EFFECTIVENESS OF THREE WATERFOWL DETERRENTS ON NATURAL AND POLLUTED PONDS

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Abstract: In 1975, 3 types of waterfowl deterrent (a model falcon, a moving series of reflectors suspended from a frame, and a human effigy) mounted on floats, were tested for efficacy in deterring waterfowl from entering a series of small natural ponds in the boreal forest of Alberta. Only the effigy appeared to be effective; diving ducks of the genus *Aythya* were affected most. In 1976, the human effigy was tested on an artificial tailings pond that received aqueous and bituminous effluent from an oil sands extraction plant near Fort McMurray, Alberta. Twenty-seven effigies were deployed over the 150-ha pond. Their effectiveness was judged by comparing the number of waterfowl dying in and associated with this pond in 1975 (without deterrents) with number dying in and associated with it in 1976 (with deterrents). Kill figures in 1976 were significantly lower than expected on the basis of relative abundance of birds in the 2 years. We concluded that this decline was due to the presence of the effigies.

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An ability to deter waterfowl from using aquatic habitats that have become potentially lethal, either through disease organisms such as botulinum or chemical pollutants such as petroleum in its various forms, has become a major concern for agencies and individuals managing waterfowl. Deterring ducks and geese from such areas, particularly when they encompass locations where these birds concentrate while migrating, molting, or nesting, are largely untried (Davis et al. 1974).

We tested 3 types of bird deterrents. In this report we record their efficacy in preventing waterfowl from entering natural and artificial ponds in the boreal forest of Alberta.

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METHODS

In 1975 we tested the efficacy of deterrents in preventing waterfowl from using a series of small natural ponds (0.3 to 3.8 ha) in the boreal forest near Utikuma Lake, Alberta (56°03′N, 115°30′W). We chose these ponds because they were known to attract a wide variety of waterfowl (Donaghey 1974). They also resembled ponds near Fort McMurray, Alberta, about 100 km northeast, where it had become necessary to deter waterfowl from artificial ponds created for effluents from an oil sands extraction plant. The scaring devices chosen were a model of an avian predator, aluminum reflectors suspended from a frame, and a model of a man.

The model avian predator was a simulated flying falcon with a wingspan of about 40 cm. It was constructed of wood and plastic, painted slate grey with black streaks, and mounted in a soaring position. The model was secured to the end of a 4-m long, hollow aluminum pole by means of smaller diameter pipe attached to its ventral surface. The base of the aluminum pole was fitted into another pipe that was welded to a base plate and that, in turn, was bolted to a plywood platform. The platform was attached to floats and the whole complex was placed, by means of ropes, in a central location on the pond. When in place, waves and wind caused the model to sway back and forth describing a small arc.

A series of aluminum pie plates, suspended by varying lengths of line, acted as reflectors. Ten of them were attached via fishing-line swivels to a commercially-available revolving rectangular clothesline (1 × 1.5 m). This deterrent was attached to a base plate, erected and deployed in the same manner as the model falcon. Wind and waves caused the pie plates to move, creating noise and reflections.

The human effigy was a clothed commercial manikin. The clothes consisted of bright orange coveralls and a knee-length bright yellow plastic raincoat. The manikin was bolted to a platform and steadied with guy wires. As with the other deterrents it was held at mid-pond position by means of ropes.

The floats that proved most satisfactory were 2 aluminum boxes (30 × 28 × 150 cm) packed with styrofoam. These boxes were attached to opposite ends of a sheet of plywood (1 × 120 × 190 cm).

Evaluation of the efficacy of these 3 types of deterrents was based on comparative daily counts of waterfowl on the 3 test ponds (A, B, and C) and 2 control ponds (D and E) lacking deterrents. All contained water of variable depth throughout the summer and were surrounded with a narrow belt of emergent vegetation (Type V: Mann 1964, Donaghey 1974). Species and numbers of waterfowl present on the pond surface were counted at dawn and dusk. In addition to counting the numbers of species present on the ponds, we recorded meteorological conditions and behavior of the birds in relation to the deterrents.

