The White-winged Scoter diet in British Columbia waters: resource partitioning with other scoters

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1. Abstract

The diet of White-winged Scoters (*Melanitta fusca deglandi*) was examined in British Columbia marine waters. Scoters are opportunistic and forage in various intertidal and subtidal zones over different substrates. At least 20 bivalve and 20 snail species were encountered as prey, which varied among regions. Of the bivalves, six clam species predominated, but blue mussels (*Mytilus edulis*) were important at one location. Of the snails, only *Batillaria attramentaria* contributed significantly to the scoter's food biomass. Barnacles were the most important crustacean food.

The distribution and food of White-winged Scoters were compared with those of Black (*Melanitta nigra*) and Surf scoters (*Melanitta perspicillata*). All three species are found over sand–mud and cobble substrates. White-winged Scoters are also abundant over gravel beds and Surf Scoters over rocky substrates. Surf Scoters outnumbered other scoters along the steep rock walls of fiords.

White-winged Scoters ate more clams and snails than did the other two scoter species, whose diets were composed mainly of mussels. Where scoters foraged over or near clam beds, the Surf Scoter partly switched from mussels to Manila clams (*Tapes philippinarum*) while the Black Scoter remained with its mussel staple. The implications of those prey preferences with respect to the scoters micro-feeding habitat are discussed.

White-winged Scoters selected larger clams and blue mussels than Surf and Black scoters. Black Scoters ate similarly sized mussels as did Surf Scoters, which suggests interspecific competition for that resource.

2. Résumé

Nous avons étudié le régime des Macreuses à ailes blanches (*Melanitta fusca deglandi*) dans les eaux salées de la Colombie-Britannique. Les macreuses sont opportunistes et puisent leur nourriture dans différentes zones intertidales et subtidales au-dessus de différents substrats. Parmi leurs proies, nous avons dénombré au moins 20 espèces de bivalves et 20 espèces d'escargots qui variaient selon les régions. Parmi les bivalves, six espèces prédominaient, mais la moule bleue (*Mytilus edulis*) était importante en un endroit. Parmi les escargots, seul le *Batillaria atramentaria* contribuait de façon significative à la biomasse alimentaire des macreuses. La balane était le crustacé le plus consommé.

Nous avons comparé la répartition et l'alimentation de la Macreuse à ailes blanches à celles de la Macreuse à bec jaune (*M. nigra*) et de la Macreuse à front blanc (*M. perspicillata*). Nous trouvons les trois espèces sur des substrats de sable, de boue et de cailloux roulés. Les Macreuses à ailes blanches sont aussi abondantes sur les lits de gravier et les Macreuses à front blanc, sur des substrats rocheux. Ces dernières étaient d'ailleurs plus nombreuses que les autres macreuses le long des falaises des fiords.

Les Macreuses à ailes blanches mangeaient plus de bivalves et d'escargots que les deux autres espèces, dont le régime se composait principalement de moules. Quand les macreuses pêchaient au-dessus ou près de lits de bivalves, la Macreuse à front blanc passait à l'occasion des moules aux tapes japonais (*Tapes philippinarum*) tandis que la Macreuse à bec jaune restait fidèle à son régime de moules. Nous discutons des répercussions de ces préférences pour certaines proies sur l'habitat micro-alimentaire des macreuses.

Les Macreuses à ailes blanches choisissaient de plus gros bivalves et moules bleues que les Macreuses à front blanc et les Macreuses à bec jaune. Les Macreuses à bec jaune mangeaient des moules de même grosseur que les Macreuses à front blanc, ce qui laisse croire à une concurrence interspécifique pour cette ressource.

3. Introduction

The White-winged Scoter has an almost circumpolar distribution in the northern hemisphere. There are three main races, of which the American one, *Melanitta fusca deglandi*, breeds in northwestern Canada and Alaska and winters on the Atlantic and Pacific coasts of North America (Bellrose 1976).

On the North American Atlantic coast White-winged Scoters feed chiefly on bivalves that include blue mussels (*Mytilus edulis*), mussels (*Yoldia* sp.), Atlantic razor clams (*Siliqua costata*), arctic wedge clams (*Mesodesma arctatum*), northern quahogs (*Mercenaria mercenaria*), and scallops (*Argopecten irradians*) (Cottam 1939, McGilvrey 1967, Cronan and Halla 1968, Stott and Olson 1973). Gastropods can be important inasmuch as Atlantic dogwinkles (*Nucella lapillus*) were observed to be a chief White-winged Scoter food item in Maine (McGilvrey 1967).

Important White-winged Scoter foods along the North American Pacific coast include rock clams (*Macoma inquinata*) in California (Grosz and Yocom 1972), Manila clams (*Tapes philippinarum*, also known as *T. japonica* by some authors) and common Pacific littlenecks (*Protothaca staminea*) in Washington (Glude 1967, Hirsch 1980), olympic oysters (*Ostrea lurida*) over planted oyster beds in Washington (Cottam 1939), and basket cockles (*Clinocardium nuttalli*) and snails (*Batillaria attramentaria*, formerly known as *B. zonalis*)

