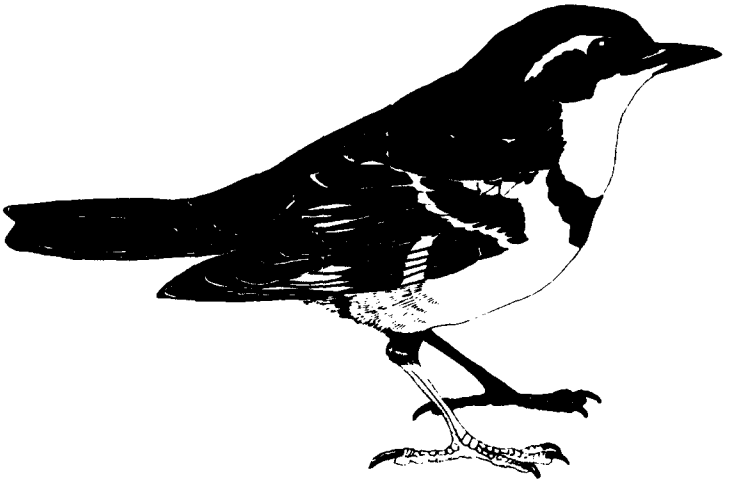
STATUS REPORT ON BARROW'S GOLDEN EYE

Jean-Pierre L. Savard



TECHNICAL REPORT SERIES No. 23
Pacific and Yukon Region 1987
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Jean-Pierre L. Savard

Technical Report Series No. 23
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This series may be cited as:

Savard, J-P. L. 1987. Status report on Barrow's Goldeneye. Technical Report Series No. 23. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Issued under the Authority of the
Minister of Environment
Canadian Wildlife Service

Ministry of Supply and Services Canada 1987
Catalogue No. CW69-5/23E
ISBN 0-662-15449-5
ISSN 0831-6481

Copies may be obtained from:
Canadian Wildlife Service,
Pacific and Yukon Region
P.O. Box 340,
Delta, British Columbia,
Canada V4K 3Y3

Abstract

The distribution of Barrow's Goldeneye (Bucephala islandica) in Canada is discontinuous with a small population (≈3,000 birds) in Quebec and a comparatively large population (≈100,000 birds) in British Columbia and the Yukon. The reliability of these estimates is, however, questionable. Over 60% of the world population of Barrow's Goldeneye breed and winter in British Columbia. The status of each Canadian population is undetermined, as no reliable monitoring scheme exists. However, Christmas bird count results (1969 to 1984) do not indicate any drastic decrease in the western population. Harvest estimates are unreliable due to low representation of the species in the sample. Threats facing Barrow's Goldeneye include: poor understanding of their ecology, especially for the eastern population; offshore petroleum exploration and transportation; toxic pollution; hunting; habitat destruction and bird harassment in winter; fish introduction into fish-free lakes; drainage of wetlands; and logging, which reduces nest site availability. Possible management options include: nest box programs to reduce the impact of logging; habitat protection; public education; stricter monitoring and regulation of hunting pressure and research to improve our ability to predict deleterious impacts and help reduce or mitigate them.

Résumé

La distribution du Garrot de Barrow au Canada est discontinue avec une petite population (≈3,000 oiseaux) au Québec et une grande population (≈100,000 oiseaux) en Colombie Britannique et au Yukon. Plus de 60% de la population mondiale du Garrot de Barrow niche et hiverne en Colombie Britannique. Le statut des deux populations canadiennes est inconnu puisqu'il n'existe présentement aucune méthode de recensement fiable. Cependant, les données des recencements de Noël (1969 a 1984) n'indiquent pas de changements importants dans la population de l'ouest. Les estimés du nombre d'oiseaux abattus lors de la chasse ne sont pas fiables à cause de la faible taille de l'échantillon. Les menaces qui confrontent le Garrot de Barrow incluent: un manque de connaissances sur l'écologie de l'espèce, surtout dans l'est; l'exploration et le transport pétrolier le long des côtes; la pollution toxique; la chasse; la destruction de l'habitat; le harassement des oiseaux en hiver; l'introduction de poissons dans les lacs où l'espèce s'alimente; le drainage des étangs et; l'exploitation forestière qui réduit le nombre de sites de nidification. Les options d'aménagement incluent: un programme d'installation de nichoirs pour réduire l'impact de l'exploitation forestière; la protection des habitats importants; l'éducation du public; une meilleure évaluation et un meilleur contrôle de la pression de chasse; de la recherche sur l'écologie de l'espèce afin d'améliorer notre habileté à prédire les impacts potentiels sur la population, de les réduire ou de les mitiger.

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Acknowledgements

I thank G.W. Kaiser, R. Butler, S. Wetmore, L. Willis, H. Boyd and A. Martell for their comments on various drafts of this manuscript. Thanks also to M. Lemon, P.M. Whitehead and L. Willis for their assistance in drafting the figures and to S. Garnham for typing the manuscript. This work was funded and supported by the Canadian Wildlife Service.

Introduction

In 1980 the Canadian Wildlife Service initiated a study on the breeding ecology of Barrow's Goldeneye in British Columbia to better identify factors affecting the reproductive success of the species. The factors that led to the initiation of this project were:

1) A general lack of knowledge on the ecology of the species,
2) The fact that more than 60% of the world population breed and winter in British Columbia,
3) Threats of oil spills on the wintering areas due to impending offshore resources development,
4) Intensive logging in central B.C. that is greatly reducing nest site availability,
5) High harvest rates for young during the hunting season in certain areas.

In this report I present an update on what is known about Barrow's Goldeneye, identifying knowledge gaps and possible threats to the species, and list some management options. It is hoped that this document will spur further research and serve as a base for the establishment of a comprehensive management plan for the species.

Distribution and abundance

Barrow's Goldeneye distribution is discontinuous, with a small population associated with the Atlantic ocean and a comparatively large population associated with the Pacific Ocean (Bellrose, 1978; Fig. 1).

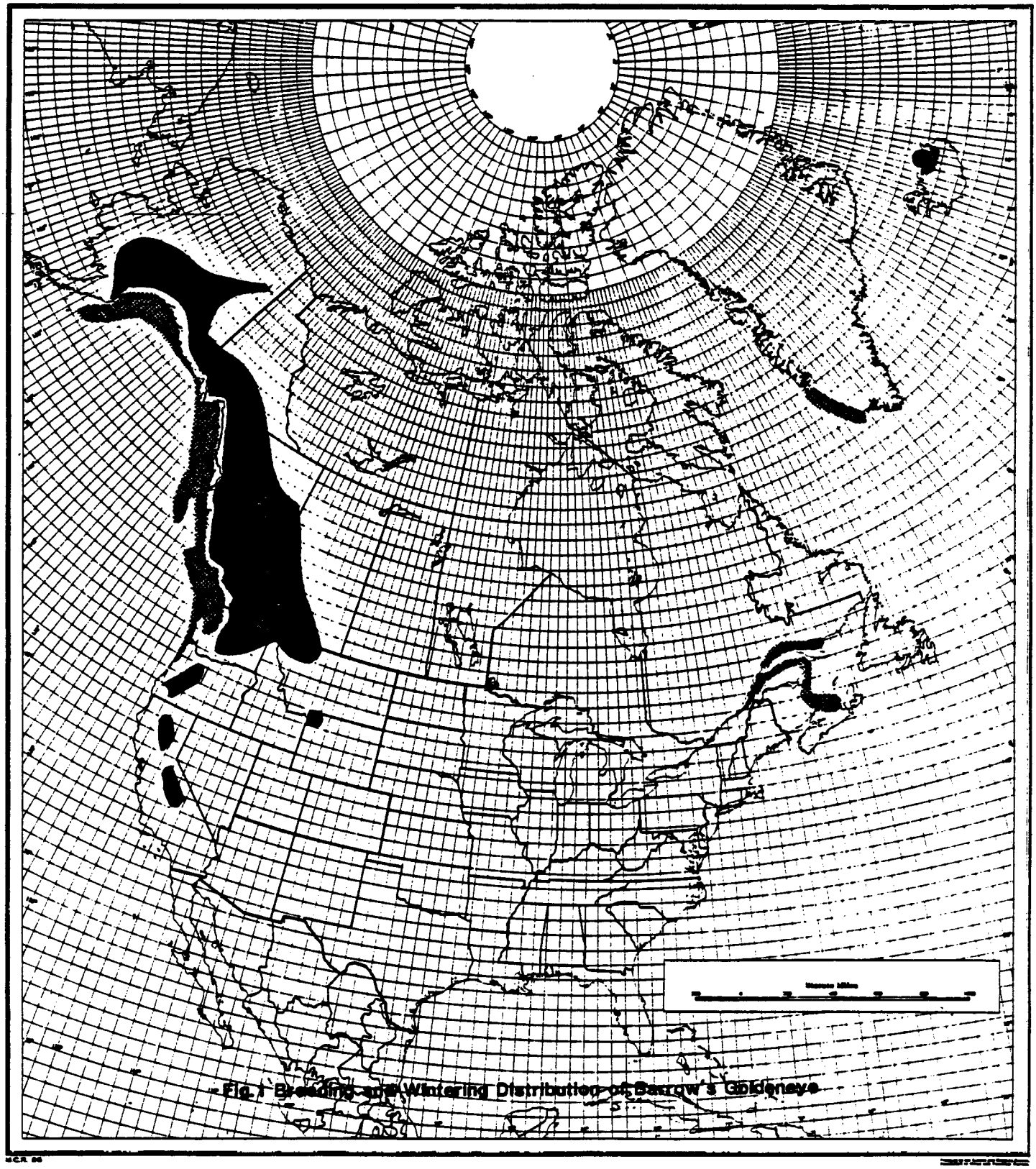

Fig. 1 Breeding and Wintering Distribution of Barrow's Goldeneye

1) Atlantic population

The Atlantic population has two components. First there is a breeding population in Iceland estimated at 2,023 birds in 1977 and 2,159 in 1978 (Bengtson 1972, Gardarsson 1978). The population winters along spring fed fresh waters and possibly on coastal waters (Bellrose 1978, Palmer 1976), although Einarsson (1985) reported that no coastal wintering grounds have been found. Second, there is a wintering population in the St. Lawrence estuary of eastern Quebec estimated at 2,547 birds (Reed and Bourget 1977). The breeding location of this population has not been located yet. It is not known if the Quebec and Icelandic populations are isolated or if they interbreed.

Hasbrouck (1944) summarized some eastern records of Barrow's Goldeneye indicating that the Eastern population may be more widespread than reported but Griscom (1945) questioned Hasbrouck's data and stated that wintering Barrow's Goldeneye were rare along the coast of Massachusetts and occurred primarily along the eastern coastline of Maine. Christmas Bird Count results for Eastern North America indicate that the St-Lawrence Estuary is the major wintering area and that few birds are observed in Maine and Massachusetts (Tables 1-2). None of the Christmas Bird Counts conducted in coastal New Brunswick reported sightings of Barrow's Goldeneye. Small numbers of Barrow's Goldeneye winter in the maritime provinces and in some of the coastal eastern states. Although Greenland has a reported wintering population (Salomonsen 1967) its size is unknown but does not appear to be substantial. Todd (1963) reports the presence of molting Barrow's Goldeneye along the coasts of Ungava.

Table 1. Number of Barrow's Goldeneye recorded during Christmas bird counts[1] in Quebec, Prince Edward Island, Newfoundland and Nova Scotia from 1979 to 1986.

