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Michael S. Connor and Robert W. Howarth

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TECHNICAL REPORT

Prepared for the Department of Commerce, National Oceanic and Atmospheric Administration, Office of Sea Grant under Grant No. 04-6-158-44106 and the Woods Hole Oceanographic Institution.

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Approved for Distribution Robert W. Morse

Robert W. Morse
Dean of Graduate Studies

Prepared by the graduate students and staff of the fall semester, 1976. Seminar in Biological Oceanography, Massachusetts Institute of Technology/ Woods Hole Oceanographic Institution Joint Program in Biological Oceanography. Presented as oral testimony at the Bureau of Land Management hearing in Boston, Massachusetts, 8 December 1976.

PREFACE

Each semester the students of the Woods Hole Oceanographic Institution/MIT Joint Graduate Program in Biological Oceanography organize a seminar exploring some aspect of biological oceanography. During the fall of 1976 we focussed on the biological communities of Georges Bank and their interaction with the proposed development of oil resources there.

Participants in the seminar (and their topics) included the following graduate students at W.H.O.I. - Larry Brand (toxicity), Russell Cuhel (microbial degradation), Joy Geiselman (nearshore communities) - and graduate students in the Boston University Marine Program - Anne Giblin (spill clean-up and metals), Brian Howes (benthos), Tom Jordan (offshore communities), Chris Werme (community variability) and Susan Vince. Other regular participants were Dr. Tom Newbury and W.H.O.I. staff members Drs. John Teal, J. Frederick Grassle and John Farrington. Guest speakers included Drs. K. O. Emery, R. C. Beardsley, H. L. Sanders and R. L. Haedrich of W.H.O.I; Drs. John Hobbie, Dan Botkin and Bruce Petersen of the Ecosystems Center, Marine Biological Laboratories; Dr. George Kelly of NMFS and Dr. Robert Stewart of Martingale, Inc. Bob Howarth and Mike Connor, both W.H.O.I./M.I.T. graduate students were the organizers of the course and the editors of this review. Earlier drafts were read by Drs. Teal, Grassle, Farrington and Sanders.

We have summarized our studies in the following review of the Draft Environmental Statement for OCS lease sale No. 42. The views expressed represent the consensus of the regular participants, but should not be construed as being the views of the guest speakers, or the official positions of either W.H.O.I. or M.I.T.

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SUMMARY

We find several major failings with the draft environmental statement (DES) for Outer Continental Shelf lease sale no. 42 and believe it to be an insufficient and overly optimistic analysis of the possible environmental effects of offshore oil exploitation. The Bureau of Land Management seems primarily concerned with assessing the likelihood of oil from a large spill reaching shore and determining what the effects of such a spill would be. While we believe that even this analysis is insufficient, we are more concerned with the lack of attention to the effects of oil exploitation on Georges Bank itself. Oil from spills — small and large — and oil from chronic discharges may have a serious impact on the fish and other organisms of Georges Bank.

Much of the oil from spills and chronic discharges will likely find its way into the sediments. Once in the sediments of the bottom, the oil will persist and accumulate over time, a process the DES ignores.

The handling of ecological considerations by the Bureau of Land Management is inadequate. While an attempt is made to assess the impact of oil on different communities, the DES lacks a view of the integrative nature of biological communities. In the view of the DES, a community either dies or it is unaffected. This is naive. We believe that chronic oil pollution associated with oil exploitation on Georges Bank may affect benthic communities in more subtle ways, changing the relative composition of the species in a given community for example. This has important ramifications for the fisheries, for most of the commercially important

fish of Georges Bank are bottom feeders, and a change in the bottom community structure may well change the abundances of the different species of fish.

The fish of Georges Bank are vulnerable for another reason. Almost all of the commercially important fish (and some shellfish, such as lobsters) have eggs and larvae which develop over a period of months while they float in the surface waters of the Bank. Some fish are most sensitive to oil at this stage in their development, and the most toxic constituents of oil following a spill will be found in these same surface waters. Fish larvae, like most life in the ocean, are not distributed evenly in a body of water, but rather are concentrated in patches. If an oil spill were to coincide with one of these patches, it could doom what would otherwise be a successful age-class of fish, even if the oil was not directly toxic. On theoretical grounds, we might expect that a stress such as oil — whether from acute spills or chronic discharges — would shift the species composition of the plankton, the food of the fish larvae, toward smaller species. Low sub-lethal concentrations of oil have been found to have this effect, shifting the composition of the phytoplankton from larger forms such as diatoms to tiny micro-flagellates. Such a non-toxic effect, ignored by the DES could have large effects on Georges Bank's fisheries.

We also believe that the Bureau of Land Management's analysis of the time needed for recovery — weeks or months — following a spill is excessively optimistic. Apparently, they consider recovery to coincide with any repopulation by organisms. A better definition of recovery is a return to the same sort of biological community as existed prior to the oil spill — the same sort of organisms in similar numbers and ages interacting with one another in the same way, with processes occurring at similar rates. A forest clearly has not recovered from a fire when the first few blades of grass colonize a few weeks after the fire. But the BLM's statements about recovery of marine communities from oil spills are just such oversimplifications.

The draft environmental statement is deficient in other regards as well. We will touch on some of these deficiencies in the following report, but because of time constraints and the difficulty of preparing page-by-page comments on a four-volume document, we are dealing only with some of the most glaring problems in the areas we know best. We believe our comments are representative of the many errors and omissions which occur throughout the statement.

Particularly bothersome are the inadequate assessments of the possible impacts of oil exploitation on endangered species and on coastal environments, particularly the wetlands, so important to fisheries and water quality. Further, the assessment of oil spill statistics contains many errors,and the proximity analysis is based on false and unsubstantiated assumptions.

For most of the discussion on oil spill impacts on the environment, the DES uses pipeline, not tanker, data for frequencies and sizes of spills (see for example pp. 691-695). Pipeline data are used despite the likelihood that economics will result in the use of tankers and not pipelines (p. 611), despite the fact that the DES considers pipelines "safer"

(p. 843), and despite the DES's claim that "maximum variables have been used in measuring impact" and that "actual impact, in most cases, would probably be less than the maximum shown" (p. 587).

After a careful study of the draft environmental statement for OCS sale no. 42, we are unconvinced that the oil of Georges Bank can be exploited without serious risk to the commercial fisheries and to this environment. Is it worth risking one of the world's richest fisheries for a few weeks' or months' supply of oil?

The BLM Draft Environmental Statement (DES) for the leasing of tracts for oil development on the Georges Bank (OCS Sale No. 42) is based on the following assumptions: that production of oil from Georges Bank will have a significant impact on the future needs of New England for oil; that there will be no significant impact on the future needs of New England for oil; that there will be no significant impact on the environment from daily drilling operations; that catastrophic spills will be infrequent, unlikely to hit the coast and, most of the time, salvageable; and that if drilling is affecting the environment, baseline studies and monitoring will give sufficient warning to prevent irraparable impact.

