ISSN 0738-2472

COASTAL OCEAN POLLUTION ASSESSMENT NEWS

MAN AND THE MARINE ENVIRONMENT

COPAS

Volume 3 Number 1 **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.

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

In This Issue

Episodes

Localized Hypoxia Recurs in The New York Bight

U.S. Environmental Protection Agency (EPA) and National Ocean and Atmospheric Administration (NOAA) research and monitoring activities have recorded this summer the evolution of another episode of hypoxic bottom waters. This condition has been forming in a nearshore band (< 20m depth) along the New Jersey coast, and in deeper parts of the New York Bight apex. In 1976 a large area (~ 8,600 km^2) of the intermediate New Jersey shelf, seaward of this nearshore zone, was affected by severe oxygen depletion and hydrogen sulfide formation. These conditions resulted in substantial losses of benthic resources. (Swanson and Sindermann, 1979). More localized "fish kills" along the New Jersey coast and in the New York Bight apex apparently have occurred in 1968, 1971, and 1974. However, for these localized episodes there is no evidence for unusual abundance of the respiring dinoflagellate, *Ceratium tripos*, which was implicated in the 1976 event. The first evidence of apex hypoxia was discovered by investigators from the Woods Hole Oceanographic Institution during 1948-1949 ocean dumping studies (O'Connor, et al., 1977)

Stoddard (1983) has simulated the evolution of the 1976 episode with a numerical model of carbon/oxygen/nitrogen cycling. His results clearly illustrate the importance of circulation in confining *C. tripos* and anthropogenic waste inputs to the affected region. He attributes the major part of the dissolved oxygen (DO) decline to decomposition of an unusually large *Ceratium* bloom. According to the simulation, carbon from dumped sewage sludge accounted for less than 5% of the bottom oxygen demand. Simulations without *C. tripos* showed no anoxia for 1976 environmental conditions, while a tenfold increase in anthropogenic loadings (carbon and nitrogen) produced a localized hypoxic region (~30 km radius about the Christiaensen Basin). For the latter case Stoddard (personal communication) was unable to distinguish estuarine from ocean dumping contributions to sub-pycnocline oxygen demand.

Boesch (1983) notes the often overlooked existence of a similar nearshore hypoxic situation that develops periodically in the northwestern Gulf of Mexico along the Louisiana and Texas coasts. Large freshwater discharge and related, enhanced stratification, followed by calm weather conditions, seem to influence the extent, intensity, and persistence of hypoxia in that region. Boesch speculates that phytoplankton production, stimulated by riverine nutrients, is responsible for the oxygen demand. (Spring Mississippi nitrate concentrations have doubled in the past 25 years.) (Boesch, 1983)

Malone, et al. (in press) have examined in considerable detail nutrient cycling and plankton dynamics in the Hudson-Raritan estuarine plume. Apex phytoplankton production (averaging 590 g C $m^{-2}y^{-1}$) generally is not nutrient limited and exceeds, by more than threefold, anthropogenic particulate organic carbon input, except during late fall-early winter. They attribute little direct impact on local bottom DO to phytoplankton production. During the stratified season, copepods graze and produce fecal pellets which account for an estimated 37% of the local sub-pycnocline oxygen demand. The remaining oxygen demand appears to be due to organic inputs from estuarine runoff and ocean dumping. During the non-stratified season most biomass (and presumably most anthropogenic inputs) is exported from the apex, preferentially along the New Jersey coast, because of prevailing winter circulation.

The normal DO decline cycle in sub-pycnocline waters over the New Jersey shelf usually shows a minimum of about 3.5 ml^{-1} between late August and early September. During most years since 1976 intensified monitoring activities by EPA and NOAA's Northeast Monitoring Program (NEMP) have revealed the formation of some relatively low DO area(s) along the New Jersey coast (<3.0 ml^{-1} generally at water depth < 30m) and/or in deeper apex locations. These annual minima have occurred as early as mid-July and as late as mid-September. Although anoxia has not been documented, the areas most severely affected (occurring more frequently north of Barnegat, NJ) have had levels of DO below 1.0 ml^{-1}. Such conditions have persisted for a number of weeks during several years. The distribution, extent, intensity and persistence of the hypoxia are sensitive to both local and regional meteorological conditions. These conditions influence local vertical replenishment (particularly at shallower water depths), horizontal mixing, and advection of the hypoxic water mass.

Special problems of monitoring are illustrated nicely in a data set being developed this year by the National Marine Fisheries Service's (NMFS) Sandy Hook Laboratory (J. O'Reilly, personal communication). Since May, a transect of seven stations (about 22 km south of Sandy Hook, NJ), extending east from the Long Branch, NJ pier to the Hudson Shelf Valley, has been sampled on a weekly basis. Figure 1 presents bottom DO concentraions at Station 3 (13 m depth, 3.5 km offshore) and Station 7 (60 m depth, 14.5 km offshore, in the Hudson Shelf Valley). Prior to late July, the average DO decline rate decreased monotonically from about 0.09 ml^{-1}/day nearshore to <0.02 ml^{-1}/day in the Hudson Shelf Valley. Based on these trends and the climate outlook, anoxic conditions would have been anticipated by early August at shallow, nearshore locations. The remaining record reveals, however, an entirely different outcome, one not expected but within the realm of monitoring experience for the area.

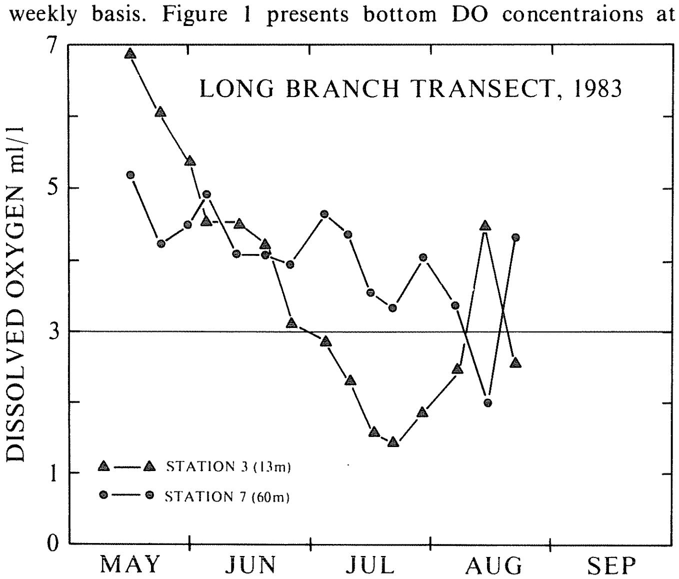


Figure 1. Bottom dissolved oxygen concentrations at two stations off northern New Jersey during summer 1983. (Data Source: J. O'Reilly, NMFS Sandy Hook Laboratory)

A preliminary assessment of climatological data reveals the existence of strikingly quiescent conditions (few storms, light and variable winds) since early June. Wind speed for June and July, at John F. Kennedy Airport, was 15 and 23% below normal, respectively. That situation appears to be continuing in August. The effects of infrequent, mild frontal systems and local thunderstorms, prior to 25 July, can be seen as breaks and temporary reversals in the DO decline trend. Late July and early August were characterized by more frequent, scattered thunderstorms. The period culminated in a regional northeasterly wind event lasting about 48 hours (12-13 Aug). At station depths less than 25 m, vertical replenishment is seen in the elevated DO levels and a total erosion of thermal stratification (not shown). At deeper stations in and near the Hudson Shelf Valley, the inverse is observed, probably due to wind-forced advection of hypoxic waters down the Hudson Shelf Valley from the Christiaensen Basin (the deep apex depression situated between the sewage sludge and dredged material dumpsites). Although not clearly obvious in the NMFS data, enhanced southerly transport and a tendency for offwelling of hypoxic bottom waters would be consistent with the northeasterly wind forcing. The northeasterly event was followed by a return to the earlier quiescent meteorological conditions. Waters have returned nearly to DO concentrations existent before the northeasterly event. For at least part of the hypoxic water mass, this suggests that recirculation of the previously displaced water may occur with little mixing.

Similar to the Gulf situation, the occurrence of hypoxia in the Bight seems to be associated with high freshwater discharge, although the effects may not be as immediate and direct in all cases. Notwithstanding data paucity, it may be significant that no occurrences are reported during the 1961-1967 drought period in the Northeast. Conversely, the period since 1971 has been characterized by above normal river discharge and frequent occurrences of hypoxia. Although the influence on stratification is not as great as in the Gulf, early and sustained high river discharge more profoundly influences the Bight-wide density structure (supporting convergent nearshore circulation) than later or episodic discharge events. Also this early non-stratified condition seems to optimize the anthropogenic loading (due to enhanced export from the apex and local inputs) throughout the New Jersey nearshore (Malone, et al., in press). This appears to be the case for 1978 and 1983. Later or short-term discharge events seem to cause more localized, even more intensive events, but without the preconditioning of shelf-wide structure (which increases vulnerability to erosion by wind events).

Despite the variable nature of the DO phenomena, an average picture emerges over recent years. Chronically low dissolved oxygen concentrations, that increase somewhat with water depth and distance from shore, evolve during summer along the New Jersey coast, except within the Christiaensen Basin and upper Hudson Shelf Valley (where severe hypoxia also occurs). The Long Island coastal waters exhibit virtually no hypoxia. To what extent these conditions are caused by anthropogenic inputs or are in the domain of natural variability for the New Jersey nearshore remains an open research question.

References

Boesch, D.F. 1983. Implications of Oxygen Depletion on the Continental Shelf of the Northern Gulf of Mexico. *Coastal Ocean Pollution Assessment News* 2(3):25-28

Malone, T.C., C. Garside, C.D. Litchfield and J.P Thomas. In press. Synoptic Investigation of Nutrient Cycling in the Coastal Plume of the Hudson and Raritan Rivers: Plankton Dymanics. NOAA Technical Report, NOS- . 119 p.

O'Connor, D.J., R.V. Thomann, and H.J. Salas, 1977. Water Quality. MESA New York Bight Atlas Monograph 27, New York Sea Grant Institute, Albany, NY. 104 p.

Stoddard, A. 1983. Mathematical Model of Oxygen Depletion in the New York Bight: An Analysis of Physical, Biological and Chemical Factors in 1975 and 1976. Ph.D. dissertation, University of Washington, Seattle, WA. 359 p.

Swanson, R.L and C.J. Sindermann (eds.). 1979. Oxygen Depletion and Associated Benthic Mortalities in New York Bight, 1976. NOAA Professional Paper 11. 345 p.

Charles A. Parker
NOAA/NOS/Ocean Assessments Division
Coastal and Estuarine Assessment Branch
Old Biology Building/SUNY
Stony Brook, NY 11794

Loomings

Coastal Wetland Loss in Louisiana

Loss and modification of coastal wetlands due to erosion, dredging and saltwater intrusion have increased to what many in Louisiana feel are crisis proportions. Although the patterns of wetland deterioration resulting from natural geomorphic processes in the Mississippi River delta have long been known (Russell, 1936), detailed habitat mapping studies based on aerial imagery have recently documented surprisingly large rates of wetland loss. In studies for the U.S. Fish and Wildlife Service's National Coastal Ecosystems Team, Gosselink et al. (1979) estimated an average annual rate of coastal wetland loss between 1955 and 1978 of 83 km^2/yr for the Deltaic Plain of southeastern Louisiana. Furthermore, comparisons of loss rates estimated by map comparisons for various intervals during this century indicate a geometric increase in this rate with time, the extrapolation of which yields a 1980 rate of 102 km^2/yr for the Mississippi Deltaic Plain alone (Gagliano et al., 1981).

A review of the causes and consequences of coastal erosion and wetland modification in Louisiana and the options available to slow these losses has been published in the proceedings of a conference on the subject (Boesch, 1982) available from the U.S. Fish and Wildlife Service, National Coastal Ecosystems team, 1010 Gause Blvd., Slidell, LA 70458.

conference on the subject (Boesch, 1982) available from the U.S. Fish and Wildlife Service, National Coastal Ecosystems team, 1010 Gause Blvd., Slidell, LA 70458.

The cause of the rapid and increasing rates of coastal wetlands loss are complex, but involve at least the senescence of the active delta, regional and localized subsidence (perhaps increased by oil and gas withdrawals), leveeing of the Mississippi River which has prevented the sediment subsidy necessary for accretion to counteract subsidence, and the effects of channelization of wetlands. The rapid deterioration of the barrier islands along the otherwise muddy southeastern coast also raises the specter of greatly accelerated wetland loss when the wetlands are directly exposed to wave energy from the Gulf of Mexico.

Man has clearly played a role, in consort with natural processes, in accelerating coastal land loss. Of particular concern is the effect of dredging of canals in wetlands for access to oil and gas well sites, pipeline corridors, and navigation canals. From 25% to over 50% of the wetland loss has been directly or indirectly attributed to these activities by various investigators.

The potential effects of these coastal changes on living resources and human society in south Louisiana are massive. The coastal wetlands of Louisiana are a major contributor to national fisheries and wildlife resources. Louisiana leads the nation in volume of fishery landings, most of which are of estuarine dependent species (penaeid shrimp and menhaden), and in fur production. Extrapolating the present rate of losses, several coastal parishes (counties) have life expectancies in the range of 50 to 100 years, and enormous social and economic dislocations would result from their disappearance.

Several structural and management approaches to stemming coastal land loss have been proposed. These range from allowing the substantial diversion of the Mississippi River down the Atchafalaya River (a change which should occur naturally) in order to promote rapid delta building to a more restrictive policy regarding activities in wetlands. In recognition of the seriousness of coastal land loss, the Louisiana Legislature in 1981 established the Coastal Environmental Protection Trust Fund of $35 million. This money is to be applied to studies and the development of projects such as smaller controlled river diversions, barrier island stabilization, wetlands management, and projections of future coastal conditions. The first group of these projects has recently been approved by the Legislature and will commence in late 1982.

References

Boesch D.F. (ed). 1982. Proceedings of the Conference on Coastal Erosion and Wetland Modification in Louisiana: Causes, Consequences, and Options. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-82/59.

Gosselink, J.G., C.L. Cordes and J.W. Parsons. 1979. An ecological characterization of the Chenier Plain coastal ecosystem of Louisiana and Texas. U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-78/9.

Wicker, K.M. 1980. Mississippi Deltaic Plain Region ecological characterization: a habitat mapping study. A user's guide to the habitat maps. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-79/07.

Donald F. Boesch
Louisiana Universities Marine Consortium
Star Route Box 541
Chauvin, LA 70344

Research & Monitoring Updates

The Chemistry of Marine Acid Rain

Few environmentally-related issues have captured the public's attention as has the phenomenon "acid rain." The excess acidity of precipitation (pH < 5.6, which represents the equilibrium of atmospheric CO_2 and pure water) in the eastern United States, southeast Canada, northern Europe and Scandanavia has been directly ascribed to sulfuric and nitric acids. The precursors of these acids, in the form of the corresponding oxides, result predominantly from the combustion of fossil fuels, with natural emissions accounting for no more than 25% of the excess acidity. The impact of this acidity on watersheds, forests, crops, and architectural structures has been well documented, but the effects on the marine environment and the interaction of acid precipitation in the coastal environment are not as well studied.

As one of nine federally-funded MAP3S (Multi-State Atmospheric Power Production Pollution Study) sites in the northeast U.S., we have been investigating the chemical nature of wet deposition at a remote coastal site in Lewes, Delaware, on an event basis, since 1977 (see Figure 1). This coastal site presents a

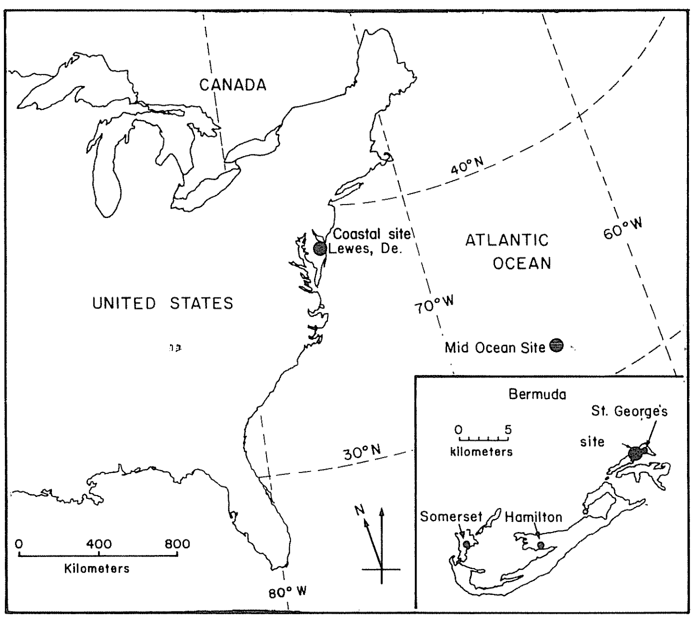


Figure 1. Location of coastal and mid-ocean precipitation collection sites.

unique location, being situated at the interface between continental air masses charged with acid rain precursors which are driven by the temperature westerlies, and marine-dominated air masses to the east. We therefore have focused our attention on the interactions of acid precipitation with marine atmosphere, for example (a) neutralization of effects of basic sea-salt aerosols (i.e., bicarbonate, and to a lesser extent, borate); (b) contributions from local natural sulfur emissions, especially marine SO_4^{-2} and biogenic emissions of reduced gaseous sulfides from salt marshes; and (c) associated wet fluxes of trace metals and synthetic organic compounds in such marine precipitation.

Qualitatively our results are quite typical of other inland continental MAP3S sites to the west and north. Sulfuric acid contributes about twice as much acidity to the rainfall as does nitric acid, with perhaps a greater contribution from sulfate during late spring to early fall and from nitrate from late fall to early spring. Using monthly averaged volume weighted concentrations (Figure 2), we observe a pH minimum as low as 3.8 in summer and as high

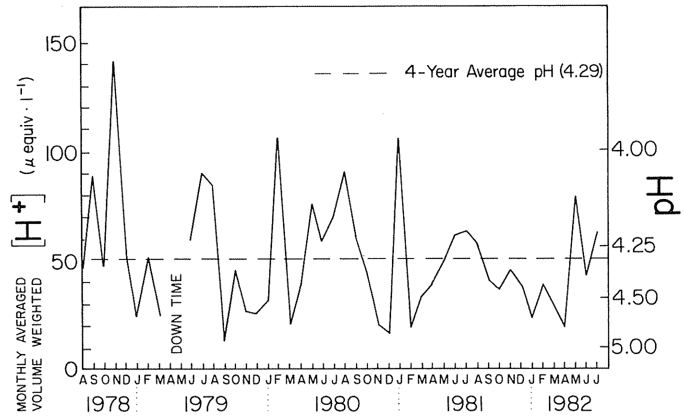


Figure 2. Temporal trends in the free acidity of Lewes, DE precipitation from August 1978 to July 1982.

as 5.0 in winter, paralleling a maximum in mean monthly averaged volume-weighted nonsea-salt sulfate in summer (45 μM) and minimum in winter (12 μM) (see Figure 3). Sea-salt sulfate is calculated from a seawater molar ratio of $SO_4^{-2}/Na^+ = 0.0603$, and assumes all the sodium is of marine origin and that there is no fractionation between Na^+ and SO_4^{-2} in aerosol formation or incorporation into marine precipitation. We calculate that marine aerosols from the sea surface contribute a yearly average of 13.7% of the total sulfate in local precipitation, but this can be as high as 41% of the total during winter when increased winds inject more sea salt into the air. Similar calculations for marine-derived alkalinity indicate that local contributions of basic sea salt components are insufficient to cause much (> 10%) neutralization of the excess acidity. The chemical trends in precipitation acidity (Figures 2 and

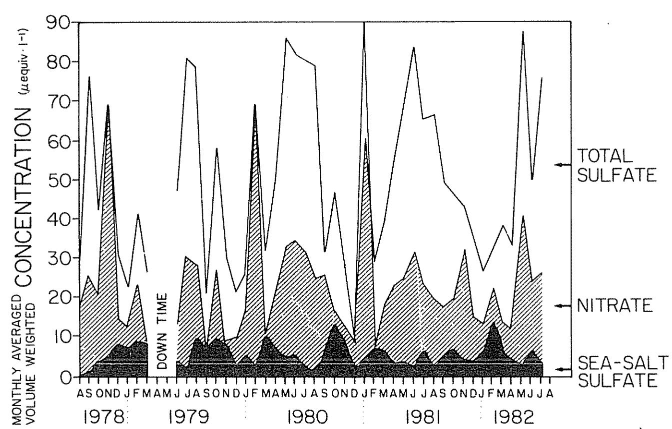


Figure 3. Relative contributions of total sulfate, nitrate, and sea salt-derived sulfate in Lewes DE precipitation from August 1978 to July 1982.

3) can result from seasonal variation in storm trajectories, greater SO_2 production during the summer, enhanced oxidation of SO_2 to SO_4^{-2}, and/or the increased advective nature of summer storms resulting in a higher vertical washout of pollutants. Sea salts may actually indirectly increase the acidity of precipitation in winter by selectively scavenging the nitric acid component resulting in a secondary peak acid period (e.g., Nov. '78, Feb. '80, Jan. '81). Greater contribution of nitrate from winter burning of home heating fuels or greater association of nitrate on frozen precipitation (i.e. snow) could also play a role. Lastly, winter peaks in nitric acid could result from faster advection and slower conversion of nitrogen oxides downwind of emission sources.

One potential source of non-marine sulfate is local biogenic contributions from exposed salt marshes. Fluxes of gaseous sulfur, including forms of carbon sulfides (CS_2, $(CH_3)_2S$, COS) as well as hydrogen sulfide, could potentially contribute up to 20% of the total non-marine sulfate. However, these organic compounds are resistant to atmospheric oxidation and are characterized by short local persistence relative to the the time scale of precipitation events. Therefore it is estimated that local wetlands contribute less than 1% to the atmospheric SO_4^{-2} budget of the northeast U.S. .. On the other hand, such coastal wetland areas are known to be geochemically sensitive, and we are now in the process of investigating how acidic precipitation can affect the geochemistry of exposed salt marsh sediments.

As part of the WATOX (Western Atlantic Ocean Experiment) project, the data base at our Lewes MAP3S site has recently been expanded to evaluate the fate of acid rain precursors and other atmospheric pollutants, and their long-range transport over the western Atlantic. Working in collaboration with Dr. James Galloway and Mr. William Keer (University of Virginia), and Dr. Anthony Knap, and Mr. Timothy Jickells and Mr. Joe Tokos (Bermuda Biological Station), we have detected acid rain components falling on the island of Bermuda, some 900 miles southeast of Lewes. Acid rain on Bermuda is predominantly in the form of sulfuric acid, which we interpret as being the result of the scavenging of gas-phase NO_3 by marine aerosols and/or the selective washout of the more readily oxidized nitric acid component. Concurrent collections of precipitation at Lewes, Bermuda, and at sea reveal extensive long range transport of the sulfuric acid component of acid rain over the western Atlantic. Analysis of storm trajectories provided by NOAA indicate efficient transport of acid rain precursors in the upper troposphere particularly during the winter when the blocking action of the Azores high is minimal.

As part of WATOX, we have expanded our collection and analysis efforts at Lewes and Bermuda to examine the wet deposition of trace metals (especially, Cu, Pb, Zn, and Cd, which are enriched anomalously in the marine atmosphere relative to crustal weathering), and synthetic organics (including but not limited to phthalate esters and chlorinated aromatic hydrocarbons such as toxaphene, DDT, chlordane and PCBs). Such experiments may greatly increase our knowledge on the fate and transport of north American pollutants to the western Atlantic Ocean.

Joseph R. Scudlark
Thomas M. Church
University of Delaware
College of Marine Studies
Lewes, DE 19958

Recent Progress Within the Ocean Pollution Data and Information Network (OPDIN)

The developing Ocean Pollution Data and Information Network (COPAS, Vol. 2, No. 1, 1982) has recently initiated the final phases of network design. Contractor assistance will be provided by EG&G's Washington Analytical Service Center, Inc. located in Rockville, Maryland. Contractor tasks through the end of FY83 will include:

- detailed requirements and design for the network.
- an in-depth investigation and analysis of those existing Federal marine pollution data and information systems pertinent to the OPDIN.
- completion of a handbook of Federal systems and services concerned with marine pollution data and information.
- Completion of a profile of potential marine pollution data and information users.

Recently completed milestones for the network include: implementation of a toxic substances data archival and retrieval system at the National Oceanographic Data Center (NODC); installation of IBM workstations at five coastal sites to provide data acquisition and other regional support activities for the network; and the initial efforts to establish an OPDIN 'Round Table,' a proposed interagency advisory group to provide guidance for OPDIN development, assistance in coordinating interagency activities, and completion of the 1982 update of the automated version of the National Marine Pollution Information System (NMPIS) for Federal projects.

Jim Audet
Central Coordination and Referral Office
National Oceanographic Data Center
NESDIS/NOAA
Washington, DC 20235
202-634-7510

Results of an Adaptive Environmental Assessment Modeling Workshop Concerning Potential Impact of Drilling Muds and Cuttings on the Marine Environment

This workshop was held 14-19 September 1981, at the Environmental Research Laboratory, Gulf Breeze, Florida, U.S. Environmental Protection Agency (EPA), as part of the Federal Interagency Energy/Environment Research and Development Program, Office of Research and Development, U.S. Environmental Protection Agency. The workshop was "facilitated" by the Western Energy and Land Use Team of the U.S. Fish and Wildlife Service under the direction of I. Ellison.

Drilling fluids or "muds" are essential components of modern drilling operations. They provide integrity for the well bore, a medium for removal of formation cuttings, and lubrication and cooling of the drill bit and pipe. This workshop considered potential impacts of discharged drilling muds and cuttings on the marine environment. The broad goals of the workshop were: synthesis of information on fate and effects, identification of general relationships between drilling fluids and the marine environment, and identification of site-specific variables likely to determine impacts of drilling muds and cuttings in various marine sites.

The workshop was structured around construction of a model simulating fate and effects of discharges from a single rig into open water areas of the Gulf of Mexico, and discussion of factors that might produce different fate and effects in enclosed areas such as bays and estuaries. The simulation model was composed of four connected submodels. A discharge/fate submodel dealt with the discharge characteristics of the rig and the subsequent fate of discharged material. Three effects submodels were exercised to calculate biological responses at distances away from the rig for the water column, soft bottom benthos, and hard bottom benthos. The model focused on direct linkages between the discharge and various organisms, rather than on how the marine ecosystem itself is interconnected.

Behavior of the simulation model indicated relatively localized effects of drilling muds and cuttings discharged from a single platform into open water areas. Water column fate and effects were dominated by rapid dilution. Effects from deposition of spent mud and cuttings were limited spatially with relatively rapid recovery, especially in soft bottom benthic communities which were conceptualized as being adapted to frequent storms. This behavior was generated by the set of assumptions about linkages and functional relationships used to construct the model. Areas of uncertainty included methods for extrapolating 96-hr LC_{50} results to exposures of varying lengths and concentrations; recovery rates of benthic communities; responses to various depths and rates of burial; fate and effects of the plume in relationship to stratification layers; and long-term and sub-lethal effects of slightly elevated concentrations of discharged materials. Evaluation of the assumptions of the Soft Bottom Submodel suggest that the assumptions used may have been relatively liberal estimates of resiliency of these communities.

Discussion of "closed" water bodies such as bays and estuaries indicated several reasons to expect different and more complex fate and effects behavior in these areas. These factors included different species and communities (such as aquatic macrophytes and oyster beds), more complex circulation and stratification patterns, and potentially more active resuspension processes. Much of the possible difference in behavior in these areas centers around the extent to which they are "closed" or in the relative residence times of water and sediments in these areas as they determine the long-term dispersion of discharged material. Despite the complexity and variability of these ares, a large body of knowledge was identified that could be employed effectively in analysis of potential fate and physical effects in enclosed areas.

This effort is continuing and another workshop will be convened to address refinements of a submodel noted above as it applies to in-shore areas. Copies of the workshop report are available from the National Technical Information Service under the following citation:

Auble, G.T., A.K. Andrews, R.A. Ellison, D.B. Hamilton, R.A. Johnson, F.E. Roelle and D.R. Marmorek. 1982. Results of an Adaptive Environmental Assessment Modeling Workshop Concerning Potential Impacts of Drilling Muds and Cuttings on the Marine Environment. EPA Series 600/9-82-019. 64 p.

T.W. Duke
St. Research Scientist
Environmental Research Laboratory
U.S. EPA
Sabine Island
Gulf Breeze, FL 32561
904-932-5311

DDT and PCB in a Mussel From the Coast of Baja California, Mexico

The Instituto de Investigaciones Oceanológicas has studied pollution along the coastal zone of Baja California since 1972. From February to September 1982, concentrations of organochlorine pesticides (total DDT) and polychlorinated biphenyls (PCB) were measured in the mussel *Mytilus Californianus* to determine regional and temporal variations along the Northern Baja California coast (from the United States-Mexican border south to Bahia San Quintin, a distance of approximately 200 km).

The tissues of 5 mussels (2 replicates of each) from each location were pooled, once a month, homogenized and analyzed by packed-column electron-capture gas chromotography (Young et al., 1976). Total DDT includes the ortho plus para isomers of DDT, DDE and DDD; PCB measurements included only Acroclor 1254.

Significantly higher concentrations (t-test; 95% confidence limit) (Sokal and Rohlf, 1969) of total DDT were found in mussels from Punta Bandera Station (36.76 ng g^{-1}wet wt.) than in those from any of the other 8 locations. The minimum value was detected at the Punta China site (3.5 ng g^{-1}wet wt.) (Figure 1). Statistical analyses

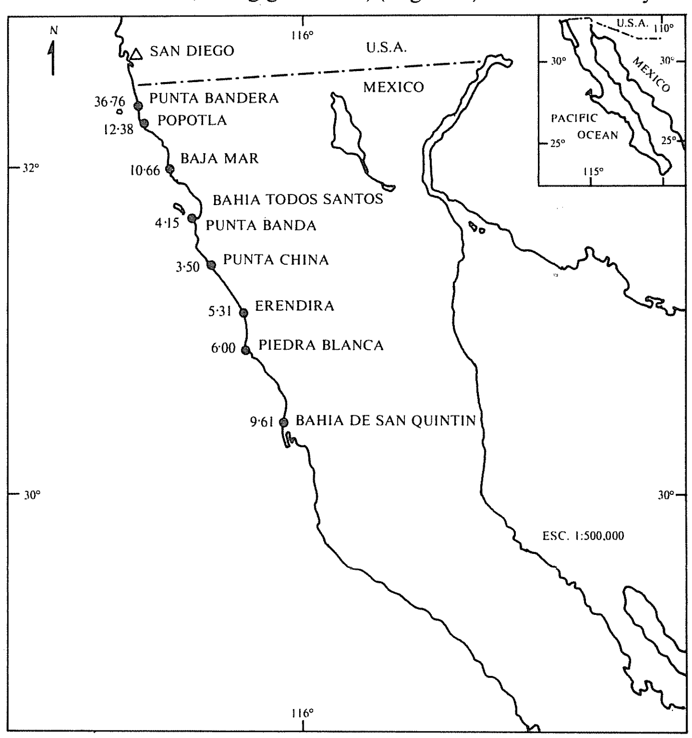


Figure 1. Mean concentrations ($10^{-9}gg^{-1}$ wet weight) of total DDT in *Mytilus californianus.*

of the mean concentrations show no significant temporal variations in total DDT. The maximum value was detected in February (74.91 ng g^{-1}wet wt.) p,p′-DDE was the metabolite detected most frequently and at the highest levels.

PCB levels ranged from 98.19 to 309.2 ng g^{-1}wet weight (Punta Bandera and Baja Mar respectively) (Figure 2). The concentrations of Aroclor 1254 in mussels collected in February (41.19 ng g^{-1}wet wt.) were significantly less than those in mussels taken from other dates. In September the maximum value (253.09 ng g^{-1}wet wt.) was registered.

The results showed that the levels of total DDT in *Mytilus Californianus* were an order-of-magnitude less than those established by the United States Food and Drug Administration for human consumption. The complete results will be published in the jounal Ciencias Marinas, of the Universidad Autonama de Baja California.

References

Sokal, R.R. and F.J. Rohlf. 1969. Biometry: The Principles and Practice of Statistics in Biological Research. W.H. Freeman and Company, San Francisco.

Young, D.R., T.C. Heesen, and D.J. McDermott. 1976. An offshore biomonitoring system for chlorinated hydrocarbons. Mar. Pollut. Bull. 7:156-159.

Sergio Adolfo Sañudo Wilhelmy
Instituto de Investigaciones Oceanológicas
Apartoado Postal 453
Ensenada, Baja California
Mexico

Reduced Numbers of Early Stages of Mollusca and Amphipoda on Experimental Sediments Containing Sewage Sludge

Earlier studies conducted by the National Marine Fisheries Service, NOAA, have shown that most species of benthic invertebrates are much less abundant in the vicinity of the New York Bight sewage sludge dumpsite than in surrounding areas. A few pollution-resistant species such as certain Polychaeta are more abundant however (Pearce et al., 1976). The dumpsite, which is located about 20 km south of Long Island and east of New Jersey where the water depth averages about 23 m, receives sewage sludge from treatment plants in New York City and northeastern New Jersey. The quantities of sewage sludge dumped annually have been increasing in recent years—6.9 million tons were dumped in 1981 (EPA). About five percent of the sludge is solid material. The densest solids sink to the bottom at the dumpsite (Gross et al., 1976) and gradually mix with bottom sediments. The present study was conducted to compare settlement densities of juvenile invertebrates on experimental clean and sewage-contaminated sediments.

Clean sediments (controls) and sediments mixed with sewage sludge were held in wooden trays coated with a non-toxic resin, at a site on the sea floor in relatively clean water during a period of heavy larval settlement of many invertebrates. The test site was beside a navigation buoy off Rockaway Beach, Long Island, at a depth of 9.5 m. The trays remained on the bottom for 27 days, from 15 July to 11 August 1982. Sludge from two sources was used in the study. One source was the sludge dumpsite, where sludge-contaminated sediments were collected with a grab. Immediately after collection, sediments were frozen to kill any live invertebrates and then thawed, but were otherwise unaltered before use. The other source was a sewage treatment plant in Sayreville, NJ. The sludge was mixed with fuller's earth in a 1:1 ration by volume.

The grain sizes of fuller's earth average 30-40 μm and are similar to those of mud. The clean sediments used were beach sands, which had a grain-size structure similar to sediments from the sludge disposal site, and fuller's earth.

The trays were square with sides 45 cm in length and legs 10 cm high, which maintained the trays off the bottom. Each tray had two compartments, each with a surface area of 890 cm^2 and a depth of 7.5 cm. The compartments were filled with sediments and covered with inert PVC screening of six meshes per cm. Eight replicates of each sediment (clean sand, fuller's earth, sludge-contaminated sediments from the dumpsite and sludge plus fuller's earth) were used in the test. The trays were placed randomly and in close proximity at the test site. By the end of the exposure period, 5-6 mm of fine silty sand had accumulated on the surface of the sediments. After the trays were retrieved by divers, the sediments were washed through a 0.5 mm sieve and the invertebrates were placed in 10 percent buffered formalin. Within a few days, the formalin was removed and replaced with ethyl alcohol containing glycerin. Finally, the invertebrates were sorted, identified and counted.

