-caught bottomfish and shellfish. Also, contaminated drinking water wells have been removed from service.

Besides providing guidance and technical assistance to the Superfund activity, the OMPA's MESA Puget Sound Project will continue to attempt to answer the "So what?" question concerning the concentration of toxicants in the marine environment of Commencement Bay. Studies, under way or planned, will attempt to measure biological responses to toxicants of concern and to model responses to mixtures of these toxicants. Transport and suspended particulate matter studies will determine whether Commencement Bay is a source of pollutants to the greater Puget Sound, or whether the pollutants are retained in the Bay. These studies, together with proposed Superfund activities, will aid in determining what remedial action, if any, will be required for Commencement Bay.

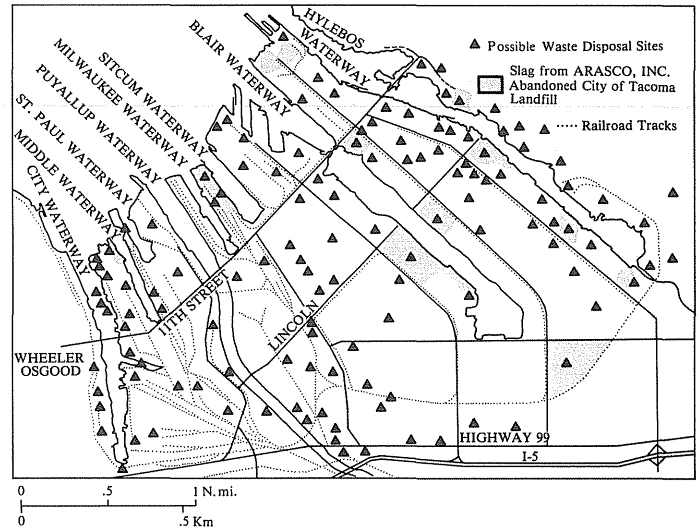

Figure 2. Areas identified as possible waste disposal sites in the Tacoma tideflat (from Washington Department of Ecology, 1982).

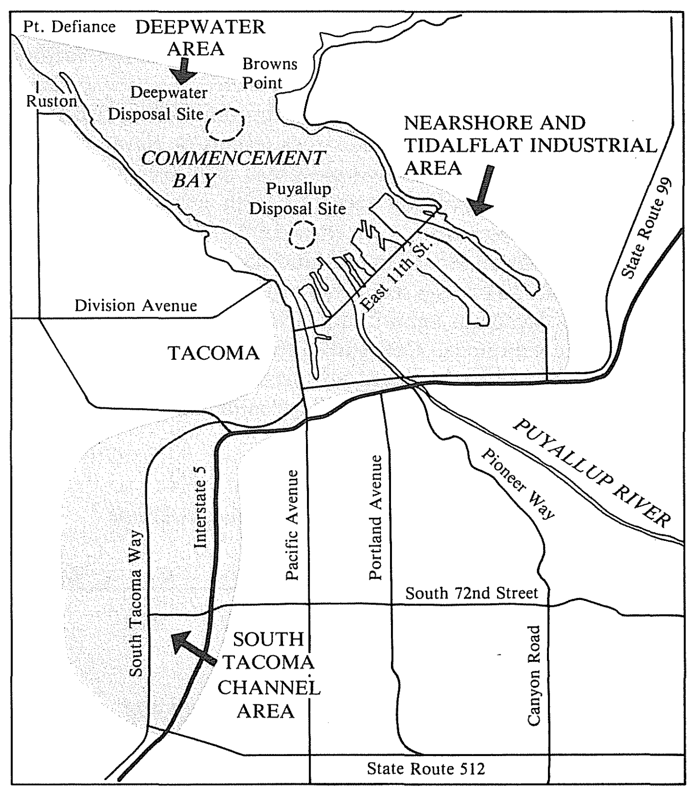

Figure 3. Commencement Bay Superfund site (from U.S. EPA et al., 1982).

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Polycyclic Aromatic Hydrocarbons in the Benthic Organisms of the Great Lakes

Complex mixtures of polycyclic aromatic hydrocarbons (PAH) have been reported in soils and sediments from around the world. These compounds are primarily the product of incomplete combustion of fossil fuels. Highest concentrations (> 1 ppm) are found near urban areas, while background levels in remote sedimentary environments (~ 10 ppb) are presumed to be the product of long range transport of fine particles in both the atmosphere and the ocean. It is generally agreed that most of the PAH are predominately anthropogenic in origin and that the increased use of fossil fuels over the past 100 years is responsible for the elevated levels in surficial sediments most evident near urban centers.

Several PAH are of environmental concern because of their known carcinogenic properties and because all short term (ca. 10-100 years) future energy scenarios call for dramatic increases of fossil fuel consumption. In the United States, this increase will be primarily in the form of coal, which produces high concentrations of PAH per BTU. Thus, it is anticipated that the production of PAH will continue to increase in the near future, causing environmental levels to rise.

PAH are relatively insoluble in water. In aquatic systems, they tend to concentrate on particulate matter and are transported to the sediments. This results in high concentrations in recent sediments with consequent elevated exposure levels for the biota which inhabit or feed in surficial sediments.

It has been shown that some invertebrates tend to bioconcentrate PAH from water presumably as an equilibrium partitioning between organism lipid and source water concentration, while other invertebrates and fish also have the ability to metabolize these compounds resulting in a lower bioconcentration factor. Oxidation of these compounds through mixed function oxidase enzymes induces carcinogenic activity. Bottom feeding fish from several urban regions exhibit tumorous lesions or elevated levels of induced aryl hydrocarbon hydroxylase in their livers, an indication that they are oxidizing relatively high levels of aromatic hydrocarbons, presumably from their food.

Work currently underway in our laboratory indicates that concentrations of PAH in the sediments of the Great Lakes are high and that the dominant benthic organisms appear to bioconcentrate PAH compounds. Concentrations of individual PAH in *Pontoporeia hoyi* (the dominant benthic organism, an amphipod) from Lake Michigan exceed the part per million level as shown in the table below.

Polycyclic Aromatic Hydrocarbons

(PAH) Concentrations and Bioconcentrations

	Ph	An	Fl	Py	Ch	BaP
P. hoyi (ppb wet)	710	200	2,210	3,380	610	410
BCF	17,800	16,600	96,000	84,500	24,400	41,000

Ph = phenanthrene, An = anthracene, Fl = fluoranthrene, Py = pyrene, Ch = chrysene + triphenylene, BaP = benzo(a) pyrene

BCF = *P. hoyi* concentration (wet)/water concentration

Bioconcentration factors with respect to water are in the range of 17,000 to 100,000. Kinetic uptake and depuration experiments with anthracene and Lake Michigan *P. hoyi* yield steady state BCF values of 16,000 in remarkable agreement with our field data.

Oligochaete worms and chironomids from western Lake Erie also appear to bioconcentrate these compounds although they exhibit a somewhat lower concentration of PAH (up to 150 ppb wet). Their BCFs would be approximately an order of magnitude less than the *P. hoyi* of Lake Michigan.

Benthic organisms constitute the base of a very important food web within the Great Lakes. Their apparent inability to metabolize PAH compounds to any significant extent leads to the conclusion that they are serving as an important vector for the transfer of PAH, with the potential for carcinogenic activity, up to the fish of the Great Lakes.

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Loomings

Burial of Dredged Sediment beneath the Floor of New York Harbor

Alternative disposal strategies could facilitate the handling of harbor sediment for port development but instigating new methods requires the participation of regulatory agencies, scientists, and the public and private sectors. One alternative involves filling a subaqueous borrow pit with dredged sediment and covering the fill with sand as a way not only to isolate and contain contaminated dredged sediment but also to restore the sea floor where it has been disrupted by sand mining.

Between July 1980 and December 1981 the feasibility of such an operation in New York Harbor was studied (COPAS: Submarine Burial of Dredged Material, Fall 1980, p. 5). The submarine burial of dredged sediment is technically feasible, but requires more careful control of the disposal operation than is normally used. Suitable borrow pits exist in New York Harbor and a demonstration disposal project now has been started to partially fill one of these pits with dredged sediment. This disposal project is unprecedented both in its engineering design and in the unusual, but effective, regulatory strategy under which it has been developed.

Advancements in technical knowledge of alternative disposal methods for dredged material have been exceeding advancements in planning for such disposal. Fragmented jurisdiction among Federal, state and local authorities is a primary cause for the permitting maze that must be traversed by those responsible for dredging and disposal operations, a process which can take up to three years for new alternatives. In an attempt to ameliorate this process, the New York District Army Corps of Engineers formed a committee composed of those Federal and state environmental agencies with jurisdiction in New York Harbor. This steering committee included representatives from the Army Corps of Engineers, the Environmental Protection Agency, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, the New York Department of Environmental Conservation, and the New Jersey Department of Environmental Protection.

The demonstration project to bury dredged sediment in a borrow pit in New York Harbor developed from a research program that was conducted by the Marine Sciences Research Center and that was reviewed every six weeks by the steering committee. The responsible agencies then had the opportunity not only to consider the management questions but also technical questions including: (1) can material be accurately placed; (2) how much will be lost; (3) how thick must the cap be; and (4) will the deposit be stable? Scientists provided state-of-the-art answers to the committee and recommended a project design. The committee's response was discussed at meetings of all the principals, at the conclusion of which a consensus would be formed as to which questions had been adequately addressed and which needed more study. The scientists' efforts were then directed toward improving the answers to the most critical questions and redesigning the project. Thus, after six meetings over a period of nine months an acceptable project was developed.

Meanwhile, however, the public had reversed their perception of the role that the pits play in the sport fishery. In 1976, soon after the pits were dug, they were perceived to be detrimental to the fishery but, in June 1981, fishermen said that the pits were now a valuable fish habitat. The project was delayed about six months while its effect on the fishery was being assessed. The delay had two causes: (1) lack of accurate information reaching the public and (2) belated opportunity for public review. Therefore, presenting planning information to the public is as important as presenting technical information to managers. In order to avoid delays in future projects, forums should be provided in which managers could periodically interact with concerned citizens, community leaders, and industry representatives in the same way as the scientists interacted with the managers during the planning of this project.

The disposal project began in December 1981. The disposal site was the southern side of a pit that had a total capacity of about 4,100,000 m^3. About 17% of this volume is to be filled and the project is being done in three stages (Fig. 1). In the first phase a compartment was created inside of a borrow pit by the construction of an underwater ridge of sand. This was done with the hopper dredge *Goethals*. Range buoys were used to mark a line along which discharges were intended to be made, but the actual discharge locations were determined by microwave navigation. In one month about 170,000 m^3 of sand was placed on the sea floor. Because of the proximity of the disposal area to the channel being dredged, as many as nine discharges were done per day and more than half were within 30 m of the intended disposal line. The form and volume of the ridge had been estimated previously by the superposition of isopach maps of the dredged sediment mounds in Long Island Sound onto the pit bathymetry. When completed, the actual ridge was close to the predicted form. The 15 m contour, for example, was displaced 230 m as predicted. The ridge created a compartment in the pit with a diameter of about 380 m; a water maximum depth of 16 m bounded on three sides by the ambient, undisturbed, sea floor where the water depth is about 8 m and on the fourth side by the ridge, which has an average depth along its crest of 11.9 m. The maximum volume of the compartment is 570,000 m^3. In the second phase of the operation, about 295,237 m^3 of dredged mud is intended to be placed in the compartment using pin-point, scow discharges. This deposit is designed to form a truncated cone in the center of the pit. The second phase is scheduled to begin in April 1982. The fill is then to be capped with about 240,000 m^3 of sand, restoring the water depth over the compartment to about 9 m and isolating the mud beneath a layer of sand at least 60 cm thick.

Research that is being conducted during the demonstration project is supported by the U.S. Army Corps of Engineers and the New York Sea Grant Institute.

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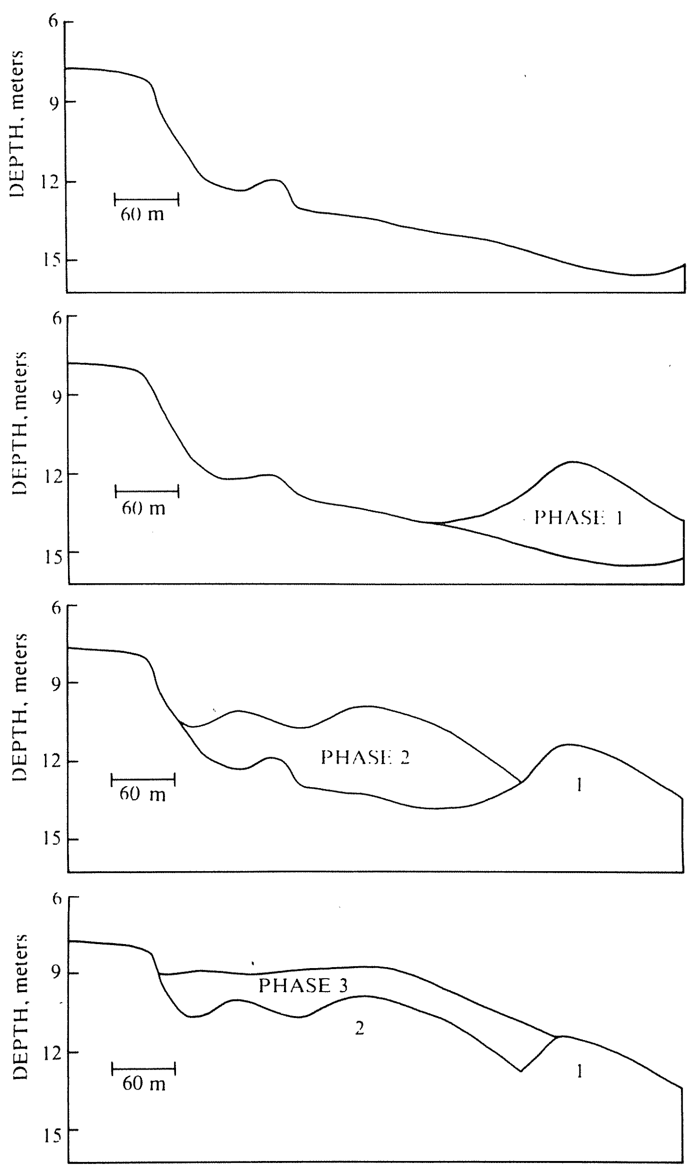

Figure 1. Three phases of filling a pit in N.Y. Harbor with dredged sediment. Phase 1 has been completed.

Research & Monitoring Updates

U.S. Experience in Capping Dredge Spoils Subject at UJNR Meeting

Dr. P. Kilho Park was invited to make a presentation at the 11th U.S.-Japan Natural Resources (UJNR) Marine Facilities Panel Meeting on the U.S. experiences in capping dredge spoils in May 1982. Dr. Park, Manager, National Oceanic and Atmospheric Administration (NOAA)/Office of Marine Pollution Assessment (OMPA) Ocean Dumping Program, represented the U.S. and summarized findings from several U.S. studies and presented a paper entitled "U.S. Experiences in Capping Dredge Spoils."

Capping of contaminated dredge spoils is a new development in dredge material management technology in which contaminated dredge materials are covered with a layer of clean sediments for a depth of 1 m and more to bury and isolate the contaminants. A cap of at least 60 cm in thickness appears to be sufficient to insulate the burrowing benthic organisms from the contaminated sediment underneath. Capping experiments have been conducted in the U.S. (Providence Harbor and River, Stamford and New Haven Harbors, and New York Harbor), in Sweden and Canada. Research into this alternative in the U.S. has been done by the Graduate School of Oceanography at the University of Rhode Island, by NOAA's Atlantic Oceanographic and Meteorological Laboratories, by Science Applications, Inc. for the DAMOS project, by the NY District Army Corps of Engineers, and by the Marine Sciences Research Center of the State University of New York.

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Progress in Implementing Ocean Pollution Data and Information Network

In February 1979, the Administrator of the National Oceanic and Atmospheric Administration (NOAA) delegated to the National Oceanographic Data Center (NODC) responsibility for implementing Section 8 of the National Ocean Pollution Planning Act (Public Law 95-273). Following funding approval in February 1981, NODC began its efforts to design and develop both short-term and long-term programs to speed the acquisition, increase the utility, and facilitate the timely dissemination of marine pollution data and information. As reported earlier in COPAS (Vol. 1, No. 4), NODC established in May 1981 a Central Coordination and Referral Office (CCRO) to head and to direct the development of an Ocean Pollution Data and Information Network (OPDIN). The OPDIN is the mechanism recommended by several advisory groups to improve communications and coordination of marine pollution data and information activities among Federal agencies.

The CCRO is currently managing preliminary OPDIN operations aimed at short-term improvements in data accessioning, processing, evaluation, and dissemination methods and practices. It is also directing the work of a contractor (Electronic Data Systems Corporation) conducting long-term system and design studies for a fully-developed OPDIN scheduled for operation in 1985.

OPDIN accomplishments to date include:

- distribution to Federal and non-Federal offices and individuals of an announcement describing the establishment and objectives of the CCRO and the planned Ocean Pollution Data and Information Network.
- completion of major portions of an NODC Toxic Substances and Pollutants Data System, which is scheduled to be fully operational by December 1982. To ensure its national acceptance, this system uses the chemical code system developed by the Chemical Abstracts Service (CAS) of the American Chemical Society.
- evaluation of methods to improve data entry of non-automated and uncoded marine pollution data (through a Cooperative Agreement with the Arctic Environmental Information and Data Center, University of Alaska; to be completed in April 1983).
- development of a prototype coastal information system for dissemination of timely and useful data and information (through a Cooperative Agreement with the Marine Sciences Research Center, State University of New York at Stony Brook; to be completed in 1984).
- installation at NODC headquarters in Washington, DC, and the NODC liaison offices in Seattle, WA; Anchorage, AK; and Miami, FL; of state-of-the-art work stations to facilitate the capture of pollution data in digital form, and the exchange of management and data files within the existing regional system. Installation of similar equipment is planned for the other liaison offices (Woods Hole, MA; and La Jolla CA) by the end of 1982.
- completion of the annual update of the National Marine Pollution Information System (NMPIS), the automated file used to generate the catalog of Federal pollution programs and projects that is a part of the biennial Federal Plan prepared by NOAA's National Marine Pollution Program Office (NMPPO).

The CCRO is managing design and development activities directed toward a fully operational OPDIN. In March 1982 the OPDIN contractor completed final draft versions of two reports, that:

- review and analyze existing marine pollution data and information systems,
- define OPDIN system requirements, and
- propose an OPDIN conceptual design.

On 4-5 May 1982, NODC held an OPDIN workshop at which invited representatives from seven Federal agencies (in addition to NOAA) discussed these reports and an OPDIN Guidelines Report prepared by the CCRO staff. Numerous ideas, concerns, and suggestions about OPDIN were voiced by workshop participants. These are reflected in the conceptual design document completed in July 1982.

A detailed system design developed from the conceptual design will be produced by late 1983 using contractor assistance. Finally, the operational OPDIN, as specified in the detailed system design, is scheduled to be completed in 1985.

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Corps of Engineers Studies Dredging Impacts on Grays Harbor Estuarine Environment

Currently, the U.S. Army Corps of Engineers is investigating the environmental impact of a proposed project to widen and deepen the existing navigation channel in Grays Harbor, Washington (Fig. 1). In June 1979, the Seattle District of the Corps invited representatives from several state and Federal resource agencies, environmental groups, and local universities to participate in an environmental studies scoping process.

The task force examined a list (compiled from various sources) of suggested environmental studies for Grays Harbor; these suggested studies had varying applicability to navigation channel improvement. Three primary areas of concern were identified: water quality, fisheries, and wetlands/wildlife. Sixteen scopes of study, written on various aspects of these topics, were selected based upon feasibility, expected quality of information, and degree of project relatedness. These scopes subsequently resulted in the funding of the 22 environmental studies listed in Table 1.

Several studies are concerned with the impacts of the disposal of dredged material on land (e.g., Wetland Habitat Mapping, Wildlife Distribution and Abundance, Endangered Species Evaluation) and in water (e.g., Preliminary Ocean Disposal, Bioassay and Bioaccumulation). Other studies address the impact of the modification of bottom contours on aquatic habitats (e.g., Water Quality and Circulation Impacts, Fish Abundance, Distribution and Feeding, Dungeness Crab Distribution and Feeding). A study of the uptake of organisms by dredges is also being conducted. The first study began in late 1979, and all final reports will be submitted by early 1982. This battery of studies represents a major investigation of an estuary located on the Pacific Coast of North America.

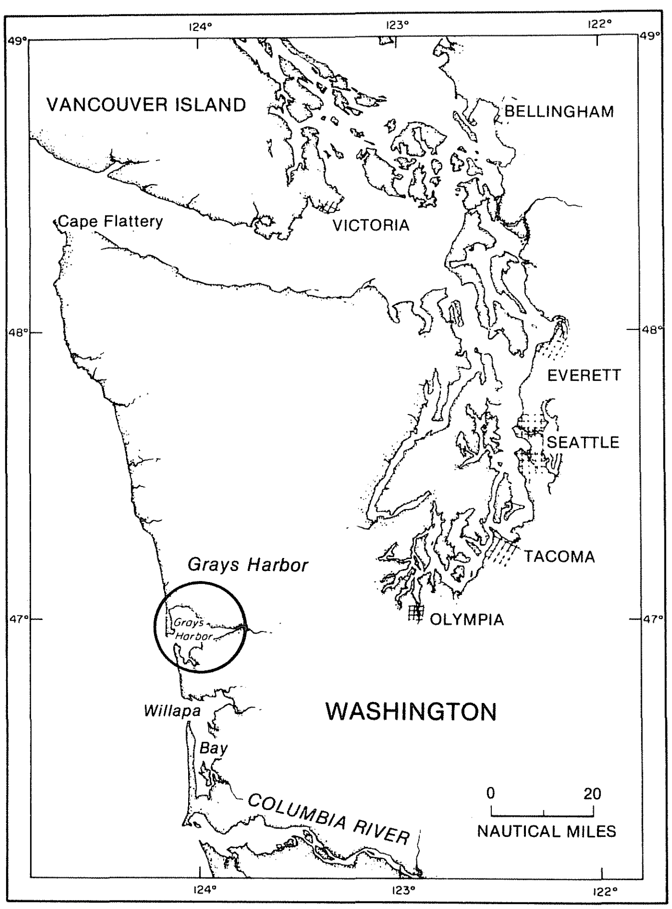

Figure 1. Grays Harbor

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TABLE 1

Environmental Studies in Grays Harbor Estuary

Wetland Habitat Mapping	Habitat Evaluation Procedure
Preliminary Ocean Disposal Study	*Klebsiella* Sp. Micro-Organism Study
Water Quality and Circulation Impacts	Sediment Chemistry Study
Fish Abundance, Distribution, and Feeding	Endangered Species Evaluation
Dungeness Crab Distribution and Feeding	Upstream Sedimentation Sources
Benthic Invertebrate Distribution, Composition, Abundance, and Productivity	Dredge Entrainment of Organisms Study
Dredging Modifications Evaluation	Bioassay and Bioaccumulation Studies Related to Disposal of Dredged Material
Primary Productivity of Aquatic Plants	Shrimp Distribution and Abundance
Wildlife Distribution and Abundance	Distribution and Abundance of Salmonid Food Organisms
Cultural Resources Evaluation	Distribution and Abundance of Shorebirds and Waterfowl during the Spring Migration
Fish and Wildlife Resource Mapping	

Baseline Inventory in San Pedro Bay, California

The Los Angeles Harbor Department, San Pedro, California has initiated an inventory of selected marine resources in a portion of San Pedro Bay. This study, conducted by the Southern California Ocean Studies Consortium (SCOSC) of The California State University, will provide baseline information on birds, juvenile and adult fishes, benthic fauna, and riprap flora and fauna located in the area of a proposed Dry Bulk Handling Terminal. The one-year survey began in September 1981. The study area covers approximately one square kilometer.

The principal investigator for the study of juvenile and adult fishes is Dr. Michael Horn, California State University, Fullerton. Sampling will be conducted every other month with plankton tows, otter trawls, and gill nets. In addition, temperature, salinity, and dissolved oxygen will be recorded at surface and bottom during both day and night of each sampling period. Water transparency will be measured with a secchi disk during daytime sampling. The relationship between single environmental factors and individual species abundances will be analyzed by multiple regression. Species richness will be recorded and a species diversity index calculated.

Dr. Donald J. Reish, California State University, Long Beach is the principal investigator for the benthic fauna program. Each of the six stations will be sampled quarterly. Mean biomass and density per m^2 of surface habitat will be calculated for each major taxon per station. Species diversity and richness will also be calculated.

The avifaunal surveys will be conducted twice a month by Dr. Charles Collins, California State University, Long Beach. All birds will be identified, enumerated, and listed. There is particular concern for the California Brown Pelican and the California Least Tern.

Dr. Reish will also direct the riprap survey. Two intertidal/subtidal transects will be sampled quarterly. Mean biomass and density per m^2 of riprap will be calculated per major taxon and sample. Species diversity and evenness will also be calculated. Voucher specimens will be collected for all species identified.

The report will include a detailed description of materials and methodology, raw data, summary of data, discussion, and conclusions concerning the impacts of the proposed dredging and filling activity.

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Ocean Pollution 1981 Conference

A conference on biogeochemistry of pollutant chemicals in the North Atlantic Ocean "Ocean Pollution 1981" was held in Halifax, Nova Scotia, Canada, 19-23 October 1981. Bedford Institute of Oceanography and Woods Hole Oceanographic Institution (WHOI) co-sponsored the conference with support from the Coastal Research Center (WHOI), the Office of Marine Pollution Assessment (National Oceanic and Atmospheric Administration), the Environmental Protection Service (Department of the Environment, Canada), and the Canadian Department of Fisheries and Oceans.

