

## Possible Accumulation of Heavy Metals Around Offshore Oil Production Facilities in the Beaufort Sea

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**ABSTRACT.** The heavy metals chromium, zinc, cadmium and lead have accumulated in the sediments around some offshore oil rigs. Oil production is now being considered for some nearshore sections of the Beaufort Sea coast. During winter in the Beaufort Sea, heavy metals in the sediments will not be dispersed; the under-ice currents are slow, and some of the bottom is covered by very saline, relatively stagnant water. Heavy metals in the sediments can probably be assimilated by epibenthic animals in the nearshore region, and then transferred through the food chain to natives who partially subsist on marine animals.

There have been many field studies on the accumulation of heavy metals in the sediments around offshore oil and gas production facilities. A study of the East Flower Garden Bank off Texas, funded by Mobil Oil Corporation, found a threefold increase in the concentration of lead near the drill site (Anon., 1975). Another study of the offshore Texas area found about threefold increases in the concentrations of zinc, cadmium and lead (Holmes and Barnes, 1977). A study of the Tanner Bank oil field off California, funded by Shell Oil Company, found a threefold increase in the concentration of chromium, and a fortyfold increase in the concentration of lead (Anon., 1978a). The exact reasons for these increased concentrations of heavy metals are not obvious.

One possible source of heavy metals is drilling muds. In the Beaufort Sea, an estimated 5,000 barrels (800 m<sup>3</sup>) of drilling muds will be discharged around each offshore oil "field" during each year of operation. Many of the drilling muds are trade products, and the exact chemical composition is not made available. Petroleum, with its heavy metal components of vanadium and chromium, is another possible source of heavy metals. Holmes and Barnes (1977) state that fuel used by supply vessels and the drilling rig may be the source of the heavy metals found in the offshore Texas area.

Fast water currents that scour the bottom can disperse the sediments and heavy metals. During the summer in the Beaufort Sea, the current speeds are closely related to the winds speeds. The wind-driven currents are often rapid, and mix the water column into a turbid state. During the winter, conditions are much different. The wind has little affect on the water surface because of the ice cover, and the currents under the ice are slow. The maximum surges of current are about 10 cm/sec; tidal currents are generally about one cm/sec; and the mean flow of the water during a week may average only one-tenth cm/sec (Aagaard and Haugen, 1977; Anon., 1978b).

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The absence of currents that can disperse sediments and heavy metals will possibly be compounded by another under-ice phenomenon. As sea ice freezes, saline brine is excluded; this saline brine is heavier than normal seawater, so it sinks to the bottom. The presence of this heavy brine on the nearshore sea bottom in winter can be seen in some of the under-ice salinity profiles that were measured in Harrison Bay, just to the west of Prudhoe Bay (Kinney *et al.*, 1971). The heavy brine collects on the bottoms of any lagoons or shallow basins that do not flush or drain easily. For example, there was heavy brine with a salinity of 70 parts per thousand in the shallow basin within Prudhoe bay in May (Horner *et al.*, 1974), and brine with salinities of 80-100 parts in nearby Simpson Lagoon by the end of the winter (Anon., 1978b).

In regions of the Beaufort Sea which may be leased for offshore oil production, there are many similar shallow basins that might collect heavy

