Habitat Hotline Atlantic

Issues of Concern for Atlantic Marine Fish Habitat

September 2004, Volume XI, Number 3

NRC Report Outlines the Impacts of Oil on Marine Fish Habitat

In March 1989, the *Exxon Valdez* made history when it spilled 10.9 million gallons of crude oil into Prince William Sound, Alaska. It was, and still is, the largest oil spill in U.S. waters. Scientists estimated that large numbers of seabirds and marine mammals were killed, including 250,000 seabirds, 2,800 sea otters and 300 harbor seals. The whole country watched and waited to see what would happen. The most intensive shoreline cleanup effort ever performed was undertaken using large volumes of pressurized heated water to flush oil from the gravel beaches and rocky shores. (NRC 2003). Fourteen years later, we are still hearing about the impacts of that spill. A recent report noted that the oil has weathered or degraded slower than it was anticipated (Peterson *et. al.*, 2003). Much was learned from the *Exxon Valdez* spill, but one outcome was the need to better understand and address sublethal and long-term impacts.

While oil spills receive the most public attention, much more oil is discharged by human activities into the marine environment as small 'spills' from runoff and boats. By their nature, these small but numerous sources are difficult to address. Unlike a major spill where the oil release is concentrated in one area over a short period of time, oil from runoff and boats enters marine waters as slow chronic releases and is not as visible as the large spills. Much more information is needed to understand and address the impact from runoff and boats.

Figure 1. A thick band of pooled oil covers this cobble beach from an oil spill in Buzzards Bay, Massachusetts in April 2003. Source: the National Oceanic and Atmospheric Administration/U.S. Dept. of Commerce (www.darpa.gov).

When we think about an oil spill we're really talking about liquid petroleum which usually refers to crude oil but can include the products that are refined from it such as tar, kerosene, and gasoline. Petroleum is a concern in waters around the world because of its impacts on marine organisms and their habitats when released into marine waters as spills or chronic discharges.

Several major oil spills have been well studied and laboratory research has provided additional information about the impact of oil on marine organisms. In addition to the direct impacts to marine organisms (death of organisms, reduced fitness from sublethal effects), oil can impact marine habitats as well (Figure 1). In some cases, habitat impacts can take years to recover. This article focuses on the potential impacts to fish habitat from oil discharged into coastal marine waters associated with transportation activities. The information is summarized from the NRC report, **Oil in the Sea III, Inputs, Fates and Effects (2003)**.

Where is the oil in our marine environments coming from?

Over 60% of the petroleum in North American waters is released from natural processes, while the remainder is released as a result of human activities. Petroleum gets into marine waters primarily in four ways (one naturally and three resulting from human activities): natural seepage, petroleum extraction, petroleum transportation, and

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petroleum consumption (see Figure 2). Natural seeps, characterized by sporadic discharges at low rates, naturally release crude oil from geologic formations below the ocean floor to the overlying water column. In North America the largest seeps are located in the Gulf of Mexico and waters off of Southern California.

Petroleum extraction activities, such as accidental surface spills from platforms and blow outs, release the least amount of petroleum into ocean waters compared to other human activities. In North America, these releases are concentrated in production fields located in the Gulf of Mexico and coastal areas off California and Alaska.

