

**Non-point Source Pollution:
Reducing Its Impact on Coastal Environmental Quality**

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Thank you Admiral Watkins and commission members for allowing me this opportunity to draw your attention to two recent reports of the National Academies that address what are arguably two of the most significant challenges to coastal and marine environmental quality: oil pollution and nutrient pollution.

A decade ago public concerns about marine pollution were driven by the dramatic footage from Prince William Sound taken in the days and weeks following the *Exxon Valdez* oil spill. In more recent years many coastal residents have come to recognize a new but equally damaging problem: surface runoff. Last year saw a record number of beach closings, and 2002 seems to be keeping pace. Beach closings, harmful algal blooms, and hypoxia events such as the well-documented “dead zone” in the Gulf of Mexico, have pushed non-point source pollution to the top of most lists as the major threat to coastal environmental quality. In 1998, at the request of NOAA, EPA, the USGS, and the Electric Power Research Institute, the National Academies undertook a two-year effort to provide advice on one of the most prominent non-point source pollution threats: nutrient over-enrichment. The final report, entitled *Clean Coastal Waters: Understanding and Reducing the Effects of Nutrient Pollution*, provided a detailed analysis of the scientific and management issues posed by nutrient pollution and outlined the key elements of a nationwide strategy to address the problem. Now a recently released National Academies report *Oil in the Sea III: Inputs, Fates, and Effects* suggests that oil may need to join nutrients, pesticides, and mercury on the list of non-point source pollution threats to the coastal environment.

New estimates reported in *Oil in the Sea III* indicate that spillage from vessels in North American waters from 1990 to 1999 was down by nearly two-thirds compared to the prior decade, and reductions in releases during oil and gas exploration and production have been dramatic as well. These releases, however, represent only about 30 percent of the worldwide petroleum inputs to the sea from human activity. Chronic low-level releases associated with the consumption of petroleum account for the other 70 percent and may pose significant risks to the sensitive estuarine environments where these inputs most often enter the marine environment. Volumetrically the most significant anthropogenic source of petroleum entering the marine environment is land-based, non-point source pollution, which delivers roughly 16 million gallons of petroleum to North American coastal waters each year, over half of the total anthropogenic load.

The effects of a petroleum release are a complex function of the rate of release, the nature of the petroleum, and the local physical and biological characteristics of the exposed ecosystem. Some hydrocarbon components are more toxic than others. Growing evidence suggests that toxic compounds, such as polycyclic aromatic hydrocarbons (PAH) in crude oil, refined products, or rivers or wastewater streams polluted with petroleum, can have adverse effects on biota at very low concentrations. This suggests that PAH released from chronic sources may be of greater concern than was recognized 10 to 15 years ago, and that in some instances effects of petroleum spills may last longer

than expected. Along with *Clean Coastal Waters*, *Oil in the Sea III* points out the significant threat non-point source pollution poses to coastal environmental quality.

Oil in the Sea

Based on analysis of data from a wide variety of sources it appears that each year on average a total of about 260,000 metric tonnes (about 76 million gallons) of petroleum is introduced to the waters off North America. Annual worldwide estimates of petroleum input to the sea exceed 1.3 million metric tonnes (about 380 million gallons). Although these are imposing figures, they are difficult to interpret in terms of their ecological significance, as they represent thousands or tens of thousands of individual releases whose combined effect on the environment is not easy to clearly establish. Regional or worldwide estimates of petroleum entering the environment are, therefore, useful only as a first order approximation of need for concern. Sources of frequent, large releases are rightfully recognized as areas where greater effort to reduce petroleum pollution should be concentrated, despite the fact that not every spill of equal size leads to the same environmental impact. Never-the-less, the sheer magnitude of non-point source petroleum pollution, the growing concern about the effect of some petroleum-related compounds, and the proximity of these releases to sensitive coastal habitats suggests that efforts to understand and reduce non-point source petroleum pollution should be on equal footing with efforts to address major spills.

Natural Seeps

Natural seepage of crude oil from geologic formations below the seafloor to the marine environment off North America is estimated to exceed 160,000 tonnes (47 million gallons), and 600,000 tonnes (180 million gallons) globally each year. Natural processes are, therefore, responsible for over 60 percent of the petroleum entering North American waters and over 45 percent of the petroleum entering the marine environment worldwide. Natural seepage of crude oil to the environment tends to occur sporadically and at low rates. Thus, areas surrounding natural seeps are extremely important natural laboratories for understanding crude oil behavior in the marine environment, as well as how marine life responds to the introduction of petroleum.