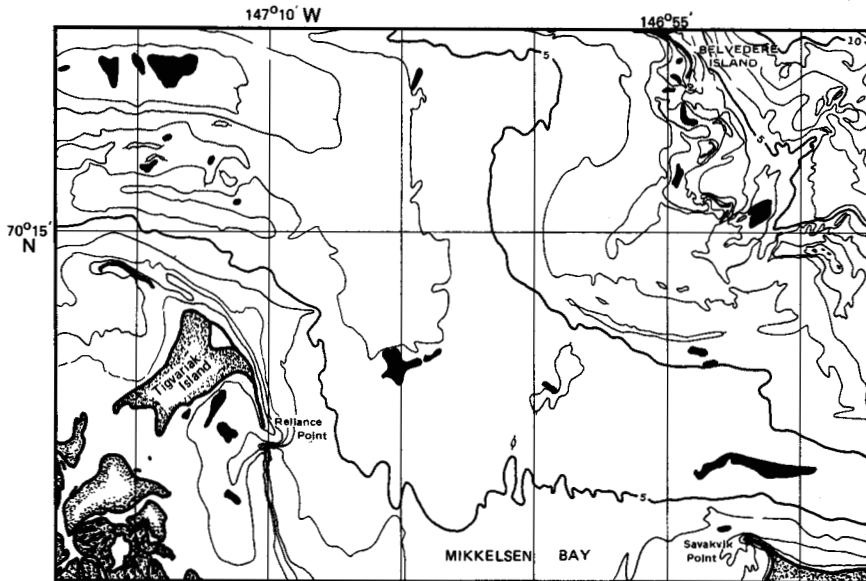


FIG. 1. A sample of the detailed bathymetry in Mikkelsen Bay, 50 km east of Prudhoe Bay. The dark shading shows basins in the sea bottom that are deeper than the surrounding sea bottom. Depths are in metres. Scale is 1 : 79,000. Map source: Bathymetric Map No. 12-75, E. Reimnitz, U.S. Geological Survey, Menlo Park, California.

saline water. Figure 1 shows a sample of detailed bottom bathymetry 50 km east of Prudhoe Bay, with dark shading on basins in the sea bottom that are deeper than the surrounding sea bottom.

In the future, additional shallow basins may be created when artificial islands, pipelines or sea bottom "glory holes" for blowout preventers are dredged into the bottom. Each of these shallow basins has the potential to collect heavy saline water that would not be completely flushed by the slow under-ice currents during winter. The proximity of the dredged basins to oil

production facilities means that potential sources of heavy metals would be surrounded by basins of possibly stagnant water during the long winters.

Epibenthic animals, such as the euryhaline amphipods and isopods, reside throughout the winter in shallow areas of the Beaufort Sea. Recently, they have been observed by several investigators studying the nearshore under-ice environment (Bendock, 1977 p. 265; Anon., 1978b; Dr. J. Brian Matthews, Univ. of Alaska, and Ken Dunton, Western Washington State College, pers. comm., 1978). By the end of the winter the epibenthic animals probably become concentrated in refugia, or saline basins, which never freeze solid and which collect detrital food on the bottom.

Epibenthic animals can probably assimilate heavy metals from the sediments. Beaufort Sea epibenthic amphipods and isopods feed on bottom detritus, and will consume detritus that is tainted with north slope crude oil (Broad, 1978; Percy and Mullin, 1975). A long time period may be necessary for assimilation and concentration of heavy metals. In a Gulf of Mexico study, the epibenthic species were continually replaced by other species, so no conclusive evidence of heavy metal assimilation was found (Holmes and Barnes 1977). In the Beaufort Sea, the overwintering populations are restricted and localized by the ice cover, so the period of exposure to possibly contaminated sediments may last for 8 months (Anon., 1978b). Even if the epibenthic animals don't accumulate high concentrations of heavy metals in their tissues, their predators may accumulate high concentrations, as indicated by the much greater natural concentration of cadmium in Bering Sea seals than in their benthic prey (Burrell, 1978).

The under-ice food chain from epibenthic animals to eskimos is direct. Arctic cod and ringed seals, which feed on epibenthic animals, are consumed by natives. The natives use of arctic cod and ringed seals has decreased with the decline in the use of sled dogs, but most of the meat consumed by natives still comes from their immediate surroundings (Brackel, 1977; Jamison *et al.*, 1978).

In summary, the possibility exists for heavy metal accumulation in the sediments around offshore oil production facilities, and then biological assimilation and transfer through the marine food chain to local natives. Though the possibility may be small, the consequence of chromium or lead transferring to humans would be hazardous. Future establishment of a proper monitoring program of marine animal tissues would determine if hazardous concentrations were being transferred to natives.

#### ACKNOWLEDGEMENTS

Several colleagues at the Alaska — Outer Continental Shelf Office have helped with the development of these ideas. Jim Seidl, Judy Gottlieb and Elaine Pratt provided suggestions. Joe Dygas helped greatly through long discussions. Anne Newbury and Don Henninger provided supportive encouragement. Eileen Carlton edited the manuscript. Jane Glynn and Frank White drew the illustration. While I have received much help from the Alaska OCS Office, these ideas in no way represent an official policy of the Office.

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