In 1976 we retested the human effigy, the most effective of the 3 deterrents, on a tailings pond that received both aqueous and bituminous effluent from an oil sands extraction plant. We chose this pond (150 ha) because we knew that birds were dying in it as the result of bitumen fouling (Smith et al. 1975). In view of the apparently limited effective radius of the effigy, we had 27 of them placed evenly over this pond by 22 April 1976.

Our approach in evaluating the effectiveness of the human effigy in deterring waterfowl from entering the tailings pond was a comparative one. We postulated that the presence of the deterrents would reduce the number of birds becoming fouled in these waters. To test this hypothesis we compared the number of birds found dead or dying in this pond in 1975 before deterrent installation with the number found in 1976. Such an approach was valid only if we could show that any change between years in numbers of birds found dead was the result of the treatment and not some extraneous factor such as a change in the numbers of birds exposed to the pond. Furthermore, we had to know that the remains of birds found in the pond represented birds dying in that year.

In 1975 and 1976, we regularly searched the shorelines, and occasionally the surface, of the tailings pond. The number, species, and state of decay of all birds found were recorded. As well, each year we recorded the number and species of all birds seen moving along the shoreline or flying over the surface of the tailings pond during a series of 1-hour observations from a blind on the dike above the pond. We observed these birds at dawn and dusk. As an additional index of avian populations in the vicinity of the

Table 1. Mean number of waterfowl counted on ponds lacking deterrents (D and E) in 1975.

Species	1–31 May		1 Jun–15 Aug		16 Aug–30 Sep	
	Pond D	Pond E	Pond D	Pond E	Pond D	Pond E
Red-necked grebe (*Podiceps grisegena*)	1.4	2.0	1.4	1.5		0.1
Blue-winged teal (*Anas discors*)	1.9	1.0	0.2	0.2	0.2	3.0
Ring-necked duck/lesser scaup[a] (*Aythya collaris*/*A. affinis*)	1.8	8.0	0.5	3.5	2.8	0.4
Bufflehead (*Bucephala albeola*)	0.4	1.7		0.7	0.3	0.5
Totals	5.5	13.4	3.1	6.2	3.3	5.0

[a] Ring-necked duck and lesser scaup combined because it was not always possible to distinguish the females in the field.

tailings pond, each year we recorded the number and species of birds seen on regular visits to 6 small natural ponds within 1 km of the test pond.

The rate of decay of birds dying in the tailings pond was ascertained by placing 5 dead western grebes (*Aechmophorus occidentalis*) in the pond in late July. The rate of decomposition in this sample was followed by inspecting the grebes daily. We repeated this procedure in early September using 3 diving ducks, all of which had been killed after becoming heavily fouled with bitumen.

RESULTS AND DISCUSSION

In analyzing the use of the natural ponds by waterfowl near Utikuma Lake we included only adult-sized loons, grebes, ducks, and coots.

To analyze the impact of deterrents on the use of the natural ponds we first determined the influence of (1) time of observation (morning vs. evening) on the number of birds recorded, (2) differing weather conditions on the number of waterfowl observed, and (3) season on the expected number of ducks on the test ponds.

Morning observations gave indices of use (3.4 to 15.7 duck-minutes) similar ($P > 0.5$) to those recorded in the evening (2.7 to 14.7 duck-minutes). Thus, we used both morning and evening indices for determining the effect of deterrents.

Weather conditions were categorized as optimum when skies were clear or with scattered cloud cover, winds were less than 17 km/hour, and there was no precipitation; and less than optimum when cloud cover was broken or com-

Table 2. Mean number of ducks and (range) recorded per visit on Pond A near Utikuma Lake, Alberta, 1975. This pond was visited 26 times before and 53 times after installation of the model falcon.

Species	Without deterrent (12 May–26 Jun)	With model falcon deterrent (27 Jun–10 Oct)
Mallard (*Anas platyrhynchos*)	0.35 (0–3)	0.13 (0–2)
Green-winged teal (*A. crecca*)		0.09 (0–4)
American wigeon (*A. americana*)	0.04 (0–1)	
Redhead (*Aythya americana*)		0.13 (0–2)
Ring-necked duck/ lesser scaup	1.42 (0–6)	0.30 (0–2)
Bufflehead	1.54 (0–5)	0.39 (0–2)
Totals	3.35	1.04
Ratio (without:with)	1:0.31	

Table 3. Mean number of ducks and (range) recorded per visit on 2 small ponds (D and E) without deterrents near Utikuma Lake, Alberta, 1975.