Petroleum Extraction

Activities associated with oil and gas exploration or production introduce on average an estimated 3,000 tonnes (880,000 gallons) of petroleum to North American waters and 38,000 tonnes (11 million gallons) worldwide each year. Releases due to these activities make up roughly 3 percent of the total petroleum input by anthropogenic activities to North American waters and 5 percent of the total worldwide. Although dwarfed by some other sources of petroleum to the marine environment, these inputs are not trivial, as they can occur as large spills or as slow, chronic releases concentrated in production fields.

Petroleum Transportation

The transportation of crude oil or refined products (including refining and distribution activities) results in the release on average of an estimated 9,100 tonnes (2.7 million gallons) of petroleum to North American waters, and 150,000 tonnes (44 million gallons) worldwide each year. Releases due to the transportation of petroleum make up roughly 9 percent of the total petroleum input through anthropogenic activities to North American waters and roughly 22 percent worldwide. Although these volumes are dwarfed by those from other sources of petroleum to the marine environment, individual releases can be large and catastrophic.

Petroleum Consumption

Releases that occur during the consumption of petroleum, whether by individual car and boat owners, non-tank vessels, or runoff from increasingly paved urban areas, contribute the vast majority of petroleum introduced to the environment through human activity. On average an estimated 84,000 tonnes (25 million gallons) of petroleum are input to North American waters, and 480,000 tonnes (140 million gallons) are input worldwide each year from these diffuse sources. Therefore, releases associated with the consumption of petroleum make up nearly 70 percent of the petroleum introduced to the world's oceans from anthropogenic sources and nearly 85 percent of the total petroleum input from anthropogenic sources to North American waters. Unlike other sources, inputs from consumption occur almost exclusively as slow, chronic releases. Because the preponderance of petroleum consumption occurs on land, rivers and waste- and stormwater streams represent the most significant source of petroleum to the marine environment.

Despite the significant progress made in understanding the behavior and effect of petroleum spills on the marine environment and on preventing their occurrence in the first place, there has been relatively little progress on understanding the threat posed by small, chronic releases of petroleum from all sources. Insights have been made from long-term studies of sites of major spills or polluted harbors, but to a large degree the significance (in terms of environmental damage) of the large inputs from land-based sources or other chronic releases is not known. Recent studies, however, suggest that PAH, even in low concentrations, can have a deleterious effect on marine biota. Furthermore, research on the cumulative effects of multiple types of hydrocarbons in combination with other types of pollutants is needed to assess toxicity and organism response under conditions experienced by organisms in polluted coastal zones. *Oil in the Sea III* recommended that federal agencies, especially EPA, NOAA, NSF, USGS, and MMS, should work with academia and industry to develop and implement a major research effort to more fully understand and evaluate the risk posed to the marine environment by the chronic release of petroleum (especially the cumulative effects of multiple types of hydrocarbons present in these kinds of releases).

Oil in the Sea III provides a reasonable snapshot of the current nature of the threat posed by oil pollution to the marine environment. Although the report makes clear that greater attention should be placed on evaluating land-based, non-point sources of

petroleum pollution, no recommendations of how to reduce the input of petroleum from these sources were put forward. We must look elsewhere for models of how to address the general topic of non-point source pollution.

Non-point Source Nutrient Pollution: Lessons Learned

Unlike non-point source petroleum pollution, where there are only preliminary indications of the potential threat, nutrient pollution has been widely documented as a major threat to coastal ecosystems. Nutrient pollution has moderately to severely degraded some 60 percent of coastal rivers and bays in the United States. Both nitrogen and phosphorus contribute to the problem, although for most coastal systems nitrogen additions cause more damage. Globally, human activity has increased the flux of nitrogen and phosphorus from land to the oceans by some two-fold and three-fold, respectively. For nitrogen much of this increase has occurred over the past 40 years, with the increase varying from region to region. For example, human activity has increased the flux of nitrogen in the Mississippi River basin by some four-fold, in the rivers of the northeastern United States by some eight-fold, and in the rivers draining to the North Sea by more than ten-fold.