The conference papers are being reviewed for publication as a special volume of the *Canadian Journal of Fisheries and Aquatic Sciences*. To provide a general impression of the papers and a general discussion of the conference, we offer a brief overview.

A broad range of field and laboratory studies around the North Atlantic Ocean leads us to express concern about continued pollution of North Atlantic coastal areas. Industrial and urban wastes, dredge spoils, and storm water runoff from cities and towns discharge chemical pollutants such as fossil fuel compounds, trace metals, and synthetic organic compounds. Valuable living resources of a few coastal areas are contaminated at a level where they pose a risk to human health.

Progress has been made, however, in identifying sources of chemical pollution, rates and routes of movement of those chemicals through marine ecosystems, and chemical and biological processes acting to alter these chemicals in the oceans. We can distinguish more accurately between normal and pollutant concentrations of trace metals in water, sediments, and organisms. We identify reliably and measure many more of the known or suspected pollutant synthetic organics than was possible five years ago. It now is possible to distinguish relatively inert from biologically-active components of certain pollutants. For example, scientists have demonstrated that initial products of metabolism of petroleum hydrocarbons are far more persistent and potentially deleterious than was previously suspected.

The amounts and varieties of hydrocarbons entering coastal ocean waters are large, and contain toxic and carcinogenic and/or mutagenic compounds. Many of these become associated with bottom sediments where they may persist for years or decades. While oil spillage no doubt accounts for a considerable amount of the hydrocarbons in the oceans, calculations for urbanized areas of the U.S. eastern seaboard indicate that a far greater amount enters the world's oceans through urban and river run-off. Heavily industrialized areas of the North American continental margin are sources of fossil fuel hydrocarbon contamination that affect their adjacent marine regions. However, the current state of petroleum analyses is limited to only a few of the compounds in crude oil and oil products.

Heavy metal and synthetic organic pollution are common in coastal waters of the North Atlantic. Heavy metal contamination is associated with industrialized and urbanized areas involving large river systems which concentrate the pollution. The contaminant metals originate from many sources, including various metal-related (copper, mercury, cadmium, chromium, etc.) industries, as well as other sources. Often the contaminating metal is a by-product of industrial production. Metals may remain in the river water and/or in coastal waters for varying times, but eventually they are incorporated in the sediment deposits, often in the heads of estuaries or embayments where they become associated with the finer-grained sediments and constitute a toxic threat to fish, shellfish (including scallop), and crustacea (including lobster).

Synthetic organic compounds, including a broad range of DDT- and PCB-type compounds and other similar products, are now detected in nearly all environmental samples analyzed. Most of these compounds are toxic to vertebrate and invertebrate, and can be accumulated by seafood. In addition, several are either carcinogenic or mutagenic. In contrast to petroleum and coal hydrocarbons and to heavy metals, this class of contaminants is a recent man-made phenomenon. These compounds can freely enter into all levels of the food chain, either from water, prey organisms, or via sediments. In some water bodies entering the North Atlantic and in estuaries, PCBs in fish tissues have risen markedly. This has led to closing of the commercial fishery in the Hudson River, where PCB contamination of such fish species as striped bass has become a health danger.

The progress described above should not generate a false sense of complacency regarding chemical pollution of the ocean. In most respects, we are only beginning to understand complex interactions of natural systems not subjected to significant inputs of chemicals from man's activities. This creates a problem when trying to consider long term (years) effects of chemical contaminants on specific populations of marine organisms or ecosystems. We barely have crossed the threshold of understanding biological responses of individual species to contaminants.

The research of the late 1960's to mid-1970's indicated that our most immediate concern should be with the more heavily contaminated coastal areas. Also synthetic organic chemicals such as DDT and PCBs have been found in North Atlantic abyssal surface sediments and bottom dwelling organisms only a few decades after first use. Since 1975 little research on chemical contaminants has been conducted in open ocean areas.

Given the large area and volume of the open North Atlantic Ocean and the long time constants of decades to centuries for processes acting on chemicals once they enter the system, we are concerned that contemplated, deliberate increases in discharges of pollutant chemicals to the North Atlantic without any increase in our knowledge of oceanic processes via increased research and monitoring will be prejudicial to following generations. We emphasize that the high concentrations of chemical pollutants found in some coastal areas are the result of only twenty to thirty years' discharges. Containing and/or reversing these pollution problems has taken or will take many years and will require funds into the many millions of dollars.

We recognize that man is part of the world and that waste discharge to the oceans is only one of the many uses man can make of the oceans. Our concern is that this one use be conducted wisely in order that the other desired uses are not unwittingly abrogated.

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Sewer Outfalls and Ocean Dumping Research in Hawaii

The University of Hawaii has recently developed and built a Pacific-wide undersea research laboratory (HURL) under the direction of John P. Craven. One facility of the laboratory is the research submersible Makali'i, formerly known as Star II. Support for the laboratory is provided by the undersea research program of the National Oceanic and Atmospheric Administration (NOAA). The laboratory is considered a national facility. Research proposals are accepted from academic institutions, government agencies, and the private sector.[1]

The 1980-81 research program contained several projects designed to evaluate the impacts of sewer outfalls and ocean dumping on the marine environment; that is, the fate, effects, and dilution of potential pollutants and the assimilation capacity of various ecosystems. One project, under the direction of Steven J. Dollar, was an impact study of Hawaii's largest sewer outfall at Sand Island. The outfall recently has been diverted from a depth of 12.2 m to 73.2 m, where approximately .265 billion liters day^{-1} of modified primary treated effluent is discharged.

In 1981 the submersible Makali'i was used to observe changes in the biota and sediments associated with the outfall, as well as to follow dye markers to determine dispersal patterns of the effluent plume. The manipulative capabilities of the submersible's mechanical arm have enabled sediment and water samples to be collected in the impact area with a degree of precision not possible with surface sampling techniques. Total benthic community metabolism under varying levels of outfall influence also have been evaluated with the use of a submersible-operated system that measures oxygen flux inside plexiglas hemispheres sealed to the bottom. In addition, the submersible has been equipped with an instrument package capable of continuously recording water column oxygen concentration, salinity, temperature, light transmission, and depth.

Another project utilizing the Makali'i submersible is a study, by James E. Maragos of the Army Corps of Engineers, that is designed to assess the long-term impacts of deep ocean disposal of dredge spoil in Hawaii. The study should also produce data needed to satisfy Environmental Protection Agency requirements to (1) characterize the transport and descent of dredged materials upon disposal at deep ocean sites; and (2) better characterize long-term recovery rates and environmental impacts on benthic communities at the sites. The first dump site to be studied is located off Pearl Harbor at a depth of 365.9 m. The Makali'i will be used for all *in situ* observations and collections. In addition to Maragos, Jacqueline Miller, Rick Spencer, Eric Guinther, and Julie and Richard Brock plan to conduct various aspects of the research on ocean dumping.

Besides pollution studies, emphasis in the HURL program has been placed on four other topics of research: energy, fisheries, geological processes, and undersea technology. In all, twenty-three projects are planned for fiscal year 1982. The program is closely patterned after priorities developed by NOAA.

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[1]Address proposals to Dr. D. Chave, Director of the Scientific Program, HURL, Makai Research Pier, Makapuu Point, Waimanalo, HI 96795.

Announcements

NMFS Galveston Laboratory Leads Research on Marine Pollution-Energy Effects in Gulf of Mexico

The development of energy resources and facilities in the northwestern Gulf of Mexico is the most intense of any coastal region in the Nation. The Louisiana-Texas continental shelf yields 96% of the U.S. Outer Continental Shelf (OCS) oil production and almost all of the offshore gas production. Despite the decline in oil production in this region, gas production is still increasing and industry interest in continued development is high, as reflected in record bonuses bid in recent Gulf OCS lease sales.

Additionally, the northwestern Gulf region is used extensively in petroleum transportation and refining. The U.S. Department of Energy is developing the Strategic Petroleum Reserve as a national oil stockpile to be used in case of emergencies. Vast underground caverns, which are created by leaching salt domes, are used for oil storage at several locations along the Texas and Louisiana coasts. The saturated brine solutions created by this leaching from several of these sites are discharged offshore.

The Galveston Laboratory of the Southeast Fisheries Center (SEFC) of the National Marine Fisheries Service (NMFS) has acted as a project management agency for several environmental studies programs in the northwestern Gulf funded by the Department of the Interior, the Environmental Protection Agency and the Department of Energy. These studies have concerned fisheries and OCS development, environmental assessment of the effects of oil and gas field development, and studies related to brine discharges on the shallow continental shelf. A comprehensive list of publications resulting from these studies and additional information can be obtained from Dr. Edward F. Klima, SEFC Galveston Laboratory, National Marine Fisheries Service, 4700 Avenue U, Galveston, TX 77550.

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New Dumping Site Assessment Report Available

The Western Gulf of Mexico Dumping Site Assessment Report has been issued as National Oceanic and Atmospheric Administration (NOAA) Dumpsite Evaluation Report 81-2. The report examines the impact of biological sludge dumping by the Shell Chemical Company at a deepwater site in the Gulf of Mexico. This dumping ended in late 1977. The NOAA studies consisted of chemical characterization and biological tolerance studies in the laboratory and site characterization and waste tracking studies in the field. The results indicate that the overall environmental consequences of the discharge of the biosludge were probably negligible. Copies of this report, as well as Dumpsite Evaluation Report 81-1 on the 106-Mile Site are available from:

Office of Marine Pollution Assessment
NOAA/OMPA, MP2
Rockwall Building - Room 320
Rockville, MD 20852

Wildlife Federation Establishes Ocean Dumping Project

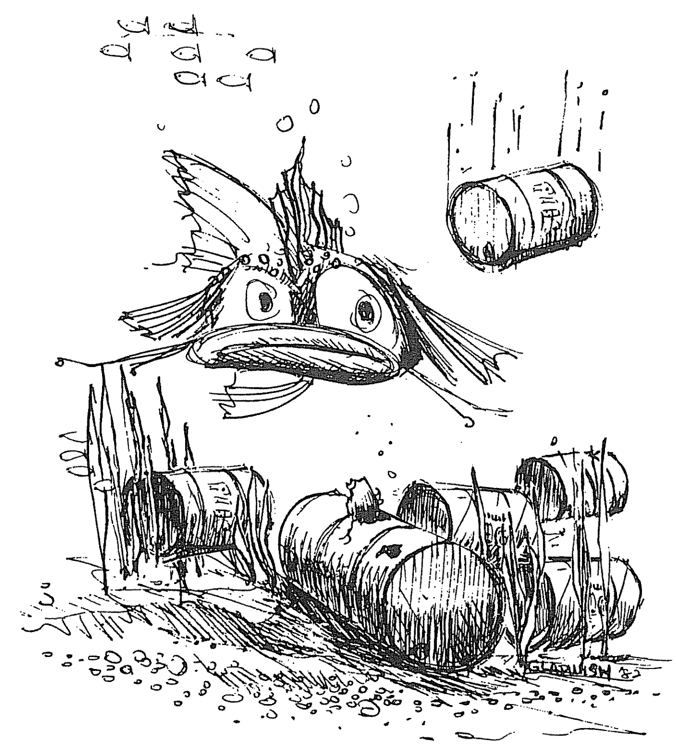
On 1 March, 1982, the National Wildlife Federation initiated a comprehensive coastal ocean protection project aimed at reversing the current regulatory trend in favor of increased ocean dumping of harmful dredged materials, sewage sludges, and industrial chemicals. Funded in part by a grant from the William H. Donner Foundation of New York, the two-year project will seek to gain wider acceptance of two basic philosophies regarding the use of the oceans as a waste disposal medium. The first is the idea that the ocean is both especially vulnerable to excessive waste disposal and a particularly unsuitable environment for the receipt of persistent toxic wastes. The second is that the ocean, because it is a ''free'' resource not subject to marketplace and political protections, will become the disposal medium of choice unless afforded special protection by law.

Specifically, the project's early goals will be to: (1) aggressively counter current efforts of the Environmental Protection Agency to relax its ocean dumping regulations and criteria; (2) limit, and ultimately reverse, the potentially wide-ranging effects of a recent Federal District Court decision which invalidated EPA regulations that would have banned the ocean dumping of harmful sewage sludge by the end of 1981; (3) gain compliance with U.S. and international laws prohibiting ocean dumping at any sites that have not been first studied for their suitability for that purpose; (4) to scrutinize and critique the dredge spoil ocean dumping practices of the Army Corps of Engineers; and (5) to demonstrate the availability, and encourage the use, of environmentally preferable alternatives to the ocean dumping of dredge spoils and sewage sludge, including pretreatment, source reduction and recycling.

The project will bolster the long-standing efforts of the Federation to secure for the ocean the regulatory status of a last—rather than a first—resort disposal medium, at least for persistent toxic contaminants. The project director is Thomas K. Bick, former special assistant to the Administrator of the National Oceanic and Atmospheric Administration.

The Federation is currently soliciting members to serve on a technical advisory committee for the project. Persons with ocean-pollution-related expertise (or with expertise in land-based alternatives) who are interested in serving on the committee, or assisting the project in a less formal capacity, should contact Thomas Bick, Director, Ocean Dumping Project, National Wildlife Federation, 1412 Sixteenth Street, N.W., Washington, D.C. 20036.

Thomas Bick
202-797-6800



''What, me worry?''

Oceans '82 - September 20-22, 1982 Shoreham Hotel, Washington, DC

Oceans '82 will feature a series of special sessions that focus on ocean disposal of municipal and industrial wastes in the United States. Eight special sessions are planned with over 60 invited papers:

I. Ocean Disposal of Municipal and Industrial Wastes in the New York Bight.

Co-Chairmen: Joel O'Connor, National Oceanic and Atmospheric Administration (NOAA) Office of Marine Pollution Assessment and Charles G. Gunnerson, International Bank for Reconstruction and Development.

II. Dredged Material Disposal in U.S. Coastal Regions.
&
III. Co-Chairmen: Gib Chase, U.S. Army Corps of Engineers, and Millington Lockwood, NOAA National Ocean Survey.

IV. Deep Ocean Disposal.

Co-Chairmen: Tom O'Connor, NOAA Ocean Dumping Program, and Pete Anderson, Environmental Protection Agency (EPA) Region II.

V. Municipal and Industrial Waste Disposal on the West Coast.

Co-Chairmen: Alan Mearns, NOAA Office of Marine Pollution Assessment, and Walter J. Spofford, Jr., Resources for the Future.

VI. Waste Disposal in the Gulf of Mexico.

Co-Chairmen: Roy Hann, Jr., Texas A&M University, and Ed Klima, NOAA National Marine Fisheries Service.

VII. Great Lakes Pollution — Past, Present and Future.

Co-Chairmen: Andrew Robertson, NOAA Office of Marine Pollution Assessment, and William Sonzogni, NOAA Great Lakes Environmental Research Laboratory.

VIII. Waste Disposal and Monitoring Strategies.

Co-Chairmen: George Peter and R. Lawrence Swanson, NOAA Office of Marine Pollution Assessment.

Michael A. Champ, Resident Scholar, NOAA's Ocean Dumping Program, developed the idea for special sessions on waste disposal at Oceans '82 through the auspices of the new Marine Technology Society (MTS) National Committee on Marine Pollution chaired by R. Lawrence Swanson, Director of NOAA's Office of Marine Pollution Assessment. The theme of Oceans '82 will be "Government, Industry, and Academia — Partners in Ocean Progress," with the Conference chaired by John V. Byrne, the Administrator of NOAA. For additional information, contact the

MTS Society
1730 M Street, N.W.
Suite 412
Washington, DC 20036
202-659-3251

Bight Of The Big Apple Available From New York Sea Grant

Dr. Donald Squires, Director of the New York Sea Grant Institute, has written an 84-page illustrated volume titled *The Bight of the Big Apple.* The book describes the history of the New York Bight, touching on how it became a thriving center of commerce. Other questions addressed in *The Bight of the Big Apple* include: (1) how badly has pollution damaged the Bight; (2) is the damage from pollution reversible; and (3) is there hope for the Bight's future? Also included is a discussion on restoration of the Bight and revitalization of its coast.

Copies of *The Bight of the Big Apple* are available from:

New York Sea Grant Institute
State University of New York
and Cornell University
411 State Street
Albany, NY 12246

Calendar

September

20-22

Oceans '82: Government, Industry, and Academia — Partners in Ocean Progress, Shoreham Hotel, Washington, DC. Contact: 1730 M Street N.W., Suite 412, Washington, DC 20036 (202-659-3251).

October

4-9

Fifty-fourth Annual Water Pollution Control Federation Conference, Detroit, MI. Contact: Conference Department, Water Pollution Control Federation, 2626 Pennsylvania Avenue N.W., Washington, DC 20037

11-13

Eighth Annual Conference of the Coastal Society, Baltimore, MD. Contact: The Coastal Society, Suite 150, 5410 Grosvernor Lane, Bethesda, MD 20814

30

Issues and Answers Concerning Ocean Waste Disposal, Stevens Institute of Technology, Hoboken, NJ. Contact: Mr. Robin D. Zimmer, New Jersey Marine Advisory Service, Ft. Hancock, NJ 07732 (201-872-1300).

December

7-15

AGU Fall Meeting & ASLO Winter Meeting, San Francisco, CA. Contact: AGU Meetings, 2000 Florida Ave., N.W., Washington, DC 20009 (800-424-2488).

February

28-3 March

1983 Oil Spill Conference (Prevention, Behavior, Control, Cleanup), San Antonio Convention Center, San Antonio, TX. Contact: 1983 Oil Spill Conference, Suite 700, 1629 K Street NW., Washington, DC 20006 (202-296-7262).

April

11-15

Fourth International Ocean Disposal Symposium, Plymouth Polytechnic, Plymouth, Devon, England. Contact: Iver W. Duedall, Marine Sciences Research Center, SUNY, Stony Brook, NY 11794 (516-246-7715).

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Information for Contributors

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1. Articles should be typed double-spaced and should not exceed 1,000 words.
2. The title should be informative and brief.
3. On first use full name and acronym must be used. Subsequent reference may be by acronym alone.
4. Measurements should be given in the metric system
5. Figures and tables should be camera-ready and suitable for reduction to a 15.2 x 10.2 cm size, not including legend. Care should be taken with lettering and symbols so that they are readable when reduced. The combined number of figures and tables should not exceed three.
6. Proofs will not be sent to the author unless requested, but if significant editorial changes are made for brevity and clarity, authors will be contacted by telephone.
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COASTAL OCEAN POLLUTION ASSESSMENT NEWS

MAN AND THE MARINE ENVIRONMENT

Volume 2 Number 2 1982

The purpose of **Coastal Ocean Pollution Assessment** (COPAS) **News** is to provide timely dissemination of information on pollution in coastal waters of the United States — its sources and effects, what is being done to eliminate or mitigate it, and what research and monitoring activities are being conducted to develop more effective strategies to manage it. We publish brief articles describing recent events and activities, new approaches to resolving chronic pollution problems, and early warnings of potential problems. Announcements of cruises, meetings, and investigations will be included.

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In This Issue

Continuity

Trace Metal Accumulation and Detoxification In Marine Shellfish

Trace metals are accumulated from food and water by marine invertebrates and many of them act as micronutrients. Some metals, however, such as Hg, Cd, and Pb, are toxic at certain concentrations. Others such as Zn and Cu are necessary nutrients, but can be toxic at elevated concentrations. Since animals do accumulate trace metals, they also have evolved mechanisms of sequestering or partitioning these potentially harmful elements. One of the strategies involved is the synthesis of low molecular weight metal-binding proteins, known as metallothioneins, upon exposure to heavy metals. These proteins are rich in the sulfur-containing amino acid, cysteine (20 cysteines per polypeptide chain of 61 amino acid residues). The cysteines form two metal (Zn, Cd, Cu, Hg and Ag) binding clusters capable of binding 3 and 4 metals respectively (Otvos and Armitage 1980). A generalized diagram of the pathways metals can follow from the environment through marine organisms and how metallothionein interacts with this process is shown in Fig. 1.

Our investigation of the role of metallothionein in trace metal detoxification is a cooperative research project between the National Marine Fisheries Service, Southeast Fisheries Center, Beaufort Laboratory and the Duke University Marine Laboratory/Marine Biomedical Center. The program is funded by the NOAA Office of Marine Pollution Assessment's Long-Range Effects Research Program (LRERP).

The research effort can be subdivided into three areas: (1) the interaction of trace metals with respiratory proteins (hemocyanins) from marine crustaceans, (2) the physiological and detoxifying properties of metal-binding proteins in marine fish and shellfish, and (3) the examination of shellfish from contaminated environments for the presence of metal-binding proteins.

When trace metals are absorbed through the gill or gut of crustaceans they must be transported in the hemolymph. Circulating respiratory proteins, which constitute up to 95% of hemolymph-protein in marine crustaceans, may therefore act either in transport or toxicity. *In vitro* studies demonstrated that hemocyanins in general have very high affinity binding sites for heavy metal ions. The stoichiometries and functional consequences of the binding of Ca, Cd, Cu, Zn and Hg to blue crab, *Callinectes sapidus,* and horseshoe crab, *Limulus polyphemus,* hemocyanin were determined in detail. All metal ions affected the oxygen binding characteristics of both hemocyanins (Brouwer et al. 1982, Brouwer and Engel in press).

From the results of both *in vitro* and *in vivo* studies, it has been concluded that heavy metal ions, at concentrations which occur naturally, are unlikely to affect normal respiratory processes. It seems inescapable, however, that any free metal ion that enters the hemolymph will be bound to hemocyanin, as has been demonstrated by *in vivo* exposure of blue crabs to mercury-laden fish (Whaling and Brouwer, unpublished data).

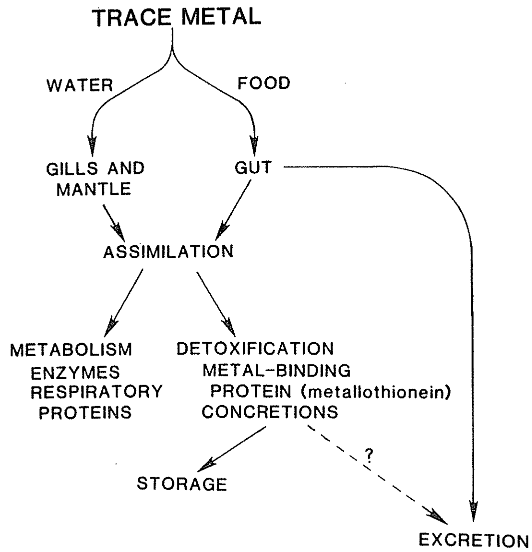

Figure 1. A diagram of some potential pathways of trace metal distribution in marine organisms and how the partitioning of the metals may be interrelated.(Brady,1982)

In other laboratory experiments, we have examined the accumulation and partitioning of Cd in the oyster, *Crassostrea virginica* and the blue crab. When oysters are exposed to Cd in the water at 0.1 ppm for 28 days, they produce cadmium-binding proteins, which can be isolated from the cytosolic fraction (e.g., soluble portion of the cellular contents) of the organism. When the cytosol is chromatographed on Sephadex G-75, a medium that is being used for separating proteins by molecular size, all of the cadmium is present in a double protein peak (Fig. 2A). The lower molecular weight portion of the double peak has about the same molecular weight as metallothionein, but the amino acid composition reveals a low cysteine content, thereby setting this protein apart from mammalian metallothionein (Roesijadi, 1981; Ridlington and Fowler, 1979; Engel and Fowler 1979). Even though oysters have high body burdens of Zn, they do not have a specific low molecular weight binding protein for that metal. When blue crabs are exposed in the laboratory to cadmium in food or water, the tissue distribution of the metal is concomitant with the localization of cadmium-binding proteins. Gill tissues contain the majority of the cadmium in crabs exposed to cadmium in the water, and concentrations of cadmium in the digestive gland are highest when the source is food. Figs. 2b, c show the Sephadex G-75 elution profile of the cadmium-binding proteins in the gill and digestive gland obtained from blue crabs exposed to cadmium in the water. When the source of cadmium is food, the reverse pattern exists (i.e., cadmium-binding protein in the digestive gland and none in the gill). The purified digestive gland metalloprotein invariably contained Cd and Zn, as opposed to the gill protein which contained only Cd (2C). Additionally, we observed a low molecular weight copper binding (no Cd or Zn) protein in the digestive gland. Characterization of these metal-binding proteins by means of ion exchange chromatography, a technique that separates proteins based on their charge densities, revealed distinct differences among them.

