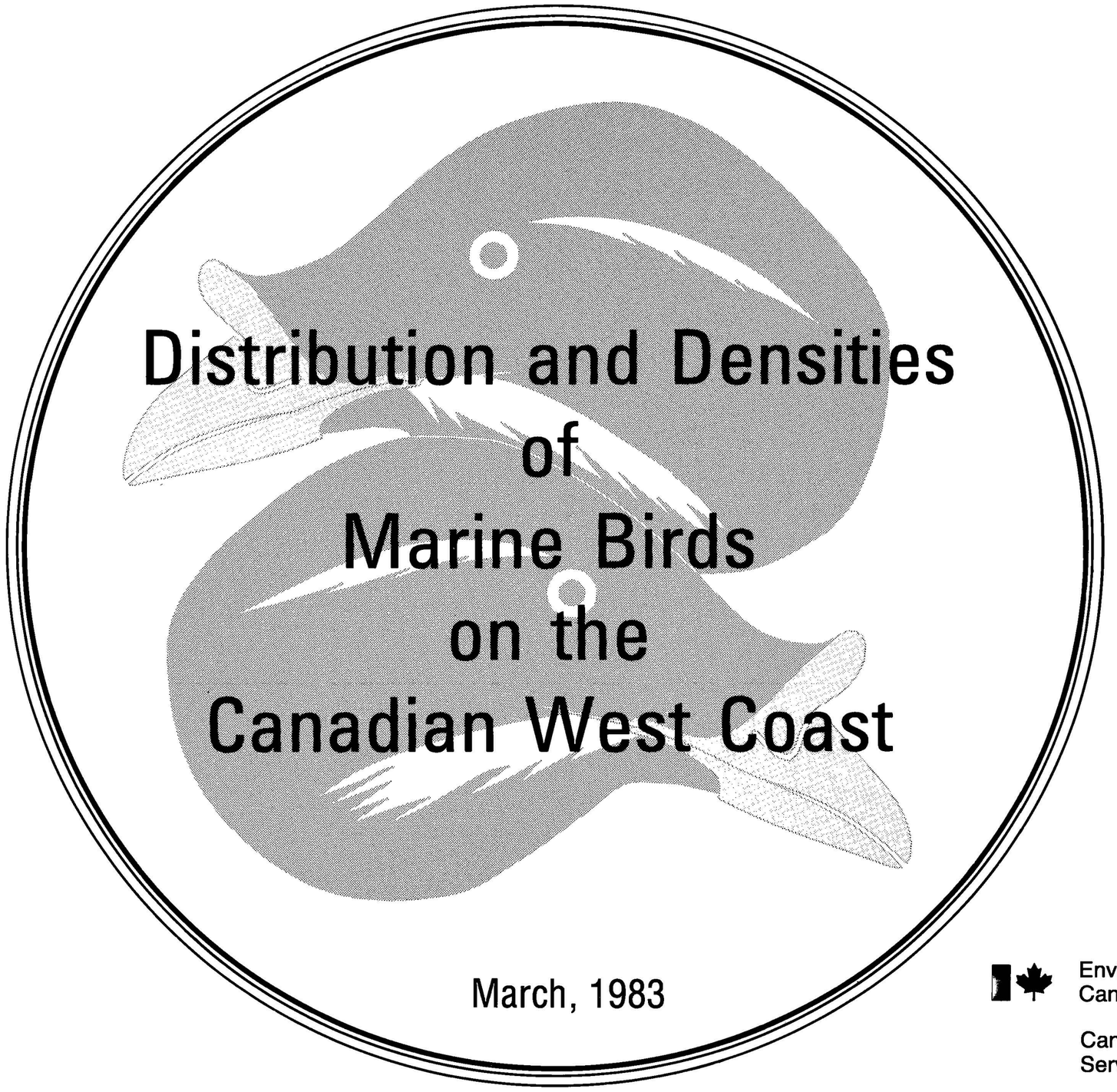

Distribution and Densities of Marine Birds on the Canadian West Coast

March, 1983

Canada

Environment Canada
Canadian Wildlife Service

Environnement Canada
Service canadien de la faune

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Abstract

This Atlas presents the results of aerial and shipboard surveys of marine birds along Canada's Pacific coast. The Atlas commences with a record of systematic sightings of marine birds from weathership Station Papa, 900 kilometers offshore; follows with results of aerial observations of birds closer to the coast; and finally to those seen along shores and inlets. The concentrations of breeding marine birds are discussed in the last chapter.

Several million birds are found within a few kilometers of the coastline from September to April. Another one million birds are present in all seasons on the open water of the Continental Shelf. Two million birds breed annually along the coast of which the Cassin's Auklet, Ancient Murrelet and Rhinoceros Auklet are the most abundant species. Those three species breed in larger numbers in Canada than anywhere else in the northeastern Pacific.

Of the birds that winter along the coastline, the diving ducks, particularly Surf and White-winged Scoters, Greater Scaup, Bufflehead and Barrow's Goldeneyes, are most numerous. British Columbia's coastal fjords contain the world's major known wintering population of Barrow's Goldeneyes. Of eleven gull species that frequent the coast, Glaucous-winged Gulls are most frequently observed, although Bonaparte's and Mew Gulls are numerous during spring and autumn migration. Tens of thousands of Arctic Loons migrate northward along the west coast of Vancouver Island each spring, while equally large numbers of Western Grebes winter in the Gulf Islands. The avifauna of Canada's Pacific coast is rich and diversified. This atlas is our first attempt at placing that complex array in perspective.

Précis

Cet atlas traite des résultats d'études aériennes et maritimes des oiseaux marins fréquentant la côte pacifique du Canada. L'atlas commence par une documentation d'observations systématiques des oiseaux marins, observations obtenues d'à bord le vaisseau météorologique Station Papa situé à 900 kilomètres de la côte; l'atlas continue avec les résultats d'observations aériennes de ces oiseaux, prises de plus près de la côte; et finalement, l'atlas se termine par les oiseaux observés sur les littorals et dans les anses. Les concentrations des oiseaux marins qui se reproduisent sont discutées dans le dernier chapître.

En dedans de quelques kilomètres du littoral peuvent être trouvés plusieurs millions d'oiseaux entre les mois de septembre et avril. Un autre million d'oiseaux sont présents en toutes saisons sur les eaux ouvertes de la Corniche continentale. Deux millions d'oiseaux se reproduisent chaque année au long de la côte. Parmi ces derniers, les espèces les plus abondants sont les Alques de Cassin, les Alques à cou blanc, et les Alques à bec cornu. Ces trois espèces se reproduisent en plus grand nombre au Canada qu'ailleurs dans le Pacifique nord-est.

Des oiseaux qui hivernent le long du littoral, les canards plongeurs, en particulier les Macreuses à front blanc et les Macreuses à ailes blanches, les Grands Morillons, les Petits Garrots, et les Garrots de Barrow, sont les plus nombreux. Dans les fjords de la Colombie-Britannique, on retrouve la population hivernante des Garrots de Barrow; cette population est l'une des mieux connues au monde. Des onze espèces de mouettes qui fréquentent la côte, sont observés le plus fréquemment les Goélands à ailes glauques, bien que les Mouettes de Bonaparte et les Goélands cendrés sont nombreux pendant les migrations du printemps et de l'automne. Chaque printemps, des dizaines de milles de Huarts arctiques émigrent vers le nord en longeant la côte ouest de l'île de Vancouver; aussi nombreux sont les Grèbes de l'Ouest qui hivernent dans les îles du Golfe. La faune ornithologique de la côte pacifique du Canada est riche et diversifiée. Cet atlas est notre premier essai de mettre en perspective ces atours complexes.

Acknowledgements

Several agencies and many people contributed to this Atlas. The authors and D. F. Hatler, R. McKelvey, J. P. Savard, R. Martin, K. R. Summers, A. Barnard, R. Davies, J. Lindeburgh, J. Merriman, M. G. Shepard, G. Smith, I. Smith, L. Cullen, C. Easthope, L. Enders, A. Farr, P. Milligan, M. Pageot, W. Prediger and G. Wolfe conducted aerial and boat surveys of marine birds. Members of the offshore oceanic group of Environment Canada contributed with observations on marine birds from weatherships "Quadra" and "Vancouver" at Ocean Station Papa (50°N; 145°W) at 900 km from the British Columbia coast. A. Farr, L. Cullen, M. Pageot and M. Porter provided assistance with teh compilation of data and initial drafting of maps. G. H. Staines and D. R. Flook gave unwavering support to the project and reviewed the initial draft of the text. Later drafts were reviewed by A. Martell, R. W. Butler and S. Groves. Surveys were chiefly financed by the Canadian Wildlife Service, but also by the British Columbia Fish and Wildlife Branch and British Columbia Provinical Museum. The Institute of Ocean Sciences, Patricia Bay, Victoria, provided manpower and boats for some surveys.

The Atlas would not have been produced without the generous financial support of Chevron Standard Limited. The senior author is greatly indebted to Chevron personnel, notably W. E. Bannister, Vice President of Exploration, E. E. Cudby and S. Groves for their support and conviction that the Atlas provides a valuable contribution to the understanding and protection of marine birds on Canada's west coast; and to J. T. Garvin who designed and supervised the production of the Atlas; to C. Barry and S. Hall for drafting the final figures and maps.