The sources of nutrients to the coast vary from site to site and from region to region. For some estuaries sewage treatment plants are the largest single input. For most systems, however, non-point sources of nutrients are now of greater importance, both because of improved point source treatment and control (particularly for phosphorus) and because of increases in the total magnitude of non-point sources (particularly for nitrogen) over the past three decades. For phosphorus, agricultural activities dominate non-point source fluxes. Agriculture is also the major source of nitrogen in many systems, including the flux of nitrogen down the Mississippi River, which has contributed to the large hypoxic zone in the Gulf of Mexico. For both phosphorus and nitrogen, agriculture contributes to non-point source pollution both through losses at the field scale—as soils erode away and fertilizer is leached to surface and groundwaters—and from losses from animal feedlot operations. In the United States, nitrogen from animal wastes that leaks directly to surface waters or is volatilized to the atmosphere as ammonia may be the single largest source of nitrogen that moves from agricultural operations into coastal waters. In some regions, including the northeastern United States, atmospheric deposition of oxidized nitrogen from fossil-fuel combustion is the major flux from non-point sources. This atmospheric component of the nitrogen flux into estuaries has often been underestimated, particularly the deposition onto the terrestrial landscape with subsequent export downstream. As the relative importance of these nutrient sources varies among regions and sites so too must appropriate and effective mitigation strategies. The regional nature and variability of nutrient sources require that nutrient management efforts cover large geographic areas.

No single policy approach will be appropriate in all cases. The size and nature of watersheds and their associated estuaries can vary dramatically nationwide. The number, type, and significance of sources of excess nutrients and the susceptibility of coastal receiving waters to nutrient pollution can vary as well. The incentives for voluntary participation in nutrient reduction programs, the cost of regulatory oversight, or the public acceptance of additional taxes or fees to support efforts to reduce nutrient

pollution will also vary. Thus, local policy makers will be forced to experiment with different mixes of approaches in order to achieve sustainable and meaningful reductions in the impact of nutrient pollution. Federal efforts should be focused on helping local entities set reasonable water quality goals within regional frameworks and on providing technical assistance that may be beyond the reach of local authorities. A fundamental understanding not only of the physical dimensions of over-enrichment but also of its economic dimensions will help local regulators design an appropriate mix of policies tailored to their own circumstances and needs.

The severity of nutrient problems and the importance of the coastal areas at risk led the National Academies to call for the development and implementation of a National Nutrient Management Strategy, which as proposed in *Clean Coastal Waters* would coordinate local, state, regional, and national efforts to combat nutrient over-enrichment in coastal areas, with the goal of seeing significant and measurable improvement in the environmental quality of impaired coastal ecosystems. One may rightly ask, “What are reasonable goals for improvement?” *Clean Coastal Waters* recommended that at a minimum federal, state, and local authorities should work with academia and industry to:

- reduce the number of coastal water bodies demonstrating severe impacts of nutrient over-enrichment by at least 10 percent by 2010.
- further reduce the number of coastal water bodies demonstrating severe impacts of nutrient over-enrichment by at least 25 percent by 2020.
- ensure that no coastal areas now ranked as “healthy” (showing no or low or infrequent nutrient symptoms) develop symptoms related to nutrient over-enrichment over the next 20 years.

Broadly Applicable Approaches for Addressing Non-point Source Pollution

Although *Clean Coastal Waters* advocates a nationwide effort to engage nutrient pollution, many of the recommended approaches are broadly applicable to other types of non-point source pollution. In all cases local and state expertise and resources, as well as the regulatory authority of those jurisdictions, will be essential components of effective solutions. Federal involvement is appropriate and essential when non-point source pollution spans multiple jurisdictions or threatens federally protected natural resources. There are six important roles the federal government is uniquely qualified to play in efforts of all scales:

1. provide data, information, and technical assistance to state and local coastal authorities
2. set nationwide goals
3. build on past experience and existing capabilities to expand monitoring
4. carry out meaningful periodic assessments
5. develop an understanding of what makes estuaries susceptible to nutrient pollution
6. shape and support research efforts that will lead to the development of more effective management solutions.

Accessible Data, Information, and Expertise

Better mechanisms for communicating information could lead to rapid improvement in management plans. Federal agencies must work together to create mechanisms to provide consistent and competent technical assistance from federal agencies to local decision makers and agency staff. Development of a national information clearinghouse on various non-point source pollutants, including a metadatabase of distributed information and data from all sources (not just federal sources) should be given high priority.

