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Ocean Issue Brief

Oil and Oil Spill Impacts

The *Deepwater Horizon* blowout in the Gulf of Mexico underscores the continuing threats facing many of the world's marine environments and, in particular, to the more than one billion coastal people worldwide whose daily living requirements are inextricably linked to clean, fully productive and undamaged coastal and nearshore environments. As the world's human population is rapidly growing and lesser-developed nations are becoming more industrialized, the demand for energy is increasing. Oil is currently the dominant energy fuel—approximately 86 million barrels per day are used (DOE/EIA, 2009)—and is expected to remain so during the next several decades (NRC, 2003).

Oil is toxic to virtually all organisms. The toxic effect depends on a number of factors, such as the composition and concentration of the oil, the exposure route and length of exposure, and the sensitivity of the species affected. A species may have a high individual sensitivity, yet population impacts may be low if, for example, the species is widely dispersed and has a high reproductive capacity. Impacts of oil spills can vary greatly depending on the amount and type of oil, spill timing and location, response effort and weather conditions.

Oil spills need to be viewed in the context of an additional stress on the many marine and coastal ecosystems, communities and populations that are already chronically depleted or weakened by human activities, including climate change. Oil spills have the potential to impart further long-term impacts to the biodiversity and productivity of those resources.

The main source of oil in the marine environment—almost half—is natural oil seeps from below the sea floor. Runoff from land and other sources from human uses account for nearly 40 percent while spills and intentional discharges from shipping make up 12 percent. The remainder, some 3 percent, is a result of spills and blowouts from offshore platforms (NAS, 2003).

The National Academy of Sciences (2003) noted that, "Nearly 85 percent of the 29 million gallons of petroleum that enter North American ocean waters each year as a result of human activities comes from land-based runoff, polluted rivers, airplanes, and small boats and jet skis, while less than 8 percent comes from tanker or pipeline spills."

Human Health Impacts

Cleanup personnel, who often include volunteers, are the most vulnerable to the acute effects associated with oil spills. Physical impacts are found mainly in uninformed and unprotected workers and include headaches, migraines, eye, throat and skin irritation, dermatitis, respiratory distress, nausea, vomiting and dizziness (Aguilera et al., 2010). Follow-up health assessments of major oil spills typically show acute effects to be reversible and to decline over time (Aguilera et al., 2010). DNA damage, alterations in endocrine status and significant increases in levels of heavy metals in blood of exposed workers have also been reported (Laffon et al., 2006; Pérez-Cadahía et al., 2008).

Psychological, psychiatric and social effects of oil spills can be severe. Workers from native Alaskan communities involved with cleanups after the *Exxon Valdez* showed higher prevalence of generalized anxiety disorder, post-traumatic stress disorder and depressive symptoms (Palinkas et al., 1993) and high levels of social disruption (Palinkas et al., 2004). Psycho-pathological symptoms such as raised anxiety, depression and decline in mental health have been reported for cleanup workers in other major oil spills (Lyons et al., 1999; Gallacher et al., 2007), though affected occupational groups (e.g., fishermen) have been shown to suffer disproportionally (Sabucedo et al., in press).

The social and psychological impact on local communities associated with an ongoing oil spill event such as the 2010 *Deepwater Horizon* blowout in the northern Gulf of Mexico appears to have little precedent. Experience with past oil spills suggests that strong community support, active participation in addressing the problem, and immediate, sufficient economic aid can serve to mitigate part of the psychological damage (Sabucedo et al., in press).

Wildlife Impacts

Marine birds

Marine birds are the wildlife species most seriously affected by oil in marine environments. Direct mortalities from large oil spills can be dramatic: 40,000 to 100,000 from the *Tricolor* sinking (Camphuysen and Leopold, 2004); between 100,000 to 300,000 due to the sinking of the *Prestige* (Castege et al., 2007); between 80,000 and 150,000 from the *Erika* grounding (Cadiou, B. et al., 2004); and 250,000 estimated from the *Exxon Valdez* (Piatt and Ford, 1996). Of particular concern is the occurrence of oil spills in regions supporting threatened species. For example, a series of oil spills off of South Africa have mainly affected African penguins and Cape gannets, both of which are classified as vulnerable to extinction (Woolfaart et al., 2009).