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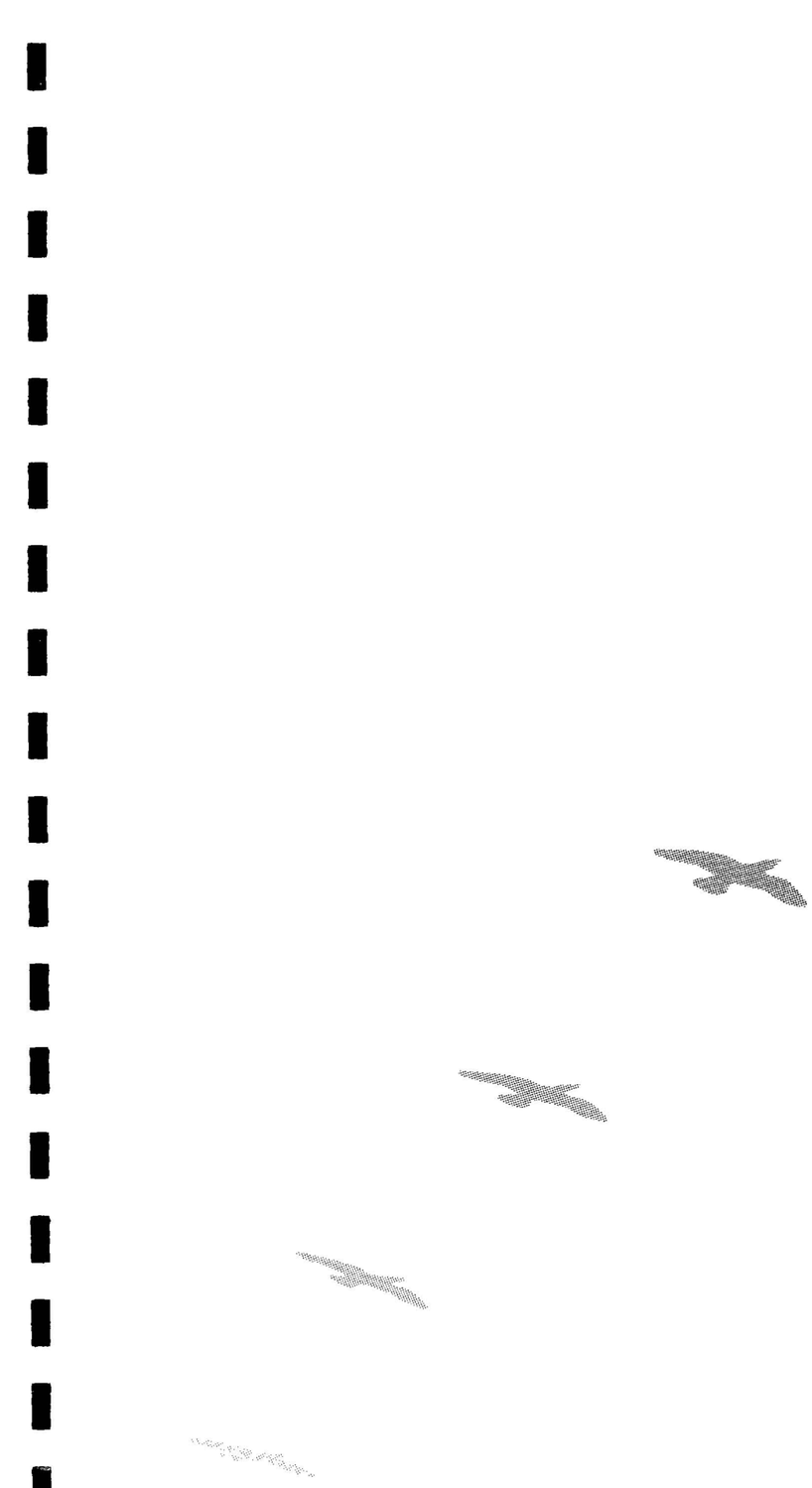


Introduction

The Pacific coast of Canada, with approximately 27,000 km of indented shoreline, is remarkable for the diversified coastal habitats created by its complex physiography. Hecate Strait and the Strait of Georgia form two large sheltered seas. Main access from Hecate Strait to the Pacific Ocean is through Dixon Entrance to the north and Queen Charlotte Sound to the south (Fig. 1). The Strait of Georgia has one main entrance to the Pacific, the Strait of Juan de Fuca to the south and one narrow connection, Johnstone Strait to the north. Johnstone Strait constitutes a passage between the Strait of Georgia and a smaller sheltered sea, Queen Charlotte Strait, which enters Queen Charlotte Sound. The Strait of Georgia and Queen Charlotte Strait are bordered by the mainland to the east and Vancouver Island to the west. The Queen Charlotte Islands shelter Hecate Strait from the Pacific Ocean. On the Pacific side of Vancouver and the Queen Charlotte Islands is a narrow continental shelf except where the Strait of Juan de Fuca enters the Pacific Ocean (Fig. 1). Many rivers empty into the coastal seas through deep fjords, and have extensive estuaries at their mouths. The Strait of Georgia could be termed an estuary because of the large volume of fresh water that pours into it from a half dozen major rivers, chief among them the Fraser River. The Fraser River estuary together with adjacent Puget Sound to the south, constitutes the largest estuarine salt marsh and tidal mud flats between the Copper River Delta in Alaska and San Francisco Bay in California.

The coastal diversification of marine habitats provides the background for a rich marine avifauna. It is for the purpose of sharing knowledge of the densities and distributions of marine bird populations, that this Atlas came into existence.

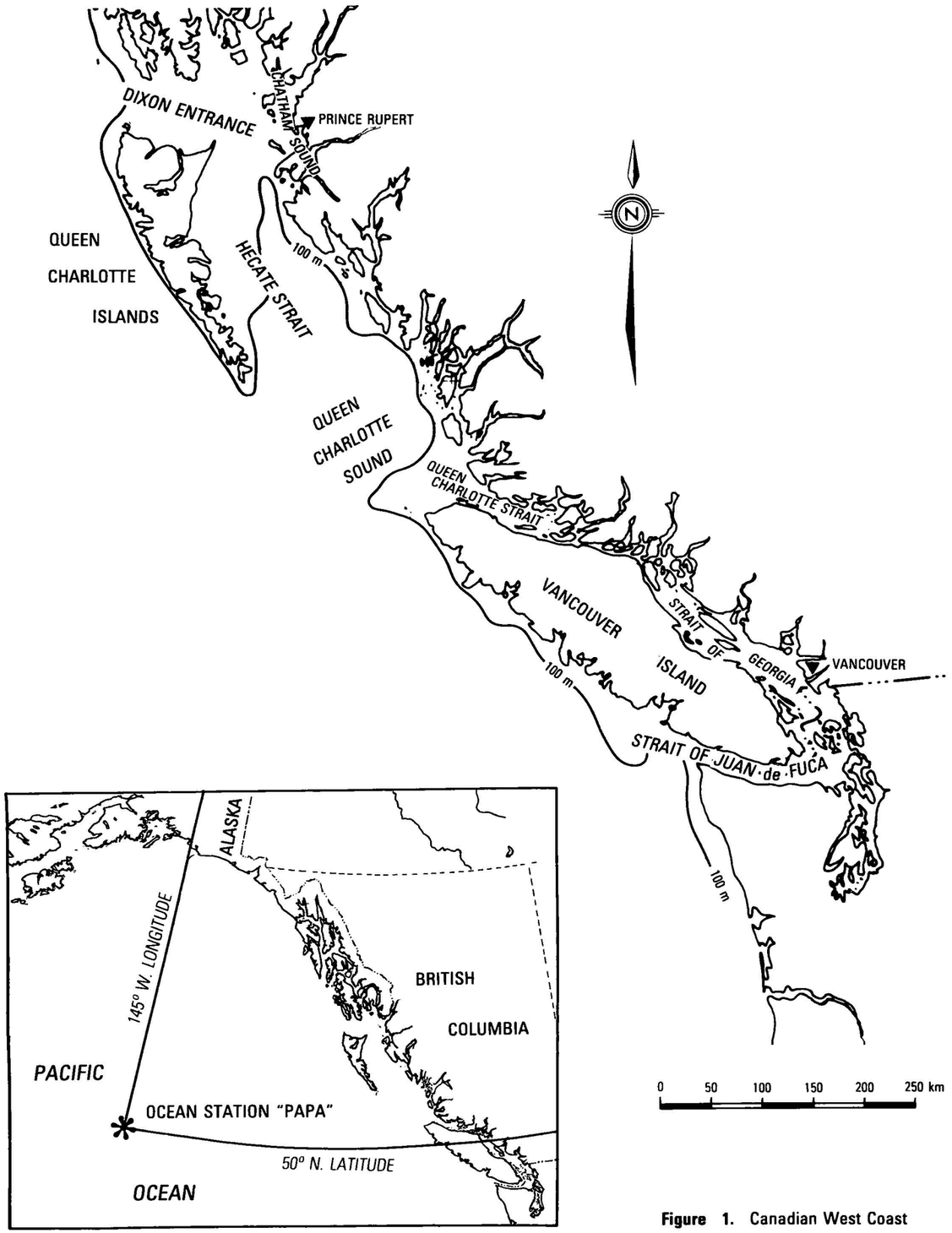


Figure 1. Canadian West Coast

Background to Atlas Maps

This Atlas presents the results of aerial and shipboard surveys of marine birds along Canada's Pacific coast. Dabbling ducks and geese are included because they visit or stage on coastal waters. Shorebirds, except phalaropes, have been omitted because they are not found on the water and as species identification was inaccurate from aerial surveys. The Atlas presentation commences with a record of systematic sightings of marine birds from weathership Station Papa (Fig. 1), 900 km offshore, and follows with results of aerial observations of birds closer to the coast, and finally to those seen along shores and inlets. Bird populations of the Strait of Georgia and the Queen Charlotte Islands are shown in greater detail because they were surveyed by boat. Those two regions were selected for boat surveys because they constituted different habitats and latitudes and were sites of potential environmental perturbances. The breeding concentrations of marine birds are discussed last.