We feel these assumptions are not justified by the data presented and will examine each point in the following review. We have intentionally not dealt with those portions of the DES which we feel are already adequate. We recognized that the DES represents an enormous compendium of literature, but we feel it is important to bring attention to gaps in the analysis which must be filled before a knowledgeable decision can be made concerning the trade-off involved in exploiting Georges Bank's oil reserves.

Significance of Georges Bank to New England Energy Needs: In the discussion of alternatives to the proposed leasing, the DES states: "it is anticipated that the oil and gas that would become available from this proposal in the next 20-year period could provide a significant contribution to this region's energy supply..." (p. 1261). The DES also implies that the development of Georges Bank oil might result in lower energy prices in New England (p.1260). Both of these are popular ideas, but are they true? No data are presented to back these assertions.

The proposed development of Georges Bank involves rather small amounts of oil and natural gas. Economic considerations will likely result in all of the oil being tankered ashore to New Jersey (as clearly stated on p. 611: elsewhere the DES implies that the oil may be piped ashore, but such implications are usually made in the sections discussing the effects of oil spills (e.g., p. 698) because pipelines are often considered safer than tankers).

Georges Bank development (Table I-1) would likely bring from 0.18 to 0.65 billion barrels of oil ashore in New Jersey and 1.2 to 4.3 trillion cubic feet of natural gas ashore in New England. How does this compare to present usage? In 1973, 1.74 billion barrels of oil were brought by sea into the ports of New England, New York and New Jersey (pp. 431-435). If all the oil in the proposed lease areas were to be suddenly developed at one time, it would supply the area (at 1973 rates of importation) for 1.24 to 4.5 months, and then it would all be gone. If enough natural gas is found to bring ashore, it would meet New England natural gas demands for five to fifteen years assuming no increase in demand over 1973 consumption rates (1975 Statistical Abstract of the U.S.). Estimates of oil and natural gas available on Georges Bank are nearly equivalent in terms of energy (B.T.U.'s), so the longer supply of natural gas merely reflects New England's low use of this fuel.

These estimates ignore the growth of energy demands. Georges Bank oil will not be available for at least ten years; so it would probably not last as long as 1973 demand figures indicate. Using projections from the U.S. Dept. of Commerce's 1975 Statistical Abstract of the U.S., we calculate that oil from the proposed lease sites would have supplied the

U. S. with oil in 1973 for at most 10 to 35 days, or will supply the U.S. with oil in 1985 for about 7 to 26 days or in 2000 for 5 to 19 days. Likewise, natural gas from Georges Bank would have met 1973 U.S. demand for 12 to 43 days, or will supply the U.S. with natural gas in 1985 for 15 to 54 days or in 2000 for 18 to 65 days.

It is hard to imagine that such a small influx of oil would have any influence on prices in New England. According to the M.I.T. report to the Council on Environmental Quality (Lahman et al., 1974, p. 49): "Assuming no price control and assuming the offshore development does not force all the $8.00 oil and $1.50 gas off the market, the offshore development will have no effect on market prices."

Acute Problems - Oil Spills: The DES suggests that tankers of a 30,000 to 70,000 dwt size range will be used to bring oil ashore (p. 631). Vessels of this size are exempt from Coast Guard regulations requiring segregated ballast tanks since crude oil is usually carried by larger vessels (DES, p. 632). We would therefore expect more problems with small spills involving these tankers than would occur with the larger tankers involved in overseas transport. Small tankers tend to have more accidents than larger tankers, and the average amount of oil spilled by them per accident is greater than for large tankers (Devanney and Stewart, 1974, pp. 60-62). Also larger tankers are carrying more oil; so the spillage rate is much higher from smaller tankers per unit volume of oil carried (Ibid). Since the spill likelihood from tankers involved in Georges Bank oil explotation was derived from world-wide tanker statistics (DES, p. 634), the likely volume of oil to be spilled from the use of the smaller tankers is underestimated.

The DES (p. 633) states: "Only United States vessels and personnel will be used [to bring Georges Bank oil ashore]; these have better over-all performance records than those of most nations." This statement is unreferenced and consequently not open to examination. However, Devanney and Stewart (1974, pp. 42-46) indicate that more spills occur for landings at U.S. ports than for foreign ports per unit volume of oil landed. They believe that this may be due to the use of smaller tankers for trade to the U.S. or to better reporting. Regardless of the reason, it means that the DES's use of world-wide tanker statistics again underestimates the number of spills likely to occur from Georges Bank oil.

How will the oil be loaded onto tankers? The DES (p. 621) indicates that loading buoys may be used; yet nowhere is the likelihood or spillage from such buoys discussed. Devanney and Stewart (1974, p. 82) report that data on such buoys is very hard to come by, but what data is available suggests this loading technique might result in many spills, perhaps as many as one every five ship calls. Industry sources seem reluctant to present data on spills from such loading buoys. According to Devanney and Stewart (1974, p. 71): "The excellent cooperation we have received from the industry in other areas simply has not been exhibited with respect to SBM (Single Buoy Mooring) spillage." In a footnote they explain: "We asked for this data direct from Shell but received no response. We also made repeated requests to the SBM Forum, an industry organization to promote the transfer of information in single buoy mooring installations among users, to no avail." (Ibid.).

Even the assessment of spillage from onshore storage facilities is inadequate. Such spillage is declared to be "zero" providing the enclosure dikes are not damaged, as might occur in an earthquake (p. 639). But earlier (p. 235), the DES reports that the oil storage facilities at Newington, New Hampshire, are an important source of pollution: "Runoff from rainfall within these dikes is periodically discharged through an oil/water separator into the Piscataqua River."

For most of the discussion on oil spill impacts on the environment, the DES uses pipeline, not tanker, data for frequencies and sizes of spills (see for example p. 698). Pipeline data are used despite the likelihood that economics will result in the use of tankers and not pipelines (o. 611), despite the fact that the DES considers pipelines "safer" (p. 843), and despite the DES's claim that "maximum variables have been used in measuring impact" and that "actual impact, in most cases, would probably be less than the maximum shown" (p. 587).

