OS-10-2

ENVIRONMENTAL HARM ISSUES REGARDING A VOLUMETRIC REPORTING TRIGGER

I. INTRODUCTION

In 1982, Chevron USA, Inc. requested that EPA modify its oil discharge reporting regulation (40 CFR Part 110) to exclude spills of less than one barrel (42 gallons), thus replacing the sheen test with a volumetric trigger for reporting. Chevron suggested that excluding small spills from reporting requirements would reduce administrative and operational costs of complying with the current reporting level, without posing significant risks to the environment or public health. In the preamble to the proposed discharge of oil regulation, published on March 11, 1985 (50 Federal Register 9776), EPA solicited information on the effects of volumetric alternatives to the sheen test.

Chevron's argument for a volumetric reporting trigger was based on both economic and environmental considerations. Chevron asserted that evidence collected since 1970 now proves that oil spills of under 42 gallons "rarely, if ever, cause environmental damage." Environmental implications of a volumetric trigger are discussed in this Issues Paper. Chevron's cost and implementation arguments for a volumetric trigger are discussed in a separate Issues Paper.

EPA received a total of 35 comment letters on the Chevron request in response to its solicitation in the Federal Register. Many of the comments received pertain to environmental issues regarding a volumetric trigger and have been carefully reviewed for the purposes of preparing this discussion.

Some commenters expressed the belief that small spills have a negligible impact on the environment or that they cause no significant environmental harm. Others cited their own experience to support the claim that small spills have caused no discernable environmental harm or adverse effects. Still others argued that a sheen may be caused by quantities of oil that have been proven to be harmless.

Only three commenters submitted extensive documentation in support of a volumetric reporting trigger. Chevron submitted a literature review by McAuliffe (1981) entitled "Sources, Fates, and Effects of Hydrocarbons Introduced into the Environment." The Offshore Operators Committee (OOC) submitted an undated report entitled "Minimum Impact of Small Oil Spills." The American Petroleum Institute (API) submitted eight documents:

- A bibliography of freshwater oil spills with approximately 2,500 citations, but no abstracts (Environmental Protection Service, undated);

- A laboratory study of effects of oil and chemically dispersed oil on selected marine biota (Vaughan 1973);

- A laboratory study of responses of marine animals to petroleum and specific petroleum hydrocarbons, with a background literature review (Neff and Anderson 1981);

- A literature review on the effects of oil and oil dispersants on fishes (Whitman, Brannon, and Nakatani 1984);

- A study of naturally occurring hydrocarbon seeps in the Gulf of Mexico and the Caribbean Sea (Geyer et al., undated);

- Proceedings of a symposium on sources, effects, and sinks of hydrocarbons in the aquatic environment, including a literature review summarizing five field studies of the impact of oil on marine life (Mertens 1976);

- A literature review on the worldwide status of research on fate and effect of oil in the marine environment (Koons and Gould 1984); and

- A booklet on fate and impact of oil spills (American Petroleum Institute 1980).

The McAuliffe and OOC reports, together with the last three documents listed above, provide the strongest statements and examples of minimal environmental harm from oil discharges. Specifically, although McAuliffe (1981) cites numerous studies, some of which support and others that refute the possibility that oil has only a negligible impact in the marine environment, he concludes that no evidence has been obtained to support claims of biological effects on populations of marine organisms. In a very limited discussion of the impacts of small oil spills, the report submitted by the OOC draws a similar conclusion. Koons and Gould (1984) further conclude that petroleum impacts on the marine environment are usually of short duration, that there is no evidence of permanent damage on a broad oceanic scale, and that there is little danger to human health. The American Petroleum Institute (1980) booklet points out that adverse ecosystem effects of open-sea oil spills are generally short-lived and that the populations of relatively few species of seabirds are in jeopardy. Furthermore, even in near-shore and coastal areas, spills of crude oil evidently have had no serious long-term effects. Mertens (1976) suggests, based on a review of five field studies of chronic low-level exposure of marine life to oil, that no measurable effects have been observed on the populations of various organisms, on species diversity, or on size, growth rate, or reproductive ability of various organisms in the local marine communities. Moreover, he finds no evidence of adverse effects such as abnormal growth and biomagnification of petroleum fractions in the food chain.

A review of other literature submitted by commenters, referenced in comment letters, or compiled in the public docket during the comment period, demonstrates that not all researchers agree with the conclusions of these studies and that many types of adverse effects from oil have been widely documented. Section II of this paper presents laboratory studies showing both lethal and sublethal effects from small quantities of oil. Section III reviews field studies of impacts from oil pollution. The discussion distinguishes acute from chronic effects and coastal from open ocean pollution effects. Section IV evaluates issues of Congressional intent relevant to the environmental harm question, including the Clean Water Act definition of harm and the applicability of the sheen test to all waters.

II. LABORATORY STUDIES

Commenters favoring a volumetric trigger cited few specific laboratory studies to support the idea that small amounts of oil are harmless. The documents submitted by the American Petroleum Institute, however, include discussions of the results of numerous laboratory studies on organisms exposed to oil and indicate that a great deal of research has been done in this area.

Some commenters considered laboratory study results to be unsatisfactory because they often correlated poorly with field observations. Because of the difficulty of establishing reliable controls in field studies, however, laboratory studies are useful for comparing the relative sensitivities of different species and the relative impacts of different petroleum products. They are easily controlled, permitting the effects of the toxin, in this case oil or its constituents, to be easily observed. Laboratory studies are useful for determining the specific concentrations of oil that cause either sublethal responses or lethal effects.

This section examines the lethal and sublethal effects of oil on aquatic organisms as determined by laboratory studies. Lethal effects are discussed first, along with general conclusions drawn from the literature and specific examples supporting these conclusions. Sublethal effects are discussed next. A summary of conclusions drawn from laboratory studies on the effects of oil is provided at the end of this section.