Observations of aerial birds such as albatrosses, shearwaters, fulmars, storm-petrels and gulls, were made by crews on the bridges of weatherships at Station Papa. Observations began at least 20 years ago, but starting in 1971 they were made daily with only a few exceptions when weatherships changed duty. The daily record was based on a four-hour watch to avoid double counting.

Offshore aerial surveys (Fig. 2) were made from June 1972 to March 1973. The approximate position of each observation was determined by recording the time of each observation to the nearest minute at a standard speed of 175 km/hr. The cruising altitude was 30 m and the transect width 65 m. The boundary of the coastal and pelagic (offshore) zones was arbitrarily set at 400 m from shore. All inlets and shallow bays were excluded from the pelagic surveys. The approach of many oceanic species to 400 m offshore justified this boundary.

Coastal aerial censuses were made by many observers from January 1977 to March 1978. Most surveys were flown during fall, winter and spring, because bird distribution and numbers in summer are best estimated by breeding colony surveys. Observations were made by two observers, seated on each side of the aircraft during each trip. Cruising speed varied from 140 to 200 km/hr according to type of aircraft used. Flights were conducted 30 to 60 m from shore at 40 to 80 m altitude depending on weather conditions. Transect width was not fixed.

Aerial observations were recorded on cassette tapes and transcribed at the end of each census. In aerial surveys many small, dark-coloured birds may be missed; large conspicuous ones may be

overrepresented in the data. No doubt error is an important feature of aerial surveys influenced by visibility, plane angle, weather condition, position of sun, wave action, observer experience, fatigue and other factors. Bird distribution may also change shortly after the plane passes by. Actual numbers of birds observed have been grouped over extensive distances. For the above reasons the maps do not provide absolute estimates of bird numbers at sea but show relative densities of populations and species over large geographical areas.

Boat censuses were conducted with the aid of binoculars by two to four observers from fishing any hydrographic vessels from October 1976 to May 1978. The boats cruised as close to the shore as depth would allow. No transect width could be fixed. Identification of birds was more specific from boats than by plane. Birds observed from boats have therefore been more rigourously divided into species than those sighted from the air.

Birds observed at sea are shown on the basis of numbers per linear kilometer. This was thought the best approach as different bird species become visible at various distances from a boat and plane, and as the many observers who participated in the surveys probably varied widely in experience and eyesight. This method allows for direct comparison of relative numbers of birds observed from boats and planes.

Censuses of breeding birds were chiefly organized by the British Columbia Provincial Museum. They were conducted by many observers from May 1973 to August 1978. The surveys of open-nesting species, like cormorants, gulls and murres were based on direct nest counts. Burrow nesters such as storm-petrels and most auks were sampled along transects and in quadrats in which burrow openings were counted. Burrow occupancy was also determined for each species. Extrapolations were made from the numbers of burrows found in quadrats and along transects to those present in the whole colony. Breeding birds are shown in numbers covering large geographical units such as the Strait of Georgia, west coast of Vancouver Island, east and west coasts of the Queen Charlotte Islands; this allows species composition comparisons between distinct areas.

The term "coast" used in the text denotes the Canadian west coast, except when specified otherwise. Common names are used throughout the test, with one exception. There is no acceptable common name for the order Procellariiformes, which include albatrosses, fulmars, petrels, shearwaters and storm-petrels. In this case the taxonomic form Procellariiformes has been used.

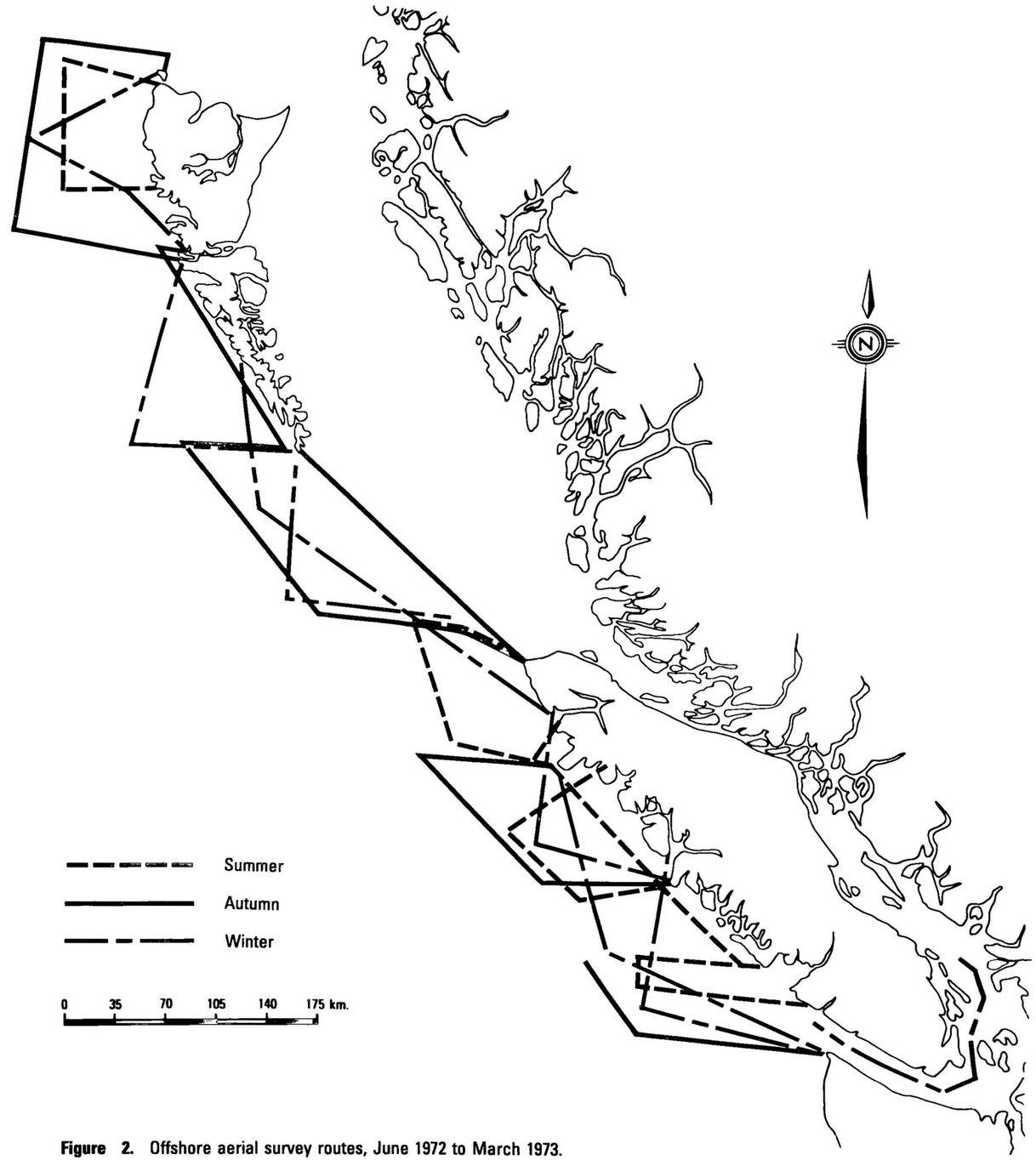


Figure 2. Offshore aerial survey routes, June 1972 to March 1973.

Climate and Ocean Currents

Topography has a marked influence on the coastal climate. The mountain ranges which parallel the coast tend to shelter near shore regions from winter air masses that penetrate the province from the north. Prevailing winds follow the northwest to southeast orientation of the coastal mountains. Controlled by atmospheric pressure systems of the Pacific air mass, those winds shift from the southeast in winter to the north in summer. Westerly winds dominate Juan de Fuca Strait in summer. However, on a local scale, winds are funneled by valleys and blocked by mountains. Such effects are particularly evident in inlets which extend deeply into the coastal mountains. Those inlets provide passageways for the movement of surface airflow. During a survey of aquatic birds in November, 1977, the senior author experienced heavy snowfall and cold air from interior British Columbia at the head of a coastal inlet, and rain and warm air at its mouth a few hours later.

Besides the topography and prevailing winds, oceanic currents also influence the coastal climate as they modify coastal land temperatures and contribute to the heavy rainfall. There are two main surface currents approaching the coast: the Alaska and California currents, which are offshoots of the Sub-Arctic current. In winter, the narrow northward flowing Davidson current appears between the coast and the southward flowing California current.