Is the assessment of oil spillage from pipelines even adequate? The DES's analysis of spill likelihood from pipelines is based on data from the Gulf of Mexico (p. 627), but conditions on Georges Bank seem likely to result in a much higher spillage incidence. A large proportion of the volume of oil spilled results from anchor dragging related accidents (p. 629), but the DES optimistically dismisses this as a problem in the North

Atlantic OCS area by referring to regulations requiring pipeline burial "when technically and economically feasible" (p. 613). The Gulf of Mexico has large areas of sediment overlain by low velocity currents where the weight of a pipeline would cause it to bury itself. Georges Bank, on the other hand, is characterized by higher velocity currents and areas of scoured sand. The potential for buried pipelines to become re-exposed is large (DES, p. 716). Pipelines can be reburied, but the expense of continually reburying them would result in political and economic pressures to no longer require burial. Lag times between exposure and reburial would be inevitable. The danger of commercial fishermen damaging pipelines is also larger for the Georges Bank area. The shrimp trawlers of the Gulf of Mexico use relatively small, light trawl doors compared to the demersal fish trawlers of Georges Bank, which use trawl doors weighing up to 2000 lbs (Allen, et al. 1976; WHOI Marine Policy Report, 1976).

The DES's use of pipeline spill statistics is misleading for another reason. Spills from pipelines offshore tend to be larger than those from pipelines near the coast (Devanney and Stewart, 1974; p. 97). Since pipelines from Georges Bank would be longer than most of those in the Gulf of Mexico, the use of the Gulf data could underestimate the spill likelihood on Georges Bank.

The DES (p. 627) also declares that lower spillage rates might be expected from OCS sale #42 (Georges Bank) due to improved technology. This assertion is unreferenced. Although the idea that improved technologies decrease the likelihood of oil spills is a popular one, supporting evidence is far from conclusive (Devanney and Stewart, p. 42). Data available can be explained by many hypotheses other than that of improved technology. Devanney and Stewart (Ibid) believe that the most likely explanation of data sometimes used in support of the improved technology hypothesis is simply due to corrosion and wear upon the older equipment, effects that will become more obvious for the newer equipment as it ages.

Once oil is spilled offshore, the DES (p. 1255) claims that it would be containable 90% of the time in spring and summer and 60% of the time in fall and winter. This assertion is apparently based on the data presented in Table II-7, "Percent Frequency of Sea Heights" for the North Atlantic region (p. 192), and assuming that tidal currents will be slight. This assessment would seem to greatly overestimate the potential for containment on Georges Bank. The containment barriers can work in seas of up to 4-6 feet, currents of under two knots and winds of under twenty knots (pp. 1167, 1255). The DES seems to assume that currents on Georges Bank will pose no problem for containment stating that currents are of low velocity offshore, "less than 0.1 knot over the shelf" (p. 182). Later the DES asserts that current velocities are nearly always less than one knot (p. 724). However, it is also stated that the Georges Bank COST well experienced much higher velocity tidal currents, "usually" two knots or less (p. 729). Yet even higher velocity currents occur on Georges Bank (Bumpus, 1976; Haight, 1942, figs. 23-35). The oil spill containment ability is even further overestimated because waves on Georges Bank are higher than in the North Atlantic region as a whole (DES, p. 184), due to the tidal currents interacting with the wind and the shallow water in some areas where the waves are steepened by the bottom. It seems likely that stormy days — days in which oil spills cannot be contained — will also have a higher probability of spills occurring. The DES ignores this important interaction.

Fate of Petroleum Substances: The DES presents some data and references which indicate that "when petroleum substances are first exposed to the atmosphere, evaporation is the predominant process" (p. 651). However, as indicated, most of the data in support of this contention come from laboratory studies. "Since much of the work done in this area has been either simulated field or laboratory experiments, the results of Smith and MacIntyre (1971) should be noted. Comparing losses of no. 2 fuel oil components in a laboratory bubbler apparatus and in the field, they found that losses of LMW hydrocarbons were significantly greater in the field" (p. 651). The authors of the draft statement apparently believe this indicates a higher evaporative loss in the field. However, it seems likely that a laboratory bubbler apparatus would yield near maximum "evaporative" losses due to the stripping action of the bubbles. Consequently, it seems more likely that the higher losses of low molecular weight hydrocarbons from the slick in the field indicate a major dissolution of these compounds into the water column, or adsorption to particulate matter and subsequent sedimentation. Emulsification of the slick by wave motion could change the oil phase matrix, further retarding evaporative loss of these low molecular weight compounds of high toxicity. The handling of these data by the DES is highly misleading.

Contrary to the implications of the DES, much of the oil from an oil spill, including all molecular weight size fractions (Kolpack et al., 1971), can very quickly enter the sediments. Waves can drive oil down into the water column as deep as 80 m (DES, p. 770), and sediment particles readily adsorb oil (Meyers and Quinn, 1973). Not surprisingly, a flux of oil to the benthos has been found whenever this possibility has been investigated; West Falmouth (Blumer et al., 1971), Santa Barbara (Kolpack et al., 1971) and Chedabucto Bay (Levy, 1971). Many of the characteristics of Georges Bank make it likely that this will be a dominant process there.

Once it has reached the sediments, the oil is very persistent. The DES declares: "If oil is entrapped in bottom or shoreline sediments this degradation would continue over weeks or months while the oil was slowly reintroduced into the system" (p. 1204). This statement is a serious understatement of the true case. There are a number of studies which show that oil can persist in sediments for years and perhaps decades (Blumer et al., 1971; Mayo et al., 1974).

Upon reaching the benthos, the oil does not sit still in one location, but remains mobile. In the case of the West Falmouth and Santa Barbara spills, the oil slowly moved about in or with the sediments, and after a considerable period of time reached the deeper, softer sediments (Blumer et al., 1971; Kolpack et al., 1971). Presumably, the oil affected a wide area of benthic communities as it moved. Oil in the sediment also can slowly leak back into the water column, providing a source of chronic pollution which can affect fish larvae and other organisms in the water column (Meyers and Quinn, 1973). In Chedabucto Bay oil is still slowly being released from the sediments five years after the spill of the ARROW (Vandermeulen and Gordon, 1976).

The DES maintains that "an oil spill that occurs offshore is less damaging than a near shore spill" (p. 659). This assertion is unreferenced; presumably it refers to a study mentioned earlier (p. 648) of an experimental spill which mostly "disappeared" after four days. The likelihood that the oil moved to the sediments is not mentioned in the DES. This "out of sight, out of mind" philosophy is far too typical of the DES. Judging from the cases cited above, a sizable fraction of most oil spills on Georges Bank will reach the benthos. Sediment transport along the bottom will eventually deposit this oil in the nearest low energy environment — very likely in the muddy basins on the bank or the canyons on the perimeter of the Bank, prime habitat for lobster.

Effects of Spills on Fish Larvae: The larvae of haddock, cod, pollock, whiting, red hake, cusk, herring, American dab, yellowtail flounder, gray sole and sea scallops all drift in surface waters while they are developing, as do the eggs of all of these species with the exception of herring (Colton and Temple, 1961). Typically the eggs and larvae are in the surface waters for 4-5 months (Colton and Temple, 1961).