Lethal Effects from Very Small Quantities of Oil

Laboratory studies have been conducted on a variety of organisms, both invertebrate and vertebrate, in order to determine lethal concentrations of oil. In the laboratory, lethal effects are commonly measured in terms of short duration median lethal concentrations (LC50s). LC50s provide the concentration of pollutant necessary to kill 50 percent of a given test population within a given time span.

Laboratory studies show a wide variation in the lethal effects of small quantities of oil, although certain results have been commonly observed. Commonly observed results include:

- <u>Different species exhibit varying sensitivities to oil</u>. Various physiological and behavioral differences make some species more susceptible to lethal effects than others (Whitman, Brannon, and Nakatani 1984; Vaughan 1973; NAS 1985).

- <u>Oil exhibits large differences in chemical composition</u>, and certain types of oil, such as refined pertroleum products, are more toxic than others (Neff and Anderson 1984; National Academy of Sciences 1985).

- <u>The life stage at which organisms are exposed to oil can have a great influence on observed toxicity</u>

(Whitman, Brannon, and Nakatani 1984; Neff and Anderson 1981; National Academy of Sciences 1985). Lethal effects of oil are generally most dramatic in eggs and larvae, with lethal concentrations in the 0.1 to 1.0 ppm range (Neff and Anderson 1981). For the adult stages of a wide variety of aquatic animals, lethal effects from water-soluble fractions (WSF) of petroleum and petrochemicals occur in the 1 to 100 ppm range (Hyland and Schneider 1976).

Most studies on the effects of oil on aquatic animals focus on invertebrates (Alexander 1983). One reason for this is that invertebrates as a class comprise the great bulk of animal biomass and productivity, making them ecologically important. In addition, most aquatic invertebrates are benthic, i.e., bottom-dwelling, and are therefore in close contact with sediments in which petroleum pollutants tend to accumulate. As a result of this behavior, they cannot escape exposure to oil as readily as more mobile organisms such as pelagic species, i.e., species living in the open ocean, and birds. Invertebrates include economically significant shellfish such as shrimp, lobsters, crabs, clams, mussels, and oysters. One study (Rice 1979) provides a compilation of median lethal concentrations for several different types of invertebrates exposed to crude oil and No. 2 fuel oil. The 96-hour LC50s are generally less than 10 ppm for crude oil and, for a few species, less than 1 ppm for No. 2 fuel oil.

A large number of studies have also been conducted that examine the lethal effects of oil on fish. Tests indicate large variations in the sensitivities of different species. Fish behavior may be a factor in determining toxicity; for example, floating oil slicks will affect a surface feeder more than a bottom feeder (Vaughan 1973).

Exhibit 2-1 compares 96-hour LC50 values for several species of fishes exposed to crude oil and No. 2 fuel oil. The No. 2 fuel oil is apparently more toxic than crude oil, with LC50s of less than 1 mg/l (1 ppm) recorded for some species. Pelagic fish appear to be more sensitive than benthic or intertidal (i.e., coastal areas between the low and high tide mark) fish (Rice et al. 1979). In a later study, Rice et al. (1981) examined the toxicity of ballast-water treatment plant effluent in flow-through tests with pink salmon fry. The 48-hour LC50 ranged from 19 to 43 percent dilution of the ballast-water effluent, or 0.8 to 2.8 ppm total aromatic hydrocarbons.

Many aquatic organisms have epipelagic eggs, i.e., eggs that reside in the upper layers of the oceanic zone where enough light penetrates for photosynthesis, that may encounter floating oil. Studies on the effect of oil on eggs, however, have had mixed results, with variations seen among species and oil types (Whitman, Brannon, and Nakatani 1984). For example, eggs of winter flounder exhibit extreme sensitivity and have a high mortality rate with exposures as low as 1 ppm of the water soluable fraction (WSF) of No. 2 fuel oil. Herring eggs are also very sensitive, and water extracted under films of different crude oils is found to be highly toxic to them. In contrast, pink salmon eggs are resistant to Prudhoe Bay crude oil and survive

EXHIBIT 2-1

MEDIAN LETHAL CONCENTRATIONS FOR FISH EXPOSED
TO CRUDE OIL AND NO. 2 FUEL OIL

Species	Habitat	96-hour LC50 (mg/1 Total Hydrocarbons) Crude Oil	No. 2 Fuel Oil
Pink salmon	Pelagic	1.50	0.54
Dolly Varden	Pelagic	2.27	0.72
Great sculpin	Pelagic	3.82	2.41
Starry flounder	Benthic	4.69	1.72
Crescent gunnel	Intertidal	5.89	1.72

Source: Rice, S.D., et al. 1979. Sensitivity of Alaskan Marine Species to Cook Inlet Crude Oil and No. 2 Fuel Oil. In API, EPA, and USCG Proceedings 1979 Oil Spill Conference, pp. 549-54. Washington, D.C.: American Petroleum Institute.

exposure to the oil for a number of days (Whitman, Brannon, and Nakatani 1984). Studies on the effects of oil on larvae also show great variation among species. Thus, it can be seen that although the egg and larval stages of fish are frequently extremely sensitive to oil contamination, there are exceptions, and certain species are more resistant than others.

Sublethal Effects from Very Small Quantities of Oil

Sublethal effects of oil range from alterations in respiration, growth, reproduction, and behavior to changes in the more specific processes of calcification, molting, ion transport, and enzyme function (National Academy of Sciences 1985). Other sublethal effects of oil include physiological, morphological, and histopathological changes and bioaccumulation and retention of oil (Whitman, Brannon, and Nakatani 1984). Laboratory studies show a variety of sublethal effects from exposure to oil pollution such as chemosensory disturbances, reproductive disorders and developmental defects (Atema 1977; Rice et al. 1979). For example, the reported threshold concentrations for the adverse developmental effects are well below 1 mg/l (1 ppm), and even down to 1 µg/l (1 ppb), for acute exposures in the laboratory (National Academy of Sciences 1985). Although these effects do not directly cause death, they may indirectly kill organisms by increasing their vulnerability to normal environmental stresses like predation, food competition, and temperature.

