Food and distribution of three *Bucephala* species in British Columbia waters

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Introduction

The Bufflehead *Bucephala albeola*, Barrow's Goldeneye *Bucephala islandica*, and Common Goldeneye *Bucephala clangula*, are closely related species. The first species is nearctic, the second one is nearctic except for a small Iceland population, and the third one is holarctic in distribution. The Bufflehead and Common Goldeneye winter on both the Atlantic and Pacific, while the Barrow's Goldeneye is mostly found on the Pacific coast of North America (Bellrose 1976).

The food of the Bufflehead on the North American west coast consists chiefly of crustaceans and molluscs (Munro 1942; Wiemeyer 1967; Erskine 1972; Hirsch 1980), whereas the Common Goldeneye eats crustaceans (Cottam 1939; Vermeer & Levings 1977; Hirsch 1980). The Barrow's Goldeneye diet on the British Columbia coast includes salmon eggs and flesh, caddis fly larvae and marine algae (Munro in Bellrose 1976).

The objective of this paper is to compare the diets and the distribution of the winter populations of the three *Bucephala* species on the British Columbia coast.

Methods

Bufflehead were collected in winter (south coasts of Cortes and Saltspring Islands, 1977–1978) and spring (Fraser Delta, 1976). Common Goldeneyes were collected in spring (south coasts of Cortes Island, 1977; Saltspring Island, 1978; and from Jervis Inlet, 1977). Barrow's Goldeneyes were collected in spring (south coasts of Cortes Island, 1977; Saltspring Island, 1978), in spring and autumn (Jervis Inlet, 1977) and in winter (Fraser Delta, 1974). The food habits of the Common Goldeneye at the Fraser Delta have been previously reported by Vermeer & Levings (1977), but the data were consolidated for the seasons. The collection areas represent different coastal habitats. Cortes Island is at the north end of the Strait of Georgia; Jervis Inlet is a deep fjord entering that Strait; Saltspring Island is representative of the Gulf Island region and the Fraser Delta constitutes the largest British Columbia estuary (see Fig. 1 & 3). Stomachs and oesophagi of the birds were dissected within one hour of collection and the food contents were stored in with 10% formaldehyde.

Aerial surveys were conducted by many observers along the whole British Columbia coast in January–February 1977 and in March 1978. Those observations were by a person on each side of the aircraft. Cruising speed varied from approximately 140 to 200 km/hr. Flights were conducted 30 to 60 m from shore at an altitude of 40 to 80 m depending on weather conditions. Transect width was not fixed. Bi-monthly surveys were conducted by the author from

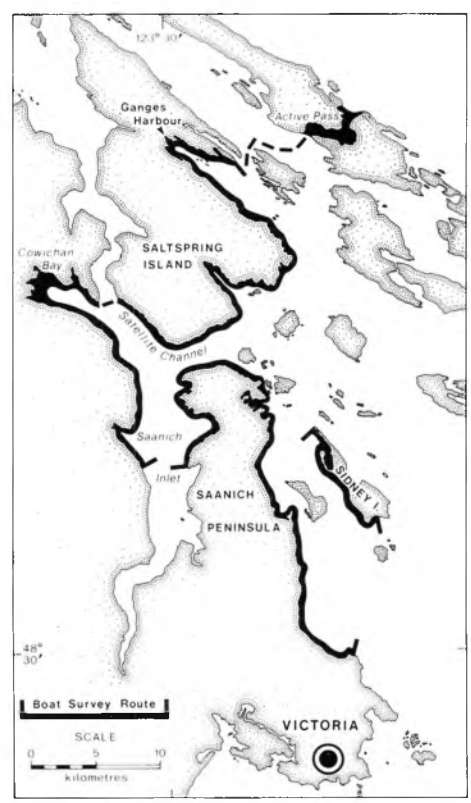

Figure 1. Boat survey routes.

a small boat 20 to 100 m from the shores of the Saanich peninsula and the nearby Gulf Islands in southern Georgia Strait from September 1977 to May 1978. Additional surveys were conducted from a hydrographic vessel along the coast of the Strait of Georgia and adjacent fjords, March and November 1977. Observations were made through binoculars.