	Year of count							
	1978	1979	1980	1981	1982	1983	1984	1985
Quebec								
Baie-Comeau	-	-	-	-	-	25	-	301
Forillon National Park	-	-	2	28	46	22	2	25
Perce	-	-	-	12	29	34	84	3
Tadoussac	120	0	10	0	9	193	0	3
Georgeville	0	0	0	2	0	0	1	0
Mont-joli	-	-	-	83	0	12	16	-
Rimouski	1	4	0	4	0	0	12	0
Mont-Louis	-	-	-	-	-	2	0	-
New Richmond	-	-	-	12	150	-	-	0
Prince Edward Island								
Hillsborough	0	0	0	0	0	0	0	5
P.E.I. National Park	4	4	6	5	1	0	40	50
Newfoundland								
Corner Brook	-	-	-	-	-	0	1	-
St-Paul's Cowhead	-	-	0	3	1	2	1	0
Terra Nova National Park	0	0	0	1	3	0	1	-
Nova Scotia								
Broad Cove	0	0	0	0	0	0	1	0

1 Source: American Birds Vol. 33 No. 4, 1979; Vol. 34 No. 4, 1980; Vol. 35 No. 4, 1981; Vol. 36 No. 4, 1982; Vol. 37 No. 4, 1983; Vol. 38 No. 4, 1984; Vol. 39 No. 4, 1985; Vol. 40 No. 4, 1986.

Table 2. Number of Barrow's Goldeneye recorded during Christmas Bird Counts[1] in Maine and Massachusetts from 1979 to 1986.

	Year of count							
	1978	1979	1980	1981	1982	1983	1984	1985
Maine								
Machais Bay area	2	4	1	1	1	3	-	2
Moose Island-Jonesport	0	1	1	0	1	1	-	1
Mt-Desert Island	0	2	1	7	2	2	5	1
Orono-old Town	10	0	0	3	7	5	6	8
Portland area	-	-	2	4	3	8	4	6
Schoodic Point	0	11	12	0	0	0	2	4
Waterville	0	0	0	0	0	0	0	2
Lewiston Auburn	-	-	0	0	1	1	0	0
Massachusetts								
Cape Cod	0	1	1	0	2	3	1	6
Greater Boston	1	1	0	1	0	1	2	4
Martha's Vineyard	0	0	0	2	1	0	0	3
Nantucket	4	6	8	5	7	13	7	7
New Bedford	0	0	0	0	0	0	0	1
Newburyport	3	2	2	0	1	1	1	2
Plymouth	0	3	3	-	2	3	4	3
Quincy	1	1	0	7	0	2	2	1
Buzzard's Bay	1	0	1	0	1	3	3	0
Cape Ann	1	0	1	1	2	0	2	0
Newport County R.I.	0	0	0	0	0	0	1	0
Mid Cape Cod	-	-	-	0	1	1	0	0

1 Source: See Table 2.

2) Pacific population

More than 90% of the world population of Barrow's Goldeneye breed west of the Rocky Mountains from Oregon to Alaska and winter along the Pacific coast. Most Barrow's Goldeneye winter in coastal waters from Alaska to Puget Sound. Small numbers winter along the Oregon and California coast. In British Columbia a few birds winter inland on open rivers. Similarly a portion of the Yellowstone population winter locally on thermally open lakes and rivers (Skinner 1937). Unfortunately most estimates of population sizes are questionable.

a) Alaska

Bellrose (1978) reported an estimate of 90,000 goldeneye as the pre-breeding population in Alaska, stating that 50% of those (45,000) were probably Barrow's Goldeneye.

b) Yukon

The Barrow's Goldeneye is a common breeder in the southern Yukon, ranking fourth in abundance behind scaup (*Aythya*), American Wigeon (*Anas americana*) and Mallard (*A. platyrhyncos*) (Blood 1979). Despite intensive surveys, Barrow's Goldeneye have not been observed breeding on the Yukon coastal plains (Gollop and Davis 1974, Sharp *et al.* 1974, Hawkings 1986). The only known molting sites in western Canada for male Barrow's Goldeneye are on the Old Crow Flats in northwestern Yukon (Mossop and Hayes 1977). There is no available estimate of the total breeding and molting population of Barrow's Goldeneye in the Yukon.

c) British Columbia.

The center of abundance of Barrow's Goldeneye is in the Aspen Parklands of British Columbia. Unfortunately no good estimate of population size is available. Bellrose (1978) mentions that William Morris and Ray Halladay estimated a prebreeding population of 70,000 to 100,000 birds. Munro and Goodchild (1981) present an estimate of 126,000 birds, based on the Canadian Land Inventory system. Unfortunately the precision of those estimates is not given.

Recent studies in central British Columbia have provided estimates of pair density of Barrow's Goldeneye for various lake sizes (Savard 1986a). The results are summarized in Table 3. Densities were similar for lakes smaller than 10 ha, averaging 0.77±0.05 pairs per ha, whereas lakes over 10 ha had densities averaging only 0.29±0.07 pairs per ha. Unfortunately, the number of lakes of each size group in this region is still unknown. Once this information is obtained, an estimate of known precision may be made for the breeding population of Barrow's Goldeneye in central B.C.

d) Washington, Oregon and other states

The U.S. Fish and Wildlife Service (anonymous 1979) estimated the Pacific Flyway population of Common and Barrow's Goldeneye for the western states at 42,000 birds, 20% (8,000) of which were assumed to be Barrow's Goldeneye. Bellrose (1978) stated that about 2,400 Barrow's Goldeneye breed in Washington, 300 in Oregon and

Table 3. Density of Barrow's Goldeneye (number of pairs/ha) on ponds of various sizes in central British Columbia.

Pond size range ha	No. Barrow's/ha	
0.1 - 0.5	0.932 ± 0.137	n=18
0.5 - 1.5	0.818 ± 0.130	n=24
1.5 - 2.5	0.799 ± 0.108	n=23
2.5 - 5.0	0.667 ± 0.077	n=22
5.0 - 10.0	0.632 ± 0.161	n=13
10.0 - 40.0	0.285 ± 0.073	n=13

a small number in California. Harris et al. (1954) summarized the status of Barrow's Goldeneye in Eastern Washington. A small population breed in Yellowstone National Park but no estimates are available (Skinner 1937).

If we take the previous population estimates at face value, the Atlantic population totals approximately 5,000 birds whereas the Pacific population totals approximately 180,000 birds, for a total world population of 185,000 birds. British Columbia alone harbours approximately 60% of the world population. I should reiterate here that the accuracy and precision of the estimates are unknown and therefore these estimates are questionable. Nevertheless, they point to British Columbia as the stronghold of the Barrow's Goldeneye population. Canadians are thus responsible for the well being of most of the world population, not only during the breeding season but also during the wintering season.

Life History

1) Breeding Biology

Barrow's Goldeneye breed at 2 years of age or later. Females, in their first year, are seen on the breeding areas prospecting for suitable nesting sites for the following year (Eadie and Gauthier 1985). Subadult males are also observed on the breeding grounds. Pairs form on wintering areas and migrate individually to breeding areas where they establish territories on lakes. Females return to the general area where they fledged

or have bred, whereas males follow their mates. Males that loose their mates and do not re-pair, return to the area where they bred the preceding year (Savard 1985). Females usually return to the same breeding territory and use the same nest site from year to year (Einarsson 1985, Savard 1986a).

Barrow's Goldeneye commonly nest in cavities in trees (Bellrose 1978). However, any cavities or protected areas may be used occasionally: crow nests (Edwards 1953, Sugden 1963), marmot burrows (Munro 1935), ground cavities (Millais 1913, Bengtson 1970), holes in basalt cliffs (Harris *et al*. 1954). In British Columbia only cavities excavated by Pileated Woodpecker (*Dryocopus pileatus*) are large enough for Barrow's Goldeneye. Other woodpecker created cavities are only suitable after they have been enlarged by decay which means the trees are fragile and subject to blowdown.

In Iceland, a normal clutch size averages 10.9 (n=101) for early clutches and 10.0 (n=78) for late clutches (Bengtson 1972). In British Columbia clutch sizes average 9.1 eggs (n=40) (Bellrose 1978). Savard (1986a) reports an average clutch size of 9.8±0.4 in 1983 (n=115) and 9.7±0.4 (n=131) in 1984. However, if only successful nests are considered, clutch size averaged 12.8±0.6 in 1983 (n=42) and 11.1±0.5 in 1984 (n=62). This is because many unsuccessful nests were incomplete clutches. Parasitic laying is common and often results in clutches of 15 to 20 eggs, which if not deserted, often hatch successfully. Because of the prevelance of parasitic laying, clutch size estimates are biased upward.

The incubation period ranges from 30 to 34 days (Palmer 1976). The rate of egg deposition varies from bird to bird. Usually, no more than 1 egg is laid per day but there could be several days between each egg.

After the young hatch they leave the nest site and follow the female to the water. Savard (1986a) showed that hatching chronology can vary by as much as 2 weeks between years depending on the timing of spring thaw. Duckling mortality varies between years but is usually significantly higher in the first week following hatching, a typical pattern in waterfowl (McGilvrey 1969, Ball et al. 1975, Pienkowski and Evans 1982a, Ringelman and Longcore 1982, Patterson 1982, Hill and Ellis 1984, Mendenhall and Milne 1985). In some years early hatching broods have a higher survival rate than late hatching ones (Savard 1986a). Bengtson (1972) found a similar decrease in survival for late hatching Barrow's Goldeneye of Iceland.

2) Territorial behaviour

a) Breeding pair territory

Barrow's Goldeneye have multi-stage territorial systems, i.e. different territories are defended during a year: 1) paired males defend territories in the spring on the breeding ponds, 2) after the young have hatched females establish and defend territories, and 3) in winter paired males defend territories on the wintering areas. These territories are defended not only against conspecifics but also against other species (Savard 1984, 1986a, 1987a).

Territorial drakes exclude all conspecifics except mates from territories. Territories are established along the shoreline and, on a large lake, the center becomes a neutral area where non-territorial adults and subadults can feed. The proximal factors affecting territory size seem to be aggressiveness of the male and pair density. Females feed exclusively within the territory and can spend up to 80% of their time feeding. The main function of the territory seems to be to provide the female with an undisturbed feeding area. Territories are defended even when the female is absent. Boundaries are often well defined and are not centered around the females.

Territorial drakes also exclude other species from their territory. There is a gradient in the level of Barrow's Goldeneye aggression according to the species involved. They are very aggressive toward congenerics (e.g. Bufflehead and Common Goldeneye) excluding them from their territory as they would conspecifics (Savard 1987a). They also regularly exclude diving ducks and sometimes dabbling ducks from their territory (Myres 1957, Savard 1982b, 1984, 1987a). They are however less aggressive toward dabbling ducks than diving ducks.

b) Brood territory

Females with broods are also territorial and their behaviour is similar to that of the territorial drake (Myres 1957, Bengtson 1971, Savard 1982b, Einarsson 1985). Female aggression limits brood density on lakes (Savard 1986a). On large lakes broods often mix during aggressive interactions, often leaving the victorious female with an enlarged brood (Savard 1987b). However, if the age of the ducklings of the two broods differ,

the victorious female may kill the strange young especially if they are very young. Such aggression has been shown to increase mortality in young in areas of high density (Bengtson 1972, Einarsson 1985).

Females also exclude all adult goldeneyes from their territories and are aggressive toward other species as well. They have been reported to attack and even kill ducklings of other species (Andrew 1960, Sugden 1960, Robertson and Stelfox 1969, Bengtson 1972, Delmotte 1978, Savard 1982b, 1987b). In British Columbia they are especially aggressive toward Bufflehead which they exclude as if they were conspecific. There is even some indication that at high density they may negatively affect Bufflehead survival (Savard 1986a). In Iceland, Bengtson (1972) reported that mortality of young scaups increased in areas of high Barrow's Goldeneye densities. In British Columbia, although female Barrow's Goldeneye occassionally attack broods of other species, it rarely results in duckling death. Female goldeneyes are more aggressive toward other diving duck broods than against dabbling duck broods (Savard 1987a).

c) Winter territory

Only paired birds are territorial in winter. Territories are located along rocky shorelines and are spaced linearly and contiguously. Territoriality is similar to that observed on the breeding areas. Males do most of the territorial defense although females occasionally attack intruders. Territorial birds also exclude other species from their territory, especially other *Bucephala* and Surf Scoters (*Melanitta perspicillata*). Not all

pairs are territorial in winter and it is not clear why (Savard 1986a).