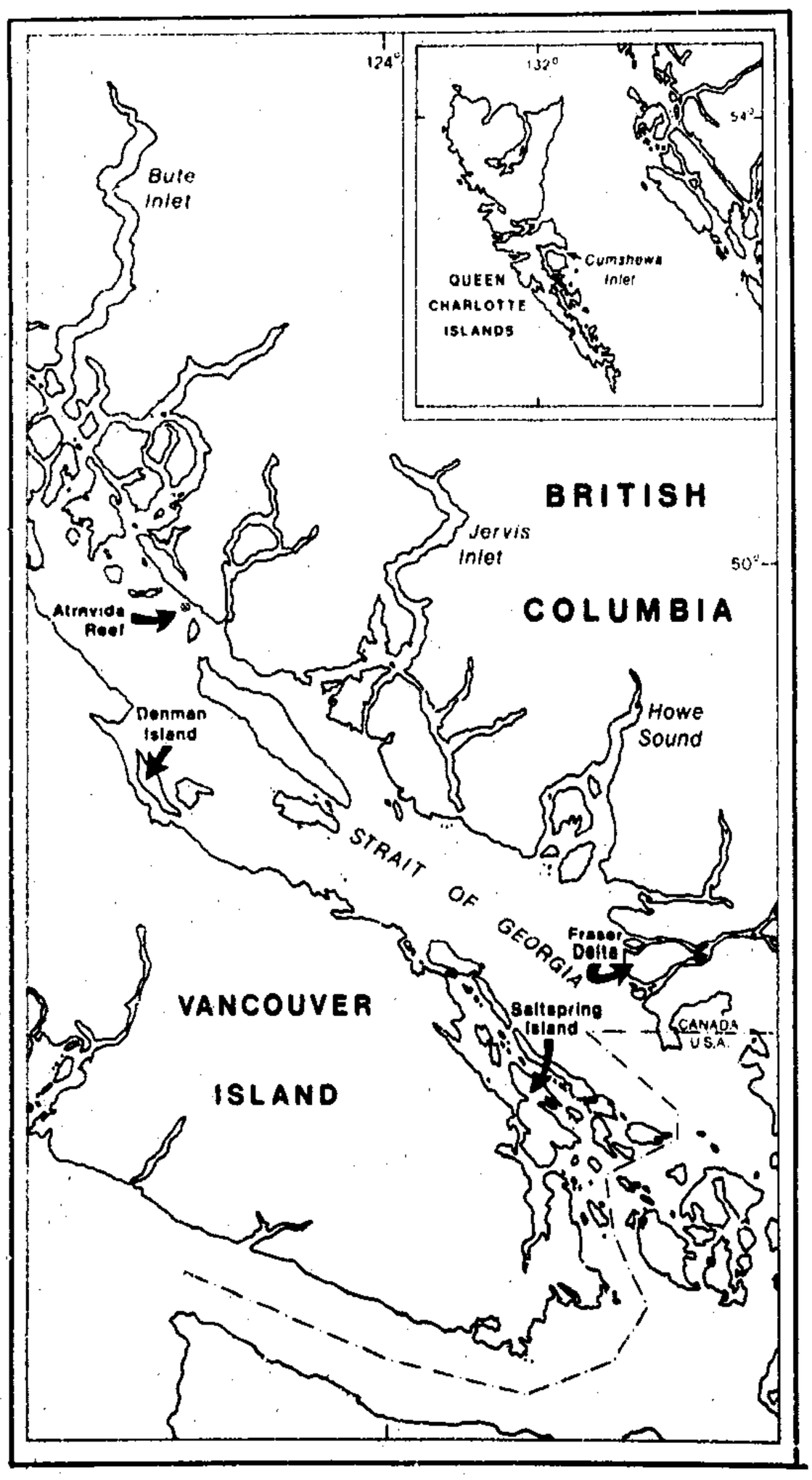
on the Fraser Delta in British Columbia (Vermeer and Levings 1977).

The objectives of this study were to determine prey variability in White-winged Scoters and compare their diets and distribution with Black Scoters (*Melanitta nigra*) and Surf Scoters (*Melanitta perspicillata*) in British Columbia waters.

4. Methods

White-winged Scoters were collected with a shotgun from a boat in January and February (north coast of Denman Island, 1967–1968; Fraser Delta, 1974, 1976; south coast of Saltspring Island, 1977), March and April (south coast of Saltspring Island, 1978; north coast of Denman Island, 1968), July and August (Fraser Delta, 1974), and October and November (south coast of Saltspring Island, 1978; north coast of Denman Island, 1968; Cumshewa Inlet, 1980) (Fig. 1). The food habits of White-winged Scoters on the Fraser Delta have been reported previously by Vermeer and Levings (1977), but the data were consolidated for the seasons. The collection areas in the present study represent different coastal habitats. Waters at northern Denman Island cover a sand-gravel-mud-shell substrate; the Fraser Delta has extensive mud flats; southern Saltspring Island is a representative of the Gulf Islands with a rocky substrate, interspersed with sand-shell-mud; and Cumshewa Inlet on the east coast of Moresby Island has primarily a cobble and gravel substrate. These areas have a maximum tidal range of 5 m, except Saltspring Island which has a range of 3.7 m. Stomachs and esophagi of the White-winged Scoters were dissected within 1 h of collection and the food contents stored in 10% Formalin. Food contents of stomachs and esophagi were consolidated as most prey of White-winged Scoters in marine waters have either hard shells or exoskeletons. The presence of soft foods could bias the data if consumed with hard foods that resist digestion.

Figure 1
Location of study areas in British Columbia waters



Surveys of bird numbers were made from a fishing vessel along the east coast of the Queen Charlotte Islands in October 1976 and from a hydrographic vessel along the coast of the Strait of Georgia and adjacent fiords in March and November 1977. Bi-monthly surveys were conducted from a small boat 20–100 m from the shores of Saanich Peninsula and nearby Gulf Islands in southern Georgia Strait from September 1977 to May 1978. Observations were made through 8-by-30 binoculars.

Distribution and abundance of bivalves and gastropods in intertidal and subtidal areas has been gathered since 1930 by several researchers of the Pacific Biological Station, Nanaimo in conjunction with regular sampling and dragging programs in the littoral waters of British Columbia (Bernard 1970).

Statistical significance was determined with the Fisher Exact Test for proportions (Zar 1974). The principal references used for scientific names of molluscs and crustaceans were Abbott (1974) and Kozloff (1976), respectively.

5. Results and discussion

5.1. Food of White-winged Scoters

The three main food categories eaten by White-winged Scoters were bivalves, gastropods, and crustaceans (Fig. 2, Table 1). Bivalves were a principal prey at all locations, and gastropods formed a substantial portion of the scoters' diet on the Fraser Delta. Crustaceans were important prey at Denman Island in both autumn and winter and on the Fraser Delta in summer.