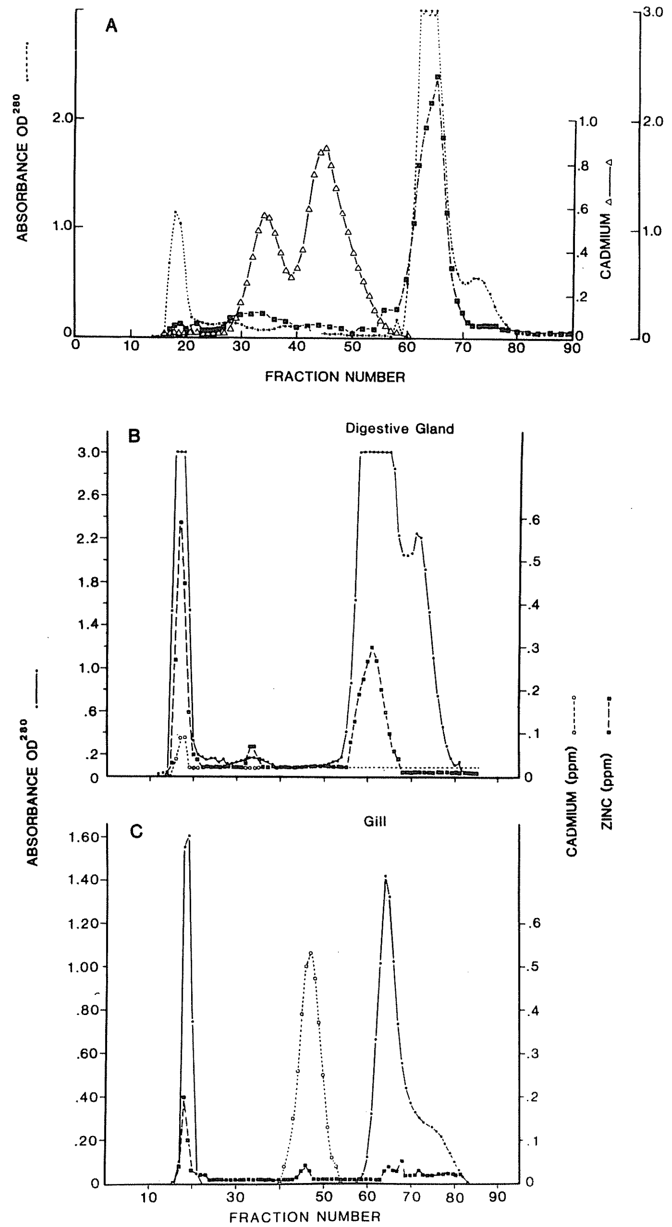

Figure 2. Sephadex G-75 chromatograms of the cytosolic fraction extracted from whole oysters (A.), blue crab digestive gland (B.) and blue crab gill (C.).

Absorbance was measured spectro photometrically and the zinc and cadmium concentrations were measured using flame atomic absorption spectrophotometry.

Preliminary studies of metal-binding proteins present in the digestive gland of the American lobster, *Homarus americanus,* after exposure to Cd dissolved in seawater, showed the presence of a Cd/Zn and a copper binding protein, as observed for the blue crab. The molecular weight of the lobster Cd/Zn protein, however, was distinctly greater than that of the blue crab.

We also have begun examining oysters that have been collected in different contaminated and uncontaminated environments to determine if laboratory and environmentally exposed animals produce the same types of metal-binding proteins. To date, the cytosolic distribution of zinc and copper have been examined. Laboratory and environmentally dosed oysters both had copper-binding proteins, but the laboratory animals had two demonstrable copper-containing proteins and environmental groups had only one (Engel and Brouwer, in press). No low molecular weight Zn-binding protein was demonstrated in any of the samples.

The pattern emerging from these studies so far seems rather complex:

1. The metal-binding proteins induced by exposure to cadmium dissolved in seawater differ in their chromatographic characteristics for the three organisms examined (oyster, blue crab, lobster).

2. Within a single organism (blue crab), the induction and chemical characteristics of the metal-binding protein seem to be dependent on the pathway of cadmium accumulation (i.e. food or water).

3. Controlled laboratory experiments may lead to results that differ from environmental exposure.

To further understand the role that low molecular weight metal binding proteins play in trace metal metabolism and for detoxification in marine organisms, it is imperative to know how many different metal-binding proteins are involved in these processes. Therefore, we have set forth to purify and chemically characterize the metal-binding proteins described in this communication.

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Loomings

Decline of Submerged Aquatic Vegetation in Chesapeake Bay

Estuaries and other coastal areas have traditionally received waste materials associated with human activities. In recent years, the amount and diversity of waste loads have increased greatly, as have the conflicts of estuarine uses. For example, many estuarine waters are used for disposal of sewage, as well as for fisheries and recreation, despite the fact that the former may have negative effects on the latter. In some cases, estuarine responses to such inputs have been obvious while other changes have been sufficiently subtle that cause-effect relationships have not been identified.

Chesapeake Bay is a case in point. In the last several decades there have been some significant changes in Bay ecology, one being the drastic decline in submerged aquatic vegetation (SAV) communities which once dominated the littoral zone. Coincident with this loss of SAV, there have been changes in water quality including increases in turbidity and nutrient concentrations and increasing use of agricultural herbicides, as well as declines and shifts in various fisheries. A few such trends are shown in Figure 1 for several areas of

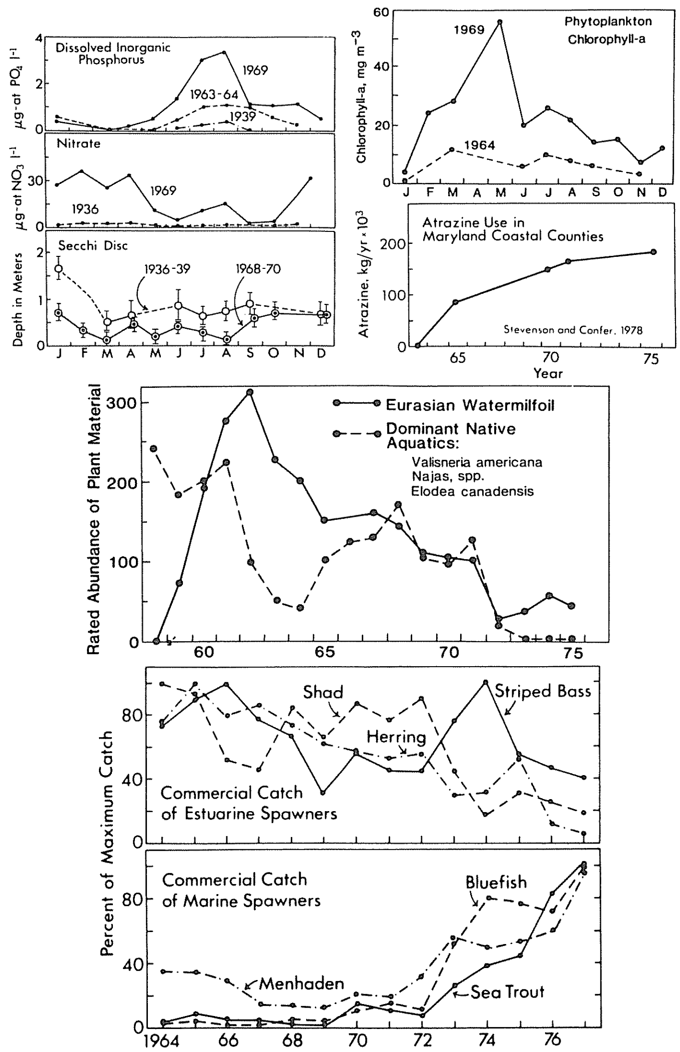

Figure 1. A summary of water quality data (excluding atrazine) from the Patuxent River, SAV data from the upper Chesapeake Bay and fishery yields from the Potomac River.

the Bay. These apparent conflicts in the use of estuarine resources prompted the U.S. EPA Chesapeake Bay Program to concentrate on SAV as a major research theme.

Investigators from the University of Maryland, Virginia Institute of Marine Sciences, the Johns Hopkins University, and several other institutions conducted a 3 year study aimed at an improved understanding of the causes of SAV decline, the ecological processes associated with SAV, and the economic consequences of the decline. A large number of reports have been generated and several monographs are being prepared summarizing the findings related to these issues. Several aspects of this research related to the cause of the SAV decline are presented here.

At the outset, numerous factors were suggested as possibly responsible for the decline of SAV. These ranged from cycles in seagrass abundance as governed by natural biological phenomena or climatic events, to point-source discharges of toxic materials such as chlorine. Inspection of historical and recent aerial photographs and analysis of SAV seed and pollen from sediment cores led to several conclusions (Brush et al. 1980, Orth et al. 1979): (1) the recent decline is unprecedented in the past several hundred years (suggesting that the cause is not related to climatic or biological cycles), (2) there is a poor correlation between point-source discharges and SAV abundance; and (3) all of the 10-12 native species were affected. Analysis of SAV abundance in a number of tributaries indicated that there was a reasonably strong negative correlation between the potential impact of diffuse-source materials and SAV distributions (Stevenson and Confer., 1978). Based on the above findings, the original list of possible causative factors was shortened and experiments were designed to test the effects of several kinds of material which enter the estuary largely in runoff. Three generic substances were considered: herbicides, suspended particulates, and nutrients.

Particular attention was given to herbicides because of the potential ramifications for agricultural and cropping practices (Stevenson et al. 1982). The effects of two commonly used herbicides (atrazine and linuron) were evaluated using microcosm systems in which SAV was grown and exposed to various concentrations of herbicides and mixtures of herbicides. Results from a few experiments are summarized in Figure 2. These studies indicated that concentrations of atrazine or linuron in excess of 10ppb caused substantial reductions in photosynthesis in the brackish water species during a 4 week test period. At test concentrations <50ppb, both species exhibited a trend of recovery towards controls, while at higher herbicide concentra-

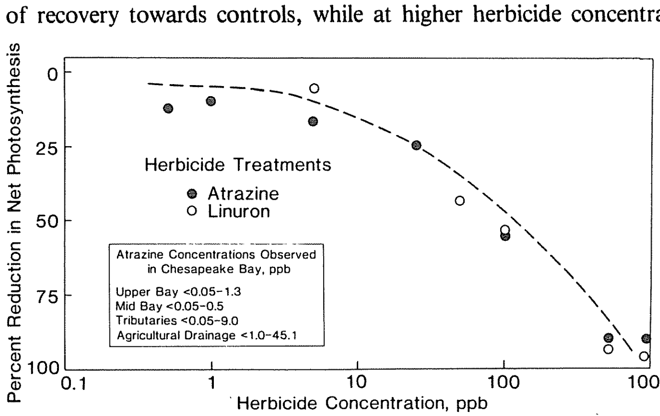

Figure 2. Results of selected SAV microcosm experiments showing relationships between herbicide concentration and percent reduction in SAV photosynthesis. Data are from Kemp et al. (1982).

tions recovery was not evident during the four week period. The results of many of these herbicide studies conducted during the Chesapeake Bay Program have been summarized by Kemp et al. (1982).

To compare the results of microcosm experiments to the potential role of herbicides in the Bay, the persistence of several herbicides in the estuarine environment was investigated and ambient herbicide concentrations in portions of Chesapeake Bay were monitored. The degradation of ^{14}C ring-labeled atrazine in estuarine microcosms was found to be more rapid than in several soil types. Half-lives for this compound averaged 6 and 17 days in estuarine water and sediments, respectively, compared to 330-385 days in local agricultural soils. Linuron appeared to have an even shorter half-life in estuarine waters. Thus, persistence of several herbicides in the estuarine environment appeared to be quite short and the possibility for parent compound accumulation in estuarine sediments appeared remote (Jones et al. 1982). A hierarchy of monitoring studies was utilized to evaluate herbicide concentrations in the northern part of the Bay. These included: measurements of herbicide runoff in drainage creeks from agricultural fields; routine sampling for herbicides along the estuarine tributary receiving such drainage; and measurements along the mainstream of the Bay emphasizing nearshore SAV habitats. Measurements in all areas, particularly those associated with drainage creeks and the tributary, were keyed to time of herbicide application and runoff events to reflect maximum herbicide concentration which might occur in estuarine waters. Ranges in atrazine concentrations in various estuarine zones are shown in Figure 2. In general, concentrations were low throughout the main body of the Bay but occasionally high in tributaries and in drainage channels adjacent to agricultural fields following rainfall. Apparently, dilution in estuarine waters coupled with rapid degradation rates maintains herbicide concentrations at levels too low to cause large reductions in SAV photosynthesis. Kemp et al. (1982) concluded that herbicide concentrations in excess of 5ppb do occur sometimes, but do not persist in some estuarine water which once contained extensive SAV beds. Such concentrations can cause losses in productivity of 10-25% in at least one species of SAV (*P. Perfoliatus*), even when exposure is as brief as one hour. Recovery from exposure may take weeks. Herbicide effects probably add an additional stress to plants which are already growing under less than optimal conditions, but it is unlikely that herbicides alone caused the massive SAV decline observed over the last twenty years.

Research was also conducted to evaluate the impacts of altered light and nutrient conditions on SAV growth. Based on field observations in the Bay, and studies in other ecosystems, we hypothesized that nutrient enrichment of the water column (such as shown in Fig. 1) would enhance the growth of both phytoplankton and epiphytic algae on SAV leaves. This increased algal biomass would reduce the amount of light reaching photosynthetic sites in SAV leaves and thus constitute a stress. In addition, we observed luxuriant colonization on SAV shoots by epifaunal feeding organisms (e.g. bryozoans and hydroids) in the estuary. This may be the result of increased phytoplankton food for these suspension feeders. These increases in epifloral and epifaunal biomass plus sediments which settle out of the water column cause reductions in light reaching SAV chloroplasts. To test these hypotheses, a number of field and experiment studies were conducted.

In one field study, SAV biomass and associated epiphytic materials were monitored over a growing season (Staver et al. 1981). Epiphytic materials (total epiphytic solids and epiphytic chlorophyll *a*)increased rapidly during the growing season, and growth corresponded with the decline in SAV biomass. In another study, eight 500 M^3 experimental ponds which contained healthy populations of several species of SAV were treated with nitrogen and phosphorus additions every two weeks for a 12 week period. Nutrient concentrations immediately after dosing were 120, 60 and 30 μmol ℓ^{-1} of NH_4^+ + NO_3^- and 12, 6 and 3 μmol ℓ^{-1} of phosphorous. Two untreated ponds served as controls. After treatment, total suspended materials, chlorophyll *a*, light attenuation and epiflora increased, generally in proportion to dosing levels. In the high dose ponds 63% of ambient light was attenuated in the top 0.25 m by material (largely phytoplankton) suspended in the water column, while 84% of the remaining light was attenuated by epiphytic growth on SAV leaves. Generally, the remaining light at that depth amounted to 50-100 $_{\mu}$Ein $m^{-2}s^{-1}$, a value close to the compensation light level for these species. After two months of treatment there was a significant decrease in SAV biomass in the high dose ponds, while growth and biomass remained high in the control and low dose ponds. Additional loading experiments are being conducted to explore further the relationships of SAV growth to nutrient enrichment and light.

Consistent with our earlier hypothesis, research has indicated that water quality variables, acting through multiple mechanisms, appear to be largely responsible for the decline of SAV. We are currently developing several mathematical simulation models which focus on the response to SAV to water quality conditions. When completed, these models may assist in more accurately defining the relative importance of individual water quality factors, identifying locations and conditions in the Bay conducive to SAV growth, and in developing management strategies in estuarine resource uses.

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Research & Monitoring Updates

Sources of Cu, Pb, Zn, and Hg to Raritan Bay, New Jersey

Metals introduced into the marine environment by natural and culturally-related sources are a subject of increasing concern. Pearce (1980) summarized the current status of the health of estuarine and coastal waters of the United States and outlined major problem areas. He indicated that high metal values have been reported for Raritan Bay, New Jersey, as well as for the adjacent New York Bight Apex (Figure 1). Grieg and McGrath (1977) reported that the area from Sandy Hook Bay to the Raritan River

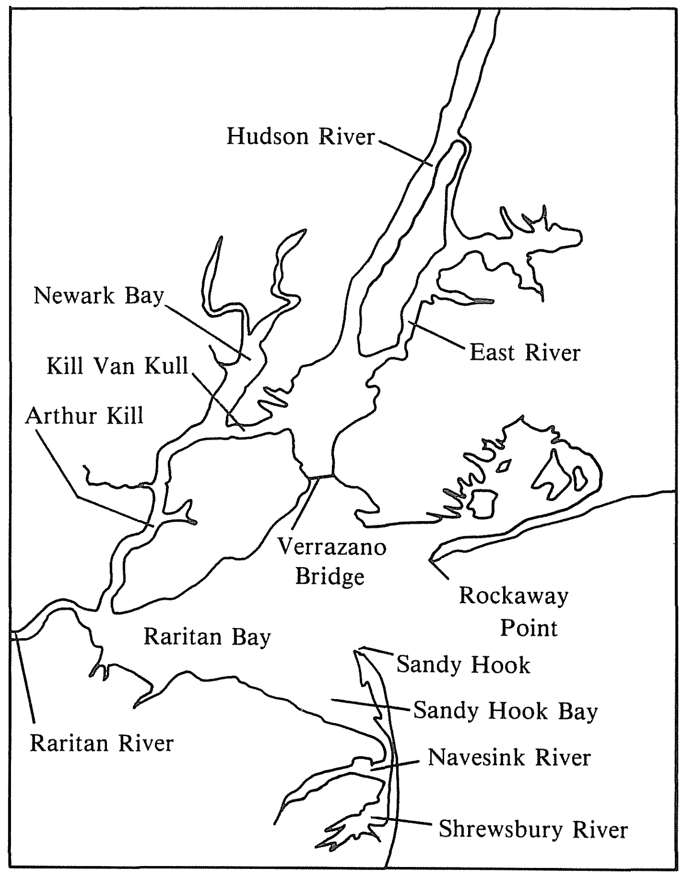

Figure 1. Location map of places considered in this study.

outlet is a sink for six metals. Their observations were confirmed by Multer and Nadeau (pers. comm.) in 1979. Waldhauer, Matte and Tucker (1978) indicated that copper and lead concentrations in waters in this area are among the highest reported for estuarine waters.

Concentrations of copper, lead, zinc, and mercury have been determined in the major tributaries contributing to Raritan Bay (Figure 2). Raritan Bay receives metals from the Raritan River at its western extremity, from Arthur Kill which enters from the western side of Staten Island, and from the Navesink and Shrewsbury Rivers which combine and empty into Sandy Hook Bay. Metals are contributed also from the Hudson River system.

Concentrations of all four of these metals in bottom sediments from the lower reaches of the Raritan River and associated major tributaries were observed to increase toward the mouth of the river. Sediments collected from Arthur Kill exhibit the highest values for metals with concentrations increasing in the upper reaches of the Kill.

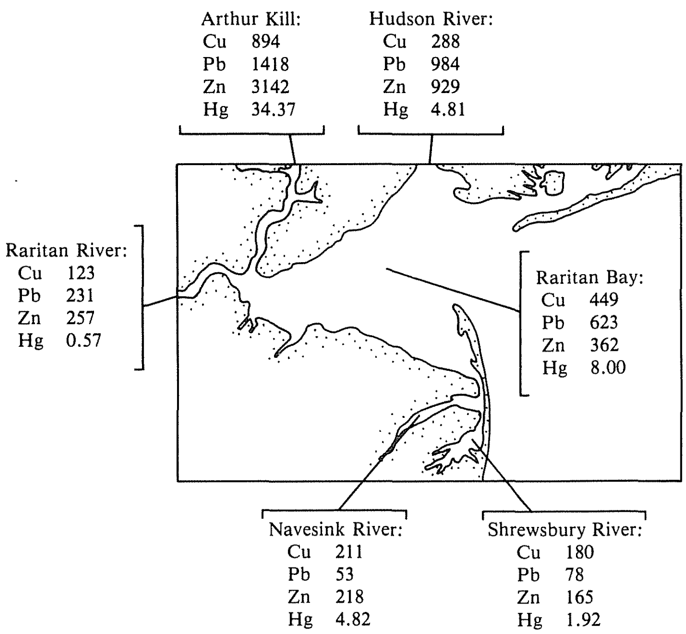

Figure 2. Mean trace metal values (in ppm) in bottom sediments from Raritan Bay and adjacent areas.

Copper, zinc, and mercury concentrations in sediments of the Navesink River were observed at relatively high levels in the upper reaches, and dropped dramatically in the lower reaches. Lead concentrations in the Navesink, however, gradually decrease in sediment downstream, and then increase markedly at the last site. Lead values were erratic and demonstrated large variations within the Shrewsbury River. The highest concentrations, however, are observed at the lower stations, and dropped markedly in the last station sampled downstream.

The highest concentrations of metals in sediments from the Hudson River (including New York Harbor), and the East River were observed in New York Harbor. The lowest values were in the vicinity of the Verrazano Narrows Bridge, where the Hudson River enters Raritan Bay, and from sites farther up the Hudson River.

Samples examined in Raritan Bay lie roughly along a traverse from the Sandy Hook-Rockaway Point transect to the mouth of the Raritan River, near the point of entry of Arthur Kill at the western end of the Bay. The metal concentrations in sediments were greatest in the sites to the west, in the vicinity of the outfalls of the Raritan River and Arthur Kill. Lower values were found in samples farther to the east. This trend generally coincides with the pattern of metal concentration reported by Grieg and McGrath (1977). Waldhauer et al. (1978) reported that high copper concentrations were found in waters of Raritan and Lower New York bays. We found this to be the case for the sediments as well.

Using average sediment concentration values for each of the four metals considered in this study, it is possible to examine the apparent relative strengths of the fluvial inputs of each metal into Raritan Bay as a first approximation (Figure 2). It appears that the primary source for copper is Arthur Kill, with the secondary contribution from the Hudson River complex. Similarly, lead and zinc appear to be contributed mainly from Arthur Kill, and secondarily from the Hudson River. Mercury appears to be contributed primarily from Arthur Kill, with lesser amounts from the Hudson River and possibly from the Navesink-Shrewsbury River. We are now studying relationships to discharges and to suspended load, and the relative mobilities of selected trace metals in the Bay environment. We hope to complete our investigation within the next year.

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Potential Changes in Marine Disposal of Municipal Wastes in the Southern California Bight

The Orange County (CA) Sanitation Districts are proposing to discharge sewage sludge to the ocean if regulatory and legal restraints can be removed. Their proposal represents a new approach to sludge disposal, for which only limited scientific information exists. Because of this, the Office of Marine Pollution Assessment (OMPA) has awarded a contract to design a research and monitoring program for use with the proposed sewage sludge outfall. The plan is being developed in collaboration with the Southern California Coastal Water Research Project (SCCWRP) and will be designed to complement their efforts.

The OMPA contract, with Dr. Norman Brooks of Caltech, will provide planning for a comprehensive research and demonstration project on deep-ocean disposal of sewage sludge via a special outfall terminating 12,200 m offshore at a depth of 305 m. The outfall will add about 150 tons of solids per day to the Southern California Bight, resulting in total solids discharge, including existing outfalls, approximately equivalent to the discharge to the New York Bight.

The first step in the planning effort was a meeting of about 25 scientists and agency people to discuss and develop research ideas. The meeting was held at Caltech on 4 and 5 March, 1982. Background information was presented on sludge quality and quantity, sludge plume behavior, physical and biological characterization of the region, and the current regulatory picture. Approximately 25% of the total solids now produced by Orange County is discharged to the ocean as part of the effluent, in compliance with existing regulations. It was stated that if the proposed sewage sludge discharge were diluted with effluent, it too could meet existing regulations after initial dilution.

The proposed outfall area is very deficient in DO ($\sim 1\ ml^{-1}$) and oxygen depletion is a potential environmental problem, perhaps the most serious one for the area. The benthic epifauna in the area is dominated by sea urchins. Infauna and pelagic biota are not well characterized. The physical oceanography of the area is not known well enough to calculate rates of water (and oxygen) replenishments. Projected dispersion and settling rates of the solids also are not well known.

Existing regulations do not permit the proposed outfall to become operational. However, California and EPA officials indicate that the regulations are subject to change, and that this planning study may influence such changes. The California Ocean Plan, which in the past has greatly influenced EPA regulations, is now being revised; and at least one California official is questioning the basis for the existing prohibition of sludge discharge.

In a related action, the EPA is considering application for 301(h) waivers from five municipal waste districts in Southern California. If the waivers are granted, which is likely, secondary treatment of the effluent now being discharged will not be required. The combination of sludge discharge and secondary treatment waivers may cause a significant change in the municipal waste burden to the Southern California Bight, and provide new justification and urgency to the concept of a regional research and monitoring program.

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Asilomar Workshop on Sublethal Effects of Stress on Marine Organisms

An informal workshop on the biological effects of sublethal stress on marine organisms was convened at the Asilomar Conference Grounds, Pacific Grove, California on 30 and 31 March, 1982. The objectives of the workshop were to (1) summarize the state of the art in sublethal biological effects studies, (2) determine the relationships or interactions between organismal- and cellular-level studies, (3) discuss the strengths and weaknesses of current studies, and (4) define new or needed research directions.

Aproximately 45 principal investigators from a variety of federal- and state-sponsored research teams summarized the current status of their research. On the first day, 11 presentations on sublethal stress at the organismal level and 10 at the cellular-molecular level were made. In addition, a keynote address on the approach to sublethal pollutant stress investigations in the United Kingdom was delivered by Dr. John Widdows of the Institute of Marine Environmental Research, Plymouth. On the second day, four subcommittees discussed approaches to stress evaluation.

The subcommittee addressing "Effects of Sublethal Stress at the Organismal Level" considered (1) components of a general pollutant-stress model, (2) integration of biological and chemical investigations, (3) relationships between sublethal responses of individuals and changes at the population and community levels, and (4) importance of pollutant interactions (antagonism and synergism). The subcommittee urged that comprehensive and more sensitive standards for the protection of fish and wildlife species be considered utilizing sublethal effects data. Recommendations for future research included scope for growth, comeasurement of cellular and subcellular responses (detoxification and intoxification mechanisms), life history analyses, and organismal responses to pollutants (bioaccumulation).

The subcommittee on "Measuring Responses to Sublethal Stress at the Organismal Level" considered four approaches: (1) analyses of energetics (scope for growth); (2) quantification of behavioral responses, (3) measurement of reproductive processes, and (4) relationships of organism responses to population dynamics. Strengths and weaknesses of each approach, and factors such as sensitivity, variability, relevance to regulations, and pollutant specificity were discussed. Some identified areas of future research are field validation of laboratory experiments; dose-response studies with multiple pollutants; correlation of fecundity with increased physiological stress; influence of reproductive cycle on stress response; behavioral response related to pollutant burdens; population response to increased stress; and hormesis.