Lobster larvae also float in the surface waters, often right at the air/water interface (George Kelly, pers. comm.). These surface waters are also likely to have the highest concentrations of toxic hydrocarbons in the event of an oil spill, and the larval stages are very sensitive to oil pollution (DES, p. 787). Mironov (1968) found 40-100% mortality of hatched prelarvae of plaice at oil concentrations of 10-100 ppb. Concentrations in the surface waters under a spill would be much higher than those levels, and even chronic pollution from formation waters and small spills could result in significant levels of oil, perhaps over much of Georges Bank.

Colton and Temple (1961) believe that strong age classes in fish species observed periodically on Georges Bank result from unusual hydrographic conditions that maintain the same surface water parcel on the Bank for many months, long enough for the fish eggs and larvae to develop and settle in this favorable environment. The same conditions would naturally be expected to keep oil on the Bank, with possibly devastating effects to the fish and fishery.

Most commercially important species of fish have strong age classes some years and weak age classes most years. This means that the production of new young fish is fairly low most years, but every so often a tremendous number of new young fish is produced. It is primarily these strong age classes which support a large fishery. An event which causes a year class failure, particularly if the event caused failures in several different species simultaneously, could wreck havoc on the commercial fisheries. Continued heavy fishing at the time of such a failure might make the long term ramifications even more serious.

The DES (p. 749) states that impacts of an oil spill on the larvae of fish and shellfish will be localized "for the most part," and "temporary in nature... in the order of one complete reproductive cycle" (p. 756). This statement fails to recognize that life in the oceans is patchy in space and time. Organisms are distributed neither evenly nor randomly as the DES implicitly assumes. Strong age classes of fish may well occur because a patch of fish larvae coincides with a phytoplankton patch, leading to high growth and survivability of the larvae. Patches of phytoplankton in the Gulf of Maine, as determined by carbon dioxide distribution, are of a size comparable to the size of an oil spill that would result from the release of 100,000 gallons of oil (John Teal, pers. comm.). If an oil spill were to coincide with a phytoplankton patch supporting a large patch of fish larvae, it might well destroy an otherwise successful age class of fish. Such an age class failure might be neither understood nor traced to the oil spill, but it would be harmful to the Georges Bank fisheries.

With the 200-mile territorial limit scheduled to begin this next year, the U.S. will at last be able to start sensibly managing the Georges Bank fishery. Possible effects of oil exploitation may make such management more difficult. Until good management again creates a more stable fishery, the effects of oil may be indistinguishable from the long term effects of overfishing. Also, most fishery stocks on Georges Bank are presently very depleted, and this may make them more vulnerable to oil pollution.

Effects on Birds and Mammals: Endangered Whales. In the summary of the adverse effects to be expected from the exploitation of oil on George's Bank, the DES (p. 1200) states: "Cetaceans are not numerous in the area and their habits are not well known therefore no definite statement about the effects of the proposed OCS development can be made." This statement is quite misleading. While it is true that not a great deal is known about whales in this area, we know enough to be concerned. As stated earlier in the DES (P. 818-820), six endangered species of whales are likely to be found in the proposed OCS area: the finback, humpback, right, blue, sei, and sperm whales. "The finback whale, although it is endangered, is the dominant large whale of the region" (p. 818). "The area most likely to be impacted by the proposed oil development includes a large portion of the finback whale's western Atlantic distribution" (p. 819). This fact was conveniently ignored in the summary statement. In the "Proximity Evaluation", the DES declares "whales and marine turtles are not considered in this evaluation (of endangered species) due to the all inclusive nature of their habitats." While this may be convenient, it is also misleading, and the draft statement contains enough facts to suggest that a proximity analysis for whales and turtles might be quite unfavorable.

The DES reports (p. 716): "After the Santa Barbara spill, a number of marine mammals were found dead including gray, sperm and pilot whales and dolphins. Subsequent analysis of the dead organisms, however, revealed no data that could link the deaths with oil." However, according to

Connell (1971) the lower limit of sensitivity of the technique used was 50 p.p.m. and only tissues of the upper respiratory (trachea) and upper digestive (baleen, esophagus) tracts or tissues from the thoracic cavity were examined.

A discussion of the feeding habits of the various whales occurring in the proposed OCS area should have been included as part of the DES, since it might aid in assessing the impact of oil on the whales. For instance, the finback and humpback whales both feed on groups of small fish (personal communication from William Watkins). Since drilling platforms attract certain types of fish, might they not also attract finback and humpback whales coming to feed on the fish? This would seem to increase the likelihood of oil affecting these endangered species. And humpback whales sometimes use the surface of the water to trap small groups of fish, particularly when the sea is calm (Watkins, personal communication). Would this increase their likelihood of interacting with an oil slick? Right whales, which are plankton eaters, also sometimes feed on the surface, but most other whales never feed on the surface (Watkins, personal communication). Most whales are very curious animals, often attracted to boats (Watkins, personal communication). Would drilling structures and support boats tend to attract whales to areas of high likelihood of impact?

As the DES points out, the populations of some whales are so depleted that "the loss of any individuals as a direct or indirect effect of oil and gas development can be considered a significant loss" (p. 819).

Food-chain Magnifications: The DES apparently does not consider the problem of food chain magnification of petroleum compounds with regard to mammals, birds, and turtles. The DES states: "...increasing evidence suggests that classical food web magnification...of petroleum hydrocarbons does not occur" (p. 665). This contention is probably true with regard to gilled aquatic animals. However, it is very likely that there is significant food chain magnification in air-breathing aquatic animals such as whales, seals, and sea birds. Food chain magnification of chlorinated hydrocarbon pesticides is known to occur in birds and mammals on land. This could pose a further threat to these groups.

Gray Seals: The DES adequately shows that gray seals are quite susceptible to oil effects. However, it is stated that: "Nantucket shields the island from the proposed leasing area and therefore a spill originating from a platform or drill rig probably would not affect Muskeget" (p. 813), the site of the only gray seal rookeries in the U.S. This is absurd, this ignores oil transport by tidal currents or shifting winds. Oil does not have to move in straight lines. Furthermore, in the "Proximity Analysis" (p. 1083) it is concluded that "proximity as a factor of high risk is not deemed great enough to constitute a high hazard potential to a seal breeding area." This conclusion results because the oil spill trajectory model (itself subject to many errors and based on many tenuous assumptions) predicts that oil from a spill at a platform would always take at least five days to reach a seal rookery, and the DES assumes that in this five day period enough weathering of the oil would have occurred to render it harmless. Again, this is absurd. But after a five day weathering period, the oil will still be "sticky," - this alone would have significant impact on the seals - and may still contain toxic constituents.