5.1.1. *Bivalves* — At least 20 bivalve species were observed in the White-winged Scoter diet (Table 1), but only seven were taken in substantial amounts (Fig. 2). Prey species varied among regions and seasons. Important items were basket cockles on the Fraser Delta in winter and summer, and at Saltspring Island in autumn; common Pacific littlenecks and Manila clams, the latter a species introduced from Japan, at Denman Island in autumn, winter, and spring; Manila clams at the Fraser Delta in winter; blue mussels at Cumshewa Inlet and Saltspring Island in autumn; butter clams (*Saxidomus giganteus*) and *Macoma* sp. at Saltspring Island in winter; and *Acila castrensis* and basket cockles at Saltspring Island in autumn. A major seasonal

Table 1
Percentage occurrence and wet weight of prey items and grit in White-winged Scoters at four British Columbia locations

	Fraser Delta				Saltspring Island				Denman Island						Cumshewa Inlet	
	Winter 1974,1976		Summer 1974		Autumn 1978		Winter 1977–1978		Autumn 1967,1968		Winter 1968		Spring 1968		Autumn 1980	
Prey items	**Occ.**	**Wt., g**	**Occ.**	**Wt., g**	**Occ.**	**Wt., g**	**Occ.**	**Wt., g**	**Occ.**	**Wt., g**	**Occ.**	**Wt., g**	**Occ.**	**Wt., g**	**Occ.**	**Wt., g**
Bivalves	71.4	45.8	93.8	39.6	94.7	88.1	100.0	100.0	82.1	62.5	94.1	59.8	100.0	79.6	91.3	58.4
Protothaca staminea	35.7	7.7							51.8	27.2	52.9	15.8	60.0	37.5	4.3	3.6
Tapes philippinarum	21.4	16.7							46.4	29.0	79.4	40.0	62.9	27.7		
Clinocardium nuttalli	35.7	17.6	25.0	31.8	63.2	20.8			12.5	1.4						
Clinocardium fucanum					5.3	6.4										
Mytilus edulis			18.8	3.1	15.8	18.4			25.0	4.7	32.3	3.5	31.4	6.4	87.0	54.4
Mya arenaria	14.3	3.5											5.7	2.9		
Macoma nasuta																
Macoma sp.			31.3	2.0	31.6	4.7	66.7	43.3								
Saxidomus giganteus					21.1	7.6	88.9	56.2			2.9	0.1	11.1	4.9	4.3	0.1
Acila castrensis					31.6	21.6										
Pandora filosa					21.1	0.7			2.0	0.2						
Transenella tantilla					21.1	0.5										
Compsomyax subdiaphana					10.5	4.7										
Lyonsia californica					5.3	0.2										
Nucula tenuis					5.3	0.2										
Nuculana minuta					5.3	0.2										
Liocyma fluctuosa					5.3	0.2										
Cyclocardia ventricosa					5.3	0.2										
Axinopsis serricata					5.3	0.2										
Gari californica											2.9	0.4				
Tresus capax							11.1	0.5					2.9	0.2		
Unident. bivalve fragments	7.1	0.3	56.3	2.7	10.5	1.3										
Gastropods	85.7	38.2	43.8	8.6	57.9	6.0			23.2	1.8	41.2	1.3	48.6	0.2	13.5	20.9
Batillaria attramentaria	71.4	32.0	25.0	3.7					1.8	3.5			11.1	5.7		
Nassarius obsoletus	7.1	3.6														
Nassarius mendicus	7.1	1.0			15.8	0.4			8.9	0.7	2.9	trace	11.1	0.1	8.7	1.7
Turbonilla eschscholtzi	7.1	0.2														
Mitrella gausapata					26.3	3.0			5.4	0.4						
Margarites papillus					5.3	2.2										
Margarites succinctus					5.3	trace										
Margarites lirulatus					5.3	trace									13.0	0.3
Margarites helicinus															13.0	0.1
Bittium eschrichtii					5.3	trace							2.9	0.1		
Bittium attenuatum					10.5	0.1			10.7	0.1	32.3	1.3	14.3	2.6	21.7	0.3
Littorina scutulata					10.5	trace									30.1	11.8
Littorina sitkana					5.3	trace									8.7	1.9
Amphissa columbiana					5.3	trace										
Tachyrhynchus lacteolus									1.8	0.1			5.7	0.1		
Olivella baetica															4.3	trace
Astraea gibberosa															4.3	0.6
Searlesia dira																
Thais (also named *Nucella*) sp.			6.3	3.7												
Unident. gastropod fragments	14.3	1.4	18.8	1.2												
Crabs and shrimps	21.4	15.0	6.3	9.8	26.3	4.4			3.6	0.1	5.9	0.4				
Telmessus cheiragonus	7.1	7.9														
Cancer productus			6.3	3.2												
Hemigrapsus nudus			6.3	6.6	21.1	4.2			3.6	0.1	5.9	0.4				
Upogebia pugettensis	14.3	7.1														
Spirontocaris prionota					5.3	0.1										
Heptacarpus brevirostris					5.3	0.1										
Barnacles																
Balanus glandula			25.0	39.7	10.5	trace			42.9	28.9	32.9	38.5	22.9	11.2	21.7	0.8
Polychaetes	7.1	0.4														
									7.1	0.5					4.3	0.1
Plants	14.3	0.6	12.5	trace											87.0	20.8
Grit	14.3	trace	12.5	2.3	21.1	1.5			1.8	3.2						
Number of scoters		14		16		19	9		56		34		35		23	
Wet weight of food, g		746		300		615	248		1067		1118		1184		691	