Results and discussion

Food

The main food of Bufflehead were shrimp and snails at Saltspring Island; snails at Cortes Island and vascular plants and seeds at the Fraser Delta (Table 1). In spring the Common Goldeneye ate mostly herring

Table 1. Percentage wet weight of prey items and grit in Bufflehead at three locations in the Strait of Georgia

Prey items	Saltspring Island Winter 77–78	Cortes Island Winter 77–78	Fraser Delta Spring 1976
Bivalves			
Mytilus edulis	—	—	1·3
Macoma sp.	—	1·9	—
Psephidia lordi	3·0	—	—
Snails			
Littorina scutulata	1·5	22·5	—
Littorina sitkana	Trace	18·8	—
Littorina marmorata	14·0	—	—
Margarites lirulatus	3·4	—	—
Margarites succinctes	trace	—	—
Margarites costalis	2·0	—	—
Unid. *margarites* fragments	0·3	—	—
Amphissa versicolor	trace	—	—
Lacuna vincta	trace	—	—
Odostomia sp.	0·5	—	—
Alvania compacta	trace	—	—
Snail fragments	0·2	—	0·5
Barnacles			
Balanus glandula	1·0	1·2	—
Crabs			
Cancer sp.	0·4	—	—
Hemigrapsus nudus	0·5	—	—
Pagurus sp.	trace	—	—
Unid. crab fragments	0·2	0·6	—
Shrimps			
Caridea sp.	35·5	9·4	—
Amphipods			
Gammaridean amphipod	trace	5·6	1·6
Isopods			
Gnoriphaeroma sp.	—	—	9·8
Unid crustacean fragments	—	19·9	—
Fish			
Hydrolagus colliei	5·7	—	—
Pholis sp.	1·5	—	—
Unid. fish fragments	0·3	—	—
Fish eggs	trace	—	—
Algae	2·2	8·8	0·1
Vascular plants and seeds	—	—	33·0
Digested matter	21·8	8·8	—
Grit	5·8	2·5	52·5
Feathers	—	—	1·2
No. birds analyzed	20	4	5
Wet weight (g)	144	16	26·4

eggs at Saltspring and Cortes Island and crabs, snails and mussels at Jervis Inlet. The main Common Goldeneye diet at the Fraser Delta consisted of crabs in spring and shrimp in winter (Table 2). In spring the Barrow's Goldeneye ate mostly herring eggs and snails at Saltspring Island, mussels, snails and herring eggs at Cortes Island, while the birds fed chiefly upon mussels in Jervis Inlet in both spring and autumn and at the Fraser Delta during winter (Table 3).

The food varied seasonally and according to locality, but similarities and differences can be discerned between the three *Bucephala* species. Bufflehead fed heavily on snails and crustaceans, Common Goldeneyes on crustaceans and herring eggs and Barrow's Goldeneye on mussels and herring eggs. The staple food of Common

Table 2. Percentage wet weight of prey items and grit in Common Goldeneyes at four Strait of Georgia locations

Prey items	Saltspring Island Spring 1978	Cortes Island Spring 1977	Jervis Inlet Spring 1977	Fraser Delta Spring 1976	Fraser Delta Winter 1979
Bivalves					
Mytilus edulis	—	—	14·7	5·7	7·3
Bivalve fragments	—	0·4	—	1·0	—
Snails					
Littorina scutulata	0·3	4·1	4·2	5·0	—
Littorina sitkana	0·1	—	5·7	—	—
Lirularia lirulata	—	2·3	3·3	—	—
Nassarius mendicus	—	—	—	—	3·9
Batillaria zonalis	—	—	—	trace	—
Margarites pupillus	1·0	—	—	—	—
Lacuna vincta	trace	—	—	—	—
Haminoea vesicula	—	—	1·1	—	—
Odostomia sp.	0·2	—	—	—	—
Trichotropsis canellata	—	—	—	—	3·9
Snail fragments	0·7	—	—	—	—
Barnacles					
Balanus glandula	2·1	—	—	trace	0·3
Crabs					
Hemigrapsus nudus	7·8	—	—	—	5·3
Hemigrapsus oregonensis	—	—	13·2	—	—
Telmessus cheiragonus	—	—	—	18·6	—
Cancer sp.	5·0	—	—	9·4	—
Pagurus sp.	—	—	—	1·0	—
Crab fragments	—	3·3	8·9	2·5	7·5
Shrimp					
Upogebia pugettensis	—	—	—	—	67·4
Shrimp fragments	3·5	—	—	—	—
Amphipods					
Anisogammarus confervicolus	—	—	—	6·8	1·3
Unid. amphipods	1·0	—	—	10·1	—
Isopods	—	—	—	2·0	—
Unid. crustacean fragments	—	—	—	3·9	—
Echinoderms					
Strongylocentrotus droebrachiensis	—	—	2·2	—	—
Fish					
Pholis laeta	—	7·4	—	—	—
Herring eggs	66·4	57·8	—	—	0·2
Vascular plants and seeds	0·5	11·3	—	10·9	1·5
Algae	1·1	0·8	8·0	11·2	—
Digested matter	5·8	6·9	22·4	0·6	—
Grit	4·5	5·7	16·3	11·3	1·4
No. birds analyzed	11	3	6	10	5
Wet weight (g)	268	39	69	98	38