Because the coastal mountain barrier helps to align the prevailing winds and the ocean currents reflect the movement of surface air masses, the coastal climate is mild and wet in winter and warm in summer. The range of temperatures is small. The mild winter climate of the coast attracts migrant aquatic birds from the north, as well as from the interior of British Columbia, and the Canadian prairie provinces, in large numbers.

Tidal Levels, Currents, and Waves

Tide is the rhythmic rise and fall of sea levels. Tidal levels affect the movement of gulls and ducks along the coastal shores. Those birds forage extensively at low tide in the middle and lower intertidal zones, especially near estuaries and exposed mud flats. In winter, when the diurnal lowtide in the Strait of Georgia occurs at night, dabbling ducks and gulls switch to inland feeding locations.

Tidal currents are the horizontal movements of water associated with the tide. The deposition of bottom sediment is closely related to the strength of the current (Thomson, 1975). Tidal currents affect marine birds either directly or through the nature of the substrate. Where tidal currents are strong, as in Active Pass, fish-eating birds such as cormorants, loons, mergansers, murres and gulls concentrate, especially in winter (Vermeer, 1977). Where currents are weak, as in sheltered bays, diving ducks and small grebes generally predominate.

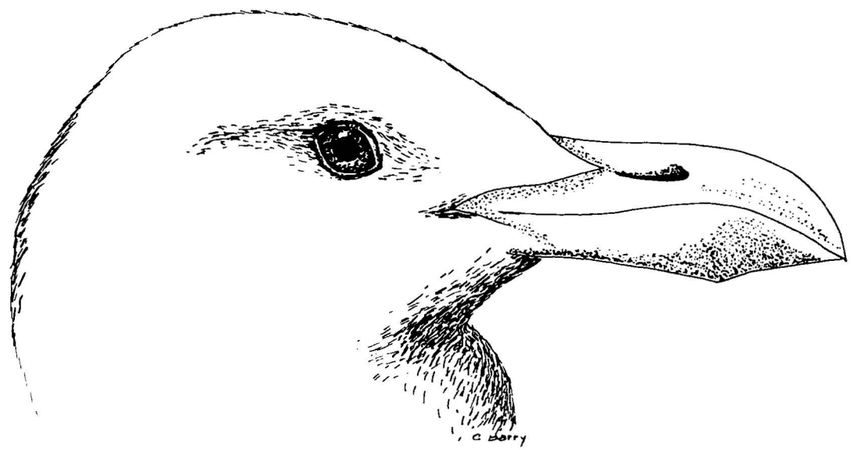
Freshwater Run-off and Upwelling

Estuaries are created where rivers enter the marine environment. Many rivers enter the Strait of Georgia and convert the Strait into a huge estuary. At least 75% of the total freshwater run-off originates from the Fraser River which drains about one quarter of the total land area of British Columbia. Sand, silt and nutrients carried in suspension are deposited at the mouth of the river to become extensive tidal flats. Many benthic organisms thrive in those flats attracting hundreds of thousands of ducks which feed on the organisms during their southward migration in fall. Many of the other estuaries are located near the heads of inlets and play a much smaller role as winter habitat for waterbirds.

Upwelling is the process by which subsurface water moves upward to the surface pumping nutrients upward. Phytoplankton make use of these nutrients and zooplankton feed upon phytoplankton in turn. Fish and plankton-eating birds concentrate in areas of upwelling.

Human Activity

Human activity has had a marked effect on the coastal environment. Within this century the major estuaries have been developed for agriculture, urbanization and marine transport. That change is nowhere more evident than in the Fraser Delta, Cowichan Bay and Howe Sound. The effluents of pulp mills and mines and log storage in inlets and estuaries combine to reduce or eliminate the food items important to many birds. Oilspills are becoming more frequent with a potential for killing birds directly, as well as degrading their feeding habitat (Vermeer and Vermeer, 1975). Pollution of the pelagic waters appears negligible compared to the intertidal and estuarine environment. Nevertheless, it is in the latter where the greatest numbers of marine birds are found and where the greater losses in diversity of marine life will occur if man will not curb his impact there.



Ocean Station Papa

Ocean Station Papa is visited regularly by marine birds. The average daily number reached 60 in the fall and 35 to 40 during the rest of the year. Albatrosses and gulls were the most conspicuous aerial birds. Diving birds, though present in small numbers, were probably overlooked, and their records were too few to present here.

Although the number of birds sighted per day remained fairly constant, species composition varied considerably from season to season (Fig. 3). Black-footed Albatross numbers peaked in summer and remained fairly high in autumn before dropping sharply in winter. Comparing detailed Black-footed Albatross sightings from the various years (Fig. 4) on a monthly basis, the low winter numbers persisted from November through March. Their onset of breeding in October and early November at their main colonies on the Hawaiian Islands (Rice in Palmer, 1962) may explain their rapid departure from Ocean Station Papa. Their return is more drawn-out.

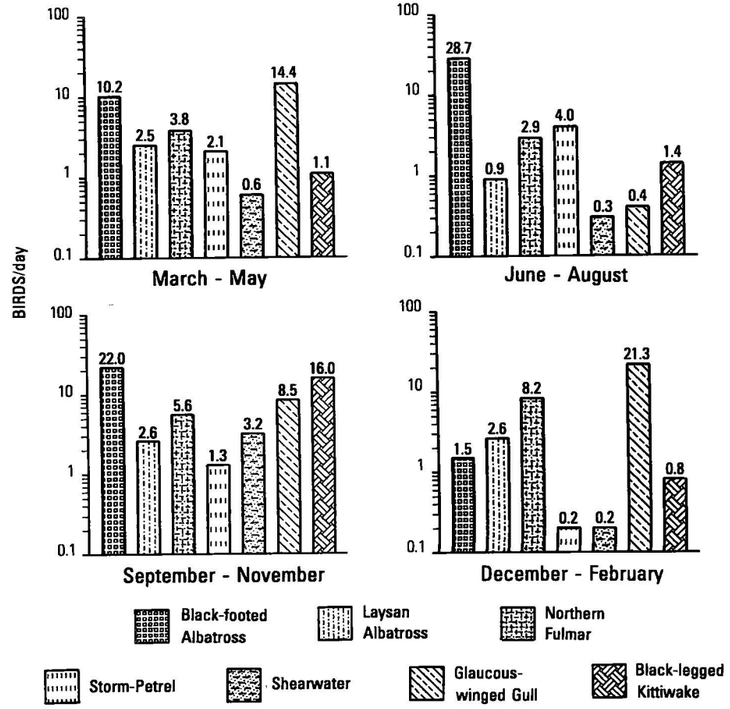


Figure 3. Average number of birds observed at Ocean Station Papa, 1971-1972 and 1974-1977 (Jaegers, skuas, auks, terns and certain gull species excluded as they each averaged less than one bird per season).

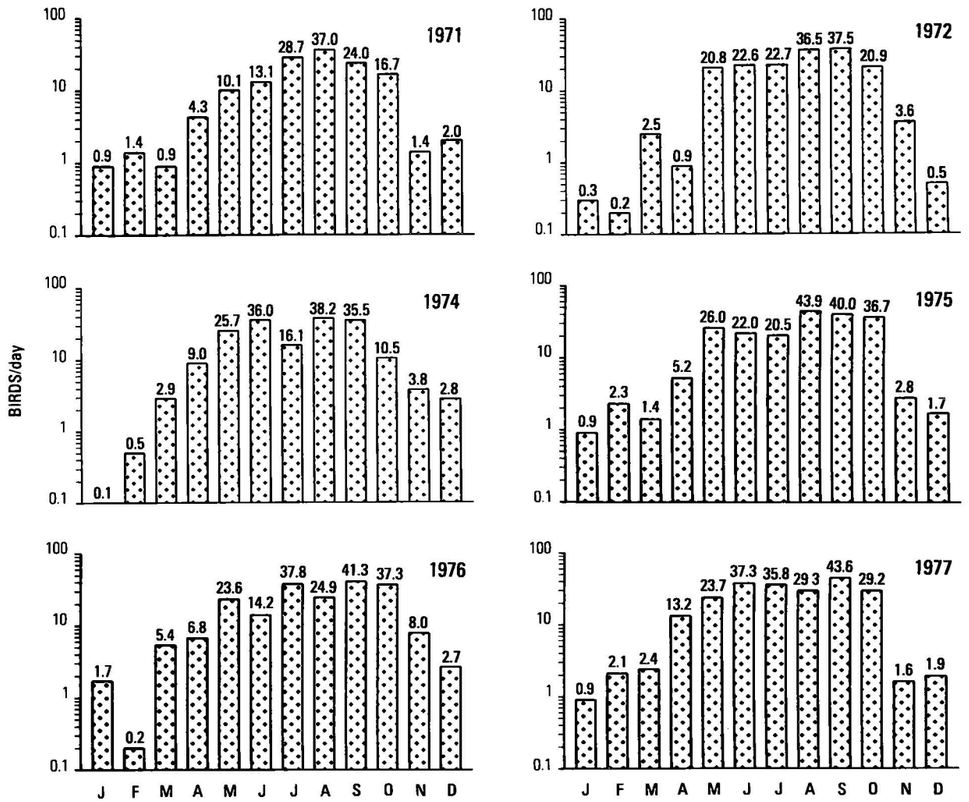


Figure 4. Average number of Black-footed Albatrosses observed at Ocean Station Papa, 1971-1972 and 1974-1977.