The results were that the two sludge-contaminated sediments had only about 20 percent as many invertebrates as the two clean sediments. The numbers of invertebrates in the two contaminated sediments were similar to one another, as were those in the two clean sediments. Contaminated sediments had an average of about 15 percent as many Mollusca and six percent as many Amphipoda, as did the clean sediments, but 57 percent more Polychaeta (Figure 1).

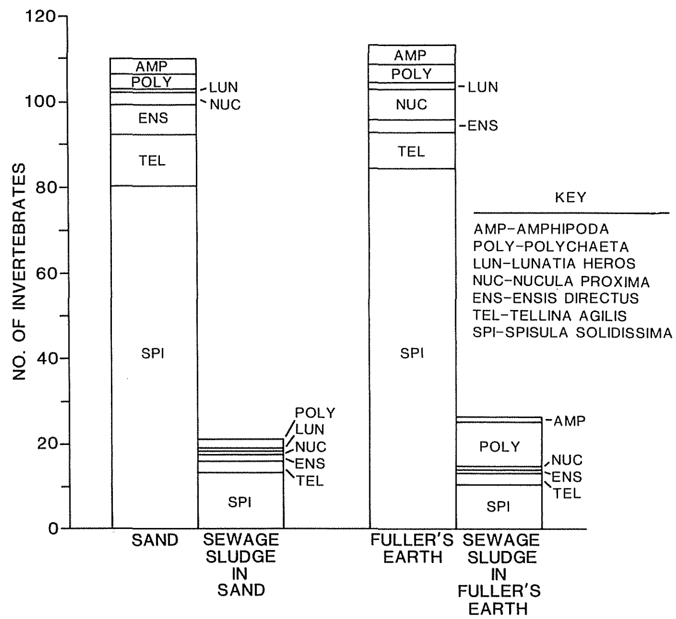


Figure 1. Average numbers of invertebrates in compartments (890cm²) of trays containing clean and sludge-contaminated sediments. The trays were held on the bottom in 9.5 m of water off Rockaway Beach, L.I., from 15 July—11 August, 1982.

Many studies (reviews by Wilson, 1952; Thorson, 1966; Keck et al., 1974) have shown that invertebrate larvae can distinguish between favorable and unfavorable substrates, based on chemical and physical attributes of the substrates. The larvae can delay metamorphosis for days and even weeks testing substrates at intervals until a substrate suitable for adult life is contacted. Thus, avoidance of sewage-sludge sediments by the Mollusca and Amphipoda is a possible explanation for our results. Another possibility is that many Mollusca and Amphipoda died immediately after they settled. If so, most Mollusca and disintegrating Amphipoda may have passed through our 0.5 mm screen and not have been counted. We do not have an explanation for the greater abundance of Polychaeta in sediments that contain sewage sludge, as compared to those of plain fuller's earth. Future studies using sediment trays will be conducted to resolve this question of avoidance or death after settling, and to test the toxicity to invertebrates of the various components of sewage sludge and other contaminants in sediments in the New York Bight.

References

Gross, M.G., R.L. Swanson, and H.M.Stanford. 1976. Man's impact on the Middle Atlantic continental shelf and the New York Blight — symposium summary. Am. Soc. Limnol. Oceanogr. Spec. Symp. Vol 2. pp. 1-13.

Keck, R., D. Maurer, and R. Malouf. 1974. Factors influencing the setting behavior of larval hard clams, *Mercenaria mercenaria.* Proc. Nat. Shellf. Ass. *64:* 59-67.

Pearce, J.B., J.V. Caracciolo, M.B. Halsey, and L.H. Rogers. 1976. Temporal and spatial distribution of benthic invertebrates in the New York Bight. Am. Soc. Limnol. Oceanogr. Spec. Symp. Vol. 2. pp. 394-403.

Thorson, G. 1966. Some factors influencing the recruitment and establishment of marine benthic communities. Neth. J. Sea Res. *3:* 267-293.

Wilson, D.P. 1952. The influence of the nature of the substratum on the metamorphosis of the larvae of marine animals, especially the larvae of *Ophelia bicornis* Savigny. Ann. Inst. Oceanogr. Monaco *27:* 49-156.

Clyde L. MacKenzie, Jr.
David Radosh
Robert N. Reid
NOAA/NMFS
Northeast Fisheries Center
Sandy Hook Laboratory
Highlands, NJ 07732
206-527-6336

Hydrocarbons and Chlorinated Hydrocarbon Measurements in the U.S. "Mussel Watch" Program 1976-1978

A technical report, WHOI-82-42, titled "Hydrocarbons, Polychlorinated Biphenyls, and DDE in Mussels and Oysters from the U.S. Coast, 1976-1978 -- The Mussel Watch" by John W. Farrington, Robert W. Risebrough, Patrick L. Parker, Alan C. Davis, Brock De Lappe, J. Kenneth Winters, Dan Boatwright, and Nelson M. Frew, has been issued and contains much of the organic compound data and interpretation for the U.S. Mussel Watch program for the years 1976-1978.

The organisms *Mytilus edulis, Mytilus californianus, Crassostrea virginica,* or *Ostrea equestris* were sampled at 90 to 100 stations around the United States coastline (Figure 1) during each of three years -- 1976, 1977, and 1978. Data for concentrations of PCBs, DDE, total hydrocarbons measured by glass capillary gas chromatography, and selected individual or groups of aromatic hydrocarbons were measured for many of these samples, especially for the east and west coasts. Similar data for monthly samples of *Mytilus edulis* from Narragansett Bay, Rhode Island, *Mytilus californianus* from Bodega Head, California, and laboratory intercomparisons were presented and discussed.

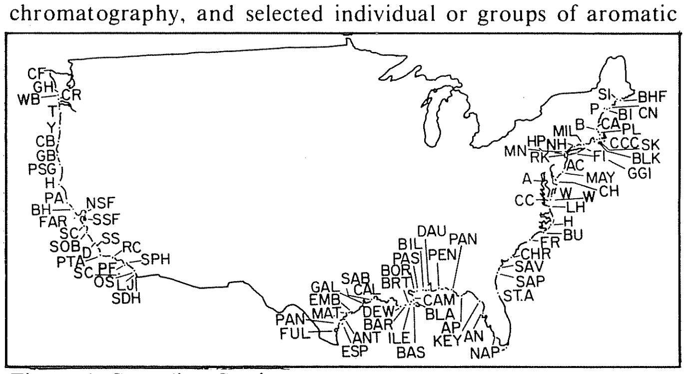


Figure 1. Sampling Stations

Monthly temporal changes of factors of two to ten were found for organic pollutants in mussels from the Narragansett Bay station. Concentrations of PCBs and fossil fuel hydrocarbons for some urban stations were one to two orders of magnitude higher than those in remote areas, as indicated by a selected set of data given in Table 1.

TABLE 1

Selected Data for Organic Chemical Pollutants in Mussels and Oysters of U.S. Coast—U.S.[1]

10^{-9} g/g dry weight[2]

	PCBs		Phenanthrene		Fluoranthene		Pyrene	
EAST COAST	1976	1977	1976	1977	1976	1977	1976	1977
Maine								
Blue Hill Falls	15	34	8	--[3]	5	--[3]	3	--[3]
Sears Island	79	105	30	10	47	35	51	25
Massachusetts								
Cape Ann	9	112	2	--	12	--	6	–
Boston	635	735	91	310	240	336	329	248
Cape Cod Canal	215	188	14	--	12	--	12	--
Rhode Island								
Block Island	102	119	20	6	37	9	23	8
New York								
Fire Island	243	133	13	--	20	--	12	–
Rockaway Point	575	476	24	15	67	30	107	22
Virginia								
Wachapreague Is.	136	42	28	--	23	--	12	--
North Carolina								
Beaufort	38	30	63	93	169	235	118	165
Cape Fear	30	18	15	--	13	--	8	--
GULF COAST								
Florida								
Panama City	20	131	36	--	36	--	17	–
Pensacola	107	46	5	--	70	--	40	--
Mississippi								
Pass Christian	20	35	34	--	26	--	18	–
Biloxi	336	297	43	--	42	--	63	--
WEST COAST								
California								
San Diego Harbor	860	800			Not Measured[3]			
Point La Jolla	84	45		"			"	
San Pedro Harbor	3000	500		"			"	
Farallon Islands	27	23		"			"	
So. San Fran. Bay	590	990		"			"	
Humboldt	17	7		"			"	
Oregon				"			"	
Gold Beach	29	10		"			"	
Columbia River	42	26		"			"	
Washington				"			"	
Cape Flattery	7	12		"			"	
Puget Sound	41	37		"			"	

[1]Exact station locations and sampling dates in Farrington et al., 1982 (see text of article).

[2]Data precise to two or three significant figures depending on compounds and concentrations measured.

[3]Not measured for these situations.

The northeast "megapolis" of the U.S. coast, from the Chesapeake Bay area to Boston, Massachusetts, was clearly indicated by elevated concentrations of PCBs and fossil fuel hydrocarbons in mussels. The composition of aromatic hydrocarbons in samples with elevated concentrations indicates inputs of both petroleum hydrocarbons and hydrocarbons of pyrogenic sources. Other studeis of aromatic hydrocarbons in sediments of many of the same areas indicate elevated concentrations, but predominantly with pyrogenic origin. The theory advanced to explain this proposes that pyrogenic source aromatic hydrocarbons are less available for biological uptake and incorporation into tissues because the polynuclear aromatic hydrocarbons are more tightly absorbed or absorbed in pyrogenic particulate matter.

If we consider the historical record of polynuclear aromatic hydrocarbon inputs preserved in cores of contemporary sediments from lakes and some coastal areas (e.g., Lake et al. 1979; Wakeham and Farrington, 1980; Gschwend and Hites, 1981), then the conclusion might be advanced that the predominant input source for polynuclear aromatic hydrocarbons to aquatic ecosystems near urban areas is a pyrogenic source from combustion of fossil fuels and that petroleum, e.g., fuel oil and crude oil, inputs are less important. From the perspective of geochemical cycles of total polynuclear aromatic hydrocarbons, this appears to be the case. This does not contradict the data for aromatic hydrocarbons in mussels and oysters. Hot solvent extraction, with or without other vigorous chemical treatment of sediments, is undoubtedly a harsher "extraction" of particulates when compared to biological filtration and digestive processes acting on particulate matter. Polynuclear aromatic hydrocarbons released to marine ecosystems by small oil spills or chronic oil inputs from industrial, municipal, or storm drain inputs would be less tightly absorbed to or incorporated into particulate material and to some extent would be dissolved or accommodated in some manner--perhaps in association with colloids--and thus be more "available" for biological uptake and incorporation into tissues.

This theory has important implications for consideration of policies aimed at decreasing aromatic hydrocarbon inputs to marine ecosystems to reduce potential impacts of marine organisms or to reduce possible food web transfers back to man. It has been tempting, when considering crude oil and fuel oil inputs from small spills and chronic sources, to argue that these sources are not significant compared to pyrogenic inputs of aromatic hydrocarbons when considering the coastal areas in total. However, if the theory discussed above is correct, then perhaps (hypothetically) only 10% of the pyrogenic input is available for biological uptake and is important when considering biological effects or transfer to man, while 90% (again hypothetically) of crude oil, fuel oil, or crankcase oil inputs are of importance to food web transfer and biological effects considerations. Thus, the predominant source for a geochemical cycle consideration may be a minor (or less major) source for biological interactions. In summary, physical chemical aspects of the biogeochemistry of aromatics and, by implication, other petrochemical pollutants and xenobiotics, join with considerations of metabolites and reaction products of these same compounds (Malins and Hodgins, 1981) as important research topics in fates and effects considerations for pollutant inputs. The situation is similar to that earlier discussed for trace metal biogeochemical research, e.g., speciation of trace metals.

Other aspects of the U.S. Mussel Watch data are discussed in Goldberg et al. (1978); Goldberg et al., in press; N.A.S., 1980; and in an overview paper in final revision by Farrington et al. (1983). An article to be published in a future issue of COPAS will discuss the history and objectives of the program. At present the concept is ready for evaluation and modification before transfer from the research sectors to those who wish to monitor for chemical contaminants in U.S. coastal area. Discussions with the E.P.A. and N.O.A.A. are in progress with respect to the transfer and future research needs. Unfortunately, there are those within the academic and government sectors who misunderstood or did not bother to read the objectives of the U.S. Mussel Watch program. This has caused considerable confusion as some government program managers attempt to extend the concept far beyond its objectives, for example, using it to assess the ecosystems effects of chronic pollutant inputs, thereby causing other program managers and academic scientists to assail the concept as "promising too much."

Several of the applications of Mussel Watch data have been briefly discussed by Farrington et al. 1982. To quote from our report:

"We are strong proponents of the view that the "Mussel Watch" concept *cannot* and *must not* be viewed as a panacea for monitoring organic pollutants in the estuarine and coastal marine environment. These measurements must be coupled with the full range of carefully designed field measurements of pollutants in other segments of the marine environment and experimentation with laboratory or larger scale systems.

For example, measurements in mussels provided a means of identifying the Acushnet River Estuary (New Bedford, and Fairhaven, Massachusetts) as a severe "hot spot" of PCB pollution, but it was not possible to predict from these measurements the exact extent of PCB contamination of fish and lobsters in the area nor to assess the size of the sediment reservoir of PCBs in the harbor.

The Mussel Watch data can assist in providing an assessment of the extent of contamination of a given area from acute scale pollution events by providing both before and after measurements. For example, we had data for hydrocarbons in *Mytilus edulis* at the Cape Cod Canal, Massachusetts for 1976 and 1977 when a small oil spill occurred in 1978. This provided us with background measurements for comparison with measurements during and after the small spill (Farrington et al., 1982). We have also shown that several oyster populations along the Gulf Coast, in particular the Texas coast which received oil input from the 1979 IXTOC-I oil well blowout (N.O.A.A., 1981; Amos, 1980, among others), were already contaminated by petroleum hydrocarbons in 1976, 1977 and 1978 (Tables 10 and 18). This data provides background for assessing the extent and severity of petroleum contamination by an event such as the IXTOC-I oil spill.

The continuing measurements of chemical pollutants in mussels should provide an assessment of the ultimate fate of and at what rate DDT family compounds and PCB concentrations in the coastal environment decrease due to restriction on manufacture and use. This information is of value in first order predictions of environmental fates for other chemical pollutants released accidentally or deliberately to the coastal and estuarine areas of the world. This is important not only for developed nations such as the United States, but also for developing nations where lessons painfully learned by developed nations should assist in wise management of coastal and estuarine resources.

The increasing recognition of chemical pollution problems on land has forced a reconsideration of ocean disposal for hazardous waste as an alternative to land based disposal options (Goldberg, 1981; N.A.C.O.A., 1981). The debate has been joined with respect to these options (Kamlet, 1981) and wise decisions on the "assimilative capacity of the marine environment for chemical wastes" (Goldberg, 1981; Kamlet, 1981) will require knowledge of the biogeochemistry of pollutant compounds in coastal and estuarine systems. Mussel Watch has begun to build a data base and should continue to contribute to this knowledge.

References

(Note: References in quotes included in this article are found in quoted reference)

Farrington, J.W., A.C. Davis, N.M. Frew, and K.S. Rabin, 1982. No. 2 fuel oil compounds in *Mytilus edulis:* Retention and release after an oil spill. Marine Biology 66:15-26

Farrington, J.W., R.W. Risebrough, P.L. Parker, A.C. Davis, B.W. deLappe, J.K. Winters, D. Boatwright, and N.M. Frew. 1982. Hydrocarbons, polychlorinated biphenyls, and DDE in mussels and oysters from the U.S. coast 1976-1978 -- The Mussel Watch. Woods Hole Oceanographic Institution Technical Report WHOI-82-42.

Farrington, J.W., E.D. Goldberg, R.W. Risebrough, J.H. Martin, and V.T. Bowen. 1983. U.S. "Mussel Watch" 1976-1978: An overview of the trace metal, DDE, PCB, hydrocarbon,and artificial radionuclide data. Environmental Science and Technology (submitted).

Goldberg, E.D., V.T. Bowen, J.W. Farrington, G.R. Harvey, J.H. Martin, P.L. Parker, R.W. Risebrough, W. Robertson, E. Schneider, and E. Gamble. 1978. The Mussel Watch. Environmental Conservation 5:101-125

Goldberg, E.D., M. Koide, V. Hodge, J.H. Martin, and A.R. Flegal, 1983. U.S. Mussel Watch; 1977-1978 -- Results on heavy metals and transuranics. Estuarine and Continental Shelf Science (in press).

Gschwend, P.M. and R.A. Hites. 1981. Fluxes of polycyclic aromatic hydrocarbons to marine and lacustrine sediments in the northeastern United States. Geochemica et Cosmochimica Acta 45:2359-2368

Lake, J.L., C. Norwood, C. Dimock, and R. Bowen. 1979. Origins of polycyclic aromatic hycrocarbons in estuarine sediments. Geochimica et Cosmochimica Acta 43:1847-1854

Malins, D.C. and H.O. Hodgins. 1981. Petroleum and marine fishes: A review of uptake, disposition, and effects. Environmental Science and Technology 15:1272

N.A.S. 1980. The International Mussel Watch. Publications Office, National Academy of Sciences, National Research Council, Washington, DC, USA.

Wakeham, S.G. and J.W. Farrington. 1980. Hydrocarbons in contemporary aquatic sediments. Chapter 1:3-32 *in* R.A. Baker (ed.). Contaminants and Sediments, Vol. 1. Ann Arbor Science Publishers, Inc., Ann Arbor, MI.

John W. Farrington
Coastal Research Center and Chemistry Department
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
617-548-1400 ext. 2740

NOAA Establishes Quality Assurance Program for Marine Environmental Measurements

NOAA marine scientists and contractors make many thousands of chemical and biological measurements each year. These measurements serve to increase our knowledge of the marine environment and also form the basis for NOAA policy and recommendations regarding various uses of the marine environment (e.g., commercial fishing, waste disposal, and energy development).

At present, individual laboratories or investigators design their own quality assurance efforts, utilize a variety of reference materials, and report the results as they see fit. The new NOAA program will document the quality (determine confidence limits) of marine environmental measurements and promote intercomparison of results among laboratories. Knowledge of the analytical precision and bias of the numerical data will permit valid interpretations, enhance comparison among data sets, and identify those analytical methods which require improvement. The new program will be national in scope, will employ uniform reference materials, and will disseminate the results in a useful form.

The measurements to be evaluated are: 1) extractable organic compounds (polynuclear aromatic hydrocarbons, polychlorinated biphenyls); 2) volatile organic compounds (dry cleaning solvents, benzenes); 3) trace metals (Pb, Cr, Hg, Cd); 4) nutrients (nitrate, nitrite, ammonium, phosphate); 5) pathogens (viruses, protozoa, bacteria); and 6) measurements of primary production ($^{14}CO_2$ uptake, chlorophyll). A Lead Laboratory will be designated for each type of analysis. These laboratories will prepare and distribute reference materials, will receive and evaluate the results of the analysis of the reference materials by the various laboratories involved, and will identify and provide suggestions for solving problems of analytical origin. In addition, the Lead Laboratories will conduct research to develop or improve analytical methods which will benefit NOAA's programs for marine environmental research and monitoring. It is anticipated that the Lead Laboratory for Extractable Organic Compounds will begin functioning in late FY 1983; others will begin in FY 1984.

The principal initial activity will be the development (where necessary) and distribution for analysis of standard and interim reference materials to NOAA laboratories and NOAA contractors. In situations for which reliable reference materials cannot be obtained (e.g., trace metals in seawater), groups of analysts will be brought together for simultaneous sample collection in a natural environment.

To initiate the program, NOAA Administrator Byrne has appointed Dr. John Calder, of the Ocean Assessments Division, Office of Oceanography and Marine Services, National Ocean Service, as the QA Program Coordinator, and has established a QA Steering Committee composed of senior scientific staff members within NOAA. An outside advisory group will be established to review the program and recommend improvements.

For further information on the program or to be put on the mailing list for future announcements and data summaries, write to Dr. Calder at the address below:

Dr. John Calder
Ocean Assessments Division
Office of Oceanography and Marine Services
National Ocean Service
NOAA N/OMS32
Rockville, MD 20852

NOAA Study Characterizes Contaminant Inputs to the Hudson-Raritan Estuary

The Hudson-Raritan estuarine system receives flow from the Hudson, Raritan, and Passaic River drainage basins. All of these river basins are polluted from industrial and urban sources throughout their drainages; thus, the Hudson-Raritan estuary receives a major portion of the waste products discharged into the environment from the New York metropolitan area. In fact, of all the major embayments of the northeastern United States, Raritan Bay is considered the most heavily polluted (Pearce, 1979)

To understand the response of the estuary to the waste discharges it receives, the National Oceanic and Atmospheric Administration's Office of Marine Pollution Assessment (OMPA) - now the National Ocean Service Ocean Assessments Division (OAD) - initiated the Hudson Raritan Estuary Project (HREP) in 1980. The ultimate objective of HREP is to determine the influence of the Hudson-Raritan estuary on the New York Bight apex and western Long Island.

A recently completed HREP study by J.A. Mueller, T.A. Gerrish and M.C. Casey, entitled "Contaminant Inputs to the Hudson-Raritan Estuary" (NOAA Technical Memorandum OMPA-21), summarizes available data on existing sources of contaminants into the estuarine system. The study focuses on the estuary itself and considers mass loads of toxic organics, heavy metals (both also known as EPA priority pollutants) and major conventional pollutants (i.e., suspended and dissolved solids, oxygen-demanding biodegradable organic matter, nutrients, oil and grease, and pathogenic indicators) from six contributing sources: non-tidal tributaries, municipal and industrial wastewater discharges, atmospheric input, urban runoff, accidental spills, and landfill leachate.

A large data base was utilized to obtain average mass loads of contaminants discharged into the estuary. Recent (1975-80) data, which was obtained from federal, state, county, municipal and private agencies, includes U.S. Geological Survey gaged flow data and pollution incident reports; U.S. Environmental Protection Agency STORET water quality data, National Pollution Discharge Elimination System (NPDES) permit discharge monitoring data, storm sewer data, and hazardous waste and landfill leachate data; U.S. Coast Guard pollution incident reports; U.S. Department of Energy air quality data; New Jersey Department of Environmental Protection landfill leachate data; Interstate Sanitation Commission file data; New York City 208 water management plan data; and major northern New Jersey wastewater treatment facilities effluent data.

Table 1 summarizes selected contaminant loadings from the six sources considered in the study. Generally, wastewater discharges are the major source of contaminant input to the Hudson-Raritan estuary. Tributaries, urban runoff, and accidental spills are significant sources for some constituents, while atmospheric and landfill leachate inputs are generally insigificant.

Source	Suspended Solids	Oxygen Demanding Matter	Nutrients	Pathogens	Heavy Metals	Toxic Organics (PCBs)
Wastewater	14	71	66	75 winter 50 summer	40-60	40
Non-Tidal Tributaries	77	9	25	--	20-40	40
Urban Runoff	9	18	9	25 winter 50 summer	10-30	7-9
Atmospheric	–	–	–	–	<5	2-15
Accidental Spills	?	?	?	?	?	?
Leachate	–	–	–	–	<1	0-4

Table 1. Percent of Contaminants Contributed to the Hudson-Raritan Estuary by Sources Considered in the Study.

Most sources of contaminants to the Hudson-Raritan discharge directly to the estuary with the possible exception of landfill leachate, which may be markedly modified prior to entering the system. Non-tidal tributary loads generally follow flow and therefore, are lower in summer and higher in winter. Drainage basins of the Hudson, Raritan, and Passaic Rivers contribute nearly 98 percent of the total tributary flow to the estuary; however, the Hudson River alone accounts for nearly 87 percent.

There is significant seasonal variability in contaminant loads discharged from wastewater treatment plants to the estuary because of factors such as influent variability, temperature, plant operation, and data quality control. Direct loading by industrial wastewater discharge is relatively small as a result of onsite treatment, process changes, plant closures, and the fact that most industries now discharge to municipal plants for combined municipal-industrial treatment rather than directly to the estuary.

Atmospheric inputs for most constituents (except alkalinity, ammonia, and phosphorus) generally are two to four times higher for urban areas than rural areas. Metal concentrations in the atmosphere near the surface of the New York Bight vary with distance form the coastal and prevailing winds; highest concentrations are generally found in the vicinity of New York City.

Urban runoff in the study area is contributed by two sources: the New York metropolitan area including New York City, northeastern New Jersey, and Westchester and Rockland Counties, and the mid-Hudson area, extending from Poughkeepsie to the Bear Mountain Bridge. Almost half of the total urban runoff flow is contributed by the mid-Hudson area. However, the bulk of the pathogens, biostimulatory materials and toxicants entering the estuary via urban runoff are derived from the New York metropolitan area.

Temporal trends indicate that, aside from single large spills, a fairly constant volume of material was spilled into the New York Bay and Hudson River between 1974 and 1979. The New York Bay region contributes at least 90 percent of the total load of spilled contaminants to the estuary. The greatest number of events occur from miscellaneous and unknown sources. Petroleum products released in the greatest quantities include fuel oils, diesel oils and gasoline from tank ships, barges, and other vessels.

The amount of landfill leachate which ultimately reaches the estuary is uncertain; however, it is assumed that leachate from landfills in the area flows either directly toward surface waters or to groundwater, and ultimately to nearby streams of the estuary.

The greatest data reliability and availability for conventional pollutants and heavy metals was found for wastewater and tributary sources. Toxic organics data were the least reliable for all sources. The loads obtained in the study are external loads which do not account for sediment-water phase-food web interactions. The actual impact of the various contaminant inputs on water quality in the Hudson-Raritan estuary was not evaluated. However, such an evaluation would be valuable in identifying potential problems and mitigative measure.

For more information on this study, or to obtain a copy, the reader is directed to the NOAA Ocean Assessments Division, Northeast Office, Old Biology Building, SUNY, Stony Brook, NY 11794.

References

Mueller, J.A., T.A. Gerrish, and M.C. Casey. 1982. Contaminant Inputs to the Hudson-Raritan Estuary. U.S. Department of Commerce, NOAA Technical Memorandum OMPA-21. Boulder, CO. 192 pp. + appendices.

Pearce, J.B. 1979. Raritan Bay a highly polluted estuary. International Council for the Exploration of the Sea, Marine Environmental Quality Committee. C.M. - ICES/E:47.

John A. Tiedemann
New Jersey Marine Sciences Consortium
Sandy Hook, NJ 07732

Announcements

Lectureship Established for Former WHOI Oceanographer

Woods Hole, Mass. — An annual lectureship in honor of well-known oceanographer Bostick H. "Buck" Ketchum, who passed away on July 15, 1982, at age 70, has been established by the Woods Hole Oceanographic Institution. Nearly $30,000 has been raised to endow the lectureship. These funds will support an annual lecture in Woods Hole by an internationally recognized scientist or support a longer visit by a younger researcher.

Buck Ketchum was associated with the Woods Hole Oceanographic Institution for more than 40 years. He was chairman of the Biology Department, Member of the Corporation, and from 1962 to 1977, as Associate Director. He played an active role in the devlopment of the Institution. He was equally at home in the physical, chemical and biological realms and authored more than 70 papers on subjects ranging from estuarine physics to deep ocean biology.

Buck Ketchum's pioneering research provided the basis for our understanding of the productivity of the ocean. In later years he turned his attention to the effects of man's activities in the costal zone and the need for research into problems in that area. At the time of his death, he was one of the four co-authors of a six-volume series on *Wastes in the Oceans* for John Wiley & Sons, Publishers. The first of two volumes were recently published, with Volume 1 dedicated to Dr. Ketchum.

Buck Ketchum was active in town and community affairs and was a respected figure in oceanographic research in the U.S. and abroad, serving as an advisor and consultant to numerous federal and international organizations.

The first Ketchum Lecture is now being arranged for the late summer or fall of 1983. Details concerning the name of the recipient, the time and location of the lecture will be announced at a later date.

Shelley Lauzon
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
617-548-1400

Ocean Service Centers

During a February luncheon address before the American Oceanic Organization, NOAA Administration John Bryne announced his intention to establish "Ocean Service Centers" in major port cities around the United States - a "NOAA one-stop service for users." The first is planned for Seattle where NOAA units are already operational and physically close together. The centers will be supervised by the National Ocean Service and will incorporate all NOAA ocean environmental products and services including marine weather forecasts, nautical and aeronautical charts, fishery products and marketing information, and satellite data. They are also to serve as a two-way communication point where users can express concerns. Additional information on the proposed centers is available from:

NOAA Public Affairs
202-377-4190

Atlas of New York Bight Apex Benthic Invertebrates Available

"An Atlas of the Distribution and Abundance of Dominant Benthic Invertebrates in the New York Bight Apex with Reviews of Their Life Histories" by Janice V. Caracciolo and Frank W. Steimle, Jr. has recently been published as NOAA Technical Report NMFS SSRF-766. The 58-page report contains distribution and abundance maps and life history summaries for 58 important species of benthic invertebrates collected in the New York Bight apex during five sampling cruises in 1973 and 1974. The affinities of these species to major community types, previously identified in the Middle Atlantic Bight, and their relationships with apex areas where New York Harbor dredge spoils and New York metropolitan area sewage sludge are dumped, are among the topics discussed.

Individual copies of this report may be obtained from Publications Service Branch (E/AI 13), National Environmental Satellite, Data, and Information Service, NOAA, U.S. Department of Commerce, 11400 Rockville Pike, Rockville, Maryland 20852.

Janice Caracciolo Ward
Frank W. Steimle, Jr.
U.S. Department of Commerce
NOAA/NMFS
Northeast Fisheries Center
Sandy Hook Laboratory
Highlands, NJ 07732

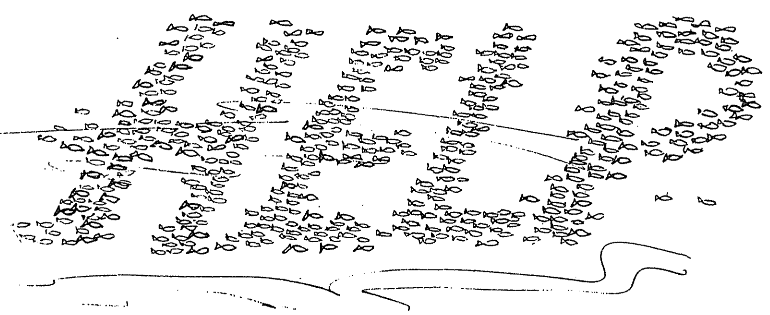
Global Marine Pollution Bibliography Available

A new volume, entitled *Global Marine Pollution Bibliography - Ocean Dumping of Municipal and Industrial Wastes,* edited by M.A. Champ and P.K. Park, is in press at IFI/Plenum Data Company, a division of Plenum Publishing Corporation, 233 Spring Street, New York, NY 10013. The following statement of the scope of the bibliography is from its introduction:

"The initial approach of this bibliography was to focus intensively on municipal and industrial wastes that are ocean dumped at sea on a global basis. In 1981 we defined ocean dumping as the transport of a waste material to sea for the sole purpose of disposal (Champ and Park, 1981). However, we realized that a broader view of marine waste disposal would contribute to the field of marine pollution. Therefore, we amended our initial approach to include all papers on disposal from outfalls that were available to us. But we did not deliberately search out papers on outfalls as we did for ocean dumping. A global bibliography on marine outfall disposal would be a mammoth undertaking. We have also not attempted a deliberate search for references on ocean-dumped dredged materials on a global basis."

The editors attempted to locate papers from the following major categories: Marine Pollution/Ocean Dumping; Municipal Wastes; Industrial Wastes; Legislation/Regulations; International Conventions; Ocean Dumping Criteria/Site Selection Studies; Waste Management Strategies; Biological Processes; Chemical Processes; Geological Processes; Physical Processes; Engineering Studies; Dumpsites (by countries); Regions; and Bibliographies.

Inquiries about the price and availability of the bibliography should be directed to the publisher at the address given above.



Calendar

23-27 January 1984
Ocean Sciences Meeting, New Orleans. Contact: American Geophysical Union, 2000 Florida Avenue NW, Washington, DC 20009 (202-462-6903)

27-29 February 1984
STD '84 Conference & Workshop, San Diego, CA (USA). Contact: San Diego Section, Marine Technology Society, P.O. Box 82253, San Diego, CA 92138

6-9 March 1984
Oceanology International '84, Hotel Metropole, Brighton. Contact: Spearhead Exhibition Ltd., Rowe House, 55/59 Fife Rd., Kingston upon Thames, Surrey KT1 1TA, UK

13-16 May 1984
40th Northeast Fish and Wildlife Conference, Ocean City Convention Hall, Ocean City, MD (USA). Contact: Eugene F. Deems, Jr., Maryland Wildlife Administration, Tawes State Office Building, Annapolis, MD 21401 (301-269-3195)

6-8 June 1984
4th Coastal Marsh and Estuary Management Symposium Baton Rouge, LA. Abstract Submission Deadline: 15 December 1983 Submit original and 1 copy to: Phillip J. Zwank, Room 212, Forestry Building, Louisiana State University, Baton Rouge, LA 70803.

26-31 August 1984
Symposium on Concentration Techniques for Collection & Analysis of Organic Chemicals for Biological Testing of Environmental Samples, Philadelphia, PA (USA). Contact: Dr. I.H. Suffet, Dept. of Chemistry, Environmental Studies Institute, Drexel University, Philadelphia, PA 19104

12-14 September 1984
International Conference on the Planning, Construction Maintenance and Operation of Sewerage Systems, Reading, England. Contact: Conference Organiser, Sewerage System, BHRA, The Fluid Engineering Centre, Cranfield, Bedford MK43 0AJ England, tel: 0234-750422, telex: 825059, BHRA G

Viewpoints

Multi-Media Mayhem

The current hot topic in ocean dumping policy is multi-media assessment, a term coined by the National Academy of Sciences and the National Advisory Committee on Oceans and Atmosphere to describe a comparison of the public health and environmental health effects, costs, and societal concerns associated with the disposal of wastes on land, in the air, or in the oceans. The topic has been the focus of meetings in the past year where multi-media has been further promoted, and an Ocean Dumping legislative proposal, recently released from a subcommittee of the House Committee on the Merchant Marine and Fisheries, calls for a comprehensive multi-media assessment for New York Bight. Despite all the hoopla, there are still major questions over just what multi-media assessments should include and how they should be used.

In their fascination with the technical aspects of multi-media assessment, scientific policy makers seem to hope that the method will provide a technical answer to the difficult political questions of waste disposal. Certainly, a technical comparison of the environmental and public health effects of different disposal options is a useful exercise, but any waste management choice must also consider political concerns of justice and rights, concerns not addressed by current conceptions of multi-media assessment.