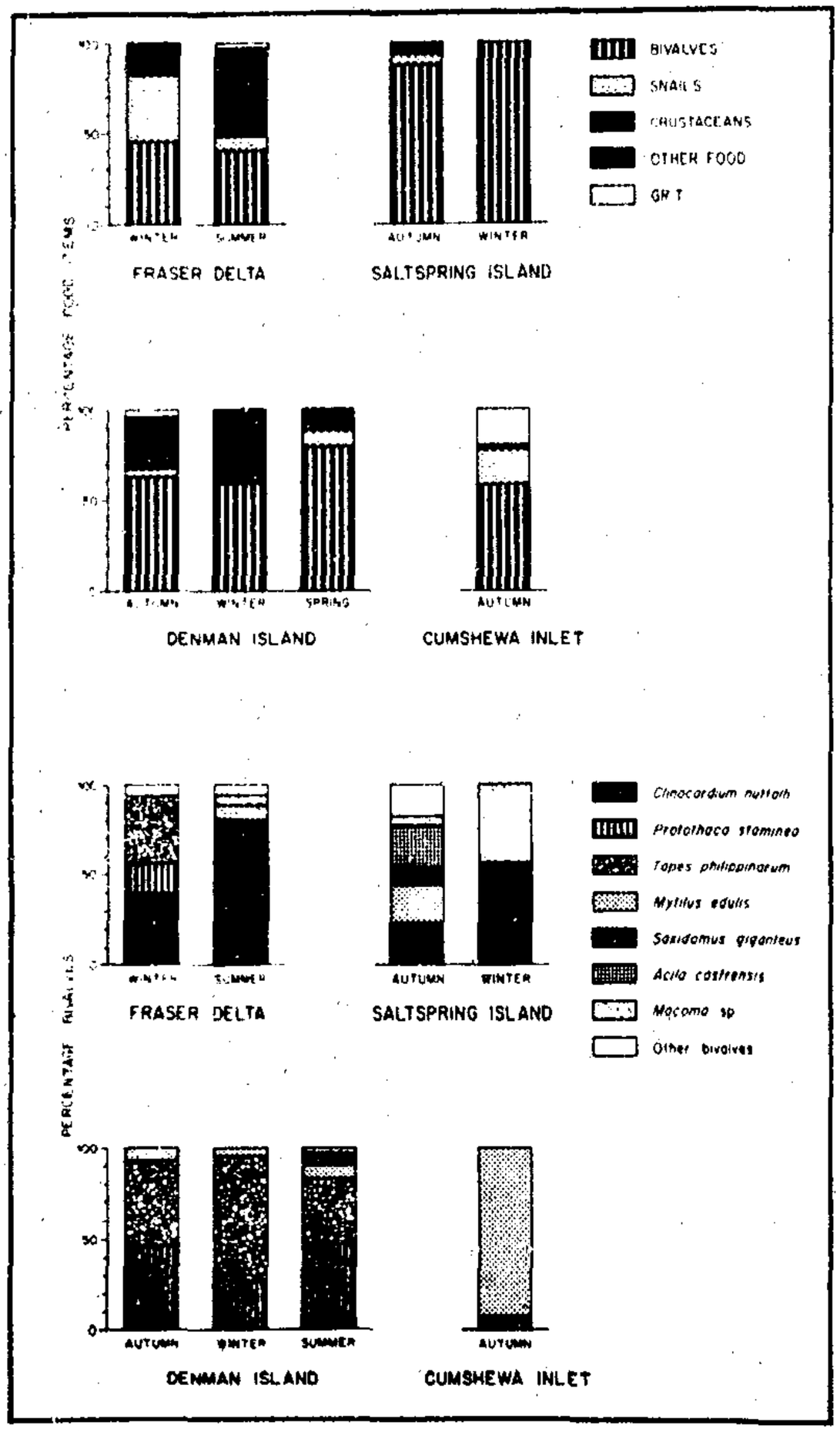
food change was observed on the Fraser Delta where scoters shifted from three principal clam species in winter to chiefly basket cockles in summer (Fig. 2). This shift may be explained in that cockles are found more frequently on the substrate surface during that season than other bivalves, where they are readily accessible to the ducks. Another seasonal food change occurred on Saltspring Island from four clam species in autumn to two species in winter (Fig. 2). No explanation can be given for the latter shift.

The bivalves eaten by White-winged Scoters reflect the abundance of prey items in the various localities. At Denman Island, Manila clams and common Pacific littlenecks are common but basket cockles are relatively scarce (Bourne, unpubl. data); in the Fraser Delta cockles are abundant but other clams are less common (Vermeer and Levings 1977); in Cumshewa Inlet clam beaches are few (Bourne, pers. observ.).

White-winged Scoters appear opportunistic in that individual stomachs contained more than one bivalve species. Of 186 bird stomachs with bivalves, 45.2% had one, 46.2% two, 7.0% three, 1.1% four, and 0.5% eight species. Bivalves eaten varied least at Cumshewa Inlet and most at Saltspring Island. At the latter location, one scoter contained eight species — basket cockles, *Compsomyax subdiaphna*, *Pandora filosa*, *Lyonsia californica*, *Nucula tenuis*, *Nuculana minuta*, *Liocyma fluctuosa*, and *Axinopsis serricata*. Scoters frequently swallowed whole bivalves. The average length of 11 blue mussels was 3.4 cm (range 1.4–4.7 cm); 60 Manila clams, 3.0 cm (range 1.4–5.3 cm); 47 common Pacific littlenecks, 3.7 cm (0.8–5.3 cm); and 6 basket cockles, 4.1 cm (range 2.1–5.4 cm).

The variety of bivalves eaten by White-winged Scoters reflects the diversity in the birds' feeding habitat. Bivalve prey occurred in different intertidal and subtidal areas as well as on different substrates (Fig. 3). Scoters fed chiefly on intertidal clams at all locations (Table 1 and Fig. 3). Some of the bivalves eaten are subtidal, e.g. *Acila castrensis*, but they were important only at Saltspring Island in autumn. Most clams bury in a silt–mud, sand, or gravel substrate, but blue mussels attach themselves to coarse gravel, boulders, solid rock, and pilings. Our results indicate that White-winged Scoters preyed primarily on species occurring on the sea-bottom rather than on rock faces. Blue mussels obtained from cobble–gravel beaches formed the main prey at Cumshewa Inlet. Much gravel occurred in scoter stomachs collected there (21%, classified as grit in Table 1).