Species	Pond D					
	12 May–25 Jun (24)[a]	27 Jun–8 Oct (37)	12 May–4 Jul (29)	9 Jul–8 Oct (32)	12 May–22 Jul (39)	23 Jul–8 Oct (24)
Red-necked grebe	1.38 (0–2)	0.70 (0–2)	1.48 (0–2)	0.50 (0–2)	1.49 (0–2)	0.17 (0–2)
Mallard	1.38 (0–5)	0.22 (0–2)	1.14 (0–5)	0.25 (0–2)	0.89 (0–5)	0.33 (0–2)
Green-winged teal	0.25 (0–3)	0.03 (0–1)	0.21 (0–3)	0.03 (0–1)	0.16 (0–3)	0.04 (0–1)
Blue-winged teal	0.13 (0–2)		0.11 (0–2)		0.08 (0–2)	
Ring-necked duck/lesser scaup	1.67 (0–6)	1.68 (0–23)	1.38 (0–6)	1.94 (0–23)	1.08 (0–6)	2.58 (0–23)
Common goldeneye (*Bucephala clangula*)						
Bufflehead	0.33 (0–3)	0.27 (0–5)	0.28 (0–3)	0.31 (0–5)	0.22 (0–3)	0.42 (0–5)
White-winged scoter (*Melanitta deglandi*)						
Total	5.14	2.90	4.60	3.03	3.92	3.54
Ratio (before:after)	1:0.56		1:0.66		1:0.90	

Species	Pond E					
	23 May–25 Jun (13)	27 Jun–23 Sep (16)	23 May–8 Jul (20)	9 Jul–23 Sep (9)	23 May–11 Jul (23)	17 Aug–23 Sep (6)
Red-necked grebe	1.62 (0–3)	0.94 (0–2)	1.45 (0–3)	0.78 (0–2)	1.52 (0–3)	0.17 (0–1)
Mallard	0.23 (0–3)	1.75 (0–6)	0.30 (0–3)	2.78 (0–6)	0.30 (0–3)	4.00 (0–1)
Green-winged teal	0.31 (0–2)	0.19 (0–1)	0.25 (0–2)	0.22 (0–1)	0.30 (0–2)	0.11 (0–1)
Blue-winged teal	0.46 (0–2)	0.50 (0–3)	0.50 (0–2)	0.44 (0–3)	0.43 (0–2)	0.67 (0–3)
Ring-necked duck/lesser scaup	9.00 (0–18)	6.19 (0–13)	9.45 (0–18)	3.00 (0–9)	9.00 (0–18)	1.50 (0–9)
Common goldeneye (*Bucephala clangula*)		1.06 (0–12)		1.89 (0–12)		2.83 (0–12)
Bufflehead	0.92 (0–3)	0.56 (0–3)	0.75 (0–3)	0.67 (0–3)	0.83 (0–2)	0.33 (0–2)
White-winged scoter (*Melanitta degandi*)	0.31 (0–2)		0.20 (0–2)		0.17 (0–2)	
Total	12.85	11.19	12.90	9.78	12.55	9.61
Ratio (before:after)	1:0.87		1:0.76		1:0.77	

[a] Number of visits.

plete, winds were more than 17 km/hour, and/or there was precipitation in 1 form or another. A comparison of indices of waterfowl use showed no difference ($P > 0.5$) between values of observations taken under the 2 sets of conditions (4.8 and 4.1 duck-minutes). Thus, it was possible to compare indices of waterfowl use of ponds, with and without deterrents, despite differences in the day-to-day weather.

Because deterrents were placed on ponds at various times throughout the season of open water, it was necessary to distinguish between changes in patterns of waterfowl use occurring naturally and those occurring because of the presence of the deterrent. We subdivided the season into 3 periods: spring (1–31 May), summer (1 June–15 August), and autumn (16 August–30 September). Spring and autumn encompassed periods when migrants made up the greatest proportion sighted, whereas summer was the period when numbers were reduced and only residents were sighted. Waterfowl use of the 2 ponds on which there were no deterrents showed this pattern of seasonal use (Table 1). Thus, in analyzing the effect of deterrents it was necessary to consider also the time of year when they were in place.