Concerns with justice arise because an "optimal" solution in relation to total societal costs and benefits will undoubtedly be differentially distributed across different geographic groups, interest groups, political boundaries, and generations. Siting any sort of waste disposal in the future will most likely involve negotiation and compensation among groups. Multi-media assessment can be useful in structuring the topics of negotiation, but not in avoiding them.

In addition, we must consider how the rights of citizens to clean air and water will be preserved while each potential dumper is doing a separate weighing of the costs and benefits of their particular disposal strategy. At what step is the total health of the public, the environment, or even the economy considered? For instance, when both air and fish are contaminated at levels above ambient guidelines, is it appropriate simply to choose the risk-minimizing option, or must we consider the additional costs of reducing the sum of all discharges below this threshold safety level?

Such concerns lead to considering multi-media comparisons within a larger context, an approach that EPA now seems to be pursuing. EPA has set standards for air, surface waters, and groundwater. For instance, under the Clean Air Act, ambient air quality standards are set for a region and loadings are apportioned to potential dischargers, which allow these air quality standards to be met. If we perceive the problem to be that the ocean is overprotected, why not let EPA set ambient water quality standards for dumpsites using the same risk analytic techniques as used for air and groundwater? Loadings that allow meeting those standards could then be divided among potential dumpers, thereby protecting ocean water quality to the same extent as air and land. This approach ensures that standards in the different media are consistent and the overall right of the citizenry to a healthy environment is preserved.

Potential dumpers would be allowed to discharge their wastes in any media where they could meet the standards. If the cumulative loading of several dumpers is too great, they could negotiate load reductions among themselves to allow the most cost-effective waste clean-up, a method EPA is using experimentally for air pollution control.

Besides these political concerns, it is not clear that multi-media assessment is the technical cure-all that it is purported to be. How much confidence can we attach to estimates of predicted effects? I believe in many cases the environmental and health effects differences between disposal options are small compared to the uncertainty in predicting those effects. As a result, the "answer" elicited from any multi-media assessment will be largely dependent on who does the analysis and the myriad of assumptions made during the process. For instance, linking emissions to health effects of incineration includes at least the following multiplicative steps: assumptions about stack gas emissions as a function of temperature, transport through the air, number of people exposed, dose to those exposed, the dose-response relationship, and how those health effects are valued. The uncertainty involving each of those estimates probably ranges from 2-10, so the uncertainty surrounding the final estimate is approximately 5^6. Furthermore, there is always some uncertainty as to whether we have included all or even the major pathways of concern---witness the controversy surrounding methodology and conclusions for the safety of nuclear power in the Rasmusson report.

It is certain that analytical comparisons of waste disposal alternatives must be done. Questions remain over how to appropriate our waste disposal budget, between sophisticated analyses of the uncertain effects of disposal practices and development of engineering solutions which minimize environmental degradation. Without other political incentives, multi-media analysis alone is insufficient to bring about our waste management goals.

Michael Connor
Research Fellow
Harvard School of Public Health
Interdisciplinary Programs in Health
665 Huntington Ave.
Boston, MA 02115
617-732-1258

Multi-Media Mahem - A Response

Michael Connor has presented some interesting and important concerns in Viewpoints about the concept of multi-media assessments as applied to waste disposal problems. There certainly has been a great deal of recent activity concerning the notion of multi-media assessments. Also, there remain many unresolved questions as to what such an assessment entails and how such assessments might be conducted. However, I believe that those who are closely associated with the technical and policy-related problems of waste management are perhaps somewhat more sophisticated in their thinking than is implied in Mr. Connor's article. In this regard, I am responding to some of his concerns.

I am not aware of an accepted definition of multi-media assessment. Segar et al. (1983), however, discuss a recommended process for attaining such an assessment comprising three steps: alternatives identification, assessment, and selection. In the assessment step, they include comparisons of human health risk, environmental effects, economic impacts, and social perception. For alternatives selection, they acknowledge that decisions may be reached through the judicial route.

It is my perception that those agencies and institutions charged with developing waste management policy are well aware that ultimate decisions will be largely, if not totally, political. Sound scientific and technical information can be made available, however, to help influence objectively the political process.

That the Congress is drafting legislation concerning multi-media assessment is indicative that legal/political concerns are being addressed. In fact, the draft of HR 2900 specifically identifies the need to consider social and economic issues of disposal and to review applicable Federal and state statutes.

The judicial process has also addressed the notion that assessment of disposal options must include a balancing of relevant environmental, social and economic factors. This stems from the Sofaer interpretation (*The City of New York v. EPA*) of "unreasonable degradation," a term that is used in The Marine Protection, Research and Sanctuaries Act and Amendments to that Act.

Mr. Connor recognizes the need to examine waste loadings in the broadest possible context. Analysis of impacts on an industry-by-industry or waste-by-waste basis is not sufficient to minimize the impact from numerous wastes on all segments of the environment. The need to undertake these broader analyses of course was recognized, at least implicitly, by NACOA. The concept of managing wastes on the basis of contaminant load allocation instead of by contaminant concentrations alone and doing so in the context of a regional plan are extremely important and have been encouraged (see for example Swanson and Devine (1982) and Swanson et al. (in press)).

Mr. Connor also identifies problems associated with understanding ecological processes and with predicting environmental and health effects. We would all be pleased if capabilities in these areas were more refined and reliable. Even given these limitations, prediction of ecological effects should be an integral part of waste management. Such prediction provides a means for scaling effects, which is important for assessing acceptability---technically, economically, socially and politically. Prediction of effects also allows selection of a baseline for conducting effective environmental monitoring programs. When combined with an effective monitoring program, prediction helps establish testable hypotheses for finding flaws in analyses and decisions, thereby allowing for implementation of corrective measures. Had we been able to predict the fractionization of sewage sludge in marine waters, at the time the sewage sludge dump site in the New York Bight was selected, we might not even be having this discussion today.

Multi-media assessment is a concept that is relatively new. It is an outgrowth of a waste management decision approach that was clearly flawed. The multi-media approach provides an analytical framework for making more enlightened, and hopefully more effective decisions. It is my impression that the term is used in a more encompassing manner than just that of seeking technological fixes; it includes analysis of a sizeable spectrum of human interests and concern.

It has taken nearly a decade for us to recognize that our former approach to waste management---media-by-media has not been particularly effective. Therefore, it is not surprising that the multi-media approach has not been precisely defined in only one or two years. Many of Mr. Connor's concerns about multi-media management are well known and are being considered in appropriate form.

He doesn't offer an alternative approach; therefore, I presume that his comments are meant to help guide the multi-media process and not to suggest that it should be abandoned. As always, the broader the base of discussion, the more effective the final product. Additional thoughts and discussion on the topic are welcomed.

References

National Advisory Committee on Oceans and Atmosphere. 1981. The Role of the Ocean in a Waste Management Strategy. Special Report to the President and the Congress. U.S. Government Printing Office, Washington, DC. 103 pp.

Segar, D.A., E. Stammen, and P.G. Davis. 1983. The multi-media management approach to ocean dumping decisions. *In* Ocean Waste Management: Policy and Strategies, Program and Abstracts, M.A. Champ (Symposium Chairman). W. Alton-Jones Campus, University of Rhode Island. May 2-6, 1983.

Swanson, R.L. and M. Devine. 1982. Ocean dumping policy. Environment 6: 14-20

Swanson, R.L., M.A. Champ, T. O'Connor, P.K. Park, J. O'Connor, G.F. Mayer, H.M. Stanford, E. Erdheim, and J.L. Verber. In press. Sewage Sludge dumping in the New York Bight apex: A comparison with other proposed ocean dumpsites. *In* B.H. Ketchum, J.M. Capuzzo, W.V. Burt, I.W. Duedall, P.K. Park, and D.R. Kester (eds.). Wastes in the Ocean, Volume 6, Nearshore Waste Disposal. Wiley Interscience, New York, NY.

R.L. Swanson
National Oceanic and
Atmospheric Administration/
Ocean and Atmospheric
Research
State University of New York
Stony Brook, NY 11794
516-751-7002

Letters to the Editor

Unrealistic Toxicity Tests
To the Editor:

The piece "Two Species Marine Algal Bioassay etc." pp. 32-34 of your Winter '83 issue has the same fault as the unrealistic toxicity tests made by EPA and others. That is, subjects test organisms to levels of contaminants far above those likely to be encountered by sea animals.

One can compare the 10 μg/L used by Lundy et al. with the highest concentrations in the effluent of the Largest Caifornia discharges (1981): DDT was 0.84 μg/L and PCB was 1.55 μg/L (SCCWRP 1982). These discharges are immediately diluted by a factor of about 150. Thus, in the worst case (in the plume) levels are only 0.005 to .01 μg/L; eslewhere they are much less. I dare say that if the authors increased their daily intake of butter by a factor of 1000 they would find equivalent ill-effects and describe butter as a pollutant. In the meantime, non-professional environmentalists are frightened by what they take to be a realistic threat to sea life.

Furthermore, there was no statement that the controls were exposed to the methanol or whether the DDT and PCB were reagent quality. (The DDT from the outfalls mentioned above is only about 2% of the *total DDT* discharged, the remainder being DDD and DDE. Thus the lab DDT may be much more toxic than the total DDT actually discharged.)

Environmental tests should be done at realistic levels under realistic conditions if they are to be meaningful.

Reference:

Schafer, H. 1982. Characteristics of Municipal Wastewaters. *in* W. Bascon (ed.), Bienn. Rept. of SCCWRP 1981-1982. Long Beach, CA.

Willard Bascom
Coastal Water Research
Southern California Coastal Water Research Project
646 West Pacific Coast Highway
Long Beach, CA 90806
213-435-7071

To the Editor:

Bascom has missed the point of our paper. We sought to develop and test a new algal bioassay procedure--not to determine the toxicities and environmental impacts of PCB or DDT. The toxicity of these polluntants is well established, which is why we chose them to evaluate the bioassay.

Our two-species, algal bioassay is intended as a rapid and inexpensive screening technique for detecting aquatic toxicity. Chemicals yielding a response could then be tested by more elaborate, time consuming and expensive tests. It could be compared with the Ames test, a well known, rapid, and inexpensive system employing mutagenesis in bacteria as a quick screening mechanism for detecting potential mammalian carcinogens. Bacterial mutagens detected by this system are then subjected to rigorous, time consuming and expensive tests using mammals.

Our earlier studies employed more "realistic" conditions and natural phytoplankton assemblages in an attempt to define environmental impacts (O'Connors et al. 1978). We have detected effects of PCB at concentrations as low as 100 parts per trillion. (Fisher et al. 1974).

The caption to Figure 1 states that 5 μl of methanol were used as solvent for all chemical additions and controls. DDE, the major metabolite of DDT, was more toxic than DDT or PCB when tested on a marine dinoflagellate (Powers et al. 1975).

References

Fisher, N.S., E.J. Carpenter, C.C. Remsen and C.F. Wurster. 1974. Effects of PCB on interspecific competition in natural and gnotobiotic phytoplankton communities in continuous and batch cultures. Microbial Ecology 1:39-50.

O'Connors, H.B., C.F. Wurster, C.D. Powers, D.C. Biggs and R.G. Rowland. 1978. Polychlorinated biphenyls may alter marine trophic pathways by reducing phytoplankton size and production. Science 201:737-739.

Powers, C.D., R.G. Rowland, R.A. Michaels, N.S. Fisher and C.F. Wurster. 1975. The toxicity of DDE to a marine dinoflagellate. Environ. Pollut. 9:253-262.

Paul Lundy
Charles F. Wurster
Ralph G. Rowland
Marine Sciences Research Center
State University of New York
Stony Brook, NY 11794
516-246-4002

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:

Coastal Ocean Pollution Assessment News
Marine Sciences Research Center
State University of New York
Stony Brook, Long Island, NY 11794

Coastal Ocean Pollution Assessment News is published quarterly. Subscription is free. Individuals wishing to subscribe should write to:
Coastal Ocean Pollution Assessment News
Marine Sciences Research Center
State University of New York
Stony Brook, Long Island, NY 11794

Coastal Ocean Pollution Assessment News
Marine Sciences Research Center
State University of New York
Stony Brook, Long Island, NY 11794

NON-PROFIT ORG.
U.S. POSTAGE
PAID
STONY BROOK, N.Y.
PERMIT No. 65

Address correction requested

COASTAL OCEAN POLLUTION ASSESSMENT NEWS

MAN AND THE MARINE ENVIRONMENT

Volume 3 Number 2 1984

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.

Editors:
M. Grant Gross, *National Science Foundation*
John B. Pearce, *NOAA/Northeast Fisheries Center/Sandy Hook Laboratory*
Donald W. Pritchard, *Marine Sciences Research Center*
J. R. Schubel (Senior Editor), *Marine Sciences Research Center*
Harold M. Stanford, *NOAA/Ocean Assessments Division*

Technical Editor:
Jeri Schoof, *Marine Sciences Research Center*

Assistant Technical Editor:
Kathleen Wallace, *Marine Sciences Research Center*

Graphics:
Marine Sciences Research Center Graphics Arts

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

In This Issue

Continuity

Ecosystem Integration and Environmental Decision-Making

"Neither society nor the environment is well served by the continued use of routine environmental assessment practices which are unable to detect, at an early stage, ecosystem degradation that would result from long-term, subtle impacts" (Van Lopik, 1980). There is a need in marine environmental assessment research to develop strategies which integrate various key dynamics that are part of the total ecosystem picture. For example, by concentrating on key processes in a coastal ecosystem (e.g., nutrient sources, primary and secondary production rates, metabolism, and population dynamics), the long-term fate of an ecosystem can be predicted, since these processes all are important to the integrated health of that ecosystem. In contrast, this usually is not possible using the more common assessment approach of simply identifying, weighing, and counting organisms. Other than direct impacts to the organisms monitored, conclusions rarely, if ever, can be drawn concerning integrated effects on an entire ecosystem from environmental change.

The Texas coast of the Gulf of Mexico is a good example of an area where pressure from industrial growth is increasing daily on coastal waters. Port facilities, the development of large petrochemical centers, harvest of fisheries, exploitation of mineral reserves, and coastal urbanization have all shown recent growth in this region and are projected for continued growth (Thayer, et al., 1983). Characteristics associated with this development often are considered incompatible with the maintenance of these coastal areas as natural, productive systems. The ingenuity of the scientist is the key to perceiving this environment holistically, considering users' needs, assessing all forms of available information, and deriving tools that will provide a sound scientific basis for managers making decisions. Only then can realistic judgments be made which strike an appropriate balance between preservation of natural resources and continued economic growth in this region.

Figure 1 provides an example of how various processes in an estuarine ecosystem can be integrated in a conceptual model that can aid in making management decisions in south Texas. This model summarizes annual biomass distribution and production of the benthos of the Corpus Christi Bay estuary. Also illustrated are seasonal rates of benthic nutrient regeneration, patterns of riverine nitrogen input, and seasonal primary productivity rates. Superimposed upon this information are the peak periods of juvenile brown shrimp abundance in the estuary and larvae colonization to populations that maintain significant parts of the benthic community. This conceptual model (Figure 1) provides an overall view of how various dynamics of the ecosystem fit together into a larger picture. Thus, if an environmental manager were faced with conducting an essential activity in this estuary that could disturb the environment, he could use the integrated information of Figure 1 as a tool to help make a decision when to conduct this activity to disturb the ecosystem the least.

For example, if a decision were required on when to dredge Corpus Christi Bay, a manager could consult the conceptual model and choose a time which would result in minimal disturbance based upon available information. Figure 1 indicates that standing stocks of benthic fauna are much lower during the fall than other periods of the year. Secondary production rates are also lowest during the fall as are phytoplankton production rates. Benthic nutrient regeneration rates are lowest during the fall when peak supplies of nitrogen come from riverine input (Nueces River). Maximum periods of larvae colonization occur in the winter, spring and summer, and the period of peak juvenile brown shrimp abundance is from winter to early summer. Most juvenile fishes using the estuary migrate to offshore waters by early fall. Therefore, the environmental manager could decide to conduct dredging activity during the fall when the dynamics for which we have information would be affected least.

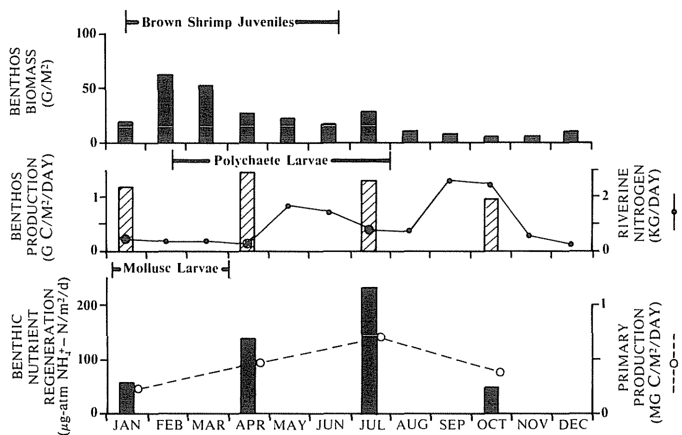


Figure 1. Multiyear data from the Corpus Christi Bay estuary on benthic macroinfaunal standing stock, benthic production and nutrient regeneration, phytoplankton primary production, and riverine nutrient input, along with periods of peak brown shrimp abundance and benthic larval colonization to illustrate the process of developing an integrated picture of how an estuarine ecosystem functions.

Of course there are other considerations with respect to dredging that could influence this decision, such as the economics of some dredging periods contrasted with other periods. This example, however, illustrates how integrated information on environmental function can be used to aid in the decision-making process. The same kind of exercise could be conducted to make decisions on freshwater diversion from this estuary, a continual problem in Texas. Using Figure 1, it could be concluded that diversion should occur in the summer when the internal cycling of nutrients (e.g., benthic regeneration) peaks, rather than during the winter-spring when population dynamics are more susceptible to change or the fall when riverine nutrient contribution is at a maximum.

Another environmental property that should be considered is resiliency after a disturbance. Information on this characteristic can be incorporated into the conceptual model described above. If it is concluded that the fall would be the period of least impact for dredging, then the resiliency of impacted components should be considered. Processes should not be inhibited long enough to affect their contribution to ecosystem function. Table 1 presents data that indicate how resilient the benthic community of Corpus Christi Bay was after a period of dredging in March and April 1982.

Sampling Date	Infaunal Abundance (animals/m²)	Infaunal Species Number	Infaunal Biomass (g/m²)
January 1982	5,055.6	26	4.59
April 1982[1]	214.8	9	1.39
July 1982	2,833.3	28	14.81
Average January	6,305.2 ± 2,031.2	29.7 ± 12.5	10.56 ± 4.83
Average April	5,873.3 ± 1,900.1	36.0 ± 17.4	16.86 ± 6.26
Average July	2,022.5 ± 1,242.3	38.9 ± 15.5	17.29 ± 6.04

[1]Sampling conducted two weeks after dredging completed.

Table 1. Benthic community data obtained from a channel station in the Corpus Christi Bay estuary prior to (1974-81) and after (1982-83) channel dredging occurred in April 1982 that illustrate resiliency of benthic species assemblages. Data from Flint and Younk (1983) and Flint (in preparation).

The January 1982 benthic characteristics of infaunal abundance, species number, and total biomass were normal for this time of year (Flint and Younk, 1983). The April 1982 measures for these same characteristics, taken immediately after the dredging event, were far below average for April of other years (Table 1). By July 1982, however, these same benthic measures were similar to average observations for that month for other years. The benthos of Corpus Christi Bay were resilient enough to show characteristics normal for these fauna three months after the dredging disturbance to the estuary. Thus, incorporating resiliency information into the conceptual model (Figure 1) provides stronger predictive power to the environmental manager and makes his decision-making process more rational.

In the past, many environmental managers concerned with maintaining the quality of an ecosystem in the context of reasonable development have focused on specific and obvious potential problems that could result from particular activities. Examples are specific populations (i.e., fisheries) that could be directly impacted. In many cases, consideration of only specific and obvious problems, taken out of the context of total ecosystem function, has confused resolution of issues and caused environmental managers to make decisions that were not based upon sound ecological judgment. The above example illustrates both the utility of integrating as much information as possible on a habitat to create a holistic view of the environment and the kinds of information one should consider.

References

Flint, R.W. and J.A. Younk. 1983. Estuarine benthos: long-term community structure variations, Corpus Christi Bay, Texas. Estuaries 6:126-141.

Thayer, G.W., D.S. Peters, D.R. Colby, and L.F. Simoneaux. 1983. Does alteration of freshwater inflow patterns impact the nursery function of estuaries? COPAS 2(4):39-40.

Van Lopik, J. 1980. Report of South Atlantic and Gulf Region Conference on Marine Pollution Research, Development, and Monitoring, FY 81-85. NOAA, Washington, DC. 54 pp.

R. Warren Flint
The University of Texas
Marine Science Institute
Port Aransas, TX 78373

Research & Monitoring Updates

Experimental Studies of Early Infaunal Recovery as a Measure of Marine Sediment Contamination

There is concern among researchers and regulators about pollutant contamination of marine sediments because they constitute a potential sink for contaminants and because fauna associated with sediments provide an important food source for fish and invertebrates directly used by man. We have carried out a number of experimental studies with trays of sediment to permit comparison of early infaunal recovery between contaminated and uncontaminated sediments, and among different depths, tidal heights, sites, and seasons of field colonization (e.g., Vanderhorst et al., 1980; 1981 Table 1).

Table 1.

LIST OF EXPERIMENTS INDIGENOUS INFAUNA BIOASSAY

SPONSOR	YEAR	SITE	DEPTH	TREATMENTS	CORES
EPA/ERDA	1976	SEQUIM	MLLW	CONTROL	94
	1977	BAY		CRUDE	
MESA	1978	PROTECTION	MLLW	CONTROL	140
	(FALL)	ISLAND	−2′	CRUDE	140
		SEQUIM	MLLW	CONTROL	140
		BAY	−2′	CRUDE	140
	1979	SEQUIM	MLLW	CONTROL	140
	(15 MO.)	BAY	−2′	CRUDE	140
	1980	DISCOVERY	MLLW	CONTROL	70
	(SPRING)	BAY	+2′	CRUDE	70
EPA	1980	SEQUIM	MLLW		
	(WINTER)	BAY	+2′	CONTROL	112
			−2′	CRUDE	112
			−20′		
OMPA	1980	SEQUIM	MLLW	CONTROL	70
	(SPRING)	BAY	+2′	NO. 2	70
			MLLW	CONTROL	70
			+2′	RESIDUAL	70
EXXON	1980	SEQUIM	MLLW	CONTROL	70
	(FALL)	BAY	+2′	CRUDE	70
				DISPERSED	70
	1981	SEQUIM	−20′	CONTROL	70
	(FALL)	BAY	SUSPENDED	CRUDE	70
				DISPERSED	70
EPA	1982	SEQUIM	−20	HYLEBOS	35
	(IN PRO-	BAY		CONTROL	35
	GRESS)			REFERENCE	35
					2,103

A main advantage of our experimental approaches is that the manipulation of sediments contained in trays allows for unbiased testing of hypotheses on the effects of experimentally-introduced and inherent sediment characteristics on preselected infaunal recovery indices. The species composition and density of colonizing organisms are representative of the habitats and seasons in which the experiments have been conducted.

In studies sponsored by the Marine Ecosystems Analysis Project Puget Sound (NOAA-MESA, Vanderhorst et al., 1980; 1981), we have shown that trays of uncontaminated intertidal sediments from Sequim Bay and Protection Island, Washington, initially purged of infaunal organisms, reached species compositions and densities comparable to those measured in sampling studies of similar habitats within a period of 15 months. Comparisons were made of the degree of colonization between sediments receiving an initial treatment of Prudhoe Bay crude oil and uncontaminated sediments using sediments from three different intertidal sources: Sequim Bay, Protection Island, and Discovery Bay, Washington. Independent experiments were conducted at two tidal heights at each of the sites. While both site and tidal height of colonization resulted in statistically significant effects on numbers of species and individual densities, the largest overall effects resulted from oil contamination. The amount of oil contamination in treatments ranged from 1728 to 2500 ppm (measured by infrared spectrophotometry [IR] at the beginning of experiments). Characterization of specific petroleum components was done by analysis with glass capillary gas chromatography (GC). About half of the original amount of oil was retained after three months of field residence. Oil contaminated sediments were colonized by only about half the number of species as were otherwise matched but uncontaminated sediments. There was also a reduction in overall density for oil-treated sediments as compared to controls.

In studies sponsored by the Office of Marine Pollution Assessment (NOAA-OMPA) (Vanderhorst et al., 1982a, submitted), similar methodology was applied using a high aromatic No. 2 fuel oil and residual (bunker) fuel oil. These experiments, also conducted in the intertidal zone of Sequim Bay, showed that the percent retention of total oil was roughly equivalent for each of the two fuel oils, and was about the same as we had seen in the experiments with Prudhoe Bay crude oil (50%). However, the retention of lighter saturated and aromatic compounds (glass capillary GC) was considerably less for sediments contaminated with residual fuel oil as compared to No. 2 fuel oil. The severity of effects on early recovery of infauna was greater for the No. 2 fuel treated sediment: in broad scale, the total number of species and individuals colonizing these sediments was significantly less than that for residual fuel-treated sediments. The individual density for 4 of 10 preselected species was significantly reduced compared to controls for No. 2 fuel oil, while only two of these same species were similarly affected by the residual fuel oil.

In other experiments, sponsored by the EXXON Research and Development Corporation (Vanderhorst et al., 1982b, submitted), the effects from chemically dispersed and undispersed sediment-borne Prudhoe Bay crude oil were evaluated. These studies, carried out over a two-year period, used a "standard" sediment, a washed riverine sand with particle size distribution similar to Sequim Bay intertidal sediment, in both intertidal and subtidal regions of Sequim Bay. We found that the contribution of sediment source to infaunal colonization in the foregoing studies had been very minor compared to other environmental variables (tidal height, season, site, contamination) and have subsequently observed that, in fact, the degree of colonization in the standard sediment has been equivalent to, or slightly greater than, that found for the range of natural sediments studied. The intertidal studies showed that equivalent initial concentrations (1500 ppm) of chemically dispersed and undispersed Prudhoe Bay crude oil resulted in essentially equivalent retention patterns, both in terms of total oil measurements and measurements of individual saturated and aromatic compounds. While significant effects on infaunal recovery (numbers and densities of species) were demonstrated for both chemically dispersed oil and undispersed oil, the difference in biological effects attributable to the type of treatment (dispersed or undispersed oil) was not significant.

The subtidal experiments revealed several important artifacts of the experimental methodology. Total colonization of the experimental sediments in subtidal sediments was slightly less in a number of species and in individual densities than has been observed in the intertidal studies. The variance among experimental units (individual trays) also was less. Thus, subtidal experiments provided higher statistical precision with equivalent replication than did intertidal experiments. Subtidal experiments also provided a comparison of the degree of colonization of sediments in trays buried with top surface flush with the surrounding bottom sediment, and trays suspended 0.5 m above the bottom. This facet of the design was included to aid in the identification of the source of colonizing organisms, i.e., suspended trays receive water-borne larvae and swimming organisms, while bottom-buried trays would have this source in addition to organisms which move along the bottom. There was significantly greater colonization in terms of numbers of species and individuals in bottom-buried trays than in suspended trays. Thus, experiments conducted with bottom-buried trays predict a more rapid recovery of infauna than might be expected if a wide area of the bottom was contaminated in similar fashion. A combination of bottom-buried and suspended trays of sediment provides a more refined estimate of expected recovery rate.

Furthermore, in the subtidal experiments, the chemically dispersed and undispersed Prudhoe Bay crude oil treatments were applied only to the top 3 cm of sediment. Several pertinent findings resulted from these treatments. First, for the contaminated portion of sediments (top 3 cm), the percentage retention of total oil (initial, 2,000 ppm) after three months of field exposure was about the same magnitude (50%) as we have shown for trays in which the whole sediment column (15 cm) was contaminated. Second, it is pertinent that there was no penetration of chemically dispersed or undispersed oil into the lower strata of cores. Third, the biological effects attributable to treatment of the top 3 cm of sediment were of about the same magnitude as the effects seen when the whole sediment column was contaminated in intertidal studies.

The foregoing studies have demonstrated clearly that early infaunal recovery, as measured in an experimental framework, is affected by introduction of a variety of petroleum-related contaminants. In a direct follow-on study, it should be possible to determine "threshold" concentrations for these effects using a variety of materials introduced to sediments. However, perhaps a more attractive application of the experimental protocols would be the evaluation of indigenous sediments in order to measure effects of existing contamination, to monitor suspected contaminant build-up in sediments, or to assess the effectiveness of cleaning up contaminated sediments.

In studies we presently are conducting for the U.S. Environmental Protection Agency, the experimental protocols are being used as a "bioassay" for contaminated sediments from Hylebos Waterway, Commencement Bay, Washington. We compared colonization of three types of sediments placed in trays in Sequim Bay: sediments collected from Hylebos Waterway, sediments of a similar texture and organic content taken subtidally from Sequim Bay and our "standard" (riverine sand) sediment.

In any study where indigenous sediments are removed for subsequent evaluation, chief concern is possible changes in toxic or other impairment qualities of the sediments following removal. In our current studies, we have monitored aspects of the chemistry of the test sediments from the time they were collected through the entire experimental process. The preliminary findings revealed that composited sediments, immediately frozen at the time of collection, were representative, in terms of saturated and aromatic hydrocarbons, of earlier sampling studies in Hylebos Waterway (Riley et al., 1981). Moreover, when sediments were transported to the laboratory (8 h at 4°C), frozen, thawed, and vigorously mixed in a cement mixer, the saturated and aromatic hydrocarbon concentrations did not significantly differ from immediately frozen sediments. Based on the variance associated with seven replicate samples within each of the two treatment groups (immediate freezing versus transport, freeze-thaw-mix), a difference of 15% in mean levels would have been detected as statistically significant. In actual fact, the mean concentrations were essentially equivalent, i.e., 29.04 versus 30.10 $\mu g/g$ for saturated hydrocarbons, and 9.52 versus 9.17 for aromatic hydrocarbons, respectively.

While removal of individual sediments for subsequent evaluation of suspected toxic or other impairment effects always will require a close monitoring of sediment properties, the foregoing analyses suggest a good prognosis for a valid evaluation of effects from at least the saturated and aromatic hydrocarbons.

Acknowledgement. I acknowledge the sponsorship of the Marine Ecosystems Analysis Project Puget Sound (NOAA-MESA), the Office of Marine Pollution Assessment (NOAA-OMPA), EXXON Research and Development Corporation, and the U.S. Environmental Protection Agency. This work was performed for the Environmental Protection Agency under a related services agreement with the Department of Energy under Contract No. DE-AC06-76RLO 1830. I also am grateful to Dr. Robert G. Riley, Environmental Sciences Department, Battelle Northwest, for chemical analyses of sediments.

References

Riley, R.G., E.A. Crecelius, M.L. O'Malley, K.H. Abel, and D.C. Mann. 1981. Organic pollutants in waterways adjacent to Commencement Bay (Puget Sound). NOAA Tech. Memo. OMPA-12. Boulder, CO. 90 pp.

Vanderhorst, J.R., J.W. Blaylock, P. Wilkinson, M. Wilkinson, and G. Fellingham. 1980. Recovery of Strait of Juan de Fuca intertidal habitat following experimental contamination with oil. DOC/EPA Interagency Energy/Environment Research and Development Program Report EPA-600/7-80-140, U.S. Environmental Protection Agency, Washington, DC. 73 pp.

Vanderhorst, J.R., J.W. Blaylock, P. Wilkinson, M. Wilkinson, and G. Fellingham. 1981. Effects of experimental oiling on recovery of Strait of Juan de Fuca intertidal habitats. DOC/EPA Research and Development Report EPA-600/7-81-088. U.S. Environmental Protection Agency, Washington, DC. 129 pp.

Vanderhorst, J.R., P. Wilkinson, and M. Wilkinson. 1982. Effects from Residual and No. 2 fuel oils on intertidal infauna recovery rate. (Submitted, Marine Environmental Research).

Vanderhorst, J.R., P. Wilkinson, and M. Wilkinson. 1982. Experimental studies of infaunal recruitment in sediments contaminated with chemically dispersed oil. (Submitted, Marine Environmental Research).

J.R. Vanderhorst
Battelle, Marine Research Laboratory
439 West Sequim Bay Road
Sequim, WA 98382

Airborne Toxin Demands Down-to-earth Study

Most people have heard of the insecticides DDT, chlordane, malathion, dieldren, and Sevin. But how many know that a chemical called toxaphene was recently the most heavily used insecticide in the United States? Perhaps only rural Southerners, who know toxaphene well as the insecticide that replaced DDT for controlling the cotton boll weevil. In that use, toxaphene became the most heavily used insecticide in the country in the 1970's. Toxaphene also controls pests on peanuts, soybeans, and cattle, and has been used to eliminate trash fish from lakes and ponds.

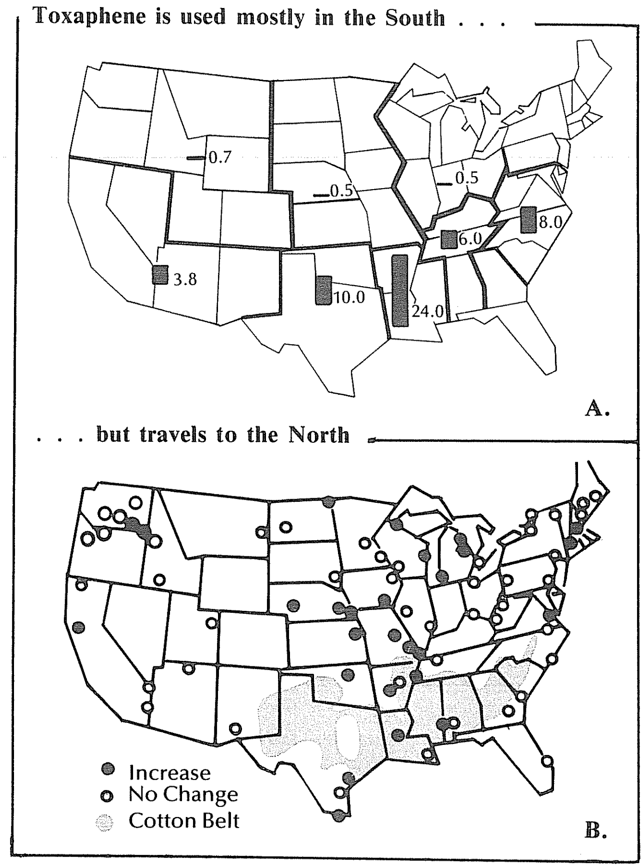
Toxaphene is an organic compound produced by the chlorination of camphene from southern pines and its empirical formula is $C_{10}H_{10}Cl_8$. Also known as camphechlor, polychlorocamphene, and Strobane, toxaphene has been in use in the United States since 1947. Between 1947 and 1977, more than 2.49×10^8kg of toxaphene were produced in the U.S. (Rice and Evans, in press).