Glaucous-winged Gull numbers followed a different pattern (Fig. 3) with high numbers in winter, persisting into spring and a sharp drop in summer. This pattern coincides with the onset of breeding in late April and early May in southern British Columbia (Vermeer, 1963; Drent et al., 1964). The distribution of Glaucous-winged Gulls in the far-offshore waters of the North Pacific has been summarized by Sanger (1973).

Black-legged Kittiwake concentrations peaked in autumn with daily records averaging 16 sightings, whereas during the rest of the year this number was about one. That species breeds in Alaska with concentrations along the Gulf of Alaska coast from Prince William Sound to the tip of the Alaska Peninsula (Sowls, et al., 1978). Post-breeding dispersal and migration to wintering areas south of Alaska probably explain the high autumn numbers at Ocean Station Papa. Low numbers in spring indicate a different return route to breeding sites, which misses Ocean Station Papa.

Average daily sightings of Northern Fulmars showed less seasonal variation, ranging from an average of 3 daily sightings in summer (during their breeding season) to 8 in winter. This was a pattern followed by other arctic breeders, but the difference was the relatively consistent number of summer sightings of Northern Fulmars indicating a significant non-breeding population. This point is explored below in the section on coastal surveys.

Storm-Petrels were seen mostly during their summer breeding season. An immature segment of the population feeding far offshore could comprise most of these numbers. Palmer (1962) implies that a sub-adult stage in Leach's Storm-Petrel may persist until 3 years old, but that view is poorly supported by

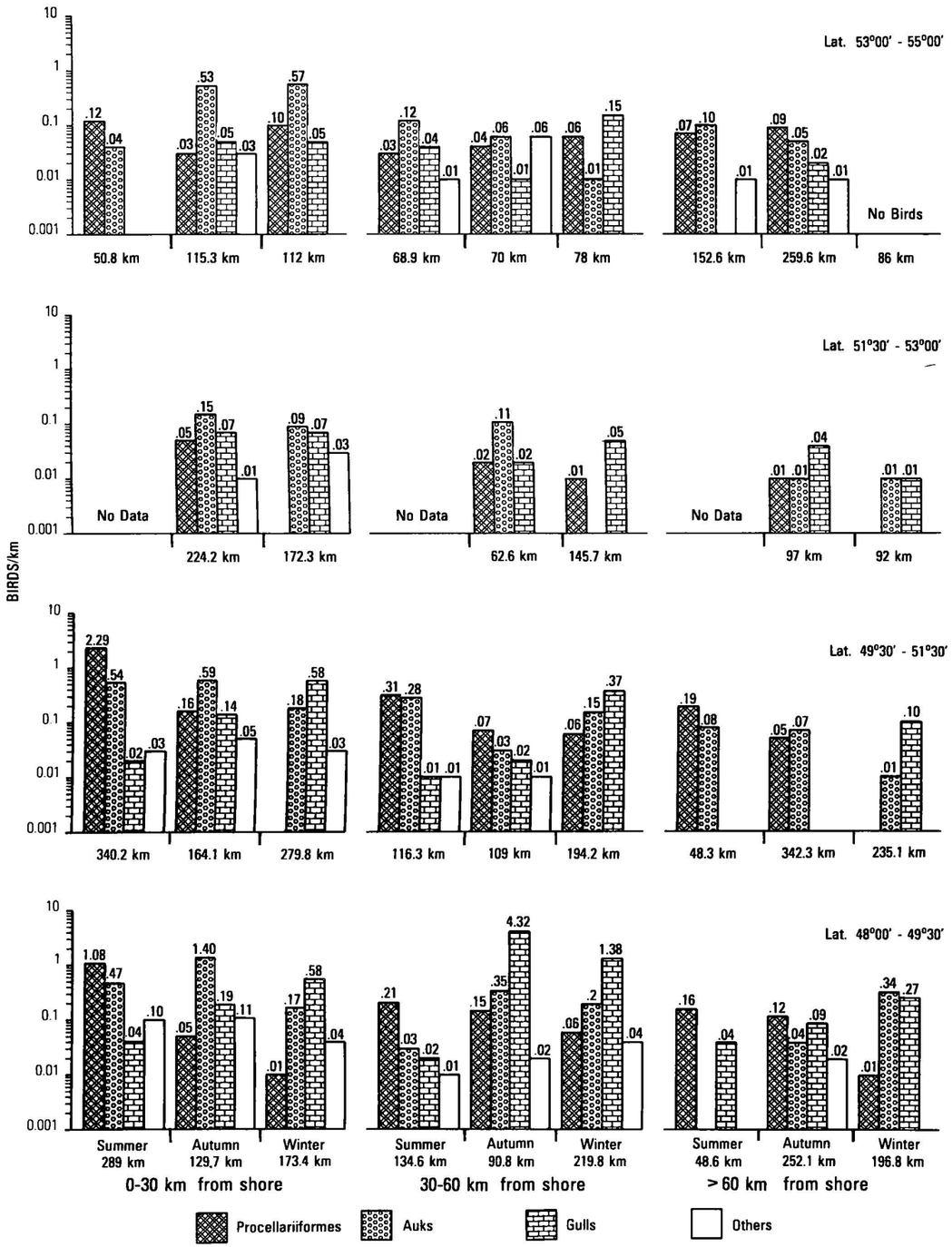


Figure 5. Distribution and densities of birds off the Canadian west coast, as observed by airplane, June and September 1972 and February 1973. (Transect length indicated).

direct evidence. Alternatively, the long absences from the nest by storm-petrels during incubation (1-5 days in Leach's Storm-Petrels; Wilbur, 1969, and 1-7 days in Fork-tailed Storm-Petrels; Boersma et al, 1980) may explain the presence of birds so far from land during their breeding season.

Laysan Albatrosses were observed in small numbers in all seasons, but the seasonal variation was small. Shearwaters were relatively scarce throughout the year except in autumn.

Continental Shelf and Adjacent Waters

Several trends emerge from aerial surveys of offshore waters (Fig. 5). The greatest seabird densities occurred in the 30 km segment nearest to shore. Highest seabird densities were recorded in southern British Columbia rather than the northern half (Table 1). In the most southern segment, the greater breadth of the continental shelf may cause the relatively uniform abundance of birds out as far as 60 km. Surveys from research and patrol vessels confirmed this result (Fig. 6). Seasonal abundance was greatest in autumn with numbers in summer slightly greater than in winter.

The most prominent groups were procellariiformes, gulls and auks. Cormorants, phalaropes, skuas and waterfowl occurred in low numbers and therefore were grouped together.

Table 1. Comparison of bird densities per linear km as observed by airplane, 0-90 km off Canada's west coast, June and September 1972 and February 1973.

	Latitudes			
Season	48°-49°30'	49°30'-51°30'	51°30'-53°	53°-55°
Summer	2.16	3.76	no data	0.18
Autumn	6.86	1.20	0.49	0.98
Winter	3.10	1.48	0.29	0.94

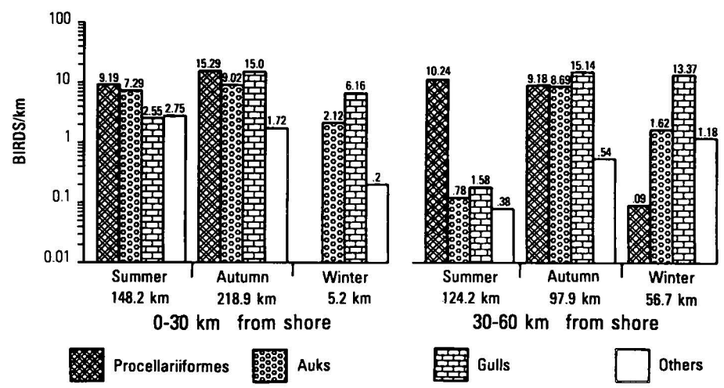
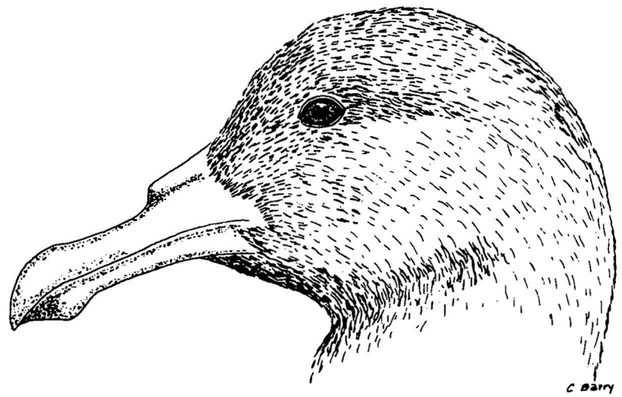


Figure 6. Distribution and densities of birds off the Canadian west coast at latitude 48:00-49:30 N, as observed by boat, June and September 1972 and February 1973.



Procellariiformes

Procellariiformes occurred throughout the area but concentrations were highest in summer close to shore and in the southern regions (Fig. 7). Sooty Shearwaters were by far the most numerous species occurring along the entire coast, and were seen mostly in summer and autumn (Figs. 7 and 8). They are difficult to distinguish from Slender-billed Shearwaters and as a consequence in the latter part of the autumn and winter when Slender-bills might occur both species were combined as "unidentified" shearwaters. At that time of year shearwaters are scarce along the coast. The abundance of the Slender-billed Shearwater off the coast is not clear. Campbell (1970a) considers it a common late summer and autumn visitant to the pelagic waters off British Columbia.