Birds: Again, the effects of food-chain accumulation of petroleum have not been considered. As for the gray seals, the proximity analysis is overly optimistic when it concludes that little impact will occur to coastal bird breeding areas since oil will weather for at least five days before arriving there. However, it should be emphasized that despite the shortcomings of the proximity analysis, the analysis indicates that George's Bank oil exploitation will have a possibly severe impact on pelagic birds (p. 1083). It is not clear from the DES why the proximity analysis concludes that "pelagic birds" might be significantly impacted, but that the pelagic bird species which are also "species of concern" -- the razorbill, common puffin, and black guillemot (p. 1075) -- would not be significantly impacted. Earlier information in the draft statement (p. 370) indicates that these species of concern might be endangered by oil exploitation (p. 370).

Further, birds are highly mobile organisms, often covering large areas in a given day. At least some species of sea birds, including the alcids, may actively seek out oil slicks and dive into them, possibly because the slick resembles shoaling fish (DES, p. 823). All of the "species of concern" referred to above are alcids.

NEAR-SHORE EFFECTS OF OIL SPILLS

Weathered oil: Large portions of the "Proximity Analysis" (pp. 1074-1091) are based on the assumption that an oil slick striking shore in 5 days or more will be sufficiently weathered to render it non-harmless No data are presented to support this assumption, and it is not valid. While it is true that the longer a slick floats at sea, the more the highly toxic constituents are leached out, it is not clear that 5 days is a sufficiently long time. Highly weathered tar balls still contain toxic constituents which can be leached to the water (Horn et al., 1971). Further, the effects of a spill will be concentrated along a shore since the oil can go no further. Wave action is greatest along the shore, resulting in the greatest mixing of oil into the water and increasing the likelihood that animals living below the surface will be affected. Further, the sediments will act to store the oil in near-shore environments, slowly leaching it back out and increasing the time period over which an oil spill may have an affect on the water column.

In an investigation of hypothetical oil spill scenarios for Long Island's south shore, Schrader, et al., (1974) conclude that even a weathered spill will kill 10-50% of all organisms it affects and that recovery will be slow: 3-5 years for exposed beaches and at least 5-10 years for bay habitats. This analysis clearly contrasts with the assumptions of the proximity analysis.

Persistence of Oil: The impact statement is excessively vague and is probably too optimistic in discussing the persistence of oil and recovery of communities in near-shore environments. Page 778 states "recovery is expected to occur in a short time." But this assertion is unreferenced and unsupported by the data available. Recovery from tanker spills during World War II is often given as an example, but as the DES (P.581) itself states: "There have been no efforts to determine the long-term effects of these spills." Without pre-spill studies or even subsequent careful analysis, nothing can be said about the time needed for return to the undisturbed community. We do not even know that recovery has yet occurred.

Similarly, the DES declares (p. 784) that "the communities impacted in both the TAMPICO and San Francisco Bay spills eventually repopulated. indicating that oil spills do not permanently damage impacted intertidal areas." Of course, repopulation of some sort will eventually occur, but repopulation alone does not constitute recovery. Did the repopulating organisms result in the same sort of biological community as existed before the spill, or did they represent opportunistic species, as has occurred following the West Falmouth spill (Sanders, 1973; Grassle and Grassle, 1974), in which case is it correct to speak of the community as having full recovered?

North's (1973) study of the TAMPICO MARU spill which occurred in 1957 indicates that complete recovery has still not occurred. Mussels and green abalones have yet to repopulate some of the affected areas. In addition, the present age-class distribution of many species is different from that which existed before the spill (personal communication from Howard Sanders). Nor have the areas affected by the West Falmouth spill in 1969 totally recovered (Michael et al., 1975) despite the erroneous implications of the DES (p. 1102).

OIL SPILLS IN SALT MARSHES

The DES dismisses the effects of an oil spill on salt marshes (p. 1198): "Salt marshes will suffer a minimal amount of damage as a result of an oil spill. Marsh plants can withstand light to moderate oiling but heavy oiling results in mortality." This assertion is unreferenced, and we believe it is insufficient, at least as applied to east coast salt marshes.

Similar statements were made earlier in the DES (1024-1025) and are based on references to Stebbings (1970), Cowell (1969), Burns and Teal (1971) and Thomas (1973). A careful reading of these references leads us to a different conclusion: salt marshes such as those found along the coast of New England and New York are very susceptible to damage due to oiling.

Stebbings (1970) did indeed find quick recovery (that is, recovery was well underway after 16 months) of a French salt marsh, but the spill he studied had weathered for 14-18 days before coming ahsore. Generally the oil only penetrated 3 cm into the sediments. At one location the oil was at a depth of 15-20 cm and was completely covered with new, uncontaminated sand. The roots of the overlying grasses grew only in this sand and did not penetrate the oil layer.

Cowell's (1969) study indicated much more extensive damage in a British salt marsh following the same spill (Torrey Canyon). The spill was less weathered when it came ashore, and it resulted in heavy mortality of grasses in the marshes except in isolated low-lying regions. Were these areas that were covered by water when the spill came ashore, and thus avoided being oiled? No data is presented on penetration of oil into the sediments.

Thomas (1973) documented extensive damage from a spill of bunker C oil which washed ashore into a Nova Scotia salt marsh. He concluded that if oil penetrates into the sediments and damages the grass rhizomes, recovery is very slow. If the rhizomes are undamaged, though, as might occur when oil does not penetrate very far into the marsh sediments, recovery might be faster. The data from the West Falmouth spill, where oil penetrated 70 cm into the sediments, would tend to support this (Burns and Teal, 1971). Thomas (1973) concludes that recovery is faster when a high sedimentation rate quickly covers the oil, allowing colonization in overlying, uncontaminated sediments as occurred in the French marsh examined by Stebbings (1970).

The sedimentation rate in marshes along the New York and New England coasts is generally quite low, about 0.15 cm per year (Redfield, 1967). They would therefore be expected to recover very slowly from an oil spill. Furthermore, these marshes, unlike European marshes, are permeated by fiddler carb burrows which might be expected to facilitate the transfer of oil into deeper sediments (Jenifer Baker, pers. comm.). This may make the local marshes more susceptible to oiling damage and result in slower recovery.

Several local spills have given us first-hand knowledge of the effects of oil on New England marshes. The West Falmouth spill has been summarized by Teal (unpublished MS): (testimony prepared for Federal District Court, 76 Civ. 1229 (J. B. W.).)