Invertebrate species demonstrate wide variations in their sensitivities and reactions to exposure to oil. Sublethal effects with possible long-term consequences have been documented by some laboratory studies, while other studies have shown few or only short-term effects (Malins 1982; Neff and Anderson 1976). These studies indicate that, in general, factors such as the type of oil to which the organism is exposed, the species and developmental stage of the organism, the mobility of the organism, and environmental conditions are at least as significant as the concentration or total quantity of hydrocarbons present. There is still substantial disagreement and uncertainty, however, regarding the effects of low concentrations of oil pollution on invertebrates. Even less is known about the specific causes of those effects.

An evaluation of current literature, presented by Malins (1982), shows that oils are capable of inducing a variety of sublethal morphological changes in exposed marine organisms. Examples of such studies, in which relatively small concentrations of oil were used, are presented in Exhibit 2-2. Although the morphological alterations are clearly documented, little progress has been made in delineating the significance of these changes on the health and survival of organisms and marine ecosystems.

Another example of a sublethal effect of oil contamination is the reduced ability of mollusks to reproduce as a result of impaired growth and development. This occurs when sexual maturity is delayed beyond the potential spawning season. Asynchronous spawning may result in otherwise viable gametes remaining unfertilized. Thus, most species may disappear from an oil polluted environment, leaving only those few species tolerant of relatively high pollution levels (Sanders et al. 1980).

EXHIBIT 2-2

EXAMPLES OF BIOLOGICAL EFFECTS OF EXPOSING MARINE INVERTEBRATES IN THE LABORATORY TO LOW CONCENTRATIONS OF PETROLEUM IN SEAWATER

Type of Organism	Petroleum Component	Concentration (Exposure Period)	Biological Effects
Clams	Phenol	100 µg/l (24 h)	Cytological damage in gill, digestive gland, and hindgut
Lobsters	South Louisiana crude oil	100 & 1000 µg/l (15 d)	Distended chromatophores
Mussels	Aromatic hyrocarbons from North Sea crude oil	30 µg/l (34-182 d)	Reduction in heights of digestive cells; structural changes in secondary lysosomes
Sea urchin eggs	Benzo(a)pyrene	4-5 µg/l (3 h)	Abnormal cleavage in embryos; development into irregular morulae

Source: Malins, D.C. 1982. Alterations in the Cellular and Subcellular Structure of Marine Teleosts and Invertebrates Exposed to Petroleum in the Laboratory and Field: A Critical Review. In Canadian Journal of Fisheries and Aquatic Sciences, Vol. 39, pp. 877-889.

Laboratory studies by Atema (1977) of the effects of WSF on adult lobsters suggest that oil in the marine environment can interfere with the chemical signals used for feeding, mating, habitat selection, and migration, and for emergency and escape situations, thus demonstrating the subtle but potentially far-ranging effects of oil pollution. At WSF concentrations between 0.08 and 0.15 ppm, little effect was noticed other than a slight slowness of movement. At 0.3 ppm, however, normal feeding behavior ceased and test lobsters would pass over food without recognizing it. At 1.5 ppm, severe neuromuscular effects occurred. Lobsters curled-up listlessly with tails tucked tightly under the carapace, or stood high on their legs attacking imaginary objects and running into walls, or lay on their backs slowly moving and twitching their legs. Atema points out that in an oil polluted environment, heavier fractions become part of the benthic sediment for many years. Thus, these chemicals may continually interfere with normal biological signals, representing one of the least detectable effects of oil pollution.

Many researchers have focused on the sublethal effects of oil that influence fish feeding behavior, migration, or reproduction. Behavioral responses, such as avoidance of petroleum or effects on equilibrium, swimming performance, or spontaneous activity, generally occur in the low ppm range (Malins and Hodgins 1981). Some changes in behavior or physiology can ultimately reduce the life span of the organism. The National Academy of Sciences (1985) concludes that on fish there exists "considerable information on the effects of petroleum at very low levels (less than 100 µg/l !0.1 ppm¢), i.e., there is the knowledge that oil exposure can enhance susceptibility to disease, that there exists a differential sensitivity of the various life-cycle stages and a greater susceptibility of larval stages, that there can occur genetic effects (although not documented in all of its forms, yet indicative of a problem area), and that there is a wide range of deleterious effects on metabolism."

Malins and Hodgins (1981) summarize the results of several studies showing physiological effects, as well as high mortality and gross morphological abnormalities, in fish eggs and larvae exposed to petroleum hydrocarbons. One example involved the exposure of sand sole eggs and larvae to crude oil in a layered surface slick. While 90 percent of the embryos and larvae in the control group were normal, none of the embryos or larvae exposed to the surface slick, with 1.9 ppm total hydrocarbons in the water, were normal. (The 1.9 ppm concentration was the analytically determined total hydrocarbon content in water sampled on day 3 of a 7 day period from fertilization to hatching.)

Physiological changes in fish as a result of exposure to oil are commonly observed. In a study of the sublethal effects of crude oil in cutthroat trout, Woodward, Mehrle, and Mauck (1981) report reduced growth for fish exposed continuously for 60 days to a concentration of 0.1 mg/l. The authors also document gill and eye lesions in the fish after 90 days with exposure concentrations of 0.45 mg/l. Fin erosion disease, which is often associated with stress, is reported in mullet held in estuarine pond-ecosystems and exposed to enough crude oil to give a calculated slick of 0.0013 to 0.0023 cm or a calculated 4.0 to 5.0 ppm concentration (Minchew and Yarbrough 1977).

This disease had previously been found in fish from highly polluted waters, such as the New York Bight.