The subcommittee on "Effects of Sublethal Stress at the Cellular and Molecular Level" considered (1) detoxification processes, (2) cytotoxic and genotoxic responses, and (3) a model to integrate cellular detoxification and organismal responses. The mechanisms of detoxification, such as metallothionein for certain trace metals or sequestration of trace metals and hydrocarbons by lysosomes, were judged important candidates for continued research. The subcommittee concluded that integration of whole-organism stress and cellular detoxification mechanisms should be emphasized, and that research is needed to define the relationships between histopathological conditions and chemical contaminant levels; the partitioning of contaminants between sites of toxic action and detoxification; and the effects of pollutants on deposition and utilization of energy reserves.

The subcommittee on "Measuring Responses to Sublethal Stress at the Cellular and Molecular Level" made general suggestions on how studies at the cellular-molecular levels of organization should be conducted and suggested techniques for detecting altered metabolism and pollutant stress. Strengths and weaknesses of the following measurements were evaluated: metallothioneins; adenylate energy charge; lysosomal latency; immune system responses; mixed function oxidase; disease resistance; gene pool composition; sister chromatid exchange; chromosomal aberrations; and histopathology changes.

Preliminary planning for a 1983 workshop has been initiated. The Centro de Investigación Cíentifica y de Educación Superior de Ensenada (CICESE) in Ensenada, Baja California, Mexico, has offered to host a workshop during February 1983.

Support for the 1982 project from the United States Department of Energy, Physiological Ecology Program, and the California State Water Resources Control Board is gratefully acknowledged. A summary of individual subcommittee reports, abstracts of informal presentations, and a roster of participants will be available in October 1982 at a nominal cost, and information about the 1983 workshop will be available from the workshop co-chairpersons:

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Oil Spill Response Actions In Long Island's South Shore Tidal Inlets

The Long Island Regional Planning Board, with funds provided by the N.Y.S. Coastal Energy Impact Program, recently completed a three-phase program to develop options for the protection of all Long Island south shore embayments from oil spills originating from either Atlantic Outer Shelf oil production activities or tanker transport of petroleum products in the New York Bight. There are five shallow tidal inlets along the Island's south shore that link the bay environments with the Atlantic Ocean: Shinnecock, Moriches, Fire Island, Jones and East Rockaway Inlets. Shinnecock Bay, Moriches Bay, Great South Bay, and Hempstead Bay comprise a system of shallow bay environments with a combined surface area totaling 450km^2. The oil spill response reports prepared for each inlet provide detailed, site-specific information for use by the U.S. Government On-Scene Coordinator and local interests in responding to significant oil spill events.

The program addressed the need for the development of adequate oil spill cleanup ability. Oil spills will continue to occur in the future in or near New York's Coastal zone. Coastal areas are fortunate if oil spill trajectories are offshore. However, onshore trajectories from spills originating offshore, and nearshore spills, regardless of their trajectories, pose potential crises requiring rapid response if meaningful attempts are to be made to safeguard valuable marine resources. Experience has shown that should a major oil spill occur off the south coast of Long Island, it would be impossible to contain most of the oil: the spill would threaten the south shore beaches and bays. While little can be done to prevent the fouling of ocean beaches, response actions could be implemented in the bays near the inlets to contain/collect oil, and thereby minimize the fouling of productive habitats and cultural features within the bays. These strategies are described in the report.

The study consisted of the following steps:

- identification of "worst case" oil spill scenarios for each inlet region;
- specification of tidal current regimes through the use of current data and computer models;
- establishment of oil spill priorities;
- prediction of oil spill movement;
- development of alternative response actions, including equipment deployment, manpower requirements and costs; and
- assessment of the efficacy of spill response alternatives.

The oil spill response action plans improve cleanup capability by identifying locations where available oil spill containment/cleanup equipment can be deployed most effectively during the initial response effort.

Speed of currents, water depth and spill transit time to shore were the major factors constraining spill response actions. In general, the use of conventional booming and skimming devices in the throats of the tidal inlets would not prevent the contamination of the bays. However, skimmers, diversion booms and containment booms can be used in the bay environments to limit the spread of oil. In some cases, an effective response to a near-shore spill will require the storage of spill control equipment locally. Recommendations are included for the purchase of equipment, and user training by local agencies to supplement the response of oil spill contractors and cooperatives in the region, and to provide some containment as quickly as possible.

The application of dispersants to a slick in offshore waters could drastically reduce the quantity of oil reaching the ocean beaches, tidal inlets and adjoining bays. A rapid decision would have to be made if dispersants are to be used because 24 to 36 hours are necessary to implement a dispersant spraying system. Therefore, in the event of a major offshore spill, steps should be taken to immediately assemble dispersant application equipment and personnel. The process to determine whether, or not, this alternative will be used also should be initiated promptly. Many factors, including possible adverse environmental impacts, should be considered in making this decision.

Inquiries on the reports or requests for circulation copies should be sent to the second of the following:

Lee E. Koppelman, Executive Director
DeWitt S. Davies,
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Long Island Regional Planning Board
H. Lee Dennison Office Building
Hauppauge, NY 11788
(516) 360-5189

Announcements

Global Ocean Data Inventory for the FGGE Operational Year

The National Oceanographic Data Center (NODC) announces the availability of the *Global Ocean Data Inventory: FGGE (Global Weather Experiment) Operational Year, September 1978 through March 1980.* This microfiche publication contains inventory information about 6,242 oceanographic data sets collected or planned to be collected during the FGGE Operational Year. Each data set is described by a one-page entry based on inventory reports received from 1,260 principal investigators in 33 participating countries. An introduction and cross-reference tables facilitate searches for inventoried data sets by: data parameter; principal investigator; country; and major ocean area. Also included is a special index to data in the tropics ("Level IIc data"). The repository holding the data (if actually collected as planned) is listed in the inventory entries.

The *Global Ocean Data Inventory (GODI)* is part of the FGGE Data Management Plan of the World Meteorological Organization (WMO). It was compiled by the Environmental Data and Information Service (EDIS), National Oceanic and Atmospheric Administration, U.S. Department of Commerce, in collaboration with and with the guidance of the Intergovernmental Oceanographic Commission (IOC). The EDIS performed this work as part of its commitment to the IOC and in its capacity as an IOC Responsible National Oceanographic Data Center (RNODC) for the FGGE Operational Year (FOY).

GODI comprises 6,440 pages on 84 sheets of microfiche. It is available for a twenty-five dollar ($25) reproduction and handling charge from: National Oceanographic Data Center, NOAA/NODC OA/D721, Washington, DC 20235. Remittance should be made payable to "Department of Commerce/NOAA/NODC."

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NOAA/EDIS
National Oceanographic Data Center
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NODC Code Files for Marine Pollutants and Toxic Substances

In 1981, the National Oceanographic Data Center (NODC) began enhancing its ability to archive and disseminate pollution data collected in the marine environment. A data format, called File Type 144, was developed for storage and retrieval of concentration value of toxic substances and pollutants in marine organisms, sediment, and the water column (Audet, 1980). In support of this format, a list of chemical substances, identified by a non-hierarchical alphanumeric code, is maintained at the NODC. The code, which contains between 5 and 9 alphanumeric characters, is a modification of registry numbers in the Chemical Abstracts Service's file of chemical substances. The first character is assigned by NODC, and is used to indicate the general class of the compound; e.g., radioactive, inorganic.

Isomeric forms of a compound are listed, in addition to the non-isomeric or generic name for a substance. These generic names are used to identify measurements of the sum or total concentration of a substance (e.g., sum of all tetramethyl benzenes) or the total concentration of breakdown of altered products of a substance (e.g., sum of DDD, DDE, and DDT is expressed as DDT).

This list currently contains the names and codes of about 420 chemical substances, including those identified by the Environmental Protection Agency as priority pollutants, plus other substances reported to the NODC from various outer continental shelf environmental assessment studies.

A second list of all synonymous names under which a chemical can be identified is maintained by NODC. This list, also derived from the Chemical Abstracts Service file, contains the more commonly used chemical names of a compound.

Both code lists are updated periodically as required for new data submissions to NODC. Hardcopy printouts of these code files and of the format description of File Type 144 are available from NODC for a three dollar mailing and handling charge or on an exchange basis for researchers who submit pollution data to the NODC. Requests should be directed to: National Oceanographic Data Center, NOAA/EDIS OA/D721, Washington, DC 20235; telephone 202-632-7500.

Mary Christman
NOAA/EDIS
National Oceanographic Data Center
Washington, DC 20235
202-634-7441

Reference

Audet, J.J. 1980. NODC Marine Pollution Data Format. COPAS 1 (1):10.

Office of Marine Pollution Assessment: Annual Report FY 1981

The Office of Marine Pollution Assessment (OMPA) has released its annual report for FY 1981. The report is organized to follow the categories of concern developed in the Federal Plan for Ocean Pollution Research, Development, and Monitoring for FY 1981-85. These categories are marine waste disposal, marine mining, marine energy, marine transportation, accidental discharge of oil and hazardous materials, coastal land-use, and ocean pollution assessment and management of cumulative effectives.

A six-page executive summary gives a brief overview of the program. The report presents the details of OMPA's work during FY 1981, and plans for the work expected to be done in FY 1982.

Copies of the report are available from Office of Marine Pollution Assessment, RD/MP, Rockwall Bldg., Room 320, 11400 Rockville Pike, Rockville, MD 20852.

F. Cava

Calendar

November

12-14

Marine Education Workshop dealing with the Looe Key Coral Reef in the Florida Keys. The workshop will be conducted by the National Oceanic and Atmospheric Administration, the Florida Department of Natural Resources, and the Newfound Harbor Marine Institute. Registration is $75, and must be paid by 1 November. Contact Erick Lindblad at (305) 872-2331.

November-December

29-1

The Third National Conference and Exhibition on Management of Uncontrolled Hazardous Waste Sites, will be held from 29 November to 1 December 1982 at the Sheraton Washington Hotel, in Washington, D.C. Attendance will be limited, and there are a number of fees. For information, call Margeurite Leishman at (301) 587-9390.

December

7-15

AGU Fall Meeting & ASLO Winter Meeting, San Francisco, CA. Contact: AGU Meetings, 2000 Florida Ave., N.W., Washington, DC 20009 (800-424-2488).

February- March

28-3

1983 Oil Spill Conference (Prevention, Behavior, Control, Cleanup), San Antonio Convention Center, San Antonio, TX. Contact: 1983 Oil Spill Conference, Suite 700, 1629 K Street NW., Washington, DC 20006 (202-296-7262).

April

12-14

The American Society of Testing and Materials will hold the Seventh Annual ASTM Aquatic Toxicology Symposium on 17-20 April, 1983. Topics will include various areas of marine pollution. For information, contact: Rich Cardwell at (206) 451-4600.

April

11-15

Fourth International Ocean Disposal Symposium, Plymouth Polytechnic, Plymouth, Devon, England. Contact: Iver W. Duedall, Marine Sciences Research Center, SUNY, Stony Brook, NY 11794 (516-246-7715).

Viewpoints

Is Statistical Significance Useful In Dredged Material Testing?

Before dredged materials can be dumped into the ocean, they must be tested for their potential to cause environmental harm in accordance with the regulations of the Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (COE) (EPA and COE, 1977). Companies undergo great expense for testing dredged materials; a full set of tests for three species costs about $20,000 per station. The regulatory intent is that these tests (1) will have some predictive value for what would happen in the ocean (2) be sensitive enough to predict the potential for adverse environmental impact. But because these tests use only a few individuals with high variability among individuals, the tests have very little power. This increases the probability of Type II errors (acceptance of the false null hypothesis that contaminants in dredge materials are not biologically available).

Two types of testing are done, (1) short-term, single species bioassays and (2) ten-day bioconcentration tests. It is generally agreed that single species bioassays are insufficient for predicting environmental effects (NRC, 1981). Ten-day solid phase bioconcentration assays also have little predictive value because the flow-through design drastically underestimates bioaccumulation rates as compared to processes in the field (Connor, in prep.).

While they acknowledge the problems of field validation, environmental regulators argue that these tests are sufficient to predict the relative toxicity of one waste to another. However, since there are no demonstrated standards of acceptable dumping yet documented by long-term monitoring, 'relative toxicity' has little meaning. Furthermore, current testing methods are not even good relative indicators of toxicity because no consideration is given to the statistical limits of the tests due to the high variation among test individuals within groups.

To demonstrate how statistical problems confound the results of bioaccumulation tests, I present some data on the bioaccumulation potential from an impact statement for a deepwater port off Gavelston Bay (COE, 1979). The tests are typical of other bioaccumulation studies I have examined. Sediments from five stations were tested against control sediments, allowing ten days for uptake and two or three days for depuration.

In this example of bioaccumulation tests done with Gavelston Bay sediments, it was concluded that there was no potential for bioaccumulation of any of the chemicals by the worm, *Diapatra cuprea,* and a potential for bioaccumulation by the clam *Mercenaria mercenaria* for only two of the chemicals (heptachlor and cadmium) (COE, 1979; Q-77).

I have calculated the ratios of the means of the test to the control organisms and the coefficients of variation for both groups (Table 1). A total of ninety comparisons were made. Thirty-four comparisons showed average concentrations in the test organisms equal to five times the concentration in control organisms. Five of these differences were statistically significant. Nine of the tests showed concentration increases greater than five times that of the control, but only one of these (heptachlor at Stn. 1B), was statistically significant.

These results demonstrate a serious problem with these tests in measuring bioaccumulation capacity. The absence of statistically significant increases in bioaccumulation is more a reflection of the extent of variation among individuals than of any intrinsic property of bioavailability of contaminants contained in the dredged materials. Since only five individuals of each species are tested, variation can be quite high. Cadmium measurements in *Mercenaria* have a low coefficient of variation so it is possible to detect differences between means of fifty percent. In other compounds (e.g. petroleum hydrocarbons) the variation among individuals is so high that differences between means of a factor of thirty-five are not detected. Relative to many of the organic compounds, the potential for bioaccumulation of cadmium is insignificant, yet the test procedure indicates just the opposite.

Using an estimate of the coefficients of variation, we can calculate the number of individuals needed to detect various differences between means (Snedecor and Cochran, 1967). For instance, assuming a coefficient of variation of 100% and a desire to detect differences in means of 100% at the 95% confidence level with 90% certainty, 21 individuals allows us to detect differences among means of about 200%. In the Gavelston Bay example, many of these tests are even less sensitive because the data have been transformed to make the variances homogenous.

The regulations are aimed at answering the question - Is there any potential for bioaccumulation from contaminated dredged materials? When no significant differences are shown, it is assumed there is no potential for bioaccumulation. Those differences which are significant statistically are further evaluated for ecological significance. In this case statistical significance is misleading. The power of statistical tests with five highly variable individuals is so poor that the tests are not sufficient to determine bioaccumulation potential.

TABLE 1

Ratio of 10-day bioaccumulation for sample stations/controls

Parameter	Organisms	Ratio Station: Control					Coefficient Of Var. %	
		1A	1B	2	P1	P2	Control	Max.
Aldrin	D. cuprea	NT	NT	⩽1	NT	NT	142	142
Aldrin	M. mercenaria	NT	NT	1.1	NT	NT	146	146
DDE	D. cuprea	1.5	⩽1	1.5	2.0	3.4	84	124
DDE	M. mercenaria	⩽1	1.2	2.9	2.6	1.5	37	115
DDT	D. cuprea	⩽1	⩽1	⩽1	⩽1	⩽1	BDL	BDL
DDT	M. mercenaria	1.5	⩽1	⩽1	⩽1	4.5	36	168
Dieldrin	D. cuprea	NT	NT	2.5	NT	NT	BDL	57
Dieldrin	M. mercenaria	NT	NT	2.6	NT	NT	BDL	94
Endosulfan	D. cuprea	⩽1	NT	⩽1	NT	NT	BDL	BDL
Endosulfan	M. mercenaria	⩽1	NT	⩽1	NT	NT	BDL	BDL
Heptachlor	D. cuprea	⩽1	2.1	⩽1	⩽1	1.0	189	189
Heptachlor	M. mercenaria	2.6*	6.6*	⩽1	2.5*	2.7*	BDL	60
Lindane	D. cuprea	⩽1	⩽1	2.0	⩽1	⩽1	108	108
Lindane	M. mercenaria	⩽1	2.5	3.2	1.0	⩽1	164	164
PCB	C. cuprea	1.4	⩽1	⩽1	3.7	5.8	BDL	124
PCB	M. mercenaria	1.3	⩽1	⩽1	1.6	5.6	BDL	96
Mercury	D. cuprea	⩽1	⩽1	⩽1	⩽1	⩽1	176	176
Mercury	M. mercenaria	⩽1	⩽1	⩽1	⩽1	⩽1	136	186
Cadmium	D. cuprea	⩽1	⩽1	⩽1	⩽1	⩽1	140	140
Cadmium	M. mercenaria	1.0	1.5*	1.5*	1.1	1.1	18	28
Arsenic	D. cuprea	NT	NT	NT	2.7	NT	128	128
Arsenic	M mercenaria	NT	NT	NT	⩽1	NT	120	120
Petroleum Hydrocarbons	D. cuprea	17	⩽1	2.5	23	36	117	184
Petroleum Hydrocarbons	M. mercenaria	21	1.1	⩽1	19	6.7	85	186

Raw data from Appendix Q (COE, 1979)
NT-Not tested
BDL-All samples below analytical detection limits
*-Station showed statistically significant ($P < .05$) bioconcentration

What are possible solutions to overcome this problem? The question of statistical significance obfuscates the question of ecological significance. Experiments can only be designed properly if we know what magnitude of body burdens of contaminants is of concern. In considering ecological significance, we want to eliminate all those cases which are trivial, e.g. when the mean concentrations in test organisms are less than the control organisms' means. Similarly we may also consider unimportant those instances where control and test organisms differ by only 10%, 50%, and even 100%. Having decided on what changes indicate ecological concern, that subset of cases can be determined statistically. The coefficient of variation of the experimental organisms could be determined beforehand, and experiments designed using a sufficient number of organisms to detect a difference of the desired magnitude.

Given the expense of the tests and the possible necessity of using dozens of test animals, I would suggest ignoring the concept of statistical significance altogether and interpreting all the results above a predetermined ecological cut-off for their ecological significance. Statistical standards of academic sciences are not necessarily appropriate to regulatory science. For instance, ethical considerations often cut short medical trials before a 95% confidence level is reached if there are early indications that the treatment is beneficial (Tukey, 1977). In dredged material testing, an arbitrary increase (e.g. 100%) of bioaccumulation from test versus control sediments could be used as a cut-off for examining ecological significance whether statistically significant or not. Contaminants elevated beyond that level would be evaluated for potential ecological and human food contamination effects for species with those body burdens of pollutants. To continue to proclaim the validity of the present system is economically wasteful — why do the testing if statistical vagaries undermine the conclusions — and diverts attention from the real question of ecological significance, a question which must be addressed even if imperfectly.

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Banning Ocean Dumping: So Near But Yet Sofaer

The National Advisory Committee on Oceans and Atmosphere (NACOA) in its 1981 report, "The Role of the Ocean in a Waste Management Strategy," published certain findings and recommendations that have affected national ocean disposal policy. NACOA found that major national environmental legislation--the Clean Water Act, the Ocean Dumping Act, the Safe Drinking Water Act, the Resource Conservation and Recovery Act, and the Clean Air Act--had been constructed independently to protect a specific environment. The Committee recommended that all media--land, freshwater, air, and ocean--be examined as options for waste disposal in a carefully coordinated manner. Ocean disposal of wastes, should be an option, NACOA believes, so long as programs of waste management, research, and monitoring are in place to guard the marine environment. In preparing for recent testimony during House hearings on the reauthorization of the Ocean Dumping Act, NACOA reviewed its 1981 findings and recommendations. NACOA's review disclosed that national policy seems to be shifting to permit increased ocean dumping, while Federal programs of research and monitoring are being reduced. Judge Abraham Sofaer of the Southern District Court of New York ruled in October 1981 that New York City can continue ocean dumping of sewage sludge until the Environmental Protection Agency (EPA) modifies its regulations. Previously, the EPA had banned ocean dumping of sewage sludge beyond December 1981 on the conclusive presumption that all sewage sludge unreasonably degrades the marine environment. EPA's permit decisions were based on environmental criteria alone, and Judge Sofaer's ruling had the effect of completing the permit process to include all relevant criteria listed in the Ocean Dumping Act, including comparison with land-based disposal. This balancing test provided by the Ocean Dumping Act is unique among environmental legislation. Because legislation protecting other environments does not allow a balancing of risks, and the Ocean Dumping Act does, some fear a bias favoring ocean dumping will result. NACOA believes that the balancing required in the Ocean Dumping Act is appropriate, and that all waste disposal options should be considered without prejudgement. Changing other environmental enactments to require cross-media balancing--or risk analysis--would be complicated; a cross-media approach might best be achieved instead through comprehensive policies developed within the regulatory agencies.

EPA is now trying to do just this. Having accepted the Sofaer decision, EPA has begun a comprehensive sludge management project that transcends agency lines and programs and includes all disposal environments. Additionally, the Office of Marine Pollution Assessment (OMPA) of the National Oceanic and Atmospheric Administration (NOAA) is sponsoring symposia to define scientifically the concept of degradation of the marine environment. Although these efforts are sorely needed and appear promising; their outcome is unclear at this point. EPA, frankly, has had its organizational problems, and the development of comprehensive sludge management regulations is an enormous task. OMPA's symposia may develop a better scientific sense of degradation of the marine environment, but the economic and political questions that bear on ocean dumping must be resolved through other means.

NOAA, the lead agency for ocean disposal research and monitoring, has published its FY 1982-1986 Program Plan and its FY 1983 budget proposals. In reviewing NOAA's plans, NACOA found program goals were designed to address EPA's regulatory objectives, but the results would not be timely enough. For example, FY 1983 program objectives for sewage sludge site selection and New York Bight monitoring were not given completion dates. Also, projects such as those assessing sewage disposal effects and human risks from pathogenic organisms in seafood have had to be deferred to budget outyears. NOAA's proposed budget for FY 1983 has a more than 50-percent reduction in ocean disposal research and monitoring, which would erode the timeliness of NOAA's results.

NACOA believes that there will continue to be increasing pressure to reduce land, deep-well and atmospheric disposal in favor of ocean dumping. Nearly 20 coastal municipalities are planning to apply to EPA for ocean dumping permits, and EPA is modifying its ocean disposal policies and regulations in a way that will probably allow increased ocean dumping. Given this trend, a solid program of ocean disposal research and monitoring is crucial.

NACOA expressed concern to Congressional Members and Administration officials about the inconsistency in reducing Federal programs assessing the effects of ocean dumping, while modifying national policy to allow increased dumping. The Committee believes the Federal Government should ensure that adequate programs for site specific research and monitoring are provided for.

Congress and EPA have suggested that dumpers support ocean disposal research and monitoring through some form of user fees. A group of municipalities, represented by the Conference of Coastal Agencies, has endorsed the notion of municipal funding, although not necessarily through user fees. NACOA supports the concept of a fee system to fund critical research and monitoring programs. If ocean disposal is to be a waste management option, the Nation must have a solid basic research program and a carefully designed monitoring system already in place to predict waste disposal and to provide an alert to unexpected negative results.

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COASTAL OCEAN POLLUTION ASSESSMENT NEWS

MAN AND THE MARINE ENVIRONMENT

Volume 2 Number 3 Winter 1983

The purpose of **Coastal Ocean Pollution Assessment** (COPAS) **News** is to provide timely dissemination of information on pollution in coastal waters of the United States — its sources and effects, what is being done to eliminate or mitigate it, and what research and monitoring activities are being conducted to develop more effective strategies to manage it. We publish brief articles describing recent events and activities, new approaches to resolving chronic pollution problems, and early warnings of potential problems. Announcements of cruises, meetings, and investigations will be included.

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In This Issue

Continuity

Implications of Oxygen Depletion on the Continental Shelf of the Northern Gulf of Mexico

The occurrence of hypoxic bottom waters, with dissolved oxygen concentrations substantially below saturation levels (for convenience, $>2 \cdot mg\ l^{-1}$), on the continental shelf of the northwestern Gulf of Mexico has recently become of considerable local interest. Hypoxia has been implicated in mortalities and habitat dislocation of benthic organisms, including commercial species (Fotheringham and Weissberg, 1979; Harper et al., 1981), sometimes with considerable consequences to the effectiveness of biological monitoring of pollutant discharges (Bedinger et al., 1981).

The occurrence of hypoxia on the northwestern Gulf shelf is not widely known outside of the region because of the paucity of papers on the subject in the open literature. In a volume of extensive reports on the 1976 Middle Atlantic Bight hypoxia incident, Sinderman and Swanson (1979) make no reference to the open shelf of this region in their review of incidents of hypoxia around the world. In fact, the only cited instances of hypoxia in open coastal waters other than the Middle Atlantic Bight were associated with coastal upwelling.

This brief review is intended to describe what is known about the spatial and temporal extent of the bottom oxygen depletion phenomenon in the Gulf, to consider whether the phenomenon has recently increased in extent or severity, to evaluate the potential causes and whether they are related to human activities, and to consider consequences of the phenomenon.

Hypoxic, and occasionally anoxic, bottom waters have been observed during warmer months (June-September) on the inner continental shelf (6-46 m depth) off Louisiana and the upper Texas coast (Ragan et al., 1978; Bedinger et al., 1981; Stuntz et al., 1982; Turner and Allen, in press a). The phenomenon is best known and most intense in the Mississippi River Delta Bight, west of the river's mouth, but may extend more or less continuously to Texas (Figure 1).