The deterrent effect of the model falcon was tested by comparing counts of waterfowl on a small pond (A), before and after installation of the model (Table 2), with counts from 2 similar ponds (D and E) lacking deterrents (Table 3). On Pond A, the average number of birds present per visit declined by 69% after installation of the deterrent. The species contributing most to the decline were ring-necked duck/lesser scaup (*Aythya collaris, A. affinis*) (79%) and bufflehead (*Bucephala albeola*) (75%). Counts during comparable periods from Ponds D and E also showed a decline that averaged 22% (Table 3). However, the decline in numbers of ring-necked duck/lesser scaup averaged only 8% and buffleheads 34%. The greater natural decline in numbers of buffleheads seemed to reflect the departure of males from the breeding ponds in mid-summer (Donaghey 1975). The difference in total decline between the test and control ponds (47%) is an estimate of the net effect of this deterrent on waterfowl. Among the species involved, ring-necked duck/lesser scaup seemed the most affected with a net decline of 71%. However, this deterrent did not completely deter any species from using Pond A.

Table 4. Mean number of ducks and (range) recorded per visit on Pond B near Utikuma Lake, Alberta, 1975. This pond was visited 35 times before and 47 times after installation of the reflectors.

Species	Without deterrent (8 May–8 Jul)	With reflector deterrent (9 Jul–8 Oct)
Mallard	0.23 (0–2)	0.06 (0–1)
American wigeon	0.06 (0–1)	
Ring-necked duck/ lesser scaup	0.63 (0–3)	
Common goldeneye	0.46 (0–2)	
Bufflehead	1.74 (0–6)	0.29 (0–2)
Totals	3.12	0.35
Ratio (without:with)	1:0.11	

The deterrent effect of the reflectors was tested in a manner similar to that of the model falcon using Pond B as the test pond and Ponds D and E as the controls. After the deterrent was installed on Pond B on 9 July, the number of waterfowl counted declined by 89% (Table 4). Most of this decline was contributed by ring-necked duck/lesser scaup and common goldeneye (*Bucephala clangula*), a decline of 100%. However, neither of these species was numerous before the deterrent was installed on this pond (Table 4). The change in numbers of ducks present

Table 5. Mean number of ducks and (range) recorded per visit on Pond C near Utikuma Lake, Alberta, 1975. This pond was visited 43 times before and 26 times after installation of the human effigy.

	Pond C	
Species	Without deterrent (8 May–22 Jul)	With human effigy (23 Jul–26 Sep)
Mallard	0.40 (0–2)	0.04 (0–1)
Green-winged teal	0.32 (0–2)	0.07 (0–2)
Blue-winged teal	1.14 (0–4)	
American wigeon	0.77 (0–4)	
Ring-necked duck/ lesser scaup	6.58 (0–12)	
Common goldeneye	0.07 (0–1)	
Bufflehead	5.37 (0–15)	0.18 (0–2)
White-winged scoter	0.14 (0–2)	0.39 (0–1)
Pintail (*Anas acuta*)	0.09 (0–2)	
Totals	14.88	0.68
Ratio (without:with)	1:0.05	

on the control ponds, for comparable periods of time, was 34% on Pond D and 24% on Pond E, an average of 27% (Table 3). The change in numbers of ring-necked duck/lesser scaup averaged a 55% decline whereas common goldeneyes only appeared on 1 control pond after 9 July. The difference in total decline between the test and control ponds (55%) is reasonably similar to the difference in decline for the ring-necked duck/lesser scaup (45%) and is an estimate of the net effect of this deterrent on the few species represented in Table 4.