Oil spills can also impact seabirds indirectly by reducing the availability of key food sources (*Velando* et al., 2005), leading to declines in reproductive performance and poor physical condition—and likely reduced survival—of chicks. For some species, the time for population recovery after a spill may be substantial: some 10 years after the *Exxon Valdez* a wide variety of bird species showed little to no recovery, while others showed evidence of increasing impacts (Lance et al., 2001).

However, chronic marine oil pollution—typically from illegal discharges from ships—may be more important to long-term seabird population stability than the occasional larger spill. An average of between 270,000 and 360,000 common and thick-billed murres and dovekies off of southeastern Newfoundland were estimated to have died from oil exposure annually between 1998 and 2001 (Wiese and Robertson, 2004; Wilhelm et al., 2009), though significant declines in recovered oil birds during the past 30 years in the region is tentatively suggestive of reduced oil pollution, likely a result of increased aerial surveillance (Wilhelm et al., 2009).

Marine mammals

A variety of impacts of oil and oil spills on marine mammals have been documented, though surprisingly few large mortality events have occurred. A ruptured storage tank discharged more than 4,750 gallons (18,000 liters) of Bunker C oil into the Gulf of St. Lawrence in 1969 and fouled sea ice at the same time as harp seals began pupping; some 10,000 to 15,000 seals were affected and most were so heavily coated with oil as to be almost unrecognizable (Sergeant, 1991). Total mortality is not known, but the event highlights the potential impacts of oil spills on wildlife requiring sea ice. An estimated 300 harbor seals and 1,000 to 2,800 sea otters died during the days after the *Exxon Valdez* spill (Peterson et al., 2003), while two orca populations—one resident and one transient—suffered losses of 33 and 41 percent, respectively, in the year following (Matkin et al., 2008).

Particularly vulnerable to oil spills will be those marine mammal populations that already suffer from low numbers and face a range of additional threats. A major feeding ground for endangered Western Pacific gray whales—which number approximately 100 animals—is also the site of vast oil reserves and intensive Russian oil exploration and drilling (Webster 2003). A major oil spill here or in the northern Bering Sea in Alaskan waters, the summer feeding grounds for the Eastern Pacific gray whale, could severely impact the species' major food source of benthic amphipods. Benthic amphipods are among the first marine animals killed and the slowest to recover from oil contamination (Spies, 1987).

Sea turtles

Oil clearly has the potential to kill or harm sea turtles, yet few reports have documented such impacts. This could be due to the low probability of observing and recovering oiled turtles (Yender and Mearns, 2003). Regardless, sea turtles are vulnerable to oiling effects at all life stages and many important sea turtle habitats overlap with exploited oil fields and shipping lanes and hubs (Milton et al., 2003).

Impacts on Coastal Environments

Mangroves

Mangroves are considered the tropical habitat most sensitive to oil spills (Shigenaka, 2002), with scientists typically using terms such as "catastrophic" and "devastating" to describe its effects (Burns et al., 1993; Dodge et al., 1995). One year and a half after the *Galeta* spill in Panama, dead mangroves were found along some 17 miles of coastline (Jackson et al., 1989) while surviving forests showed continued deterioration six years after the event (Burns et al., 1993). If they are not killed outright by a spill, then sublethal exposure eventually may do so, as oil weakens mangroves, making them highly susceptible to mortality from natural stresses such as cold temperatures and increased salinity, which they would normally survive (Snedaker et al., 1997).