The earliest documented shelf hypoxia was observed by a team of researchers from Nicholls State University (Ragan et al., 1978) in 1973 following a period of extreme discharge from the Mississippi and Atchafalaya rivers. Although Bedinger et al. (1981) and Gallaway (1981) refer to observations of hypoxia in the northwestern Gulf in the mid-thirties, these measurements were clearly of the oxygen-minimum layer impinging on the upper

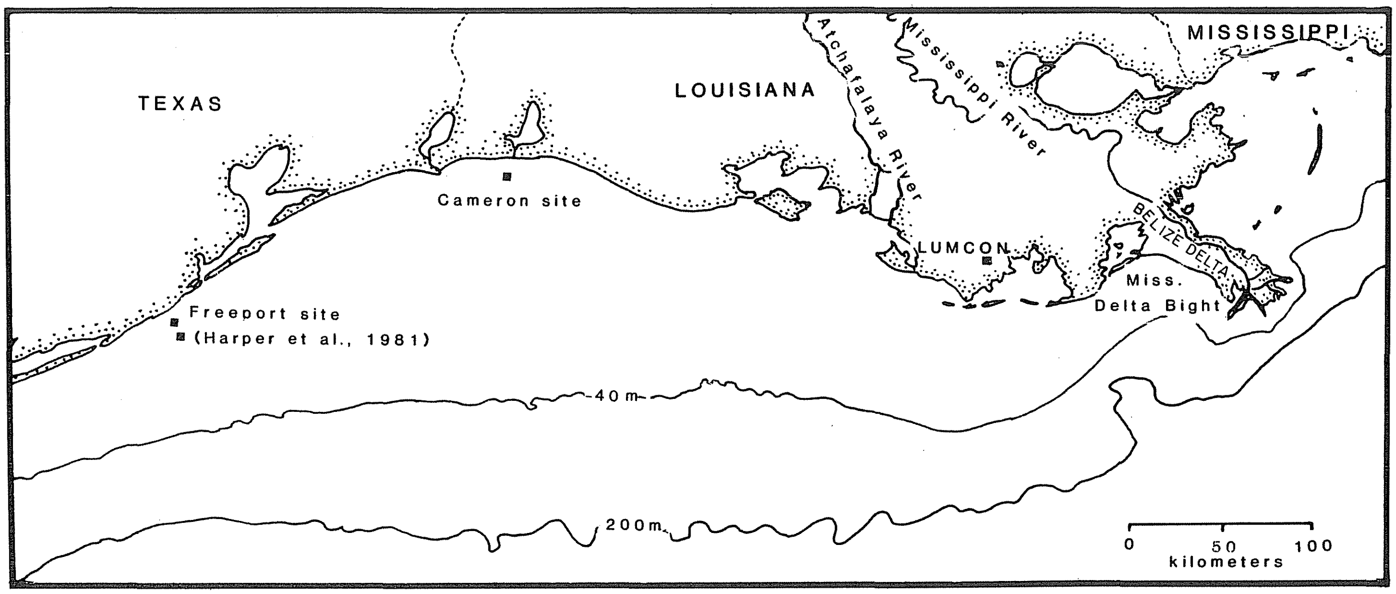

Figure 1. Louisiana and upper Texas continental shelf. Incidents of hypoxia have been reported on the inner continental shelf of the Mississippi River Delta Bight west to the Atchafalaya River and from monitoring studies off Freeport, Texas, in 1979 and off Cameron, LA., in 1981 and 1982.

continental slope and not of shelf waters (Richards, 1957). Unfortunately, knowledge of the history and current distribution of oxygen depletion of bottom waters is hindered by the fact that the oceanography of the Louisiana continental shelf is among the poorest-known oceanographically in the U.S., despite the fact that it is one of the most important economically (28% of U.S. fishery landings and over 90% of U.S. OCS oil and gas production).

The extent and intensity of hypoxia appears to be related to the volume of freshwater discharge of the region's major rivers. Hypoxia was intense and persistent in 1973, when an extensive area of seabed off Grand Isle, Louisiana, was anoxic (Ragan et al., 1978), following a 100-year frequency flood of the Mississippi River. Severe hypoxia and mortalities of benthic organisms were also observed in 1978, another major flood year (Bedinger et al., 1981). Hypoxic conditions, and attendant mortalities of benthos, occurred off Freeport, Texas, in 1979, but not in other years, following a freshening of surface waters (Harper et al., 1981).

Density stratification of the water mass, which reduces vertical eddy diffusion, and thus oxygenation of bottom waters, is an obvious requisite of oxygen depletion at shelf depths. In the Middle Atlantic Bight incident, the stratification was mostly attributable to temperature differences but in the northwestern Gulf it is due mainly to salinity differences. Calm weather conditions, which reduce vertical mixing, were also coincident with observations of intense hypoxia. A tropical storm was observed to cause mixing and oxygenation of bottom waters in August, 1978 relieving hypoxia (Bedinger et al., 1981).

In addition to reduced vertical diffusion, the other ingredient necessary for oxygen depletion is a source of oxidizable organic material. Although Gallaway (1981) suggested this source may be organic material discharged by the Mississippi River, several lines of evidence suggest that phytoplankton production, perhaps stimulated by river-borne inorganic nutrients, is the primary source of readily oxidizable organic matter. Organic matter in a large river, such as the Mississippi, has ample opportunity for decomposition by microorganisms during its long residence in the river, thus most organic matter discharged into the sea is relatively refractory. Rather, most labile organic material is mineralized, contributing to high inorganic nutrient concentrations which are utilized only slowly by phytoplankton in the highly turbid river. The river discharge consequently results in nutrient stimulation of primary productivity in surface waters in the Gulf as mixing and suspended sediments moderate light limitation. Surface waters become supersaturated with oxygen because of the high photosynthetic rate (Ragan et al., 1978; Turner and Allen, in press a) and water column respiration is correlated with chlorophyll levels (Turner and Allen, in press b). Beyond 10-20 km from the Mississippi River mouth organic seston is primarily of a marine rather than a terrestrial origin based on stable carbon isotope ratios (Sackett et al., 1965; Thayer et al., in press).

In a comment in the companion newsletter *Coastal Oceanography and Climatology News,* Ingham (1982) asked whether hypoxia and other recent reports of dinoflagellate blooms in the Gulf of Mexico represent "distress signals from inner space", announcing degradation resulting from human activities. The area affected by hypoxia is the most heavily developed offshore oil and gas basin in the world, with over 2,500 operational platforms on the Louisiana and Texas shelf. However, there is no evidence of isolated hypoxia or benthic mortalities around specific discharge points and the broad distribution of the phenomenon and its apparent relationship to freshwater discharges point toward land based sources of potential human influence.

Walsh et al. (1981) have presented evidence of a two-fold increase in the nitrate content of Mississippi River spring effluent over the past 25 years to 150 μg-atom $NO_3 \cdot l^{-1}$. They presented further evidence of High nitrate concentrations (70-350 μg-atom $NO_3 \cdot l^{-1}$) in the world's rivers which drain heavily populated areas, such as the Yangtze, Mississippi, Mekong and Rhine, compared to low levels (7-10 μg-atom $NO_3 \cdot l^{-1}$) in large rivers with less populated basins, such as the Amazon, Congo, Orinoco and

Niger. While this difference may in part be due to the tropical location of the latter rivers, it seems likely that the nitrogen content of rivers draining heavily populated areas has dramatically increased because of sewage inputs, agricultural fertilizers and nitrate release to ground water after deforestation (Walsh et al., 1981).

The increased nutrient input of the Mississippi River system could stimulate enhanced primary production over a wide area of the Louisiana shelf because of the net westward flow of shelf waters west of the main Mississippi distributary (the Belize delta; Figure 1) and also because 30% of the Mississippi's flow is carried by the Atchafalaya River, which discharges into a shallow bay and ultimately onto a broad, very shallow continental shelf. The enchanced primary productivity, in turn, results in increased secondary productivity (Walsh et al., 1981) and contributes to the large fisheries of the area. However, the large riverine nutrient inputs are accompanied with large discharges of fresh water which may cause water mass stratification and, consequently, hypoxia of bottom waters.

Coupled with the recent changes in nutrient concentration in the rivers are changes in the freshwater dispersal systems in the Mississippi delta. Leveeing the river for flood protection has prevented overbank flooding and broad dispersal of nutrients and sediments over the extensive wetlands in the Mississippi deltaic plain (Gunter, 1952). Furthermore, the rapid reduction in wetlands due to removal of this sediment source and other human activities (Boesch, 1982) may be reducing the potential for burial and denitrification.

Hypoxia of shelf waters may be resulting in considerable loss of fishery resources. The area leads the nation in landings of shrimp, the most valuable fishery in the U.S. Substantial fruitless effort is spent by shrimp trawlers in areas under severe hypoxia, which shrimp either avoid or in which they are killed. Furthermore, white shrimp *(Penaeus setiferus)* spawn on the inner continental shelf during early to mid-summer. The catch of white shrimp has declined markedly since the 1940's. The particularly poor white shrimp catch during 1982 may be a result of the earlier than usual development of hypoxia (late May - June) this year (Figure 2), coinciding with the peak of the white shrimp spawning and larval development. Decline in white shrimp production is frequently attributed to the loss of the estuarine nursery habitat of juveniles, but the implications of shelf hypoxia remind us that the population yields of such migratory species may depend on environmental conditions throughout the spectrum of their habitat range.

Clearly, the hypothesis that nutrient increases in river discharges and alteration of natural flow pattern have exacerbated hypoxia of shelf waters in the northwestern Gulf is highly speculative. Lacking are reliable records prior to the 1970's which indicate that such hypoxic conditions were previously not regular occurrences and rate measurements and realistic models of critical metabolic and food chain processes. If it is the case that the hypoxia phenomenon is a system dysfunction triggered by human influences, the environmental effects of these influences dwarf most conventional and better studied marine pollution problems in areal extent and economic consequence. Such effects would demand reevaluation of strategies regarding waste disposal in the marine environment (generally limited to direct discharges and ocean dumping), which could have repercussions far inland.

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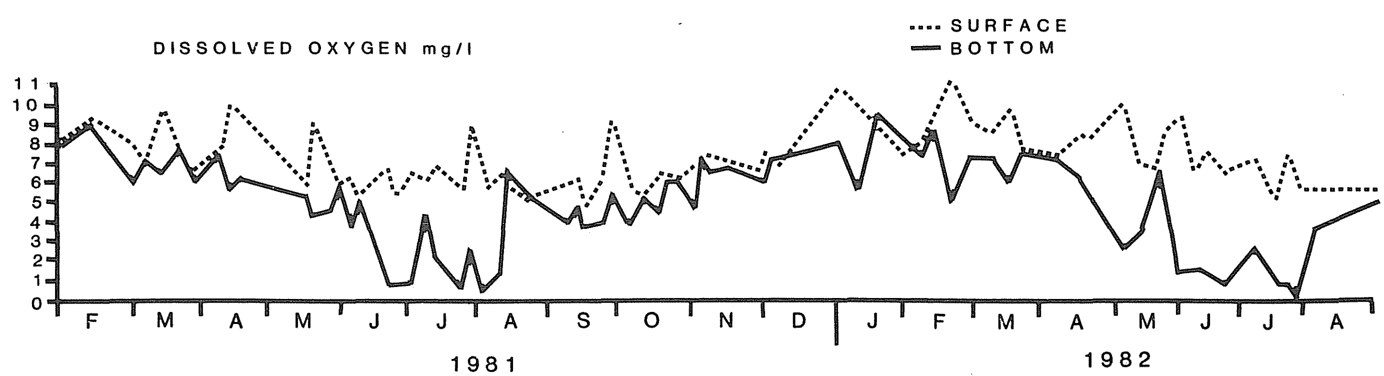

Figure 2. Variations in surface and bottom (10 m) dissolved oxygen 5 mi. east of the Department of Energy's Strategic Petroleum Reserve brine discharge site off Cameron, Louisiana (source, McNeese State University).

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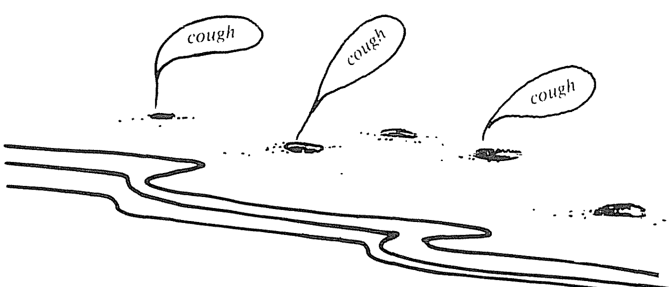

Loomings

The Dynamics of Dissolved Hydrocarbons in Seawater

Oily ballast water is discharged into Port Valdez at a rate of 1.5 million barrels per day. This water comes from Puget Sound, Washington, and points south. The ballast replaces Prudhoe Bay crude from the holds of tankers, and is shipped back to Port Valdez, Alaska at the same rate oil flows through the Trans-Alaska Pipeline. During the ten day trip back, this ballast water mixes with oil remaining in the tanker holds. In Alyeska's treatment plant at the pipeline terminus, visible oil is separated from the seawater for reloading into the tankers. Much of the lighter petroleum fractions, such as benzene and toluene, escape removal and remain with the ballast water waste. In this way about 14 tons of hydrocarbons per month flow into Port Valdez.

While enroute from Washington State, bacteria consume some of the oil from the ballast water and grow to substantial populations. In the treatment plant at Valdez these organisms, as well as soluble hydrocarbons, escape removal. The bacteria are discharged into Port Valdez at a rate of about one ton per week together with the hydrocarbons as part of the ballast waste water. Discharge is through a perforated pipe about 60m below the surface. At a depth of neutral density near there the ballast water spreads outward to form a pancake shaped layer containing hydrocarbons, bacteria and other products.

The dissolved hydrocarbons are eventually metabolized by bacteria. We have chosen toluene as a representative component of the soluble aromatic hydrocarbon fraction for metabolic studies. The rate that biodegradation proceeds depends significantly on both the concentration of the hydrocarbon and the population of hydrocarbon oxidizing bacteria (second order), as well as the state to which hydrocarbon utilizing metabolic pathways are induced. In the layer of ballast water bacterial metabolism of the hydrocarbons is quite fast, giving residence times as short as 48 hours. However, oceanic currents flush the oil and bacteria seaward before metabolism is complete. Thus, most of the hydrocarbons and early products of their metabolism are carried out to the open ocean.

Residence times of toluene outside the ballast water rich layer but within the Port Valdez fjord are several years, based on the rates of toluene metabolism observed. In Resurrection Bay, a similar but non-polluted Alaskan estuary, residence times were greater than 33 years. However, a mixture of terpene hydrocarbons in this conifer surrounded fjord disappeared in a few days. Apparently toluene can persist in the presence of hydrocarbon oxidizing populations for short periods before induction occurs. Toluene residence times were also short in Aransas Bay near Corpus Christi, Texas where bacterial populations were very active. In laboratory studies we found that both the bacterial population and its state of induction were significant in setting dissolved hydrocarbon biodegradation rates, and these seemed to be related to both the quality and size of the hydrocarbon source.

Toluene metabolism kinetics are unusual for a carbon and energy source, having both small Michaelis constants and specific affinities. We believe the kinetics reflect hydrocarbon/lipid partitioning followed by vectorial hydroxylation as the significant steps in a third and generally unrecognized mechanism for nutrient transport.

Another surprising finding is that when the aromatic hydrocarbon biodegradation occurs at low concentration, 60-90% of the carbon reappears as partly oxidized organic products. It has long been known that metabolic intermediates are liberated, but the extent of this process in seawater had not been recognized. Product accumulation may be a particular phenomenon of dilute populations where product concentrations required for rapid metabolism of them are reached only slowly. Accumulation in mixed cultures suggests that these products may have residence times in seawater that is even longer than their parent hydrocarbons. Kinetics predict that they therefore accumulate and contribute to the biochemistry of seawater.

Current EPA-sponsored work centers on the formulation of mechanistically sound kinetics which describe mixed dissolved hydrocarbon metabolism rates by marine bacteria in very dilute systems.

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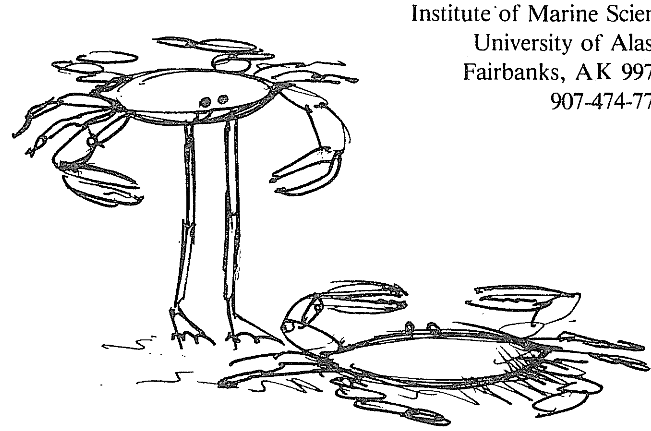

"Ick! You actually get down and scuttle around in that stuff?"

Research & Monitoring Updates

ICES Tackles The Problem Of Petroleum Hydrocarbon Analytical Intercomparability

The International Council for the Exploration of the Sea has for the last ten years been active in the promotion of joint studies on pollution in the North Atlantic and Baltic Sea. During that period baseline studies have been conducted for metals and chlorinated hydrocarbon residues in marine biota and cooperative monitoring has been initiated in certain more heavily contaminated seas. As an aid to ensuring intercomparability of results, 17 intercalibration exercises have been completed and these are continuing on an on-going basis.

Recently the field of interest has been extended to petroleum hydrocarbons and the first intercomparison exercise was completed early in 1982. The results are to be published in ICES Cooperative Research Report No. 117.

Analysts from 36 laboratories in 11 countries, including the USA and Canada, took part in the exercise. Samples of crude oil, natural marine sediment from a contaminated area and a mussel homogenate were analyzed by the analysts according to their standard procedures. In several instances this involved a number of different methods within one laboratory and between laboratories a wide number of techniques were employed. These included gravimetry, infra-red and ultra violet spectrophotometry, fluorescence spectroscopy, gas and liquid chromatography including capillary gc and combined gas chromatography-mass spectrometry.

The program was planned as a dual function exercise, firstly to establish the number of interested organizations and the range of methods used by analysts and secondly to establish the degree of intercomparability in results obtained by different methods and different analysts. In all respects the exercise appears to have been successful. Among the analysts using relatively simple methods, the extent of comparability was remarkably good considering that no standard procedures were specified. Larger differences were noted with the more complex techniques but some possible explanations are offered for these and solutions are suggested for the follow-up exercise. For further details of the report on the completed exercise or the new study contact the ICES Environment Officer, Palaegade 2-4, 1261 Denmark.

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Instrumental Determination of ^{210}Pb in Sediments

^{210}Pb is one of the naturally-occurring radionuclides most frequently measured by geochemists and geologists who use it for 'dating' sedimentary and environmental processes over the past 100 years. Analyses of ^{210}Pb are difficult and time consuming because they involve sample leaching, radiochemical purification and counting. To obtain greatest accuracy in ^{210}Pb dating it is also necessary to measure ^{226}Ra in order to correct for the "supported level." Previous attempts at direct sample analysis by gamma-ray spectrometry have been imprecise because self-absorption of the 46.5 keV ^{210}Pb gamma-ray is highly dependent on sample composition. A new instrumental procedure has been developed in the Environmental Sciences Division, Oak Ridge National Laboratory to correct self-absorption (reported by Cutshall et al., Nuclear Instruments and Methods, in press).

The attenuation coefficient on each sample is determined by measuring the transmission of ^{210}Pb gamma-rays from a solid source. Then a correction factor, $F = \frac{Ln\ (T)}{T-1}$, is calculated where T is the transmitted ^{210}Pb source count rate divided by the count rate without a sample present. When F is multiplied by the sample ^{210}Pb gamma-emission rate and by an efficiency factor, the result yields the ^{210}Pb content of the sample.

The method has been applied to several standardized materials and to samples previously analyzed by radiochemical methods. Accuracy of gamma-ray ^{210}Pb results for standard reference materials and agreement for radiochemically analyzed samples is excellent. The number of samples for which the cost of gamma-ray instruments equals the cost of radiochemical processing is estimated at 300.

The gamma-ray instrumental procedure is advantageous because it, 1) reduces the time of sample preparation, 2) eliminates chemical recovery problems, 3) is non-destructive so that the sample can be reanalyzed at any time or used for other purposes, and 4) allows the supported level of ^{210}Pb to be measured concurrently using the ^{214}Pb peak at 352 keV.

Laboratories which seriously pursue ^{210}Pb analyses will find the instrumental method improves the accuracy of their analyses at reduced cost compared to radiochemical methods.

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Trace Metal Content and Distribution of Inner Shelf Sediments Off Southern New Jersey

The organic free clay fraction of bottom sediment samples collected from the inner continental shelf off southern New Jersey and from Delaware Bay, in summer 1978 and winter 1979, were analyzed for absorbed trace metal content. Objectives of this project are to: 1) measure trace metal concentrations associated with clay-sized sediments; 2) document deposition of Delaware Bay-derived clay sediments deposited on the inner shelf of southern New Jersey; and 3) determine depositional patterns of these river-derived sediments on the inner shelf.

The organic-free clay fraction was treated with hydroxylamine hydrochloride acetic acid, and analyzed by flame atomic absorption spectroscopy. Trace metal concentrations within the clay fraction were variable (Zn 70-600 ppm, Cu 10-100 ppm, Cd .02-9.5 ppm, Ni 3.6-42 ppm, and Cr 2-33 ppm), with highest values occurring in sediments from Delaware Bay. Areal distribution patterns for trace metal concentrations (Figure 1) on the inner shelf indicate that clay-sized sediment with its associated trace metal content is deposited in decreasing quantities to the north, east and west of Cape May Peninsula. Lower metal content in the shoreward (western-most) samples reflect the effect of longshore currents and oscillating tidal currents. These tend to move sediments parallel to the coastline and subsequently into tidal lagoons (Kelley, 1980), thereby removing these sediments from the nearshore zone (Hall, 1981). Because too few sample sites are located near the southern tip of Cape May, trace metal contours are not continued into Delaware Bay. Distribution trends, however, suggest that some clay sediments are transported out of Delaware Bay and deposited on the inner shelf of New Jersey. Currently, we are investigating trace metal content in sediments around Cape May Peninsula, and continuing into Delaware Bay.

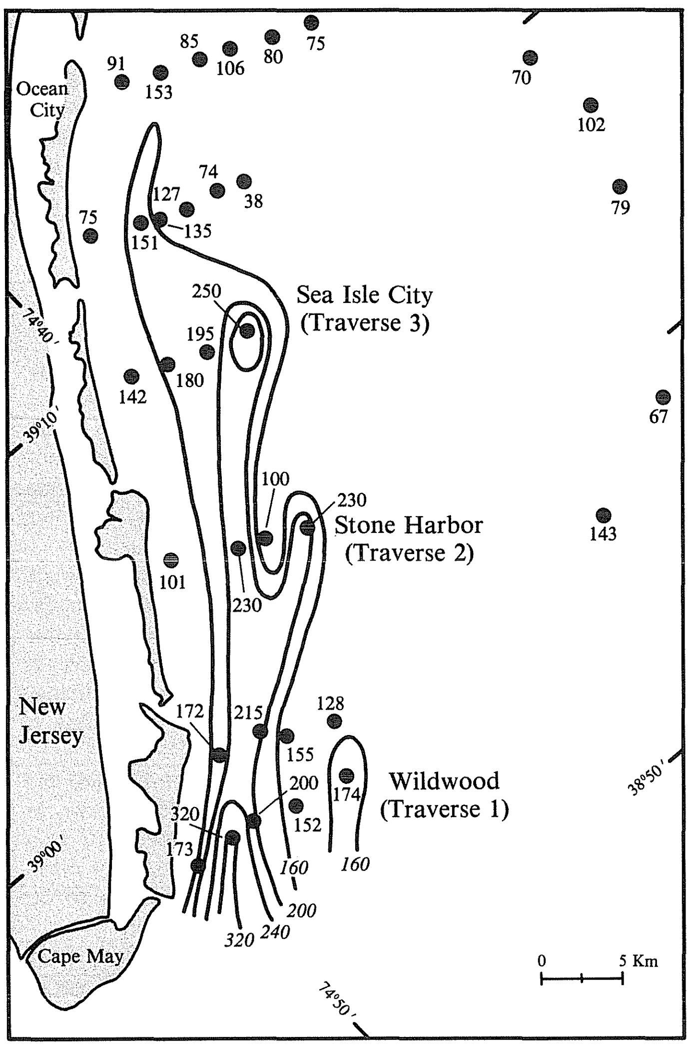

Figure 1. Average Zn concentrations ($\mu g/gm$ of clay) for Winter (March 1979) bottom samples. The areal distribution of Zn is comparable to other trace metal patterns on the inner shelf for both summer and winter samples.