The severe consequences of a spill to a nursery area are illustrated by Wild Harbor. A large fish kill occurred immediately after the oiling. Since the spill happened in September, a time when many species of young fish are not present, the immediate effect was probably minimized. However,the reduction in marsh animal production, on which many species of young fish would depend at the next and consequent spawnings, continued for years due to the oiling, creating a long-lasting effect on the nursery value of the marsh.

The Wild Harbor research offers a number of other lessons in the effect of a spill on coastal wetlands. Where the oil came ashore on the marsh, nearly all life was killed. The year after the spill there was a complete absence of marsh grasses though there was some growth of blue-green algae. All macroscopic marsh animals were missing. Surface sediments contained large amounts of oil which had begun to weather and be degraded by microorganisms. Oil penetrated more than one meter into the muds from which it has been released into the water for six years. The spill was a small one but was of #2 fuel oil, a light oil containing about 40% of the toxic aromatic fraction. Crude petroleum is a mixture of a vast variety of hydrocarbon compounds that can be divided into several fractions. Crudes vary widely in weight and content of the aromatic fraction, but a light crude with a high aromatic content (crude containing about 25% of aromatics) might approach the effects of this fuel oil.

In the more lightly oiled marsh areas, recolonization began but at first the organisms were uniformly contaminated with petroleum hydrocarbons. The residence times of the various petroleum fractions in the mud were nearly four years for the paraffins. This is the waxy fraction of petroleum and the part most readily metabolized by organisms. The residence time is over six years for the toxic 1 and 2 ring aromatics (benzenes and naphthalenes) and over six years (probably decades) for the larger aromatics (which include the carcinogens) and the naphthenes (relatively inert fractions).

The effects of the West Falmouth spill have also been seen in other local spills. A small spill in Quincy, Massachusetts, resulted in damage to another salt marsh, creating a clear outline of dead vegetation where oil came ashore (Ivan Valiela, pers. comm.). A similar effect was observed from a small spill in a marsh at the head of Buzzards Bay. The spill, originally estimated by the Coast Guard to be only two barrels, killed over 150 species of animals (pers. comm., Howard Sanders). All these observations seem to confirm that salt marshes are quite sensitive to spills of all sizes.

Heavy Metals: The DES implies (pp. 744, 774) that daily discharges of oil and metals from formation waters, drilling muds, drill cuttings, small spills, etc., will have no impact on the water quality of the lease tracts and negligible impact on the biological communities. Heavy metals introduced with the drilling muds are partially dismissed with the highly oversimplified statement, "Most metals of concern from the standpoint of possible contributions from oil and gas operations are a part of the biological catalyst system..." (p. 668). This leave a misleading impression. The DES does mention (pp. 666-670) that heavy metals will be introduced into the environment, that they will be taken up by marine organisms, and that food web magnification may occur. However, at no point (except in Appendix 12) is the effect of the metals discussed. Although some of these metals are used in minute quantities in enzyme systems, all of them are toxic at certain concentrations. It is typical of biological systems that too much of anything is toxic, and this is particularly true of heavy metals.

The DES glosses over the subject of drilling muds, yet they represent a major input of metals. Nowhere does the DES give a weight composition of drilling muds. While individual mixtures of drilling mud components vary widely, Simpson (1975) has summarized a typical mixture:

SOME DRILLING MUD CONSTITUENTS

Component	Composition (lb./bbl.)	Concentration*
Bentonite	15-30	19-37 ppt
Lignite	1-6	1-7 ppt
Lignosulfonate	2-10	2.5-12.5 ppt
Sodium hydroxide	.5-1.5	.6-1.9 ppt
Barium sulfate	0-500	0-620 ppt
Bactericide	.1-.5	120-600 ppm

*Barrel weight assumed to be approximately 800 lbs.; DES p. 590.

Most attention has focussed on two of these components. Used as a weighting agent, barium sulfate is the major constituent of the muds. Altogether about 10,000 tons of barium will be discharged with the drilling muds.

Because ferrochrome lignosulfonate, a dispersant and emulsifier, contains 3% chromium, it is one of the more toxic constituents, e. g., Chesser and McKenzie, 1975). The maximum production of drilling muds will be 218 x 10^3 tons in addition to the 1213 x 10^3 tons of drill cuttings produced (values from DES Table I-1, which are different from the values summarized on p. 783). At five ppt in the drilling muds, this would represent an overall discharge of 33 tons of chromium present in a concentration of about 23 ppm.

Tables III-26,27,28 of the DES summarize the input of metals from formation waters. The data in III-26 is presented poorly; no comparison is made with natural waters to allow interpretation. No attempt is made to indicate minimum toxic concentrations. The data in III-28 is incorrect, suffering from conversion errors of three orders of magnitude when compared to pp. 215 and 735. Summarizing the original source (Rittenhouse _et al_., 1969), we find chromium (20-200 times), copper (5-50), manganese (20-200), strontium (1-50) and lithium (55-200) to be much more concentrated in formation waters than normal oceanic waters.

Assuming maximum production from the wells (.65 billion barrels) and a one-to-one ratio for formation waters to oil (p. 609), we calculate the major input of metals will be as follows:

MAJOR HEAVY METAL INPUT FROM DAILY OPERATIONS

Component	Range in formation waters (ppb)	Total from formation waters (tons)	Drilling muds (tons)	Total (tons)
Barium	-	-	10^4	10^4
Copper	10-100	1-10	-	1-10
Chromium	1-10	0.1-1	33	33-34
Lithium	10-35 ppm	1-4 (x10^3)	-	1-4 (x10^3)
Manganese	300-3000	30-300	-	30-300
Strontium	10-45 ppm	1-5 (x10^3)	-	1-5 (x10^3)

The DES (p. 670) indicates that investigations of heavy metal concentrations in the water column around platforms showed concentrations to be in the ranges for ocean water except for zinc. This statement is incomplete because it is neither referenced nor indicates the identity of the metals. It is also wrong. Montalvo and Brady (1975) report increased concentrations of lead, zinc and cadmium around the drilling platforms. The values for lead (50 ppb) and cadmium (20 ppb) are 1000 and 100 times greater than natural levels for oceanic waters reported in Table III-27. Most importantly the authors also indicate higher values near the bottom for zinc which they attribute to resuspension of sediment. From the data above it seems very likely that the sediment surrounding drilling platforms could have elevated values for many of the heavy metals.

It is unreasonable to predict the toxicity of the metals in these sediments in the absence of concentration measurements or estimates. Depending on their chemical speciation, chromium and copper will probably be the most toxic metals released, showing effects in the high ppb, low ppm range (Raymont and Shields, 1963). The fate of the released metals is not well known. They are not "degraded" as stated by the DES (p. 668), but become associated with various inorganic and organic complexes whose nature determines the metals' reactivity. Preliminary data (Montalvo and McKown, 1975) suggest that about half of the total metals sedimented during drilling operations are available biologically.