Figure 2
Comparison of biomass of major food categories of White-winged Scoters, and of bivalves, at four British Columbia locations



5.1.2. *Gastropods* — White-winged Scoters fed on 20 gastropod species. *Batillaria attramentaria* introduced from Japan, was a particularly important food item at the Fraser Delta mudflats (Table 1). The average length of 45 *Batillaria* taken from scoters was 1.7 cm (range 0.9–2.5 cm). It is not surprising that scoters fed extensively upon that species because of its large size and abundance on the Delta mudbanks. *Batillaria* was more important as a food for White-winged Scoters in winter than summer on the Fraser Delta; this may be due to young *Batillaria*, which hatch in early summer, being larger in winter. Although gastropods were not generally important foods, their variety in the scoters' diet reflects diverse and opportunistic feeding in intertidal and subtidal zones (Fig. 4). Scoters may strip gastropods that occur on eelgrass (*Zostera marina*) and sea lettuce (*Ulva* sp.)

5.1.3. *Crustaceans* — Of the crustaceans, barnacles (*Balanus glandula*) were the most important prey of White-winged Scoters (Table 1). Barnacles appeared as a scoter food in the Fraser Delta only in summer. Barnacles may be accidentally ingested when attached to mussels, but their predominance over any other prey in many scoter meals suggests that they are selected as food. Twenty-one percent of the scoter stomachs from Denman Island contained 80 percent or more barnacles, which were often swallowed whole. Barnacle meals weighed as much as or more ($\bar{x} = 28.6$ g, $n = 26$) than did meals containing predominantly other foods such as common Pacific littlenecks and Manila clams ($\bar{x} = 26.8$ g, $n = 99$). Barnacle and mollusc shells may substitute for grit inasmuch as little gravel occurred in White-winged Scoter stomachs except at Cumshewa Inlet. Cottam (1939) also observed the use of shells as grit and marvelled at the strength and grinding power of the scoter's gizzard, stating that "as many molluscs that a man's fingers cannot break are found in it being ground and chemically disintegrated." Gizzard weights of male scoters averaged 118.4 g (range 74–175 g, $n = 10$) and those of female scoters 109.5 g (range

80–151 g, $n = 13$). Gizzards of male scoters made up 7.7% and those of female scoters, 7.9% of their respective body weights. The largest gizzard of 23 scoters measured was 10 cm across. Gizzard size apparently relates to diet. Gizzards of female White-winged Scoters in Alberta and Saskatchewan averaged 35 g during pre-laying and 19 g at the end of incubation (Brown 1981); those weights are only a fraction of gizzard weights observed in this study. White-winged Scoters chiefly eat amphipods (*Hyalella azteca*) on the breeding grounds (Brown 1981) which do not need as much grinding as barnacles and bivalves, the scoters' winter foods.

Crabs and shrimps were other common crustacean foods of White-winged Scoters (Table 1). The crab diet of scoters on the Fraser Delta consisted of helmet crabs (*Telmessus cheiragonus*), red crabs (*Cancer productus*), and purple shore crabs (*Hemigrapsus nudus*) and was the most diversified of those from the various collecting sites. Purple shore crabs were also common prey at Saltspring and Denman islands. Blue mud shrimps (*Upogebia pugettensis*) were the only shrimp found in scoters feeding on the Fraser Delta, while deep-bladed shrimp (*Spirontaris prinonota*) and stout coastal shrimp (*Heptocarpus brevirostris*) were taken as prey at Saltspring Island.

5.1.4. *Other foods* — Two White-winged Scoters (not shown in Table 1) collected at Atrevida Reef, March 1977, contained mostly Pacific herring (*Clupea harengus pallasi*) eggs. One scoter from the northern end of the Strait of Georgia (not shown in Table 1) contained mostly the chink snail (*Lacuna marmorata*) and remains of a 6-cm unidentified fish. Cottam (1939) found that White-winged Scoters occasionally eat fish.

Figure 3
Tidal-zone location and substrate of bivalve species eaten by White-winged Scoters. Rectangles indicate principal range of occurrence and horizontal lines indicate overall range of occurrence