Expand Federal Leadership in the Setting and Obtaining of Nationwide Goals

Federal leadership is critical to resolving issues that span multiple jurisdictions, involve several sectors of the economy, threaten federally held resources, or fall under such existing federal regulations as the Clean Air Act. This leadership should be focused on:

- setting clear guidelines for loads.
- identifying, evaluating, and encouraging implementation of best management practices.
- evaluating existing efforts to determine common elements of success.

Expand Monitoring Capabilities

The United States lacks a coherent and consistent strategy to monitor the effects of non-point source pollution in coastal settings on a regular and uniform basis. One consequence is that the full economic and ecological impact of non-point source pollution is not currently known.

The best approach is probably to use a partnership of efforts by local, state, and federal agencies, as well as academic and research institutions where appropriate. Standard procedures, criteria, quality control, and data management and reporting are essential.

Estimates of contaminant inputs to estuaries are essential for management, and data on long-term trends on such inputs are invaluable for determining their sources. Throughout the United States the USGS is the best and primary source of data on nutrient inputs to estuaries from upstream rivers. The data it collects are invaluable, and continuation of this monitoring is essential. However, the USGS monitoring networks were not designed to assess nutrient inputs to coastal regions, and the EPA or other entities monitor other compounds of concern. Clean Coastal Waters recommended that USGS, EPA, and other groups work together to:

- implement monitoring framework, including the adoption of a tiered national monitoring program.
- include monitoring of the effectiveness of management projects and strategies, including best management practices.
- develop and implement regional or national monitoring and management strategies for atmospheric deposition of contaminants of concern.

Conduct Periodic Comprehensive Assessments of Coastal Environmental Quality

One key deficiency in the nation's approach to coastal water quality deficiencies is the lack of periodic, comprehensive analysis like the recent NOAA National Estuarine Eutrophication Assessment. In the future such efforts will be essential components of decision making because they provide information about how systems have changed, a key element in understanding whether policy and management choices have been effective in bringing about desired improvements. Thus, the nation needs to conduct periodic (every 10 years) assessments of the status of the nation's coastal waters (similar in scope to NOAA's National Estuarine Eutrophication Assessment). Such assessments should be sufficiently detailed to support regional watershed management decisions. Although derivative products may have value as elements of a "report card," the purpose of the assessment should be to provide adequate information to develop a detailed tactical picture for watershed management.

Develop a Susceptibility Classification Scheme

Estuaries vary in the degree they exchange seawater with the open ocean. This and other factors mean that lessons learned in one estuary may not readily transfer to another. Thus, a widely accepted estuarine classification scheme is a prerequisite for a systematic approach to extending lessons learned and management options from one estuary or affected coastal water body to others. A high priority should be the development of a national framework of "index sites," among which there would be an integration and coordination of environmental monitoring and research. The goal of work at these sites of more intensive study should be the development of predictive understanding of the response of similar coastal systems to various pollutants and efforts to reduce the amount of pollution introduced to these systems.

Expand and Target Atmospheric Research

Unlike some other types of non-point source pollution for which atmospheric sources are of lesser concern, atmospheric deposition of nitrogen and mercury can play a major role in coastal pollution. Local, state, and federal agencies and managers are just beginning to estimate and fully recognize the potential impacts of atmospheric deposition of these contaminants on coastal waters. In addition to expanded monitoring called for earlier, national programs should also direct more effort toward quantifying sources, fate, transport, and impacts (including economic) of atmospheric deposition of nitrogen, mercury, or other air born contaminants on watersheds and coastal receiving bodies. Furthermore, federal programs that fund basic research (such as EPA, NSF, and NOAA) should provide competitive grants for academic support of research into the role atmospheric deposition plays in non-point source pollution.