Goldeneyes appeared to be crustaceans and that of Barrow's Goldeneyes, mussels, while herring eggs often formed the main diet of both goldeneye species during their northward migration in spring. Herring eggs were frequently the sole food of many goldeneyes feeding in or near herring spawn areas in March.

Observations on the staple diets of the three *Bucephala* species are supported from other studies on the north-west coast of North America. Munro (1942) reported that 12 of 15 Bufflehead from Vancouver Island in winter, contained snails, 7 had crabs and 3 contained fish and fish remains. Hirsch (1980) found that crustaceans and snails made up 61% and 24% respectively of the food volume of 13 Bufflehead, collected in winter from Sequiem Bay, Washington. Wiemeyer (1967) observed predominantly bivalves and crustaceans in Bufflehead in Northern California at Arcata and South Bays, respectively. However, the bivalve diet at Arcata Bay may have been atypical as the birds fed near a barge which stirred those organisms from beneath a mud surface (Weimeyer 1967).

Cottam (1939) lumped food data of 395 Common Goldeneyes collected from fresh and marine waters in North America, and reported that shore crabs *Hemigrapsus nudus* and *H. oregonensis* were the most important food of those birds in marine waters of the Pacific Northwest. Hirsch (1980) also observed that crabs were a major food for 11 Common Goldeneyes from Sequiem Bay, Washington.

Cottam (1939) combined data from 81 stomachs of Barrow's Goldeneyes from British Columbia, Quebec, Alaska, Oregon, New Brunswick, Vermont and Colorado, found that *Mytilus edulis* made up 12·25% of the food volume. That mussels are a staple food of Barrow's Goldeneyes in British Columbia coastal waters does not appear to have been recognized before this study. Munro (1939) examined 116 Barrow's Goldeneye stomachs, of which 106 were obtained from freshwater habitats, and summarized that the food items of chief economic importance on the British

Table 3. Percentage wet weight of prey items and grit in Barrow's Goldeneyes at four Strait of Georgia locations

Prey items	Saltspring Island Spring 1978	Cortes Island Spring 1977	Jervis Inlet Spring 1977	Jervis Inlet Autumn 1977	Fraser Delta Winter 1979
Bivalves					
Mytilus edulis	trace	23·1	62·1	95·0	90·6
Snails					
Littorina scutulata	3·9	12·3	2·9	—	—
Littorina sitkana	1·6	—	2·3	—	—
Lirularia lirulata	—	3·8	trace	—	—
Margarites lirulatus	1·4	—	—	—	—
Margarites costalis	0·1	—	—	—	—
Thais lamellosa	0·1	—	—	—	—
Odostomia sp.	0·1	—	—	—	—
Snail fragments	19·5	—	3·4	trace	—
Limpets					
Acmea persona	10·3	—	—	—	—
Crabs					
Hemigrapsus oregonensis	—	1·2	—	—	—
Crab fragments	1·0	3·2	0·4	—	—
Shrimp					
Crangon sp.	—	9·7	—	—	—
Isopods	—	—	—	—	1·4
Fish					
Herring eggs	49·2	14·0	—	—	—
Algae	12·3	3·4	23·5	—	—
Vascular plants	—	—	—	—	1·3
Digested matter	—	8·0	0·4	—	—
Grit	0·5	21·3	5·0	5·0	6·7
No. birds analyzed	4	10	21	4	3
Wet weight (g)	97	169	327	63	36

Columbia coast were salmon eggs. Salmon eggs were the most important food of those ducks during the salmon run in some Vancouver Island rivers and in Henderson Lake (Munro 1939). Fortunately, Munro separated Barrow's Goldeneye food items from each geographic region and the food volume of the 10 ducks he collected from estuarine and salt waters in winter was composed of 72% *Mytilus edulis*.