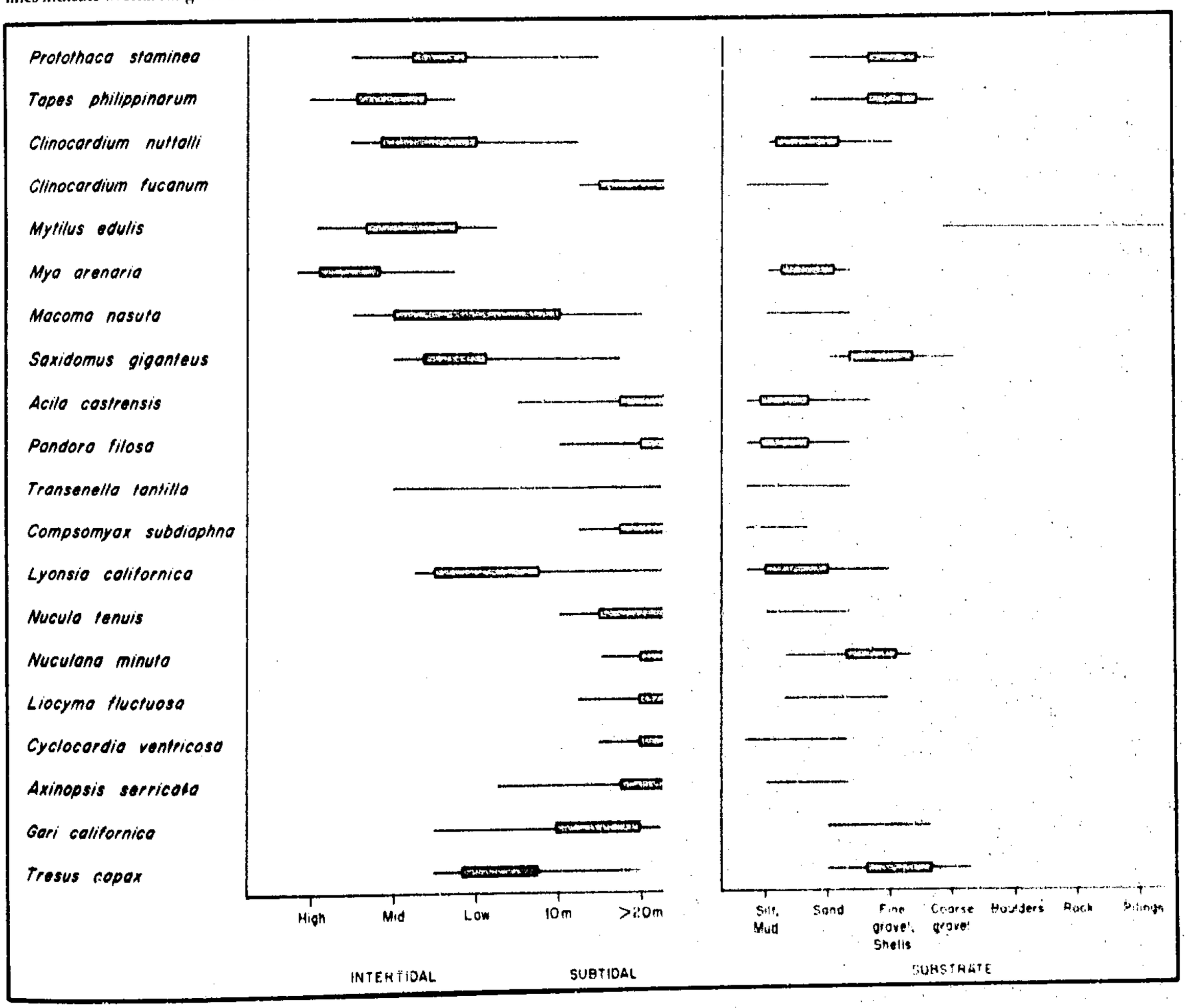
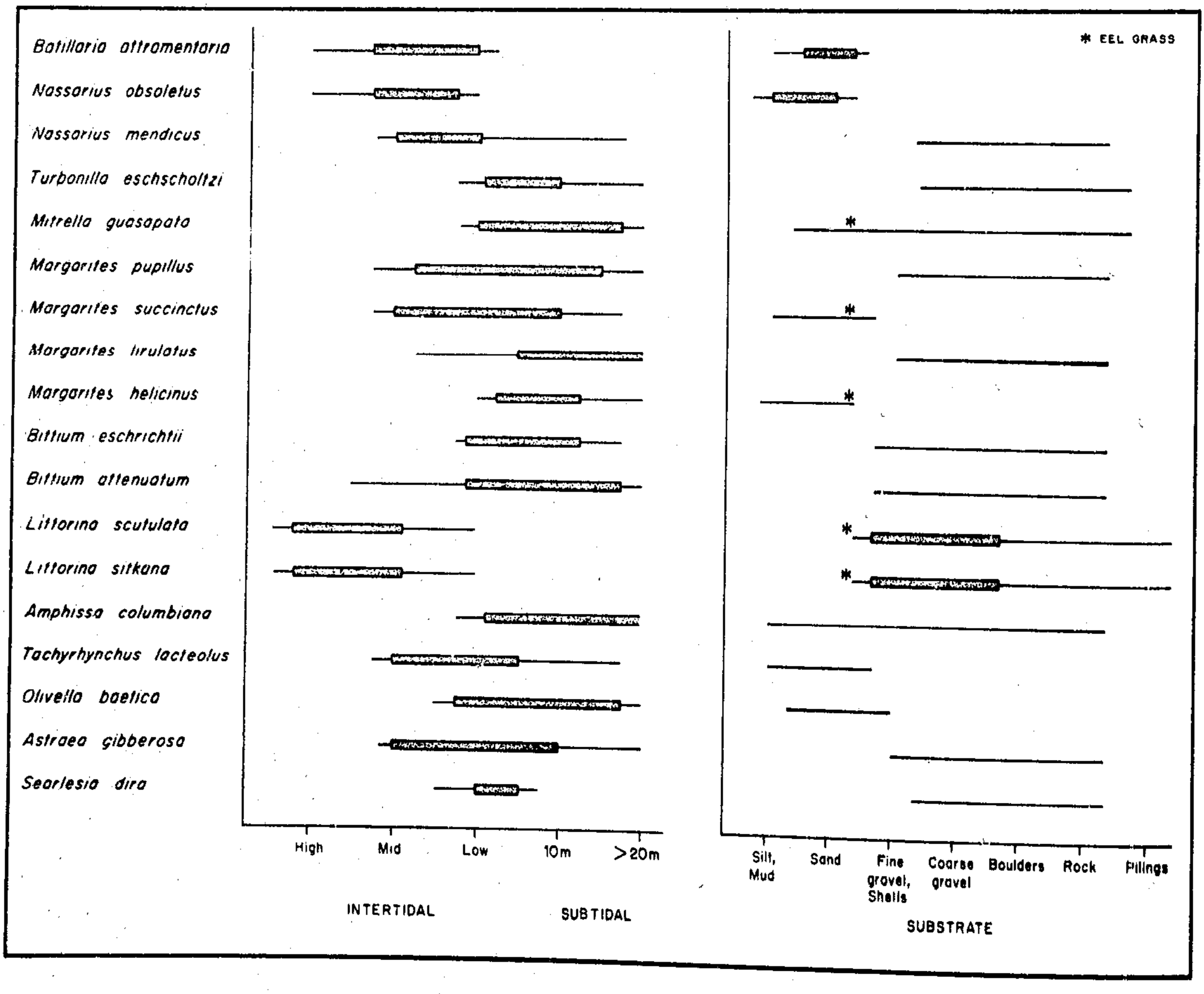


Table 2
Comparison of scoter densities as observed by boat along the Strait of Georgia coast, March and November 1977

	Number of scoters per km					
	Surf Scoter		White-winged Scoter		Black Scoter	
Location	March	November	March	November	March	November
East coast Vancouver Island	41.5	25.9	3.4	10.0	0.5	0.1
Northern Strait of Georgia	6.6	6.9	0.4	0.03	0.3	—
Mainland	46.8	24.7	0.02	0.5	—	—
Mainland fiords						
Bute Inlet	6.5	122.8	—	1.4	0.09	—
Jervis Inlet	7.9	26.5	0.01	—	—	—
Howe Sound	20.5	18.0	0.1	—	—	—
Total no. identified scoters	21 575	35 440	1182	2985	182	27
No. km shoreline surveyed	1 107	964	1107	964	1107	964
Birds/km	19.5	36.8	1.1	3.1	0.2	0.03