The most significant difference between values for winter and summer samples is in the absolute concentration of trace metals in the inner shelf clays. Summer metal values are two-to-three times higher than those of similar winter stations (Table 1). These data

Metal	Traverse 1 (Wildwood)		Traverse 2 (Stone Harbor)		Traverse 3 (Sea Isle City)	
	Summer	Winter	Summer	Winter	Summer	Winter
Zn	523.0	204.0	383.0	165.0	504.0	192.0
Cu	61.0	56.6	69.0	49.0	61.0	48.0
Cd	3.8	1.1	1.9	1.3	3.2	1.6
Ni	35.6	10.5	20.3	4.8	16.3	8.9
Cr	24.3	14.5	11.3	7.2	20.8	7.6

Table 1. Average trace metal content ($\mu g/gm$ of clay) for winter and matching summer traverses.

are based on averages of metal values for three matching transverses. Because of this significant seasonal difference in trace metal content, and because of the northward-flowing surface currents during the summer (Bumpus and Lauzier, 1965), it is probable that more sediment is transported north and deposited during the summer than in the winter. An exception may be due to isolated winter storms which move up the coast from the south. In addition, there may be an influx of "non-polluted" Pleistocene clays to the inner shelf during the winter, which would dilute metal concentrations of Delaware-derived clays. Pleistocene clays that are in shelf troughs undergo erosion during winter storm events and deposition during calm periods (Swift et al., 1977).

Inner shelf topography is dominated by a series of northeast-southwest trending ridges and troughs. The ridge-crest samples are characterized statistically by higher trace metal concentrations (Table 2) than adjacent troughs. Furthermore, ridge sediments

	Mean Trace Metal Concentration ($\mu g/gm$ of clay)		Mean Squares Among Samples	Mean Sq. Error Variance Within Samples	Calculated F Value	Degress of Freedom	Critical 90%F Value
	Crest	Trough					
Zn	191	141	11718	952	12.0	1,10	
Cu	59	48.3	690	92	7.3	1,10	
Cd	1.8	1.08	1.47	.337	4.35	1,10	3.14
Ni	0.7	6.5	53.7	8.3	6.47	1,10	
Cr	0.8	8.2	52.4	8.2	6.4	1,10	

Table 2. Analysis of variance of trace metal content in sediment samples for ridge crests and adjacent troughs.

contain lower clay content (<2% by mass) than troughs (>5% by mass) so that there is no direct relationship between the amount of clay and the amount of trace metal present on the inner shelf for winter or summer samples. One possible explanation is that the clay content of crestal sediments is predominantly a modern deposit of Delaware Bay-derived clays with their associated pollutant metals. Clays in troughs, however, consist not only of modern clays (and their trace metals originating from Delaware Bay), but also may include older, exposed, underlying clay deposits (Swift et al., 1977) and/or clays from offshore sources—both of which may contain very low trace metal content.

In addition to completing analysis of grab samples south and west of Cape May Point, studies in progress are investigating trace metal content with increasing depth in core samples taken from troughs and ridges in the area.

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Region-Wide Taxonomic Inter-Calibration Program Underway In California

The first monthly regional meeting of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) was held in May at Marine Biological Consultants, Inc., Costa Mesa, Ca. The new organization was formed to act as a vehicle for southern California marine biologists to work together to resolve common taxonomic problems arising from the region's myriad marine monitoring programs. The aim of SCAMIT is to produce a regionally inter-calibrated list of southern California marine invertebrate species an inter-calibrated museum collection. To date (September, 1982) membership includes over 40 biologists representing at least 14 public agencies, utilities, private consulting companies, universities and museums.

The need for regional taxonomy inter-calibration efforts is clear to anyone involved in assessing and comparing the effects of pollution on marine invertebrate communities, especially infaunal benthic communities which can produce individual survey lists totaling several hundred species.

The task of accomplishing the goal is not easy considering the thousands of species encountered in southern California. Meetings are held on a monthly basis, each meeting dealing with a different taxonomic group. Specimens are exchanged at the meetings so that participating members can examine them individually in a practicum manner. Then each species is discussed by the participants to identify and resolve any differences in species identification that may have occurred.

The specimen exchange is supported with guest speakers and a literature exchange. The results of the meetings are published in a monthly newsletter that is distributed to all members of SCAMIT.

To date the approach using a specimen exchange has proven to be an excellent way of resolving regional taxonomic problems. Also, the inter-calibrated museum collection has been started from the species that have already been discussed. Each entry in the museum is accompanied by a voucher sheet that details the characteristics of that species as well as comments on pertinent literature, common synonyms, and similar occurring species.

SCAMIT replaces and revises an earlier regional effort, the Taxonomic Standardization Program that resulted in provisional guides to the region's invertebrate fauna (Ward, 1977). More importantly, SCAMIT represents one of the first efforts to act on recommendations from a suite of federal-regional workshops on marine pollution monitoring (Segar et al., 1981 and Peter and Lockwood, 1982). Those recommendations viewed national marine pollution monitoring as a suite of regionally coordinated efforts with emphasis on enhancing intra-regional communication, data exchange and inter-calibration. Thus, SCAMIT may serve as a model to stimulate such efforts elsewhere.

For more information, contact SCAMIT secretary, Ann Martin.

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A Two-Species Marine Algal Bioassay to Determine The Toxicity Of Chemical Pollutants

The environment is confronted with thousands of synthetic organic and inorganic chemicals, and the task of testing so many chemicals for their impacts on aquatic organisms would be monumental. It would be useful to screen potentially harmful toxic chemical pollutants with a simple, sensitive, rapid, and inexpensive laboratory algal bioassay. We therefore developed such a bioassay based on the simultaneous use of two species of marine diatoms. Species ratio and total biomass alteration are used as the indices of toxicity. Substances toxic to phytoplankton significantly alter species cell ratios, reduce total biomass, or both.

The advantages of a two-species bioassay over a single-species system have not generally been recognized. A two-species system is usually more sensitive to chemical stress. Mosser et al. (1972b) reported that the toxicity of polychlorinated biphenyls (PCB) to *Thalassiosira pseudonana,* grown in pure and mixed culture, was greatest when in competition with another species.

A two-species system is one step closer to the multi-species, competitive natural environment. The addition of chemical pollutants affects competitive interactions in two-species cultures. PCB, DDT [1,1,1-trichloro-2,2-bis (*p*-chlorophenyl)ethane] and a liquid industrial waste caused a substantial species alteration, when compared to controls (Mosser et al. 1972b; Walsh and Alexander 1980).

Because algal species show differential sensitivities to different chemical pollutants (Hollister and Walsh 1973), a two-species system has a greater chance of detecting toxicity than does a single-species test, without being any more difficult or time-consuming.

In choosing bioassay organisms, we sought to meet several criteria not fully utilized in previous algal bioassays. The phytoplankters must be single cells; the two species must differ in cell size sufficiently to be differentiated by an electronic particle counter; the clones must be relatively sensitive to toxic chemicals; growth rates should be about the same for both species; and the clones should be relatively easy to grow under routine laboratory culture conditions (Guillard 1975).

Based on these criteria, a systematic screening of cell size, sensitivity to 10 μg per liter (ppb) of PCB (Aroclor 1254), and growth characteristics of 40 different clones of algae were performed. Fifteen potential bioassay pairs were chosen and their behavior and sensitivity were tested with 10 ppb of PCB.

Of the algal pairs tested, the *Phaeodactylum tricornutum* (clone Phaeo)/*Cyclotella cryptica* (clone 03A) pair was chosen as the best bioassay system. These phytoplankters are single cells, differ sufficiently to be differentiated by the particle counter, are relatively easy to grow under routine laboratory culture conditions and an alteration in species ratio is produced by PCB, DDT and dieldrin.

A significant ($P<0.001$) alteration in the Phaeo/03A ratio by 10 ppb of PCB arose from the inhibition of 03A concurrent with the enhancement of Phaeo (Figure 1a and Table 1). This chemical produced a significant ($P<0.01$) reduction in 03A and total biomass ($P<0.01$).

In the experiment represented by Fig. 1a, the increase in Phaeo biomass was not significant ($P>0.05$).

In three of the five replicate experiments, however, Phaeo was significantly ($P<0.05$) greater in treated than control cultures.

PCB at 1 ppb had no effect on the bioassay; 20 ppb produces a significant ($P<0.001$) biomass reduction of both species. There

	Day	Treatment	Phaeo	03A	Total	Ratio
1(a)	1	Control	2.00 ± 0.18	8.92 ± 0.92	10.92 ± 1.08	0.22 ± 0.01
		PCB 10 ppb	1.90 ± 0.09	8.17 ± 0.97	10.07 ± 1.05	0.23 ± 0.02
	3	Control	11.78 ± 1.11	43.75 ± 3.00	55.53 ± 3.04	0.27 ± 0.03
		PCB 10 ppb	8.76 ± 0.60	21.16 ± 1.42	29.91 ± 1.62	0.41 ± 0.04
	5	Control	42.19 ± 4.97	92.47 ± 4.79	134.67 ± 8.07	0.46 ± 0.05
		PCB 10 ppb	41.60 ± 6.40	28.55 ± 0.92	70.16 ± 6.28	1.46 ± 0.24
	6	Control	72.20 ± 10.44	94.96 ± 2.33	167.17 ± 8.82	0.76 ± 0.13
		PCB 10 ppb	94.75 ± 11.13	36.03 ± 1.93	130.78 ± 12.96	2.63 ± 0.18
1(b)	1	Control	3.14 ± 0.10	10.88 ± 0.17	14.01 ± 0.26	0.29 ± 0.01
		DDT 10 ppb	3.08 ± 0.02	12.41 ± 1.50	15.49 ± 1.48	0.25 ± 0.03
	3	Control	15.78 ± 1.39	38.79 ± 3.62	54.57 ± 4.95	0.41 ± 0.01
		DDT 10 ppb	13.31 ± 1.29	35.32 ± 2.47	48.63 ± 3.73	0.38 ± 0.01
	5	Control	52.36 ± 2.82	76.32 ± 4.04	128.68 ± 6.82	0.69 ± 0.01
		DDT 10 ppb	49.21 ± 1.85	89.84 ± 8.73	139.05 ± 10.09	0.55 ± 0.04
	6	Control	104.22 ± 3.24	83.42 ± 3.35	187.64 ± 2.97	1.25 ± 0.08
		DDT 10 ppb	93.28 ± 10.26	97.38 ± 14.91	190.63 ± 2.47	0.96 ± 0.06

Table 1. Response of the Phaeo/03A Bioassay to 10 μg per liter of PCB, top, and 10 μg per liter of DDT, expressed as volume concentration ($\mu m^3 \times 10^6 ml^{-1}$) of *Phaeodactylum tricornutum* (Phaeo), *Cyclotella cryptica* (03A) and *P. tricornutum* plus *C. cryptica* (Total) ± standard deviation (n = 3). Ratio is Phaeo/03A.

was, however, still a significant (P<0.001) species alteration produced by 20 ppb of PCB, caused by a greater inhibition of 03A (P<0.001) than Phaeo (P<0.05).

Results using 10 ppb of DDT are presented in Fig. 1b and Table 1. A significant (P<0.01) species alteration was produced by 10 ppb of DDT, but no significant (P>0.05) change in Phaeo or 03A biomass occurred. An unexpected result was that the DDT-induced species alteration was opposite to that produced by the PCB.

The Phaeo/03A bioassay is no more difficult or time-consuming than a single-species test, yet has the advantage of having a greater chance of detecting chemical toxicity. The bioassay responds to 10 to 20 ppb of PCB, DDT and dieldrin, and this sensitivity could probably be increased by altering culture conditions. Growth is rapidly and reliably measured with an electronic particle counter. Both clones are easily maintained in culture. Bioassay results were consistent with existing toxicological information, and replicate experiments yielded consistent results for all chemicals tested.

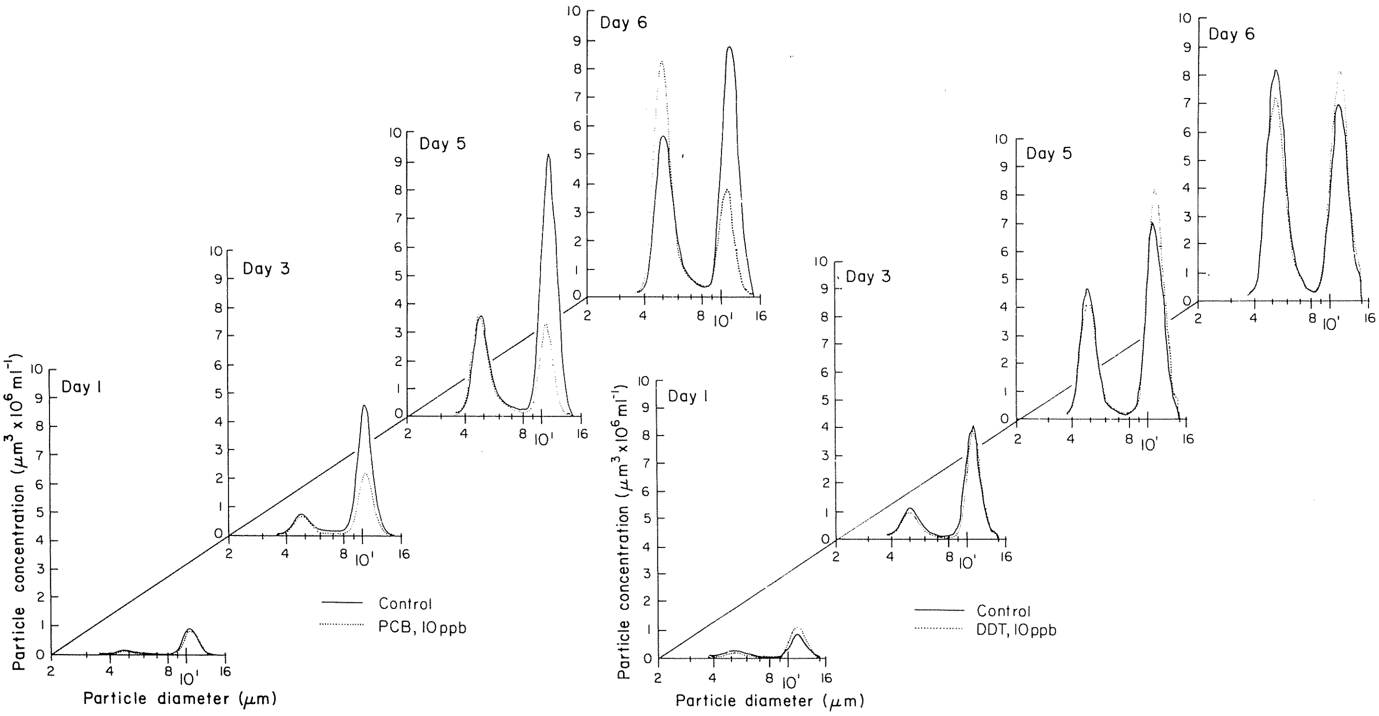

Figure 1. Growth of *Phaeodactylum tricornutum* (clone Phaeo) and *Cyclotella cryptica* (clone 03A) exposed to 10 μg per liter of PCB (a) or 10 μg per liter of DDT (b), in 5 μl of methanol. Controls contained 5 μl of methanol. Phaeo and 03A cells averaged 4.8 and 10.4 μm equivalent spherical diameter, respectively. Each curve represents the mean particle concentration of triplicate cultures.

DDT at 20 ppb significantly (P<0.01) altered the species ratio, but did not significantly (P>0.05) reduce total biomass because a significant (P<0.05) decrease in Phaeo biomass was offset by a significant (P<0.01) increase in 03A biomass. Results of experiments employing 20 ppb of dieldrin were almost identical to those produced by 20 ppb of DDT.

The bioassay was subjected to PCB, DDT and dieldrin treatments to determine the behavior and the sensitivity of the system to chemicals with known toxic effects on phytoplankton. In general, bioassay results were consistent with previous studies in recognizing PCB, DDT and dieldrin as toxic pollutants, and in finding DDT to be less toxic to phytoplankton than PCB (Mosser et al. 1972a; Luard 1973). In most cases, the bioassay was more sensitive than single-species tests (Batterton et al. 1971; Bowes 1972; Mosser et al. 1972a,b; Fisher et al. 1974; Fisher 1975; Harding and Phillips 1978) and as sensitive as the one previous two-species test (Mosser et al. 1972a,b).

This work is the first to develop a specific two-species algal culture for bioassay purposes, based on an extensive screening to select the optimum bioassay organisms. Many studies have been devoted to the development of bioassay procedures and techniques (Jensen et al. 1972; Brezonick et al. 1975; Wright 1975; Shoaf and Lium 1976; Roberts 1977; Walsh and Alexander 1980), but little has been done to determine the most suitable bioassay organisms.

For these reasons, the Phaeo/03A algal bioassay is suitable for testing the toxicity of chemical pollutants.

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Announcements

7th International Estuarine Research Conference — First Call For Abstracts.

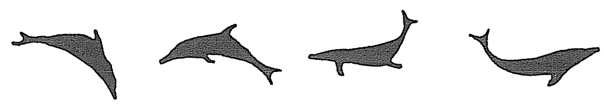
The Estuarine Research Foundation has put out the first call for abstracts for its 7th International Estuarine Research Conference, which will be held on 22-26 October, 1983.

The Conference volume theme will be "THE ESTUARY AS A FILTER." Sessions will deal with the biological, chemical/geochemical, geological, and physical processes that cause the estuary to function as a filter for the signals it receives from the land and from the sea, and with the processes that determine the characteristics of that filter. Sessions will consider management applications. Contributed papers in all areas of estuarine research and management will be considered for presentation orally or in poster sessions. Other invited sessions now being planned include: Submerged Aquatic Vegetation and Salt Marshes—An Assessment of Utilization and Habitat Value; Estuarine Subsystems as Filters of Ecological Flows; Tidal Freshwater Wetlands; Tidal Mixing and Plankton Dynamics; Long-term Estuarine and Coastal Data Sets—Design, Analysis, Interpretation, and Use; Tidal Power and Environmental Consequences; and Hard Substrate Communities.

Four workshops now being planned are "Personal Computers and Coastal Zone Planning and Decision Making", "The New Salinity Scale And What It Means To Estuarine Oceanography", "Measuring Estuarine Degradation—A Review and an Assessment", and "A National Program for Estuarine Research".

A special invited evening session will be devoted to the history of coastal zone management and environmental conditions in the World's most famous lagoon—the lagoon of Venice, Italy—and to an examination of the most recent proposals to rehabilitate it.

The deadline for all abstracts is 15 February 1983. For more information, contact the Program Chairman, J.R. Schubel, SUNY at Stony Brook, Marine Sciences Research Center, Stony Brook, NY 11794 . . . 516-751-5428.



Announcement and Call for Papers

The International Council for the Exploration of the Seas (ICES), in collaboration with the Intergovernmental Oceano graphic Commission (IOC), the Office of Marine Pollution Assessment (OMPA) and National Marine Fisheries Service (NMFS), of the United States National Oceanic and Atmospheric Administration (NOAA), is to hold an interdisciplinary symposium on CONTAMINANT FLUXES THROUGH THE COASTAL ZONE.

The purpose is to discuss the transport of contaminants through estuaries, marginal seas, and continental shelf regions of the World's oceans.

Objectives and Scope of the Symposium:

1. Present and discuss techniques for measurements of contaminant fluxes at the boundaries and within the coastal zone as well as through the zone itself; case studies, methods and techniques, their limitations, required improvements, and ideas on new developments.
2. Review information on contaminant budgets for coastal zones, using case studies, new data together with long time series, theoretical and experimental model considerations.

The overall problems the symposium should address are 1) the quantification of how much of the contaminant material supplied to the coastal zone really passes through to the open ocean on different time scales, 2) how much is recycled and 3) how much is re tained in the coastal zone. Substances of interest occur in both dissolved and particulate form. Various transformations occur in the coastal zone, of physical, chemical, or biological nature. Physical, chemical and biological processes will be reviewed, but it is the intention to focus on measurements of contaminant fluxes. The symposium is inter-disciplinary by virtue of the nature of the subject and it is hoped that a balance of physics, chemistry, and biology will be maintained through participation, presentations and discussions.

Structure of Symposium

The symposium, lasting three full days, will be organized in four non-parallel inter-disciplinary sessions, with introductory keynote presentations and possibly some invited reviews. Poster contributions and oral contributions are solicited. There will be 20 minutes for oral presentations of contributed papers. It is the intention to publish the proceedings.

Abstracts and Manuscript Requirements

A 250-500 word abstract should be sent to the Convenor by 1 June 1983. The organizing Committee will review the abstracts and notify authors by October 1983. To facilitate both presentations and discussions, a draft manuscript will be required by 1 February 1984 for either oral or poster contributions. At least 250 copies should be sent to the ICES Secretariat, from where the manuscript will be distributed to all participants, in good time before the symposium.

Time and Venue

ISTPM, Nantes, France, in May 1984

Accommodation, Fees, Registration

There is no fee and no symposium accommodation organization. Information on local conditions can be obtained from Dr. Crepey, ISTPM, Nantes.

There will be limited funds available for travel support. Applications should be sent to the Convenor:

Professor G. Kullenberg, Institute of Physical Oceanography, University of Copenhagen, Haraldsgade 6, 2200 Copenhagen N, Denmark.

OMPA Contact: Dr. John A. Calder, NOAA Office of Marine Pollution Assessment, Rockville, MD 20852.

Volume On New York Bight Pollution Available

A summary of the implications of pollution to the New York Bight ecosystem has been published by the Estuarine Research Federation. Entitled *Ecological Stress and the New York Bight: Science and Management* and edited by Garry F. Mayer, the volume presents a compilation of 42 papers relating to the impacts and management of pollution in the New York Bight and adjacent waters. The volume focuses on research undertaken in the New York Bight but includes relevant papers from other areas of the country, including the Southern California Bight and Puget Sound areas. Findings from other areas are presented in light of their significance to the New York-New Jersey metropolitan area.

Ecological Stress and the New York Bight: Science and Management is intended for a wide readership. The first nine papers offer an overview of the findings and implications of technical papers presented in the remainder of the book. These initial papers should prove useful to specialists as well as to individuals who are interested in environmental problems but may lack scientific or environmental engineering backgrounds. The book focuses on species-level effects of pollutants on benthic organisms, plankton, and fishes; on the effects of toxicants and biostimulants on communities and ecosystems; and on the management of domestic wastes, dredged materials, industrial wastes, and wastes from non-point sources.

The book may be obtained from the Estuarine Research Federation, Belle W. Baruch Institute for Marine Biology and Coastal Research, University of South Carolina, Columbia, SC 29208 at a cost of $10.00 per copy. Checks and money orders should be made payable to the Estuarine Research Federation.

Garry F. Mayer
NOAA Office of Marine Pollution Assessment
Old Biology Building, SUNY
Stony Brook, New York 11794

Series on Ocean Waste Disposal

"Wastes in the Ocean," a comprehensive six-volume overview of the state of knowledge concerning the disposal of wastes in the ocean will become available during 1983. The first volume will be available after January 27, 1983, and is entitled, "Industrial and Sewage Wastes in the Ocean." Volumes 2-6, entitled, respectively: Dredged-Material Disposal in the Ocean; Radioactive Wastes in the Ocean; Energy Wastes in the Ocean; Deep-Sea Waste Disposal, and; Near-Shore Waste Disposal; will be released in order during 1983.

Most of the series is comprised of papers presented at the Second International Ocean Dumping Symposium, which was held at Woods Hole, Massachusetts in April 1980. The contributors, editors, and reviewers represent interests world-wide.

In the Preface the editors express a hope that the, "series will provide the framework for the evaluation of the impact of specific types of waste in the ocean." The material represents new and original contributions to the evaluation of the impacts of the disposal of waste materials on human health and welfare, on the marine biota, and on other legitimate uses of the ocean.

The series Editors are Iver W. Duedall, Dana R. Kester, Bostwick H. Ketchum, Wayne Burt, and P. Kihlo Park.

"Wastes in the Ocean," is part of "Environmental Science and Technology," a Wiley-Interscience Series of Texts and Monographs, published by John Wiley and Sons, Inc.

Inquiries on the price and availability of the series should be addressed to John Wiley and Sons, Inc., 605 3rd Avenue, New York, NY 10158.

Calendar

February-March 1983

27-4

13th Conference of Engineering Foundation ("Environmental and Energy Engineering in the Food Processing Industry") Contact: Engineering Foundation, 345 E. 47th St., New York, NY 10017 (212-705-7835).

28-3

1983 Oil Spill Conference (Prevention, Behavior, Control, Cleanup), San Antonio Convention Center, TX. Contact: 1983 Oil Spill Conference, Suite 700, 1629 K St. NW, Washington, DC 20006 (202-296-7262).

28-4

Short Course on Port Engineering, Gainsville, FL. Contact: Port Engineering Short Course, c/o Dr. H. Wang, Chairman, Coastal & Oceanographic Engineering Dept., Univ. of Florida, 336 Weil Hall, Gainsville, FL 32611 (904-392-1436).

March

17-19

Coastal Zone Resources and Law of the Sea Expo '83, World Trade Center, Singapore. Contact: Cahners Exposition Group, Cahners Plaza, 1350 E. Touhy Ave., PO Box 5060, Des Plaines, IL 60018 (312-299-9311).

June

18-22

10th World Fishing Exhibition, Bella Center, Copenhagen. Contact: Helena Durban, Industrial & Trade Fairs Intl. Ltd., Radcliffe House, Blenheim Court, Solihull, West Midlands B91 2BG U.K.

Information for Contributors

There is no prescribed format for preparation of manuscripts because of the wide range of material accepted. Authors should be guided by articles in COPAS.