Early studies of waterways and soils near cotton fields showed no significant residues of toxaphene (LaFleur et al., 1973; Swoboda et al., 1971). But, in the early 1980s, scientists discovered that toxaphene is highly mobile, showing up in organisms hundreds and even thousands of miles from where it is used, such as in the Great Lakes, Nova Scotia, the Tyrolean Alps, and Antarctica (Swain, 1982; Zell & Ballschmiter, 1980). Scientists determined that this was because of toxaphene's volatility, which cause it to evaporate from soil and plant surfaces in the South and to be transported by air currents (Bidleman and Olney, 1975). These findings, together with confirmation of toxaphene's mutagenic properties (Hooper et al., 1979) and carcinogenic effects on rodents (Reuber, 1975) led to intensive EPA study. In the summer of 1982, severe restrictions were imposed on toxaphene use in the United States.

However, toxaphene is still being used freely in many other countries, such as Mexico, the USSR, and several European nations. And toxaphene is persistent (Johnson et al., 1966). Concentrations of toxaphene in the Great Lakes have not shown any decline, even though toxaphene use in the U.S. has declined drastically since 1976 (Rice & Evans, In press).

Much remains to be learned about toxaphene. It is a complex chemical, consisting of 177 isomers (Holmstead et al., 1974) and it also has various breakdown products. The commonly used methods of analyzing chlorinated hydrocarbons—packed gas column chromatography and electron capture detection—have not been adequate for analyzing toxaphene. Many toxaphene components have long retention times and form late eluting gas chromatographic peaks that are broad and difficult to distinguish above natural baseline drift (Ribick et al., 1982). Also, electron capture sensitivity to toxaphene is less than for other chlorinated compounds (McMahon, 1977). And, in environmental samples containing toxaphene and PCBs, toxaphene peaks are sometimes masked by PCB peaks. Only recently has the technology become available for analyzing toxaphene. Capillary column chromatography and capillary-equipped negative chemical ion mass spectometry are more effective, and their application is now being tested.

Because of the analytical problems, little is known about toxaphene's pathways and fate in the environment, that is, how it travels through the food chain, sediments and water column, and what types of compounds it breaks down to in the process. The effects of toxaphene on humans are not well understood, but it may be carcinogenic (Durkin et al., 1980). And, although some environmental effects of toxaphene are known, new information about its pathways and breakdown products may reveal additional impacts.



A. Toxaphene use by region in 1972 (millions of pounds).

B. Changes in Toxaphene concentrations in fish at stream monitoring stations between 1974 and 1979. Use declined after 1974, but concentrations increased at many northern stations because Toxaphene moves easily through the air.

The Michigan Sea Grant College Program is addressing these problems in an effort to understand toxaphene behavior, both in the Great Lakes and worldwide. One study, conducted by Marlene Evans and Clifford Rice of The University of Michigan, is investigating how toxaphene is transferred through different levels in the Great Lakes food chain, assessing toxaphene metabolism or degradation that may occur along the way, and identifying the physical mechanisms for toxaphene transport.

Another study, by Fumio Matsumura of Michigan State University, is investigating the changes toxaphene undergoes in the environment and identifying the resulting stable and toxic residues. One interesting question he will address is whether toxaphene's rapid disappearance from soil surfaces is due to volatility alone, or whether oxidative metabolism of toxaphene by aerobic microorganisms also plays a role.

The third study, by Matthew Zabik, also of Michigan State University, will improve methods of analyzing toxaphene residues and will examine what happens to toxaphene compounds when exposed to sunlight. Procedures he is working with include gas and high pressure liquid chromatography, mass spectrometry, and UV or electrochemical detection.

The findings of the Michigan Sea Grant researchers will add to the understanding of a chemical found worldwide and will be applicable to the entire field of pesticide research. Findings about trophic transfer, bioaccumulation, and photochemistry should aid in predicting the fate of other persistent pollutants and in developing environmentally degradable pesticides.

References

Bidleman, T.F. and C.E. Olney. 1975. Long Range Transport of Toxaphene Insecticide in the Atmosphere of the Western North Atlantic. Nature 257:475-477.

Durkin, P.R., P.H. Howard, J. Saxena, S.S. Lande, J. Santodonato, J.R. Strange, and D.H. Christopher. 1980. Reviews of the Environmental Effects of Pollutants: X Toxaphene. EPA Report No. 600/1-79-044. 500 pp.

Holmstead, R.L., S. Khalifa, and J.E. Casida. 1974. Toxaphene Composition Anaylzed Combined Gas Chromatography-Chemical Ionization Mass Spectrometry. Agric. Food Chem. 22:939-944.

Hooper, N.K., B.N. Ames, M.A. Saleh, and J.E. Casida. 1979. Toxaphene, a Complex Mixture of Polychloroterpenes and a Major Insecticide is Mutagenic. Science 205:591-593.

Johnson, W.D., G.F. Lee, and D. Spyridakis. 1966. Persistence of Toxaphene in Treated Lakes. Air Wat. Pollut. Int. J. 10:555-560.

LaFleur, K.S., G.A. Wojeck, and W.R. McCaskill. 1973. Movement of Toxaphene and Fluometuron Through Dunbar Soil to Underlying Ground Water. J. Environ. Quality 2:515-518.

McMahon, B. 1977. Gas Chromatograph Response Factors and Relative Retention Times. Special Addendum to: Pesticide Analytical Manual, Vol. I. Food and Drug Administration, Washington, DC.

Reuber, M.D. 1975. Carcinogenicity of Toxaphene: A Review. J. Toxicol. Environ. Health 5:729-748.

Ribick, M. A., G.R. Dubay, J.D. Petty, D.L. Stalling, and C.J. Schmitt. 1982. Toxaphene Residues in Fish: Identification, Quantification, and Confirmation at Part Per Billion Levels. Environ. Sci. Technol. 16:310-318.

Rice C.P. and M.S. Evans. In press. Toxaphene in the Great Lakes. *In* J.O. Nriagu and M.Simmons, eds. Toxic Contaminants in the Great Lakes. Wiley Interscience, NY.

Swain, W.R. 1982. An Overview of Contaminants in the Lake Superior Ecosystem. *In* Proceedings of the 25th Conference on Great Lakes Research, International Association for Great Lakes Research.

Swoboda, A.R., G.W. Thomas, F.B. Cady, F.W. Braid, and W.G. Knisel. 1971. Distribution of DDT and Toxaphene in Houston Black Clay on Three Watersheds. Environ. Sci. Technol. 5:141-145.

Zell M., and K. Ballschmiter. 1980. Baseline Studies of the Global Pollution. II Global Occurence of Hexachlorobenzene (HCB) and Polychlorocamphenes (toxaphene) (PCC) in Biological Samples. Fresenius Z. Anal. Chem. 300:387-402.

Sources for Maps

A. adapted from Von Rumker R., A.W. Lawless, A.F. Meiners, K.A. Lawrence, G.C. Kelsco, and F. Horay. 1974. Production, Distribution, Use and Environmental Impact Potential of Selected Pesticides. National Technical Information Service, Springfield, VA.

B. adapted from Schmitt, C.J., M.A. Ribick, J.L. Ludke, and T.W. May. 1983. National Pesticide Monitoring Program: Organochlorine Residues in Freshwater Fish. Resource Publication 152, U.S. Fish and Wildlife Service. 63 pp.

Martha Walter Deline
Michigan Sea Grant College Program
The University of Michigan
2200 Bonisteel Boulevard
Ann Arbor, MI 48109

National Research Council's Study of Drilling Fluids and Cuttings in the Marine Environment

As a result of expanded exploration for oil and gas on the U.S. outer continental shelves (OCS), concerns have been raised about the effects of overboard discharges of drilling fluids and cuttings on the marine environment. Despite rather intensive research on the subject, controversies still exist. Consequently, the Marine Board of the National Research Council convened the Panel on Assessment of Fates and Effects of Drilling Fluids and Cuttings in the Marine Environment at the request of the Department of the Interior. Dr. John D. Costlow of the Duke University Marine Laboratory served as Chairman of the 13-member group. The Panel's report, entitled "Drilling Discharges in the Marine Environment" has been published by the National Academy Press (2101 Constitution Avenue, NW, Washington, DC).

The Panel was charged with establishing a technical basis for decisions about discharging fluids and cuttings, reviewing and critically appraising available knowledge, assessing the adequacy, applicability and transferability of research, and recommending procedures to mitigate adverse environmental effects.

Drilling fluids are required in rotary drilling to remove cuttings, control pressure, cool and lubricate, and seal the well. They must eventually be disposed because of loss of properties. Cost and operational considerations in offshore drilling favor onsite disposal. The bulk constituents (water, barite, clay minerals, chrome lignosulfonate, lignite and sodium hydroxide) are essentially nontoxic at concentrations reached quickly after discharge. Minor constituents (including biocides and diesel fuel) may be more toxic and there is limited information on the composition and quantities of these additives used. Two million metric tons of solid constituents are discharged annually in the U.S. OCS, 90% of this in the Gulf of Mexico. Future discharges are likely to be concentrated in the Gulf of Mexico, Southern and Central California, and Alaska. The total particulate loading from drilling fluids discharged approximates 1% of the annual discharge of the Mississippi River, but the loading of barium may be as much as twice that of the Mississippi.

Greater than 96% of the whole drilling fluids tested in short-term bioassays (44-144 hours) exhibited an LC-50 greater than 1,000 ppm and can be classed as "slightly toxic" to "essentially nontoxic". Over 98% of the tests using the suspended particulate phase had an LC-50 greater than 10,000 ppm. Acute toxicity tests with over 70 different fluids and 60 species of marine animals indicate most water-based fluids are relatively nontoxic. In a few cases where the LC-50 was 100 to 10,000 ppm, the toxicity was probably attributable to diesel oil in the fluid. Tests of sublethal effects are few but generally do not show effects at levels less than one-fifth those exhibiting acute lethal toxicity. The direct application of bioassay results to the prediction of field effects is limited by the fact that these tests generally do not simulate the short and variable exposure conditions actually experienced. Tests of effects on benthic organisms in sediment systems have not separated chemical and physical effects. Studies of bioaccumulation have not considered sequestering and detoxification of metals by organisms. There is no evidence of biomagnification of metals.

There are no clear trends based on toxicity tests that species from one OCS region are more sensitive than those from another, nor that inshore species are necessarily inappropriate surrogates for offshore counterparts. There exists no evidence that justifies different regulatory policies concerning the use of additives in different OCS regions.

On the continental shelf about 90% of the particulates in the drilling fluid and almost all of the cuttings settle rapidly to the bottom. The upper, visible plume is but a small portion of the discharge but has commanded most attention. Horizontal turbulent diffusion results in a dilution of 10,000 or more of dissolved components within one hour of discharge; greater attenuation can be expected in particulate concentrations as a result of settlement. Despite the heterogeneities in environmental conditions, observations of upper plume dispersion generally conform with theory. Based on these observations, toxic responses in the water column can only be expected beyond the immediate vicinity of the discharge pipe if they are expressed at concentrations approximating 100 ppm over one hour of exposure. Given this, there is no basis for restrictions of dilutions or rates of discharge for mitigating water column effects.

The extent of contamination of bottom sediments and the resultant effects of the sedimented muds and cuttings depend on sediment dispersal processes which have not been modeled. Effects on benthic communities have been observed in the field under low to moderate energy regimes within 1,000m of the discharge. Because residual chemical toxicity of sediments should be low, the recovery of affected communities should be similar to that following other physical disturbances: weeks in frequently disturbed shallow waters, months to a few years in continental shelf environments and several years in continental slope and deepsea environments. Long-term effects on the benthos resulting from discharges from multiple wells are not well known and are difficult to separate from other effects. A hard-substrate epibiota may be particularly sensitive to deposition of drilling muds, but most such communities exist in dynamic regimes where sediments are not accumulated.

The notable deficiencies of current knowledge (variable quality of research, limits to the relevance and realism of laboratory experiments, ascribing effects to causes, and poor understanding of ecosystem processes) also pertain to effects of other pollutants in the coastal ocean. Emphasis should be placed on research on the broader topics of accumulation and transfer of materials and ecosystem response. Extensive further research specifically focused on the fate and effects of drilling fluids is not needed.

Because effects of individual discharges of drilling fluids and cuttings are limited to the benthos, are small in scale and ephemeral, the risks of exploratory drilling discharges to most OCS communities are small. Discharges from development drilling are greater and more prolonged, but accumulation is less than additive, suggesting that extrapolations can be made from effects observed during exploratory drilling. Uncertainties exist for low energy, depositional environments which experience large inputs over long periods of time.

Effects of drilling discharges can be minimized by avoiding deposition in sensitive benthic environments which are not naturally exposed to significant sediment flux. The use of toxic additives, such as diesel oil, should be monitored or limited. Drilling fluids demonstrating significant toxicity in laboratory experiments should be chemically analyzed to determine the toxic components.

John D. Costlow (Panel Chairman)
Duke University Marine Laboratory
Beaufort, NC 27706

Donald F. Boesch
Louisiana Universities Marine Consortium
Chauvin, LA 70344

Coastal Information System Development Reaches Milestone

The Marine Sciences Research Center two-year coastal information system development effort using IBM personal computer technologies reached a milestone in January 1984 with a demonstration of the system to a group of interested regional agencies. The demonstration was held at the State University of New York's Marine Sciences Research Center (MSRC) in Stony Brook, NY and was attended by over twenty Federal, State and regional representatives of the New York/New Jersey port area. The development, which was initiated in June 1982, is being directed by Dr. Peter Weyl of the MSRC and is jointly funded by the William H. Donner Foundation and the National Oceanographic Data Center's Ocean Pollution Data and Information Network (OPDIN).

Using the Hudson-Raritan estuary as a prototype, an atlas of the area that defines linear coordinates along the shores and waterways was prepared. The coordinates are then used to index a wide variety of space specific information of interest to environmental managers. Data on such features as political jurisdiction, land use, soil type, shore type, sediment characteristics, land use and port facilities were collected, evaluated and organized into information files.

The Lotus 1-2-3 applications program is used to facilitate information retrieval and processing by the personal computer. The system is organized into "1-2-3 worksheets". Each worksheet deals with a specific topic and combines data files with macroprogramming that permits menu driven information retrieval. The worksheets cover such topics as the natural and cultural attributes of shorelines, waterways and water areas. There are worksheets giving details about port facilities and point sources of pollution. Historical information files deal with population trends and the changes in waste water treatment. A glossary of terms, reference files, a generic worksheet on the characteristics of the fishes in the area and a map index supplement the space specific data files.

With nearly all data files completed, the remaining effort will focus on how the system can best be integrated into the day to day operations of the various agencies concerned with space specific data in the port. With funding from the Maritime Administration, an information system for the Port of New Orleans and its connections with the Gulf of Mexico is currently under development.

The system uses the XT version of the IBM PC (hard disk) with a total memory of 320 K. A more limited version using 192k memory can be implemented on the IBM Personal Computer with floppy disks. Transfer of the system to other microcomputers for which the Lotus 1-2-3 software is adaptable also is feasible. The January demonstration utilized both versions of the IBM PC and a portable "COMPAQ" computer.

Arrangements for demonstrations of the system at Stony Brook, NY or Washington, DC can be made through the undersigned.

Peter Weyl
Marine Sciences Research Center
State University of New York at Stony Brook
Stony Brook, NY 11794
516-246-6115

Jim Audet
Central Coordination and Referral Office
National Oceanographic Data Center/NOAA
Washington, DC 20235
202-634-7510

Pollutants and Remineralization of Organic Matter in Sediments

The effects of pollutants in sediments on decomposition of organic matter have important implications regarding organic and industrial waste disposal, the remineralization and recycling of primary nutrients, and the biological productivity of aquatic ecosystems. Many contaminants, including pesticides, heavy metals, aromatic hydrocarbons and chlorinated hydrocarbons have accumulated in San Francisco Bay sediments (Risebrough et al., 1978). We are trying to determine if the pollutant burden of bay sediments has measurable effects on the ability of benthic communities to decompose organic matter.

Coastal sediments are anoxic typically below a thin surface layer. Hence, the main bulk of pollutants in bays and estuaries are expected to be in a reduced state. We need to know the effects of such pollutants on the activity of anaerobic decomposers.

There are many kinds of anaerobes in sediments, besides many kinds of aerobes. Heat is the common metabolic by-product of all organisms performing all kinds of chemical transformations. Under carefully controlled conditions, the metabolic breakdown of organic matter into heat can be measured by direct calorimetry. We have been using this technique to measure total benthic energy flow because of its advantage in sediments containing unknown, complex, functionally-coupled mixtures of different types of aerobes and anaerobes (Pamatmat, 1982, in press).

Continuous heat flow measurements show the response of a microbial population or a community to the addition of food (Figure 1). The heat flow from a freshly inoculated batch culture

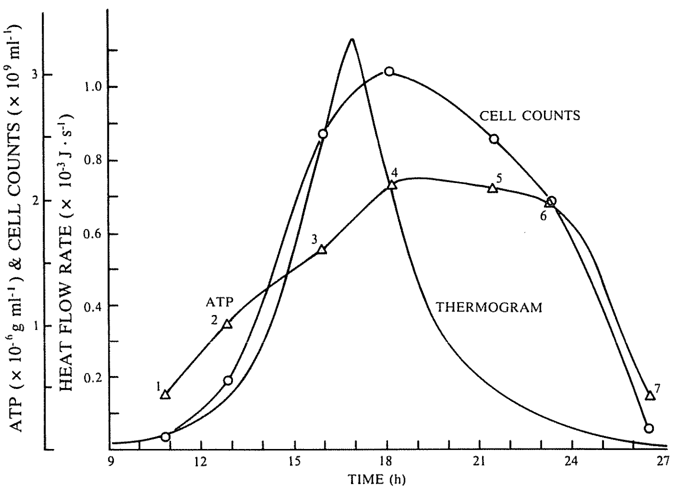


Figure 1. Continuous heat flow and periodic changes in cell numbers and ATP concentration in an anaerobic batch culture of *Bacteroides sp.* in Brewer's thioglycollate medium. The sample (a 50-ml aliquot) was placed inside the calorimeter at time zero. The remainder, outside the calorimeter but inside a nitrogen glove box at the same temperature as the calorimeter (27°C), was subsampled at the successive times indicated.

of bacteria clearly depicts its growth cycle (Pamatmat et al., 1981). The change in numbers and biomass (as ATP) also reflect the well-known stages in bacterial growth cycle, but the changing relationship between heat flow and measures of standing stock also reflects continuously changing physiological state of the culture. This points to the problem of estimating metabolic rates from biomass measurements using assumed conversion factors and to the need to measure metabolic rates directly whenever this is the primary interest.

We are trying to determine if sediments of different pollutant loads will show the same heat flow pattern following identical addition of an organic substrate that occurs naturally in the bay. We use homogenized tissue of the ribbed mussel, *Ischadium* (= *Modiolus,* = *Geukensia) demissum demissum,* a common inhabitant of surrounding marshes in San Francisco Bay. A batch of 50 mussels was pureed in a blender, frozen, and subsampled as needed.

When added to the anoxic layer of sediment cores, mussel tissue caused a slow increase in heat flow to a peak in 35 h and subsequent decline (Figure 2). Sediment cores of different pollutant

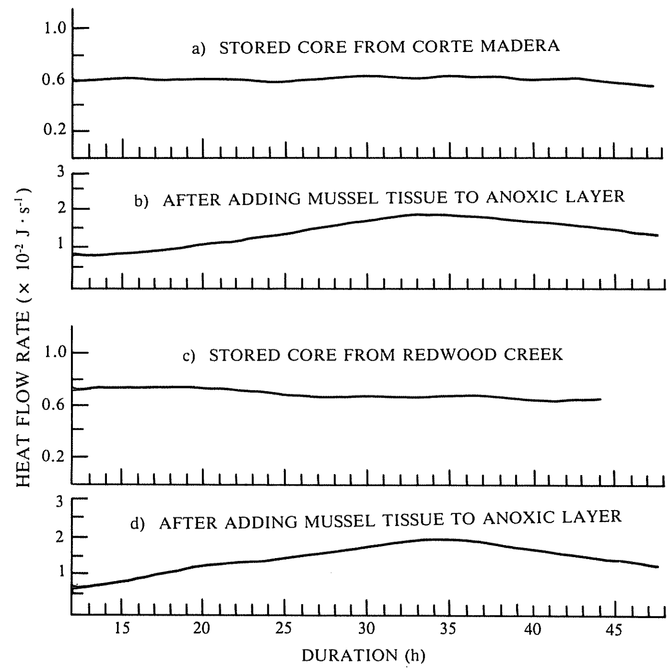


Figure 2. Heat flow from stored sediment cores before and after addition of mussel tissue below the sediment surface. Both cores were from the intertidal: a and b represent an area in the northern SF Bay with no known pollution discharge; c and d represent the mouth of Redwood Creek, a more polluted biotope.

burdens show the same pattern and magnitude of increase in heat flow, indicating the same capacity to decompose the added organic matter. The increase in heat flow is comparable to that of a batch culture of bacteria going through its growth phases.

Fresh sediment cores show some fluctuations and a relatively rapid decline in average heat flow initally (Figure 3a). The addition of 0.8g $HgCl_2$ on the surface accelerated the drop in heat production rate as organisms died and total metabolic activity declined (Figure 3b). The fluctuations in heat flow also disappeared, indicating that these were related to the activity of the poisoned macrofauna (polychaetes, amphipods, bivalves). When the entire core was subsequently mixed thoroughly (giving a final concentration of 1000 ppm for the wet sediment) and mussel puree was added below the sediment surface, there was an increase in heat flow followed by a subsequent decline (Figure 3c). As little as 10 ppm of $HgCl_2$ in the overlying water of a core killed amphipods, clams, and polychaetes, which appeared on the sediment surface; but after several days the dead animals began to decompose and the sediment surface turned black.

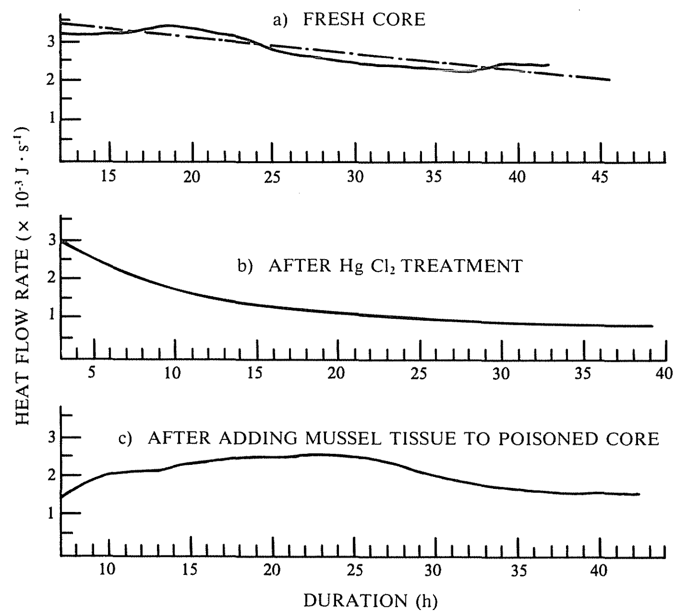


Figure 3. a) Heat flow from a fresh sediment core (broken line represents an average decline of 0.04×10^{-3}J. $s^{-}\cdot h^{-1}$), b) after addition of $HgCl_2$, and c) after mixing the $HgCl_2$ in the entire core to give 1000 ppm concentration and adding mussel tissue. Mixing the sediment by itself has negligible effect on heat flow in comparison with the increase resulting from the added organic matter.

Differences between Figure 2b and 3c, or 2d and 3c, indicate different growth patterns. We do not yet know the implications of these differences. We can tell from Figure 3c that some anaerobic microorganisms can grow in 1000 ppm Hg, a much higher concentration than present anywhere in San Francisco Bay, if mercury is in a chemical state that exists in anoxic sediment. Mercuric chloride is detoxified by precipitation as sulfides, as is the case with copper (Vosjan and van der Hoek, 1972). Test results with other pollutants also indicated that they are relatively innocuous in the reduced state (Hallas et al., 1982; Mahaffey et al., 1982) as compared to their toxicity in aerobic conditions. However, this may not be universally true.

We still have to test other toxic substances directly to find out how sediment burial affects their toxicity. We are also interested in testing sediments from other estuaries that are known to be more polluted than SF Bay and which have been shown, using other methods, to have suffered some degradation in benthic community activity.

This research was supported by NOAA, Office of Marine Pollution Assessment, Grant NA81RAD00028.

References

Hallas, L.E., J.S. Thayer and J.J. Cooney. 1982. Factors affecting the toxic effect of tin on estuarine microorganisms. Applied and Environmental Microbiology 44:193-197.

Mahaffey, W.R., P.H. Pritchard and B.W. Bourquin. 1982. Effects of kepone on growth and respiration of several estuarine bacteria. Applied and Environmental Microbiology 43:1419-1424.

Pamatmat, M.M. 1982. Heat production of sediment: ecological significance. Science 215:395-397.

Pamatmat, M.M. 1983. Measuring the metabolism of the benthic ecosystem. *In* Flow of Energy and Materials in Marine Ecosystems: Theory and Practice (M.J. Fasham, ed.). Plenum Press, N.Y. (in press).

Pamatmat, M.M., G. Graf, W. Bengtsson and C.S. Novak. 1981. Heat production, ATP concentration and electron transport activity of marine sediments. Marine Ecology - Progress Series 4:135-143.

Risebrough, R.W., J.W. Chapman, R.K. Okazaki and T.T. Schmidt. 1978. Toxicants in San Francisco Bay and estuary. The Bodega Bay Institute of Pollution Ecology, Berkeley, CA.

Vosjan, J.H. and G.J. van der Hoek. 1972. A continuous culture of *Desulfovibrio* on a medium containing mercury and copper ions. Netherlands Journal of Sea Research 5:440-444.

Mario M. Pamatmat
Tiburon Center for Environmental Studies
San Francisco State University
P.O. Box 855
Tiburon, CA 94920

Gonyaulax excavata Monitoring in New Jersey

Off the northeast coastal states, the incidence focus for paralytic shellfish poisoning (PSP) associated with the dinoflagellate *Gonyaulax excavata (G. tamarensis)* historically has been the northern half of the Gulf of Maine. Hurst (1975) documented the first major recorded incidence of PSP in Maine in the summer of 1958. The greatest expansion of PSP to more southerly locales took place in 1972 when high levels were detected in Maine, New Hampshire, and Massachusetts (Mahoney et al., 1976). In 1979, PSP was detected in Narragansett Bay, Rhode Island (newspaper account cited in Anderson et al., 1982). Recently, benthic cysts of this dinoflagellate were found in locales throughout southern New England and along both shores of Long Island, New York (Anderson et al., 1982). Planktonic vegetative cells have also been identified in Long Island waters (A. Freudenthal, S. Schrey, personal communication). Both the benthic cysts and vegetative cells can be toxic (Dale et al., 1978). However, PSP levels of toxin have not been reported as yet in Long Island shellfish, although Anderson et al. (1982) did determine that isolates from Long Island were toxic.

If *G. excavata* can flourish in Lower New York Bay and adjacent waters, a very dense "red tide" is a possibility because of the extreme richness of these waters in phytoplankton nutrients. However, although these waters are regions of intense annual phytoflagellate blooms (Cohn and Van de Sande, 1974; Mahoney and McLaughlin, 1977), red tide caused by *G. excavata* has not been observed in our monitoring over the past 20 years. Also, to our knowledge, based on ongoing and completed long-term surveys (e.g., Olsen and Cohn, 1979 which identified 332 phytoplankton species, 208 of these being newly recorded for the area), *G. excavata* is not in New York Harbor and New Jersey coastal waters, even in low numbers.

Despite the absence of a PSP problem in New York and New Jersey, and the absence of the dinoflagellate in New Jersey waters, several factors prompted early examination of the potential problem. These include the possible continued southward spread of *G. excavata,* close proximity to New York waters where the dinoflagellate is currently resident, and the importance of New Jersey's fishing and resort industries. Accordingly, the New Jersey State Department of Environmental Protection and the National Marine Fisheries Service (Sandy Hook Laboratory) began a cooperative survey in late 1981 for cysts of *G. excavata* in New

Jersey, particularly in prime shellfish areas. An assay study to determine the growth potential of *G. excavata* throughout the Lower New York Bay system and through the June-September flagellate peak growth season was also begun last year at the Sandy Hook Laboratory.

Between December 1981 and the present, 24 estuarine sites in New Jersey between Raritan and Delaware bays were examined at least once for the presence of *G. excavata* cysts. Dr. D. Anderson of the Woods Hole Oceanographic Institution kindly provided advice on the method of sediment collection and cyst enumeration. With the possible exception of one sample from the Atlantic City area, we have not detected the cysts in New Jersey. The Atlantic City sample had a single cyst which resembled one of *G. excavata.* Subsequent intensive sampling at the same site did not recover more of the cysts. We plan to continue seasonal monitoring for both benthic and planktonic stages.

References

Anderson, D.M., D.M. Kulis, J.A. Orphanos and A.R. Ceurvels. 1982. Distribution of the toxic dinoflagellate *Gonyaulax tamarensis* in the southern New England region. Est. Coast. and Shelf Sci. 14:447-458.

Cohn, M. and D. Van de Sande. 1974. Red tides in the New York-New Jersey coastal area. Underwat. Nat. 8:12-21.

Dale, B., C.M. Yentsch and J.W. Hurst. 1978. Toxicity in resting cysts of the red-tide dinoflagellate *Gonyaulax excavata.* Science 201: 1223-1225.

Freudenthal, Dr. Anita. Nassau County Department of Health, 240 Old Country Road, Mineola, NY 11501.

Hurst, J.W., Jr. 1975. History of paralytic shellfish poisoning on the Maine coast. Pages 525-528 *in* V.R. LoCicero (ed.). The First International Conference on Toxic Dinoflagellate Blooms. Massachusetts Science and Technology Foundation, Wakefield, MA.

Mahoney, J.B., J.P. Thomas and W.J. Blogoslawski. 1976. "Red tide", a synopsis of its causes and effects, and discussion of pertinent research by the Middle Atlantic Coastal Fisheries Center. Technical Report, Middle Atlantic Coastal Fisheries Center, Sandy Hook Laboratory, Highlands, NJ. 58 pp.

Mahoney, J.B. and J.J.A. McLaughlin. 1977. The association of phytoflagellate blooms in Lower New York Bay with hypertrophication. J. Exp. Mar. Biol. Ecol. 23:53-65.

Olsen P. and M. Cohn. 1979. Phytoplankton in Lower New York Bay and adjacent New Jersey estuarine and coastal areas. Bull. N.J. Acad. Sci. 24:59-70.

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

Paul Olsen[1]
Myra Cohn[2]
John B. Mahoney[2]
Eric Feerst[1]

[1]New Jersey Department of Environmental Protection
Division of Water Resources
Bureau of Monitoring and Data Management and Bureau of Shellfish Control
Trenton, NJ 08625

[2]U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Center
Sandy Hook Laboratory
Highlands, NJ 07732

Detection of a DNA Virus Within an Upper New York Bay Soft-Shell Clam Population

Over the past two decades much attention has been focused on the possible relationship of molluscan proliferative disorders to the presence of viral agents. Farley et al. (1972) first reported Herpes-like viral particles within oysters using electron microscopy. Later Farley (1976a) observed massive hypertrophied cells in the oyster, *Crassostrea virginica*, in conjunction with Feulgen-positive nucleii. Based upon morphologic and developmental criteria Farley tentatively identified the virus as a papillomavirus. While histologically examining soft-shell clams, *Mya arenaria*, from the Annisquan River, Massachussetts, Farley (1976b) noted that 20 percent of those animals examined had finely-granular intranuclear Feulgen-positive inclusions within gill epithelial cells. Harshbarger et al. (1977) have described a second DNA virus, Polyoma type, within connective tissue, hemocytes and gill epithelia of *M. arenaria*. Ongoing research at the University of Rhode Island (Appeloorn and Oprandy, 1980) has demonstrated experimentally the seawater transfer of neoplasia between viral-infected and healthy soft-shell clams.

As yet no published reports exist as to the presence of viruses within soft-shell clams known to inhabit the heavily stressed waters of Upper New York Bay. In this regard our laboratory conducted a histopathologic survey of *M. arenaria* collected bimonthly between May and November, 1980, from a single shallow site in Upper New York Bay (Figure 1). The station, located in Bayonne,

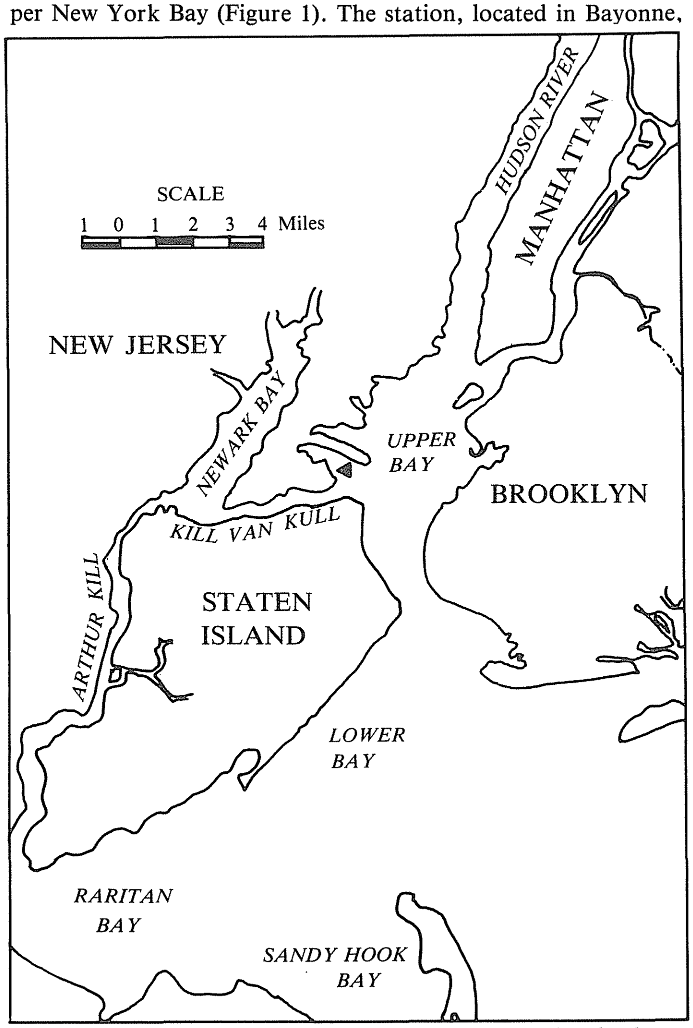


Figure 1. Lower Hudson River-Raritan Bay Estuary showing location of sampling site (▲) in Upper New York Bay.

New Jersey, adjacent to the Military Ocean Terminal, is subject to both domestic and industrial sewage discharges as well as frequent oil spills. Four separate collections of 50 soft-shell clams each (representing three weight classes) were made. For reference purposes a single sample of 50 *M. arenaria* was obtained in November, 1980, from the Chesapeake Bay near Oxford, Maryland. Both gill and gonadal tissues were examined subsequently using light and electron microscopy.