It can be concluded that the Barrow's and Common Goldeneyes feed on herring eggs in spring but differ in staple foods: mussels for Barrow's and crustaceans for Common Goldeneyes. The Bufflehead eats fewer herring eggs but its staple diet of crustaceans is similar to that of the Common Goldeneye. Snails were eaten predominantly by Bufflehead, although the goldeneyes also ate them.

Distribution of winter populations

The distribution of Bufflehead and Goldeneye along the British Columbia coast in January–February 1977 and in March 1978 is shown in Table 4. Bufflehead densities along the British Columbia coast were 0·7 birds/km in January–February and 10·5 birds/km in March. The greatest Bufflehead densities occurred in sheltered waters and inlets of the Strait of Georgia but not in the deep mainland fjords. In March, Bufflehead densities were much higher in the Gulf Islands and in Queen Charlotte Island inlets than in January–February, perhaps reflecting an influx of ducks migrating northward. The highest Bufflehead densities observed from the air were lower than those counted from a small boat along 132 km of shoreline in the Gulf Islands and southeastern Vancouver Island from September 1977 to May 1978 (Figure 2). Bufflehead were the most numerous *Bucephala* species from mid-October to May in those southern sheltered waters of British Columbia. They peaked there at 48·5 birds/km in November and then declined to 23·5 birds/km in February. A small second peak of Buffleheads occurred in March, probably corresponding to their northward migration. Because there are

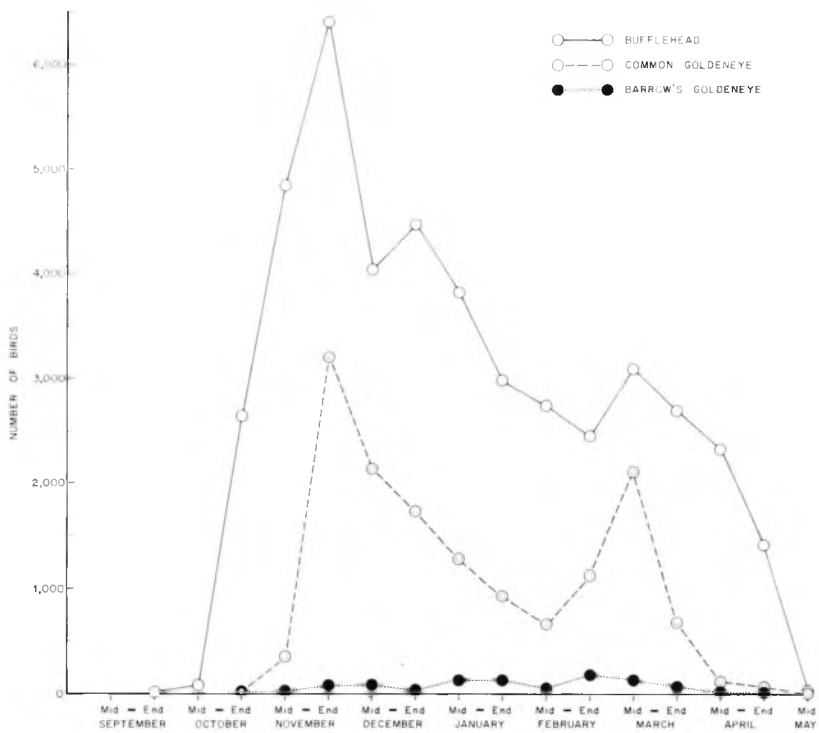

Figure 2. *Bucephala* fluctuations along 132 km of south-eastern Vancouver Island and adjacent Gulf Island shorelines observed from bimonthly surveys from a small boat between September 1977 and May 1978.