The effect of the human effigy was tested on Pond C where this deterrent was installed on 23 July 1975. Counts of ducks present on this pond before and after 23 July were compared with comparable counts on the control ponds (D and E). After installation of this deterrent, counts of ducks on Pond C declined 95% (Table 5). Ring-necked duck/lesser scaup contributed the most to this decline, falling from 6.58 ducks per visit to 0. Counts of ducks on Ponds D and E for comparable periods showed an average total decline of 20%. The difference in total decline (75%) is an estimate of the net effect of this deterrent, which also seemed to have completely prevented some species such as ring-necked duck/lesser scaup from using Pond C (Table 5)

We judged the effective radius of the deterrents by observing the behavior of waterfowl. At all ponds resident waterfowl showed habituation to the deterrents and with continual exposure approached them more closely. The model falcon had the least effective radius of deterrence, about 6 m initially, declining to a point at which ducks even sat on the float beneath the model. The reflector was avoided to a greater extent but even so ducks regularly swam within 4–5 m of it. The human effigy initially caused ducks landing on the pond either to leave the pond or move into the emergent vegetation. Resident broods on Pond C became accustomed to its presence and would approach within 5 m. Other waterfowl, however, were never seen closer than about 20 m.

None of the 3 deterrents was completely effective. Habituation occurred and was most noticeable among birds that resided on the ponds. Thus, because it was known that significant numbers of resident birds also were homing to specific ponds (buffleheads, colored-marked in previous years [Donaghey 1975] were recorded back on these same ponds in 1976), it was obvious that such birds would be much more difficult to deter. The presence of these homing resident birds from the onset of the season (they were among the first to arrive [Donaghey 1975]) also would have had the effect of decoying other birds to these ponds, particularly when the deterrents were present. However, of the 3 deterrents tested,

Table 6. Number of waterfowl and shorebirds recorded in 1975 and 1976 on 6 small natural ponds around the tailings pond near Fort McMurray, Alberta.

Month	*N* observations	*N* per observation		
		Waterfowl	Shorebirds	Total
Apr				
1976	115	2.09	0.11	2.20
May				
1975	46	1.48	0.78	2.26
1976	154	1.08	0.95	2.03
Jun				
1975	40	0.98	2.05	3.03
1976	138	1.90	0.87	2.77
Jul				
1975	47	0.81	2.00	2.81
1976	102	5.94	2.71	8.65
Aug				
1975	34	7.94	2.53	10.47
1976	159	8.64	3.42	12.06
Sep				
1975	23	12.13	0.57	12.70
1976	164	12.24	0.36	12.60
Oct				
1975	27	0.37		0.37
1976	60	3.78	0.05	3.83
Total May–Oct				
1975	217	3.24	1.43	4.67
1976	777	5.98[a]	1.48	7.46

[a] Different from 1975 datum ($P < 0.05$).

Table 7. Number of waterfowl and shorebirds recorded in 1975 and 1976 during a series of 1-hour observation periods, undertaken around dawn and dusk, at the tailings pond near Fort McMurray, Alberta.

Month	*N* hours observed	*N* per hour		
		Waterfowl	Shorebirds	Total
Apr				
1976	35.3	10.11	0.02	10.13
May				
1975	46	1.35	0.02	1.37
1976	49	5.24	1.59	6.83
Jun				
1975	20			
1976	31	4.58	0.16	4.74
Jul				
1975	18.5	5.51	0.27	4.78
1976	24.2	0.99	1.61	2.60
Aug				
1975	21.5	0.51	2.47	2.98
1976	36	11.36	5.72	17.08
Sep				
1975	17.5	3.43		3.43
1976	44.6	5.42	0.65	6.07
Oct				
1975	13	0.08		0.08
1976	15	5.67		5.67
Total May–Oct				
1975	136.5	1.72	0.43	2.15
1976	235.1	4.94	1.52[a]	6.46[a]

[a] Different from 1975 datum ($P < 0.05$).

we believe the human effigy was most effective.

Because the tailings pond near Fort McMurray had no resident waterfowl population, we could test the effectiveness of the human effigy in deterring only transient birds. In evaluating the effectiveness of the effigy in deterring birds from entering the tailings pond we confined our analyses to comparative numbers of grebes, ducks, geese, coots, sandpipers, and plovers because they were the principal victims of bitumen fouling in the tailings pond (85% of 98 birds found dead in 1975 and 87% of 104 birds found dead in 1976).

Censuses of a series of nearby natural ponds in 1975 and 1976 indicated that a greater number of waterfowl ($P < 0.05$) and shorebirds was present in 1976 than in 1975 and that their presence on these ponds was not distributed evenly among months (Table 6). The numbers of waterfowl increased steadily to a major peak in September followed by a rapid decline. Among shorebirds, peak numbers were reached in August.