The Upper New York Bay soft-shell clam population exhibited symptoms of chronic stress at gross, histologic and cytologic levels. Regardless of month of capture and weight class, clams showed a yellowish visceral discoloration, blackened siphons and abnormal musculary responses. A relatively small average size was observed for individuals of this population (versus that observed for the reference population). Gill tissues of those clams sampled invariably exhibited profound cellular injury, including intercellular and extracellular swelling of epithelia and pronounced inflammation (Table 1). Gonadal examination suggests that an aborted secondary spawn occurred in early fall among clams of the Upper New York Bay population.

Table 1

Gill Histopathology of *Mya Arenaria*
(Each pathologic manifestation expressed as percent occurrence based upon a sample size of 50 clams)

Sampling Month (1980)	May	July	Sept.	Nov.	Nov. (Reference)
intracellular swelling	60	46	40	36	2
intercellular swelling	60	72	52	72	2
inflammation	52	24	50	80	40
necrosis	20	8	2	12	8
degradation	4	0	6	10	0
neoplasia	0	0	0	0	0
hyperplasia	2	4	0	2	0
Feulgen-positive nucleii	36	48	32	26	2

Eighty-two of the 200 clams collected at the Bayonne site contained Feulgen-positive nucleii within gill epithelia. No clear correlation was noted between month of capture and clam weight class versus viral presence. In every case, virus particles were limited to ciliated epithelia associated with the gill food groove. Electron microscopic examination of Feulgen-positive nucleii (Figure 2) revealed intranuclear particles consisting of a large compact aggregate of virus-like particles in crystalline array. Subject to further characterization, the virus has been tentatively identified as belonging to the genus *Papillomavirus*. Members of this genus have doubly-stranded DNA viruses and are capable of promoting both benign and malignant tumors in various natural and experimental hosts, including mammals (Luria et al., 1978). Feulgen-positive nucleii were observed in only 2% of the Chesapeake Bay reference clams examined.

Although some evidence of atypical hyperplasia was apparent among the Upper New York Bay population, viral infection could not be positively correlated with cell transformation. In this regard, neoplasia was only infreqently observed (and then only within the connective tissue stroma of the gonad) and never within gill tissue. Indeed, the freqency of neoplasia is significantly lower for this population than for soft-shell clams collected at two oil-spill sites in Maine (Yevich and Barszcz, 1977).

Figure 2. Electron micrograph of the gill epithelium of *Mya arenaria* showing a viral-infected cell nucleus (arrow).

Definitive assessment as to the contribution, if any, of the infecting virus to the observed squalid condition of this Upper New York Bay population is complicated by the ubiquitous nature and sources of anthropogenic perturbations within this complex estuarine system. Analysis of trace metal residues within this same soft-shell clam population has revealed (Ellis et al., 1981) significantly-elevated soft tissue concentrations of mercury, cadmium, zinc and copper. Chronic exposure to these and other metals as well as a myriad of available organic contaminants, may well predispose gill epithelial tissue to viral infection. Concomitant infection with animal and bacterial parasites might also contribute to the latter. Although the exact source of the virus cannot be pinpointed at this time, the liberal discharge of primary sewage into Upper New York Harbor and its tributaries is suspect.

At the very least this investigation has resulted in the first confirmed report of a DNA virus in *Mya arenaria* collected in the immediate vicinity of New York Harbor. This finding should stimulate a more comprehensive assessment of this bivalve, particularly in view of its economic importance in the region. Efforts are continuing in this laboratory toward determination of the frequency of viral infection over a wider geographical area as well as continued characterization of the virus.

References

Appeldoorn, R.S. and J.J. Oprandy. 1980. Tumors in soft-shell clams and the role played by a virus. Maritimes 24(3):4-6.

Ellis, R.H., S.J. Koepp, J. Weis, E.D. Santoro and S.L. Cheng. 1981. A comprehensive monitoring and assessment program for selected heavy metals in New Jersey aquatic fauna. New Jersey Marine Sciences Consortium Report. 165 pp.

Farley, C.A., W.G. Banfield, G.K. Kasnic and W.S. Foster. 1972. Oyster Herpes-type virus. Science 178: 759-760.

Farley, C.A. 1976a. Ultrastructural observations on epizootic neoplasia and lytic virus infection in bivalve mollusks. Progressive Experimental Tumor Research 20: 283-294.

Farley, C.A. 1976b. Proliferative disorders in bivalve mollusks. Marine Fisheries Review 38(10): 30-33.

Harshbarger, J.C., S.C. Chang and S.V. Otto. 1977. Chlamydiae (with phages), mycoplasmas, and rickettsiae in Chesapeake Bay bivalves. Science (Wash., D.C.) 196: 666-668.

Luria, S.E., J.E. Darnell, D. Baltimore and A. Campbell. 1978. Properties of Virons. Pages 33-58 *in* General Virology. John Wiley and Sons, New York.

Yevich, P.P. and C.A. Barszcz. 1977. Neoplasia in soft-shell clams *(Mya arenaria)* collected from oil-impacted sites. Annals of the New York Academy of Sciences 298: 409-426.

Stephen J. Koepp
Biology Department
Montclair State College
Upper Montclair, NJ 07043
201-893-7173

Announcements

Proceedings of Marine Ecosystem Modeling Workshop

Proceedings of a workshop on marine ecosystem modeling are now available. The workshop, held April 6-8, 1982, was sponsored and convened by NOAA's Environmental Data and Information Service*. It addressed the application of marine ecosystem modeling to management of natural marine resources and assessment of the effects of human activities on the marine environment. Participants included more than 50 marine scientists, managers, and administrators from both the private and public sectors.

The 274-page publication contains 11 invited papers that were delivered at the workshop and reports of four working panels that considered various aspects of marine ecosystem modeling with respect to resource management and environmental assessment.

Copies of the workshop proceedings may be ordered at $10.00 each by writing:

Marine Ecosystem Modeling Workshop
Assessment and Information Services Center
Page 2 Building, Room 162
3300 Whitehaven Street, N.W.
Washington, D.C. 20235

*As part of the NOAA reorganization effective December 1982, the Environmental Data and Information Service was merged with the National Earth Satellite Service to form the National Environmental Satellite, Data, and Information Service.

Ken Turgeon
NOAA/NESDIS
Assessment and Information Services Center
Washington, DC 20235
202-634-7394

OCEAN POLLUTION 1981 - Conference Reports Research Progress, But Also Continued Broad-Scale Coastal Zone Pollution

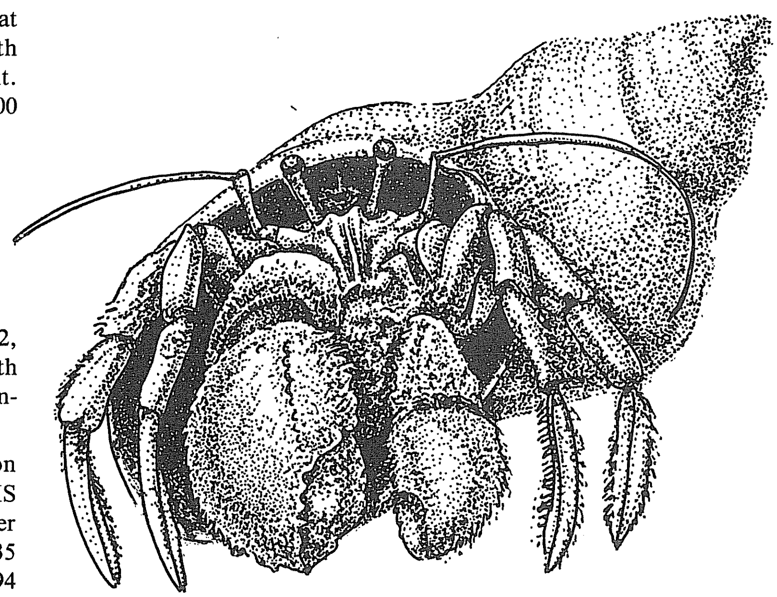
Proceedings of the October 1981 Conference on Pollution in the North Atlantic Ocean have now been published formally by the Canadian Journal of Fisheries and Aquatic Sciences (Supplement No. 2, Vol. 40, 1983).

The Conference was convened in Halifax, Nova Scotia, Canada by two major eastcoast research centers—Woods Hole Oceanographic Institution and the Bedford Institute of Oceanography—to initiate scientific discussions and assessment of coastal pollution. Discussions were confined to the North Atlantic ocean, although eventually it is the intent to extend these discussions to other areas of the world's oceans. About one hundred working scientists from the various north Atlantic rim-countries attended and participated. These proceedings represent the peer-reviewed presentations made at the week-long meeting.

The conference agenda was divided along four main lines: petroleum hydrocarbons, heavy and trace metals, organic synthetic contaminants, and ocean dumping. Focus of the meeting was limited to the physicochemical aspects of pollutants, exploring various inputs, routes, and rates of movements through the north Atlantic ecosystems, and attempting to assess their short- and long-term fates. While of interest, the subject of radioactive nuclides and their disposal was not included because of time restrictions.

The conference was timely and productive. The more serious aspects of ocean pollution appear now to be mainly local problems in coastal waters. Considerable research is being done in these waters, and knowledge necessary for defining, confirming and abating current problems is being assembled steadily. However, conference participants expressed concerns for increasing inputs of a range of contaminants, and lack of knowledge of their persistence and fate in coastal regions. Of particular concern in this respect are the more heavily contaminated coastal areas, both of North America and also of industrialized European waters.

John H. Vandermeulen
Research Scientist, Environmental Quality
Marine Ecology Laboratory
Bedford Institute of Oceanography
Dartmouth, N.S. Canada B2Y 4A2



Calendar

5-9 August 1984
7th International EPR Symposium, Denver, CO. Contact: Gareth R. Eaton, Dept. of Chemistry, University of Denver, CO 80208

19-22 August 1984
Atlantic Fisheries Technological Conference, Wilmington, NC. Contact: Frank B. Thomas, NCSU Seaford Lab, P.O. Box 1137, Morehead City, NC 28557

26-31 August 1984
3rd International Congress on Cell Biology, Tokyo, Japan, Contact: III ICCB Office, Japan Convention Services, Inc., c/o Nippon Press Center Bldg., 2-1, 2 chome, Uchisaiwai-cho, Chiyoda-Ku, Tokyo 100, Japan. Tel: 03-508-1205, Telex: 222 9025 JCSJ

3-7 September 1984
19th International Conference on Coastal Engineering, Houston, TX. Contact: 19th ICCE, Institute for Storm Research, 3600 Mt. Vernon, Houston, TX 77006

3-7 September 1984
6th International Air and Water Pollution Control Exhibition and Conference. Jönköping Sweden. Contact: Elmia Air and Water 84, Box 6066 S-55006, Jönköping, Sweden

10-14 September 1984
Fifth International Ocean Disposal Symposium, Oregon State Univ., Corvallis, OR. Contact: Prof. Iver W. Duedall, Organizing Committee Chairman, Fifth International Ocean Disposal Symposium, Florida Institute of Technology, Dept. of Oceanography & Ocean Engineering, Melbourne, FL 32901

12-14 September 1984
12th International Association on Water Pollution Research and Control Biennial International Conference. *Preconference Seminar* on Degradation, Retention and Dispersion of Pollutants in Groundwater, Copenhagen, Denmark. Contact: Prof. E. Arvin, Dept. of Sanitary Engineering, Building 115G, Technical University of Denmark, DK-2800 Lyngby, Denmark

12-14 September 1984
12th IAWPRC Biennial International Conference. *Preconference seminar,* Freshwater Biological Monitoring, Cardiff, UK. Contact: Dr. D. Pascoe, Unversity of Wales Institute of Science and Technology, King Edward VII Avenue, Cardiff CF1 3NU, Wales, UK

17-20 September 1984
International Association on Water Pollution Research and Control (IAWPRC) 12th Biennial International Conference. AQUATECH 84, Amsterdam, The Netherlands. Contact: IAWPRC, Alliance House, 29/30 High Holborn, London WC1V 6BA, UK

1-4 April 1985
Neurotox 85, Neuropharmacology and Pesticide Action. Contact: The Conference Secretariat, The Society of Chemical Industry, 14 Belgrave Square, London SW1X 8PS Tel: 01-235-3681, ext. 67

17-19 July 1985
Estuarine and Coastal Pollution: Detection, Research and Control, Plymouth Polytechnic, Plymouth, Devon, UK. Contact: Dr. P. Williamson, Natural Environmental Research Council, Polaris House, North Star Avenue, Swindon, Wilts. SN2 1EU, UK

8-12 September 1985
An International Meeting on Fish Immunology, Northeast Fisheries Center, Sandy Hook, Highlands, NJ. Contact: Dr. Joanne Stolen, NEFC, Sandy Hook Laboratory, Highlands, NJ 07732

Viewpoints

Beyond the Bight – The Broader Issues in the Ocean Dumping Debate

The seemingly endless debate over the dumping of contaminated sewage sludge in the New York Bight is likely to continue through 1983 on several fronts. In Congress, the House and Senate are soon expected to begin debate on amendments to the Ocean Dumping Act, including a bill likely to be introduced by Congressman William Hughes (D-NJ) and others, to ban, by a certain date, all sludge dumping at the Bight's so-called "12-mile dumpsite." At the Environmental Protection Agency (EPA), the Administration is putting the finishing touches on proposed regulations intended to implement Judge Sofaer's opinion in the *City of New York v. EPA* case. That opinion ordered EPA to revise its ocean dumping regulations to substantially relax the test for what may or may not be lawfully dumped in the Bight. EPA's decision last year not to appeal that opinion marked a major federal policy reversal on ocean dumping. The proposed regulations, due out in late February, will indicate just how far EPA plans to go in liberalizing its ocean disposal criteria in response to Judge Sofaer's order. In the meantime, the National Wildlife Federation (NWF) has filed a separate lawsuit in a New Jersey federal court to compel a phaseout of the dumping of sludge at the 12-mile site by six New Jersey sewerage authorities. A primary goal of that suit is to limit the potentially far-reaching effects of the Sofaer decision.

The eventual outcome of these events, while focused on the New York Bight, could have a major impact on the quality of all U.S. Coastal waters. Sewage sludge now dumped in the Bight by New York and Northern New Jersey sewerage authorities is among the most highly contaminated in the country. Many of the contaminants in this sludge are known to have adverse effects on marine organisms, and some readily accumulate in the edible tissues of fish and shellfish, consequently threatening humans. If this contaminated sludge can be lawfully ocean-dumped, one wonders how the federal government will be able to justify preventing others – municipalities and industrial sources alike – from disposing of their toxic wastes in the same way.

If EPA elects to incorporate in its ocean-dumping regulations the "extreme" interpretation of Judge Sofaer's decision in *City of New York v. EPA,* which is now a distinct possibility, it will be establishing a policy that sludge management decisions are to be based on a balancing of the economic costs and environmental impacts of all disposal options. Because the costs of ocean dumping are often so low, and because the environmental impacts of ocean dumping are still so speculative, the adoption of the type of balancing test propounded by Judge Sofaer is tantamount to a government-sanctioned preference for ocean disposal. This legal and economic preference, coupled with the reality that ocean disposal is almost always the sludge management alternative of least political resistance, could well translate into a massive increase in the ocean dumping of polluted wastes.

Such a scenario is not idle speculation. Lawrence Swanson, head of the Office of Marine Pollution Assessment of the National Oceanic and Atmospheric Administration, has estimated that nation-wide, over 17 million tons of sludge might be ocean dumped by 1985 if major sludge producers on the East and West coasts, who are now considering ocean dumping, are permitted to do so. This would be more than a threefold increase since Congress amended the Marine Protection Research Sanctuaries Act in 1977 to prohibit the dumping of harmful sludge beyond 1981. At least twenty coastal municipalities are now weighing the ocean dumping option, with a close eye on events in the New York Bight. Increasingly, local sewerage authorities, faced with drastic cuts in federal sludge management funds and growing public concern over the effects of land-based disposal of contaminated wastes, will look for cheaper and less controversial disposal alternatives. For coastal communities, that will often mean ocean dumping, unless some type of statutory barrier to easy ocean access is maintained.

Sewage sludge is not the only material with which waste managers must contend. Growing amounts of toxic industrial wastes, radioactive wastes, coal ash and dredge spoils must also be disposed of. The Sofaer decision, should it become federal policy, will affect the disposal of these wastes as well. In short, the City of New York decision, if allowed to drive U.S. ocean dumping policy, is likely to extend far beyond the New York Bight and sewage sludge—to other coastal areas and other types of contaminated wastes. It is in this broader context that one must view both EPA's refusal to appeal the Sofaer decision to a higher court, and the National Wildlife Federation's ongoing effort to counter that decision in its New Jersey suit.

Perhaps even more significant than the national implications of the Sofaer decision is the potential impact of EPA's failure to invoke the London Dumping Convention in the course of the City of New York litigation. The Convention is an international ocean dumping treaty ratified by the United States and 48 other nations. It has been made fully binding on the EPA Administrator through the Ocean Dumping Act. The Convention flatly prohibits the dumping of certain toxic materials in more than trace contaminant amounts. Although sludges now being dumped in the Bight contain high levels of these prohibited materials, EPA failed to raise the Convention during the City of New York litigation.

Certainly, the United States will be in no position to persuade other countries to take the Convention seriously if it refuses to do so itself. Major industrialized nations, particularly those with large populations and relatively small land areas such as Japan and the United Kingdom, are already under great pressure to dispose of toxic wastes in their coastal waters. An about-face by the United States with respect to sludge dumping in the New York Bight is a clear signal to the rest of the world that the U.S. has no intention of meeting its responsibilities under the Convention. It is with this in mind that the National Wildlife Federation intends to make the restrictions in the Convention a central focus of its New Jersey suit.

Hopefully, it is in the larger national and international context that the discussion of the dumping of sewage sludge in the New York Bight will now take place. For too long the debate has been confined to the now-familiar arguments for and against the continued use of the Bight dumpsite. That such arguments could have persuaded a federal court to bend the law to allow the continued dumping of toxic wastes in the Bight is unfortunate. That the same arguments are now being used to justify a major federal policy reversal on ocean dumping—with all of its potential national and international ramifications—could prove disastrous.

Thomas K. Bick
Ocean Dumping Project
National Wildlife Federation
1412 Sixteenth St. N.W.
Washington, DC 20036

Contamination of the New York Bight and other Populated Coastal and Estuarine Areas: A Comparison

A detailed comparison of the contamination of coastal marine waters in the New York Bight with that of other populated coastal and estuarine areas will be published soon in a NOAA report (Segar and Davis, In Press). The following is a brief summary of the major findings of that report. Contrary to a popular belief that the New York Bight is "the most severely degraded coastal area in the world", this analysis indicates that the Bight does not appear to be more polluted or to suffer from pollution impacts to any greater degree than a number of other coastal regions studied from around the world. For example, toxic contaminant levels in the New York Bight ecosystem are well within ranges from a number of the world's heavily populated and industrialized coastal areas.

An evaluation of various coastal regions was conducted which was based on the population densities of the region discharging to the coastal zone, the degree of industrialization, volumes of the discharge area, and coastal hydrography. Based on this evaluation, the New York Bight is not among the most pollution-susceptible regions of the world ocean, but is comparable to the large, but poorly flushed, semi-enclosed seas (e.g., the Baltic, Mediterranean, Irish and North Seas, and the Seto Inland Sea). Smaller embayments, with limited dispersion and flushing, and with large populations [e.g., the Hudson-Raritan Estuary, Guanabara Bay (Brazil), the Firth of Clyde (Great Britain), Singapore and Hong Kong Harbors, and the Saronikos Gulf (Greece)] are much more highly susceptible to pollution and its impacts. Other areas such as Puget Sound and the Chesapeake Bay may enter this category, if population density and industrialization increase.

Total annual inputs of contaminants to the New York Bight are within the range of annual mass contaminant loadings of other regions which are similar in terms of pollution susceptiblity (Table 1). The relationship of population density to contaminant inputs is apparent when pollutant loadings to the regions are normalized by population (Table 1).

While contaminant inputs may be similar for regions considered, differences in hydrography and geography of the various regions may influence strongly the pollutant distributions. The Mediterranean, Baltic and North Seas are considerably larger than the New York Bight in terms of both area and volume, while the Seto Inland Sea and the Irish Sea are in the same size range as the Bight. Therefore, the latter two areas might provide more closely matched examples for comparison with the New York Bight.

Despite considerable differences in input rates and hydrographic, geographic, and geological features among the areas studied, the ranges of contaminant concentrations reported in sediments from the different areas (Table 2) do not show obvious major differences. However, it is important to note that the highest concentrations observed in the New York Bight are consistently and substantially below those observed in some other regions including Southern California.

Concentrations of metals and organic contaminants in marine organisms, including those in the New York Bight, do not appear to pose any threat to human health, since they only very rarely exceed established regulatory levels for these contaminants. Exceptions occur in localized areas which receive large inputs of industrial and sewage discharges, such as portions of the Hudson-Raritan Estuary. In fact, available data on contaminants in the

Table 1
Estimated Contaminants and Natural Inputs to Selected Regions

		BOD ($x10^4$)	N ($x10^4$)	P ($x10^3$)	Hg	Pb	Cr	Zn	Cd	Oil & Grease	Total PCB
New York Bight	A	55	14	19	53	2,100	1,600	6,800	110	NA	10
	B	3.2	0.84	1.1	3.1	220	96	400	6.2	NA	0.59
Southern California	A	25	NA	>10	2.8	150	370	840	42	49	2300
	B	3.6	NA	1.4	0.4	21	53	120	6	7	330
Mediterranean	A	330	100	360	130	4,800	2,800	25,000	NA	1,000	6,000[1]
	B	3.3	1.0	3.6	1.3	48	28	250	NA	10	60
Seto Inland Sea	A	91	16	17	NA	NA	NA	NA	NA	NA	NA
	B	4.6	0.8	0.9	NA	NA	NA	NA	NA	NA	NA
Baltic Sea	A	41	59	17	29	6,200	900	19,000	250	NA	NA
	B	2.3	3.3	0.9	1.9	>55	NA	NA	NA	NA	NA
Irish Sea	A	37	8.0	22	35	2,400	1,100	10,000	110	NA	NA
	B	4.6	1.0	2.8	4.3	300	140	1,300	14	NA	NA
North Sea	A	110	92	110	47	4,900	4,000	24,000	330	NA	NA
	B	5.0	4.2	5.0	2.1	220	180	1,100	15	NA	NA

Adapted from Segar and Davis (in press). Source references cited therein.
A metric tons/yr
B metric tons/10^6 persons/yr
NA Not available
1 Total organochlorines

marine environment analyzed in this study show that concentrations are universally below lethal toxicity levels, except within extremely limited areas adjacent to contaminant discharges, ocean outfalls, or within rapidly dispersed ocean dumping discharge plumes.

Table 2.
Heavy Metal and PCB concentrations in Selected Marine Sediments (ug/g dry wgt)

	Zn	Cd	Pb	Cu	Cr	Hg	PCB
New York Bight	4.6-541	<0.47-9.6	5-270	1-320	2-370	0.12-4.9	0.0005-2.2
Southern California	44-2900	0.22-140	7-600	9.0-1000	25-1500	0.04-6.1	0.03-12.8
Mediterranean	2.1-3000	0.02-7.0	2.8-200	3.8-130	1.3-1200	0.01-57	NA
Japan	110-240	0.14-3.5	10-110	23-54	5-180	<0.1-713	0.01-390
Baltic Sea	110-270	NA	25-84	33-78	90	NA	NA
Irish Sea	14-800	NA	10-460	5-200	15-360	0.07-3.3	NA
North Sea	<20->200	0.1-0.8	<10-240	2-50	4.0-41	0.05-0.9	NA
Norwegian Sea	24-2000	0.3-1.5	5.0-11,000	2-2400	NA	90-350	NA
Australia	3-1200	0.15-9.9	4.6-180	2.2-120	1.3-42	NA	NA
Narragansett Bay Rhode Island	53-170	0.06-2.5	17-81	26-98	13-81	NA	NA
Spain & Portugal, Atlantic Coast	6-3100	0.9-4.1	6-1600	2-1400	NA	NA	NA
Bermuda	16-65	<0.25-0.99	6.4-230	7-130	15-484	NA	NA

Adapted from Segar and Davis (in press). Source references cited therein. Ranges represent data from multiple sources.

Biotic sublethal effects which result in population changes have been very rarely field-demonstrated in the oceans. Most ecological changes in the New York Bight and elsewhere, including changes in species composition of finfish and benthic fauna, are more likely caused by anthropogenic inputs of non-toxic organics and/or nutrients, natural climatic variations, and overfishing. Anoxic events observed in the Bight and throughout the world are natural phenomena which in some areas, including the New York Bight, may be significantly exacerbated by nutrient-induced eutrophication, but apparently not by the input of sewage sludge. Serious adverse effects of pollutants on the world's oceans, including the New York Bight, appear to be highly localized, and marine systems have demonstrated a high degree of recuperative ability when major sources of contaminants to a degraded area are reduced.

Under appropriate conditions of introduction and dilution, the oceans are capable of accommodating large anthropogenic inputs without significant effects on biota and human health, and without causing oxygen depletion. Given the large diversity of conditions in the ocean which affect dispersion and assimilation, some regions of the ocean can safely accommodate greater inputs of contaminants than others. However, within a given region, the ability to assimilate wastes is dependent upon the mode of disposal, which, in turn, directly affects the concentrations of contaminants in the discharge environment and any possible effects on the biota. For example, the coastal area off Southern California has dispersive conditions which perhaps are ideal, but contaminant concentrations immediately surrounding a Southern California sewage sludge outfall far exceed the highest concentrations found in the vicinity of the sewage sludge dumpsite in the New York Bight.

In summary, the New York Bight is a moderately effective dispersive ecosystem, and contaminant concentrations are not extreme compared to other highly populated coastal areas of the world. Although the New York Bight appears to have suffered no irreversible ecological damage, some ecological change has been observed, especially in benthic populations. This change is probably attributable to increased organic loadings to the Bight apex, primarily from the Hudson-Raritan Estuary. The most serious pollution related problem facing the New York Bight is the potential increased frequency of anoxic events if nutrient inputs to the ocean should continue to increase.

References:

Segar, D.A., P.G. Davis. In Press. Contamination of populated estuaries and adjacent coastal ocean—A global review. Special Report Series, Perspectives on the New York Bight, National Oceanic and Atmospheric Administration, NOAA NOS (OMS).

Douglas A. Segar and Paul G. Davis
SEAMOcean, Inc.
P.O. Box 1627
Wheaton, MD 20902

Correspondents

National

Richard J. Abram, NOAA/National Oceanographic Data Center
Merton Ingham, NOAA/Northeast Fisheries Center
H. Perry Jeffries, University of Rhode Island
Kenneth S. Kamlet, National Wildlife Federation
Janet Pawlak, International Council for the Exploration of the Seas

Atlantic

Ford Cross, NOAA/Southeast Fisheries Center
John Farrington, Woods Hole Oceanographic Institution
Wayne Leathem, University of Delaware
Richard Lee, Skidaway Institute of Oceanography
Candace A. Oviatt, University of Rhode Island
John Zeigler, Virginia Institute of Marine Science

Gulf

Donald Boesch, Louisiana Universities Marine Consortium

Pacific

Check Gibsons, Battelle/Pacific Northwest Division
M. Jawed Hameedi, NOAA/Ocean Assessments Division
Gary Kleppel, Southern California Coastal Water Research Project
Donald Malins, NOAA/Northwest and Alaska Fisheries Center
Donald Maurer, Southern California Ocean Studies Consortium

Alan J. Mearns, NOAA/Ocean Assessments Division
William S. Reeburgh, Institute of Marine Science

Great Lakes

Alfred M. Beeton, Great Lakes and Marine Water Center
Ronald A. Scrudato, State University of New York Research Center, Oswego

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:

   Coastal Ocean Pollution Assessment News
   Marine Sciences Research Center
   State University of New York
   Stony Brook, Long Island, NY 11794

Coastal Ocean Pollution Assessment News is published quarterly. Subscription is free. Individuals wishing to subscribe should write to:
Coastal Ocean Pollution Assessment News
Marine Sciences Research Center
State University of New York
Stony Brook, Long Island, NY 11794

Coastal Ocean Pollution Assessment News
Marine Sciences Research Center
State University of New York
Stony Brook, Long Island, NY 11794

NON-PROFIT ORG.
U.S. POSTAGE
PAID
STONY BROOK, N.Y.
PERMIT No. 65

Address correction requested

COASTAL OCEAN POLLUTION ASSESSMENT NEWS

MAN AND THE MARINE ENVIRONMENT

copas

Volume 3 Number 4 1986-1987

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.

Editors:
M. Grant Gross, *National Science Foundation*
John B. Pearce, *NOAA/Northeast Fisheries Center/Sandy Hook Laboratory*
Donald W. Pritchard, *Marine Sciences Research Center*
J. R. Schubel (Senior Editor), *Marine Sciences Research Center*
Harold M. Stanford, *NOAA/Ocean Assessments Division*

Technical Editor:
Jeri Schoof, *Marine Sciences Research Center*

Graphics:
Marine Sciences Research Center Graphics Arts

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

In This Issue

Episodes

Extensive Depletion of Oxygen in Bottom Waters of the Louisiana Shelf During 1985

For over a decade, the occurrence of oxygen-depleted bottom waters has been documented on the inner continental shelf of the northern Gulf of Mexico (reviewed by Boesch, 1983; Rabalais *et al.,* 1985; Renaud, 1985). Unfortunately, little is known about spatial and temporal scales of hypoxic conditions (dissolved oxygen values <2 mg l^{-1}), although there are some general trends which have emerged from the sparse data available.

Oxygen depletion is an annual phenomenon of varying intensity, occurring mainly during the months of June, July and August. The low oxygen areas are usually found in water depths of 5 to 30 m. Most available data were collected peripherally to other research projects so that details are lacking on the areal extent, sequencing and duration of these events. Also, the lack of records prior to the 1970s leaves questions as to whether hypoxia is occurring more frequently, is more widespread, or is more intense. The effect of hypoxic bottom waters on living resources is not fully understood, but it is clear that catch rates of penaeid shrimp and demersal fishes are reduced or virtually zero when bottom waters are hypoxic (Pavela *et al.,* 1983; Renaud, in press).

With support from NOAA's Ocean Assessments Division and Sea Grant Program, the Louisiana Universities Marine Consortium (LUMCON) and Louisiana State University initiated a program during 1985 to specifically assess the extent, duration, and intensity of oxygen depletion in the northern Gulf of Mexico. In addition, we collected associated hydrographic, chemical, and biological data with which we could begin to address those processes involved in the development and breakdown of hypoxia. Ultimate goals include an understanding of the effects on living resources and the degree to which human activities may be involved in this phenomenon. Of particular interest in this regard are the effects of increasing concentrations of inorganic nutrients in the Mississippi and Atchafalaya Rivers and channelization of river flow.

Sampling began in mid-June and continued through early-October. Data were collected on eight occasions along two transects on the southeastern Louisiana shelf (B and C′, Figure 1), the region experiencing the greatest oxygen depletion based on previous data. In addition, two quasi-synoptic surveys were conducted aboard the LUMCON R/V *Pelican* from the Mississippi River delta to the Texas-Louisiana border during mid-July and early September.

Hypoxic (<2 mg O_2 l^{-1}) and anoxic (<0.1 mg O_2 l^{-1}) bottom waters were already present on the Louisiana shelf when we began collecting data on June 14. At this time low oxygen bottom waters occurred off southeastern Louisiana in 13 to 20 m depths, at least to 24 km offshore, and extended up to 4 m above the bottom. We suspect, based on anecdotal information, that serious hypoxia began to develop during the first two weeks of June. Within two weeks (June 26), we found hypoxic and anoxic waters at depths of 6 to 30 m, from 2 to 45 km offshore, and extending up to 12 m above the bottom.

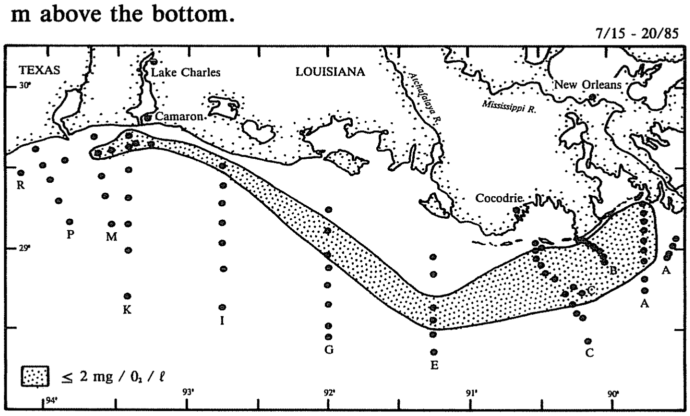


Figure 1: Stippled area depicts bottom waters with dissolved oxygen concentration $<2mg^{-1}$ during the *Pelican* cruise on July 15-20. (Transects A′, B, and C′ were not sampled.).

Our first synoptic survey was conducted at probably the peak of the extent and intensity of hypoxia (July 15-20) and included cross-shelf sections covering an area of 31,000 km^2 off Louisiana and part of Texas. Broadly interpolating between transects, we plotted the occurrence of low oxygen bottom waters (Figure 1) over 8,000 km^2 of shelf from 5 to 60 km offshore in depths of 5 to 60 m. Areas of low oxygen extended from 2 to 20 m above the bottom. Off Grand Isle (Transect A), the low oxygen zone started 5 km from the beach and extended 45 km offshore into waters 60 m deep. Off Point au Fer and Marsh Islands (Transect E and G), the band of low oxygen bottom water was 35 to 60 km offshore (because of extremely shallow waters inshore) in depths ranging from 7 to 20 m. Off Cameron (Transect K), the band narrowed and was confined to 9 to 12 m depth. Similar low oxygen conditions were not found off Texas but have been occasionally noted in the past (Harper *et al.*, 1981; Rabalais *et al.*, 1985; Harper and Guillen, in preparation).

Hypoxic conditions continued off southeastern Louisiana through late July with some variability in the shoreward encroachment, extent above the bottom, and dissolved oxygen concentrations. Where dissolved oxygen concentrations were less than 1 mg l^{-1}, however, they were usually less than 0.2 mg l^{-1}. Low oxygen levels were found, not unexpectedly, below a sharp pycnocline. This stratification was due to some extent to temperature differences (Figure 2) but much more so to a wide salinity gradient with a sharp halocline (Figure 2).

In the first week of August, the offshore extent of hypoxic bottom water off southeastern Louisiana retreated somewhat toward the coast. The dissolved oxygen values, although still hypoxic, were not as low as they had been previously, despite continued strong stratification.