Coral and coral reefs

Oil exposure can kill coral or, in the case of sublethal effects, such as reduced fertility and reproductive success, among a host of other impacts (Loya and Rinkevich, 1980). Oil spills have had devastating effects on some reefs (Haapkylä et al., 2007). The 1986 *Galeta* spill off the coast of Panama, for example, caused extensive mortality (Jackson et al., 1989) with no recovery of most formerly dominant coral species more than five years later (Guzmán and Holst, 1993). Yet in other events, such as the massive release of oil into the Persian Gulf during the Gulf War, only minor impacts on coral reefs appear to have occurred (Downing and Roberts, 1993).

As nearly all reefs globally are stressed from a range of human activities any additional stress, such as from oil or dispersant, particularly on colonies that are recovering from bleaching, are likely to have a greater impact (Mumby, 1999).

Other coastal habitats

Short-term impacts of oil on beaches after the *Prestige* spill included a decline in total species richness of up to 66.7 percent, though the affected dry sand level was more damaged by cleaning than by the oil itself (de la Huz et al., 2005). Two decades after the *Exxon Valdez* spill, high amounts of toxic aromatic hydrocarbons still persist in the subsurface of gravel beaches in Prince William Sound (Li and Boufadel, 2010). And four decades after the *Florida* barge fuel oil spill in Buzzards Bay, Mass., oil still persists in salt marsh sediment where it affects fiddler crabs and ribbed mussels while the ongoing loss of smooth cordgrass has led to coastal erosion (Culbertson et al., 2007, 2008).

Arctic Oil Spills

A warming climate is dramatically raising the possibility of oil spills in the Arctic, as melting sea ice attracts more shipping and energy exploration. As well, increasing global demand for fossil fuels and the fact that more than 5 percent of the world's known oil reserves—some 215,000 million barrels—are in the Arctic (AMAP, 2007) is further propelling oil and gas development in the region. Drilling is expected to increase in Arctic Alaska and may begin in Canada's portion of the Beaufort Sea. Iceland and Greenland are in exploratory phases. Norway is set to begin natural gas production in the Barents Sea, while Russia has already begun oil production and has more projects on the horizon (AMAP, 2007).

Even under ideal conditions only 30 percent of spilled oil can be recovered (NRC, 1999). But that amount is expected to be much lower in Arctic regions, where severe winter weather, few locations from which to launch recovery efforts, no effective means of containing and cleaning up oil spills in broken sea ice and lack of prior technical experience increase the probabilities of a catastrophic event (NERI, 2002). Meanwhile, the U.S. oil spill research program has not been updated since 1997 and is being heavily criticized by scientists and policymakers for its low level of funding (Torrice, 2009). Furthermore, there are few systems to monitor and control the movement of ships in ice-covered waters; no uniform, international standards for ice navigators; and no specifically tailored and mandatory international environmental standards for vessels operating in Arctic waters (Arctic Council, 2009).

References

Aguilera, F. et al. 2010. Review on the effects of exposure to spilled oils on human health. *Journal of Applied Toxicology* 30(4): 291–301.

AMAP (Arctic Monitoring and Assessment Programme). 2007. *Oil and Gas 2007.* Arctic Monitoring and Assessment Programme, Oslo.

Arctic Council. 2009. *Arctic Marine Shipping Assessment 2009 Report.* Arctic Council. 194 p.

Burns, K.A. et al. 1993. How many years until mangrove ecosystems recover from catastrophic spills? *Marine Pollution Bulletin 26*(5): 239–248.

Burns, K.A. et al. 1994. The Galeta oil spill. II. Unexpected persistence of oil trapped in mangrove sediments. *Estuarine, Coastal and Shelf Science* 38(4): 349–364.

Cadiou, B. et al. 2004. Ecological impact of the "Erika" oil spill: Determination of the geographic origin of the affected common guillemots. *Aquatic Living Resources* 17: 369–377.

Camphuysen, C.J. and Leopold, M.F. 2004. The *Tricolor* oil spill: characteristics of seabirds found oiled in The Netherlands. *Atlantic Seabirds* 6(3): 109–128.