Table 4. Distribution of *Bucephala* in various British Columbia coastal habitats as observed by airplane, January–February 1977 and March 1978

Location	No. km surveyed	January–February 1977 *B. albeola* No. birds	*B. albeola* Birds/km	*B. clangula islandica* No. birds	*B. clangula islandica* Birds/km
Vancouver Island	2,181	3,000	1·4	3,936	1·8
East Coast (St. of Georgia) and Gulf Island area	839	1,294	1·5	2,038	2·4
N.E. coast (Qu. Charl. St.)	155	247	1·6	171	1·1
West and S.W. coast	497	490	1·0	186	0·4
West coast inlets	690	969	1·4	1,541	0·4
Mainland	4,054	1,377	0·3	27,254	6·7
Strait of Georgia coast	239	478	2·0	1,135	4·7
Queen Charlotte Sound and Hecate Strait coast	821	—	—*	923	1·1
Mainland fjords	2,994	899	0·3	25,196	8·4
Queen Charlotte Islands	904	315	0·3	334	0·4
Coast	594	81	0·1	174	0·3
Inlets	310	234	0·8	160	0·5
British Columbia coast	7,138	4,692	0·7	31,524	4·4
			March 1978		
Vancouver Islands	1,523	2,256	1·5	8,023	5·3
East coast (St. of Georgia) and Gulf Island area	362	1,137	3·1	2,778	7·7
N.E. coast (Qu. Charl. St.)	147	275	1·9	273	1·9
West and S.W. coast	528	75	0·1	1,816	3·4
West coast inlets	486	769	1·6	3,156	6·5
Mainland	3,534	2,920	0·8	5,964	1·7
Strait of Georgia coast	228	245	1·1	128	0·6
Qu. Charlotte Sound and Hecate St. coast	908	1,648	1·8	502	0·6
Mainland fjords	2,398	1,027	0·4	5,334	2·2
Queen Charlotte Islands	280	407	1·5	248	0·9
Coast	159	61	0·4	33	0·2
Inlets	121	346	2·9	215	1·8
British Columbia coast	5,337	5,583	1·0	14,235	2·7

*Data lost.

approximately 1,090 km of shorelines in the Canadian Gulf Island region, and adjacent south-eastern Vancouver Island it is estimated that 52,900 Bufflehead were present there in November and 25,600 birds by the end of February. The decline in Bufflehead in the Gulf Islands after November indicates that half of the ducks migrate elsewhere later on (cf. November and February figures in Figure 2). Up to 49,000 Bufflehead have been projected to winter in the Strait of Juan de Fuca and northern Puget Sound in 1978 and 1979 (Hirsch 1980). Bufflehead were the most numerous diving ducks there. As most of Puget Sound was not included in the survey results reported by Hirsch, and as the Sound contains a large wintering population of Bufflehead (Bellrose 1976), it is estimated that at least 100,000 Bufflehead winter in the Canadian Gulf Islands, south-eastern Vancouver Island, Strait of Juan de Fuca and northern Puget Sound, which may make that region the wintering grounds for the largest known concentration of Bufflehead on the Pacific coast of North America.

Goldeneye densities along the British Columbia coast observed from the air were 4·4 birds/km in January–February 1977 and 2·7 birds/km in March 1978 (Table 4). Those densities are much higher than for the Bufflehead. The highest goldeneye densities occurred in mainland fjords in