Hurricane Danny crossed the southwestern Louisiana shelf on August 14-15 resulting in 20.4 to 27.9 km sec^{-1} winds and 2.13 to 2.75 m seas in the vicinity of the two transects on the southeastern shelf. Sampling along the two transects four days later showed that the water column was still stratified, but less strongly so, and that hypoxia was present but was diminished in both areal extent and intensity. Within the next two weeks, a major low pressure system

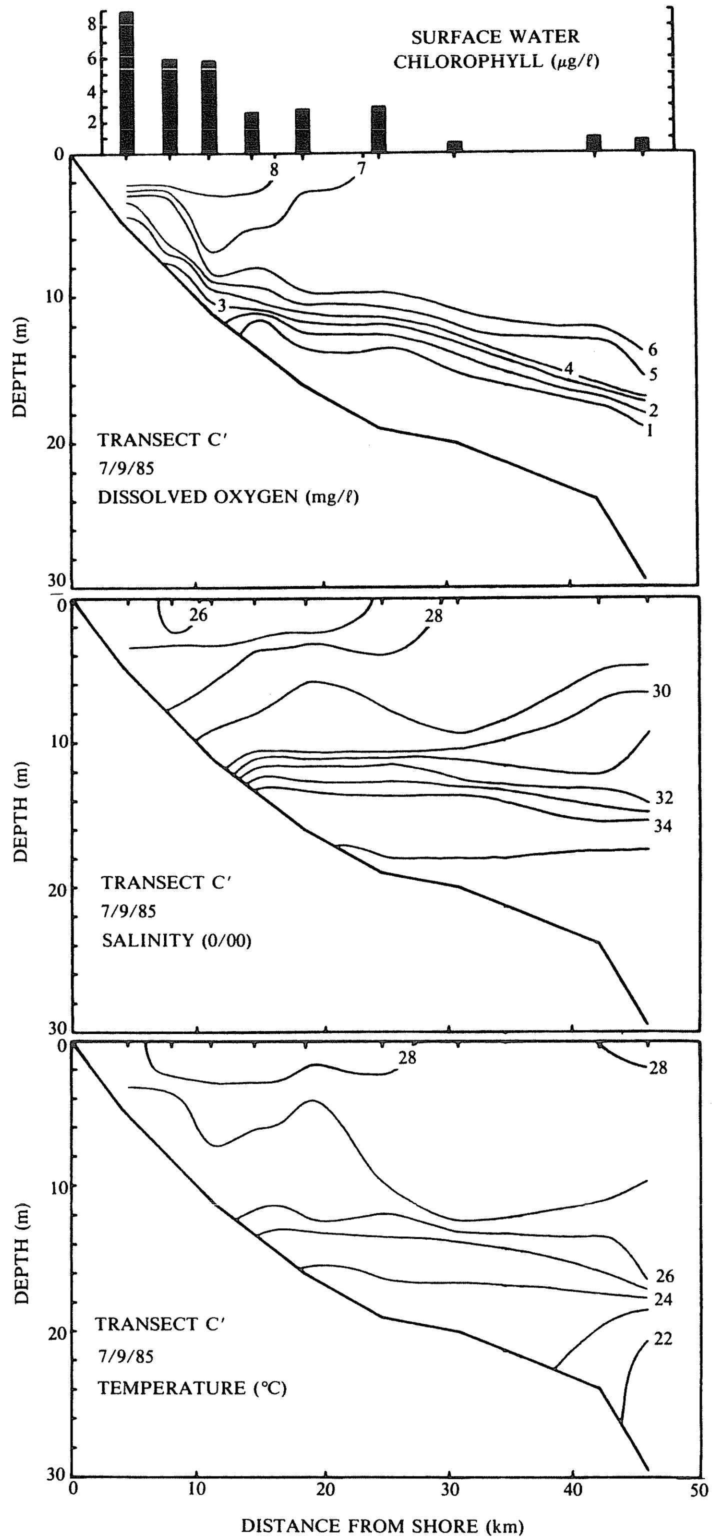


Figure 2: Values for selected hydrographic and biological parameters on Transect C′ for July 9, 1985.

crossed the northern and northwestern Gulf. Strong and persistent winds from Hurricane Elena, which crossed the coast at Gulfport, Mississippi, were felt along the southeastern Louisiana coast. By September 4, the water column was oxygenated (all values >4.5 mg l^{-1}) and well-mixed along the two transects.

During the second *Pelican* survey during the second week of

September, hypoxic bottom water was found at one station in 9 m, and dissolved oxygen concentrations ranged between 2 and 2.5 mg^{-1} at four other stations between 4 and 30 m, on Transects A and A′ adjacent to the Mississippi River delta. Water column stratification, mainly due to low salinity surface water, persisted there. Elsewhere on the shelf, the water column was well-mixed except at some of the deeper stations, and a few dissolved oxygen concentrations fell below 3 mg l^{-1}.

Leming and Stuntz (1984) found a coincidence between hypoxic bottom waters and high surface temperatures (≥31°C) and chlorophyll levels (1 to 30 mg m^{-3}) as measured by the Coastal Zone Color Scanner satellite on the Louisiana shelf during 1982 and 1983. Their data suggested algal blooms on the shelf as a source of organic matter which upon degradation consumes oxygen in bottom waters. Leming and Stuntz (1984) suggested that satellite imagery may be useful for predicting the extent of bottom hypoxia and could be used to direct bottom fishing activity away from affected areas. Our results show that the relationship between surface chlorophyll levels and bottom hypoxia is not so straightforward. Highest surface chlorophyll concentrations (> 5 $\mu g\ l^{-1}$) were found inshore of or along the inner margin of the oxygen-depleted zone (Figures 2 and 3). Pigment concentrations were also

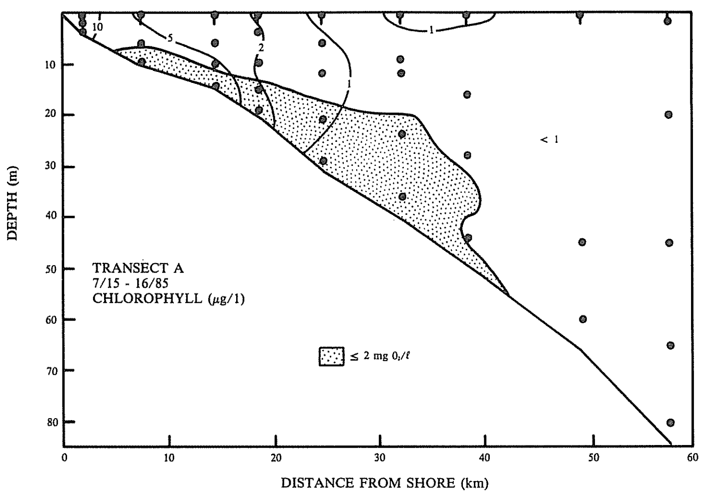


Figure 3. Profiles for chlorophyll concentrations along Transect A with areas of oxygen-depleted waters superimposed.

higher toward the Mississippi River delta (along Transect B compared to C′). Under conditions of severe hypoxia, bottom pigment concentrations were generally higher than those at the surface. Also, a greater proportion of the total plant pigments was composed of phaeopigments (i.e., degradation products) in bottom waters compared to surface waters. The data suggest that consumption of oxygen in bottom waters is fueled by surface production by the plankton, but that such production such may emanate from the highly productive coastal boundary layer inshore or the Mississippi River plume to the east.

Although lack of comprehensive historical data limits comparisons, it appears that hypoxia on the Louisiana shelf during the summer of 1985 began earlier, extended farther offshore, and was more spatially and temporally continuous than usual (Rabalais *et al.,* 1985). The area affected was roughly equal to that similarly affected during the 1976 incident in the New York Bight (Swanson and Sindermann, 1979), and approximately four times the hypoxic bottom area developed during the summer in the Chesapeake Bay area (Officer *et al.,* 1984). It is certainly premature to attribute hypoxia on the Gulf of Mexico shelf to eutrophication or other human activities. However, it is interesting to note that in several regions for which there are better historical records hypoxic conditions have apparently recently developed or expanded, presumable as a result of eutrophication. These include such large and often open coastal environments as the Baltic, the northwestern North Sea (Rosenberg, 1985), and the northwestern shelf of the Black Sea off the Danube River (Tolmaxin, 1985) as well as Chesapeake Bay.

References

Boesch, D.F. 1983. Implications of oxygen depletion on the continental shelf of the northern Gulf of Mexico. Coastal Ocean Pollution Assessment News 2:24-28.

Harper, D.E., Jr., L.D. McKinnery, R.R. Salzer, and R.J. Case. 1981. The occurrence of hypoxic bottom water off the upper Texas coast and its effects on the benthic biota. Contrib. Mar. Sci. 24:53-79.

Leming, T.D. and W.E. Stuntz. 1984. Zones of coastal hypoxia revealed by satellite scanning have implications for strategic fishing. Nature 310:136-138.

Officer, C.B., R.B. Biggs, J.L. Taft, L.E. Cronin, M.A. Tyler, and W.R. Boynton. 1984. Chesapeake Bay anoxia: Origin, development, and significance. Science 223:22-27.

Pavela, J.S., J.L. Ross, and M.E. Chittenden, Jr. 1983. Sharp reductions in abundance of fishes and benthic macroinvertebrates in the Gulf of Mexico off Texas associated with hypoxia. Northeast Gulf Sci. 6:167-173.

Rabalais, N.N., M.J. Dagg, and D.F. Boesch. 1985. Nationwide Review of Oxygen Depletion and Eutrophication in Estuarine and Coastal Waters: Gulf of Mexico (Alabama, Mississippi, Louisiana and Texas). Report to National Oceanic and Atmospheric Administration, Ocean Assessments Division, Rockville, Maryland, 60 p.

Renaud, M.L. 1983. Annotated Bibliography on Hypoxia and Its Effects on Marine Life, with Emphasis on the Gulf of Mexico. NOAA Tech. Rep. NMFS 21, 9 p.

Renaud, M.L. (in press) Hypoxia in Louisiana coastal waters during 1983: Implications for fisheries. Fish. Bull.

Rosenberg, R. 1985. Eutrophication — the future marine coastal nuisance? Mar. Poll. Bull. 16:227-231.

Swanson, R.L. and C.J. Sindermann (eds.). 1979. Oxygen Depletion and Associated Benthic Mortalities in New York Bight, 1976. NOAA Prof. Paper 11. National Oceanic and Atmospheric Administration, Washington, D.C., 345 p.

Tolmazin, D. 1985. Changing coastal oceanography in the Black Sea. *In:* Northwestern shelf. Prog. Oceanog. 15:217-276.

Nancy N. Rabalais
Donald F. Boesch
Louisiana Universities Marine Consortium
Chauvin, LA 70344

Anoxia in the Chesapeake Bay. A Turbidity Hypothesis

The Chesapeake Bay has long been characterized as one of the largest and most productive estuaries in the world (Figure 1). However, as of the present time, October 1985, this productivity appears to have been seriously impaired.

a) Annual landings of shad *(Alosa sapidissima)* have been reduced from 7.9 x 10^6 kg to zero.
b) Annual landings of striped bass *(Morone saxatilis)* have been reduced from 2.5 x 10^6 kg to a level where a moratorium has been imposed in Maryland.
c) Annual landings of oysters *(Crassostrea virginica)* have been reduced from more than 352.4 x 10^6 1 to less than 35.2 x 10^6 1.

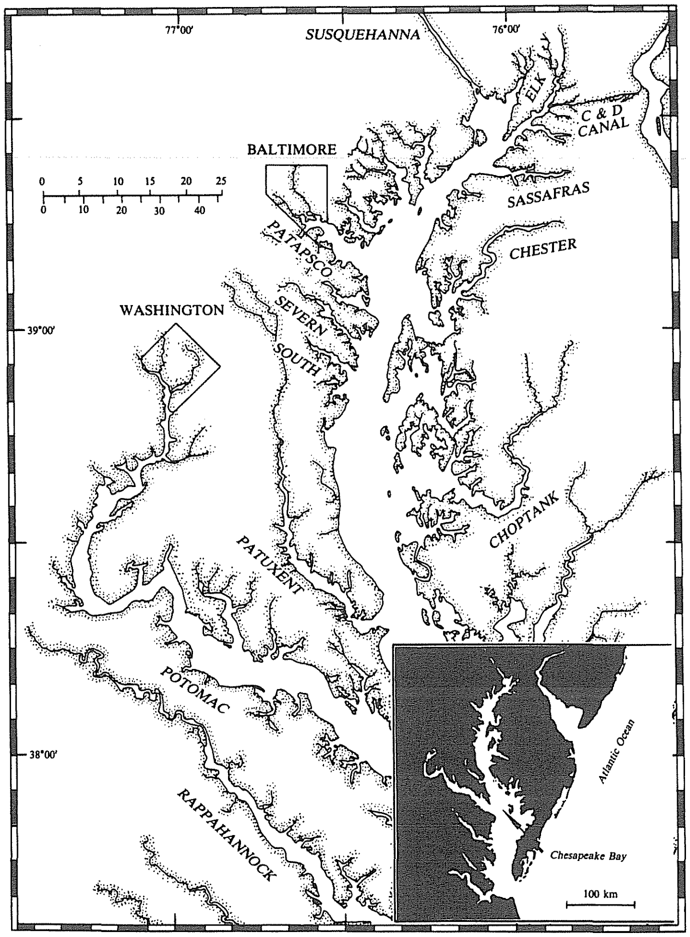


Figure 1: Maryland portion of the Chesapeake Bay.

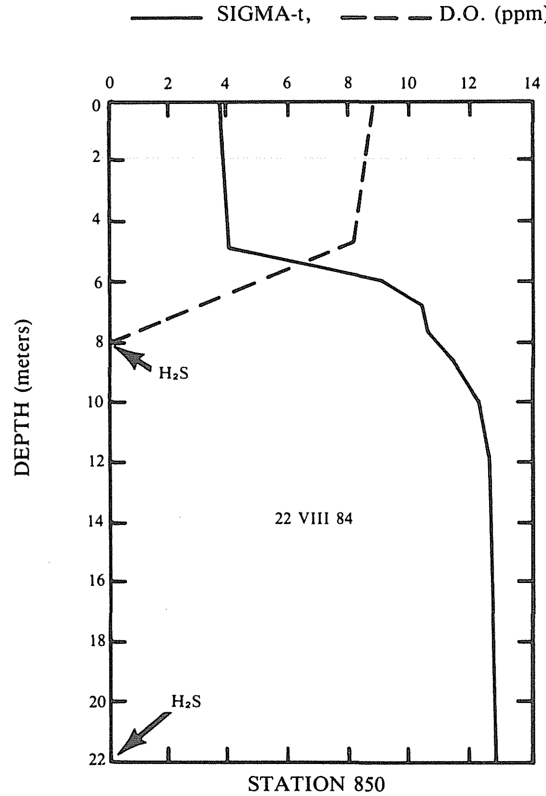


Figure 2: Dissolved oxygen (DO) and water density (sigma-t) values for a representative station (38°50'N. Lat.) in the central channel of Chesapeake Bay, opposite the mouth of Eastern Bay, 22 August 1984, showing the upwardly eroded and steepened pycnocline and the sharp decrease in dissolved oxygen beginning at 5 meters.

It would be extremely convenient to management agencies if these major losses of commercial and sportfisheries were directly attributable to excessive nutrient deliveries to the bay. It would also be convenient if the anoxia in bottom waters of the bay, which has been implicated in the loss of benthic organisms, were also the direct result of excessive nutrient deliveries. For then the problem could be easily solved and the bay would be restored to its former greatness by administrative order. Sewage treatment, phosphate reduction in detergents and more careful application of fertilizers in agriculture would replace the nagging inconsistencies raised by ecosystem scientists. Food chain research could be replaced by routine monitoring for nutrients and dissolved oxygen, and we could all sit back and watch the recovery of this tremendous resource.

Unfortunately for the nutrient management concept, but a consequence of environmental selection of species, the abiotic factors leading to the success of specific food chains are complex and differ both qualitatively and quantitatively in different regions of the bay, at different times during the year, and from one year to another. For example, Captain John Smith, early in the 17th century, reported episodes of finfish and shellfish mortalities in tributaries in summer, presumably due to transient anoxia. Anoxia in bottom waters of the middle bay, also in summer, was reported by Newcome and Horne (1938) and by the Chesapeake Bay Institute, beginning in 1949. In 1984, four climatic sequences combined to produce an early and major development of stratification and subsequent anoxia in the northern bay and an apparently unusual intrusion of hypoxic and anoxic bottom waters into portions of major tributaries in the Maryland portion of the bay (Figure 2) (Seliger *et al.,* 1985). This caused extensive mortality to shellfish on beds deeper than 6 meters. Had this anoxia not been dissipated by an early fall partial turnover, the remaining shallow oyster sprawning and seedbed areas would have been similarly exposed to hypoxic waters and the pelagic portion of the food chain severely stressed.

During a wet year, streamflow delivers high turbidity waters containing high concentrations of inorganic and organic nutrients to the northern bay. High streamflow results in strong stratification just south of the Chesapeake Bay Bridge. Increased benthic production and inhibition of vertical replenishment of oxygen from surface waters to bottom waters accelerates loss of oxygen in bottom waters below the pycnocline. Thus, anoxia first appears in bottom waters at 38°58'N. The timing will be dependent upon streamflow. It has been proposed (Taft *et al.,* 1980; Officer *et al.* 1984) that anoxia in bottom waters of the bay has increased in frequency and in areal extent over the past decades and that hypereutrophication is the causal agent of this increase. It is our contention that while hypereutrophication correlates with anoxia, the causal agent in the observed anoxia and in the decline of the fisheries in the Maryland section of Chesapeake Bay is turbidity and siltation due to uncontrolled erosion.

Sediment cores from the Susquehanna River (39°33'N) indicated that land clearing as early as the 18th century resulted in a shift in rooted aquatic plants from waterweed and pondweed to wild celery (eelgrass) (Brush and Davis, 1982). This transition is really a clear ecoindicator of increase turbidity. Again, an increased sediment turbidity which correlates with increase nutrient delivery has been ignored in favor of the concept of hypereutrophication (Wells *et al.,* 1983). Wolfe *et al.* (1926) reported spring and fall diatom blooms throughout the bay as far north as 39°10′, *north of the Chesapeake Bay Bridge* during 1916 and 1920 through 1922, with diatoms still dominant during summer. The dinoflagellate *Prorocentrum,* when dominant in the northern bay, was below 300 cells ml^{-1}, and total diatoms during a bloom were below 1,000 cells ml^{-1}. Presently, diatoms do not bloom in the northern bay; their northermost occurrence in the central bay in early spring is limited by the turbid surface plume due to streamflow; *Prorocentrum* and *Gyrodinium* dominate the central and northern bay in summer. Dinoflagellate patches as high as 150,000 cells ml^{-1} and diatom blooms greater than 5,000 cells ml^{-1} are common. These concentrations can only result from hypereutrophication of a previous nutrient limited estuary.

However, the key to understanding what has happened in this bay is the displacement of diatom populations from the northern and central regions of the bay despite the increased nutrient runoff. This is specific evidence that *sediment erosion* has converted this region of the bay and its tributaries into a *light limited environment unsuitable for diatoms.* During the spring runoff pulse, a 98% reduction of the ambient light can occur in the first meter of surface waters when suspended sediment concentrations are greater than 50 $mgml^{-1}$ in the northern bay. Loss of diatoms results in a loss of copepod herbivores. Loss of (macro) copepod herbivores results in a loss of carnivorous larval stages of anadromous fish. The increased soluable and particulate organics select for (micro) bacterial growth and benthic production. High, soluble inorganic N in turbid waters selects for short, nannoplankton-benthic bacteria food chains.

The high turbidity of the surface plume, independent of its high nutrient concentrations, is what effectively prevents the subsurface transport and retention of diatoms in this region. Reduction of nutrients without reduction of sediment loading, should therefore have no effect on the recovery of commercial and sport fisheries in the Maryland portion of Chesapeake Bay. The siltation which has already taken place is for the most part irreversible. The loss of marshland which effectively buffered submerged aquatic vegetation (SAV) habitats and nursery areas is also irreversible. Therefore, the reduced areas of viable shellfish beds (macrobenthos), of nursery areas and SAV and increased areas of significant bacterial respiration cannot be reclaimed to any apprecible extents.

It should be possible by suitable food chain research to identify areas *in specific tributaries* where stringent controls over watershed erosion can most effectively retain present marginal nursery grounds and where intensive reclamation efforts to enlarge these areas are feasible.

There are, unfortunately, tributaries on the western shore of Chesapeake Bay which are at present not economically retrievable and for which the time for stringent controls over erosion and wetland conservation has long since passed. Thus, the site-specific approach appears to be the only workable and economically practical means of gaining a foothold on "saving" the Bay.

References

Brush, G.S. and F.W. Davis. 1982. Stratigraphic evidence of human disturbance in Chesapeake Bay tributaries. Final draft report to the U.S. Environmental Protection Agency's Chesapeake Bay Program. Annapolis, MD.

Newcombe, C.L. and W.A. Horne. 1938. Oxygen poor waters of the Chesapeake Bay. Science 88:80-81.

Officer, C.B., R.B. Biggs, J.L. Taft, L.E. Cronin, M.A. Tyler, and W.A. Boynton. 1984. Chesapeake Bay anoxia: Origin, development and significance. Science 223:22-27.

Seliger, H.H., J.A. Boggs and W.H. Biggley. 1985. Catastrophic anoxia in the Chesapeake Bay in 1984. Science 228:70-73.

Taft, J.L., W.R. Taylor, E.O. Hartwig and R. Loftus. 1980. Seasonal oxygen depletion in Chesapeake Bay. Estuaries 3 (4):242-247.

Wells, H.W., S.J. Katsanos and F.H. Flanigan. 1983. An introduction to Chesapeake Bay. *In:* Chesapeake Bay: A framework for action. U.S. Environmental Protection Agency's Chesapeake Bay Program. Annapolis, MD.

Wolfe, J.J., B. Cunningham, N.F. Wilkerson and J.T. Barnes. 1926. An investigation of the microplankton of the Chesapeake Bay. J. Elisha Mitchell Sci. Soc. 42:25-54.

Howard H. Seliger
Jeffrey A. Boggs
The Johns Hopkins University
Biology Department
Baltimore, MD 21218
(301) 338-7307

Loomings

Impact of the 1985 Phytoplankton Bloom in Long Island's Coastal Bays

Throughout the summer of 1985, an exceptionally dense phytoplankton bloom persisted in major bay systems of Long Island (LI), New York. Environmental conditions (e.g., light, temperature, nutrient availability, lack of grazing by herbivores) which may promote initial development of phytoplankton blooms typically do not persist, and hence most blooms are short-lived phenomena (< 1 month). This bloom was exceptional not only for its duration, but for its maximum cell concentrations (up to 6 x 10^6 cells ml^{-1}), its nearly monospecific composition of an extremely small alga (2-3 μm diam.), and its extensive impact on LI's living marine resources.

Chronology of the Bloom

The phytoplankton bloom was first reported in Great South Bay (GSB) during early May 1985. Aerial surveys conducted during the bloom's peak in mid-July showed that virtually all of LI bays were affected (Figure 1). While the east end bays are connected to the GSB, there were discontinuities in the bloom's distribution, suggesting that the bloom developed independently in these water bodies. Marine Sciences Research Center (MSRC) scientists measured bloom concentrations as high as 6 x 10^6 cells ml^{-1} in GSB and 2 x 10^6 cells ml^{-1} in the Peconic-Gardiners Bays. Chlorophyll measurements in surface waters, which do not normally exceed 7-14 $\mu g\ 1^{-1}$ in the Peconic Bay (Hardy, 1976; Bruno *et al.,* 1980; Turner *et al.,* 1983) were as high as 141 $\mu g\ 1^{-1}$ in Little Peconic Bay during the bloom's peak. Particle size frequency distributions of field samples (Figure 2) indicated that this small alga (2.0-3.2 μm diam.) clearly dominated the phytoplankton in terms of volume and numbers. Cells larger than 4.0 μm comprised an insignificant volume fraction of the phytoplankton in Peconic-Gardiners Bays field samples until the bloom began to receed in late August. Secchi disk readings (a measure of turbidity, and attenuation of light in the water column) were as low as 0.5 m throughout east end waters for most of the summer. Concern about swimming in the presence of the bloom, or consuming shellfish taken from affected waters was widely voiced, although local health officials found no evidence of a public health threat (R. Nuzzi, Suffolk County Health Services, pers. comm.). As the bloom reached its maximum densities in July, there was concern that its rapid collapse could lead to widespread oxygen depletion in the benthos as the dead algal biomass decomposed. In fact, total organic content of sediment samples taken at stations in the Peconic-Gardiners Bays during the bloom was 71% higher than that of similar samples taken in 1984 (I-J. Cheng, MSRC, pers. comm.). The decline of the bloom was gradual (Figure 3) with major reductions in cell concentration associated with two periods of rainfall (July 26 and August 30).

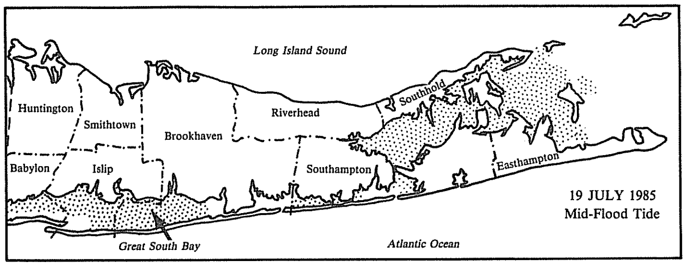


Figure 1. Distribution of phytoplankton bloom during peak cell concentrations, July 19, 1985, mid-flood tide, observed in aerial survey.

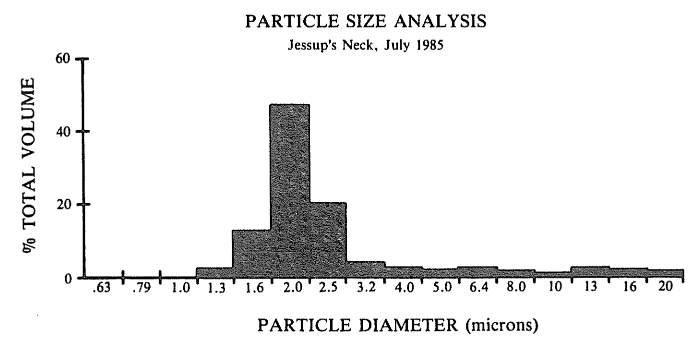


Figure 2. Particle size analysis (Coulter Counter Model TA-II) of field sample taken during peak bloom conditions.

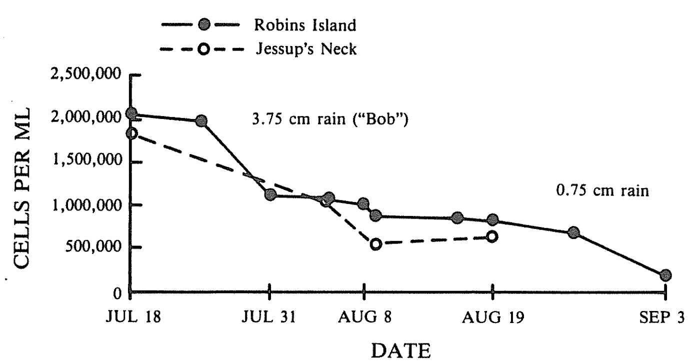


Figure 3. Decline of phytoplankton bloom at two locations in the Peconic Bays, 1985.

Identification and Causes

The identification of such small nannoplankton is difficult at best, and work to positively identify the species causing the bloom continues. A small diatom, *Minutocellus polymorphus,* isolated earlier from GSB waters (Hargraves and Guillard, 1974) was present in field samples (G. Hasle, University of Oslo, pers. comm.). Scanning electron microscopy (SEM) indicated however, that perhaps a different alga of the same size range was the principal species of the bloom. This as yet unidentified species is a diatom which grew under field conditions of silicate limitation (the diatom test was very poorly silicified and often destroyed in SEM preparations) (J. Mitchell, MSRC, pers. comm.). This alga has been isolated, and in laboratory culture, it takes up silicate and deposits a silicate test (x-ray diffraction analysis).

In general, historical data on phytoplankton cycles and nutrient distributions for GSB and Peconic-Gardiners Bays are insufficient to permit analysis of cause and effect relationships for this phytoplankton bloom. An examination of meteorological records from eastern LI and oceanographic data for the Peconic estuary is underway. Salinities at a site within Sag Harbor were approximately 2-3 ppt higher in 1985 than in 1984, probably as a result of an unusually dry summer. However, the bloom first appeared in the Peconic-Gardiners Bays system during a period of exceptional rainfall (May and June). Point sources would have been unlikely sources of nutrients for such a widespread bloom; however, nutrient levels are not adequately monitored on a long-term basis. Conclusive studies of the causes of this bloom will be very difficult without more extensive data on these water bodies, particularly nutrient and plankton data. Several arguments for a long-term monitoring program have been advanced since the appearance of the bloom.

Impacts of the Bloom on Fisheries

During the bloom hard clams *(Mercenaria mercenaria)* landed in the economically important wild fishery (worth $11 million in 1983) and those cultured as 1-8 mm "seed" clams apparently were starving on this unialgal diet in spite of the fact that phytoplankton cell densities in GSB reached 3.5 x 10^6 cells ml^{-1} by July (Bluepoints Co., West Sayville, New York). For a two-to-three week period in July, meat weights of adult hard clams being harvested fell below market standards and could not be sold. Aquaculture production of seed clams had to be relocated to LI Sound waters which were not affected by the bloom. Summer flounder *(Paralichthys dentatus)* taken in LI's recreational fishery were uniformly smaller and significantly fewer in number during the bloom (C. Zawacki, New York State Dept. of Environmental Conservation, pers. comm.). Many bay fishermen were forced to fish the traditional grounds of the offshore trawler fleet, areas outside of GSB and unaffected by the bloom.

On Scallops

Several commercially important shellfish and the area's ecologically important eelgrass beds were significantly affected by the density and persistence of the phytoplankton bloom. The bay scallop, *Argopecten irradians,* was most severely affected. This species supports a local fishery worth $1.3-1.8 million annually (U.S. Department of Commerce; 1981, 1982, 1983; Current Fisheries Statistics; U.S. Department of the Interior; 1981, 1982, 1983; Historical Catch Statistics). The bay scallop is a rapidly growing, short-lived species which spawns only once in its 18-22 month life span. Each harvested year class consists exclusively of progeny from the preceeding year's spawn. Scallop larvae are planktotrophs for their one-to-three week larval life, after which they settle usually in association with eelgrass beds. MSRC scientists working on a Sea Grant funded program investigating the distribution of bay scallop larvae noted what was later confirmed to be a widespread failure of larval recruitment throughout the Peconic-Gardiners Bays

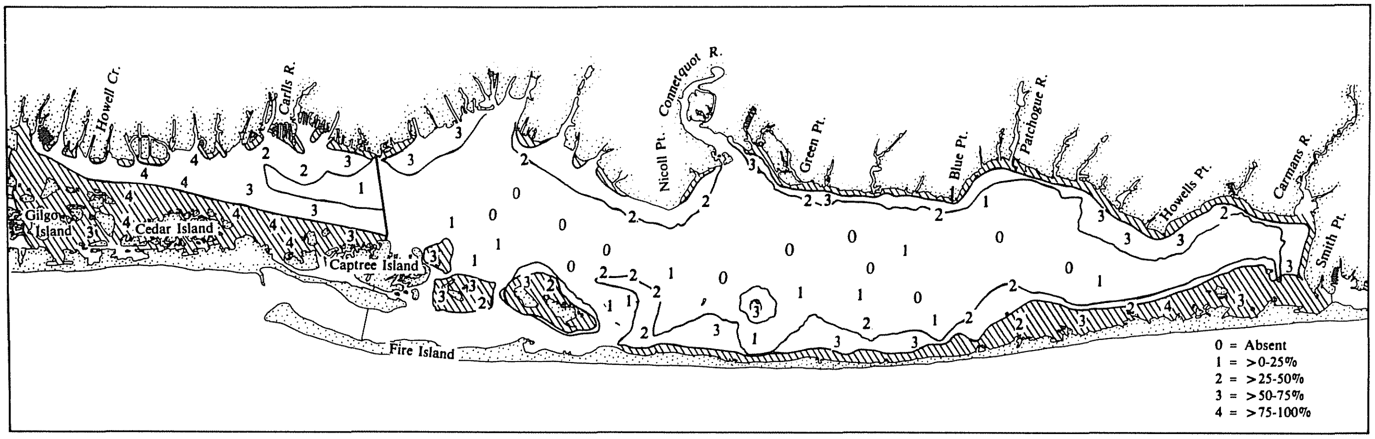


Figure 4. Known (1972) and predicted (post-bloom) distribution \\\\\\ of eelgrass in Great South Bay.

system, which typically supplies 15-20% of the nation's landings of bay scallops (U.S. Department of the Interior; 1981, 1982, 1983; Historical Catch Statistics) and over 80% of New York's bay scallop catch (Hardy, 1976). As a result, there is a widespread absence of juvenile scallops to maintain stocks for spawning and harvest in 1986. A study (funded by New York Sea Grant) of growth and reproduction of bay scallops was also undertaken by MSRC scientists throughout 1984. Appearance of the bloom led to continued sampling of the same populations from July through October of 1985 to determine effects of the bloom on adult scallops. By early August, mean dry weight of the adductor muscle (the only part of the scallop which is consumed) was 76% lower than it had been at the same time and sampling stations in 1984 (Bricelj *et al.,* in prep.). Opening of the harvesting season was delayed in some local towns to allow surviving scallops to build up their muscle weight as the bloom receeded. Additionally, most of the oysters being cultivated in east end bays (worth $1.6 million) died during the last month of the bloom, just prior to harvest (J. Mulhall, Long Island Oyster Farms, pers. comm.).

The mechanisms by which the blooming phytoplankton affected shellfish larvae and adults are being investigated with a "Quick Response" grant from New York Sea Grant and through a Suffolk County (NY) research contract. Several underlying mechanisms for these impacts on shellfish are plausible. As a food source for bivalves, this alga might be too small to be efficiently retained by the feeding apparatus, could lack important dietary components, have a cell wall that resists digestion by bivalves, be present in too high concentrations, and/or produce toxic metabolites.

Retention efficiencies of scallops decline exponentially at particle sizes less than about 5-6 μm in diam. (Palmer and Williams, 1980; Mohlenberg and Riigard, 1978), yet under elevated bloom concentrations, guts off scallops were consistently full of algae, suggesting that they could retain significant amounts in spite of the alga's small size. Palmer and Williams (1980) have shown that at phytoplankton concentrations greater than 1×10^5 cells ml^{-1} retention efficiencies of bay scallops increase significantly, probably due to increased mucus production on the suspension feeding apparatus. Bivalve larvae are theoretically able to capture 1-2 μm particles (Strathmann and Leise, 1979). In view of high mortalities of scallop larvae, it is possible that this alga lacks one or more of the essential nutritional components required to support growth and survival, or the alga may have an indigestible cell wall which prevents efficient utilization by bivalves. It is also possible that neither larvae nor adult bivalves could effectively regulate their intake of food particles under bloom conditions (up to 6×10^6 cells ml^{-1}). A massive input of food particles may overload the gut of suspension feeding bivalves resulting in reduced absorption efficiencies as food is forced through the alimentary tract without passing through the digestive gland. Finally, the alga may have produced toxic metabolites, especially at such high cell concentrations. Researchers at the University of Rhode Island (URI) working on a concurrent and extraordinary algal bloom in Narragansett Bay noted toxic effects on mussels from the Rhode Island bloom (J. Sieburth, URI, pers. comm.).