We recorded a similar pattern in numbers of waterfowl and shorebirds flying along the shoreline or over the surface of the tailings pond (Table 7). More shorebirds ($P < 0.05$) and waterfowl were recorded in 1976 than in 1975, and the sea-

Table 8. Numbers of waterfowl and shorebirds found dead or moribund at the tailings pond in 1975, without deterrents, and in 1976, with deterrents.

	Apr–May[a]		Jun–Jul		Aug–Oct		Apr–Oct	
	1975	1976	1975	1976	1975	1976	1975	1976
Waterfowl								
Grebes			1			1	1	1
Geese	4					2	4	2
Dabbling ducks	11	10	2	7	5	7	18	24
Diving ducks	19	11	17	5	6	7	42	23
Unknown ducks	3				2	1	5	1
Coots	5	5	2	11		3	7	19
Shorebirds								
Waders	1				9	7	10	7
Total	43	26	22	23	22	28	87	77

[a] Actually 8–31 May in 1975 and 14 April–31 May in 1976. Before 14 April 1976, when Pond A lacked deterrents, the following birds were found dead in this pond: dabbling ducks—3, diving ducks—10, unknown ducks—1.

sonal distribution resembled that seen at the nearby small natural ponds (Table 6). However, the data in Table 7 suggest a bimodal peak in abundance of waterfowl with an initial peak in April (spring migration) and a 2nd in late August and early September (autumn migration). The data in Table 6 only hint at this phenomenon, probably because spring resident ducks breeding on nearby ponds would have been territorial at this time (Donaghey 1975), preventing additional birds from entering these water bodies, a situation that would not prevail in late summer nor ever at the tailings pond.

The data in Table 6 enabled us to postulate that if conditions in the tailings pond were equal in both years the relative numbers of birds fouled by bitumen could be expected to be 1.60 times greater in 1976 than in 1975. Based on the data in Table 7 and assuming constant conditions between years, the numbers fouled in 1976 could be expected to be 3.01 times that in 1975. The physical conditions at the tailings pond, relative to shoreline length, distance from dike top to water, and amount of floating bitumen, remained constant through both years. The only major difference was the presence of 27 human effigies in 1976.

The number of bitumen-fouled birds that we recovered from the tailings pond is recorded in Table 8. The relative numbers of birds recovered, 87 in 1975 and 77 in 1976, were different from those associated with nearby ponds ($P < 0.05$) and from those recorded flying over and along the shore ($P < 0.05$) in the 2 years (Table 9). The possibility that the fouled birds we recovered each year could have died in previous years was disproven. The rate of decay was such that any bird dying in this pond could not be expected to remain floating and retrievable from it for more than 1 month because both the grebes and the diving ducks placed in the warm waters (22 C) became completely disarticulated by this time. Thus, the small actual, but large relative, decrease in numbers recovered in 1976 (Table 6), in relation to abundance of birds in the area, suggests that the deterrents were effective. This suggestion is reinforced by the fact that members of the genus *Aythya* made up a smaller proportion of the deaths recorded in 1976 than in 1975. This group was judged most vulnerable

Table 9. Numbers of waterfowl and shorebirds recorded at the tailings pond and other nearby ponds in 1975 and 1976.

Location	1975	1976
On natural ponds nearby ($\bar{x}$ per 10 visits)	46.7	74.6
Over and around the tailings pond ($\bar{x}$ per 10 observation hours)	21.5	64.6
At the tailings pond (found dead)	87	77

to bitumen fouling in 1975 and most effectively deterred by the human effigy from small natural ponds (Table 5). We also noted that prior to establishment of the effigies on the tailings pond in the spring of 1976, 10 of 13 identified ducks dying in that pond were *Aythya* spp. (Table 8). This ratio (1:1.30) was similar to that recorded for all of 1975 (1:1.43). However, after the establishment of the deterrents the ratio was diminished to only 1:2.08 (Table 8).

The data in Table 8 suggest that waterfowl may be more vulnerable to bitumen fouling during spring migration and shorebirds during autumn migration.