Commenters on the proposed volumetric trigger pointed to bioaccumulation of oil as another sublethal effect. Studies show that marine organisms are able to accumulate hydrocarbons from either dilute pollution or dispersion in seawater (Neff and Anderson 1981). No one marine organism has been found capable of actively excluding petroleum hydrocarbons from its tissues, be it plant or animal (National Academy of Sciences 1985). Fish readily absorb aromatic hydrocarbons from their environment and these compounds are then differentially bioconcentrated among the tissues, with the highest levels reached in the most lipid-rich tissues. Ovaries and eggs, with their high lipid content, are often found to have among the highest concentrations of hydrocarbons (Whitman, Brannon, and Nakatani 1984). Concentrations of hydrocarbons in tissues have been shown to correlate both with behavioral abnormalities and tainted flavor of the flesh.

Several studies cited by opponents to the sheen test conclude that marine animals are generally able to release petroleum hydrocarbons from their tissues when returned to hydrocarbon-free seawater (Neff and Anderson 1981). Because most organisms are able to purge or metabolize bioaccumulated petroleum components, it does not appear that petroleum can be biomagnified by transfer to higher levels in the food chain (Koons and Gould 1984). However, according to other studies, bioconcentration does occur and some of the larger more complex molecules may remain in an organism for some time (Whitman, Brannon, and Nakatani 1984). For example, elimination of hydrocarbons by bivalves is a long process and appears to occur only incompletely in most cases (National Academy of Sciences 1985).

Summary

Laboratory studies demonstrate that very low concentrations of oil can have lethal effects on a wide variety of exposed organisms, and sublethal effects on a broad range of biological processes. The sensitivity of an organism to oil depends on species, life stage, and the type of oil to which it is exposed. Large variations are seen in lethal and sublethal concentrations, with some organisms more sensitive to very low concentrations of oil than others. Lethal effects are documented at concentrations below 1 ppm and sublethal effects at concentrations as low as a few parts per billion. Despite the difficulties in applying laboratory results to field situations, there is considerable evidence to suggest that low levels of oil resulting from spills can have a significant adverse impact on aquatic organisms.

III. FIELD STUDIES

The bulk of the evidence cited by commenters in support of a volumetric trigger is based on field studies. Although field study results may correlate more closely than laboratory studies with events in nature, their interpretation is often problematic because of the difficulty of establishing adequate controls. Hyland and Schneider (1976) point out that because the prespill conditions (i.e., concentrations of petroleum hydrocarbons, species density, and diversity before a spill) of an area are often unknown, there are no control data that can be applied toward evaluating the spill data. Because few field studies exist and data are often conflicting, individual studies may not be conclusive. For this reason and others (discussed below), a number of the studies cited by commenters have been controversial. This section presents field studies cited by commenters, as well as others drawing different conclusions. Field studies have been useful in demonstrating the differences between acute and chronic pollution effects and between coastal and open ocean effects.

Acute versus Chronic Pollution

Acute Pollution. Several studies indicate that although acute pollution episodes are damaging, the effects may be short-lived. McAuliffe (1981) and the American Petroleum Institute (1980) note that even in those cases where oil spills have affected sensitive coastal areas, effects have not been long-lasting and recovery has been relatively rapid in most situations.

Although the degree and rapidity of recovery may be open to question, the harmful effects of acute pollution incidents are well documented in field studies (Teal and Howarth 1984). The effects of high levels of oil pollution may include reduction in population size and changes in species abundance and distribution. Mortality from exposure to spilled oil in the field depends on a number of variables, including the nature of the petroleum compounds and environmental conditions (Rice et al. 1979).

Accounts of the 1969 barge Florida spill of 4,000 barrels of No. 2 fuel oil off of West Falmouth, Massachusetts, include reports of mass mortality (Sanders et al. 1980; U.S. Environmental Protection Agency 1979); following the spill, large numbers of dead and dying marine organisms were washed onto the Buzzards Bay beaches. At the most heavily polluted sites of the West Falmouth spill, an average of about 80 percent of most species were eliminated in the immediate post-spill period. The opportunistic polychaete Capitella capitata, considered a good indicator of pollution because it rapidly populates areas that are too polluted to support most other species, grew in great abundance (10,000/m^2) making up about 95 percent of the whole faunal population. At the more moderately polluted sites, species were reduced by 50 percent, and rapid growth of another opportunistic polychaete Mediomastus ambiseta was noted. Sanders reports the 1970 mortality of 769 bushels of soft-shelled clams, 1,135 bushels of native seed clams, and all seed and parent stocks of clams transplanted in that year in the Wild Harbor River. A few of the shellfish harvesting areas closed after the spill were reopened in 1973, but the catch was below former levels.

Other field studies document effects of oil spills on fish eggs. Dead or moribund fish eggs were found contaminated with oil after the Argo Merchant spill off Nantucket (Longwell 1977). In the case of the tanker Tsesis grounding in the Baltic Sea, hatching success of eggs was decreased, although this was in part because the oil killed gammarid amphipods, which reduce fungal growth on the fish eggs (Teal and Howarth 1984).

At least one study notes substantial persistence of effects from an acute pollution episode. Sanders et al. (1980) demonstrate the significance of sublethal effects of the barge Florida spill on populations of fiddler crabs in Wild Harbor Marsh over a span of seven years. Sublethal effects include locomotory and behavioral impairment, resulting in increased vulnerability, evident at least four years after the spill. These behavioral changes may, in part, be caused by physical changes reducing the habitability of the substratum, probably as a direct result of initial mass mortality. The normal activities of benthic invertebrates loosen the sediment, allowing penetration of oxygenated water to a depth of approximately six inches. Sanders et al. report that mortality halted bioturbation and oxygenation for several weeks. Concentrations that were sublethal for short periods, became lethal if they persisted. The crab population remained low for at least seven years following the spill. Eight years after the Florida spill, a number of biochemical differences were also found between the killifish from Wild Harbor Marsh and those from an uncontaminated marsh.