On Eelgrass

The phytoplankton bloom has also affected the distribution of eelgrass *(Zostera marina)* in LI bays. Phytoplankton blooms are known to shade benthic macrophytes such as eelgrass. It was suspected that eelgrass living in the deeper reaches of their range (individuals most susceptible to a reduction in light dosage) would no longer be receiving sufficient light to survive. Using an empirical relationship between light availability and eelgrass growth, the maximum depth penetration was predicted. Predictions were tested with field examinations along a depth transect. Plants were predicted to survive in water depths up to 0.63 m (mean low water depth). This agreed with summer field observations where above ground plant material was not found below the 0.73 m mean low water level. In Figure 4, the known previous distribution (Jones and Schubel, 1978) of eelgrass is compared with the predicted, post-bloom distribution.

Research and Management

Research and resource management efforts are underway to understand and mitigate efforts of this phytoplankton bloom. State and local funds have been allocated for a bay scallop transplantation program in which seed scallops will be cultured and placed in protected, spawner sanctuaries, areas from which as many predators as possible have been removed. This management effort will be supervised by state environmental officials but conducted, in large part, by scallopers who will be paid for their effort. Site selection for the spawner sanctuaries will be based in part on a circulation model for the Peconic estuary (M.E.C. Vieira and E. Gomez-Reyes, MSRC, pers. comm.) and a two-dimensional computer model of larval drift developed by MSRC scientists (see Carter *et al.,* 1984) to predict locations which should result in maximum retention of the planktonic larvae in the estuary. Additional research on identification and physiological requirements of the phytoplankton isolated from the bloom and the mechanisms by which it affected shellfish and eelgrass will begin in 1986.

References

Bricelj, V.M., J. Epp and R.E. Malouf. Fecundity and growth and reproductive cycles of bay scallops, *Argopecten irradians,* in the Peconic estuary, N.Y. In preparation.

Bruno, S.F., R.D. Staker and G.M. Sharma. 1980. Dynamics of phytoplankton productivity in the Peconic Bay estuary, Long Island. Est. and Coast. Mar. Sci. 10:244-263.

Carter, H.H., K-C. Wong and R.E. Malouf. 1984. Maximizing hard clam sets at specific locations in Great South Bay by means of a larval dispersion model. MSRC Special Report 54, ref. 84-1. 65 pp.

Hardy, C.D. 1976. A preliminary description of the Peconic Bay estuary. MSRC Special Report 3. 65 pp.

Hargraves, P.E. and R.R.L. Guillard. 1974. Structural physiological observations on some small marine diatoms. Phycol. 13(2):163-172.

Jones, C.R. and J.R. Schubel. 1978. Distribution of surficial sediments and eelgrass in New York's south shore bays: An assessment from the literature. MSRC Special Report 13, ref. 78-1. 80 pp.

Mohlenberg, F. and H.V. Riisgard. 1978. Efficiency of particle retention in 13 species of suspension feeding bivalves. Ophelia 17:239-246.

Palmer, R.E. and L.G. Williams. 1980. Effect of particle concentration on filtration efficiency of the bay scallop, *Argopecten irradians,* and the oyster, *Crassostrea virginica.* Ophelia 19(2):163-174.

Strathmann, R.R. and E. Leise. 1979. On feeding mechanisms and clearance rates of molluscan veligers. Biol. Bull. 157:524-535.

Turner, J.T., S.F. Bruno, R.Y. Larson, R.D. Staker and G.M. Sharma. 1983. Seasonality of plankton assemblages in a temperate estuary. Mar. Ecol. (Pubbl. Stn. Zool. Napoli I) 4(1):81-99.

Scott Siddall
V. Monica Bricelj
Edward J. Carpenter
Andrew Chiaraviglio
William C. Dennison
Marine Sciences Research Center
State University of New York
Stony Brook, NY 11794-5000

Research & Monitoring Updates

Evolution of Ocean Disposal Testing Requirements for Dredged Material

The continued operation of the Port of New York and New Jersey depends upon dredging an average of 7.9 x 10^6 m^3 of sediment each year. The urban nature of the area precludes upland disposal of large quantities of dredged material. Disposal of over 90% of the sediment dredged from the Port has taken place in the Atlantic Ocean.

Ocean disposal in the New York/New Jersey area has a long history, with records going back to 1888. As disposal continued, the designated disposal site was moved further offshore until it reached its current location, 11 km east of New Jersey and 20 km south of Long Island.

The contamination associated with sediment in the harbor is due primarily to the discharge of municipal and industrial waste water. This waste water often carries significant quantities of heavy metals and organohalogens, which often becomes attached to suspended sediment particles.

The disposal of dredged material has been of environmental concern since the late 1960s. At that time, the River and Harbor Act of 1899 was the only regulatory control of dredging and dredged material disposal. The Act did not specify any testing or quality requirements for the material proposed for disposal. The criteria were more general in prohibiting the disposal of "...refuse matter of any kind or description whatever other than that flowing from streets and sewers...whereby navigation shall or may be impeded or obstructed".

In 1971, the Federal Water Quality Administration (predecessor of the U.S. Environmental Protection Agency (EPA)) promulgated the so-called "Jenson Criteria" to be applied to all sediments dredged and to be disposed of in United States waters. These criteria, originally developed to characterize municipal and industrial wastes, required determination of seven parameters and specified total concentration limits based on the dry weight of sediment tested (bulk analysis). The parameters were chemical oxygen demand, total Kjeldahl nitrogen, volatile solids, and the levels of oil and grease, mercury, lead, and zinc. If the concentration of any constituent exceeded the numerical limits, the dredged material was classified as unacceptable for open-water disposal. Several problems with the Jensen Criteria led to general dissatisfaction with the procedure; the shortcomings included lack of consideration of background levels of constituents, geochemical location of contaminants, and bioavailability of contaminants (Engler, 1980).

The purpose of this article is to present a summary of the development of current testing requirements for dredged material proposed for disposal in the New York Bight. As research has been conducted on the impacts of dredged material disposal, the New York District Corps of Engineers has updated the guidance manual to reflect state-of-the-art knowledge. Since 1977, seven editions of the guidance manual have been issued.

Guidance Manuals

With the 11 January 1977 publication of the final revision of the "Regulations and Criteria for Ocean Disposal" by EPA (EPA, 1977), the criteria for dredged material shifted to include a biochemical assessment of contamination. Publication of these regulations was a result of direct negotiations between the Corps' and EPA's technical and policy staffs and represented conclusions from the Corps' Dredged Material Research Program that was completed the following year (Engler, 1980). The 1977 requirement for bioassays represented state-of-the-art procedures. In compliance with these criteria, the New York District issued an Interim Guidance Manual in February 1977 (USAED, New York 1977) for testing dredged material proposed for ocean disposal. That guidance specified a testing protocol of elutriate testing, bulk chemical analyses, and liquid phase bioassay. There were only standard procedures available for the liquid phase bioassay at that time.

The bioassay analysis can consist of the testing in three phases: liquid, suspended particulate and solid. The phases are obtained by mixing water and dredged material together then letting the mixture settle. The supernatant is the suspended phase-when this suspension is filtered, it is the liquid phase. The settled material is the solid phase. An elutriate test is a chemical analysis of the liquid phase. The liquid and suspended particulate phase bioassays provide information on the impact to the water column. The solid phase assay is conducted to evaluate potential impact to benthic organisms.

In July 1977, an implementation manual for Ocean Dumping Criteria was published by EPA and the Corps (EPA/COE, 1977). The purpose of this manual was to present procedurally sound, routinely implementable guidance in complying with the technical requirements for analysis of dredged material. The manual was not intended to establish rigid standards but to form "...a foundation to be augmented by more meaningful and comprehensive evaluation procedures and guidelines as these evolve from current and future environmental research."

While the implementation manual has been a necessary and useful resource, it must be kept in mind that it was prepared for a national audience and thus, by its nature, could not answer all the problems encountered on a local level. For this reason, the New York District updated its Interim Guidance Manual and published "Guidance for Performing Tests on Dredged Material to be Disposed in Ocean Waters" in November 1977. This guidance was prepared in conjunction with EPA Region II; it outlined specific regional requirements of the respective agencies and tried to ensure uniformity in administration of the program. For example, this guidance specified grain-size analysis techniques and appropriate bioassay organisms for the three phase bioassay to be utilized in the New York region.

In February 1979, the New York District revised the guidance manual to include bioaccumulation analysis of organisms surviving the solid phase bioassay. Since larger volumes of tissue for bioaccumulation analysis were required, the genus of shrimp was changed from *Mysidopsis* to the much larger *Palaemonetes.* In addition, the utilization of the phytoplankton *Skeletonema costatum* in the suspended particulate bioassay was modified to specify the zooplankton *Acartia tonsa.* This change was necessary because the high mortality exhibited by *Skeletonema* in the suspended particulate phase was found to be due to inhibition of light penetration in the highly turbid waters of the suspended particulate phase, rather than to chemical toxicity. To ensure the quality of the bioaccumulation results, minimum detection limits were established. In addition, subsampling and reextraction were required to provide information concerning laboratory precision.

In January 1981, the regional guidance manual was again revised to implement changes in the testing protocol. At that time, the testing of reference sediment was included with the analysis of control and test sediments. The site for collection of the reference sediment was to be one impacted by the same pollution as the ocean disposal site, but not influenced by the disposal of dredged material. Statistical comparison of test sediment with the reference sediment allowed the determination of potential for increased degradation in the area of the disposal site if the proposed dredged material was authorized for ocean disposal. The control treatment continued to serve as a monitor of testing conditions and the health of the test organisms during the bioassay.

Other changes implemented by the January 1981 guidance included core sampling of the proposed dredging area to project depth, rather than merely surficial grab sampling. This allowed characterization of the dredging area in both horizontal and vertical plane. Flow-thru of water for the solid phase bioassay replaced the static testing that was previously required because the flow-thru system better stimulates actual conditions at the ocean disposal site. Representative samples of the organisms to be utilized in the solid phase bioassay/bioaccumulation analysis were tested for contaminants of concern in order to determine that acceptable background levels existed.

August 1981 guidance revisions addressed concerns that the sediment samples were inadequately mixed prior to analysis. A new stricter procedure for homogenizing sediment required the use of a shaker platform or a stainless steel impeller. The acceptable value for total petroleum hydrocarbon (pretest) bioaccumulation was raised from below the detection limit of 0.10 ppm to 0.15 ppm. This change was required since the total petroleum hydrocarbon analysis involves extraction and detection of all petroleum hydrocarbon-like substances, including natural body lipids. By increasing the acceptable pretest value to allow for lipids, a more meaningful threshold is obtained.

The April 1982 edition of the regional guidance manual implemented further changes to the testing protocol, including designation of a specific estuarine site for collection of control sediment. The site selected ensured that the control sediment would be clean fine-grained material having a grain size similar to the bulk of the dredged material tested. Prior to this time, there was no consistency in regard to the origin or grain size of the material used as control sediment.

To facilitate interpretation of the test results of the elutriate analysis, as of April 1982 the testing protocol required analysis of dredging site water for the same constituents as required for elutriate analysis. The results of the two tests are then statistically compared in order to determine if there would be a significant increase in the release of contaminants into the water column during dredging.

At the time of issuance of the guidance manual in April 1982, approximately 75 sets of bioassays/bioaccumulation test results had been reviewed for dredging projects throughout the New York Harbor area. Since not a single case indicated that a release of DDT was anticipated, further testing for DDT in the elutriate and bioaccumulation phase was suspended. When concern was expressed in 1983 that a possible spill of DDT occurred in the northern part of the Arthur Kill, DDT testing was reinstated for this area only.

The most recent edition of the Guidance Manual was issued in December 1984. In order to ensure that standardized analytical procedures were being followed in conducting tissue bioaccumulation analysis, required protocols were established. In addition, the requirement for liquid and suspended particulate bioassay testing were eliminated for small dredging projects proposed for ocean disposal. Solid phase bioassay/bioaccumulation analysis is still required as are bulk sediment, elutriate and site water testing.

Summary

As more information concerning the impacts of dredging and disposal becomes available, the New York District, in conjunction with EPA, is developing a regional approach to the evaluation of dredged material proposed for ocean disposal. Since passage of the Ocean Dumping Act, the New York District has published seven editions of its guidance manual for testing of sediment from dredging projects for the Port of New York and New Jersey. The guidance manual allows implementation of certain changes in the testing protocol for the analysis of dredged material proposed for ocean disposal. The changes that have been implemented have resulted in testing and quality control procedures in keeping with state-of-the-art improvements since the publication of the Ocean

Dumping Criteria implementation manual. In addition, where test results have established that aspects of the sediment analysis are no longer needed, these can be eliminated reducing the cost of testing to the applicant.

James M. Mansky
U.S. Army Engineer District, New York
26 Federal Plaza
New York, NY 10278

References

Engler, R.M. 1980. "Prediction of Pollution Potential through Geochemical and Biological Procedures: Development of Regulation Guidelines and Criteria for the Discharge of Dredged and Fill Material," *Contaminants and Sediments,* Vol. 1, Chapt. 7, Ann Arbor Science Publishers, Inc., Ann Arbor, MI.

Environmental Protection Agency. 1977. "Ocean Dumping, Final Revision of Regulations and Criteria," *Federal Register,* Vol. 42, No. 7, January 11, 1977, U.S. Government Printing Office, Washington, D.C.

Environmental Protection Agency/Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material. 1977 (second printing 1978). "Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters," *Implementation Manual for Section 103 of Public Law* 92-532, Vicksburg, MS.

U.S. Army Engineer District, New York. February 1977. "Interim Guidance for Performing Tests on Dredged Material to be Disposed of in Ocean Waters". New York, NY (note: Later editions were published in November 1977, February 1979, January 1981, August 1981, April 1982 and December 1984).

Environmental Trends in Puget Sound, Washington

Are environmental conditions in Puget Sound getting better or worse? This question is currently attracting a great amount of attention among agencies responsible for planning environmental controls for Puget Sound. A wide variety of remedial actions are underway and planned to solve the problems identified in urban bays of the Sound. Also, major changes in the level of sewage treatment are anticipated. This question — are conditions getting better or worse — is important since the answer(s) will have implications in setting priorities for remedial actions.

Long-term monitoring data acquired with consistent methods are needed to answer the question. Since no comprehensive region-wide monitoring program exists for the Sound, data must be assembled from numerous groups performing mission-oriented research and monitoring programs. In most cases the available data were restricted to specific parts of the Sound and trends observed in those areas may not be applicable to other areas influenced by different pollutant sources. The following are a few examples of temporal trends identified by Dexter *et al.* (1985).

Pollutant Discharges

Total biological oxygen demand (BOD) inputs to the Sound from major pulp mills have decreased dramatically from 0.63 x 10^6 kg d^{-1} in 1970 to less than 45.45 x 10^3 kg d^{-1} 1984. Meanwhile, daily BOD inputs from the largest sewage treatment plant (West Point), near Seattle, have increased a relatively small amount from 13.64 x 10^3 kg d^{-1} in 1970 to about 45.45 x 10^3 kg d^{-1} in 1984.

Inputs of copper from the West Point sewage treatment plant have fluctuated from 45.5 to 136.36 kg d^{-1} from 1976 to 1984 with the beginnings of a diminishing trend since 1980. The daily discharge rate of lead from the West Point plant has also fluctuated from month to month, but a trend of decreasing rate has also occurred from 1980 to 1984. Annual atmospheric discharges of arsenic from the large ASARCO smelter, near Tacoma, have decreased from 23 metric tons in 1978 to zero following plant closure in April 1985.

Water and Sediment Quality

Dissolved oxygen concentrations in deep (80 to 120m) water in central Puget Sound have fluctuated from 1950 to 1984. These fluctuations are controlled by a variety of meteorological and oceanographic processes and the influence of anthropogenic activities is difficult to discern. However, a slight increase in dissolved oxygen may be occurring.

The concentrations of high molecular weight aromatic hydrocarbons in sediment cores from Puget Sound showed an increase in about 1900 to a peak in about 1940 and a subsequent steady decrease to the present. The maxima appears to be correlated to the peak in coal production, coal use and annual acreage lost in forest firs. Cores taken in Commencement Bay, also near Tacoma, show similar subsurface maxima in aromatics, generally corresponding with the 1940s levels.

Analyses of cores from the Sound generally show subsurface maxima of PCBs corresponding with the 1960s. However, these trends are not nearly as clear as those for aromatics. A range of 1 to 4 ppm (dry weight) of PCBs was detected in surface sediments in the lower Duwamish Waterway in the 1970s. Analyses performed in the 1980s consistently indicate that PCBs now occur at a concentration of about 0.5 ppm at these locations.

Analyses of cores from Puget Sound for trace metals indicate the following concentration trends since the 1920s: silver increasing; copper unchanged; lead, cadmium and mercury increasing until the 1960s with a recent possible slight decrease.

Biological Populations and Pathology

The annual production of Olympia (native) oysters *(Ostrea lurida)* has steadily decreased from about 2.7 x 10^5 kg in 1905 to less than 2.3 x 10^4 kg in 1982, reportedly due to pulp mill effluents. Commercial landings of shrimp *(Pandalus jordani)* have fluctuated yearly at about 22.7 x 10^3 kg — 45.5 x 10^3 kg with no discernible long-term trends. Commercial landings of crabs *(Cancer magister)* have increased steadily since the 1940s (4.5 x 10^5 kg yr^{-1}) to the 1980s (about 9.1 x 10^5 kg yr^{-1}). Commercial landings of all salmonids *(Oncorhynchus* spp.) have either increased or remained unchanged in the past 20-40 years.

Surveys of the benthos performed in the 1950s in the industrial harbors of Everett and Tacoma showed that some areas were azoic or inhabited only by "sludge worms". Surveys performed in the 1980s rarely encounter azoic benthic samples, though the benthos in some contaminated areas are devoid of sensitive crustaceans.

The percent prevalence of selected liver disorders among English sole *(Parophrys vetulus)* has been monitored for five years at eight sites in the Sound. Some sites reflected increasing prevalence, others reflected decreasing or unchanged prevalence. At those sites with increasing prevalence, the average age of the fish also increased, confounding attempts to relate prevalence of these age-related disorders to trends in contamination.

Summary

It is apparent from a broad-spectrum review of monitoring data that environmental conditions of the Sound are not getting precipitously worse. They may, in fact, be improving in many places for many parameters. However, parts of the Sound are by no means pristine. Serious disorders still occur among the biota in some of the urban bays.

The approach taken in Puget Sound — a compilation and review of existing data — can be applied anywhere. Many agencies, research groups and industries were queried for pertinent data. Most were very helpful and interested in seeing the final product. The resulting report was very well received and has proven useful to those groups involved in planning the future of Puget Sound.

Reference

Dexter, R.N., L.S. Goldstein, P.M. Chapman, and E.A. Quinlan. 1985. Temporal trends in selected environmental parameters monitored in Puget Sound. NOAA Technical Memorandum NOS OMA 19. National Ocean Service, National Oceanic and Atmospheric Administration, Rockville, MD. 166 pp. September 1985.

Edward R. Long
NOAA/Ocean Assessments Division
7600 Sand Point Way NE
Seattle, Washington 98115

In-Situ Observations of the Water Column, Sediments and Biota at the New York Bight Acid Waste Dumpsite and a Control Area.

From 1950-1982, the New York Bight acid waste disposal site, 28 km east of Long Branch, NJ, received the byproduct from the manufacture of titanium dioxide at a rate of up to 2 million wet tons per year. This waste was mostly sulfuric acid, but also contained ferrous sulfate, residual ilminite ore and some titanium dioxide, which when dumped create a ferrous hydroxide flocculant which colors the water yellowish-green (Bermingham, 1982). The dumpsite, known locally as the "acid stain" when a semi-permanent discoloration was maintained by large-scale dumping, was at times popular with sport fishermen. Environmental groups have campaigned to have the dumping ended, claiming environmental degradation. The U.S. Environmental Protection Agency at the same time made a decision to permit continued dumping. Most acid waste disposal ended in 1982 when National Lead Industries, the major dumper, closed its Sayreville, NJ plant. Documenting effects while the dumping was ongoing can still be useful, however, in assessing toxicity of the dumped materials and predicting impacts at other dumpsites. Effects have been studied from shipboard (Rowe, 1971; Vaccaro et al., 1972), but there has been little direct observation or photodocumentation.

On 3 August 1982, diving began at a greenish-yellow stain from a dump that had taken place approximately two hours earlier in 26 m of water. About one hour of color video tape was made, and five random sediment cores (78.5 cm^2 by 7.5 cm) were taken for infaunal analysis. We repeated these activities the next day at a "control" site in 25 m of water, 10 km NE of the dumpsite, after which the dumpsite was resurveyed. In all, three videotaping dives were made at the dumpsite and two at the control, with each dive covering about 360 m^2 of bottom.

The dumpsite was marked by light green surface water; however, the ship's propeller churned up bright yellow-green water. Just under the surface the divers observed fairly clear water with visibility about 2 m. A whitish, stringy gelatinous material, commonly observed in the New York Bight, was seen above the thermocline. Visibility diminished gradually to the thermocline where it was less than 20 cm due to a very fine, bright yellow floc. The thermocline began at 8 m, was strong and about 2 m thick. Under the thermocline the water was dark but clear (visibility ~4 m) with pea-sized yellow-orange aggregates uniformly distributed at 10-20 m^{-3} throughout (Figure 1). Figure 1 illustrates

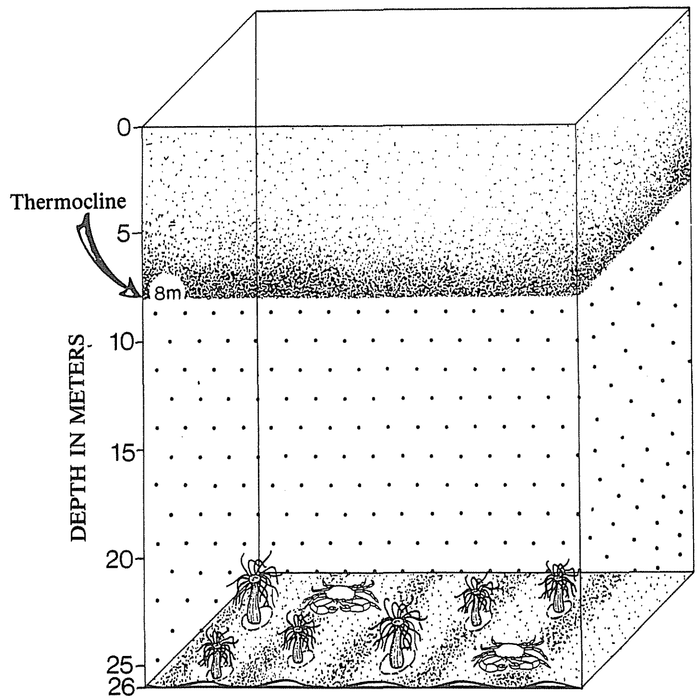


Figure 1. Conceptual drawing of the water column and seabed in the acid waste disposal site approximately two hours after a dump. The shading depicts an increased concentration of fine flocculent material on the thermocline. Below the thermocline the water is clear but dark with a uniform distribution of floc aggregates to the bottom. Numerous aggregates are depicted rolling on the seabed with high concentrations in the troughs of sand ripples. Rock crabs and the numerous anemone-like *Ceriantheopsis* are shown.

the patchy covering of the bottom by these aggregates, which the current gently shifted and which tended to concentrate in troughs of sand ripples. Sediments were yellow-brown, medium/fine sand with large numbers of anemone-like *Ceriantheopsis americanus* (see Table 1).

In the acid dumpsite the following day, when no new dumps were observed, the water just under the surface was clearer and the floc at the thermocline made up of larger particles. Under the thermocline the water was again dark and clear but the yellow-orange aggregates, while uniformly distributed, were less numerous. The number of aggregates on the bottom, however, had substantially increased, almost covering the sediments.

The control site also had a strong thermocline at 8 m with surface and bottom temperatures of 24.6°C and 10.3°C respectively. The visibility just under the surface was about 3 m and remained the same down to the bottom where it was just slightly darker. Visually, the only indication of the thermocline was a light accumulation of the common stringy gelatinous material above it.

Surface sediments were brown fine sand with some dark brown organic material.

Table 1 compares the relative abundance of biota observed at each site. At the control site, with the exception of the stringy gelatinous material above the thermocline, no material, living or otherwise, was observed in the water column. At the dumpsite, a 1.5 m unidentified shark was noted swimming slowly at the surface, ctenophores were common above the thermocline where visibility permitted observation, juvenile fishes (3-4 cm long) were seen near the surface, and small juveniles (1-2 cm) were observed among the floc particles at the thermocline. One flounder and one skate were observed at the sea floor of the dump and control sites respectively. At both sites *C. americanus* was the most abundant (ca. $20/m^2$) benthic species observed. Most of the *C. americanus* at the dumpsite had an area of 10-15 cm in diameter around the stalk which was clear of aggregates. The stalks also appeared to be higher than those at the control site. Rock crabs, identified as *Cancer irroratus*, and an occasional sulfur sponge, *Cliona celata*, were observed to be of the same size and abundance at both sites; however, only at the control site were numerous small (about 0.5 cm long) crabs (possibly *C. irroratus*) observed. Starfish, *Asterias forbesi*, were observed at both sites but those at the dumpsite were smaller and much less abundant than those at the control. The dumpsite had an occasional hermit crab (*Pagurus sp.*) whereas none were seen at the control.

Table 1. Relative abundance of pelagic and epibenthic animals seen at the control and acid waste disposal sites. For epibenthic animals, ''high'' is an estimated ≥ 10 individuals/m^2, ''moderate'' is 1-10/m^2 and ''low'' is $<1/m^2$; for ctenophores and juvenile fish, ''high'' is $\geq 1/10m^3$, and ''low'' is $\leq 1/10m^3$.

Species	Acid Site	Control Site
Ceriantheopsis americanus	High	High
Cancer irroratus (adults)	Moderate	Moderate
Asterias forbesi	Low and small	Low; larger
Cliona celata	Low	Low
Pagurus sp.	Low	None
Flounder (unidentified)	One	None
Ctenophores (unidentified)	High	None
Juvenile fish (unidentified)	Low	None
Shark (unidentified)	One	None
Skate (unidentified)	None	One

Table 2. Summary statistics for macrofauna of acid and control sites, with numbers of individuals and species of most abundant major taxa. Data are means (± standard error) of five 78.5 cm^2 core samples.

		Acid Site	Control Site
Number of species		7.6 ± 0.6	11.4 ± 0.9
Number of individuals		11.2 ± 1.4	26.0 ± 3.3
Species diversity (H′)		1.90 ± 0.09	2.15 ± 0.12
Equitability (J′)		0.94 ± 0.02	0.89 ± 0.03
Polychaetes	# species	4.4 ± 0.7	6.8 ± 0.6
	# individuals	5.8 ± 1.2	16.4 ± 2.5
Crustaceans	# species	0.2 ± 0.2	2.4 ± 0.8
	# individuals	0.2 ± 0.2	6.2 ± 2.5
Molluscs	# species	2.0 ± 0.3	1.6 ± 0.5
	# individuals	4.2 ± 1.0	2.6 ± 1.0

Results of macrofauna analyses in core samples are summarized in Table 2. Number of species, number of individuals and species diversity (Shannon-Weaver) were all higher at the control site than at the dumpsite, although too few samples were taken to determine statistical significance of the differences. Two-thirds of the difference between sites in number of individuals was due to polychaetes. Relative differences in numbers of individuals and species between sites were greatest for crustaceans.

We assume our observations are typical for summer conditions while acid wastes were being dumped. When a strong thermocline exists, the precipitated floc of ferrous and ferric hydroxides is concentrated at the thermocline. Aggregates of the floc, and probably other material, are formed and become dense enough to pass through the thermocline, eventually accumulating on the sediments. Without renewed input, the water column should be cleared of aggregates within a few days; however, the persistence of the aggregates on the bottom would be determined by the direction and speed of bottom currents.

A strong north-northwesterly surface tidal current had negligible effects on the floc at the thermocline and aggregates on the bottom except for slight oscillations. As no net transport of the aggregates was observed during this period of near maximum tidal current velocity, and no floc or aggregates were observed at the control site to the north-northeast, it is our tentative conclusion that storms are required to disperse the aggregates to any considerable degree, at least when a strong thermocline is present.

Table 1 indicates only small differences in abundance and size of the animals observed at each site, suggesting that, for these species at least, there are no major effects of the acid wastes. The data in Table 2 may indicate minor effects of acid dumping on benthic macrofauna, especially crustaceans. Crustaceans as a rule are thought to be sensitive to contaminants, and apparently have been excluded from much of nearby Christiaensen Basin by pollution (Boesch, 1982). Contaminant stress could also be limiting populations of these at the acid dumpsite. Again, the small size and number of samples collected, and the lack of corresponding information on sediment grain sizes and other variables influencing benthic distributions, precludes rigorous analysis and definitive statements on differences between sites.

Our observations during five dives detected no obvious differences in the condition of the biota at the acid waste disposal site and the Cholera Bank control site, which is in agreement with conclusions reached by Vaccaro et al., (1972) and Arnold & Royce, (1950). Only minor differences in the abundance of animals at the two sites were seen and, as the observations were temporally and spatially limited, these differences cannot be ascribed to dumping of acid wastes. There were, however, major differences between the sites with regard to the presence and absence of materials related to the dumped acid wastes, i.e. floc and aggregates, and an associated decrease of sunlight to the bottom of the dumpsite.

Acknowledgements

The authors wish to acknowledge the support of the NOAA Diving Office, Rockville, MD and Paul Pegnato and Steve Urick of that office for their assistance.

References

Arnold, E.L., and W.F. Royce. 1950. Observations of the effect of acid-iron waste disposal at sea on animal populations. Special Scientific Report: Fisheries No. 11, Fish and Wildlife Service, U.S. Dept. of the Interior: 12 p.

Bermingham, P.E. Regional Hearing Officer, EPA. [May 13, 1982 Memorandum to J.E. Schafer, Regional Administrator, EPA, Region II].

Boesch, D.F. 1982. Ecosystem consequences of alterations of benthic community structure and function in the New York Bight region. Pages 543-568 in G.F. Mayer (ed.), Ecological stress and the New York Bight: Science and management. Estuarine Research Federation, Columbia, SC.

Rowe, G.T. 1971. The effects of pollution on the dynamics of the benthos of New York Bight. Thalassia Jugoslavica 1:353-359.

Vaccaro, R.F., G.D. Grice, G.T. Rowe and P.H. Wiebe. 1972. Acid-iron waste disposal and the summer distribution of standing crops in the New York Bight. Water Res. 6:231-256.

William C. Phoel
Robert N. Reid
David J. Radosh
Peter R. Kube
Steven A. Fromm
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Center
Sandy Hook Laboratory
Highlands, NJ 07732

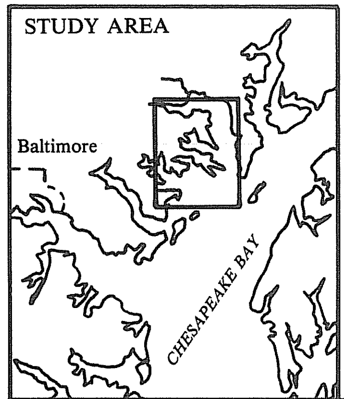
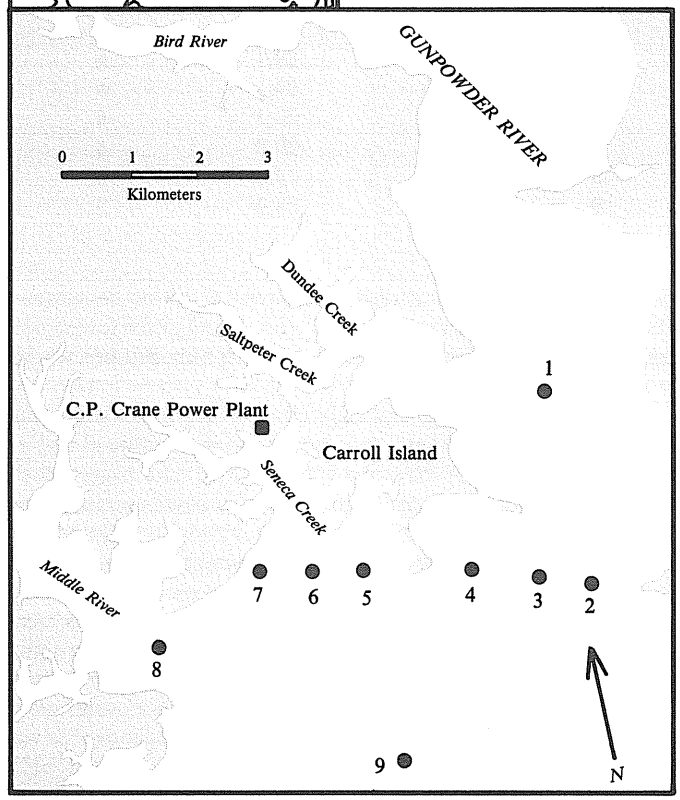


Figure 1 Location of Study Area, Sampling Stations and C.P. Crane Power Plant in the Upper Chesapeake Bay region, Maryland.



Occurrence of Low pH in Oligohaline Waters

Concern over possible degradation of biological communities in estuaries, due to acid deposition, has focused on pH shifts that occur near the freshwater/saltwater interface. Biologists and chemists appear to have assumed that the buffering capacity of oligohaline water would not permit sustained low pH. Data on organic rich blackwater rivers of the southeastern Coastal Plain suggest this assumption may not be valid for all estuaries (Beck, *et al.*, 1974). A basic assumption, concerning effects of acid deposition in estuaries, has been that low pH pulses were uncommon and that organisms are susceptible to these events. Low pH events have been suggested as one possible cause for decline of striped bass *(Morone saxatilis)* stocks in Chesapeake Bay. Larval and juvenile fish are thought to be particularly susceptible to these pulses. Reports in scientific (Hall, 1984) and popular (Boyle, 1984) literature have suggested toxic effects of acidification and aluminum on striped bass and other estuarine organisms.