In summary, we concluded that placing 27 human effigies on a 150-ha tailings pond was effective in diminishing the number of waterfowl and shorebirds dying there due to bitumen fouling. This conclusion is based on correlative evidence and also rests on a number of assumptions. For example, we assumed that the observers' abilities to see and record birds were not significantly different in the 2 years. By confining our analysis to the species most conspicuous and most vulnerable to bitumen fouling, we minimized any potential difference in this regard. Furthermore, our conclusions are strengthened by the fact that the number of birds found in 1975 probably is biased downwards in that the pond was not searched until after 8 May in contrast to 1976 when dead birds were first picked up on 6 April. Thus, in view of their rapid decay in these warm waters, some birds dying during the early migration period of 1975 may have been missed. Additionally, searches of the shorelines of this pond were not permitted between 19 July and 12 September 1975, and consequently it is unlikely that all birds dying during this interval were retrieved.

We also assumed that the numbers of birds recorded on nearby ponds and flying over and around the tailings pond provide a valid measure of the pressure on waterfowl and shorebirds to use this pond. These assumptions are probably not valid in absolute terms because of the inherent differences in the nature of physical and biological surroundings of the natural and artificial ponds. Nevertheless it was the numbers of birds recorded over and around the tailings pond that showed the greatest increase in 1976, suggesting that there were relatively more birds investigating this pond in that year. We believe that this can be construed legitimately as increased pressure to use this pond in 1976.

The fact that the kill of dabbling ducks increased in 1976 suggests that they are not effectively repelled by the deterrents used. The same argument could be used for coots. However, since the frequency with which waterfowl were observed to land in the bitumen-polluted waters of the tailings pond during daylight hours was so small (geese once, dabbling ducks once, diving ducks never, unknown ducks once, coots never, out of a total of 372 hours of observations), it seems reasonable that most of the entry into the pond was at night, at a time when the visibility of the deterrents was minimal.

Thus, some means of increasing visibility of the deterrents at night might increase their effectiveness in deterring these species. The coots seem to be a special case in that the state and timing of the recovery of these birds, especially in 1976, suggest that they entered the pond as a flock. Eleven of them were recovered within a short span of time and all were in a similar state of decay suggesting a common date of entry into the polluted waters. Because coots were never recorded flying over this pond it is likely that they entered it at night. Peak times for initiation of migratory movements in this region have been shown to occur 1 hour before sunrise and 2 hours after sunset (Richardson and Gunn 1971).

The validity of these assumptions needs to be tested before firm conclusions can be reached. Furthermore, the causal elements in the correlation reported herein need to be tested by using experimental and control ponds in a given time period and thus avoid the necessity of using the same pond successively as a control and then as an experimental pond.

LITERATURE CITED

DAVIS, T. J., W. J. RICHARDSON, AND W. W. H. GUNN. 1974. Review of current knowledge on reducing bird mortality associated with oil spills. Petroleum Association for Conservation of the Canadian Environment, Ottawa. L. G. L. Limited, Environ. Res. Assoc., Toronto, Rep. 75-4. 96pp.

DONAGHEY, R. H. 1974. Waterfowl use of boreal forest water bodies near Utikuma Lake, northern Alberta: final report. Ducks Unlimited (Canada), Edmonton. 97pp.

———. 1975. Spacing behaviour of breeding buffleheads (*Bucephala albeola*) on ponds in the southern boreal forest. M.S. Thesis. Univ. of Alberta, Edmonton. 216pp.

MANN, G. E. 1964. Improved techniques for aerial wetland survey. J. Wildl. Manage. 28:575–580.

RICHARDSON, W. J., AND W. W. H. GUNN. 1971. Radar observations of bird movements in east-central Alberta. Pages 35–68 *in* V. E. F. Solman, ed. Studies of bird hazards to aircraft. Can. Wildl. Serv. Rep. 14.

SMITH, J. A., D. A. BIRDSALL, AND P. L. SHARP. 1975. A study of birds and mammals at the GCOS tailings pond, Fort McMurray, autumn 1974. Syncrude Canada Ltd., Edmonton. L. G. L. Limited, Environ. Res. Assoc., Edmonton. 182pp.

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