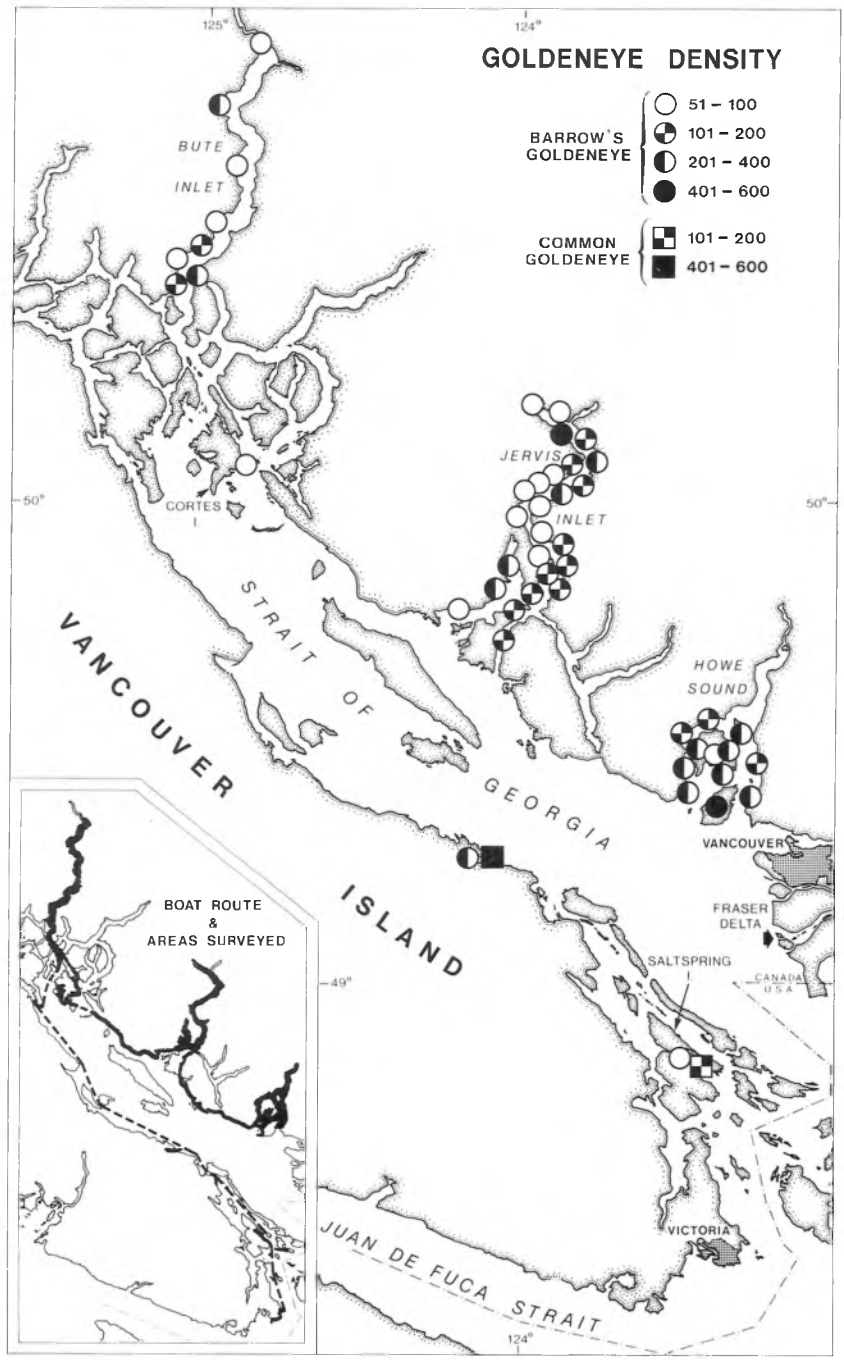

Figure 3. Barrow's and Common Goldeneye aggregations in the Strait of Georgia and adjacent fjords, observed from a hydrographic vessel, March–April 1977.

January–February, and in sheltered waters around Vancouver Island in March (Table 4). Boat surveys in Bute Inlet, Jervis Inlet and Howe Sound indicated that 98% of the goldeneyes wintering there were Barrow's Goldeneyes. The distribution of goldeneye flocks observed from a hydrographic vessel in the Strait of Georgia and mainland fjords in March–April 1977 is shown in Figure 3. A total of 8,013 Barrow's and 157 Common Goldeneyes were then observed along 627 km of fjord shores of Bute and Jervis Inlets and Howe Sound but only 706 Common and 340 Barrow's Goldeneyes were seen along the Vancouver Island coast between Victoria and Campbell River in the Strait of Georgia. The latter figures are not representative of the goldeneye population occurring there as in most instances the vessel could not approach the shallow water near shore where most goldeneyes are usually found. The figures for Bute and Jervis Inlets and Howe Sound are representative because there was no problem with access. The approximate numbers of Barrow's Goldeneyes wintering in British Columbia's mainland fjords can be calculated. There are about 8,500 km of fjord shoreline with a density of 8·6 goldeneyes/km observed during aerial surveys in January–February 1977 (Table 4). About 98% of those appear to be Barrow's Goldeneyes. Boat surveys indicate that about one third of the goldeneyes in the fjords are missed during aerial surveys. Therefore approximately 108,000 Barrow's Goldeneyes were estimated to be present in the fjords in January–February 1977. British Columbia apparently has the world's largest breeding concentration of Barrow's Goldeneyes (Bellrose 1976), and its fjords appear to contain the major wintering complement for that species.