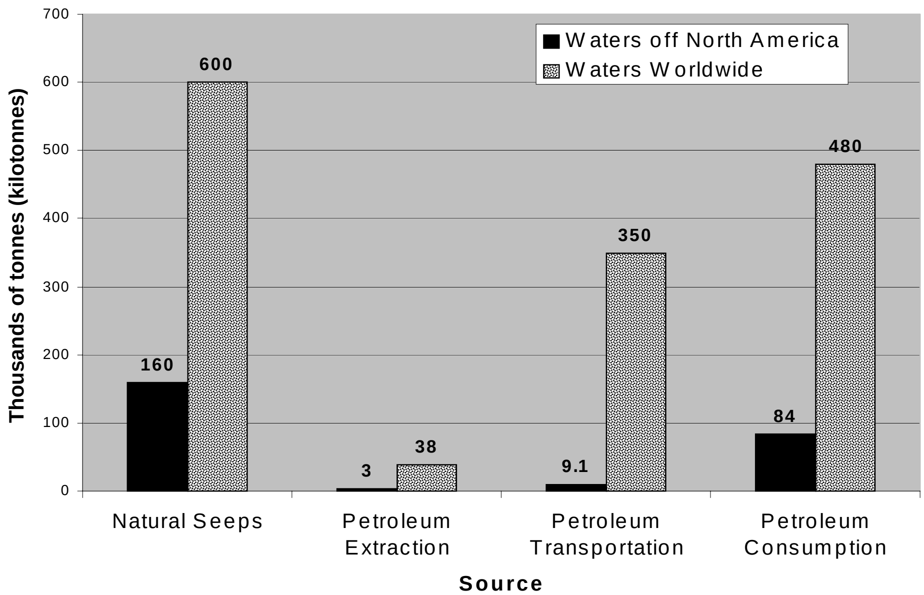

Figure 2. Average annual petroleum input (1990-1999) to marine waters. Data from NRC 2003.

Spills from petroleum transportation are the most widely publicized human releases, but they account for only about 9% of the total petroleum input from human activities. These releases can occur anywhere tanker vessels travel, or where pipelines and major petroleum handling facilities are found.

By far, the largest amount of petroleum released through human activities results from petroleum consumption. Cars, boats, paved urban areas, and 2-stoke engines all release petroleum. Even though individual releases are small, they are also frequent, and when combined they contribute nearly 85% of the total input from human activities. Although most of the petroleum consumption activities are land-based, rivers and storm and waste water streams carry the petroleum to marine environments such as estuaries and bays.

Petroleum discharges resulting from tank vessel spills, two-stroke engines, and land-based sources are of particular concern as these discharges are often released directly into ecologically sensitive coastal areas, often the same areas that are important nursery and spawning habitat for marine and anadromous fish. The impact of a petroleum discharge depends on several factors including the rate of release, nature of release (toxicity), and the local physical and biological ecosystem exposed. The toxicity of the petroleum depends on the compounds it contains, so even small releases can be lethal and affect a population.

How is oil impacting marine fish habitat when released into the environment?

While the majority of oil in the marine environment resulting from human activities is not from large oil spills, large oil spills can have large impacts on marine life and marine habitats, for example immediately after the spill and, as some studies are indicating, years after the spill. To determine the impact of an oil release to marine fish habitat, there are a number of factors to consider including specific characteristics of the oil and of the environment. In low energy environments with calm seas or in protected coves with little wave action, discharged oil can produce large surface slicks that can reach shorelines. However, if the oil is discharged in higher energy environments (rough seas or areas of high wave action) the discharged oil can be transported down through the water column and eventually reach the bottom sediments. For example, during a storm in January 1996, 828,000 gallons of home heating oil was spilled from the tank barge *North Cape* in Rhode Island's nearshore coastal waters. Although it was a light oil, the high energy and wave conditions associated with the storm caused the oil to be mixed throughout the water column. As a result, very little oil reached the shoreline. Instead, a plume of dissolved oil moved offshore impacting benthic resources to the extent that an estimated 9 million lobsters (mostly juveniles) and 19.4 million surf clams died as a result of the spill.

In addition, in near shore areas, the oil can get trapped—either in bottom sediments (coarse pebbles and gravel) or by plants (eelgrass beds and algal holdfasts). Some types of oil evaporate quickly, and thus do not have as much potential for getting trapped. However, this type of oil is very toxic, so it can have a lethal impact in a short time period. Other types of oil that are heavier don't evaporate and they are especially susceptible to getting trapped.

Subtidal Vegetation

Most of what is known about the affects of oil on submerged aquatic vegetation (SAV), including eelgrass (*Zostera marina*), has resulted from particular oil spills. During the first year of an oil spill, scientists have found that eelgrass meadows

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generally die-off when they are directly exposed to oil in the tidal zone. Whereas in the subtidal zone, damage is limited to dying leaves for eelgrass exposed to oil. Results differ with regard to the long-term effects of oil on eelgrass. In the case of oil spills in the Persian Gulf, there was no difference found between oiled and non-oiled seagrass meadows after one year (Kenworthy et al., 1993 in NRC 2003). In the case of the *Exxon Valdez* spill, differences in mean shoot density and flowering shoots were detected between oiled and non-oiled areas after five years, although biomass was the same (Dean et al., 1998 in NRC 2003).