3) Courtship behaviour

Barrow's Goldeneye drakes have an elaborate courtship which has been described in detail by several authors (Sawyer 1928, Myres 1957, 1959a, 1959b, Nickell 1966, Palmer 1976, Pourtois 1978, Bellrose 1978). Pairing occurs mostly on the wintering areas but may occasionally occur on the breeding areas. Pair reunion occurs in the fall on the wintering areas and there appears to be little courtship involved. A female that had lost her mate re-paired on her wintering area within 2 weeks (personal observation). Elaborate courtship observed in late winter probably involved mostly young females pairing for the first time. Because of the unequal sex ratio in favour of males, competition may be high: in one study, all females that lost their mates returned to the breeding areas paired, whereas males that lost their mates returned unpaired (Savard 1985).

4) Molt

Half way through incubation, males leave their mates for the molting areas. The molting location of Barrow's Goldeneye drakes in British Columbia has not yet been identified. They probably molt inland and not along the coast as suggested by Munro (1939), because adult drakes are observed inland late in the fall (Ducks Unlimited, pers. comm.) and because the return of drakes to coastal wintering areas coincides with the freeze-up of inland lakes. Swarth (1926) observed flocks of males flying southward in

June, near Atlin, indicating that the molting lakes may be located in British Columbia. Thousands of Barrow's Goldeneye drakes molt on the Old Crow Flats and on the Yukon flats in the Yukon and Alaska (King 1963, Mossop and Hayes 1977). However, all the band returns from these molting birds come from Alaska indicating that they may be from the Alaskan breeding population (Mossop and Hayes 1977).

Females do not molt in the same locations as the males. Even unsuccessful females remain on the breeding ground when males leave for their molting area. In mid July, successful females desert their broods and congregate on larger lakes to molt where they join the unsuccessful females that have preceded them. By early August they become flightless and regain their flight by early September. They are believed to remain on their molting lakes until ice formation (Palmer 1976).

5) Wintering biology

Most Barrow's Goldeneye winter along the Pacific coast although a few winter inland on those lakes and rivers that remain open. In coastal waters they are associated with rocky shores which harbour large mussel beds. They are the most abundant goldeneye wintering in our coastal inlets (Vermeer 1982).

Barrow's Goldeneye are philopatric to their wintering sites, returning to the same location every winter. This facilitates the re-formation of pairs (Savard 1985). Pairs that re-unite early in the fall often separate from large wintering flocks and establish winter territories from which they exclude conspecifics as well as other diving ducks. Non-paired birds and yearlings

sometimes form large flocks near extensive mussel beds. At night, birds aggregate in large groups in protected waters. Near Vancouver, more than 300 birds roost on a small freshwater pond adjacent to the sea.

Recoveries of birds banded in the breeding areas indicate that wintering sites do not seem to correspond to specific breeding areas (Figs. 2-3). Birds from a given breeding locality seem to disperse on the wintering areas. Banding returns indicate that goldeneyes breeding in British Columbia winter along the British Columbia coast and in Puget Sound.

6) Migration

The spring migration to breeding areas occurs in early April. Birds do not form large flocks but rather migrate alone or in pairs (Palmer 1976, Savard 1985). One marked pair covered the 320 km to its breeding area in one night (Savard 1985). However, if breeding ponds are still frozen, birds will concentrate on open lakes and rivers until the ice recedes from their breeding ponds. Pairs are often observed on their breeding lakes as soon as a few meters of open water is available and become territorial immediately.

Fall migration occurs in late October or early November. Birds seem to wait until freeze-up to migrate to the coast. When they reach the coast they form large groups which rapidly separate into smaller ones and disperse.

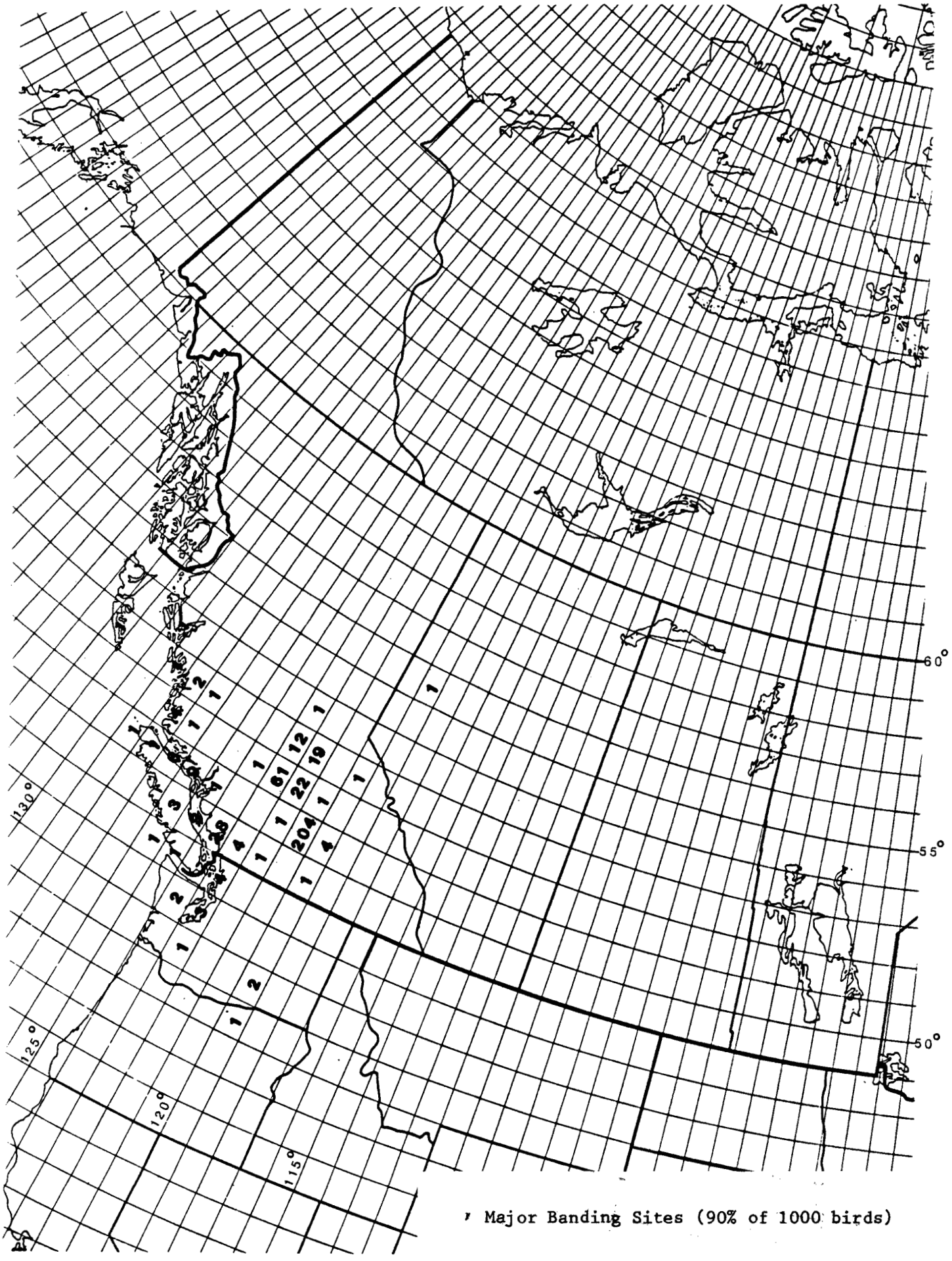

Fig.2 Indirect recoveries (birds shot at least 1 year after being banded) of Barrow's Goldeneye banded in British Columbia before 1970.

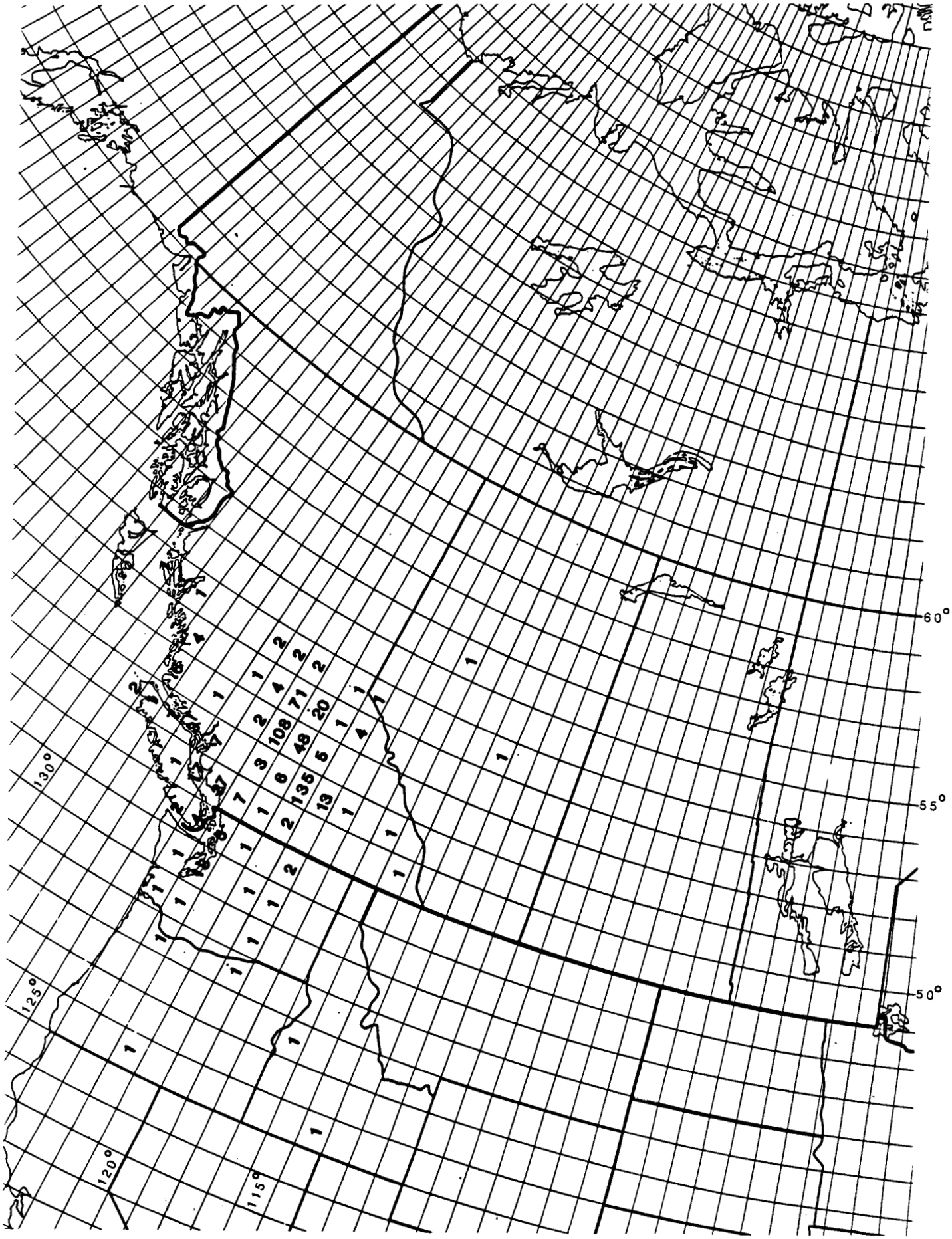

Fig.3 Direct recoveries (birds shot the same year they were banded) of Barrow's Goldeneye banded in British Columbia before 1970.

