Impacts of Petroleum Development in the Arctic

In their article "Cumulative impacts of oil fields on northern Alaskan landscapes," D. A. Walker *et al.* (*1*) document some direct and indirect impacts of petroleum development in the Arctic on selected portions of the Prudhoe Bay Oil Field. While most of the *kinds* of impacts they discuss are valid points to consider in designing an arctic oil field, the *magnitude* of what they describe is not representative of the Prudhoe Bay field, in general, or of newer oil fields, such as Kuparuk to the west of Prudhoe. It is even less applicable in areas of higher topographic relief, such as the coastal plain of the Arctic National Wildlife Refuge (ANWR).

Any development will cause an impact to the land. In the Arctic, as noted by Walker *et al.*, gravel roads and pads have been built that are thick enough to support facilities while the thermal integrity of the underlying permafrost is maintained. Decision-makers must evaluate whether or not the gains of development are worth the impacts incurred. Accurate assessment of both direct and indirect impacts is essential.

In the abstract, Walker *et al.* state that "flooding and thermokarst covered more than twice the area directly affected by roads and other construction activities" in thaw-lake plains. In a draft report of their study, the authors stated (*2*) that their map 22 (shown in their figure 1) "must not be used to make interpretations for the field as a whole. We emphasize that it is a worst-case scenario within the Prudhoe Bay field." In the *Science* article, notification that their analysis was conducted "in the most heavily disturbed portions of the oil field" appears only in a footnote.

From figure 5 of the article by Walker *et al.* it can be calculated that the indirect impacts shown in map 32 (also shown in their figure 1) are only one-third those of the direct impacts. If this worst-case area (second only to map 22) were representative of the entire field, the total impact to the landscape would still equal only about 2.5% of the oil field. Few roads in oil fields are as heavily traveled as the one depicted in their figure 3. Most are drill-site access roads that have infrequent traffic and consequently far less dust.

Roads traversing the tundra require culverts to maintain normal drainage patterns. In defined drainages, multiple culverts are installed to accommodate high flows (15 to 35 m^3/s) during "breakup," the <2-week period of spring thaw, as well as the low flows (approaching 0 m^3/s) that prevail for the remainder of the summer (*3*). In flatter areas, single culverts are placed in intervals to allow drainage of sheet flow during breakup. During this period of area-wide flooding, temporary (<1 week) impoundments may occur. Culverts that are not optimally placed or that become damaged can result in permanent impoundments which remain until the situation is repaired. For example, the impoundment depicted in figure 2 of Walker *et al.* has been eliminated by better culverts. The art and science of culverting in areas of near-surface permafrost is one of the lessons learned in the Prudhoe Bay Oil Field. Consequently, large impoundments do not occur in the Kuparuk field.

Walker *et al.* correctly point out that the timing of aerial photography can bias the estimate of the amount of impoundments. The year-15 photography (see their figure 5) was taken on 4 July 1983, when there was still ice on some of the lakes and snow and ice was plugging some culverts. Two weeks after the photographs had been taken, most large impoundments had drained. Had 1984 (year-16, August photography) been included in their analysis, a substantial reduction in flooding would have been documented. It is now standard practice to clear culverts before the spring thaw to minimize the formation of temporary impoundments.

It is often assumed that any man-made change, for example, the alteration of the "mosaic of water and terrestrial microsites essential for waterfowl and shorebird[s]," is always deleterious. Actually, such alteration can have a positive (attraction), negative (avoidance), or no effect on bird distribution, depending on the species (*4, 5*). For example, the "other roadside impoundments" mentioned in figure 2 of Walker *et al.* have been judged to have high habitat value for waterfowl, and federal regulatory agencies have not allowed rectification of these impoundments.

Contrary to the statement that dry sites are "most valuable for waterfowl and shorebirds," dry and moist habitats are not nearly as important to shorebirds and waterfowl as are wet and aquatic habitats (Fig. 1). The lack of abundance of a habitat does not necessarily result in that habitat being more valuable. State and federal agencies require that wetter areas are avoided as much as possible and encourage construction on drier sites.

With regard to the concern expressed by Walker *et al.* about industry operations heating the tundra, it should be noted that (as mentioned in their article) oil-field facilities are constructed specifically to limit the transfer of heat to the underlying permafrost. Otherwise differential settling of facilities would occur, resulting in damage to expensive equipment and shutdown of operations. Additionally, if general climatic warming sufficient to "lead to more extensive thawing of ground ice" were to occur, the ultimate consequences to permafrost regions would be far broader than the combined effect of oil field operations. In contrast to the authors' speculations about heating is the documentation of the cooling of permafrost under oil field gravel pads, perhaps because of a thinner layer of insulating snow during winter (*6*).