Carrasco, L. et al. 2001. Systemic aspergillosis in an oiled Magellanic penguin (*Spheniscus magellanicus*). *Journal of Veterinary Medicine Series B* 48(7): 551–554.

Castege, I. et al. 2007. Estimating actual seabirds mortality at sea and relationship with oil spills: lesson from the "Prestige" oil spill in Aquitaine (France). *Ardeola* 54(2): 289–307.

Couillard, C.M. et al. 2005. Effect of dispersant on the composition of the water-accommodated fraction of crude oil and its toxicity to larval marine fish. *Environmental Toxicology and Chemistry* 24(6): 1496–1504.

Culbertson, J.B. et al. 2007. Long-term biological effects of petroleum residues on fiddler crabs in salt marshes. *Marine Pollution Bulletin* 54(7): 955–962.

Culbertson, J.B. et al. 2008. Long-term consequences of residual petroleum on salt marsh grass. *Journal of Applied Ecology* 45(4): 1284–1292.

de la Huz et al. 2005. Biological impacts of oil pollution and cleaning in the intertidal zone of exposed sandy beaches: Preliminary study of the "Prestige" oil spill. *Estuarine, Coastal and Shelf Science* 65(1-2): 19–29.

Dodge, R.E et al. 1995. The effects of oil and chemically dispersed oil in tropical ecosystems: 10 years of monitoring experimental sites. *MSRC Technical Report Series* 95–104. Marine Spill Response Corporation, Washington, D.C. 82 pp, appendices.

DOE/EIA. 2009. *Annual Energy Review – 2008*. DOE/EIA 0384(2008). Energy Information Agency, Washington, D.C. 407 pp.

Downing, N. and Roberts, C.M. 1993. Has the Gulf War affected coral reefs of the northwestern Gulf? *Marine Pollution Bulletin* 27: 149–156.

Gallacher, J. et al. 2007. Symptomathology attributable to psychological exposure to a chemical incident: a natural experiment. *Journal of Epidemiology and Community Health* 61(6): 506–512.

Guzmán, H.M. and Holst, I. 1993. Effects of chronic oil-sediment pollution on the reproduction of the Caribbean reef coral *Siderastrea siderea. Marine Pollution Bulletin* 26(5): 276–282.

Haapkylä, J. et al. 2007. Oil pollution on coral reefs: a review of the state of knowledge and management needs. *Life and Environment* 57(1/2): 91–107.

Jackson, J.B.C. et al. 1989. Ecological effects of a major oil spill on Panamanian coastal marine communities. *Science* 243(4887): 37–44.

Laffon, B. et al. 2006. Genotoxicity associated to exposure to *Prestige* oil during autopsies and cleaning of oil-contaminated birds. *Food and Chemical Toxicology* 44(10): 1714–1723.

Lance, B.K. et al. 2001. An evaluation of marine bird population trends following the Exxon Valdez oil spill, Prince William Sound, Alaska. *Marine Pollution Bulletin* 42(4): 298–309.

Li, H. and Boufadel, M.C. 2010. Long-term persistence of oil from the *Exxon Valdez* spill in two-layer beaches. *Nature Geoscience* 3(2): 96–99.

Loya, Y. and Rinkevich, B. 1980. Effects of oil pollution on coral reef communities. *Marine Ecology Progress Series* 3:167–180.

Lyons, R. et al. 1999. Acute health effects of the *Sea Empress* oil spill. *Journal of Epidemiology and Community Health* 53(5): 306–310.

Matkin, C.O. et al. 2008. Ongoing population-level impacts on killer whales *Orcinus orca* following the 'Exxon Valdez' oil spill in Prince William Sound, Alaska. *Marine Ecology Progress Series* 356: 269–281.

Milton, S. et al. 2003. Oil toxicity and impacts on sea turtles. In *Oil and Sea Turtles: Biology, Planning, and Response*, pp. 35–47. NOAA's National Ocean Service, Office of Response and Restoration, Seattle, WA.

Mumby, P.J. 1999. Bleaching and hurricane disturbances to populations of coral recruits in Belize. *Marine Ecological Progress Series* 190: 27–35.