Additional toxicity will certainly be supplied by the almost 100 tons of bactericide added during the course of drilling to prevent hydrogen sulfide formation. Presently the industry uses aldehydes, quaternary amines, dramine salts and chlorinated phenols (Robichaux, 1975).

Zingula is quoted to report even the "so-called 'sterile' pile of drill cuttings under a platform in the Gulf to be inhabited by benthic organisms" (p. 775). Without knowing what sort of organisms are living there, it is hard to be too encouraged. Certain opportunistic species are quite tolerant of polluted conditions, but these do not necessarily represent desirable conditions.

Total drilling operations will produce 1.4×10^6 of cuttings and muds over the life of the most productive find. This represents approximately (by volume conversion on p. 590, 1 ton = .394 m^3) 5.5×10^5 m^3 or 5500 hectares of sediment 1 cm thick (about one percent of the lease tract area). As a comparison Wright (1975) has indicated that 1 mm layer of drilling fluid settling on the sediments can cause a 50% reduction in the survival of some invertebrate larvae.

The DES implies (p. 739, 775) that the drill cuttings and muds will remain in discrete little piles within the radius of a common turbidity plume in the Gulf of Mexico (about 200 m). We feel that this is most unlikely given the hydrographic conditions on Georges Bank. The DES fails to treat sediment transport at any length, although it hints (pp. 715, 716) that it is significant in a discussion of sediment scour around the Texas Towers. Given the strong tidal mixing and the shallowness of the Bank, we feel these metal-rich sediments produced daily will move over the bottom, increasing greatly the proportion of Bank benthos they affect.

Chronic Oil Releases: As a result of production on Georges Bank, oil will be discharged daily to the surrounding water. During normal operations on board the rigs and platforms, small amounts of oil will be spilled. These spills are removed with solvents (themselves highly toxic), collected and treated before release (p. 737) — regulations can and should require disposal ashore. Co-produced with the oil will be formation waters which contain 30 ppm oil after treatment. Present treatment is by oil-water gravity separation, a process which selectively removes the light gaseous hydrocarbons. Consequently the remaining dissolved hydrocarbons, chiefly the more toxic aromatics, are relatively increased (Moore et al., 1974).

Given the turbidities and currents along the Bank, it seems likely that most of the discharged oily water will be thoroughly mixed through a tidal cycle. Particulate organic matter contains many binding sites for hydrocarbons (Meyers and Quinn, 1973), and should soon transport most of the oil to the sediments. Over the life of the fields, as much as 6.5×10^8 barrels of formation waters will be discharged (p. 733) equivalent to the release of 19,500 barrels of oil.

The DES (p. 733) calculates the effect formation water release will have on the water quality of the lease areas. This calculation is an unsatisfactory underestimate because it does not include a residence time for water on the Bank, and release of formation waters may increase with the age of the well to sometimes more than twice the volume of the oil produced (Brooks, 1975). Nor is there a good estimate of the input of oil from small spills.

We are not aware of reliable data on the hydrocarbon load of water surrounding drilling platforms. Brooks (1975) showed greatly increased concentrations of light hydrocarbons near the Gulf of Mexico platforms, mostly due to gas venting. The data of Brown et al. (1973) suggests that heavy hydrocarbons are enriched in tanker lanes to levels of 1-20 ppb (not "less than ten" as the DES incorrectly states, p. 732) with higher levels in the Gulf of Mexico. These values are in or near the range of potential sub-lethal effects (See below).

Chronic Community Effects: While the affected sediments probably would not suddenly become devoid of life, this does not preclude a significant effect. Time and time again the DES ignores the possibility that a community can be significantly changed without a massive die-off. A general review of pollution literature would suggest that the oil and metals would be perceived as a stress by the benthic community. Community composition would be shifted towards the hardiest individuals which are common to most disturbed environments. We interpret Farrell's (1975) species lists for bivalves and crustacean communities near the Louisiana drill sites to show just this effect, domination by the known opportunistic bivalve *Mulina lateralis* (Rhoads, 1974).

A change in the benthic community structure and population would affect the animals exploiting the bottom. Tables II-38,39,40 of the DES indicate that a majority of the fish on Georges Bank are demersal feeders; so fishery production and composition could be very sensitive to changes in the benthos. In the Gulf of Mexico catch per unit effort has declined and fish type has changed (Onuf, 1973) although any correlation with oil drilling is confounded by a number of other interacting variables. Nonetheless, the trends are not encouraging.

Seemingly subtle changes in the phytoplankton could greatly affect the larval and adult fish which use them as food. The success of year classes of commercial species is extremely tenuous and dependent on suitable food. A change in the phytoplankton from diatoms to microflagellates as shown by Lee and Takahashi (1975) to result from low-level oil pollution could affect many larval and adult fishes of species like herring through the disappearance of their normal food. Even without direct toxicity to the fish, an age class could be destroyed.

Small regions of polluted sediments could also affect migrating fish depending on the rates at which they could detoxify themselves. Depuration studies indicate that even gilled creatures may store some amount of petroleum hydrocarbons for a long time (Teal, 1976) and specific organisms have been shown to accumulate certain ingested hydrocarbons (Blumer *et al.*, 1970). In Australia a point source of refinery wastes in the sediment was found to be tainting white mullet for 100 miles along the coast (Connell, 1974). We have recently witnessed similar instances along our own coast with kepone and PCBs (PCBs also come from widespread discharges).

Toxicity: Lethal and sub-lethal toxicity data are hard to evaluate. When determining concentrations of oil in solution, many investigators have failed to take into account the amount of oil evaporated or absorbed to the sides of the container. Yet the DES's statement (p. 757) -- "Chronic low-level --- Other than the fertilizing effect of sublethal dosages of hydrocarbons upon the phytoplankton, little is known about the sublethal impacts upon the planktonic community" is grossly mistaken, as is a similar statement (p. 747) implying that the high productivity of Raritan Bay is due to oil release rather than the discharge of nutrients from sewage. A survey of the literature shows some striking sub-lethal effects (see Table below).

Many toxicity studies have not tested concentrations down to below the level at which an effect is detectable and therefore have not established minimum toxic concentrations. All but two of the studies listed above found an effect at the lowest concentration used, leaving doubt about how low a concentration is necessary before no effect is detected. Even at the low levels used by Mironov (1972), one species was still found to be inhibited at 10 ppb. It is possible that 10 ppb had an effect on phytoplankton even though Lee and Takahashi (1975) could not detect one, simply because of the difficulty of analyzing the dynamics of a whole community. Despite this difficulty, they were able to detect a change in community type in the CEPEX bags with 20 ppb. Most toxicity experiments are only short term; longer term experiments would probably show effects at lower concentrations.