Priorities for Moving Forward

It's a familiar story: Inputs from such land-based sources as river and urban runoff are poorly understood, difficult to measure, and sparsely sampled, so estimates have a high degree of uncertainty. The estimates for various land-based, non-point sources of petroleum reported in *Oil in the Sea III* have a very large uncertainty (the range of values defined by the minimum and maximum estimates varies by three orders of magnitude). This uncertainty in the land-based estimate of petroleum pollution reflects a lack of fundamental information about the concentration of various compounds of concern derived from crude oil or refined products in rivers and streams. The calculation of the total load of any contaminant (e.g., mercury, nutrient, petroleum compound) delivered to a receiving body is a key component of developing goals for watershed management. The load carried by a river to a receiving water body is simply calculated by multiplying the flow rate of a river or stream by the concentration of a compound of concern. This simple calculation, however, requires data collected by stream gages and in situ water sampling. At present less than 10 percent of the rivers entering U.S. estuaries are monitored for nutrient concentration and even fewer streams are monitored for total petroleum hydrocarbons (TPH) or PAH.

Oil in the Sea III recommends that federal agencies work to develop and implement a system for monitoring input of petroleum to the marine environment from land-based sources via rivers and storm- and wastewater facilities. Just as with monitoring the nitrogen and phosphorus responsible for nutrient over-enrichment of coastal waters, it will be as important to measure the concentrations and flows in rivers and streams as it will be to understand total concentration in receiving waters. Veteran coastal zone managers and others responsible for local water quality monitoring programs will undoubtedly groan at the thought of trying to find additional funds to expand the patchwork of monitoring systems currently in place. Federal efforts fair little better. For example, each year the USGS fights to maintain funding for existing programs like National Stream Quality Accounting Network (NASQUAN) and the National Water Quality Assessment (NAWQA), yet few would argue that these efforts are adequate to the overall task.

As discussed earlier, *Clean Coastal Waters* recommended that USGS monitoring should be expanded with the objective of assessing nutrient inputs to estuaries and monitoring how these change over time. There is a clear need for a consistent backbone of information about stream flow and contaminant concentration, so that year-to-year variation in rainfall or other climatic factors can be considered when calculating average annual loads. (Variation in annual rainfall within a watershed can increase or decrease the annual load of nutrient delivered downstream to an estuary; differentiating such natural fluctuations is important when evaluating the impact of various management strategies.) This backbone of information, to be provided by the USGS, could then be expanded where possible by making fuller use of data collected by state and local agencies. Often these data are collected for other purposes (such as assuring drinking water quality), and their collection may be more transitory in nature. Yet these state and local data collection efforts can provide useful information on non-point source inputs to estuaries if appropriate collection and analysis techniques are employed and the data are made widely available. Such a system would benefit state and local entities by providing

needed resources and expertise, as well as regional data sets that local watershed managers could use for comparison. This would limit the need for a single state or local agency to “bootstrap” an understanding of which management approaches will be most effective.

Monitoring efforts must move beyond fecal coliform counts and dissolved oxygen or simple “oil and grease” measurements to routinely and consistently monitor for dissolved nitrogen and phosphorus, TPH, PAH, and other known compounds of concern. Such an expansion will require additional federal financial and technical resources, but local and state involvement will be critical to developing the support in Congress that such a nationwide effort will require.

State and local coastal zone managers understand the difficulties in improving coastal environmental quality. Increasingly they will need to expand existing partnerships with watershed managers, wastewater engineers, federal agencies, and academia to bring the necessary resources to bear on the problem. There are many barriers to effective interaction between federal, state, and local entities, and even among federal agencies. Although management of the various entities is working on many of these barriers, the federal funding process makes truly joint planning and implementation of multi-entity plans difficult. There are, however, some examples of success. The National Acid Precipitation Assessment Program (NAPAP) is often mentioned as worthy of emulation. More recently the Gulf Hypoxia Action Plan was developed through a wide-ranging dialogue and iterative process involving many federal, state, and local interests, including non-governmental groups and industry representatives. The Action Plan embodies many of the recommendations put forward in *Clean Coastal Waters*, and while it is too early to claim victory, all indications are that significant first steps have been taken to address nutrient pollution effects on the Gulf of Mexico. The type of national dialogue on local, state, and federal partnerships advocated in various National Academies reports and embodied in recent efforts to address non-point source pollution at the watershed scale will be an essential part of any effort to improve coastal environmental quality and ensure informed and effective coastal resource stewardship in the future.

I strongly recommend that the Commission articulate to Congress the pressing need for the kind of integrated, nationwide effort envisioned here. Furthermore, the Commission should encourage a re-thinking of how the Executive and Legislative Branches can work together to more effectively provide the tools and resources needed to tackle what is clearly a problem of nationwide scope and importance, non-point source pollution and its impact on coastal environmental quality.