7) Habitat

In summer, Barrow's Goldeneye in British Columbia prefer alkaline lakes to freshwater ones (Munro 1918, Savard 1984). Such lakes are usually more productive because of the higher amount of nutrients in the water and because of the absence of fish which compete with waterfowl for invertebrates. In the Columbia Valley, Barrow's Goldeneye are rarely seen on ponds of the floodplain whereas they are abundant on the alkaline ponds of the benchlands (Savard 1984).

Habitat preferences during molting and fall staging are unknown. In winter they occur typically along rocky shorelines and are rarely seen over mud flats, sandy beaches or in estuaries. They prefer protected shorelines to exposed ones and are especially numerous in inlets (Mitchell 1952, Vermeer 1982).

8) Food habits

a) Summer

Seventy-one stomachs analysed by Cottam (1939) had a variety of aquatic insects, the most important being damselfly and dragonfly nymphs, caddisfly larvae, water boatmen and midge larvae (Bellrose 1978). Amphipods and cladocera also appeared important in the diet of goldeneye collected in central B.C. In Iceland, cladocerans were the most important component of the ducklings' diet (Gardarsson 1979a, 1979b), whereas adults fed mostly on chironomids (Gardarsson 1979b).

b) Winter

Munro (1939), Vermeer (1982) and Koehl *et al.* (1984) summarized the winter diet of the species. Barrow's Goldeneye fed mostly on bivalves, Blue Mussels (*Mytilus edulis*) in particular, and on a variety of crustaceans. Munro (1923) reported that some feed extensively on salmon eggs. Winter flocks in British Columbia are often located near mussel beds and the Blue Mussel appears to be their main winter food.

9) Factors affecting reproductive success

A) Weather

Duckling survival is greatly reduced when hatching coincides with cold and rainy weather. Bengtson (1972) found that cold spells with precipitation caused a high mortality among newly hatched goldeneye ducklings. Similar negative effects have been documented in other waterfowl (Koskimies and Lahti 1964, Hilden 1964, Makepeace and Patterson 1980).

B) Predation

In a study in central British Columbia, Savard (1986a) reported that an average of 31±3% of the nest boxes used by Barrow's Goldeneye were preyed upon each year. The two main predators were the Black Bear (*Ursus americanus*) and the American Red Squirrel (*Tamiasciurus hudsonicus*). Squirrels usually removed only a few eggs, but if yolk spilled on the other eggs, the nest was usually deserted. Black Bears usually destroyed the nest box and ate the eggs. Some predation by Black Bear was selective i.e. only occupied nests were destroyed, but in some instances all boxes in a given area were destroyed.

Two other predators are known to eat eggs and sometimes kill incubating females: The Marten (*Martes* sp.) in the boreal forest and the Raccoon (*Procyon lotor*) in southern areas. Predation has been recognized to affect a variety of cavity nesting species, especially when nest boxes are used (Naylor 1960, Bellrose *et al.* 1964, Bolen 1967, Eriksson 1979b).

C) Nest sites

Barrow's Goldeneye are secondary cavity nesters and depend upon already existing cavities. Because of their size they can only use cavities excavated by the relatively rare Pileated Woodpecker. They also use other cavities that have been naturally enlarged by decay. Reproduction can be adversely affected by lack of nest sites and/or by their poor quality (Savard 1986a). The more open the site is, the more susceptible it is to predators. The more distant a sight is from the pond, the more likely it is that young will be preyed upon, become lost or deplete their energy reserves before reaching the water. A shortage of suitable nesting cavities has been reported in several cavity nesting species (Siren 1951, Dennis and Dow 1984).

D) Territorial behaviour

Territorial behaviour can deter some pairs from settling on a given pond and, if sites are limited, keep them from breeding or force them to breed later in the season when the reproductive success is often lower. Territoriality of females with broods often limits the number of broods on a pond. Excess broods are either expelled and exposed to predation during their travel

overland to other ponds, or the ducklings are killed directly (Savard 1987b). Fights between females with broods can have several outcomes depending upon the circumstances of the encounter: 1) establishment of territorial boundaries, 2) expulsion of one of the females and her brood from the lake, 3) death of young, or 4) complete or partial brood amalgamation. Aggressiveness of females is more likely to have a greater effect on reproductive success during drought years when broods are forced to concentrate on a few ponds. Einarsson (1985) showed that in areas of high food density Barrow's Goldeneye numbers were limited by territorial behaviour.

E) Parasitic laying

Female goldeneye often lay eggs in other female's nests, therefore increasing the clutch size of the host and increasing the chance of encounters at the nest. This phenomenon, common in some species of waterfowl, is still poorly understood. Some adults apparently will lay parasitically and also lay their own clutch. Current research indicates that this phenomenon is most common when nest sites are conspicuous. In addition, there is evidence that this behaviour may increase the nest desertion rate, and therefore negatively affect reproductive success (Eriksson and Andersson 1982, Andersson and Eriksson 1982). Semel and Sherman (1986) indicated that in Wood Ducks, parasitic birds are stimulated by the activity of another bird at the nest, and that unoccupied boxes were rarely parasitized.

F) Food

Females require high quality food when laying. Lack of food may influence reproductive success in various ways: 1) by reducing the number of eggs laid, 2) by reducing the size of the eggs and thus the size of the ducklings, 3) by delaying nesting and forcing the bird to nest later in the season, 4) by preventing nesting altogether, 5) by slowing duckling growth rate, 6) by starving ducklings and making them more susceptible to predators and disease, 7) by forcing the brood to move to other lakes, thus increasing the chance of predation, and of confrontation with other broods, 8) by affecting survival of adults.

G) Pair bonds

A few studies on seabirds have shown that pairs that re-united were more successful than newly formed pairs (Coulson and Thomson 1983, Rowley 1983). The same may apply in goldeneyes. A female may be more likely to retain the same territory on successive years if she retains the same mate. His motivation to defend the territory may be stronger if he has defended the same area before (Hinde 1956, Figler and Einhorn 1983).

H) Population density

When population density is high, interference at nest sites increases and this often leads to nest desertion. Grenquist (1963) showed that 2 years after a year of high production, the desertion rate increased in Common Goldeneye. Bengtson (1972) showed that hatching success of Icelandic Barrow's Goldeneye was lower at high nesting densities because of a greater desertion rate. He also showed that young survival was lower in areas of

high brood densities. Eriksson (1979b) found a density-dependent relationship between population size and the proportion of breeding adults in Common Goldeneye.

10) Hybridization

Barrow's Goldeneye sometimes hybridize with other Bucephala. Hybridization with Common Goldeneye is the most frequent (Snyder 1953, Schultz 1958, Jackson 1959, Johnsgard 1960), but hybridization with Hooded Mergansers has been reported (B. Emery, personal communication). Interspecific nest parasitism is probably one major factor facilitating hybridization. Ducklings raised by a foster species will imprint on the species and develop similar behaviour (Gottlieb 1971, Hess 1973). This likely lowers behavioural barriers to interspecific pairing. Forced copulation, which may produce hybrids in dabbling ducks has not been documented in the genus Bucephala despite intensive observations (Gauthier 1985, Savard 1986a).

Population trends

1) Eastern population

It is not known whether the Barrow's Goldeneye population of eastern Quebec is stable or not. However, its small size suggests it is vulnerable. The Icelandic population appears stable (Gardarsson 1979a,b) although recent counts suggest a possible decrease (Gardarsson, pers. comm.)

2) Western population

Trends of the Alaska, Washington, Oregon and Yellowstone populations are unknown. Monitoring techniques in the U.S. do not

distinguish between Common Goldeneye and Barrow's Goldeneye. Similarly, aerial surveys cannot be used in B.C. to monitor either species because of the difficulty of identifying them from the air.

I summarized the results of Christmas bird counts for the Strait of Georgia and Puget Sound for Barrow's Goldeneye. The Vancouver count had the greatest number of Barrow's Goldeneye and went back as far as 1958 (Fig. 4). From 1958 to 1968, the number of observers may have affected the counts. However after 1968 the coverage was extensive. Counts of Barrow's Goldeneye fluctuated between 1,300 and 3,200 birds but with no consistent trend (Fig. 4). The number of areas surveyed increased in 1975. Counts since 1975 are summarized in Fig. 5. The population appears stable for a given area. Fluctuations in numbers of Barrow's Goldeneye were similar for the Vancouver count and a regrouping of Puget Sound counts. However, it is not known at the present time if these fluctuations reflect population changes or only weather conditions that affect bird distribution and/or count accuracy.

Harvest

I summarized harvest results for the Pacific population only. Harvest monitoring is better in the U.S. than in Canada. In Canada, Common Goldeneye and Barrow's Goldeneye are not separated and therefore it is impossible to assess the harvest of Barrow's Goldeneye. Table 4 summarizes the western U.S. Harvest of Barrow's Goldeneye. The average harvest for 9 years of monitoring was 2,691 (Carney _et al_. 1983). Table 5 summarizes the harvest of goldeneye in British Columbia (Metras 1983, 1984,