Subtidal kelps do not seem to be particularly vulnerable to oil. Kelps located near shallow-water natural seeps did not accumulate very high concentrations of petroleum hydrocarbons. However, although the kelp plant may not accumulate petroleum products in its tissues, kelp holdfasts can trap and retain oil and oil residues for as much as five years after a spill, which is what happened with the diesel oil spill at Macquarie Island in the sub-Antarctic.

Mangroves

Scientists have found that oil spills can cause severe and long-term damage to salt marshes and mangroves. Furthermore, the effects of oiling are greater when the oil coats the vegetation or is trapped in the sediments underneath the vegetation. Oiling effects on mangroves have been documented and include death, defoliation, genetic and other damage. The damage to mangroves varies depending on the amount and toxicity of the oil spilled and other factors such tidal height and range, time of year, and oil residence time. In particular, oil can disrupt gas exchange when above ground roots are covered with oil and can't supply oxygen to below ground roots. Mangrove root systems can take up oil and transport it to leaves, where it disrupts vital processes. Oil can affect root membranes causing deadly amounts of salt to accumulate in mangrove tissues. Large numbers of mangrove trees died after the *Galeta* oil spill in Panama in 1986. Sediments became unstable after the dead trees rotted and fell. The sediment and remaining oil were eroded and transported to nearby seagrass and coral habitats that had not been previously contaminated from the spill.

Salt Marshes

Several factors determine the impact of oil on salt marsh vegetation including the type and amount of oil, depth of penetration into sediments, amount of plant coverage, the season, and cleanup actions. For example, lighter and more refined oils are very toxic to smooth cordgrass (*Spartina alterniflora*). Heavier oils including crude oil have little toxic effect on the plants unless oil gets trapped in sediments and provides continuous exposure to the plant roots. If oil covers the entire plant surface, the aboveground part of the smooth cordgrass dies, but if the sediments aren't heavily contaminated, regrowth from the roots can occur. In cases where high levels of heavy oil accumulate in sediments or remain in the marsh for long periods, plant recovery is diminished and massive die-off of smooth cordgrass can occur. Studies have found that the recovery for oiled marshes ranges from a few weeks to greater than 20 years. Longer recovery times were related to factors such as cooler northern climates, high organic soils, sheltered locations, heavy oiling, spills of heavier fuel oils, and disturbance during spill response and cleanup. Much shorter recovery times were related to warm climates, more mineral-rich soils, light to moderate oiling, spills of light to medium crude oils, and less intrusive cleanup methods.

Intertidal Shores

Several factors such as shoreline geomorphology, wave action, tidal energy, weather conditions, time of year, nature of the oil, thickness and surface area of the slick determine the impact to intertidal shores, including both rocky intertidal shores and areas of softer sediments like bays and harbors. Intertidal areas are particularly vulnerable to damage from oil spills. If the shoreline is a higher energy exposed coast without a lot of low energy interstices, then oil will be washed away fairly quickly and recovery will happen more quickly. However, recovery is much slower in lower energy shorelines areas that are sheltered and/or have substantial interstices. Here, oil can be incorporated into the substrate and persist for years and even decades. The most sensitive organisms to oil in the intertidal areas are crustaceans (such as amphipods), a common food of many larval and juvenile fish.

Subtidal Areas

Oil can also reach the bottom sediments in subtidal areas. Surface oil can weather and sink, or it can attach to particulate matter in the water column and sink. Oil can also be transported from nearby oiled shorelines. However, spills don't always have adverse effects in subtidal habitat. One study found no differences between tar-affected and non-affected benthic communities after an oil spill in Italy (Guidetti et al., 2000 in NRC 2003). Oil from the *Exxon Valdez* spill was not discernable below 40 meters in most areas of Prince William Sound and was not found in measurable quantities below 100 meters (Feder and Blanchard, 1998 in NRC 2003). During a crude oil spill off the Shetland Islands, an estimated 35% of the oil was transported to the seabed during hurricane strength winds and deposited in bottom sediments in water depths ranging from 2 to 100 meters. As a result, it provided long-term exposure to benthic fisheries; the burrowing Norway lobster was contaminated for more than 5 years (Kingston, 1999 in NRC 2003). Crustaceans, including amphipods and lobsters, appear to be the most sensitive organisms to oil in subtidal areas.