NERI (National Environmental Research Institute). 2002. Potential environmental impacts of oil spills in Greenland. An assessment of information status and research needs. *NERI Technical Report* 415. NERI, Denmark. 118 pp.

NRC (National Research Council. 2003. *Oil in the Sea III*: *Inputs, Fates, and Effects*. National Academies Press, Washington, D.C. 265 pp.

Palinkas, L.A. *et al.* 1993. Community patterns of psychiatric-disorders after the *Exxon-Valdez* oil-spill. *American Journal of Psychiatry* 150(10): 1517–1523.

Palinkas, L.A. *et al.* 2004. Ethnic differences in symptoms of post-traumatic stress after the *Exxon Valdez* oil spill. *Prehospital and Disaster Medicine* 19(1): 102–112.

Pérez-Cadahía, B. *et al.* 2008. Relationship between blood concentrations of heavy metals and cytogenetic and endocrine parameters among subjects involved in cleaning coastal areas affected by the 'Prestige'tanker oil spill. *Chemosphere* 71(3): 447–455.

Peterson, C.H. *et al.* 2003. Long-term ecosystem response to the *Exxon Valdez* oil spill. *Science* 302(5653): 302–306.

Piatt, J.F. and Ford, R.G. 1996. How many seabirds were killed by the *Exxon Valdez* Oil Spill? *American Fisheries Society Symposium* 18: 712–719.

Sabucedo, J.M. *et al.* In press. Symptomatic profile and health-related quality of life of persons affected by the *Prestige* catastrophe. *Disasters* 10.1111/j.1467–7717.2010.01170.x.

Sergeant, D. 1991. Harp Seals, Man and Ice. *Canadian Special Publication of Fisheries and Aquatic Sciences* 114. 153 pp.

Shigenaka, G. 2002. Oil toxicity. In *Oil Spills in Mangroves,* pp. 23–35. Office of Response and Restoration, NOAA Ocean Service, NOAA, Seattle, Washington.

Snedaker, S.C. *et al.* 1997. Oil spills and mangroves: an overview. In: *Managing Oil Spills in Mangrove Ecosystems: Effects, Remediation, Restoration, and Modeling,* pp. 1–18. OCS Study MMS 97-0003. Minerals Management Service, Gulf of Mexico OCS Region, New Orleans.

Spies, R.B. 1987. The biological effects of petroleum hydrocarbons in the sea: assessments from the field and microcosms. In *Longterm Environmental Effects of Offshore Oil and Gas Development*, pp. 411–467 Elsevier, London.

Torrice, M. 2009. Science lags on saving the Arctic from oil spills. *Science* 325(5946): 1335.

Velando, A. *et al.* 2005. Short-term indirect effects of the 'Prestige' oil spill on European shags: changes in availability of prey. *Marine Ecology Progress Series* 302: 263–274.

Webster, P. 2003. Will oil spell trouble for Western Pacific gray whales? *Science* 300(5624): 1365.

Wiese, F.K. and Robertson, G.J. 2004. Assessing seabird mortality from chronic oil discharges at sea. *Journal of Wildlife Management* 68(3): 627–638.

Wilhelm, S.I. *et al.* 2009. Re-evaluating the use of beached bird oiling rates to assess long-term trends in chronic oil pollution. *Marine Pollution Bulletin* 58(2): 249–255.

Woolfaart, A.C. *et al.* 2009. Review of the rescue, rehabilitation and restoration of oiled seabirds in South Africa, especially African penguins *Spheniscus demersus* and Cape gannets *Morus capensis*, 1983-2005. *African Journal of Marine Science* 31(1): 31–54.

Yender, R.A. and Mearns, A.J. 2003. Case studies of spills that threaten sea turtles. In *Oil and Sea Turtles: Biology, Planning, and Response,* pp. 69–85. NOAA's National Ocean Service, Office of Response and Restoration, Seattle, WA.

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