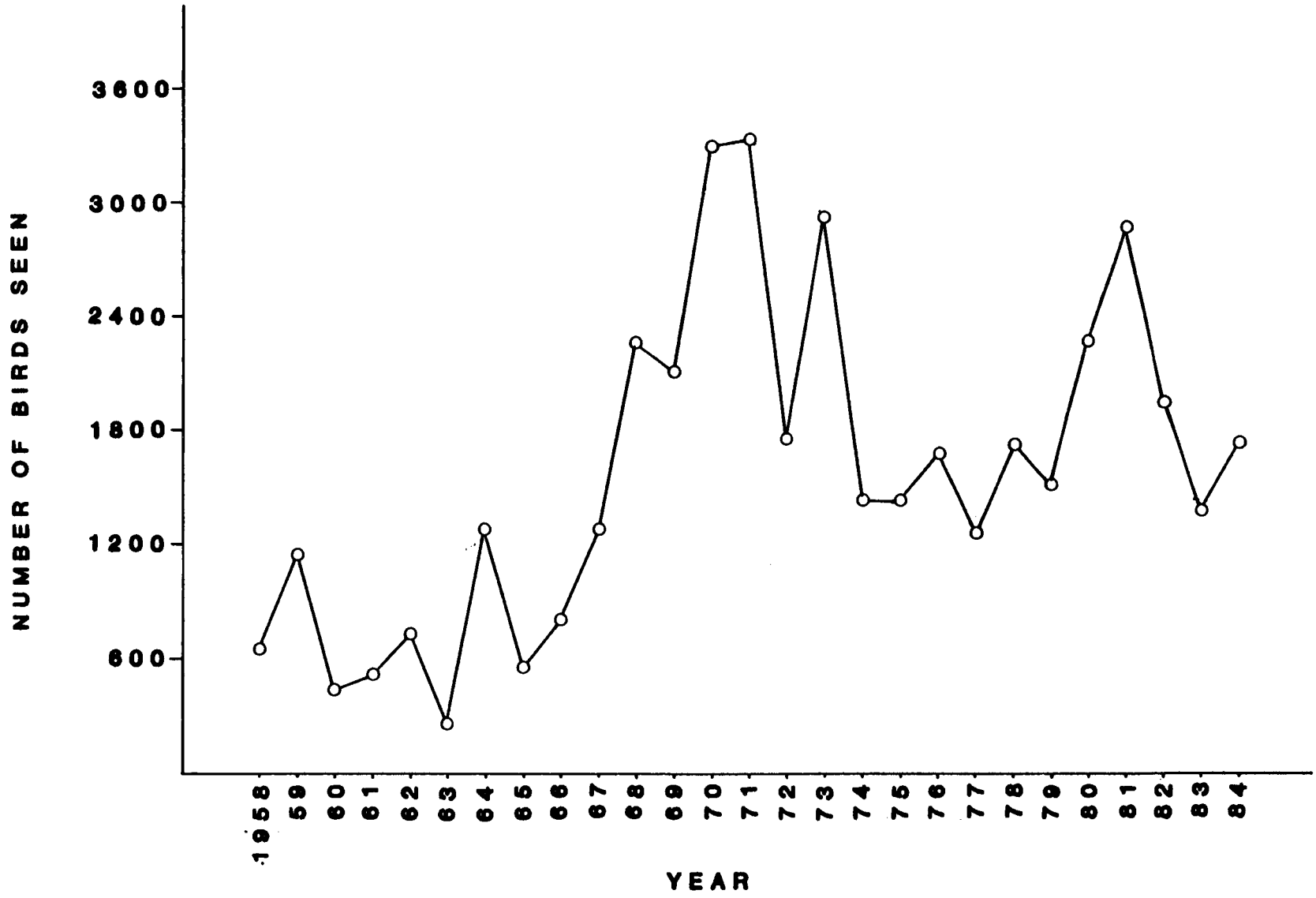

Fig. 4 Barrow's Goldeneye abundance in the Vancouver Christmas Bird Count

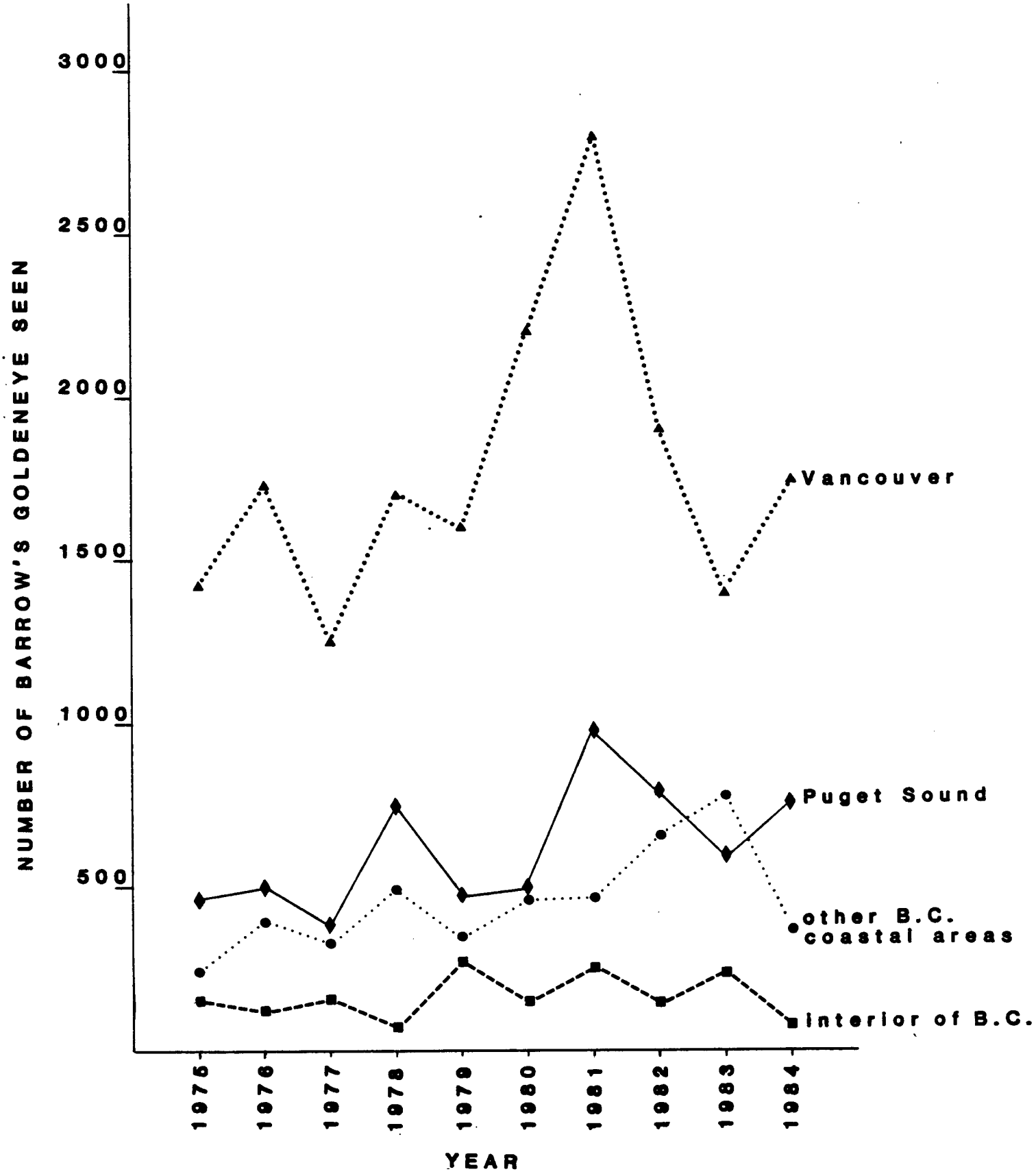

Fig. 5 Barrow's Goldeneye abundance in various Christmas Bird Counts since 1975

Table 4. Summary of Barrow's Goldeneye harvest in the western United States for the period 1971-1980 (Carney *et al.* 1983).

Location	Average Number of birds shot
Alaska	1,137
Washington	891
Oregon	175
Montana	497
Idaho	480
Wyoming	139
California	205
Nevada	0
Utah	163
Colorado	138
Arizona	0
New Mexico	3
Total of averages	3828
Average for the whole flyway	2691

Table 5. Summary of the number of Common and Barrow's Goldeneye harvested in British Columbia.

Year	Number of goldeneyes shot
1978	1,614
1979	7,399
1980	4,947
1981	6,702
1982	836
1983	3,132
$\bar{x}$	4,105 ± 1,097

1985). The average harvest for the period between 1978 and 1983 was 4,105 ± 1,097. If we assume that one half is Barrow's Goldeneye, then the average annual harvest in British Columbia is 2,000 birds.

If we assume: 1) an annual harvest of 5,000 birds on the west coast,

2) a population of 63,000 pairs

3) a yearly production by pairs of 5 young

then yearly production is 315,000 birds of which 2% are shot annually. This indicates that harvest on the west coast is not extensive. However the data base is weak and the calculated estimates here may be misleading. Also, harvest may be important in some areas and affect the local population. Clearly better estimates are required. Recoveries of Barrow's Goldeneyes banded before 1970 indicate that most birds are shot locally and that most of the harvest occurs in British Columbia (Figs. 2-3). Return rates of marked adult females to their breeding areas average between 60-70% indicating a rather high annual mortality rate of 30%. However, none of the 300 adult females I marked have been reported by hunters, suggesting either a low reporting rate or that hunting is not the major source of mortality.

Actual and potential threats

1) British Columbia

A) Restricted distribution and relatively small global population.

Because of their restricted distribution and small global population Barrow's Goldeneye are more sensitive to man-made or natural environmental perturbations than more widespread species.

B) Offshore petroleum exploration and transportation.

Barrow's Goldeneye winter along the Pacific coast where they feed mostly on Blue Mussels (Palmer 1976, Vermeer 1982). Oil spills on their wintering areas could affect the birds directly by weakening them and/or indirectly by destroying their food resources. Many of the wintering areas are inaccessible or subject to severe weather conditions and are therefore unlikely to be rehabilitated after a spill.

C) Toxic pollution.

Blue Mussels concentrate toxic chemicals. Several important wintering sites of Barrow's Goldeneye are located in areas of great industrial activities (e.g. Vancouver, Kitimat and Alice Arm). Accumulation of heavy metals may affect the reproductive success and survival of Barrow's Goldeneye.

D) Hunting.

Hunting mortality could be excessive in some local areas and may affect local populations by taking a large proportion of young each year. Preliminary surveys have indicated that the Barrow's Goldeneye is an actively hunted species in local areas of British Columbia (Savard 1982a).

E) Habitat destruction and bird harassment on wintering areas.

Coastal development reduces winter habitat, and increasing recreational boating may cause undue harassment to some wintering concentrations.

F) Habitat modification on breeding areas.

i) Drainage of wetlands reduces available breeding habitat.

ii) Fish introductions decrease invertebrate densities in

lakes and reduce the lake's attractiveness to goldeneye. Barrow's Goldeneye densities are the highest in alkaline lakes which are usually devoid of fish. Fish competition has been shown to reduce food availability in lakes (Eriksson 1979a, Andersson 1981, Eadie and Keast 1982, DesGranges and Brodeur 1985).

iii) Recreational development may also negatively affect Barrow's Goldeneye survival by increasing disturbance on breeding lakes and thus subjecting young to higher mortality due to territorial behaviour of adults or by modifying the habitat (e.g. cottage development).

iv) Logging is by far the greatest threat. In the last decade an epidemic of Mountain Pine Beetle in the interior of British Columbia has spurred intense logging activities. The result is the removal of all large trees from great tracks of forest. Current forestry practices in the Aspen Parkland remove all snags, often up to the edge of ponds. Therefore, large cavities which Barrow's Goldeneye require to breed become rare and are more distant from lakes.

G) Habitat modifications on wintering areas.

Development of aquaculture along the coast of British Columbia could severely affect wintering Barrow's Goldeneye if the best wintering sites become aquaculture sites. Good wintering sites could also be destroyed by industrial development along the coast.

H) Lack of knowledge.

The molting locations of Barrow's Goldeneye in British Columbia are still unknown and those areas may be subject to any of the above threats. Adults lose their flight capabilities for several weeks when they concentrate to molt, and are therefore highly vulnerable during this period. Because we do not know the location of molting areas, or the behaviour and requirements of the birds during this period, we cannot protect them. Similarly, we do not know the crucial area for fall staging (see the section on Research needs for further examples). Lack of knowledge impairs our ability to adequately manage the species in some phases of its life cycle.

2) Quebec

The population of Barrow's Goldeneye in eastern Canada is especially vulnerable because of its small size. It appears to be completely isolated from the western population and even possibly from the Icelandic population. Because of our poor knowledge of this population it is difficult to identify specific threats. However, threats similar to those present in British Columbia probably exist for the eastern population.

Almost nothing is known about this isolated population: 1) their breeding location is unknown, thus 2) nothing is known of their breeding ecology there. 3) Molting locations are unknown. 4) Staging sites are unknown. 5) Wintering ecology is poorly known. 6) Important wintering habitats have not been identified.

The only information about this population is derived from winter inventories of waterfowl in the St. Lawrence estuary (Reed

and Bourget 1977, Lehoux et al. 1985). In January 1986, a survey of the wintering concentration of Barrow's Goldeneye of Baie des Rochers, Quebec, yielded 156 (52%) adult females, 103 (34%) adult males and 41 (14%) yearlings and/or subadults. The predominance of adult females in the flock suggests that different factors may impinge on this population than on the western population. In British Columbia, large flocks of adult birds are rare and adult males always outnumber adult females.

Furthermore, the population is subject to some hunting pressure (Lehoux et al. 1985). Over 70% of Barrow's Goldeneye harvest occurs on the wintering areas in late October, November and December. However, the national harvest survey is usually too crude to provide reliable harvest estimates for specific provinces and especially for relatively rare species. Lehoux et al. (1985) for example, reports an average harvest over 5 years of 2,176 Barrow's Goldeneye in Quebec. If this estimate was correct then 80% of the estimated wintering population (2,547 birds, Reed and Bourget 1977) would be shot. Obviously this is impossible. Thus, no reliable estimate of hunting pressure on the eastern population of Barrow's Goldeneye exists and even population estimates are of unknown precision and accuracy.

This lack of knowledge on the eastern population of Barrow's Goldeneye constitutes the greatest threat because it impairs our capability to foresee problems and establish preventive measures or find solutions. We can not protect habitat unless we know which habitat to protect. We can not properly manage a species unless we know some of its ecological requirements.

Competition with other species

1) Competition with waterfowl

Barrow's Goldeneye are twice the size of Bufflehead and usually dominate them in aggressive encounters. Female goldeneye have been reported killing female Bufflehead in taking over tree cavities (Erskine 1959, 1960, McLaren 1969). Such competition could explain the low use of large nest boxes by Bufflehead.