Other shearwaters were much less numerous (Figs. 7 and 8). New Zealand Shearwaters were observed in flocks off southwestern British Columbia during September and October only. Small numbers of Pink-footed Shearwaters were observed regularly throughout the summer and autumn. On two occasions Pale-footed Shearwaters were observed from boats.

Distribution and abundance information on Northern Fulmars does not yet provide a clear pattern of their occurrence on the coast. Observations from boats off the southwestern coast indicate they were common in this area during the summer, still fairly numerous in fall, but absent in winter. When present, they were frequently observed in association with the deep sea fishing fleet. From the air they were difficult to distinguish from gulls. Thus, the aerial survey results that indicate only scattered observations in autumn and winter are potentially misleading until further information is collected. Sanger (1972) indicates that fulmars are abundant or common in winter and spring, and rare or uncommon in summer offshore British Columbia and Washington State. If his observations and ours are valid, the distribution of the fulmar off British Columbia appears to vary markedly from year to year.

Leach's and Fork-tailed Storm-Petrels were common in summer and autumn along the entire coast. They were absent in winter. Although observed at all distances from shore they were most common far from shore. Our species-specific information confirms the conclusions of earlier studies that Leach's Storm-Petrel is most common far offshore, where warmer waters occur, and Fork-tailed Storm-Petrels tend to occur in the cold waters nearer shore (Martin and Myres, 1969). As a consequence, the outer limits of the area surveyed (90 km) probably missed a large proportion of the Leach's Storm-Petrel's offshore range.

Only Black-footed Albatrosses were observed during this study, although the Laysan Albatross has been recorded several times recently off the coast (Campbell and Shepard, 1973). Black-footed Albatrosses were recorded at all seasons but the greatest numbers were in summer (Figs. 7 and 8), between 30 and 60 km from shore.

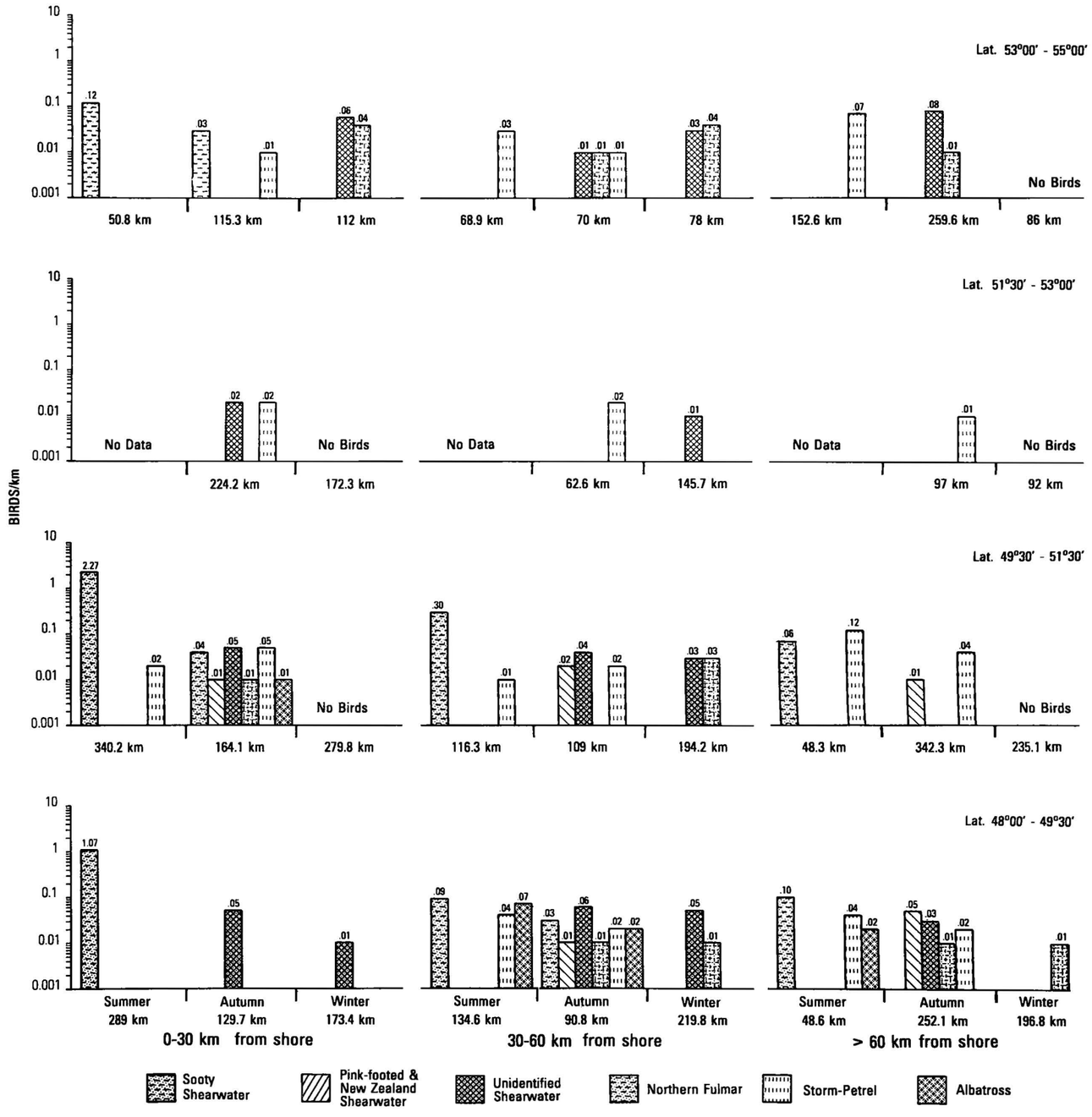


Figure 7. Distribution and densities of shearwaters, fulmars, storm-petrels, and albatrosses off the Canadian west coast, as observed by airplane, June and September 1972 and February 1973.

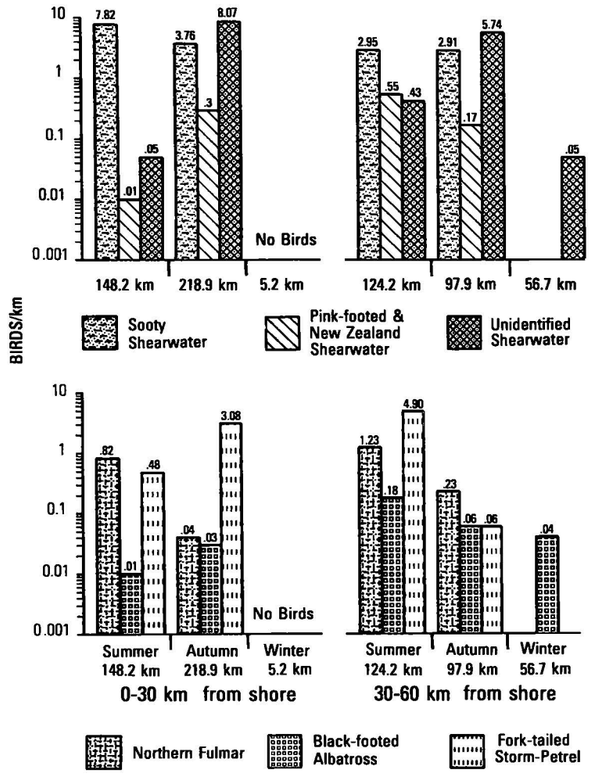


Figure 8. Distribution and densities of shearwaters, fulmars, albatrosses and storm-petrels off the Canadian west coast at latitude 48:00-49:30 N, as observed by boat, June and September 1972 and February 1973.

Gulls

The distribution and abundance of gulls was characterized by autumn and winter peaks in numbers. The greatest concentrations occurred along the southern half of the coast and within 60 km of shore (Fig. 9). Of the gulls, the most numerous were Glaucous-winged, California, Thayer's and Herring Gulls. An increase in sightings in autumn can be related to the completion of the breeding season and the subsequent immigration of those species. The greatest numbers of gulls were recorded off Vancouver Island, and mostly within 60 km of shore, but according to Sanger (1973), Glaucous-winged and Herring (including Thayer's) Gulls range up to 500 km offshore in the eastern North Pacific particularly in winter. The data from Ocean Station Papa support a significant offshore distribution. During winter the larger gulls were by far the most numerous offshore seabirds.