Clean-up, Compensation, and Restoration

Once the oil is discharged and in the water, the next issue is how to deal with it. Catastrophic discharges are treated very differently than chronic low-level discharges. When there is a major spill, response can be quick and efficient, however, sometimes the cause of the spill such as bad weather, can prevent quick clean-up. Shoreline cleanup is another issue. Currently, there are

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two approaches to shoreline cleanup, aggressive cleanup that uses high pressure water hoses to remove the oil and passive cleanup that lets the oil degrade naturally. Aggressive cleanup physically impacts marine animals and plants and it can take several years for areas to recover from the disturbance caused by the cleaning activities. But experience shows that aggressive cleaning can successfully remove the oil from the shoreline. Although letting the oil degrade naturally does not physically disturb the marine plants and animals, it can take much longer for a shoreline community to recover from the oil and its degraded products. As mentioned previously, oil can be stored in sediments for years, impacting plants and animals that are exposed to it. More research is needed to determine the impact of sequestered oil on benthic organisms.

The *Exxon Valdez* spill is also noted for providing the impetus for passage of the Oil Pollution Prevention Act of 1990 (OPA) as well as sparking research into assessing the impact of oil spills on marine organisms and their habitat. The spill also marked a major agreement in which Exxon settled a claim and provided $900 million for natural resource damages. The OPA is the primary federal legislation addressing oil spills to the nation's waterways and coasts. The OPA defines the responsible parties who must pay for oil removal and monitoring efforts; allows for recovery of economic losses, preempts the Limitation of Liability Act that limits the recoverable damages for vessels, and establishes the Oil Spill Liability Trust Fund to provide funds when responsible parties can't be identified or can't pay for costs associated with clean-up, monitoring and mitigation. For example, the U.S. Department of Commerce's National Ocean and Atmospheric Administration (NOAA) and the Florida Department of Environmental Protection received $2.2 million from the federal Oil Spill Liability Trust Fund to restore beaches and marine habitat damaged by an oil spill near Fort Lauderdale, Florida in August 2000, because those responsible for the oil spill were never discovered.

How are cleanup, compensation and restoration working under OPA? In 1990, the Damage Assessment and Restoration Program (DARP) was established within NOAA to protect and restore coastal and marine natural resources in the United States by promoting cooperation among trustee agencies and parties responsible for damaging these resources. DARP collaborates with other federal, state, and tribal natural resource trustees to (1) assess and quantify injuries to natural resources (caused by spills and chronic releases of hazardous materials or oil), (2) seek damage for those injuries, (3) implement restoration actions, and (4) monitor restoration progress. Over $300 million has been collected for restoration and more than thirty cases have been settled and moved into the restoration phase since the program began. For example, in June 1989 a quarter of a million gallons of home heating oil was spilled off Newport, Rhode Island from the oil tanker *World Prodigy*. The spill hit during a peak spawning period in Narragansett Bay. Eggs and larvae of fish and shellfish—lobsters, quahogs (hard clams), tautog and others—were exposed to the oil, as they floated at the surface. Damage to natural resources was assessed and a settlement of $567,000 was negotiated for restoring the natural resources harmed by the spill. Restoration efforts were designed and undertaken to improve the health of Narragansett Bay by enhancing habitat for lobsters, quahogs, and estuarine finfish. Projects included eelgrass bed restoration, lobster reef restoration, quahog bed restoration and salt marsh restoration.

Prevention

The best way to protect marine organisms and their habitats from the impacts of oil discharges is to implement measures to prevent and minimize discharges from all types of human activities. Since 1981, several regulations have been implemented to reduce oil inputs into the oceans. OPA and MARPOL (the 1978 Protocol of the International Convention for the Prevention of Pollution from Ships) require double-hulls in all new tankers and establish a phase-out schedule for single–hull tankers to prevent oil spills.

Other actions are being undertaken to reduce discharges of oil from land-based sources via runoff such as the creation of buffer zones. In addition, the U.S. Environmental Protection Agency (EPA) and 8 northeastern states have agreed to a voluntary initiative to promote the sale of low-polluting outboard motors and personal watercraft engines. These engines emit 75 percent less air pollution, burn 35 to 50 percent less fuel, use up to 50 percent less oil, and discharge significantly less gasoline directly into the water than conventional engines. EPA regulations require that by 2006, all manufacturers' average emissions for new outboard motors and personal watercraft engines meet low-pollution standards.