Barrow's Goldeneye drakes and females with broods exclude Bufflehead from their territories and may affect their reproductive success. An increase in the density of Barrow's Goldeneye in an area may be accompanied by a decrease in the density of Bufflehead.

Such interrelations between species should be kept in mind whenever a nest box program is put in place. Present data are too limited to determine if Barrow's Goldeneye have a negative effect on other species.

In some regions of British Columbia, Common Goldeneye and Barrow's Goldeneye breed on the same lakes. The ecological relationship between these two species is not clear. Several questions remain to be answered. Does one species have a competitive advantage over the other? In areas of sympatry are their breeding densities similar and/or stable? What allows the two species to coexist? Current data suggests that Barrow's Goldeneye prefer or are limited to productive lakes whereas Common Goldeneye are often found on lakes of lower productivity (Savard 1984). They also may dominate Common Goldeneye in aggressive interactions (Savard 1984) but this remains to be confirmed.

2) Competition with fishes

In most areas where Barrow's Goldeneye occur, they are associated with productive waters (Skinner 1937, Harris et al. 1954, Bengtson 1971, Palmer 1976, Savard 1985). This contrasts with Common Goldeneye which in most of its breeding range is often associated with flood plains and oligotrophic lakes (Siren 1952, Carter 1958, Gibbs 1961, Prince 1965, Palmer 1976, Danell and Sjoberg 1978, Eriksson 1979b) which are often of lower productivity. This apparent restriction of Barrow's Goldeneye to productive ponds and lakes remains to be quantified and tested. In British Columbia Barrow's Goldeneye breed mostly on alkaline lakes and avoid oligotrophic lakes. Moderately saline lakes tend to be more productive than freshwater lakes because of a higher amount of dissolved solids (Rawson and Moore 1944, Cannings and Scudder 1978). Also, fishes are often absent from saline lakes, further increasing food availability to goldeneye. Several studies have shown that fish have a significant impact on invertebrate densities and therefore may compete with goldeneye (Eriksson 1979a, Andersson 1981, Eadie and Keast 1982, DesGranges and Brodeur 1985, Hunter et al. 1985).

Fish introduction into lakes that do not have fish may have negative impact on waterfowl and especially on Barrow's Goldeneye. Close cooperation with the provinces is required to see that management toward improving fishing opportunities does not have a drastic impact on local waterfowl populations.

Research needs

Lack of understanding of the ecology of a species reduces our ability to adequately foresee the impacts of developments and impairs our capability to reduce the impact or to protect habitat. Once we have detected a decrease in a population, lack of knowledge could lead to a further decrease by impairing our ability to identify the causes of the decline and find a solution, thus delaying the implementation of remedial action. Furthermore, once a population is declining it becomes very difficult to study its ecology as the population may not behave normally and the pressure to act to stop the decline may lead to premature and/or unsound decisions.

I have listed below some of the knowledge gaps that still exist in our understanding of Barrow's Goldeneye. The list is far from complete, but nonetheless provides a good starting point.

1) Breeding season

a) Behaviour of subadults

Little is known of the behaviour of yearlings in their first winter and during their second summer. (How and when do they disperse? Are yearling males philopatric to their breeding areas?)

b) Parasitic laying

The causes and functions of parasitic laying are still unknown; some studies have indicated that it may be advantageous (Eadie and Lumsden 1985) whereas others have indicated the contrary (Andersson and Eriksson 1982). What causes parasitic laying? Is it advantageous? Who does it? Can or should we reduce it?

c) Survival rate

The survival rate of adult goldeneyes is poorly known. How long do they live? What is their life table? Do males have a higher survival rate than females?

d) Habitat selection

The breeding requirements of Barrow's Goldeneye are still poorly understood especially when compared to Common Goldeneye. Why are Barrow's limited to highly productive ponds when Common Goldeneye are not? What is the importance of food and nest sites in habitat selection of Barrow's?

e) Nest boxes

Although nest boxes are readily adopted by Barrow's Goldeneye, there are still several aspects to be documented to improve their usefulness. Should nest boxes be cleaned every year? How can we protect next boxes from black bears? What is the optimal number of boxes per pond? What is the most cost effective nest box design?

f) Relationship between Common and Barrow's Goldeneye

Common Goldeneye appear to have invaded the Cariboo since 1982, and several hybrids have been observed. How do the two species coexist in areas of sympatry? Is one species dominant?

2) Staging and Molting

No work has ever been done on fall staging and on molting Barrow's Goldeneye, therefore nothing is known.

a) Where do adult Barrow's Goldeneye males and females molt and stage? Are they dispersed or concentrated? Do they use the

same area every year? Do molting and staging areas correspond to specific breeding areas?

b) What are the requirements of molting and staging birds in terms of food and habitat? Are the molting and staging locations threatened? Can they be protected?

c) What is the behaviour of the birds when molting? How susceptible are they to disturbance?

d) Can we monitor population density by counting birds in molting and/or staging areas? Are fluctuations in the breeding population reflected in the density of molting and/or staging birds?

3) Winter

Only a few studies have been conducted in winter and they mainly indicate our poor understanding of the needs of the species at this time.

a) What is the structure of wintering populations? What characterizes areas used by yearling, subadults and non-paired birds compared to areas used by paired birds? Why are some pairs territorial and others not?

b) How stable are wintering sites? Are wintering groups stable or do the numbers fluctuate from month to month or year to year? Can counts of an area in winter be used to monitor population size?

c) Barrow's Goldeneye diet in winter is composed almost exclusively of Mussels (*Mytilus* sp.). What size do they eat? How fast do they exhaust a Mussel bed? Do they compete with

Surf Scoter? How predictable is Mussel abundance from year to year?

d) When do birds disperse? How do they settle in a particular wintering site? Are there discrete wintering populations corresponding to discrete breeding populations?

e) Why do some goldeneye winter inland? Do they represent non-breeders or discrete populations?

4) Hunting

The national harvest survey was not designed to provide adequate data for management on a local basis and does not do so. More intensive monitoring of harvest is necessary to determine the impact of hunting on the population. How many birds are shot? Where? Are adult males and females equally vulnerable? Are young also vulnerable? Do we need to change hunting regulations?

5) National and international

Because of the relatively small world population and its restricted distribution, it is important to document the ecology of each isolated population.

Little is known of the population of Barrow's Goldeneye of Eastern Quebec. Their breeding area is still unknown. Behaviour, habitat selection, distribution and food in winter has not been documented. The relationships between Icelandic, Quebec and Pacific populations is unknown. Is their behaviour similar? Do they have similar habitat requirements? Are the Icelandic and Quebec populations mixing?

6) Surveys

Several portions of British Columbia still have to be surveyed to determine nesting densities of Barrow's Goldeneye. The abundance of Barrow's Goldeneye in the boreal forest is unknown. We still do not have any systematic surveys to monitor fluctuations in populations of Barrow's Goldeneye. We still have to determine what will be the best time to monitor the population: on the breeding areas, molting areas, staging areas, wintering areas or on a combination of these areas. The accuracy and precision of aerial surveys is unknown and should be documented. Estimates of hunter harvest have to be refined. We need to know the number of ponds of various sizes within the breeding range of Barrow's Goldeneye.

Management options

1) Nest box program to reduce the impact of logging

Nest boxes have been used successfully to increase breeding densities of cavity nesting waterfowl: Wood Duck (Shreiner and Hendrickson 1951, McLaughlin and Grice 1952), Black-bellied Whistling Duck (Dendrocygna autumnalis) (McCamant and Bolen 1979), Common Goldeneye (Siren 1951, 1952, Johnson 1967). The provision of nest boxes has been the key in the successful establishment of new populations of Wood Duck and Common Goldeneye (Doty and Kurse 1972, Eriksson 1982, Dennis and Dow 1984). In central British Columbia the erection of nest boxes resulted in an increase in the breeding density of Barrow's Goldeneye (Savard 1986a).

Several factors influence the use of nest boxes by Barrow's Goldeneye:

a) Height.

Nest boxes higher than 5 meters are preferred to lower nest boxes, and the higher the box, the more likely it is to be used. Similar preferences have been found for Wood Ducks and Common Goldeneye (Dow and Fredga 1985, Lumsden et al. 1986). High boxes may also be less susceptible to bear predation.

b) Previous use of the box.

Nest boxes that have been used by goldeneye one year are more likely to be used by Barrow's Goldeneye the following year. Similar preferences have been documented for Common Goldeneye (Eriksson 1979b, Dow and Fredga 1983).

c) Success of breeding attempt.

Nest boxes in which the breeding attempt was successful are more likely to be used the following year than those in which the breeding attempt failed. Dow and Fredga (1983, 1985) found similar trends in Common Goldeneye.

d) Location.

Highly visible nest boxes are more likely to be detected by prospecting birds and therefore to be subsequently used. Conversely these are also the most likely to be subject to parasitic laying (Semel and Sherman 1986).

e) Age of box.

Old boxes (2-3 years old) received more use than newly installed boxes. This is because goldeneye prospect for nest site a year prior to breeding (Eadie and Gauthier 1985).

f) Presence of nest material.

Boxes with a good layer of wood shavings or grass were more likely to be used. Laying females often cover their eggs with the

nest material until they deposit their down. This renders the eggs less conspicuous to predators. Lumsden *et al*. (1986) found similar preferences in Common Goldeneye.

Although not tested in Barrow's Goldeneye, the following factors have been tested for Common Goldeneye. In all likelihood the results could apply to Barrow's Goldeneye as well.

g) Size of entrance hole.

Medium size entrance holes (13x10 cm) were preferred to small (10.5x8 cm) and large ones (21x12 cm) (Lumsden *et al*. 1980, 1986).

h) Depth of box.

Deep boxes (33 cm deep) were preferred to shallow boxes (<33 cm) (Lumsden *et al*. 1980).

i) Material.

Boxes made of natural logs received more use than artificial boxes (Bragin 1981). Nest boxes containing nest material were preferred to those without (Lumsden *et al*. 1986).

j) Colour interior.

Dark interiors were preferred to light ones (Lumsden *et al*. 1980).

k) Direction of entrance holes.

It was not found to be an important factor either for the Common Goldeneye (Lumsden *et al*. 1980, Dow and Fredga 1985) or the Wood Duck (Morse 1969).

Although nest box programs for cavity nesting waterfowl have been generally successful, some have been plagued by serious problems:

A) Predators

In some locations, nest box programs may be greatly affected by predation. If predators cue on nest boxes, the program as a whole would be detrimental, as it would expose the population to higher losses. Therefore, predation should be monitored during the early phases of a nest box program.

There exist several techniques to reduce predator effects:

i) Several types of predator guards have been developed that successfully reduce the predation level (Webster and Uhler 1970, Grice and Rogers 1965). Bolen (1967) increased the breeding success rate of Black-bellied Whistling Ducks from 44% to 77% with predator guards.

ii) Dispersal of nest boxes would also reduce predation impact. For example, if raccoons are a problem, then boxes located farther from the water's edge may be preferable.

iii) Boxes located over water will be protected from squirrel and Black Bear predation.

In the Aspen Parkland of British Columbia the major predators are the Black Bear, the American Red Squirrel, and the Marten in forested areas.

B) Competition.

Several species of birds and mammals compete for nesting cavities. In the Aspen Parkland, squirrel, American Kestrel (Falco sparverius), Mountain Bluebird (Sialia currocoides) and European Starling (Sturnus vulgaris) compete for nest boxes. Of those, starlings present the greatest problem. However, Barrow's Goldeneye are sometimes successful in taking over starling nests.

Removal of starling nests is an efficient way of discouraging starling use of the boxes. The erection of a smaller box, near the nest box, is also often successful because starlings prefer the small box and exclude other starlings from using the larger one.

C) Parasites.

The benefits of cleaning the boxes every year remains to be demonstrated for waterfowl. Whether old boxes have a heavier parasite load is unknown.