Black-legged Kittiwakes were recorded mostly in winter, were most numerous off Vancouver Island, and although found at all distances from shore were slightly concentrated between 30 and 60 km (Fig. 9). Boat records are similar, except that some observations were made in autumn (Fig. 10). Martin and Myres (1969) commented on the presence of kittiwakes along the coast until the end of May, with only scattered sightings in summer. There are apparent disparities, for Hatler et al. (1978) report the bulk of their

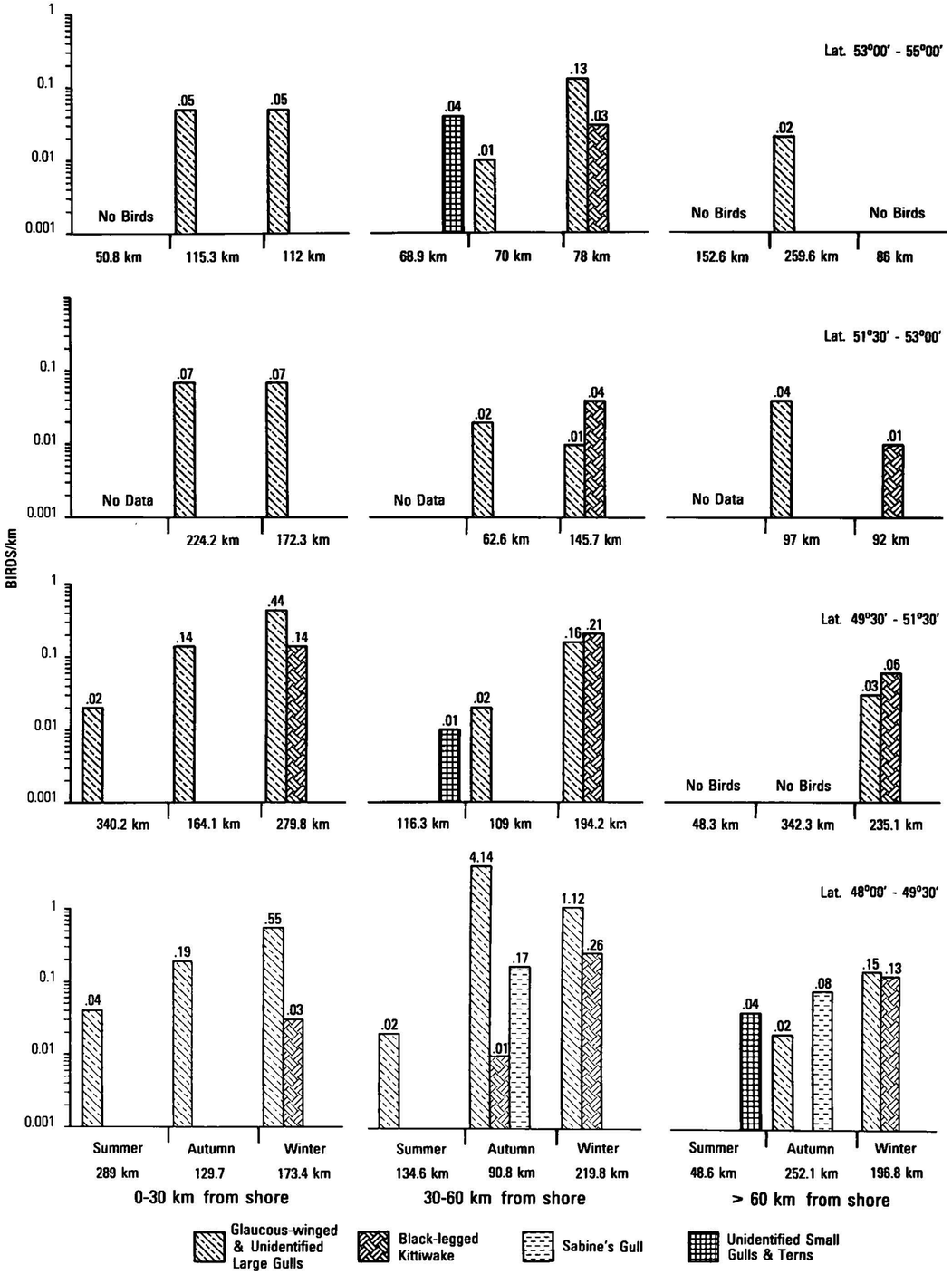


Figure 9. Distribution and densities of gulls and terns off the Canadian west coast as observed by airplane, June and September 1972 and February 1973.

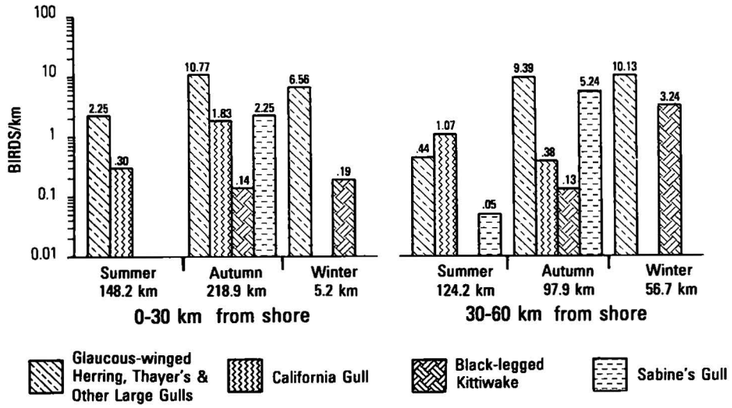


Figure 10. Distribution and densities of gulls off the Canadian west coast at latitude 48:00-49:30 N, as observed by boat, June and September 1972 and February 1973.

kittiwake sightings in June and July in Pacific Rim National Park. Their sightings were restricted to southwestern Vancouver Island and reflect a littoral rather than a pelagic perspective.

California Gulls were not identified in the pelagic aerial surveys, but boat surveys indicated that they were a conspicuous part of the offshore fauna in late summer and fall off southwestern Vancouver Island (Fig. 10). They were frequently observed in association with the deepsea fishing fleet during the day, returning to roosting sites along the shore at night (Robertson, 1974). They were not observed in winter.

Most observations of Sabine's Gull were made in autumn in the southern part of the study area (Figs. 9 and 10). The fact that none were observed elsewhere indicates that that species is strictly a passage migrant elsewhere on the coast, or perhaps arrives off Vancouver Island directly from southern Alaska. Off southern Vancouver Island, Sabine's Gulls were observed in the areas of heavy commercial fishing, but did not congregate around the factory ships of the deepsea fishing fleet.

Auks

In contrast to the preceding groups, all of the auks considered here breed on the coast and for the most part are year-round residents. Auks were observed throughout the year, and no peak periods of abundance were apparent (Fig. 11). They were observed throughout the study area, but concentrated in the south. Greater numbers breed in the north however, and this disparity might be explained by their absence in Hecate Strait data. As a group, more were recorded close to shore but the differences were slight. The small auklets were most numerous. Their points of concentration - close to shore at the north ends of Vancouver Island and Queen Charlotte Islands - are contiguous with two of their important colonies: Triangle Island in the south and Frederick Island in the north. However, they breed on islands the full length of the coast as well as the adjacent United States and were recorded at sea throughout the area surveyed.

Boat survey results (Fig. 12) should be interpreted with caution since they were made in the south outside the main centers of concentrations of small auklets. The large number of Marbled Murrelets is based on one observation of a concentration just barely within the pelagic zone. Most of the Marbled Murrelets were within 4 km of land. Adjacent to major inlets around which they presumably breed, Marbled Murrelets may wander regularly into pelagic waters particularly on ebb tides. The survey results do show that Cassin's Auklets are distributed 30 - 60 km from shore, but clarification of coastal distribution of small