While Barrow's Goldeneyes predominated in the fjords Common Goldeneyes were more numerous than Barrow's on the east coast of Vancouver Island. Present data are insufficient to estimate Common Goldeneye numbers along the British Columbia's coast, except for the Gulf Island region. Common Goldeneye numbers peaked in the Gulf Islands and south-eastern Vancouver Island at 24·2 birds/km in November and declined from then on to 4·9 birds/km in February (Figure 2). A second peak of Common Goldeneyes occurred in March, reflecting northward migration and/or a search for herring spawn. It is estimated that 26,400 Common Goldeneyes were present in the Canadian Gulf Islands and adjacent Vancouver Island waters in November 1977, but only 5,350 birds by late February 1978. Hirsch (1980) estimated that 7,390 Common Goldeneyes wintered in the Strait of Juan de Fuca and northern Puget Sound in 1978 and 1979, while Bellrose (1976) reported that at least 12,000 birds winter in Puget Sound.

Common Goldeneyes also winter in larger numbers than Barrow's Goldeneyes in rivers and river mouths. For instance, several thousands of Common Goldeneyes compared to only a few hundred Barrow's Goldeneyes were observed in the Squamish River mouth and adjacent estuary during the winter of 1972–1973 (D. Trethewey, pers. com.). Squamish River enters Howe Sound, where Barrow's Goldeneyes are the chief species (Figure 2). Bellrose (1976) also reports Common Goldeneyes wintering in larger numbers on rivers and fresh water bodies than Barrow's Goldeneyes. However, both goldeneye species congregate in streams and rivers along British Columbia's coast at the time salmon spawn (Munro 1939).

It can be concluded that large numbers of Bufflehead and Common Goldeneyes winter in the Canadian Gulf Islands and adjacent south-eastern Vancouver Island while the highest densities of wintering Barrow's Goldeneyes occur in British Columbia's mainland fjords.

Bucephala distribution in relation to food habits

All three *Bucephala* species feed close to shore. The Bufflehead and Common Goldeneye were observed in small numbers or in groups of several hundred birds in shallow waters along shores with a sandy, silty, gravel, boulder-strewn or rocky substrate. This distribution undoubtedly correlates to the distribution of snails and crustaceans on which the birds feed. Barrow's Goldeneyes occurred in shallow as well as deep waters along rocky shorelines, inhabited by mussels. When foraging on herring eggs, the three *Bucephala* species mingled with other ducks near eelgrass beds in sandy or silty substrate. That the predominance of Barrow's Goldeneyes and relative scarcity of the other two *Bucephala* in the deep fjords relates to the mussel diet of the former is supported by the observation that another mussel-eating duck, the Surf Scoter is also abundant (Vermeer 1981). Although the Barrow's

Goldeneyes elsewhere shifted their diet to herring eggs in spring, in Jervis Inlet they maintained their mussel diet which probably relates to the fact that herring do not usually spawn in deep fjord waters.

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Summary

The food habits and distribution of winter populations of the Bufflehead *Bucephala albeola*, the Common Goldeneye *B. clangula* and the Barrow's Goldeneye *B. islandica*, were investigated in British Columbia and coastal waters. The two goldeneye species fed on herring eggs in spring but differed in staple foods: mussels for Barrow's Goldeneyes and crustaceans for Common Goldeneyes. The Bufflehead's diet consisted mostly of snails and crustaceans.

Large concentrations of Bufflehead and Common Goldeneyes wintered in sheltered waters of the Canadian Gulf Islands and south-eastern Vancouver Island while Barrow's Goldeneyes chiefly wintered in mainland fjords. The distribution of the *Bucephala* species appears to be related to the distribution of their prey species.

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