Figure 4
Tidal-zone location and substrate of snail species eaten by White-winged Scoters. Rectangles indicate principal range of occurrence and horizontal lines indicate overall range of occurrence



5.2. Resource partitioning with other scoters

Vermeer and Levings (1977) reported on Black, Surf and White-winged scoter diets in the Fraser Delta. The distribution and food of Surf Scoters in British Columbia have been investigated by Vermeer (1981). Bourne (unpubl. data) examined Black and Surf scoter food at Denman Island at the same time that White-winged Scoters were collected there. Information from those sources and the present data allow for comparison on the distribution and food of scoters.

5.2.1. *Macro- and micro-feeding habitats* — In British Columbia the Surf Scoter is the most numerous scoter followed by the White-winged Scoter, while the Black Scoter occurs only in small numbers (Vermeer 1981). The most apparent difference in distribution between Surf and White-winged scoters is that the former is one of the most numerous ducks in the fiords, while the latter is scarce there (Table 2, Vermeer 1981). Surf Scoters feed predominantly on blue mussels on fiord walls. White-winged Scoters are chiefly bottom feeders, and the fiords are generally too deep to allow that type of foraging. White-winged Scoters were scarce along the continuous rocky shores of the mainland coast (Table 2). They occurred in higher densities over sand–mud, gravel, and cobble substrates but were still less numerous than Surf Scoters on the east coast of Vancouver Island and in the Gulf Islands (Table 2, Fig. 5). White-winged Scoters outnumbered Surf Scoters by about one order of magnitude in autumn 1976 at northeastern Moresby Island, which includes Cumshewa Inlet, where they fed over cobble and gravel substrates.

Black Scoter populations were small compared to those of the other two scoters in British Columbia. Their numbers were most substantial in March during migration, when they occurred over sand–mud and cobble substrates between Nanaimo and Campbell River on the east coast of Vancouver Island. In March 1978 they were the main scoter species observed in kelp beds off northeastern Vancouver Island.

Differences in prey predominance in the diets of the three scoter species in the same region may define differences in their feeding habitats. Blue mussel presence reflects feeding over coarse gravel, boulders, and a rock substrate in the intertidal zone (Fig. 3). Most clams occur in a silt, mud, sand, and fine gravel substrate (Fig. 3). This suggests that at Denman Island, Black Scoters foraged in the former and White-winged Scoters in the latter habitat, whereas Surf Scoters were found over both substrates. The presence of *Acila castrensis* in White-winged Scoters and not in Surf Scoters at Saltspring Island suggests more subtidal feeding by the former. White-winged Scoters were generally seen farther from shore and in deeper waters at that location than at the other locations. Hirsch (1980) also observed that White-winged Scoters are frequently found in deeper waters than other diving ducks in areas along northern Puget Sound and the Strait of Juan de Fuca in Washington State. The greater occurrence of snails in White-winged Scoters than in the other two species indicates extensive feeding over sand–mud and fine gravel substrates and in eelgrass to which snails attach (Fig. 4). Vermeer and Levings (1977) reported that White-winged Scoters fed extensively on basket cockles (Table 3) in eelgrass beds of the lower Fraser Delta intertidal zone. The above observations show that, although the three scoter species feed in the same area, there is partitioning of feeding habitats.

5.2.2. *Diet* — The diets of the three scoters were compared when investigated at the same locations (Table 3). Bivalves formed the main diet for all three species. Black and Surf scoters fed significantly more on blue mussels than did White-winged Scoters ($P<0.05$); the main food of White-winged Scoters consisted of a variety of clams. At Denman Island, Surf and White-winged scoters fed extensively upon Manila clams whereas Black Scoters remained with their mussel staple. White-winged Scoters fed significantly more on gastropods than the Surf Scoter at Denman Island, the Fraser Delta, and Saltspring Island and than the Black Scoter on the Fraser Delta ($P<0.05$). White-winged Scoters contained significantly more barnacles than did Surf Scoters at Denman Island, and the Black Scoter ate significantly more barnacles than the Surf Scoters at the Fraser Delta ($P<0.05$). Apparently, barnacle predominance in White-winged Scoters reflects deliberate feeding on that prey, whereas the barnacles taken by Black Scoters are ingested incidentally to blue mussels. Polychaetes occurred most frequently in Black Scoters at the Fraser Delta.