Chronic Pollution. Although the effects of large oil spills may be more obvious, chronic oil pollution involving repeated or continuous spills may present a more serious long-term ecological threat. The effects of repeated spills are an important area of study, but results to date are inconclusive. For example, Dicks and Hartley (1982) note the complete disappearance of gastropods and barnacles by 1979 from a shoreline in Wales that was the site of eight oil spills in the period 1977-1979. However, a nearby area that was oiled seven times in the same period showed no significant change in these communities.

Commenters opposing the sheen test cited a number of field studies and examples demonstrating that in certain circumstances harm from chronic pollution has not been detected. Commenters cited examples of areas chronically polluted in the course of oil production and transport activities and through natural marine oil seeps. These examples include the Offshore Ecology Investigation by the Gulf Universities Research Consortium (GURC), which concludes that no significant ecosystem changes have resulted from petroleum drilling and production in the Gulf of Mexico and that exposure to oil from these operations has had no measurable effect (Leek, Blevins, and Loftin 1981; McAuliffe 1981). Similarly, in Lake Maracaibo, Venezuela, despite significant discharges of oil from oil production and natural seeps, Mertens (1976) claims that both laboratory and field data show that the presence of oil has caused no discernable damage to the local ecosystem, although he cites no specific studies to support this claim. In Milford Haven, United Kingdom, studies reportedly show that the spawning and migration of herring and the clam fisheries do not appear to be affected by Britain's largest oil port (Leek, Blevins & Loftin 1981; Offshore Operators Committee to EPA 1985), although, again, no references are provided.

The environments of naturally occurring oil seeps have also been examined to determine effects of low levels of chronic oil pollution. Some studies conclude that natural oil seepage in the Santa Barbara Channel at Coal Oil Point has had no adverse effects on the benthic community in the area (McAuliffe 1981). In addition, studies of naturally occurring hydrocarbon seeps in the Gulf of Mexico and the Caribbean Sea conclude that the low intensity and persistent introduction of hydrocarbons over thousands of years into the ecosystem has not been deleterious to the marine environment (Geyer, undated).

Several scientists, however, have criticized studies concluding that chronic pollution does not cause harm. The GURC study has been particularly controversial. Sanders (1981) questions the validity of the GURC investigation and cites three major flaws in the study. First, the participants in the study expressed concern that the control and rig areas may have been uniformly exposed to chronic low-level petroleum discharges, rendering the control stations invalid. Second, the study contains no information about the passage of petroleum hydrocarbons into the bottom sediments, which serve as the ultimate sinks for oil released in the water column. Third, according to Sanders, the consensus report is based on the interpretation of the one scientist who expressed certainty that there were no harmful effects from chronic pollution; the doubts of the other investigators, Sanders says, were omitted from the final report.

The National Academy of Sciences (1985) reports that recent findings cast doubt on the earlier conclusions of the GURC study. Studies show that the entire Louisiana Outer Continental Shelf is experiencing chronic contamination and that the effects of periodic flooding from the Mississippi River and of tropical cyclones mask any oil platform-related effects. Furthermore, the National Academy of Sciences explains that laboratory studies of organisms near natural oil seeps are inconclusive, although adaptation to the chronic presence of petroleum appears to be poor in general.

A number of studies do document harmful effects in areas subject to chronic pollution. Large-scale studies demonstrate that communities can experience dramatic changes and shifts due to low-level oiling and that a wide range of changes can be expected at surprisingly low concentrations (National Academy of Sciences 1985). Most species may disappear from an oil polluted environment, leaving only those few species tolerant of relatively high pollution levels (Sanders 1980).

Around certain offshore drilling platforms in the North Sea, some population decline and changes in species composition in benthic fauna have been reported within 2 km of the platforms (Clark 1982; Dicks and Hartley 1982). Although there are a number of potential environmental stresses associated with offshore exploration and production, the chief source of sediment contamination in these North Sea studies appears to be chronic low-level discharges of oil-based drilling fluids. Such discharges occur when water from underground deposits containing oil or gas is pumped up with the oil and discharged into the sea at average concentrations of 25 ppm (Hileman 1981). In addition, accidental tanker spills and the expulsion of ballast water containing oil add to the amount of oil in the water. The discharge of drilling fluids is prohibited in marine waters off the U.S. coast. Nevertheless, similar local adverse effects on benthic faunal populations have been observed at some Gulf of Mexico production platforms (Menzie 1983).

Coastal and Inland versus Open Ocean Pollution

Many commenters acknowledged the harmful effects of oil to coastal and inland areas but claimed that oil has no adverse effects in the open ocean environment. Although harm from small amounts of oil in coastal areas is well documented, there is indeed much less evidence that concentrations of oil from spills in the open ocean persist long enough to produce significant and long-lasting toxic effects (Teal and Howarth 1984). Some evidence, however, is presented in this section of possible adverse effects in the open ocean. It is clear that continental shelf areas (extending up to 200 miles or more from the U.S. coast) are likely to be more environmentally sensitive than deep ocean waters farther from shore.

Coastal and Inland Pollution. As Rice et al. (1979) point out, the vulnerability of organisms to oil depends largely on the interaction of the oil with the physical and biological environment. For example, benthic and intertidal environments may be more easily damaged because of mixing and accumulation of the oil in shallow nearshore waters, and oil incorporated in sediments may persist longer than in a pelagic environment. The initial impact of oil on coastal areas, particularly vulnerable wetlands, estuaries, bays, and harbors, is often devastating. However, the long-term effects are difficult to assess (Alexander 1983). It is known that recovery is slow and repercussions may be felt throughout the ecosystem for many years after the initial spill.

Individual ecological communities such as mangrove swamps and corals are highly vulnerable to damage from oil. McAuliffe (1981) concludes that spills reaching sensitive coastal areas have had little ecological consequence for the ocean community as a whole; however, he notes that coral reefs offer natural protection to a variety of marine organisms and that these communities could be slow to recover from severe damage. If the corals die, erosion results, with loss of the ecosystem and most of the dependent organisms.