Data collected in 1985 at the Crane Aquaculture Facility, C.P. Crane Power Plant, on Seneca Creek in the upper Chesapeake Bay (Figure 1), has demonstrated sustained low pH in oligohaline estuarine water. This facility began operation in the spring of 1983 and utilizes a once-through cooling system to deliver either ambient water from Seneca Creek or warmed discharge water from the power plant to tanks for rearing striped bass. All water (minimum of 1250 gpm flow) to the facility is through PVC pipe and is continuously monitored for temperature, salinity, pH and dissolved oxygen. Discharge canal pumps were turned off 29 April 1985 and only amient Seneca Creek water was used for the remainder of the period covered by this report. A decrease in pH from 7.2 to 6.4 occurred between 17 April and 8 June 1984 when salinities were between 0 and 2°/oo. April to May 1985, pH levels were above 7.0 and salinities were °/oo or less. Normal pH monitoring of intake waters at the facility revealed a drop in pH during May 1985. During the first half of May pH fell below 6.0, and salinity rose to 4°/oo. From 22 May to 20 August 1985, pH was consistently below 6.0, while salinity continued to increase to 6°/oo. The lowest pH, 4.8, was recorded on 29 July 1985, with a salinity of 5°/oo. A survey of pH, salinity, and temperature of surface waters adjacent to the facility indicated low pH in surrounding embayments; however, pH from areas more directly influenced by

Chesapeake Bay and/or the Susquehanna River had values ranging from 6.7 to 7.8 (Figure 1 and Table 1). The existence of low pH in this portion of the Chesapeake Bay system was also recorded by a 1980 water quality study (Ecological Analysts, Inc., 1981).

Table 1
Water quality parameters of surface waters adjacent to the Crane Aquaculture Facility, Seneca Creek, Maryland 14 August 1985. See Figure 1 for station locations.

Station	pH	Temp (°C)	Salinity (°/oo)
Intake	5.7	28.6	6
1	5.9	29.9	6
2	6.8	29.4	6
3	6.7	29.2	6
4	6.8	29.1	6
5	6.0	29.1	6
6	5.9	29.1	6
7	5.9	29.0	6
8	5.8	29.0	6
9	7.8	28.9	7

Findings of that study included pH below 6.0 during September 1980 with concurrent salinities of 6-7°/oo. Many of the lowest pH values recorded by Ecological Analysts were near stations where we found our lowest readings. Data from river systems in Georgia (Beck, *et al.*, 1974) suggest that organic material from swamps and marshes may dominate these systems. Our surveys indicated higher pH values upstream of the embayments. These data suggest that the system was not analogous to the blackwater southeastern rivers. Both 1980 and 1985 were relatively dry years with low flow from the Susquehanna River and little other apparent flushing action. Parts of the area surveyed have submerged aquatic plant beds and water enriched with nutrients. One possible hypothesis is that decomposition of organic material overwhelmed the buffering ability of the oligohaline waters. The low pH waters could then remain in relatively isolated embayments until an exchange of water took place. We have no evidence to support such a hypothesis, but we are presently unable to find an alternate source of the low pH.

Survival of larval and juvenile striped bass at Crane Aquaculture Facility during 1985 was the best in three years of operation in spite of chronically low pH. One-day-old larvae first arrived at the facility on 19 April 1985, and two additional stocks were received 29 April and 15 May 1985. Larvae were first exposed to pH below 7 at ages ranging from 2 to 20 days and first exposed to pH below 6 at ages ranging from 25 to 34 days. This raises questions about the hypothesis that low pH and sudden pH shifts are a major source of mortality for striped bass stocks in the Chesapeake Bay. Bonn *et al.* (1976) stated that a pH of 7.5 to 8.5 is optimum for striped bass. It has been reported that striped bass larvae have difficulty tolerating a sudden change in pH (Doroshev, 1970) or pH levels below 7 (Boyle, 1984; Hall, 1984). It has also been suggested that waters with a salinity of 2-10°/oo will be buffered sufficiently to negate pH fluctuations (Bonn, *et al.*, 1976). Most, perhaps all, studies which reported effects of sudden change in pH or chronically low pH on larval and juvenile striped bass survival were using freshwater. According to Mackin and Aller (1984), there are indications that no appreciable changes in pH occur if such comparisons are made using saline water in the 6-10°/oo range. This year pH below 6 with salinity as high as 7°/oo has yielded good survival of young striped bass.

We are continuing to monitor and field survey the low pH in waters surrounding the facility, and hope to report on the additional data.

References

Beck, K.C., J.H. Reuter and E.M. Perdue. 1974. Organic and inorganic geochemistry of some coastal plain rivers of the southeastern United States. Geochimica et Cosmochimica Acta 38:341-364.

Bonn, E., W. Bailey, J. Bayless, K. Erickson, R. Stevens (eds.). 1976. Guidelines for striped bass culture. American Fisheries Society.

Boyle, R. 1984. A rain of death on the striper? Sports Illustrated 60(17):40-54.

Doroshev, S.I. 1970. Biological features of the eggs, larvae and young of the striped bass *(Roccuss saxatilis)* (Walbaum) in connection with problems of its acclimatization in the USSR. J. Ichthyology 10:235-248.

Ecological Analysts, Inc. 1981. C.P. Crane Power Plant: An environmental assessment and ecological survey of the aquatic biota; Final Report, August 1978-November 1980. Ecological Analysts, Inc. Sparks, Maryland.

Hall, L. 1984. Field Assessment of striped Bass *(Morone saxatilis)* larval survival as related to contaminants and changes in water quality parameters. The Johns Hopkins University, Applied Physics Laboratory, Shady Side, Maryland. Final Report October 1984. 39 pp.

Mackin, J.E. and R.C. Aller. 1984. Processes affecting the behavior of dissolved aluminum in estuarine waters. Mar. Chem. 14:213-232.

David R. Sager
L. Curry Woods III
John N. Kraeuter
Baltimore Gas and Electric Company
Crane Aquaculture Facility
P.O. Box 1475
Baltimore, MD 21203

Determination of Aromatic Compounds in Bile of English Sole *(Parophrys vetulus)* from Polluted Sites in Puget Sound

Certain idiopathic liver lesions, including neoplasms, in bottom-dwelling fish in Puget Sound have been linked to the presence of aromatic hydrocarbons (AHs) in the associated sediments (Malins *et al.*, 1984; 1985). Aquatic organisms can accumulate aromatic compounds and metabolize some of them, e.g., the AHs, to toxic or carcinogenic products. However, because metabolites in fish tissues are notidentifiable by customary analytical techniques, suitable methods were needed to characterize complex mixtures of metabolites in environmentally exposed organisms.

For several years, we have been working on the development of high-performance liquid chromatography (HPLC) techniques for estimating relative concentrations of metabolites of selected aromatic compounds in bile of English sole (Krahn *et al.*, 1980; 1984). Recently, we examined livers of English sole from arious embayments of Puget Sound for the presence of various hepatic lesions. Lesion presence was then statistically correlated to relative concentrations of total metabolites in bile. In addition, methods were developed to determine the concentrations of certain specific metabolites in the bile of fish from contaminated sites within Puget Sound.

Concentrations of total metabolites

The sums of peak areas in the HPLC/fluorescence chromatogram of fish bile (area sums) indicate exposure of fish to specific groups of environmental contaminants. HPLC chromatograms from direct injections of 5 μL of fish bile were recorded at fluorescence excitation/emission wavelength pairs for typical aromatic compounds: e.g., the naphthalenes and the benzo[*a*]pyrenes (BaPs). Integrated areas of chromatographic peaks eluting after 7 minutes were then summed for each bile injection and converted to an AH equivalent based on a particular AH such as BaP. Some types of compounds which fluoresce at a particular wavelength pair include (a) the parent aromatic compound (e.g., BaP) and its metabolites, (b) alkylated homologs of the parent and their metabolites, and possibly (c) N-, S- or O-containing analogs with same or similar aromatic ring structure.

English sole from polluted sites in Puget Sound had naphthalene and BaP area sums that averaged 9 and 19 times, respectively, those of fish from reference sites (Table 1). Krahn *et al.* (1984) found that in the Duwamish Waterway, English sole with liver lesions had significantly higher concentrations measured at BaP wavelength pair of metabolites in bile than did sole without such lesions ($p \leq 0.05$). No correlation was found between the same liver lesions and concentrations of metabolites measured at the naphthalene wavelength pair.

Table 1
Mean HPLC/fluorescence area sums (converted to AH equivalents) in bile of adult English sole *(Parophyrys vetulus)* captured in Puget Sound[a]

Site	AH equivalents ± SD (ng/g, wet wt)	
	BaP	Naphthalene
Duwamish Waterway	1,800 ± 2,600[b] (n = 37)	150,000 ± 130,000[c] (n = 58)
Lake Washington Ship Canal	NA[d]	150,000 ± 120,000[c] (n = 12)
Port Madison (reference)	NA	12,000 ± 3,000 (n = 6)
Meadow Point	100 ± 100 (n = 20)	17,000 ± 15,000 (n = 27)

[a] Adapted from Krahn *et al.* 1984. Fluorescence was monitored at wavelengths for BaP and naphthalene metabolites: excitation/emission 380/430 nm and 290/335 nm, respectively. Integrated peak areas were converted to "AH equivalents", the amount of particular AH that would be present if all the integrated area were attributed only to that compound.
[b] Significantly different from Meadow Point, $p \leq 0.001$.
[c] Significantly different from reference sites, $p \leq 0.001$.
[d] Not analyzed.

Identification of individual metabolites

The major bile conjugates were separated from other metabolites and natural interfering compounds by isolating an HPLC fraction early in the gradient elution. This permitted a subsequent enzymatic hydrolysis to be carried out directly in the HPLC eluate (mostly water). Automated extraction was then utilized to remove biliary metabolites from solution rapidly and efficiently (Krahn *et al.* 1982).

Several metabolites in a hydrolyzed bile extracts from three English sole from polluted sites were identified and quantitated by GC/MS. Table 2 lists concentrations of these metabolites which ranged from 90-19000 ng/g, wet wt. Several tentatively identified xenobiotics are also shown (Table 2). Xenobiotics of these types have not been found in the bile of English sole from a reference site.

Table 2
GC/MS quantitation of metabolites of xenobiotics in hydrolized bile of English sole from polluted sites in Puget Sound, WA.[a]

Compound	Concentration (ng/g wet wt) (ng/g, wet wt)			
	Fish 1[b] (n = 3)	R.S.D.* (%)	Fish 2 (n = 1)	Fish 3 (n = 1)
C_2-naphthol	410	51	ND[c]	ND
Methylnaphthalene-methanol	90	26	ND	ND
9-Hydroxyfluorene	890	52	160	ND
Hydroxybiphenyl	1400	26	140	ND
Hydroxyfluorene	3500	37	500	ND
9,10-Anthraquinone	4800	31	ND	ND
Phenanthrene-carboxaldehyde	560	38	ND	ND
Phenanthrol[d]	19000	39	2100	5100
Phenanthrol[d]	16000	42	2100	5800
Anthracene-carboxaldehyde	2700	44	ND	ND

* Relative Standard Deviation.
[a] Adapted from Krahn *et al.* 1984. Fish 1 and 2 were from the Duwamish Waterway, and Fish 3 was from Lake Washington Ship Canal. No metabolites of xenobiotics were found in bile of fish from Meadow Point (reference site).
[b] Other compounds tentatively identified, but not quantitated: dibenzofuranol, dibenzodioxin, and benzonaphthofuran. Several peaks remained unidentified; some appeared to be N- or S-containing compounds.
[c] Not detected.
[d] The phenanthrol isomers resulted from dehydration of 1,2-dihydro-1,2-dihydroxyphenanthrene in the gas chromatograph.

Implications

Our HPLC/fluorescence method is a relatively simple and rapid way to survey for exposure of fish to aromatic compounds such as those from fossil fuel products. The results show, for example, that in the Duwamish Waterway, English sole with liver lesions had significantly higher concentrations of metabolites of aromatic compounds in bile (measured at the BaP wavelength pair) than did sole without such lesions. This method is now being employed by the National Marine Fisheries Service in a major U.S. coastal survey (NOAA's Status and Trends Program). In addition, a number of individual metabolites of 2-3 ring aromatic compounds have been identified in extracts of hydrolyzed bile from English sole. Additional research is underway to increase the sensitivity of the analytical methods to identify additional metabolites of large-ring aromatic compounds, particularly those of known carcinogens.

References

Krahn, M.M., D.W. Brown, T.K. Collier, A.J. Friedman, R.G. Jenkins and D.C. Malins. 1980. Rapid analysis of naphthalene and its metabolites in biological systems: determination by high-performance liquid chromatography/fluorescence detection and by plasma destroying chemical ionization mass spectrometry. J. Biochem. Biophys. Methods 2:233-246.

Krahn, M.M., T.K. Collier and D.C. Malins. 1982. Aromatic hydrocarbon metabolites in fish: automated extraction and high-performance liquid chromatographic separation into conjugate and nonconjugate fractions. J. Chromatogr., 236:441-452.

Krahn, M.M., M.S. Myers, D.G. Burrows and D.C. Malins. 1984. Determination of metabolites of xenobiotics in the bile of fish from polluted waterways. Xenobiotica 8:633:646.

Malins, D.C., B.B. McCain, D.W. Brown, S-L. Chan, M.S. Myers, J.T. Landahl, P.G. Prohaska, A.J. Friedman, L.D. Rhodes, D.G. Burrows, W.D. Gronlund and H.O. Hodgins. 1984. Chemical pollutants in sediments and diseases of bottom-dwelling fish in Puget Sound, Washington. Environ. Sci. Technol. 18:705-713.

Malins, D.C., M.M. Krahn, M.S. Myers, L.D. Rhodes, D.W. Brown, C.A. Krone, B.B. McCain and S-L. Chan (in press). Toxic chemicals in sediment and biota from a creosote-polluted harbor: Relationships with hepatic neoplasms and other hepatic lesions in English sole *(Parophyrys vetulus).*

Margaret M. Krahn
William D. MacLeod, Jr.
National Marine Fisheries Service/NOAA
Northwest and Alaska Fisheries Center
Environmental Conservation Division
2725 Montlake Boulevard East
Seattle, WA 98112

Biological Control as a Management Strategy for Great Lake Disturbances

To protect large investments in fish stocking and maintain suitable waters for recreational use, management responses to Great Lake environmental problems have often been reactive (interventional), usually through the use of chemicals or other unnatural means, rather than preventive, where action is taken before a particular problem reaches crisis level. For example, offensive growth of aquatic weeds and macroalgae along lakeshores has been controlled through harvesting or use of herbicidal chemicals. The sea lamprey *(Petromyzon marinus)* and its parasitic attack on stocked salmonids, sought by recreational fishermen, have been addressed by use of poisons as an interventional control strategy. This was done at the expense of the habitats in which lamprey spawn and despite the probability of eventual genetic resistance. Many such situations exist and nuisance are economically undesirable, but to sustain natural resources convergent strategies, ones that do not achieve economic goals at the expense of the environment, have to be developed. Aquatic systems are quite resilient and often capable of tapping their own resources to recover and adapt from perturbations (Deangelis, 1980). Man must work with these ecosystem characteristics for the enhancement of natural attributes that will contribute to pest control. With increasing progress in biotechnology more effort is needed to develop, adapt, and exploit those characteristics of Great Lake ecosystems that will contribute to the control of nuisances.

Biological control, an extension of biotechnology, is largely based on processes that regularly occur in nature. An excellent example of this occurs with cotton agriculture, in the form of integrated pest (insect) management (Adkisson *et al.,* 1982; Frisbie and Adkisson, 1985), which is a successful method of controlling terrestrial pests (insects). An example of biological control in the aquatic environment involves the killifish, *Fundulus heteroclitus,* and its ability to control mosquito populations on Long Island, New York (Chidester, 1916). A more recent example is the manipulation of trophic levels to control or eliminate nuisance populations in lake ecosystems (Spencer and King, 1984).

Lake restoration techniques which focus on macrophyte removal often destroy important littoral zones by the use of herbicides, mechanical harvesting, and the introduction of grass carp *(ctenopharyngodon idella).* These fish are capable of completely eliminating weeds in a short time span. Such treatments can cause structurally complex habitats to become relatively simple, often then serving as an additional source of nutrients supporting nuisance phytoplankton blooms (Carpenter *et al.,* 1983). Submerged macrophyte removal also appears to disrupt lake food web stability (Loucks, 1985). Consider, as an alternative, the use of crayfish *(Oronectes* spp.) to control aquatic weeds. Is it possible that by promoting crayfish populations, the need for using chemical or mechanical controls in weed-choked lake embayments could be reduced? Herbivory on macrophytes by crayfish has been extensively documented (Flint and Goldman, 1975; Lorman and Magnuson, 1978). Crayfish population manipulations could thus provide a less harmful and more natural solution than present control methods. Although the state of Wisconsin is experiencing problems in several lakes overpopulated by crayfish, balancing population of this herbivore with other trophic levels (integrated pest management) could potentially serve as a macrophyte-controlling mechanism. Despite widespread crayfish occurrence, no examples are known of testing the use of these grazers to specifically control nuisance macrophyte abundance in littoral areas.

Predation by sea lampreys has long been a significant cause of fish mortality in the Great Lakes (Christie and Kolenosky, 1980). Control methods have been developed which utilize selective chemical toxicants to destroy lamprey ammocoetes (larvae) in their stream habitat (Smith and Tibbles, 1980). Sawyer (1980) indicated that there may be a more natural means of controlling sea lamprey than chemical treatment, which impacts on more than just the target species, and suggested manipulation of natural ecosystem characteristics to limit lamprey predation. If the lamprey population explosion is due to a lack of natural enemies, then introduction and/or enhancement of predators could be a solution. Sea lamprey are used as bait by sturgeon fishermen in midwestern lakes. Sturgeon *(Acipenser fulvenscens)* were all but eliminated in the Great Lakes at about the time the sea lamprey began to make significant inroads. Is it possible that the benthos-feeding sturgeon could significantly reduce sea lamprey populations before their parasitic state is completed, thereby reducing the need for chemical controls? The life cycle of the sturgeon includes spawning and juvenile development in tributaries, and overlaps the distribution of sea lamprey ammocoetes. Therefore the juvenile sturgeon feeds from the same sediments where ammocoetes are growing before their transition to parasitic phases. Annual stocking of sturgeon fry to these tributaries might constitute an effective control and at the same time restore another lost fishery to the Great Lakes, as is already being done for lake trout. Biological control, either alone or in concert with chemical treatment, may thus present a viable alternative to present management methods.

The intent of the preceding "straw men" is not to suggest that they are viable alternatives, because research does not yet support this conclusion, but rather to stimulate thought toward the general concept of integrating biological control with present management strategies to address a variety of Great Lake problems. The recent success of biological control applied to terrestrial problems demonstrates a need for its serious consideration in aquatic environments. Biological control may be an overdue response to the cry for an ecosystem approach in lake management (Risser, 1985).

References

Adkisson, P.L., G.A. Niles, J.K. Walker, L.S. Bird, and H.B. Scott. 1982. Controlling Cotton's insect pests: A new system. Science 216 (2 April 1982): 19-22.

Carpenter, J.R., J.J. Elser, and K.M. Olson. 1983. Effects of roots of *Myriophyllum verticillatum* on sediment redox conditions. Aquat. Biol. 17:243-249.

Chidester, F.E. 1916. A biological study of the more important of the fish enemies of the salt-marsh mosquitoes. N.J. Agri. Exp. Sta. Bull. 300:3-16.

Christie, W.J. and D.P. Kolenosky. 1980. Parasitic phase of the sea lamprey *(Petromyzoo marinus)* in Lake Ontario. Can. J. Fish. Aquat. Sci. 37(11):2021-2038.

Deangelis, D.L. 1980, Energy flow, nutrient cycling, and ecosystem resilience. Ecology 61:764-771.

Flint, R.W. and C.R. Goldman. 1975. The effects of a benthic grazer on the primary productivity of the littoral zone of Lake Tahoe. Limnol. Oceanogr. 20:935-944.

Frisbie, R.E. and P.L. Adkisson. 1985. Integrated pest management is at hand. BioScience 35(2):69.

Lorman, J.G. and Magnuson. 1978. The role of crayfish in aquatic ecosystems. Fisheries 3:8-10.

Loucks, O.L. 1985. Looking for surprise in rearranging stressed ecosystems. BioScience 35:428-432.

Risser, P.G. 1985. Toward a holistic management perspective. BioScience 35:415-418.

Sawyer, A.J. 1980. Prospects for integrated pest management of the sea lamprey *(Petromyzon marinus)*. Can. J. Fish. Aquat. Sci. 37(11):2081-2092.

Smith, B.R. and J.J. Tibbles. 1970. Sea lamprey *Petromyzon marinus)* in Lakes Huron, Michigan and Superior: History of invasion and control, 1936-78. Can. J. Fish. Aquat. Sci. 37(11):1780-1801.

Spencer, C.N. and D.L. King. 1984. Role of fish in regulation of plant and animal communities in eutrophic ponds. Can. J. Fish. Aquat. Sci. 41:1851-1855.

R. Warren Flint
Research Center
State University of New York College
Oswego, NY 13126

Elliott Bay and Commencement Bay Contaminant Transport

The Pacific Marine Environmental Laboratory (PMEL) of NOAA conducted a one-year study for EPA during 1985 and 1986 to determine how pollutants might be transported from Elliott Bay and Commencement Bay (two of five priority marine embayments in Puget Sound) to the main basin of Puget Sound. Elliott Bay (Port of Seattle) and Commencement Bay (Port of Tacoma) are the two major commercial embayments of the Sound and are major morphological features with horizontal dimensions of about 5 x 6 kms and 3 x 3 kms, respectively. Both embayments are deep, 150 - 200 m, have steep sidewalls, and there is relatively little water less than 50 meters deep.

The waters of the embayments are mixtures from two sources. The largest in volume is the subsurface water from the main basin. The second, but of major significance, is the fresh water discharge from the rivers entering the bays which appears as a relatively thin lens a few meters thick at most within the bays. Freshwater discharges are from the Duwamish and Puyallup rivers, respectively. These are not large rivers. Maximum discharge of the Duwamish can be as high as 300 cubic meters per second primarily due to rain in winter; the Puyallup can be as high as 1000 cubic meters per second also associated with winter storms. The maximum flow of the Duwamish river is controlled by flood control dams on its tributaries.

Prior to this study several investigations have focused specifically on transport processes in Elliott Bay and the main basin of Puget Sound. Transport studies in Elliott Bay have shown that pollutant-bearing particles are added to the surface waters by river inflow, combined sewer outfalls, atmospheric precipitation, and other routes. Those particles that remain suspended above the pycnocline are advected out of the bay by the estuarine circulation. Particles that rapidly settle out of the surface layer contribute to pollutant accumulation in the bottom sediments. Bottom sediments may be a net sink for particles rather than a source to the main basin, but no quantitative information on the remobilization of bottom sediments by resuspension at specific locations (such as disposal sites) was available. Trace metal budgets constructed for Elliott Bay also suggest that, although the bay is a sink for particles, it is a net exporter of pollutants. For example, surface advection and tidal exchange carry about 75% of the Mn input out of the bay. The enrichment of Pb, Cu, and Zn in the hydrous Mn oxide phase on suspended particles suggests that pollutants such as these are likewise lost from the bay to the same extent.

The Puget Sound Action Program, under the direction of EPA and the Washington State Department of Ecology, developed a Program Plan in 1985. The Plan identified five priority marine embayments in Puget Sound as potential sources of pollutants for the rest of the Sound: Elliott Bay, Commencement Bay, Port Gardner, Sinclair Inlet and Budd Inlet. PMEL developed a study that addressed the question of pollutant transport from Elliott Bay in some detail and Commencement Bay to a lesser extent. There were four objectives:

1. obtain reliable, first-order estimates of the relative scale of each transport path (surface plume vs bottom nepheloid layer);
2. obtain information on the temporal variability within each path (e.g., is removal via the surface riverine plume predominated by a few winter runoff events?);
3. determine the partitioning of pollutant contaminated sediments between the transport paths;
4. identify the most profitable direction for obtaining quantitative estimates of specific pollutant fluxes.

A data report has been completed and submitted to EPA. Analysis of the data will be in a final report to EPA later this year.

Glenn A. Cannon
Herbert C. Curl, Jr.
Edward T. Baker
Richard A. Feely

Pacific Marine Environmental Laboratory
NOAA
7600 Sand Point Way NE
Seattle, WA 98115

Assessment of Long-Term Effects of Offshore Oil and Gas Development Completed

Of the many issues raised regarding the potential effects of expanded development of offshore oil and gas resources, its potential for long-term and insidious effects on the marine environment has particularly frustrated resolution. It is suspected that chronic effects are of greatest concern but, paradoxically, they are hard to detect and quantify.

In recognition of the need to resolve issues concerning long-term effects, the 1981 National Marine Pollution Program Plan recommended a 10-year interagency research program on the effects on ecosystems of long-term, chronic low-level exposures resulting from accidental spills, leaks and disruptions caused by offshore oil and gas development activities. The Louisiana Universities Marine Consortium was contracted by the National Oceanic and Atmospheric Administration to conduct an in-depth review for the Federal Interagency Committee on Ocean Pollution Research, Development and Monitoring (COPRDM) of present knowledge of such long-term effects and to provide recommendations for future research efforts (see COPAS, vol. 2, no. 4). Technical experts were commissioned to prepare critical reviews and a steering committee, composed of Donald F. Boesch, James N. Butler, David A. Cocchione, Joseph R. Geraci, Jerry M. Neff, James P. Ray and John M. Teal, developed conclusions and recommendations from this information base. A final report was submitted to NOAA in June, 1985, and will shortly be commercially published. This article briefly summarizes our findings.

We focused on those marine environmental effects which are long-lasting (>two years) and significantly deleterious to resources of human concern (such as fisheries) and ecosystem integrity. Our evaluation was based on interpretation of relative risks based on the probability and potentially severity of effects and on the potential that new scientific information or reinterpretation of existing information could contribute to resolution of an issue. Recommendations were provided for required studies, their feasibility and the use of resulting information.

The potential for long-term effects depends on the environment in which development takes place or through which oil and gas is transported and how the development is accomplished. In the United States, offshore oil and gas production has to date been limited to the northwestern Gulf of Mexico (the vast majority), southern California and Cook Inlet, Alaska. Although an ambitious program of exploration and development of previously undeveloped "frontier" areas was begun in the 1970s, no economically viable discoveries have yet been made outside of these producing regions. Based on indicators, including proven reserves, current drilling activities, estimates of undiscovered resources and industry interest, it is now clear that, although some exploratory activity and potential production may take place off the Atlantic coast, Florida, the northwestern states and in the Gulf of Alaska, United States offshore oil and gas development will be concentrated in the northwestern Gulf of Mexico, off southern California and in the Beaufort and Bering Seas of Alaska for the remainder of the century. Drilling in the deeper waters of the continental slope and under heavy sea ice conditions will present new challenges to the industry in terms of environmental engineering and safety.

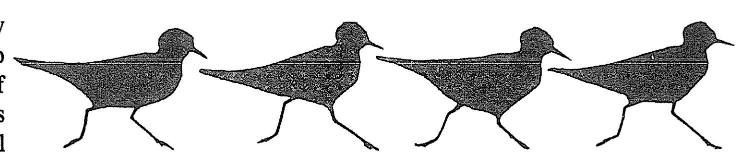
Modes of transportation of oil and gas from offshore will vary depending on the product and amount of production, distance to shore, nature of intervening environment, and the capability of onshore facilities. The extent and duration of effects of oil spills resulting from pipeline ruptures or loss from transshipment will vary depending on the nature of the coastal ecosystems affected and the presence of colonies of birds and mammals. Similarly, dredging for pipelines and required navigational access will pose different threats to disparate coastal environments. Knowledge of the comparative sensitivity of marine ecosystems often limits extrapolation of results from one area to another.

Based on detailed consideration of the probability and severity of effects and the potential for resolution of uncertainties, COPRDM identified ten categories of potential long-term environmental effects of offshore oil and gas development activities for future investigation. Of high priority are 1) chronic biological effects resulting from persistence of medium and high molecular weight aromatic hydrocarbons and heterocyclics and their degradation products in sediments and cold environments; 2) residual damage from oil spills to biogenically structured communities, such as coastal wetlands, reefs and vegetation beds; and 3) effects of channelization for pipeline routing and navigation in coastal wetlands. Of intermediate priority are 1) effects of physical fouling by oil of aggregations of birds, mammals and turtles; 2) effects on benthos of drilling discharges accumulated through field development rather than from exploratory drilling; and 3) effects of produced water discharges into nearshore rather than open shelf environments. Of lower priority are 1) effects of noise and other physical disturbances on populations of birds, mammals and turtles; 2) reduction of fishery stocks due to mortality of eggs and larvae as a result of oil spills; and 3) effects of artificial islands and causeways in the Arctic on benthos and anadromous fish species.

For each of these major categories of effects, sequential approaches were developed for quantification of long-term effects. Recommended research includes generic experimental approaches, for example, on persistence of medium and high molecular weight hydrocarbons in sediments and their metabolic fate in organisms; observational studies, for example, following the recovery of oiled communities and monitoring of potentially affected colonies of birds and mammals; carefully designed measurements of environmental processes, for example, transport of contaminated sediments and hydrologic flow in altered wetlands; and regionally focused field assessments.

Given the great diversity of potential effects and regional differences in potential effects, COPRDM recommended implementation of and commitment to a U.S. interagency program plan which guides regional research and monitoring effects together with generic research programs. Of critical importance to the success of such a program are centralized management within agencies and sufficient interagency overview to assure compliance; iterative review of objectives and progress; emphasis on innovation and application of state-of-the-art methods; and multi-year research funding.

Donald F. Boesch
Louisiana Universities Marine Consortium
Chauvin, LA 70344



Announcements

Chesapeake Bay Data Sources

A new publication has been issued that identifies and describes environmental data for Chesapeake Bay area available from the NOAA National Environmental Satellite, Data, and Information Service (NESDIS). *Environmental Data Sources for the Chesapeake Bay Area* contains data inventory plots and tables that show types of data available, where they are located, and the time span of the data record. It covers oceanographic, climatological, geological/geophysical, and satellite data archived at the national data centers operated by NESDIS.

This publication describes other sources of data and information for Chesapeake Bay including data referral services, other NESDIS publications, and selected data collections and information services of other organizations and agencies. Contact points are listed for all data and information sources described. This publication is available without charge from: National Oceanographic Data Center, User Services Branch, NOAA/NESDIS E/OC21, Washington, DC 20235. Telephone: 202-634-7500 or FTS 634-7500.

Richard J. Abram
National Oceanographic Data Center
NOAA/NESDIS
Washington, DC 20235
202-634-7394

New Edition of NODC Taxonomic Code

The National Oceanographic Data Center (NODC) announces the availability of the fourth edition of the new NODC Taxonomic Code. This edition contains nearly 46,000 entries giving scientific names and corresponding numerical codes of worldwide flora and fauna from viruses to mammals; nearly twice the number included in the third edition.

The NODC Taxonomic Code is a hierarchical system of numerical codes of up to 12 digits used to represent the scientific names of organisms to the level of subspecies or variety. The bowhead whale *(Balaena mysticetus),* for example, is coded by the 10-digit code number 9219030102. The code links the Linnean system of biological nomenclature to a numerical schema that facilitates modern methods of data storage and retrieval. The code was specifically developed by NODC to simplify and systematize NODC processing, storage, and retrieval of marine biological data. NODC requires the use of the code in all marine biological data it accepts for processing.

This edition introduces new features to make the code more flexible and useful. For example, a series of terms and symbols is used to annotate code entries with information about changes or corrections and to provide cross-references between certain related entries.

The published version of the code (Key to Oceanographic Records Documentation No. 15) is available either as a paper copy or on microfiche. The NODC Taxonomic Code is also available on magnetic tape. A four-page brochure that describes the code and its new features and provides information on costs of the different output media is available on request from: National Oceanographic Data Center, User Services Branch E/OC21, Washington, DC 20235. Telephone 202-634-7500 (Commercial) or FTS 634-7500.

Richard Abram
National Oceanographic Data Center/NOAA
Washington, DC 20235
202-634-7394

Viewpoints

During recent years, Great Lakes researchers have focused on gaining perspectives on the sources, mechanisms and processes affecting chemical contaminant transport, distribution and migration. Based on research sponsored primarily by federal, state and Canadian agencies, we have learned that microcontaminants have invaded all segments of the Great Lakes ecosystem and that many of these will persist for decades, even if all point sources were eliminated today.

Although a great deal more needs to be accomplished, there is currently reasonable understanding of the mechanisms and processes affecting microcontaminant cycling and distributions. Because new high priority pollutants will be found and improved sampling and analytical techniques will identify contaminants which pose threats to aquatic resources and/or human health, Great Lakes researchers will continue characterizing and modeling to predict partitioning, persistence, distribution and fate of Lake microcontaminants. These directives are essential and should continue to receive high priority, particularly by the state and federal regulatory agencies.

Perhaps it is also time for Great Lakes researchers to begin considering means and mechanisms for eliminating, or at least reducing, environmental chemical impacts by investigating ways in which natural or induced biological processes can be used to reduce the use and availability of chemicals in Lake waters. For example, U.S. and Canadian agencies currently cooperate in attempting to reduce the impacts of the sea lamprey *(Petromyzon marinus)* to Lake samonids by chemically treating tributaries with lampricides. Sea lamprey are used as bait by sturgeon fishermen and sturgeon populations were all but eliminated in the Great Lakes at about the time the sea lamprey made significant inroads. Is it possible that the benthos-feeding sturgeon could significantly reduce sea lamprey populations thereby reducing the need for relying solely on chemical controls?

Consider also that crayfish *(Oronectes* spp.) have been used in lakes to control aquatic weed growth. It may be possible to reduce dependency on chemical treatment or mechanical harvesters to rid Great Lake embayments of the weed growth enhanced by nutrient enrichment during summer months when Lake communities expand.

One other possible biological control which should also be considered is the role *Cladophora,* a common macroalga which grows prolifically in the near shore waters of the lower Great Lakes, plays in the cycling and possible recycling of microcontaminants. This macroalga is known to assimilate a variety of organic and inorganic microcontaminants and Lake Ontario production is estimated to be about 19,500 tonnes dry weight annually. If it is assumed that *Cladophora* accumulates a contaminant at 1 ppm dry weight, it may be possible to remove as much as four (4) kilograms of the substance per year, assuming ten percent of the alga was harvested and removed. Although this may appear to be an insignificant amount, four kilograms has the potential to contaminate $4x10^6$ kilograms of biomass at 1 ppm. Removal of the 4 kilograms may also eliminate that amount from continually recycling through the lake ecosystem.

Three possible, albeit untested, biological control mechanisms are suggested for eleviating impacts to Great Lakes ecosystems and there are, no doubt, dozens of other possible alternative controls which have been considered by the Great Lakes research community. It is not suggested that Great Lake researchers redirect their efforts or attentions away from contaminant characterization to gain better perspectives on processes and mechanisms. I am suggesting, however, that it is time to more thoroughly consider natural biological controls which may help reduce our dependency on artificial controls and reliance on time to eleviate known and future chemical contaminant impacts.

R.J. Scrudato
State University of New York
College of Oswego
Oswego, NY 13126

Special Note to Readers: This is the last issue of the Coastal Ocean Pollution Assessment Newsletter. Funding for COPAS has been discontinued. We thank our correspondents and particularly our readers for the support and encouragement you've given over the past five years.

The Editorial Board

Coastal Ocean Pollution Assessment News
Marine Sciences Research Center
State University of New York
Stony Brook, Long Island, NY 11794

NON-PROFIT ORG.
U.S. POSTAGE
PAID
STONY BROOK, N.Y.
PERMIT No. 65

Address correction requested