D) Costs.

Monitoring costs and maintenance costs have to be considered as they may be substantial.

Savard (1986a) showed that nest sites were limiting breeding pair densities in some areas in central British Columbia. Gauthier (1985) and Peterson and Gauthier (1985) found a scarcity of large natural cavities in the aspen parkland of British Columbia. On several lakes, Barrow's Goldeneye breed only in nest boxes.

Provision of nest boxes would thus improve the breeding habitat of Barrow's Goldeneye and increase their density. Local Rod and Gun Clubs could be encouraged to erect, maintain and monitor nest boxes in their areas. Nest boxes with predator guards would be ideal. In areas where black bears are a problem, boxes should be erected above water. In several areas of British Columbia such programs would also benefit Wood Ducks. Such programs could be developed in cooperation with the province and with Ducks Unlimited. Monitoring of these nest boxes throughout

the province would provide an index of the size and health of the Barrow's Goldeneye population.

2) Education

Publication of popular articles on the species dealing with its ecology will help sensitize people to problems that this species faces. Barrow's Goldeneye is still a poorly recognized species: Lansdowne, (1976, 1980) in his two volume series on the birds of the west coast, does not even include a painting of the species. In addition, most people in eastern Quebec are not aware of the presence of the species because of its restricted distribution.

Artists depicting wildlife on the west coast almost never use Barrow's Goldeneye as a subject. The Audubon Field Guide of the west coast does not include the Barrow's Goldeneye. This neglect is the most striking considering that over 95% of the world population of Barrow's Goldeneye occurs on the west coast of North America.

3) Protection of key habitats.

Once key habitats have been identified, measures should be taken to ensure their protection through available measures such as acquisition, legislation, federal-provincial agreements, establishment of sanctuaries, creation of parks, and public education.

4) Research.

A better understanding of the ecology of Barrow's Goldeneye will enable us to better predict the impact of various man made

and/or natural habitat changes or disasters on the population. Better understanding also allows us to respond to correct or reduce these impacts more efficiently. Thus, research is especially crucial for the eastern population of which almost nothing is known.

5) Industry cooperation.

It is necessary to cooperate with the logging industry to help them modify their logging strategy. Among modifications that would be useful are:

1) retention of snags in logged areas;
2) retension of a 50 m unlogged band around ponds in logged areas.

6) Harvest Regulation

Although harvest appears small in the west on a province wide scale, it may be extensive in some areas. There is some indication that young birds are more vulnerable to hunting than adults because the latter apparently molt in secluded areas. Also, adult females may be more vulnerable than adult males. Better estimates of harvest on a local basis are required to adequately assess the impact of hunting. This is especially true for the eastern population which, because of its size, cannot withstand extensive harvesting.

7) Development and implementation of a monitoring system.

Good monitoring techniques are essential to assess the impact of the management options we may implement. They also may help in determining whether populations are stable or not.

Concluding remarks

In recent years, our knowledge of the ecology of Barrow's Goldeneye has greatly increased. I hope this report will encourage further progress and lead to the development of a comprehensive management plan for the species. Some of the management options listed here could be implemented now while others require more research.

Literature Cited

Andersson, G. 1981. Influence of fish on waterfowl and lakes. Anser 20: 21-34. (In Swedish with English summary).

Andersson, M. and M.O.G. Eriksson 1982. Nest parasitism in goldeneyes Bucephala Clangula: some evolutionary aspects. Amer. Nat. 120:1-16.

Andrew, D.G. 1960. Aggressive behaviour of Barrow's Goldeneye with young. British Birds 53:572-573.

Anonymous. 1979. Concept plan for waterfowl wintering habitat preservation. U.S. Fish & Wildlife Service, Portland, Oregon. 146 pp.

Ball, I.J., D.S. Gilmer, L.M. Cowardin and J.H. Reichmann. 1975. Survival of Wood duck and Mallard broods in North-Central Minnesota. J. Wildl. Manage. 39:776-780.

Bellrose, F.C. 1978. Ducks, geese and swans of North America. Stackpole Books. Harrisburg, Pa.

Bellrose, F.C., K.L. Johnson and T.U. Meyers. 1964. Relative value of natural cavities and nesting houses for Wood Ducks. J. Wildl. Manage. 28:661-676.

Bengtson, S.A. 1970. Location of nest-sites of ducks in lake Mivatn area, north-east Iceland. Oikos 21: 218-229.

Bengtson, S.A. 1971. Habitat selection of duck broods in lake Myvatn area north-east Iceland. Ornis-Scand. 2:17-26.

Bengtson, S.A. 1972. Reproduction and fluctuations in the size of duck populations at lake Myvatn, Iceland. Oikos 23: 35-58.

Blood, D. 1979. Surveys of breeding waterfowl and songbirds along the Alaska highway in southern Yukon. contracted report, Can. Wildl. Serv., Pacific and Yukon Region. 171pp.

Bolen, E.G. 1967. Nesting boxes for Black-bellied Tree Ducks. J. Wildl. Manage 31(4): 794-797.

Bragin, A.B. 1981. Breeding ecology of the goldeneye (Bucephala clangula) in artificial nests. Ornithologia 16: 22-32. (In Russian)

Cannings, R.A. and Scudder, G.E. 1978. The littoral chironomidae (Diptera) of saline lakes in central British Columbia. Can. J. Zool. 56:1144-1155.

Carney, S.M., M.F. Sorensen, E.M. Martin 1983. Distribution of waterfowl species harvested in states and Counties during 1971-80 hunting seasons. U.S. Dept. Int. Fish & Wildl. Serv. Sp. Sc. Rep. Wildl. No. 254.

Carter, B.C. 1958. The American Goldeneye in central New Brunswick. Wildl. Manage. Bull. Ser. 2 No. 9.

Cottam. 1939. Food habits of North American diving ducks. U.S. Dep. Agric. Tech. Bull. 643. 142p.

Coulson, J.C. and C.S. Thomson 1983. Mate choice in the kittiwake gull. pp. 361-376. In Mate Choice (P. Bateson, Ed.). Cambridge, England, Cambridge Univ. Press.

Danell, K. and Sjoberg, K. 1978. Habitat selection by breeding ducks in boreal lakes in Northern Sweden. Viltrevy 10:161-190.

Delmotte, C. 1978. Contribution a la description du comportement et de la biologie du Garrot Arlequin (Histrionicus histrionicus) et du Garrot d'Islande (Bucephala islandica) sur leurs lieux de nidification. Aves 15: 52-54.

Dennis, R.H. and H. Dow. 1984. The establishment of a population of goldeneyes (Bucephala clangula) breeding in Scotland. Bird Study 3:217-222.

DesGranges, J.-L. et J. Brodeur, 1985. Effets de l'acidité des lacs et de la compétition avec les poissons sur l'alimentation et la croissance de deux espèces de canetons du Bouclier laurentien: Première étape. pages III-1 a III-41 in J.-L. DesGranges (ed.), 1985. L'acidité des lacs et les canards: Première étape. Rapport technique préparé dans le cadre du programme "Environnement 2000" par Canards Illimités et le Service Canadien de la Faune.

Doty, H.A. and A.D. Kruse. 1972. Techniques for establishing local breeding populations of Wood Ducks. J.Wildl. Manage 36:428-435.

Dow, H. and S. Fredga. 1983. Breeding and natal dispersal of the goldeneye, Bucephala clangula. J. Anim. Ecol. 52:681-695.

Dow, H. and S. Fredga. 1985. Selection of nest sites by a hole-nesting duck, the goldeneye (Bucephala clangula). Ibis 127:16-30.

Eadie, J.McA. and G. Gauthier. 1985. Prospecting for nest sites by cavity-nesting ducks of the genus Bucephala. Condor 87:528-534.

Eadie, J.McA. and A. Keast. 1982. Do goldeneye and perch compete for food? Oecologia 55: 225-230.

Eadie, J.McA., H.G. Lumsden 1985. Is nest parasitism always deleterious to goldeneyes? Amer. Nat. 126:859-866.

Edwards, R.Y. 1953. Barrow's Goldeneye using crow nests in British Columbia. Wilson Bull. 65: 197-198.

Einarsson, A. 1985. Use of space in relation to food in Icelandic Barrow's Goldeneye (Bucephala islandica). Ph.D. Univ. Aberdeen, Aberdeen, Scotland. 245pp.

Eriksson, M.O.G. 1979b. Aspects of the breeding biology of the goldeneye Bucephala clangula. Hol. Ecol. 2: 185-194.

Eriksson, M.O.B. 1979a. Competition between freshwater fish and goldeneye Bucephala clangula (L.) for common prey. Oecologia 41: 99-107.

Eriksson, M.O.G. 1982. Differences between old and newly established goldeneye (Bucephala clangula) populations. Ornis Fenn. 59:13-19.

Eriksson, M.O.G. and M. Andersson 1982. Nest parasitism and hatching success in a population of goldeneye Bucephala clangula. Bird Study 29: 49-54.

Erskine, A.J. 1959. A joint clutch of Barrow's Goldeneye and Bufflehead eggs. Can. Field Nat. 73: 131.

Erskine, A.J. 1960. Further notes on interspecific competition among hole nesting ducks. Can. Field Nat. 74: 161-162.

Figler, M.H. and D.M. Einhorn. 1983. The territorial prior residence effect in convict cichlids (Cichlasoma nigrofasciatum Gunther): Temporal aspects of establishment and retention, and proximate mechanisms. Behaviour 85:157-183.

Gardarsson 1978. Distribution and numbers of the Barrow's Goldeneye (Bucephala islandica) in Iceland. Natturu Fraedin gurinn 48: 162-191.

Gardarsson, A. 1979a. Waterfowl populations of Lake Myvatn and recent changes in numbers and food habits. oikos 32: 250-270.

Gardarsson, A. 1979b. Population trends in diving ducks at Myvatn, Iceland, in relation to food. Verh. Orn. Ges. Bayern 23: 191-200.

Gauthier, G. 1985. A functional analysis of territorial behaviour in breeding Buffleheads. Ph.D. Thesis, Dept. Zool. Univ. of British Columbia, Vancouver, Canada. 165pp.

Gibbs, R.M. 1961. Breeding ecology of the Common Goldeneye, (Bucephala clangula americana) in Maine. M.Sc. Thesis, Univ. of Maine. Orono.

Gollop, M.A. and R.A. Davis. 1974. Studies of bird populations and productivity on lakes on the Yukon north slope, July 1972. Arctic Gas Biol. Rep. Ser. 12(1). 35pp.

Gottlieb, G. 1971. Development of species identification in birds. An inquiry into the prenatal determinants of perception. Univ. Chicago Press, Chicago, 176pp.

Grenquist, P. 1963. Hatching losses of Common Goldeneye in the Finnish Archipelago. Proc. XIII Intern. Ornithol. Congr.: 685-689.

Grice, D. and J.P. Rogers. 1965. The Wood Duck in Massachusetts. Mass. Div. Fisheries and Game. Proj. W-19-R. 96pp.

Griscom, L. 1945. Barrow's Goldeneye in Massachusetts. Auk 62: 401-405.

Harris, S.W., C.L. Buechele and C.F. Yocom. 1954. The status of Barrow's Goldeneye in eastern Washington. Murrelet 35: 33-38.

Hasbrouck, M.E. 1944. The status of Barrow's Goldeneye in the eastern United States. Auk 61: 544-554.

Hawkings, J.S. 1986. A review of migratory waterbird populations on the Yukon coastal plain and adjacent Mackenzie Delta. Technical Rep. Ser. No. Can. Wildl. Serv., Pacific and Yukon Region, British Columbia.

Hess, E.H. 1973. Imprinting, early experience and the developmental psychobiology of attachment. Behav. Science Series, Van Nostrand Reinhold Company. New York, Toronto, 472pp.