Coastal oil spills often have a more detrimental effect on marine organisms than spills at sea, in part because coastal regions may contain sheltered or enclosed areas where oil is not readily dispersed, as well as nursery and spawning habitats for many fish species. Because fish egg and larvae stages are particularly sensitive to oil pollution (Malins and Hodgins 1981), these coastal habitats can be severely damaged.

Amphibians and aquatic reptiles are often subject to high mortality rates during the initial periods of a freshwater oil spill (Alexander 1983). Their limited habitats, usually low lying wetland areas, are often completely permeated by oil after a spill. Frogs tend to rest partially submerged in shore areas; aquatic turtles tend to rest with only their head above water, or sun on floating logs; and water snakes swim at the surface of bodies of water. Thus, their behavioral characteristics and dependency on water do not allow them to avoid oil spills readily.

Bird species that live most of their lives on the water or that dive to feed or to escape predation or disturbance are vulnerable to oil spills. Fresh water, tidal brackish waters, and coastal marine waters are critical habitats to large populations of waterfowl and wading birds. Alexander (1983) reports that oil spills have affected large numbers of seabirds in Great Britain's coastal waters.

Mammals that live close to water, such as muskrats, land otters, mink, and rats, can be adversely affected by coastal oil pollution. Sublethal effects of oil on land mammals include matting of the fur and subsequent loss of insulative protection, loss of buoyancy, and impaired swimming ability (Alexander 1983). Oil taken into the digestive tract when the animals attempt to groom the oil from their fur may produce toxic effects.

Inland waterways can be devastated by relatively small oil spills. Many inland waterways are small streams that can be irrevocably damaged by the direct killing of fish and by oil entering the sediments and killing the benthic organisms that are the primary food source for the aquatic population. EPA Region III reports a decline in the quality of small streams, especially in Pennsylvania's Allegheny National Forest and in Northern West Virginia, areas where oil production is a primary industry and oil spills and unpermitted discharges already threaten birds and other wildlife (Meyer to EPA 1985).

Open Ocean Pollution. Although oil spills in the open ocean may be rapidly diluted and readily dispersed, some adverse effects have been documented. As noted above, benthic fauna may be affected around offshore drilling platforms. Studies show that sediments may be contaminated with hydrocarbons, even in the absence of major oil spills, around such platforms (Howarth 1981). Experiments indicate that fish eggs and larvae can be affected by exposure to petroleum hydrocarbons in water at levels similar to those found in polluted marine areas (National Academy of Sciences 1985). This is of particular concern when oil operations are conducted in an area that supports an important commercial fishery. Particularly vulnerable is the neustonic portion of the plankton population, which normally lives in the immediate surface layer, and the eggs and larvae that spend part of their life cycles in or near the surface layer. Some open ocean areas, such as Georges Bank, which lies 150-250 miles off the New England coast, provide major breeding and nursery grounds for commercially and ecologically important species. Low levels of soluble oil fractions may also taint commercial shellfish or affect the behavior of other species (Hyland and Schneider 1976; Howarth 1981).

The Argo Merchant spill occurred 25 miles southeast of Nantucket Island in an important spawning area for many marine fishes. After the spill, toxic water soluble fractions of petroleum penetrated the water column and contaminated pelagic fish eggs below the slicks. This spill consisted of about 80 percent No. 6 fuel oil, which moved out to sea in the form of "pancakes" on the surface of the water, and about 20 percent No. 2 fuel oil. A thin oil sheen surrounded the "pancakes" and could have contributed to the egg contamination. Highest concentrations of petroleum hydrocarbons (on the order of 0.25 ppm) were observed a few meters below the surface (Longwell 1977).

Although not particularly well studied or documented, the fact that floating oil slicks affect sea birds and some mammals is unquestioned (Teal and Howarth 1984). McAuliffe (1981) notes that there is no acceptable evidence that breeding populations of sea birds have been reduced by oil pollution, but he admits that small oil slicks even in open ocean areas may cause many seabird deaths. Small amounts of oil were responsible for one of the largest kills on record, when 30,000 birds were oiled in the Skaggerak in January 1981 (Clark 1982). Floating oil damages the waterproofing and insulating properties of the plumage. Alexander (1983) indicates that alcids, penguins, diving ducks, and other pelagic sea birds are the most frequently oiled groups when spills occur in outer shipping lanes.

Summary

Different field studies draw conclusions on both sides of the question of harm from small amounts of oil. Studies of acute pollution episodes indicate resulting harm, but recovery times and the significance of the damage are widely disputed. A number of studies of chronically polluted areas suggest that ecological effects are minimal, but the methods and interpretations of some of these studies are controversial.

Commenters have provided little or no evidence to refute the U.S. Environmental Protection Agency (1976) claim that floating sheens of oil may result in deleterious environmental effects, such as:

> (a) drowning of waterfowl because of loss of buoyancy, exposure because of loss of insulating capacity of feathers, and starvation and vulnerability to predators due to lack of mobility; (b) lethal effects on fish by coating epithelial surfaces of gills, thus preventing respiration; (c) potential fishkills due to increased biochemical oxygen demand; (d) asphyxiation of benthic life forms when floating masses become engaged with surface debris and settle on the botton; and (e) adverse aesthetic effects of fouled shorelines and beaches.

EPA believes that the literature clearly demonstrates that discharges of small quantities of oil can cause environmental harm. Even many opponents of the sheen test concede that coastal and inland areas are vulnerable to damage from low levels of oil pollution. There is evidence, however, that oil in the open ocean may also produce harmful effects in the environment. Although research is ongoing, it is clear that a significant number of scientists are concerned with the potentially harmful effects of even small amounts of oil in the marine environment.