The lowest level of hydrocarbons tested in any experiment, down to 10 ppb, has usually shown a detectable effect on phytoplankton growth (see next page). Considering the few phytoplankton studies and communities that have been

SOME SUB-LETHAL EFFECTS AT LOW CONCENTRATIONS OF PETROLEUM HYDROCARBONS

Reference	Organism	Time Period	Type of Hydrocarbon	Lowest Conc. Tested	Conc. Having Effect	Effect
Mironov, 1972	phytoplankton, various spp.	hours	oil and oil products	10 ppb	10-100 ppb	growth inhibition
Pulich, *et al.*, 1974	phytoplankton, *Thalassiosira pseudonana*	hours	#2 fuel oil	40 ppb	40 ppb	growth inhibition
Lee and Takahashi, 1975	phytoplankton, various spp.	19 days	#2 fuel oil	10 ppb	20 ppb	microflagellates replaced diatoms
Mironov, 1968	plaice eggs	days	oil and oil products	10 ppb	10 ppb	40% mortality
Linden, 1976	amphipod, *Gammarus oceanicus*	20-23 days	Venezuelan crude oil	1 ppm added 0.3-0.4 ppm detected	1 ppm 0.3-0.4 ppm	reduced reproduction
Jacobson and Boylan, 1973	gastropod, *Nassarius obsoletus*	minutes	Kerosene extract	4 ppb	4 ppb	interference with chemoreception
Stegeman, 1976	fish, *Fundulus* and *Stenotomus*	up to 1 month	#2 fuel oil	125-200 ppb	125-200 ppb	altered metabolic systems
Stegeman and Teal, 1973	oyster, *Crassostrea virginica*	50 days	#2 fuel oil	106 ppb	106 ppb	20-fold increase in hydrocarbon content
Corner, *et al.*, 1976	copepod, *Calanus helgolandicus*	hours	naphthalene	0.1 ppb	0.1 ppb	organism's conc. increases and not all is released
Nelson-Smith, 1973	oyster, *Crassostrea virginica*	months	unknown	10 ppb	10 ppb	tainting

studied and that these are coastal and culturable species which tend to be the hardiest, it is a distinct possibility that lower concentrations could have an effect on the phytoplankton. Furthermore, the toxicity studies have only looked at growth. No one has determined how petroleum may affect the life cycle of phytoplankton, which could be crucial to their continued survival.

Experiments showing the slight stimulation of photosynthesis at levels of 10-30 ppb of Venezuelan crude oil (Gordon and Prouse, 1973; the paper cited by the DES, p. 746) may confirm the results of Lee and Takahashi instead of showing a beneficial effect. It is likely that Gordon and Prouse's results reflect a change in the composition of the phytoplankton. They did not look at the species composition, and their experiment only ran for 24 hours so it is difficult to compare it to the longer term CEPEX experiments.

Mironov (1968) also found that 10 ppb petroleum caused 40% mortality in plaice eggs. When both lethal and sub-lethal effects are considered, perhaps lower concentrations would change egg viability.

Tainting: Even at concentrations which do not affect the health of the organisms, it is possible that the suitability of the organisms for human food may be reduced. Nelson-Smith (1973) found that oysters exposed to 10 ppb of petroleum hydrocarbons became tainted. The lowest levels tested for uptake by organisms is in Corner *et al.*'s (1976) work in which naphthalene was taken up by a copepod in significant amounts from water containing .1 ppb naphthalene. We can only speculate on the lowest levels necessary to cause tainting of marine organisms important to the fisheries.

Other Effects: We have only fragmentary knowledge of how other biological processes are affected by oil. Jacobsen and Boylan (1973) found that 4 ppb kerosene extract interfered with chemoreception which is of great importance for the survival of many marine organisms. The possibility of the accumulation of carcinogens from oil by marine organisms is suggested by the work of Shimkin *et al.* (1951) who identified carcinogens in barnacles on creosoted pilings. Powell *et al.* (1970) have shown that bryozoans placed in boat basins develop abnormalities which they attribute to low levels of carcinogens in the water.

ENVIRONMENTAL STUDIES PROGRAM

Hopefully many of the uncertainties expressed in the preceding pages could be explored by proper scientific studies, and then either verified as real dangers or dismissed. Indeed the DES asserts that such will be the case. The BLM has established an environmental studies program whose objectives are to enable the BLM to "detect the impact of OCS oil and gas exploration and development on the marine environment" and establish "guidelines permitting efficient resources recovery while also ensuring the protection of the marine environment" (pp. 26-27).

We are not convinced that the proposed environmental studies program can meet the stated objectives. The biological section would best be described as a cataloguing, although an incomplete one. The phytoplankton are totally ignored as well as neuston sampling for larvae. Without good controls it could be hard to separate a natural catastrophic change (like the eelgrass die-off 40 years ago, Renn, 1937) from one caused by pollution. Year to year variability, a particularly important phenomenon (for example, strong age classes demonstrated by the various species of fish), is also ignored.

The biological and chemical processes determining the interactions between organisms and oil are mostly ignored. Community processes such as productivity or mineral cycling are not even mentioned. A much better understanding of the following processes is necessary: distribution and fates of petroleum hydrocarbons and hetero-compounds, toxicity of end products of hydrocarbon metabolism, genetic changes in response to oil and food chain transfer to name just a few.

A number of drastic changes which greatly affect the community would probably not even be detected by the proposed program yet reverberate through the fishery. Examples might include larval death on a large scale or a shift in the size range of the phytoplankton community.

CONCLUSIONS

The Draft Environmental Statement for Outer Continental Shelf lease sale No. 42 is insufficient for the following reasons:

(1) The integrative nature of biological communities is not emphasized. Sub-lethal changes in community structure and function are not sufficiently addressed, particularly as such changes may affect phytoplankton, fish larvae and bottom communities.

(2) The accumulation and persistence of oil and metals in the water column and the sediments and their effects on bottom communities is inadequately presented.

(3) Recovery times implied for communities after an oil spill are mistakenly short, possibly because recovery is wrongly implied to be recolonization rather than the return of similar organisms, interactions and processes as occurred before a spill.

(4) The effects of chronic discharges and small spills are largely ignored.

(5) The assessment of the possible impacts of oil exploitation on endangered species and coastal environments is inadequate.

(6) The analysis of the effects of large spills underrates the harmful effects of weathered oil and fails to clearly represent the large errors possible using spill trajectory models.

(7) The assessment of oil spill statistics contains many errors and underestimates the spillage from tankers.

(8) The analysis does not clearly show how much of New England's present and projected energy needs can be met by the development of Georges Bank oil.

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