1. Articles should be typed double-spaced and should not exceed 1,000 words.
2. The title should be informative and brief.
3. On first use full name and acronym must be used. Subsequent reference may be by acronym alone.
4. Measurements should be given in the metric system
5. Figures and tables should be camera-ready and suitable for reduction to a 15.2 x 10.2 cm size, not including legend. Care should be taken with lettering and symbols so that they are readable when reduced. The combined number of figures and tables should not exceed three.
6. Proofs will not be sent to the author unless requested, but if significant editorial changes are made for brevity and clarity, authors will be contacted by telephone.
7. Reprints are not provided.
8. Deadlines for contributions are January 25, April 10, July 10, and October 10. Send all correspondence and material to:

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   Marine Sciences Research Center
   State University of New York
   Stony Brook, Long Island, NY 11794

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COASTAL OCEAN POLLUTION ASSESSMENT NEWS

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MAN AND THE MARINE ENVIRONMENT

Volume 2 Number 4 Spring 1983

The purpose of **Coastal Ocean Pollution Assessment** (COPAS) **News** is to provide timely dissemination of information on pollution in coastal waters of the United States — its sources and effects, what is being done to eliminate or mitigate it, and what research and monitoring activities are being conducted to develop more effective strategies to manage it. We publish brief articles describing recent events and activities, new approaches to resolving chronic pollution problems, and early warnings of potential problems. Announcements of cruises, meetings, and investigations will be included.

Publication in COPAS is not to be construed as publication in the refereed scientific literature. COPAS is not copyrighted, and any reference to material printed in COPAS should be approved by the author.

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In This Issue

Continuity

Studies on Long-Term Effects of OCS Oil and Gas Development

Over the past 10 to 12 years the Federal government has spent several hundred million dollars gathering environmental information for predicting probable environmental impacts from outer continental shelf (OCS) oil and gas development activities. Most of this work has been descriptive and aimed at developing environmental information in regions prior to significant development. Considerable monitoring of exploratory drilling activities has also been conducted. Such studies are limited in their potential to allow confident prediction of the ultimate environmental effects should extensive and prolonged oil and gas development occur.

The National Marine Pollution Plan for 1981 (as required by Sec.4, P.L. 95-273) states that "The most significant questions that remain unanswered for OCS development are those concerning the effects on ecosystems of long-term, chronic low-level exposures resulting from the accidental spills, leaks and disruptions caused by development activities." The Plan recommended a 10-year interagency research program be planned and implemented to investigate such long-term effects. As an initial step, a workshop sponsored by the Federal Interagency Committee on Ocean Pollution Research, Development and Monitoring (COPRDM) and the Bureau of Land Management was held in December 1981, to develop an approach to studies of long-term effects. The workshop recommended that "...a rigorous and objective analysis of previous field studies...assess the most effective chemical and biological indicators of effects, (and) limitations and advantages of sampling designs and statistical requirements..."

COPRDM has initiated a study intended to provide this critical review of development and to develop a refined design for a long-term effects research program. The assessment will review critically the state of scientific knowledge, in particular, that developed from previous field assessment programs such as those conducted in the historically developed Gulf of Mexico; review industry trends and practices; predict probable long-term environmental impacts associated with likely development options; described pertinent on-going and planned research programs; and develop a recommended study design.

The study is cosponsored by the National Oceanic and Atmospheric Administration (NOAA), Minerals Management Service of the Department of the Interior and the National Science Foundation through the National Marine Pollution Program Office. The study is managed by the Louisiana Universities Marine Consortium (LUMCON) as a component of an agreement between NOAA and the Center for Bioorganic Studies of the University of New Orleans. Donald F. Boesch of LUMCON serves as Project Manager. The assessment will involve a large number of highly qualified scientists who will serve as Steering Committee members and authors of study components. Steering Committee members are James N. Butler (Harvard University), Joseph Geraci (University of Guelph), James P. Ray (Shell Oil Company), David A. Cacchione (U.S. Geological Survey), Jerry M. Neff (Battelle New England Marine Laboratory) and John M. Teal (Woods Hole Oceanographic Institution).

Comments and suggestions are welcome and should be addressed to:

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Loomings

Sources and Fates of Petroleum Hydrocarbons in the Hudson-Raritan Estuary

A great deal of attention has been focused on the water quality problems of the Hudson-Raritan Estuary (HRE) and the adjacent New York Bight, (e.g. Mueller and Anderson, 1978; O'Connor and Stanford, 1979). The two areas are closely linked in that some of the contaminants in the Bight originate from the heavily urbanized and industrialized HRE.

Petroleum hydrocarbons, and the often associated polycyclic aromatic hydrocarbons (PAH), have been implicated in many cases of biological damage (Connell, 1981). These substances can originate from a wide variety of diverse sources ranging from urban run-off to oil spills, and may suffer a similarly wide variety of ultimate fates, from degradation to incorporation into sediments. The identification and quantification of these sources and fates in the HRE would help clarify particular areas requiring research or management attention.

Consideration of the data and information available on the HRE, and other areas throughout the world, indicated the following inputs of petroleum:

INPUTS	Kg/d^{-1}
Sewage discharges	35,000
Oil refinery discharges	1,300
Non-oil refinery discharges	17,000
Oil spills	1,500
Atmospheric deposition	2
Urban and rural run-off	37,000
Total	91,802

The figures were calculated from discharge volumes and concentrations (Connell, 1982). These figures are approximate only since the data are from sources having limited distribution in time and space, or were taken from areas having somewhat different characteristics than the HRE.

Quantification of losses from the estuary posed considerable difficulties since this aspect has received less attention than inputs. From the literature (Connell, 1982) the following processes were quantified:

LOSSES	Kg/d^{-1}
Permanent deposition in sediments	10,000
Dredging	5,800
Advection	11,300
Bed sedimentary transport	70
Decomposition in water and sediments	42,000
Evaporation	400
Movement of surface slicks to the sea	400
Total	69,970

As with the input figures, these figures are approximate.

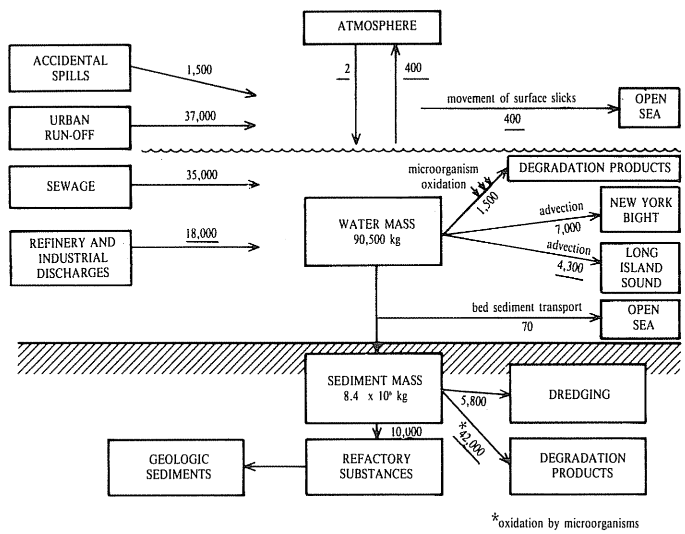

Figure 1. Diagram of transfers of petroleum hydrocarbons in the Hudson-Raritan Estuary (kg d^{-1}). Estimates considered to be of low to very low reliability are underlined.

A diagramatic representation of the processes involved is shown in Fig. 1. Reasonable agreement exists today between the total input (≈92,000 kg/day) and losses (≈70,000 kg/day). The role of the benthic sediments is clearly of critical importance. The bulk of petroleum in the system at any time (ca 98% by mass) is contained in this environmental segment. Degradation by microorganisms in the sediments results in the major loss to the system (60% of total) and the second most significant loss (14%) is the permanent deposition of the refactory substances in the petroleum in geologic sediments.

Export, by advection, dredged spoil disposal and bed sedimentary transport, to the New York Bight is significant but represents only a modest proportion of the total petroleum discharged to the HRE (ca 20%). The results also indicate a significant input of petroleum into Long Island Sound from the HRE.

It is interesting to note that oil spills comprise a minor proportion (ca 2%) of the total petroleum input and sewage discharges and urban run-off comprise the major source (ca 78%). However, oil spills present a number of problems in relation to birds, recreation and so on which do not occur as dramatically with the other sources.

In general, this analysis has shown that processes of removal and degradation of petroleum in aquatic areas need increased attention in order to understand the factors which control the occurrence of these substances. Within this general area the dynamics and metabolism of petroleum in benthic sediments is of particular importance.

This work was carried out by the author under the sponsorship of the Marine Sciences Research Center at the State University of New York with the advice and assistance of the MESA New York Bight Project, NOAA.

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Does Alteration of Freshwater Inflow Patterns Impact the Nursery Function of Estuaries?

In the southeastern coastal region of the United States, approximately 96% of the commercial and 58% of the recreational fishery yields are comprised of species which spend much of their early lives in estuaries prior to recruitment into a fishery. Estuarine systems provide these prerecruits with abundant food resources, a relative scarcity of predators, and low competition with adults. The importance of estuarine nursery grounds cannot be overstated. Therefore, an environmental change in an estuarine nursery area, e.g. alteration of freshwater inflow patterns, may be expected to alter production and recruitment to fishable stocks with a subsequent change in yield. Understanding how an environmental modification of an estuary impacts a fishery thus entails the development of an understanding of how the modification has changed food resources and predator abundance, and consequently growth and survival of fishery organisms.

Along a 50-mile-wide strip of land adjacent to the Gulf of Mexico from Florida to Texas, the current population growth rate is 23.7 people per 100 per year. This is more than three times the growth rate for the U.S. as a whole (Thayer and Ustach 1981). Man's modification of essential fishery habitat can be expected to accelerate with time as our population grows. Degradation of these critical areas unfortunately is cumulative. Therefore, a reliable information base is required to make rational management decisions regarding these habitats. Recent publications have documented many of the alterations to wetland systems in this region (e.g., Hackney 1978, Lindall et al. 1979, Armstrong 1982). As pointed out by Lindall et al. (1979), some of the most insidious perturbations include construction and maintenance of navigation channels, dredging and filling; ditching, draining and impounding of wetlands, petroleum exploration and production, and pollution from domestic, industrial, and agricultural discharges.

The upland and wetland areas of coastal Florida have undergone extensive development during the past 20 years. Two major developments near the Ten Thousand Island region of south Florida are Marco Island and Golden Gate Estates. The pattern of freshwater flow into Faka Union Bay (centrally located in the Ten Thousand Island region) was greatly altered by channelization of the upland drainage basin associated with the development of Golden Gate Estates in the 1960's. Freshwater from Golden Gate Estates now drains as a point source discharge into Faka Union Bay rather than flowing overland as it did previously. Subsequent to the development of the Faka Union Canal several scientific studies were carried out to sample fishery populations and habitats. The studies, however, did not specifically address the impact which this point-source discharge may have had on the nursery function of the Ten Thousand Island area in the vicinity of the Faka Union Canal.

The question posed by the title of this article is the subject of a study being conducted in the region by the NMFS Southeast Fisheries Center's Beaufort and Miami Laboratories. The two year study (FY's 82 & 83) is funded by the U.S. Army Corps of Engineers, Jacksonville, FL District. To address the potential impact of excessive freshwater inflow on the nursery function of the Faka Union Bay area, the laboratories have developed a two-pronged research approach. To place the acute effects of freshwater inflow into appropriate perspective, personnel from Ecology Division of the Beaufort Laboratory are conducting intensive short-term correlative studies relating fish and crustacean community characteristics such as species composition, abundance, average size, and food intake to such habitat characteristics as water depth, salinity and bottom type (sediments and vegetation). Samples are being collected during the summer rainy season over an 8-day period during each of the months of July, August and September. A stratified random sampling design is being employed within the impacted bay, and within the remainder of the bay system between Goodland and Chokoloskee Bays. The Miami Laboratory phase of the study is designed to describe and compare seasonal changes in abundances of larval and juvenile fishes and macroinvertebrates in Faka Union Bay and two adjacent bays. Sampling is being carried out along salinity gradients over a three day period each month for 18-months. Both laboratories are employing similar sampling techniques for fishery organism abundance assessments.

The impact of channelized flow into Faka Union Bay is being assessed by relating salinity to important estuarine characteristics such as relative abundance of fishery organisms, their distribution and feeding, and the habitat types utilized by these organisms. While not providing a direct measure of effects on recruitment, this study will clarify our understanding of the nursery function of the impacted bay and of adjacent bays of the system which are further removed from the point-source discharge of freshwater.

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Research & Monitoring Updates

Fate of Pentachlorophenol Introduced into the Mississippi River Gulf Outlet

On July 22, 1980, a ship collision on the Mississippi River Gulf Outlet near Shell Beach, Louisiana dumped 25,000 pounds of granular pentachlorophenol (PCP) into the water channel of the Mississippi River Gulf Outlet. PCP is a widely used wood preservative, an insecticide for termites, and a general herbicide. The Coast Guard vacuumed the bottom of the Outlet in early August in an effort to remove as much of the PCP as possible. It was not determined how much PCP was recovered using the vacuuming operation, but a significant amount remained in the system.

The presence of PCP as well as a host of other synthetic organic chemicals in riverine and coastal sediment-water systems is not new. Chronic, low-level movement of these synthetic organics into sediment-water systems as a result of agricultural and urban runoff and industrial discharges is a well-known phenomenon. The spill in the Mississippi River Gulf Outlet (a ship channel from New Orleans to the Gulf of Mexico) differed from typical, low-level releases in that a very large quantity of a fairly persistent, toxic organic was introduced into a biologically productive and economically important Louisiana Gulf Coast wetland ecosystem. Simply stated, this was a major chemical spill rather than a chronic, low-level input.

Sediment and water were collected from the immediate spill area in October 1980, for studying the degradation of PCP in laboratory microcosms and for determining its partitioning between dissolved and sediment-bound phases. By altering sediment pH and oxidation-reduction levels, it was possible to study degradation of ^{14}C-labelled PCP under a variety of natural conditions. In January 1982, sediment was collected from selected sites (Fig. 1) for determining the amount of PCP remaining in the spill area 18 months later.

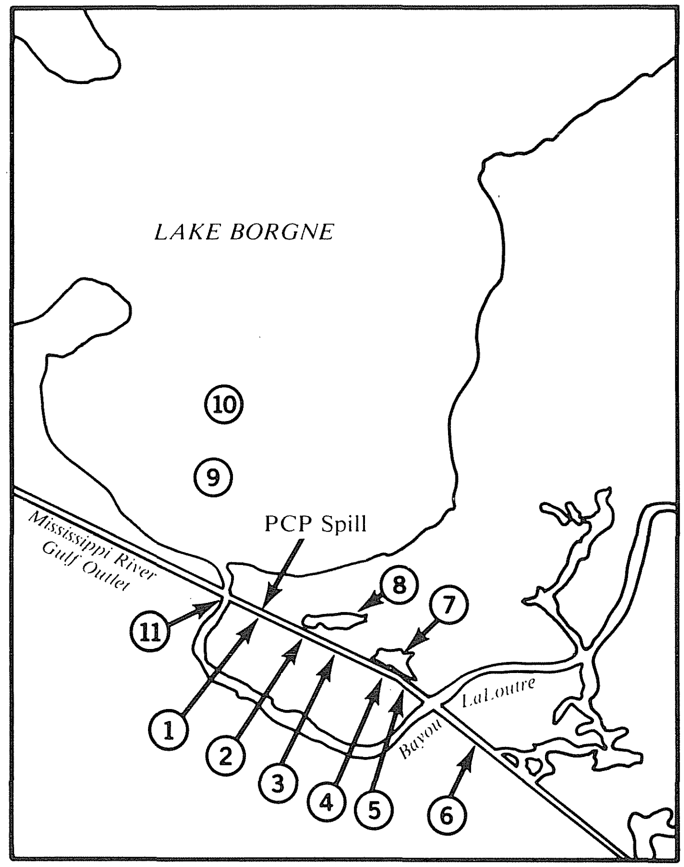

Figure 1. Map of spill area.

Though photodegradation in the water column, dilution, and tidal transport may have played a role in the removal of residual PCP from the spill area, the laboratory degradation studies conducted suggest degradation was rapid enough to account for the disappearance of any residual PCP left in the immediate vicinity of the spill or any PCP transported and deposited in bottom sediments of adjacent waterbodies. Analysis of PCP in field samples indicated almost no PCP present after 18 months. Degradation of PCP was strongly influenced by sediment pH and oxidation-reduction potential conditions. Degradation rates decreased with decreasing sediment oxidation-reduction potential or increasing anaerobiosis. Maximum degradation occurred at pH 8.0. Adsorption/desorption studies show PCP to be more tightly bound to oxidized sediment than to reduced sediment. This indicates a tendency for the compound to become associated with suspended particulates in the water column and a thin oxidized sediment horizon likely present at the sediment-water interface. Thus our work suggests this particular compound would tend to adsorb to sediments where the physicochemical conditions contribute to more rapid degradation.

Research was supported by the Louisiana Sea Grant College Program.

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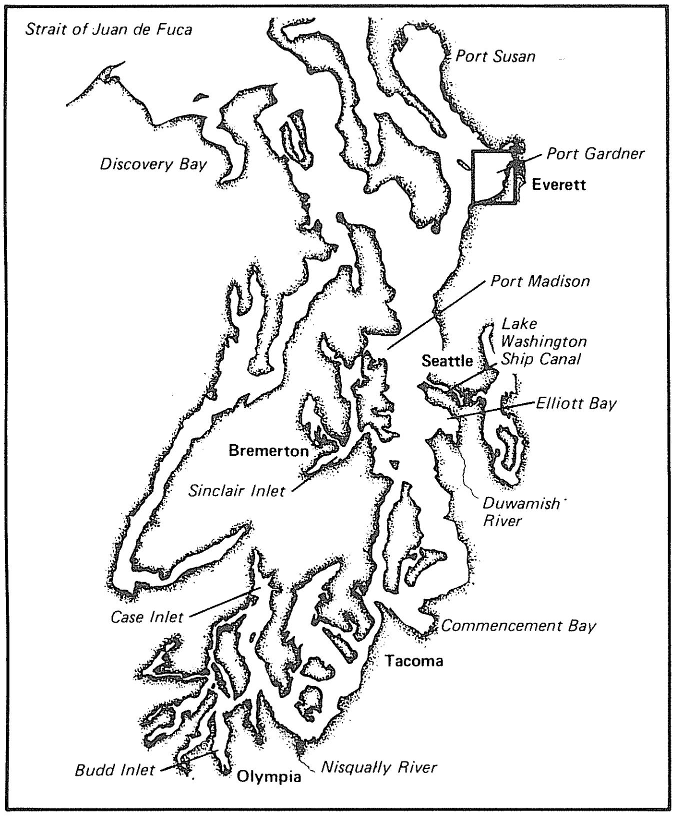
Liver Diseases of Bottom Fish from Everett Harbor, Washington

In August and September 1982, samples of English sole (*Parophrys vetulus*) and Rock sole (*Lepidopsetta bilineata*) were obtained from the Everett Harbor, Washington (see attached map, Fig. 1) and examined for pathological conditions. The prevalence of liver diseases in these fish was generally higher than was found elsewhere in Puget Sound, including the highly polluted Duwamish Waterway (Malins et al. 1982).



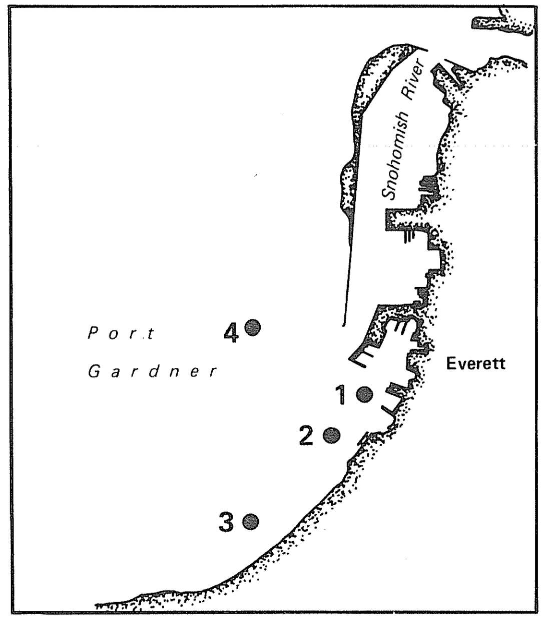


Figure 1. Locations of sampling stations.

Of 66 English sole examined at Site 1 in Everett Harbor (Pier 1), 70% had at least one type of liver lesion. Two of the most serious types of liver lesions were neoplasms (tumors, 12%) and specific degeneration/necrosis (53%) (Table 1). In a previous study (Malins et al. 1982), tumors and specific degeneration/necrosis were observed at frequencies of 16% and 21%, respectively, in livers of English sole from the Duwamish Waterway; 55% of the fish from the Duwamish Waterway of comparable age to the Everett fish had at least one type of liver lesion. English sole from Port Madison, a reference area, were virtually free of these diseases.

In addition to liver disease, 26% of the English sole from Everett Harbor had deformed fin rays. By contrast, 1.3% of the English sole from the Duwamish Waterway had eroded fins (Malins et al. 1982).

A smaller number (43) of Rock sole were collected at Site 1 in the Everett study. Liver diseases were found in this species, although the prevalence was lower than for the English sole; 44% of the Rock sole had one or more types of liver diseases, including 5% with liver tumors and 23% with specific degeneration/necrosis.

English sole obtained from three additional sites in Port Gardner (Fig. 1) had a lower disease incidence. These sites were located as follows: south of Everett Harbor (Site 2); next to Harborview Park, which is about one nautical mile south of the Harbor (Site 3); and across from the Harbor, just northwest of the mouth of the Snohomish River (Site 4). Liver tumors were not found in English sole from Site 4, and only 7% and 3% of individuals of this species from Sites 2 and 3, respectively, had liver tumors. Comparable trends in prevalences of degenerative liver lesions were also found (Table 1).

Types of Idiopathic Liver Disease	English sole				Rock sole
	Site 1 n=66[a]	Site 2 n=30	Site 3 n=31	Site 4 n=30	Site 1 n=43
Specific degeneration/ necrosis	53%	17%	0%	3%	23%
Non-specific degeneration/ necrosis	53	10	13	17	14
Intrahepatocellular storage disorders	23	3	0	3	12
Proliferative lesions	26	7	3	0	5
Preneoplastic lesions	17	3	6	0	2
Neoplastic lesions	12	7	3	0	5
Overall idiopathic liver lesion prevalence	70	23	19	17	44

[a] n = number of fish examined from each site

TABLE 1. Prevalences of idiopathic liver diseases in English sole and Rock sole from the Everett Harbor area.

Gas chromatograms of sediment extracts from the Everett Harbor showed that the sediment contained hydrocarbons and PCBs, as well as a large group of chemicals that were not resolved (unresolved components, Fig. 2.) The highest concentrations of unresolved components were found in the inner Harbor (A, Fig. 2). A chromatogram of sediment extract from a non-urban site, Port Madison (C, Fig. 2), which depicts relatively few unresolved components and a low level of chemical pollution, is provided for comparison.

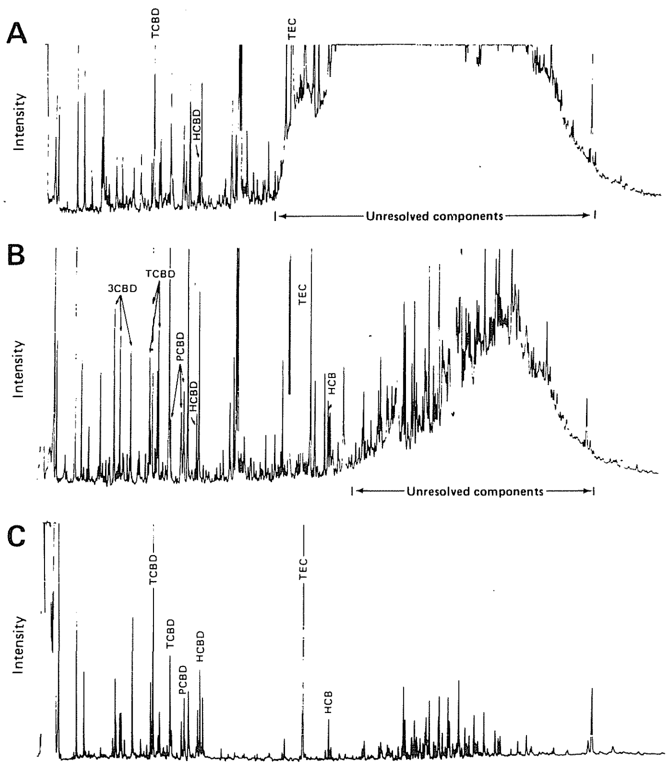


Figure 2. Gas chromatograms of sediment extracts, using electron capture detector. Samples from: A) inner reaches of Everett Harbor, north of Site 1; B) Site Site 1; C) Port Madison. Equivalent weights of sediment were analyzed in each case; technazene (TEC) was the internal standard.

The findings support the perception gained from studying other portions of Puget Sound that serious liver diseases in certain species of bottom fish are characteristic of urban areas containing relatively high concentrations of toxic chemicals in sediment.

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Climate Impact Assessment—Chesapeake Bay Marine Environment

The Assessment and Information Services Center (AISC) of NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) produces periodic assessments of weather impacts on economic sectors of marine activity. From September 1981 through March 1982, AISC issued monthly assessments of Chesapeake Bay covering fisheries, recreation, and transportation. Assessments are presently issued on a quarterly basis coinciding with the regional environmental cycle. The geographical area considered in the assessment includes the Chesapeake Bay and all its tributaries.

The quarterly assessment includes three sections: General Events and Impacts; Weather and Oceanography Summary; and Impact of Climate/Weather on Bay Fisheries, Recreation, and Transportation. The assessment reviews weather events and their effects on activities in the marine environment. Air temperature, precipitation, wind, and storm systems influence marine environmental variables such as water temperature, salinity, water levels, and ice. Meteorological data such as air temperature and precipitation are acquired through a network of National Weather Service stations around the Bay. Water temperature and salinity are acquired through a computerized database of NOAA's National Ocean Service. Other environmental data related to specific events are obtained from Federal and State governments, academia, and private industry. Long-term data records are acquired whenever possible to calculate normals. Departures from normal are then computed using long-term average and monthly values. Data are not available for every subject area and assessment frequently requires qualitative investigation and coordination with ongoing studies by Chesapeake Bay specialists.