IV. CONGRESSIONAL INTENT RELEVANT TO THE BIOLOGICAL HARM ISSUE

Some commenters have argued that the sheen test is too stringent because there is little evidence that oil discharges cause permanent harm on a broad scale to commercial fisheries or seabird populations or that they cause significant human health hazards. There simply is no persuasive indication in the statute that Congress intended this narrow interpretation of the harmful quantity standard. In fact, the Congressional policy expressed in CWA section 311(b)(1) "that there should be no discharge of oil" (emphasis added) suggests just the opposite.

Equally important, nothing in the legislative history of the CWA or in judicial interpretations of the Act suggests that a demonstration of permanent harm on a broad scale is required. In court cases such as U.S. v. Atlantic Richfield Co., 429 F.Supp. 830, 837 (E.D. Pa., 1977), the court suggested that Congress believed that even transitory pollution of waters was deleterious to the environment. In other cases, such as U.S. v. Boyd, 491 F.2d 1163 (9th Cir. 1973), courts have specifically upheld the sheen test as a valid basis for distinguishing harmful and nonharmful discharges.

Some commenters have asserted that a sheen can be caused by a quantity of oil that is not biologically harmful. A sheen is typically associated with discharges containing concentrations of oil in the 10 to 20 ppm range. Woodward, Mehrle, and Mauck (1981), for example, note that the 10 ppm oil discharge limitation established by several State water quality programs is based on aesthetic considerations; specifically, discharges with concentrations greater than 10 ppm can be seen readily in water. In this regard, it is worth noting that Regulation 1(16) of MARPOL 73/78 defines clean ballast as either ballast that does not exceed 15 ppm, or ballast that, if discharged into clean, calm water on a clear day, would not produce a visible sheen. Thus, for purposes of this definition, a discharge causing a sheen may be roughly equated to a discharge with a concentration of 15 ppm. Assuming that an oil discharge may be diluted a hundred-fold within several meters of a discharge point, an oil discharge with a concentration of 10 ppm may be diluted, in the receiving waters, to a concentration of 0.1 ppm. The previous sections of this paper have indicated that adverse biological effects from oil occur at concentrations of 0.1 ppm or less. Thus, EPA believes that a sheen is an appropriate indicator of a harmful discharge.

Commenters have not presented a volumetric reporting standard that can definitively be said to meet the harmful quantity criteria. Various recommendations of an appropriate volumetric trigger for oil were submitted, but there was no conclusive evidence to suggest that any of these quantities was a level below which an oil discharge can not cause harm.

Some commenters conceded that the sheen test is appropriate for ecologically sensitive waters (e.g., coastal and inland areas such as spawning grounds and estuaries) where there is substantial evidence that small spills are harmful, but they argued that the sheen test is too stringent for open ocean discharges. Shell Oil Company, for example, wrote that:

> For inland waters and near-shore coastal waters (seaward to the usual territorial limit of three miles), Shell recommends retaining the sheen test as the oil spill notification trigger. This will ensure continued maximum protection for sensitive shoreline, estuaries and quiescent inland waters.
>
> For open waters seaward of the territorial limit, however, Shell recommends replacing the sheen test with a one barrel volumetric trigger (Kienle to EPA 1985).

EPA believes that the sheen test must be applied to all waters to ensure certain, consistent, and effective implementation of the harmful quantity standard. A single reporting trigger is entirely consistent with Congressional intent as reflected in the 1977 CWA amendments, which eliminated the distinction between discharges in navigable waters, including the territorial seas, and those in the contiguous zone. Prior to the 1977 amendments, a discharge in the contiguous zone was only harmful if it threatened fishery resources or threatened to pollute the waters of the territorial seas. Congressional intent that there be a single reporting trigger was also reflected in the 1978 CWA amendments, which eliminated the requirement that a determination of harm must consider the specific "times, locations, circumstances, and conditions" of a given spill. Senator Muskie, in the debates on these amendments, stated that the determinations of harmful quantities under CWA section 311 "are nationally applicable, before-the-fact decisions and are not expected to reflect the myriad of actual circumstances that may occur" (Congressional Record at 519653, December 15, 1977).

EPA has previously expressed the view that Congress intended a single reportable quantity, for a given CWA hazardous substance, to apply to all waters. As stated in the 1978 preamble to the regulations establishing reportable quantities for hazardous substances, "Congress was aware that requiring tailoring of such determinations to water body type and other circumstances is administratively unwise and could prevent achievement of the goals of the !Clean Water¢ Act" (43 FR 10491, March 13, 1978). EPA believes this same principle should apply to discharges of oil.

EPA continues to believe that a single reporting trigger is a practical and environmentally sound requirement. It is true that discharges of the same amount of oil into different bodies of water may result in different degrees of harm. The boundaries and differentiation of various ecologically significant waters are not clearly defined nor readily discernible. Waters seaward of the territorial seas or the contiguous zone, which may contain neustonic communities or productive fisheries, can be sensitive to small spills. As sensitivity of individual aquatic environments to oil is dependent on much more than just distance from shore, EPA believes that it would be impractical to establish varying oil discharge reporting requirements for different waters. The sheen test, identifying a single threshold for all waters, provides a clear and definitive trigger for the reporting requirements of 40 CFR Part 110.

A single reporting trigger for all waters is thus practical, effective, and fully reflective of Congressional intent underlying section 311. The sheen test is the appropriate reporting trigger for all waters.

REFERENCES

Alexander, M.M. 1983. Oil, Fish and Wildlife, and Wetlands. Northern Environmental Scientist 2:13-24.

American Petroleum Institute. 1980. Oil Spills, Their Fate and Impact on the Marine Environment. International Petroleum Industry Environmental Conservation Association and the Oil Companies International Marine Forum.

Atema, J. 1977. The Effects of Oil on Lobsters. Oceanus 20(4):67-73.

Clark, R.B. 1982. Biological Effects of Oil Pollution. Water Science and Technology 14:1185-94.

Dicks, B., and Hartley, J.P. 1982. The Effects of Repeated Small Oil Spillages and Chronic Discharges. Philosphical Transactions of the Royal Society of London B 297:285-307.