Hilden, O. 1964. Ecology of duck populations in the island group of Valassaaret, Gulf of Bothnia. Ann. Zool. Fenn. 1:153-279.

Hill, D.A. and N. Ellis. 1984. Survival and age related changes in the foraging behaviour and time budget of Tufted ducklings (Aythya fuligula). Ibis 126: 544-550.

Hinde, R.A. 1956. The biological significance of the territories of birds. Ibis 98:340-369.

Hunter, M.L., Jr., J.J. Jones, K.E. Gibbs, J.R. Moring, and M. Brett. 1985. Interactions among waterfowl, fishes, invertebrates, and macrophytes in four Maine lakes of different acidity. U.S. Fish and Wildlife Service, Eastern Energy and Land Use Team. Biol. Rep. 80 (40.20), 80pp.

Jackson, M.F. 1959. A hybrid between Barrow's and Common Goldeneyes. Auk 76:92-93.

Johnsgard, P.A. 1960. Hybridization in the Anatidae and its taxonomic implications. Condor 62:25-33.

Johnson, L.L. 1967. The Common Goldeneye duck and the role of nesting boxes in its management in north-central Minnesota. J. Minn. Acad. Sci. 34: 110-113.

King, J.G. 1963. Duck banding in Arctic Alaska. J. Wildl. Manage. 27(3): 356-362.

Koehl, P.S., T.C. Rothe and D.V. Derksen 1984. Winter food habits of Barrow's Goldeneyes in southeast Alaska. In Marine birds: their feeding ecology and commercial fisheries relationships. D.N. Nettleship, G.A. Sanger and P.F. Springer (Eds.). Min. Supply and Services Canada No. CW66-65/1984.

Koskimies, J. and L. Lahti. 1964. Cold-hardiness of the newly hatched young in relation to ecology and distribution in ten species of European ducks. Auk 81:281-307.

Lansdowne, J.-F. 1976. Birds of the west coast Vol 1. M.F. Fehely Publishers Ltd. Toronto.

Lansdowne, J.-F. 1980. Birds of the west coast Vol. II. M.F. Fehely Publishers Ltd. Toronto.

Lehoux, D., A. Bourget, P. Dupuis and J. Rosa. 1985. La sauvagine dans le système du Saint-Laurent. Can. Wildl. Serv. Rep., Quebec Region.

Lumsden, H.G., Page, R.E., Gauthier, M. 1980. Choice of nest boxes by Common Goldeneye in Ontario. Wilson Bull. 92: 497-505.

Lumsden, H.G., J. Robinson, R. Hartford. 1986. Choice of nest boxes by cavity-nesting ducks. Wilson Bull. 98:167-168.

Makepeace, M. and I.J. Patterson. 1980. Duckling mortality in the Shelduck, in relation to density, aggressive interaction and weather. Wildfowl 31:57-72.

McCamant, R.E. and E.G. Bolen. 1979. A 12-year study of nest box utilization by Black-bellied Whistling Ducks. J. Wildl. Manage. 43:936-943.

McGilvrey, F.B. 1969. Survival in Wood Duck broods. J. Wildl. Manage. 33:73-76.

McLaren, W.D. 1969. Further data on interspecific competition at a joint Bufflehead-Goldeneye nest site. Can. Field Nat. 83: 59-60.

McLaughlin, C.L. and D. Grice. 1952. The effectiveness of large-scale erection of Wood Duck boxes as a management procedure. North Amer. Wildl. Conf. 17:242-259.

Mendenhall, V.M. and H. Milne. 1985. Factors affecting duckling survival of Eiders (Somateria mollissima) in northern Scotland. Ibis 127:148-158.

Metras, L. 1983. Migratory birds killed in Canada during the 1981 season. Can. Wildl. Serv. Progr. Notes No. 137.

Metras, L. 1984. Migratory birds killed in Canada duirng the 1982 season. Can. Wildl. Serv. Progr. Notes No. 143.

Metras, L. 1985. Migratory birds killed in Canada during the 1983 season. Can. Wildl. Serv. Progr. Notes No. 154.

Millais, J.G. 1913. British diving ducks. London.

Mitchell, G.J. 1952. A study of the distribution of some members of the Nyrocinae wintering on the coastal waters of southern British Columbia. Unpubl. M.A. thesis. Univ. of British Columbia, Vancouver, B.C., Canada. 93pp.

Morse, T.E. 1969. Nest box selection of Wood Ducks as influenced by color and site factors. M.Sc. Thesis, Oregon State Univ., Oregon. 48pp.

Mossop, D. and R. Hayes. 1977. Ornithological investigations in the northern Yukon Territory. Unpublished Annual Report, Yukon Game Branch. 75pp.

Munro, J.A. 1918. The Barrow's Golden-eye in the Okanagan Valley, British Columbia. Condor 20: 3-5.

Munro, J.A. 1923. A preliminary report on the relation of various ducks and gulls to the propagation of sockeye salmon at Henderson Lake, Vancouver Island, B.C. Can. Field-Nat. 37:107-116.

Munro, J.A. 1935. Barrow's Golden-eye nesting in Marmot's burrow. Condor 37: 82-83.

Munro, J.A. 1939. Studies of waterfowl in British Columbia, Barrow's Golden-eye, American Golden-eye. Trans. Royal. Can. Inst. 48:259-318.

Munro, W.T. and S.T. Goodchild. 1981. Preliminary duck management plan for British Columbia. Province of British Columbia, Ministry of Environment.

Myres, M.T. 1957. An introduction to the behaviour of the goldeneyes: Bucephala islandica and B. Clangula (class aves, family Anatidae). M.Sc. thesis Dept. Zool. University of British Columbia.

Myres, M.T. 1959a. The behaviour of the sea ducks. Ph.D. Thesis. Univ. British Columbia, Vancouver, B.C.

Myres, M.T. 1959b. Display behaviour of Bufflehead, scoters and goldeneyes at copulation. Wilson Bull. 71:159-168.

Naylor, A.E. 1960. The Wood Duck in California with special reference to the use of nest boxes. Calif. Fish and Game 46:237-269.

Nickell, W.P. 1966. Behavior of Barrow's Goldeneye in Wyoming. Wils. Bull. 78:121-122.

Palmer, R.S. 1976. Handbook of North American birds Vol. 3. Waterfowl (Part 2). Yale Univ. Press. New Haven and London.

Patterson, I.J. 1982. The Shelduck a study in behavioural ecology. Cambridge Univ. Press, New York. 276pp.

Peterson, B. and G. Gauthier. 1985. Nest site use by cavity-nesting birds of the Cariboo Parkland, British Columbia. Wilson Bull. 97:319-331.

Pienkowski, M.W. and P.R. Evans. 1982a. Clutch parasitism and nesting interference between Shelducks at Aberlady Bay. Wildfowl 33:159-163.

Pourtois, A. 1978. Contribution a la description du comportement et de la biologie du Garrot Arlequin et du Garrot d'Islande sur leur lieux de nidification. Aves 15:52-54.

Prince, H.H. 1965. The breeding ecology of Wood Duck (Aix sponsa L.) and Common Goldeneye (Bucephala clangula L.) in central New Brunswick. M.Sc. Thesis, Univ. of New Brunswick, Fredericton.

Rawson, D.S. and Moore, J.E. 1944. The saline lakes of Saskatchewan. Can. J. Res. Sect. D. 22:141-201.

Reed, A. and A. Bourget. 1977. Distribution and abundance of waterfowl wintering in southern Quebec. Can. Field-Nat. 91: 1-7.

Ringelman, J.K. and J.R. Longcore. 1982. Survival of juvenile Black Ducks during brood rearing. J. Wildl. Manage. 43:622-628.

Robertson, J. and H.S. Stelfox 1969. Some interspecific intolerance between Barrow's Goldeneye and other duck species during brood rearing. Can. Field Nat. 83:407-408.

Rowley, I. 1983. Remating in birds pp. 331-360. In mate choice (P. Bateson, Ed.). Cambridge, England, Cambridge Univ. Press.

Salomonsen, F. 1967. The waterbirds of Greenland. The loon, grebe, duck and goose chapters. Translated by R.G.B. Brown from Fuglene pa Gronland, Rhodos, Copenhagen. Can. Wildl. Serv.

Savard, J.-P.L. 1982a. Preliminary assessment of hunting pressure near Riske Creek, British Columbia. Regional Report Can. Wildl. Serv., Pacific and Yukon Region. 24pp.

Savard, J.-P.L. 1982b. Intra and inter-specific competition between Barrow's Goldeneye (Bucephala islandica) and Bufflehead (Bucephala albeola). Can. J. Zool. 60: 3439-3446.

Savard, J.-P.L. 1982c. Barrow's Goldeneye nest box utilization in the Cariboo parkland, British Columbia: year 1. Progress Notes No. 131. Canadian Wildlife Service, Ottawa, Canada.

Savard, J.-P.L. 1984. Territorial behaviour of Common Goldeneye, Barrow's Goldeneye and Bufflehead in areas of sympatry. Ornis Scand. 15:211-216.

Savard, J.-P.L. 1985. Evidence of long-term pair bonds in Barrow's Goldeneye. Auk. 102:389-391.

Savard, J.-P.L. 1986a. Territorial behaviour, nesting success and brood survival in Barrow's Goldeneye and its congeners. Ph.D. Thesis, Univ. of British Columbia, Vancouver, Canada. 219pp.

Savard, J.-P.L. 1986b. Polygyny in Barrow's Goldeneye. Condor 88:250-252.

Savard, J.-P.L. and J.N.M. Smith. 1987a. Interspecific aggression by Barrow's Goldeneye: a descriptive and functional analysis. Behavior. In press.

Savard, J.-P.L. 1987b. Causes and functions of brood amalgamation in Barrow's Goldeneye and Bufflehead. Can. J. Zool. In press.

Sawyer, E.J. 1928. The courtship of the Barrow's Goldeneye. Wilson Bull. 40:5-17.

Schreiner, K.M. and G.O. Hendrickson 1951. Wood Duck production aided by nesting boxes, Lake Odessa, Iowa, in 1950. Iowa Bird Life 21(1):6-10.

Schultz, Z.M. 1958. Sight record of a hybrid male goldeneye. The Murrelet 39:11.

Semel, B. and P.W. Sherman. 1986. Dynamics of nest parasitism in Wood Ducks. Auk 103:813-816.

Sharp, P.L., P.S. Taylor, W.J. Richardson and J. Ward. 1974. Continuing studies of bird populations and productivity on lakes of the Yukon Coastal Plain, 1973. Arctic Gas Biol. Rep. Ser. 29(1). 51pp.

Siren, M. 1951. Increasing the goldeneye population with nest boxes. Suomen Riista 6:189-190.

Siren, M. 1952. Studies on the breeding biology of the goldeneye (Bucephala clangula) Rustat. Julk. 8:101-111.

Skinner, M.P. 1937. Barrow's Goldeneye in the Yellowstone National Park. Wilson Bull. 49:3-10.

Snyder, L.L. 1953. An apparently hybrid golden-eye. Wilson Bull. 65:199.

Sugden, L.G. 1960. An observation of interspecific strife between Barrow's Goldeneye and Lesser Scaup. Can. Field Nat. 74: 163.

Sugden, L.G. 1963. Barrow's Golden-eye using crow nests. Condor 65: 330.

Swarth, H.S. 1926. Report on a collection of birds and mammals from the Atlin region, northern British Columbia. Univ. Calif. Publ. in Zool. 30: 51-155.

Todd, W.E.C. 1963. Birds of the Labrador Peninsula and adjacent areas. Carnegie Museum and Univ. of Toronto press, Toronto. 819pp.

Vermeer K. 1982. Food and distribution of three Bucephala species in British Columbia waters. Wildfowl 33: 22-30.

Webster, C.G. and F.M. Uhler. 1970. Improved nest structures for wood ducks. U.S. Dept. Inter., Fish and Wildl. Serv. Wildl. Leaflet 458.