Clearly, there is much that we need to learn about long-term and sublethal impacts of petroleum in marine waters and more that can be done to protect these important habitats.

Fishermen and Boaters can help protect fish habitat by:

✔ Recycling used oil and filters, batteries, and antifreeze.

✔ Using oil absorbent materials in your bilge and for spill cleanup. Refraining from using detergents and bilge cleaners; never pumping them overboard.

✔ Doing repairs and painting away from the water whenever possible.

✔ Reporting oil spills to the proper authorities.

✔ Being careful when refueling; catching any overflow with petroleum absorbent materials.

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Coast Guard Establishes Mandatory Ballast Water Management Program

The U.S. Coast Guard published regulations on July 28, 2004 establishing a national mandatory ballast water management program for all vessels equipped with ballast water tanks that enter or operate within U.S. waters. These regulations also require vessels to maintain a ballast water management plan that is specific for that vessel and allows any master or appropriate official to understand and execute the ballast water management strategy for that vessel. These regulations increase the Coast Guard's ability to prevent the introduction of non-indigenous species via ballast water as required by the Nonindigenous Aquatic Nuisance Prevention and Control Act and the National Invasive Species Act.

"The establishment of a nationwide mandatory ballast water management program is a major step by the Coast Guard in protecting our environment, food supply, economy, health and overall biodiversity from the impacts of non-indigenous species," said Capt. David Scott, chief of the Coast Guard's office of operating and environmental standards.

"Studies have shown that ballast water is a major pathway for the introduction of non-native species into U.S. coastal waters," said Lori Williams, executive director of the National Invasive Species Council. NISC is a Cabinet-level group composed of the secretaries or directors of 12 Departments and Agencies charged with providing leadership to all federal programs on invasive species issues. "The Coast Guard is an important member of NISC, and we congratulate all involved with the development of this regulation which should help aid in the prevention of future introductions and spread of potentially invasive species."

The U.S. Commission on Ocean Policy recently stated support for a national ballast water management program in its preliminary report. The Commission calls for establishing a national plan for early detection of invasive species and a system for prompt notification and rapid response. (The June 2004 issue of Habitat Hotline Atlantic summarizes recommendations from the U.S. Commission on Ocean Policy and the The Pew Oceans Commission). Future Coast Guard regulations may outline specific ballast water discharge standards, and approval procedures for ballast water treatment systems.

More information on the Coast Guard's ballast water management program can be found at: http://www.uscg.mil/hq/g-m/mso/ans.htm. The final rule can be found at: http://dms.dot.gov. In this web site, proceed to simple search, and under docket number, enter 14273. The U.S. Commission on Ocean Policy's Final Report can be found at www.oceancommission.gov.

Sources: July 28, 2004 U.S. Coast Guard Press Release and www.oceancommission.gov.

New Coral Reef Web Site

In August, the National Oceanic and Atmospheric Administration (NOAA) announced the launch of a new Web site featuring information and products regarding the nation's coral reefs. Created by NOAA's Coral Reef Conservation Program, the Web site supports the program's mission to provide effective management and sound science to preserve, sustain and restore valuable coral reef ecosystems.

The Web site, available at **http://www.coralreef.noaa.gov**, provides links to:

▶ **Search for NOAA Coral Reef Data, Information and Products**: This page directs users to NOAA's Coral Reef Information System, launched in 2002, to consolidate access to NOAA's coral reef information and data products.

▶ **Funding Opportunities**: This page provides links to several grant programs supported by NOAA that fund coral reef conservation activities. Detailed information on the NOAA Coral Reef Conservation Grant Program is provided as well. In 2004 this grant program expects to award over $5.5 million for activities supporting coral reef science and management.

▶ **News and Highlights:** This section includes highlights from NOAA Coral Reef News, the Coral Reef Conservation Program's monthly electronic newsletter. An archive of past news items is also available.

▶ **Outreach and Education:** This new section includes resources for students interested in learning more about reefs, as well as lesson plans and other useful information for educators.

▶ **About the Program:** This page provides background information on the Coral Reef Conservation Program. Among the new resources available on the site are fact sheets that contain information on how healthy coral reefs provide valuable services such as income, coastal protection and habitat, medicines and recreation.

Source: NOAA press release 2004-074, 8/5/04

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