The statement by Walker *et al.* that "the amount of thermokarst just exceeds the area covered by roads on the flat thaw-lake plains" is not supported by their figure 5, which shows that, for the areas studied, the thermokarst area is approximately 64% of the road area. Walker *et al.* state that flat thaw-lake plains, and floodplain and terraces "are areas of distinct similar geobotanical character," then subsequently describe their differences.

Areas of greater topographic relief, such as the ANWR, should encounter fewer thermokarst problems than described here. It is much easier to properly culvert roads in hilly areas with defined drainages. Better drainage control leads to less impoundment, which leads to less thermokarst. Moreover, contrary to the statement made by Walker *et al.*, there is evidence which suggests that much of the better drained landscape of the ANWR is thaw-stable and does not have highly ice-rich soil (*7*).

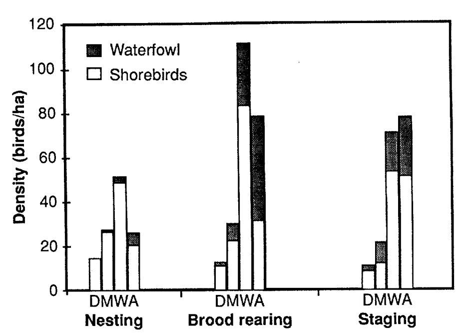

Fig. 1. Seasonal habitat use of an area west of the Prudhoe Bay Oil Field by waterfowl and shorebirds. The area sampled (93 km^2) covered all available habitats. D = dry, M = moist, W = wet, and A = aquatic including riparian and shoreline areas. All birds observed during a life history sampling period were counted, not merely the birds performing the named activity. The sampling periods were Nesting, 16 to 24 June 1984; Brood rearing, 15 July to 19 August 1984; and Staging, 20 to 30 August 1984 (*14*).

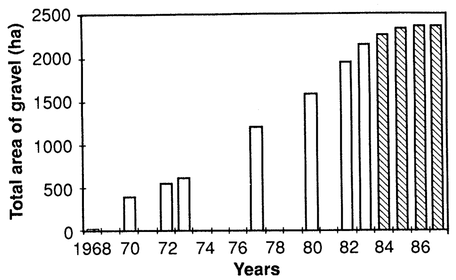

Fig. 2. Total area of gravel placement (pads and roads) in the Prudhoe Bay Oil Field through 1987. Amounts for the last 4 years were calculated by adding the yearly increments to the 1983 value of Walker *et al.* (*1*). The industry estimate for the total gravel area through 1987 is 1910 ha (*8*).

The authors' description of development in the Arctic oil fields requires some modification and updating. The Prudhoe Bay Unit extends beyond the Kuparuk and Sagavanirktok Rivers to the west and east and includes an area of more than 950 km^2. Estimates of gravel coverage in the unit total 19 km^2 (2% of the unit) through winter 1987 (*8*). Gravel coverage in the Kuparuk Unit is less than 1%, which reflects evolution in oil field development design. The pace of development is no longer proceeding at a nearly constant rate, but has abated sharply in the 4 years since the data of Walker *et al.* were collected (Fig. 2). Current drilling technology allows close spacing of many wells on a pad without enlarging the pad. While most of the Prudhoe Bay field now has eight wells per square mile [80-acre (32-hectare) spacing], the gravel drill-pads are approximately 2 miles (3.2 km) apart. The subsurface target areas are reached by directional drilling. Increases in gravel on the tundra are usually a function of developing new areas of the reservoir, not increases in well density.

After several years of study, the U.S Fish and Wildlife Service and the Alaska Department of Fish and Game have concluded that floodplains may be ideal sources of gravel with beneficial secondary utility (*9*). Spent mines that have been rehabilitated by flooding from the adjacent stream can provide excellent overwintering habitat for freshwater and anadromous fish.

Once a decision to proceed with a development is made, concern over aesthetics becomes somewhat moot: an oil field will not look like pristine, untouched wilderness. Most (>98%) of the field will remain as open space, however, and the appropriate concern is whether or not wildlife will continue to use it. Of the many functional values attributed to wetlands, most are absent or have limited presence in permafrost-based wetlands. One important attribute that does remain is that of bird habitat (*10*). Habitat does not appear to be a limiting factor controlling bird densities on the North Slope. Other wetland areas in Alaska are orders of magnitude more productive for waterfowl (*11*). While positive and negative distributional changes have been noted next to roads and pads, oil field operations do not generally result in disturbance effects that displace birds from normal habitats (*12*). Nor has "fragmentation" of habitat by the roads resulted in decreased bird use (*5*). Regarding wildlife corridors and calving grounds, data from the Kuparuk oil field, which, unlike Prudhoe Bay, is a historically high-use area for caribou, show that, while there have been some distributional changes in the vicinity of facilities, caribou have continued to use traditional calving grounds and insect relief areas within the oil field. Further, this caribou herd has tripled in size during development of this oil field, demonstrating that environmentally conscientious oil development can coexist with wildlife (*13*).