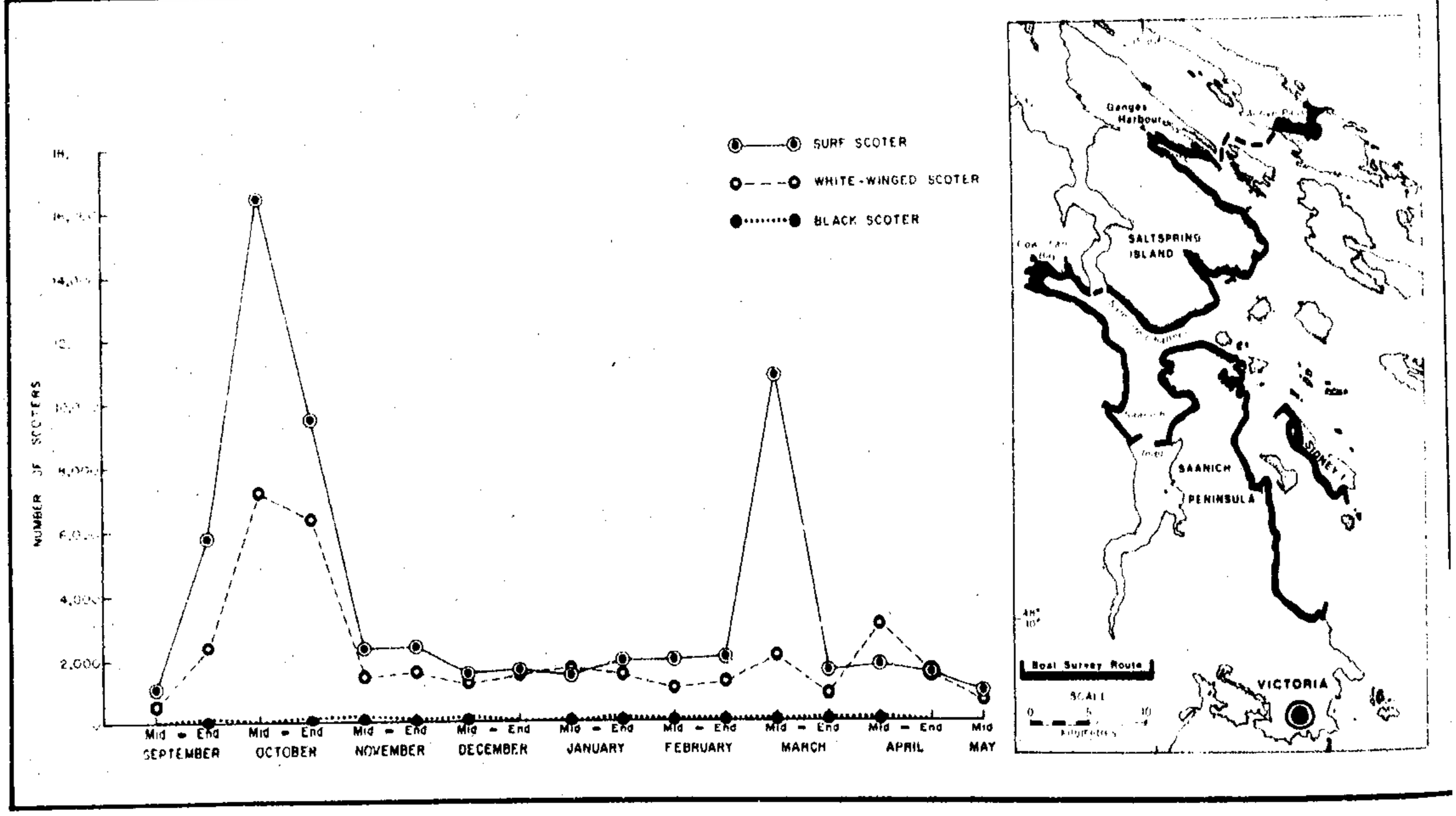
5.2.3. *Prey size* — White-winged Scoters select different-sized bivalves than Surf and Black scoters. Because size of scoter prey varies between regions (Vermeer 1981), valid comparisons for prey size can be only made for the same locations. At Saltspring Island the average length and standard error of 11 blue mussels from White-winged Scoters was 3.4 ± 0.4 cm whereas 218 blue mussels from Surf Scoters averaged 1.6 ± 0.01 cm long. At Denman Island the average length of 60 Manila clams from White-winged Scoters was 3.0 ± 0.2 cm whereas 38 Manila clams from Surf Scoters averaged 1.9 ± 0.2 cm in length. The mussels and clams eaten by White-winged Scoters averaged significantly larger than those taken by Surf Scoters ($P<0.05$). On the Fraser Delta, 85 blue mussels from Surf Scoters averaged 2.0 ± 0.08 cm long, compared to 19 blue mussels from Black Scoters which averaged 1.9 ± 0.2 cm in length. The Surf Scoter therefore feeds on similarly-sized mussels as the Black Scoter. It is not surprising that the White-winged Scoter takes larger bivalves than Surf and Black scoters as the former is much larger than the other two species, which resemble each other more closely in body weights. The mean weights, standard errors and numbers of scoters sampled were as follows: White-winged Scoter, 1722 ± 51 g (21 males) and 1437 ± 46 g (19 females); Surf Scoters, 1153 ± 12 g (61 males) and 1025 ± 15 g (26 females); Black Scoters, 1268 ± 10 g (25 males) and 1135 ± 49 g (7 females).

The similar size of their food items and overlap in prey species suggests interspecific competition between Black Scoters and Surf Scoters in which the latter are more successful in British Columbia. Black Scoters are numerous in the Aleutians and northern Europe where Surf Scoters are scarce or absent. In northern Europe, blue mussels are also a principal food of Black Scoters (Madsen 1954, Nilsson 1972). More information is needed to clarify the ecological relationship between Black and Surf scoters.

Table 3
Percentage occurrence of food items in scoter species at three British Columbia locations (sample number of scoters in parentheses)

	Denman Island			Fraser Delta			Saltspring Island	
Food species	**White-winged (*N* = 125)**	**Surf (*N* = 72)**	**Black (*N* = 15)**	**White-winged (*N* = 30)**	**Surf (*N* = 58)**	**Black (*N* = 13)**	**White-winged (*N* = 28)**	**Surf (*N* = 22)**
Bivalves	91	93	93	90	83	100	96	95
Mytilus edulis	29	53	93	10	38	38	11	68
Tapes philippinarum	60	58	13	10	3	—	—	—
Protothaca staminea	54	36	20	17	10	—	—	5
Clinocardium nuttalli	6	8	—	30	2	8	43	—
Mya arenaria	—	—	—	7	10	23	—	—
Saxidomus giganteus	4	—	—	—	—	—	43	—
Acila castrensis	—	—	—	—	—	—	21	—
Gastropods	34	17	13	63	17	15	39	9
Batillaria attramentaria	4	4	—	37	7	8	—	—
Littorina scutulata	18	1	7	—	—	—	7	—
Nassarius mendicus	8	3	—	3	—	—	11	—
Mitrella gausapata	2	1	—	—	—	—	18	—
Barnacles	40	18	60	13	2	15	7	9
Balanus glandula	—	1	—	3	12	46	—	—
Polychaetes								

Figure 5
Comparison of scoter numbers as observed by boat in Canadian Gulf Islands and adjacent Vancouver Island, September 1977 – May 1978



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