Environmental Protection Service (undated). A Bibliography of Freshwater Oil Spills. Ottawa, Canada: Environmental Protection Service.

Fitch, R.A. (Offshore Operators Committee) 1985. Letter to U.S. Environmental Protection Agency, May 3, 1985.

Geyer, Richard A., et al. (undated), Naturally Occurring Hydrocarbon Seeps in the Gulf of Mexico and the Carribean Sea. College Station, Texas.

Hileman, B. 1981. Offshore Oil Drilling: How Will Rapid Development of the Outer Continental Shelf Affect the Environment? Environmental Science and Technology 15(11):1259-1263.

Howarth, R.W. 1981. Fish Versus Fuel: A Slippery Quandary. Technology Review 83(3):68-77.

Hyland, J.L. and Schneider, E.D. 1976. Petroleum Hydrocarbons and Their Effects on Marine Organisms, Populations, Communities, and Ecosystems. In Sources, Effects, and Sinks of Hydrocarbons in the Aquatic Environment, pp. 464-506. Washington, D.C.: American Institute of Biological Sciences.

Kienle, R.R. (Shell Oil Company) 1985. Letter to U.S. Environmental Protection Agency, May 7, 1985.

Koons, C.B., and Gould, H.R. 1984. Worldwide Status of Research on Fate and Effect of Oil in the Marine Environment - 1982. Exxon Production Research Company.

Leek, W.R., Blevins, H.J., and Loften, S.D. 1981. It's Time to Redefine a Harmful Quantity of Oil. In American Petroleum Institute, Environmental Protection Agency, and U.S. Coast Guard Proceedings 1981 Oil Spill Conference, Washington, D.C.: American Petroleum Institute.

Longwell, A.C. 1977. A Genetic Look at Fish Eggs and Oil. Oceanus 20(4):46-58.

Malins, D.C. 1982. Alterations in the Cellular and Subcellular Structure of Marine Teleosts and Invertebrates Exposed to Petroleum in the Laboratory and Field: A Critical Review. Canadian Journal of Fisheries and Aquatic Sciences 39:877-89.

Malins, D.C. and Hodgins, H.O. 1981. Petroleum and Marine Fishes: A Review of Uptake, Disposition, and Effects. Environmental Science and Technology 15:1272-80.

McAuliffe, C.D. 1981. Sources, Fates, and Effects of Hydrocarbons Introduced into the Environment Chevron Oil Company.

Menzie, C.A. 1983. Environmental Concerns About Offshore Drilling -- Muddy Issues. Oceanus 26(2):32-38.

Mertens, E.W. 1976. The Impact of Oil on Marine Life: A Summary of Field Studies. In Sources, Effects, and Sinks of Hydrocarbons in the Aquatic Environment, Washington, D.C.: American Institute of Biological Sciences.

Meyer, R.L. (U.S. Environmental Protection Agency, Region III). 1985. Letter to U.S. Environmental Protection Agency, May 9, 1985.

Minchew, C.D., and Yarbrough, J.D. 1977. The Occurrence of Fin Rot in Mullet (Mugil Cephalus) Associated with Crude Oil Contamination of an Estuarine Pond-Ecosystem. Journal of Fish Biology 10:319-23.

National Academy of Sciences. 1985. Oil in the Sea: Inputs, Fates, and Effects. Washington, D.C.: National Academy Press.

Neff, J.M., and Anderson, J.W. 1981. Response of Marine Animals to Petroleum and Specific Petroleum Hydrocarbons. London: Applied Science Publishers, Ltd.

Rice, S.D., Korn, S., Brodersen, C.C., Lindsay, S.A., and Andres, S.A. 1981. Toxicity of Ballast-Water Treatment Effluent to Marine Organisms at Port Valdez, Alaska. In American Petroleum Institute, Environmental Protection Agency, and U.S. Coast Guard Proceedings 1981 Oil Spill Conference, pp. 55-62. Washington, D.C.: American Petroleum Institute.

Rice, S.D., Moles, A., Taylor, T.L., and Karinen, J.F. 1979. Sensitivity of 39 Alaskan Marine Species to Cook Inlet Crude Oil and No. 2 Fuel Oil. In API, EPA, and USCG Proceedings 1979 Oil Spill Conference, pp. 549-54. Washington, D.C.: American Petroleum Institute.

Sanders, H.L. 1980. Position Paper of Howard Sanders. Unpublished. Submitted to the National Academy of Sciences, August 1980.

Sanders, H.L., Grassle, J.F., Hampson, G.R., Morse, L.S., Garner-Price, S., and Jones, C.C. 1980. Anatomy of an Oil Spill: Long-Term Effects from the Grounding of the Barge Florida Off West Falmouth, Massachusetts. Journal of Marine Research 38:265-380.

Teal, J.M., and Howarth, R.W. 1984. Oil Spill Studies: A Review of Ecological Effects. Environmental Management 8(1):27-44.

U.S. Environmental Protection Agency. 1976. Quality Criteria for Water. Washington, D.C.: Government Printing Office.

U.S. Environmental Protection Agency. 1979. A Small Oil Spill at West Falmouth. Washington, D.C.: Office of Research and Development.

Vaughan, E., ed. 1973. Effects of Oil and Chemically Dispersed Oil on Selected Marine Biota -- A Laboratory Study. Richland, Washington: Battelle Memorial Institute/Pacific Northwest Laboratories. American Petroleum Institute Publication No. 4191.

Whitman, R.P., Brannon, E.L., and Nakatani, R.E. 1984. Literature Review on the Effects of Oil and Oil Dispersants on Fishes. Seattle, Washington: Fisheries Research Institute, University of Washington. Prepared for the American Petroleum Institute.

Woodward, D.F., Mehrle, P.M. Jr., and Mauck, W.L. 1981. Accumulation and Sublethal Effects of a Wyoming Crude Oil in Cutthroat Trout. Transactions of the American Fisheries Society 110:437-45.