I agree with the authors' opinion that development in new areas should be preceded by comprehensive regional planning that includes an evaluation of cumulative impacts. However, I strongly disagree that large impacts "are likely to occur on the coastal plain in the next few years." Current design, construction, and operation techniques will keep indirect impacts to the landscape at negligible amounts and allow continued wildlife use of the area with little detrimental impact.

In summary, development of other Arctic regions is not likely to induce changes similar to those described in these worst-case areas of Prudhoe Bay.

Scott B. Robertson
Environmental Affairs Department,
ARCO Alaska, Inc.,
Post Office Box 100360,
Anchorage, AK 99510

REFERENCES

1. D. A. Walker *et al.*, *Science* **238**, 757 (1987).
2. D. A. Walker *et al.*, "The use of geobotanical maps and automated mapping techniques to study the historical changes in the Prudhoe Bay Oil Field, Alaska" (draft final report prepared for the U.S. Fish and Wildlife Service, Anchorage, AK 1984).
3. B. Drage, J. F. Gilman, D. Hoch, L. Griffiths, in *Proceedings of the Fourth International Permafrost Conference*, Fairbanks, AK (1983), pp. 249–254; Peratrovich, Nottingham, & Drage, Inc., "1985 summer hydrology program, Kuparuk development area" (report prepared for ARCO Alaska, Inc., Anchorage, AK, 1985).
4. D. M. Troy, D. R. Herter, R. M. Burgess, "Prudhoe Bay Waterflood Environmental Monitoring Program 1982, Tundra Bird Monitoring Program" (report prepared for the U.S. Army Corps of Engineers, Alaska District, Anchorage, AK, 1983).
5. D. M. Troy, "Bird use of the Prudhoe Bay Oil Field during the 1986 nesting season" (report prepared for Alaska Oil and Gas Association, Anchorage, AK, 1988).
6. A. H. Lachenbruch and B. V. Marshall, *Science* **234**, 689 (1986).
7. Unpublished data, soil borings taken during petroleum industry seismic survey.
8. Computation by Registered Professional Land Surveyors with Kuupik Technical Services, Inc., Anchorage, AK (1987).
9. M. R. Joyce, L. A. Rundquist, L. L. Moulton, "Gravel removal guidelines manual for arctic and subarctic floodplains" (FWS/OBS-80/09, U.S. Fish and Wildlife Service, Anchorage, AK, 1980); A. G. Ott, Habitat Division, Alaska Department of Fish and Game, personal communication.
10. S. B. Robertson, *Proc. Coast. Zone '87* (1987), p. 5295.
11. D. V. Derksen, T. C. Rothe, W. D. Eldridge, "Use of wetland habitats by birds in the National Petroleum Reserve—Alaska" (Resource Publ. 141, U.S. Fish and Wildlife Service, Anchorage, AK, 1981).
12. P. D. Hampton *et al.*, "An evaluation of the effects of noise on waterfowl in the vicinity of CPF-3, Kuparuk Field, 1985–1986" (report prepared for ARCO Alaska, Inc., Anchorage, AK, 1987); S. M. Murphy, B. A. Anderson, C. L. Cranor, R. H. Day, "The effects of the Lisburne development project on geese and swans, 1986" (report prepared for ARCO Alaska, Inc., Anchorage, AK, 1987).
13. S. B. Robertson, *Proc. Coast. Zone '87* (1987), p. 3040.
14. "West Sak development, environmental studies, birds and wetlands" (report prepared by Woodward-Clyde Consultants and Entrix, Inc. for ARCO Alaska, Inc., Anchorage, AK, 1985).

29 January 1988; revised 1 August 1988; accepted 10 January 1989

Response: Robertson's defense of the environmental record of the oil industry in northern Alaska points out many steps the industry has taken to minimize impacts, but it largely misses the point of our article. The cumulative effects of the existing oil fields need to be assessed before new developments can be planned. Our studies were a first step which chronicled the history and extent of direct terrain alterations that can be mapped from a historical series of aerial photographs. Our 1:24,000 scale maps accurately portrayed for the great majority of the field the timing and acreages of direct impacts (those where the areas affected are planned, such as gravel roads and pads). At the 1:6000 scale, we were able to map many indirect impacts (those that are unplanned, such as flooding, dust, and thermokarst). At that scale, we focused on areas of intensive development because these were most interesting from the standpoint of cumulative impact and because we did not have the resources to map the entire field. We did not intend to imply that our 1:6000 scale data were representative of the entire field. They are representative only of the more intensively developed areas. Even so, the total mapped area covered about 63 square kilometers and included 31% of the total roads, 25% of the gravel pads, and 27% of the permanently flooded areas within the Prudhoe Bay Oil Field. We did not map the actual "worst case" of development in the oil field. This occurred in the area near the main airport at Deadhorse, where oil field contractors, hotel operators, tourist facilities, and retail merchants have been attracted by