The fisheries section assesses the impact of climate-weather on finfish and shellfish and their diseases and predators. Distribution and abundance of many species strongly depends on salinity and temperature regimes in the Bay which, in turn, relate to precipitation and air temperature. Harvest of commercial species varies with weather conditions, fishing effort, and market conditions.

Levels of recreational usage of the Bay are measured by indirect indicators including licenses and revenues, bridge traffic statistics, State park usage, marine accident statistics, and search and rescue operations. The recreational sector responds quickly to regional weather variations, but also correlates with localized pollution incidents and the presence of annoying or dangerous organisms in the water. The Bay is used heavily for recreation including swimming, boating, fishing, and tourism.

Shipping, dredging, ice clearing, and related shore activity are covered in the section on transportation. The ports of Baltimore and Norfolk-Hampton Roads are two of the largest ports in the United States. During most months of the year shipping and related shore activities remain unaffected by climate or other activity. During winter, however, severe ice conditions may affect transportation on the Bay.

Assessment categories are not limited to the fisheries, recreation, and transportation sectors. In addition, the assessment covers specific events related to industry, tourism, and marine pollution. The Bay and its tributaries form a large resource for disposal of waste from surrounding industry and populations. Heavy use of the Bay for transportation leads to an unavoidable number of spills of cargo substances, some harmless, others potentially harmful. Several types of events and activities such as oil spills and sewage disposal, are not routinely analyzed in quarterly assessments but are covered in a comprehensive Annual Summary. The first Annual Summary published was that of 1981. The 1982 Annual Summary is in preparation although no publication date has yet been set.

The Chesapeake Bay region served as a prototype for assessment development. AISC may expand coverage to other geographical areas as resources permit. For more information on AISC assessment capabilities or to obtain copies of publications, direct requests to: NOAA/NESDIS/AISC, Marine Assessment Branch, E/AI32, 3300 Whitehaven Street, N.W., Washington, D.C. 20235, or call (202) 634-7379.

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Bioavailability of Potentially Toxic Cadmium in Oysters During Trophic Transfer

Background

The potential toxicity to humans of cadmium contained in oyster meat is a function not only of the cadmium concentration in the oysters, but of the amount of cadmium assimilated from oyster tissue through the human intestinal membrane. Several metals, occurring both naturally and as contaminants in marine mollusks, are bound to various organic moieties (Ridlington and Fowler, 1979; Engel and Fowler, 1979; Sick and Fair, 1981; Siewicki et al., 1982a,b). The assimilation efficiency and potential toxicity of organically-bound metals, including cadmium, when ingested by consuming organisms is largely unknown. The objective of continuing research has been to investigate physiological mechanisms governing the trophic transfer and potential toxicity of organically-bound cadmium. Specific rationale for these investigations is to be able to assess more accurately the risk to human health associated with the consumption of seafood.

Experimental Design

Organically-bound cadmium in oysters was produced by exposing several groups of oysters to 1 ppm dissolved cadmium for 6 days. The form of the accumulated, organically-bound cadmium was characterized (according to molecular weight fractions) using molecular sieve columns in a coupled HPLC-AAS separatory-analytical system. Fractions of organically-bound cadmium and chemical transformation occurring during the vertebrate digestion process were measured using an *in vitro* model simulation of a vertebrate stomach and intestinal digestive environments. Chemical transformations during digestion in live fish were monitored at several stages during digestion by determining the concentration of cadmium associated with given protein size fractions. In addition, cadmium was expressed on a ninhydrin positive nitrogen basis as a mechanism of estimating association with free protein subunits (i.e. peptides and free amino acids). Comparisons were made between *in vitro* and *in vivo* digestion of cadmium-enhanced oyster tissue. Changes in bound amino acid composition of oyster tissue organic fractions having high amounts of free nitrogen (i.e. ninhydrin positive nitrogen) were also measured as evidence for protein degradation and cadmium binding to specific free amino acids or small peptides.

Results

Analyses of oyster tissue following exposure to 1 ppm of dissolved cadmium, indicated that cadmium was bound to molecular weight fractions of 20,000 to 40,000, 7,500 to 10,000, and <4,000 daltons. Concentrations of cadmium associated with these fractions were 145, 880, and 20,700 μg Cd (g protein)$^{-1}$ respectively. If cadmium concentrations were calculated on a nitrogen basis (estimate of association with small peptides and free amino acids), concentrations were non-detectable—3,600, and 14,000 μg Cd (g N)$^{-1}$ respectively.

Following digestion of oyster tissue in a simulated stomach environment, the association of bound cadmium in specific organic size fractions and the division of bound cadmium between total protein and total nitrogen was not statistically significantly different from the distribution found in undigested oyster tissue. After 9 to 12 hours of further digestion in a simulated intestinal environment, however, a significant increase in total ninhydrin positive nitrogen was observed compared with concentrations observed in undigested oyster tissue. Similarly, a significant amount of cadmium, relative to undigested oyster, was associated with fractions indicative of small peptides or free amino acids in tissue subjected to simulated stomach-intestinal digestion.

The distribution of cadmium during digestion of cadmium-enhanced oyster tissue in live black sea bass generally was predictable from results obtained using *in vitro* simulation of the live fish intestinal environment. However, much less cadmium *per se* was measurable and a much greater amount of cadmium was associated with free nitrogen (i.e. peptides and amino acids) fractions than predicted from the *in vitro* simulation model. Furthermore, in the *in vivo* intestinal environment, much less protein and free nitrogen was measurable compared to the *in vitro* model. Both discrepancies probably were attributable at least partially to the processes of assimilation and excretion.

Oyster tissue organic fractions having relatively small molecular weight (i.e. <4,000 daltons) had amino acid composition high in aspartic acid, glutamic acid, alanine, glycine, serine, leucine and valine. This composition, favoring dicarboxylic amino acids rather than sulfhydryls is in agreement with results reported by Ridlington and Fowler (1979) for a larger molecular weight cadmium binding fraction (i.e. ≈6,000 to 10,000 daltons). This correlation suggests that observations in the present study were degradation products of protein digestion. During intestinal digestion *in vivo*, bound amino acids in both the 8,000 to 10,000 molecular weight units and the fraction <4,000 daltons decreased significantly. Furthermore, aspartic acid, glutamic acid, alanine and glycine preferentially decreased from protein fractions, presumably due to digestion.

Conclusion

Results from this investigation, as well as from experiments in progress, suggest that organically-bound cadmium in oyster tissue becomes progressively associated with smaller molecular organic moieties (probably small peptides and primary amines) during the process of digestion in fish. Similar observations, using other molecular weight fractions, have been observed in rats (Siewicki et al., 1982a). Many of the individual amino acids identified and measured in small molecular weight fractions associated with intestinal cadmium complexes were those amino acids known to be actively transported through vertebrate intestinal membranes and also complexed with selected minerals in enhancing active intestinal absorption of minerals (e.g. Wasserman et al., 1957). It is, therefore, likely that the quality and quantity of proteins ingested or complexed with ingested cadmium will have a significant effect on cadmium bioavailability and potential toxicity. The amount of cadmium available to oysters initially may also affect the mechanisms regulating trophic transfer. For example, recent evidence has suggested that for exposures to relatively low concentrations, detectable amounts of cadmium are not bound to the 6,000 to 10,000 molecular weight fraction in oysters (Siewicki et al., 1982b).

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Metal Loading to Narragansett Bay, Rhode Island

Metals enter coastal marine ecosystems through a variety of point sources (rivers, domestic sewage discharges, industrial discharge pipes) and non-point sources (atmospheric and urban runoff). Assessment of metal loading to coastal ecosystems can be achieved by sampling the sources near the points of discharge or by estimating accumulation rates in sediments. The latter estimates measure only the metals which are retained in the sediment and thus do not necessarily indicate the total loading to the system. The head of Narragansett Bay is typical of estuaries which have undergone urbanization and industrialization. Industrialization of this region began in 1805 when Samuel Slater established the first cotton mill, initiating the industrial revolution in the United States. During the intervening years a variety of industrial, commercial and residential land uses have developed, with the jewelry industry becoming particularly important to the region.

During the 1970's several sources of metals and hydrocarbons to Narragansett Bay were identified. In spite of this, a consistent, coordinated program to quantify the relative importance of all discharge sources to the upper bay was not established, leaving little information by which to describe modern loading of pollutants (Olsen and Lee, 1979). In late 1979 a program to quantify major sources of nutrients to the upper Narragansett Bay region—rivers and sewage treatment plants—was initiated in conjunction with a study of ecosystem recovery conducted at the Marine Ecosystems Research Laboratory (Oviatt, 1981). A study designed to estimate hydrocarbon inputs from urban runoff was also in progress at the time (Hoffman et al. 1983). Personnel involved in these studies collected samples for metal analysis. Samples from the Pawtuxet and Blackstone Rivers and effluents from the three major sewage treatment plants discharging into the upper bay were collected every two weeks between January and September, 1980. Urban runoff samples from four representative land uses—commercial, residential, industrial and highway—were obtained during 10 storms in 1980. Metal concentrations in unfiltered, acidified (pH 2.5) samples were determined by flame or flameless atomic absorption spectrometry. Standard protocols to avoid contamination of samples were observed.

Annual input of metals in urban runoff was calculated by determining the average flux of metal from each land use (kg cm^{-1} rainfall, km^{-2} land use) during storm surges. This flux was multiplied by the total area associated with each land use in the upper Bay drainage basin (from Hoffman et al. 1983) and the average annual rain fall (100 cm). The total runoff from urban areas was estimated by summing all land use estimates. Input from rivers and treatment plants was estimated from the time weighted mean discharge rate (kg d^{-1}). The annual inputs of metals in urban runoff and other sources are summarized in Tables 1 and 2.

Land Use	Fe	Mn	Cu	Pb	Cd
Commercial	6.1	0.42	0.16	2.2	0.03
Residential	26.8	11.1	0.65	5.6	0.05
Highway	15.1	5.4	2.37	18.7	0.04
Industrial	20.1	1.9	1.09	5.0	0.02
Total	68.1	18.8	4.27	31.5	0.14

Table 1. Annual input of metals from urban runoff to the upper Narragansett Bay drainage basin (metric tons y^{-1}).

Source	Fe	Mn	Cu	Pb	Cd
Blackstone River	592	88	12.0	7.2	1.7
Pawtuxet River	207	44	4.0	1.2	0.24
Fields Point Sewage Treatment Effluent	138	31	50.4	—	—
Bucklin Point Effluent	28	5.5	2.2	0.7	0.02
Riverside Effluent	3	1.5	0.6	0.04	0.002
Urban Runoff	68	19	4.3	32	0.14
Total	1036	189	75.5	41	2.1

Table 2. Annual input of metals (metric tons y^{-1}) to upper Narragansett Bay from both point and nonpoint sources.

Generally, urban runoff from residential, highway and industrial land uses was more important than from commercial areas. Highway runoff contributed the majority of the Cu and Pb to urban runoff while iron was associated primarily with industrial and residential land uses. Manganese was associated primarily with residential runoff while Cd was equally distributed between all land uses studied.

Estimates of metal loading to upper Narragansett Bay from urban runoff agree reasonably with calculations based on urban land use loading factors employed by Graber (1978) in compliance with Section 208 Water Quality Planning Management Project for this region (Hoffman, personal communication). Except for Pb, urban runoff accounts for only 6 to 10% of the total metal loading to the upper Narragansett Bay. The Cu loading was dominated by sewage inputs (72%), Cd by the Blackstone River (81%), Fe (77%) and Mn (70%) by river input.

Data on Pb and Cd in effluents from the Fields Point treatment plant were not collected. However, estimates of the contribution of trace metals based on the Fe/metal ratio in the Bucklin Point effluents or the increase in Cu between Bucklin Point and Fields Point suggests the total Pb and Cd inputs shown in Table 2 are not more than 20% low.

This preliminary quantification of metal loading to Narragansett Bay indicates that the metals come from a variety of sources and that one source does not dominate the input of all metals. The loading estimates for Pb and Cu based on runoff sources to Narragansett Bay are also within the range of accumulation rates found in the sediments of the Bay by Santschi et al. (In prep.). Thus, within the constraints of these estimates, these metals appear to be primarily retained within the Bay as expected for those metals showing high affinity for particles.

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Summary of Biological Baseline Inventory in San Pedro Bay, California

As reported earlier in COPAS (Vol. 2, No. 1) a baseline inventory of selected marine resources in a portion of San Pedro Bay, California, was undertaken by the Southern California Ocean Studies Consortium, California State University and funded by the Los Angeles Harbor Department. This study provides a basis for assessing impacts of a proposed landfill in the study area. A brief summary follows.

More than 8400 juvenile-adult fishes belonging to 50 species, weighing over 950 kg were collected in otter trawl and gill net samples taken every other month during the survey. *Genyonemus lineatus, Seriphus politus* and *Atherinopsis californiensis* constituted over 77 percent of the total numbers. *A. californiensis, G. lineatus* and *Myliobatus californica* together accounted for 52 percent of the biomass. Juveniles comprised almost 58 percent of the total number of individuals. Three species, *Engraulis mordax, Pleuronichthys ritteri* and *Sardinops sagax* were represented by all four life history stages (egg, larval, juvenile, adult). More than 7500 eggs (10 identified taxa) and almost 6200 larvae (24 identified taxa) were collected in plankton samples. Eggs of *Sciaenidae* (68% of total) and larvae of *Gobiidae* (70% of total) and *Engraulis mordax* (21%) dominated the collections.

A total of 180 species of invertebrates and 19,974 specimens were collected during the four benthic surveys of which 83 (46%) were polychaetes, 37 (21%) were mollusks, 49 (27%) were crustaceans, and 10 (6%) were in remaining groups (cnidarians, flatworms, nemerteans, phoronids, echinoderms). Polychaetes constituted the dominant group by number with a total of 15,567 specimens (80%); crustaceans accounted for 3059 (15%), mollusks for 1111 (5%) and the remaining animal groups for 337 (1+%) specimens.

The rip rap survey consisted of observation of the conspicuous organisms within 1.0 m^2 areas and subsamples of 17 cm^2 within the 1.0 m^2. Biomass within the 17 cm^2 samples varied considerably (0.01 g - 79.48 g wet weight). Barnacles contributed most of the biomass in the high intertidal zone and *Mytilus edulis* in the low intertidal zone.

It is important to consider seasonal variation whenever this method of study is used for environmental assessment. Seasonal differences in the number of species in the subtidal sites were greater than in the intertidal zone. The number of species varied from 6 to 49 at one station and 2 to 29 at another. One station exhibited a reduction in species composition in December 1981 and the other in March 1982. The fluctuations in species composition and population can be largely attributed to seasonal variations in smaller crustaceans (harpacticoid copepods, tanaids and amphipods) and to a lesser extent in the polychaetes.

A total of 61 species of birds was recorded in the project area. On single surveys the number of species present varied from 11 to 32 species; the number of individuals varied from 172 to 1771. Double-crested Cormorants and Western Gulls were the only species recorded on all 24 surveys. An additional 10 species were recorded on 75 percent or more of the surveys: Western Grebe, Pelagic Cormorant, Great Blue Heron, Surf Scoter, Black-bellied Plover, Willet, California Gull, Heerman's Gull, Forster's Tern and Caspian Tern. Several species were present regularly (Western Grebe, Double-crested Cormorant, Surf Scoter). Most individuals belonged to the 9 species of gulls.

Two endangered species utilized the study area. The California Brown Pelican was frequently observed in numbers ranging from 1 to 198. They were most abundant from July to November. This coincides with the time of dispersal of adults and young birds from the local breeding colonies and a typical northward influx of birds from breeding colonies in coastal Mexico and the Gulf of California. The California Least Tern also utilized portions of the area for nesting and feeding.

A majority of the bird species recorded were migratory. They must depend on a steadily decreasing amount of suitable habitat both in breeding and wintering areas as well as stop-over points en route. Thus it is important not only to consider the effects of decreases in habitat on permanent or nearly permanent resident species, but also on those species present for only a part of the year or for only a brief interval during migration.

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Announcements

The 1983 Great Lakes Research Conference

The 26th Conference on Great Lakes Research and Annual Meeting of the International Association for Great Lakes Research will be held in Oswego, New York, from 24-26 May 1983 at the State University of New York College at Oswego campus. The College is located on the southeastern shore of Lake Ontario, 45 miles north of Syracuse and 60 miles east of Rochester. Diverse and interesting environments, including Lake Ontario and its coastline, the Oswego River watershed (second-largest drainage basin in New York State), the Tug Hill Plateau, Adirondack Mountains, the Finger Lakes Region and the Thousand Island area, are all within a 100-mile radius of Oswego.

The State University Research Center at Oswego, in conjunction with the College at Oswego and the New York Sea Grant Institute, are co-hosting the Conference. The conference location is right on the lakeshore with all scheduled activities to be conveniently held on campus. For further information contact:

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International Symposium on Coastal Pollution and Productivity Held in Brazil

A symposium entitled "International Symposium on Utilization of Coastal Ecosystems: Planning, Pollution and Productivity" was held at the University of Rio Grande in Rio Grande, Brazil from November 21-27, 1982. This meeting was attended by more than 600 participants from 25 countries including 32 scientists from the United States. The sponsoring institutions were the University of Rio Grande and Duke University Marine Laboratory. Financial support was received from several agencies within the Brazilian government as well as from UNESCO, UNEP, NOAA and the Rockefeller Foundation. The primary organizers from the Symposium were: Symposium Chairperson -Dr. John Costlow (Duke University Marine Laboratory), Secretary General - Dr. Labbish Chao (University of Rio Grande), and Executive Secretary - Prof. Mario Figueiredo (University of Rio Grande).

Over 150 papers (both invited and contributed) were presented in either English or Portuguese during the meeting and covered a wide range of topics including coastal and estuarine ecology, marine pollution and coastal zone management. The abstracts are published in *Atlantica 5*(2): 1-134, 1982 and proceedings of the symposium will be published. For further information concerning the symposium or its forthcoming proceedings please contact: Dr. William Kirby-Smith, Duke University Marine Laboratory, Beaufort, NC 28516.

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Calendar

May

2-5
1983 Offshore Technology Conference, Houston, TX. Contact: Program Manager, OTC, 6200 N. Central Expressway, Drawer 64706, Dallas, TX 75206.

9-13
17th Intl. Symposium on Remote Sensing of Environment, Ann Arbor, MI. Contact: Remote Sensing Center, Environmental Research Institute of Michigan, PO Box 8616, Ann Arbor, MI 48107.

15-18
39th Northeast Fish and Wildlife Conference, Mount Snow Resort, Dover, Vermont. Contact: Angelo Incerpi, Agency of Env. Cons., Fish and Game Dept., State Office Bldg., Montpelier, VT 05602.

May-June

30-3
1983 AGU Spring Meeting, Baltimore, Maryland. Contact: Spring Meeting, American Geophysical Union, 2000 Florida Avenue, NW, Washington, DC 20009.

June

1-4
Coastal Zone '83, San Diego, CA. Contact: Coastal Zone '83, PO Box 26062, San Francisco, CA 94126.

Viewpoints

Position Paper on Land, Sea, and Air Options for Waste Disposal

In my view, the choice of a waste disposal medium should be governed by a number of basic policy and scientific considerations which can be summarized as follows:

- **Minimization of risk**—for wastes containing persistent toxic chemicals, no waste disposal medium or method will be totally free of risk to health or the environment; the objective of management should be to achieve the greatest degree of risk reduction (and not merely the least costly alternative that will meet minimal environmental standards).
- **Subordination of economic considerations**—any multi-medium or multi-method comparison of waste disposal options must first and foremost assess comparative risks to health and the environment; only afterwards should the environmentally preferred alternatives be assessed as to their economic feasibility. This enables increments of environmental protection to be weighed against increments in cost. Any economic comparison must address significant externalities as well as more readily quantifiable costs and benefits to ensure that cost savings to the waste disposer are not achieved at the expense of the environment or society at large.
- **Subordination of public opinion**—while every effort must be made to fully ventilate the issues publicly and to solicit and address legitimate public concerns, waste management decisions should be made on the basis of minimizing environmental and public health risks. An otherwise optimal site or method should not be rejected simply because of public opposition.
- **Matching of wastes to disposal media and methods**—simply because a waste contains persistent toxic contaminants does *not* mean it will pose the same environmental hazard no matter how it is treated or disposed of. Obviously, thermal destruction of organics and organohalogens will pose less residual risk than landfilling or open water disposal. On the other hand, certain heavy metal-containing wastes are doubtless better land-applied than incinerated or ocean-dumped. Controlled land-application

of contaminated sewage sludges, for example, can greatly minimize the risk of food-chain contamination by heavy metals as compared with either ocean disposal or incineration. Even with regard to persistent organic contaminants, application to the land may favor the proliferation of microorganisms capable of eventually degrading these compounds to a degree unlikely to be approached in the ocean disposal context. Waste management decisions must assess the comparative effectiveness of waste destruction, neutralization, and/or inactivation (as well as of waste isolation/containment) of alternative disposal methods and media.

- **Maximization of management control**—the more persistent and the more toxic a waste, the more management it needs. Open-water dispersal offers very little in the way of management potential. Once you release a material into the water, your control over it is effectively lost. It becomes subject only to the vicissitudes of winds, currents, and biological availability. By contrast, virtually complete thermal destruction provides the ultimate in management control. Confinement on land—at sites with low water tables, high cation-exchange capacities, low porosities, and large distances or lack of ready access to surface waters—presents an intermediate, but potentially high, degree of management control.
- **Isolation-containment of persistent toxics**—biodegradable organic matter, such as human sewage, and readily assimilable materials such as nutrients, acids, and alkalis, can appropriately be disposed of under conditions designed to maximize dispersal and dilution. Persistent, toxic pollutants on the other hand—particularly those with a propensity to accumulate in living tissues—cannot be detoxified and dissipated through mere physical dispersion. Spreading such pollutants around to the point that they can no longer be detected may simply frustrate any ability to monitor, manage, or modify the discarded material. In general, persistent toxics—to the extent they cannot be destroyed or beneficially recycled—should be isolated and contained to maximize the opportunity for management and monitoring control.
- **Avoidance of cumulative harm**—the tendency to engage in case-by-case cost-benefit balancing may well be environmentally counter-productive. Where multiple waste-disposers or pollutant sources contribute to the aggregate degradation of an area, we need to be as concerned about resolving that problem as we are when only one or two very visible and identifiable polluters are responsible for the same degree of degradation. There is something offensive about the argument that there is no point in requiring a fractional contributor to a pollution problem to abate it because even if that polluter cleans up, a badly degraded environment will persist. Waste management decision-makers must take the long view and consider the cumulative as well as the individual consequences of their actions.
- **Pre-disposal screening**—some common-sense maxims are equally valid in the waste management context. For example "look before you leap" and "an ounce of prevention is worth a pound of cure." Reliance on screening procedures to detect a potential problem *before* pollutants are injected into the environment is far better than seeking to undo an environmental problem which has been allowed to occur. While it may take decades, if at all, to identify and rectify a problem once a persistent toxic chemical enters the environment, it may take only months or years for the problem to reach crisis proportions. During this period, irreversible or irreparable damage can be done. After-the-fact monitoring is a poor substitute for precautionary, preventive testing and regulation. Both are necessary.
- **"Early warning" monitoring**—expanded use of "sentinel organisms" which could provide an early warning of the assimilative capacity endpoint in the marine environment, and analogous indicators in the land and air environments, should be encouraged, including making such monitoring part of applicable regulatory responsibilities of waste-disposers. The "Mussel Watch Program" is an example of the use of this approach.
- **Definition of "unreasonable risk"**—how much harm to the environment, and how great a risk of such harm, is too much? A judgment on this question underlies every regulatory decision to grant or deny a disposal permit. And although such judgments largely hinge on value systems, science can and does have an important role to play in suggesting criteria and endpoints for such judgments.
- **Source reduction and beneficial use**—Basic thermodynamics suggests that more energy (and usually more money) must go into controlling the same amount of pollution the further one gets from the pollution source. To the extent contaminants can be kept out of the waste stream, the risks posed by all disposal methods and media diminish. Where recovery and beneficial use of waste stream constituents can also be achieved, further net benefits or reduced costs may be realized.
- **Protection of the ocean "commons"**—the ocean as a disposal medium is fundamentally different in at least one respect from disposal on land. In the land environment, marketplace and political forces are fully operative and demand accountability. For example, a land disposal site must be purchased or leased, displaced residents or businesses must be compensated, and nearby communities and their political representatives must be appropriately reassured. The ocean, by contrast, is a "free" dumping ground; nobody owns it, so no one need be compensated for its use or abuse. Moreover, the ocean, since it represents nobody's "backyard," furnishes a convenient expedient to politicians whose constituents object to having wastes put down anywhere in their neighborhoods. Out of sight all too often is out of mind. And fish don't vote. Moreover, the ocean as a global "commons," encourages over-exploitation. Common resources are inevitably used to the point of destruction. To treat the ocean the same as other disposal media would be to condemn it to preferential use and abuse. True equality demands an extra degree of government regulation to ensure wise management consistent with the ocean's assimilative capacity. It also requires internationalization of the "external costs" of ocean disposal and assurance that an appropriate value will be placed on reducing risks associated with uncertainties.
- **Safety margins and burden-of-proof**—given our generally rudimentary ability to predict the fate and effect of toxic pollutants in the environment, lack of observed effects under field conditions can seldom be equated with lack of risk. Therefore, persistent toxic chemicals must be presumed dangerous unless the would-be disposer can prove otherwise.

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