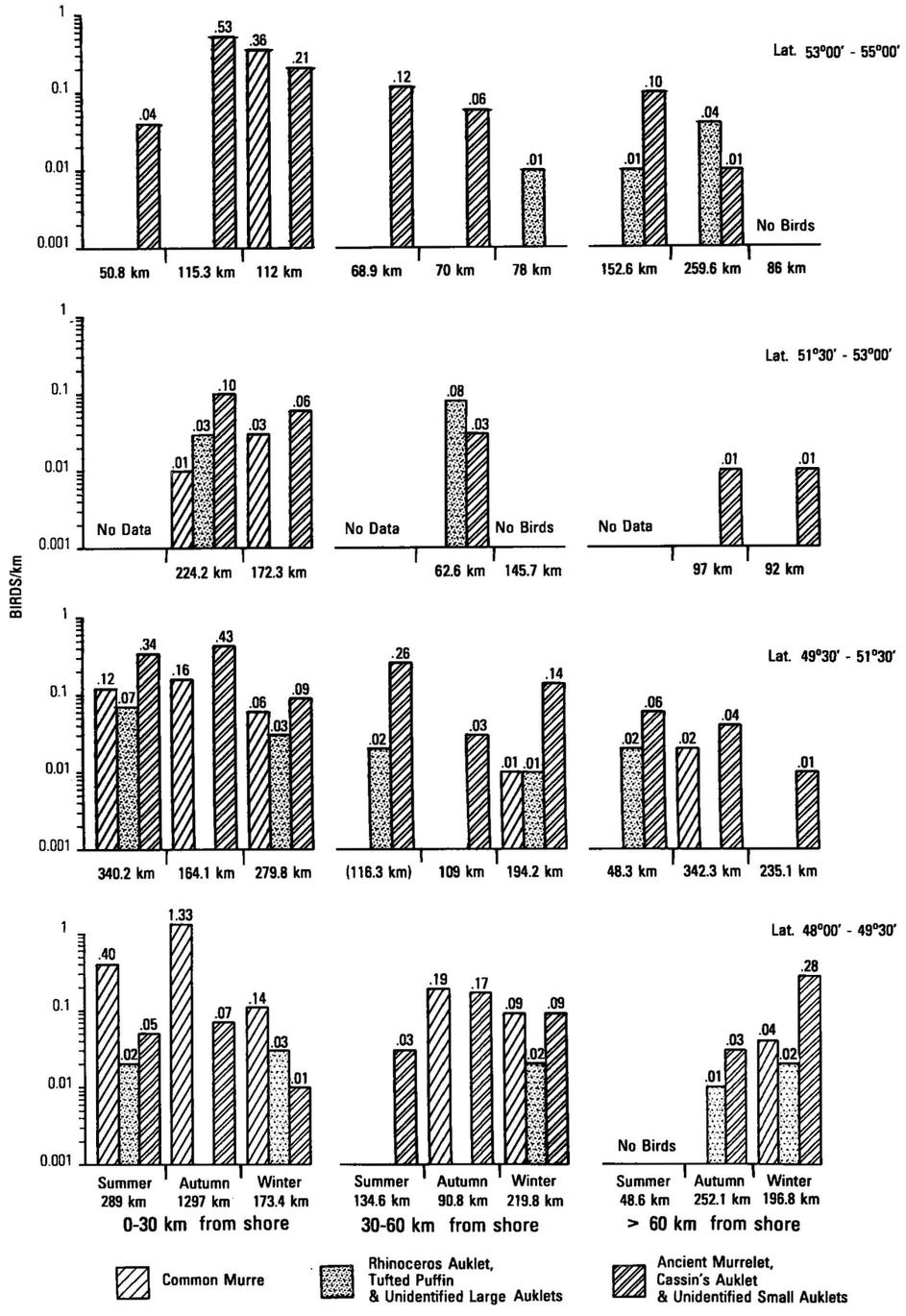


Figure 11. Distribution and densities of auks off the Canadian west coast, as observed by airplane, June and September 1972 and February 1973.

auklets requires more study.

Though the number of Common Murres breeding on the coast is small, large numbers were seen offshore particularly within 30 km of the southwest coast (Figs. 11 and 12). Peak numbers in autumn off Vancouver Island may reflect the postbreeding dispersal of murres from large colonies in coastal Oregon (Varoujean 1979). Numerous Common Murres were also recorded in the north in winter during the aerial survey, but during summer and autumn they were scarce in those waters.

Rhinoceros Auklets and Tufted Puffins were much less numerous than murres and small auklets. In the summer, the only concentration area was within 30 km of shore adjacent to the north end of Vancouver Island near Triangle Island (Fig. 11). In autumn and winter, they were observed further offshore along the entire coast (Fig. 11). The boat surveys confirmed this post-breeding movement offshore with respect to Rhinoceros Auklets (Fig. 12), but more information is needed.

Pigeon Guillemots were sighted at sea on three occasions only. All were summer sightings, and near shore. One bird was observed off Nootka Island, and two were observed off Graham Island, Queen Charlotte Island. The Pigeon Guillemot is a frequently observed species of inshore and sheltered waters, and the infrequent offshore sightings confirms its preference to those habitats.

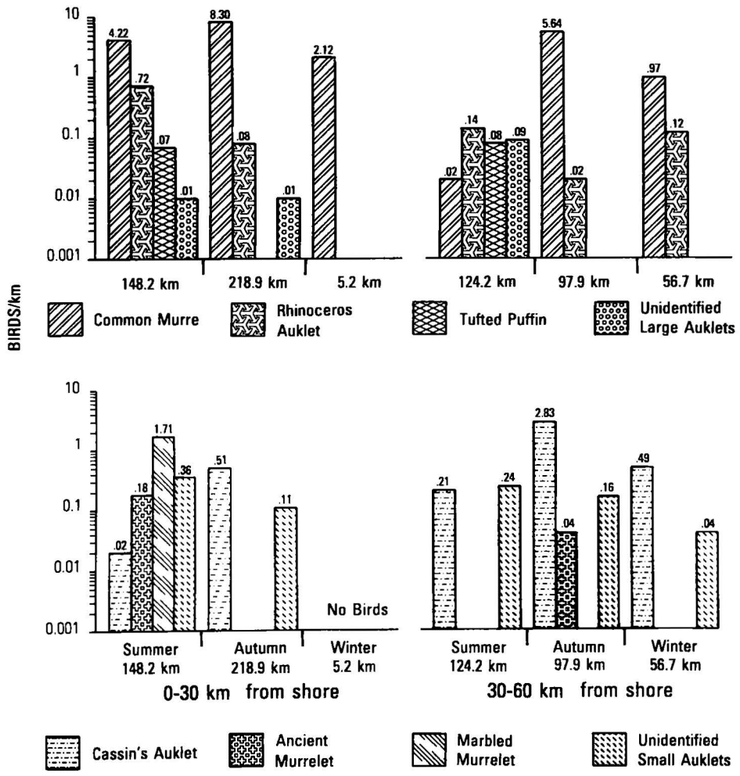


Figure 12. Distribution and densities of auks off the Canadian west coast at latitude 48:00-49:30 N, as observed by boat, June and September 1972 and February 1973.

Other Species

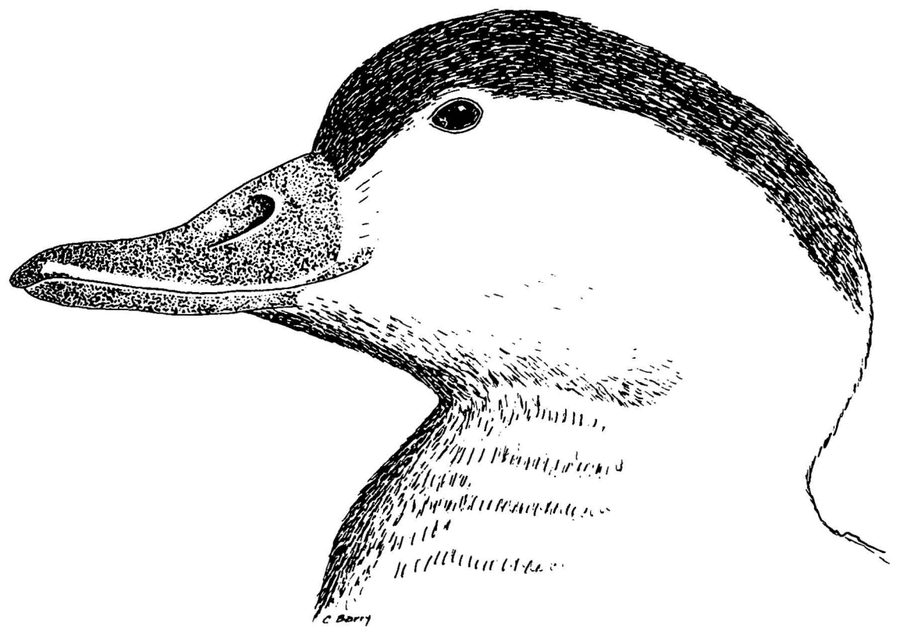
Among the less numerous species, certain results from boat surveys represent new information and are summarized here. In winter off the west coast of southern Vancouver Island, Brandt's Cormorants were common up to 50 km offshore, and comprised 6.5% of all birds seen in that area in January 1973. Phalaropes, both northern and red, were observed offshore in summer and autumn. They were recorded up to the offshore limits of the area surveyed but were observed most frequently within 30 km of land. Small numbers of jaegers (Parasitic, Pomarine, and Long-tailed) and Skuas were observed in summer and autumn, but no concentration sites were identified. Small numbers of loons, ducks and geese were observed flying during autumn migration, and these make up the remainder of the 'other' category in Fig. 6.

Coastal Waters

Overall Distribution and Density of Birds

The only surveys conducted from the air along the whole coast were made in January and early February 1977, and in late March, 1978. Birds in January and February were mostly winter residents while those in March were spring migrants and winter residents. In January and February, highest bird densities occurred in the protected waters of the Strait of Georgia and various coastal inlets (Map 1). In late March, highest densities occurred again in sheltered waters such as inlets, but also among the Gulf Islands, in the Fraser River estuary and on the east coast of Vancouver Island (Map 2). Robertson (1974) observed major concentrations of marine birds along the exposed outer coastline in summer. By autumn there was a marked shift in distribution from exposed to sheltered waters. That reflects, in part, the seasonal change in species composition and habitat preference. Also, prevailing storms in winter may force the birds to take refuge in sheltered waters.

Overall bird densities along the British Columbia coast show 47.1 birds/km for late March compared to 31.9 birds/km in January and February (Table 2, Fig. 13). Duck densities were higher than those of all other birds combined (Fig. 13 and 14). The coastal population of marine birds can be estimated for January-February, 1977 and March, 1978 from the data in Table 2. As many birds were missed, because of the biases of aerial surveys, we estimate that only half the birds present have been observed (see Savard, 1982). It is estimated that along the 27,000 km British Columbia coastline there were 1.5 million birds in January-February, 1977 and 2.5 million birds in March, 1978. These densities were at least one magnitude higher than numbers in pelagic waters off western Vancouver and Queen Charlotte Islands (Tables 1 and 2). Pelagic bird densities in the semi-sheltered seas were also lower than along the coastline. Savard (1979) reported 0.5 birds/km in Dixon Entrance, 1.8 birds/km in Chatham Sound and 7.9 birds/km in Hecate Strait in January and February, 1979. Robertson (1977) found that the average annual bird density in the pelagic environment of the Strait of Georgia was 3.16 birds/km^2 which is even lower than the average of 21.6 birds/km^2 occurring in pelagic waters off the west coast of Vancouver Island in 1972. From the above comparisons it can be concluded that in winter and spring the highest marine bird densities occurred in sheltered waters directly along the coastline.



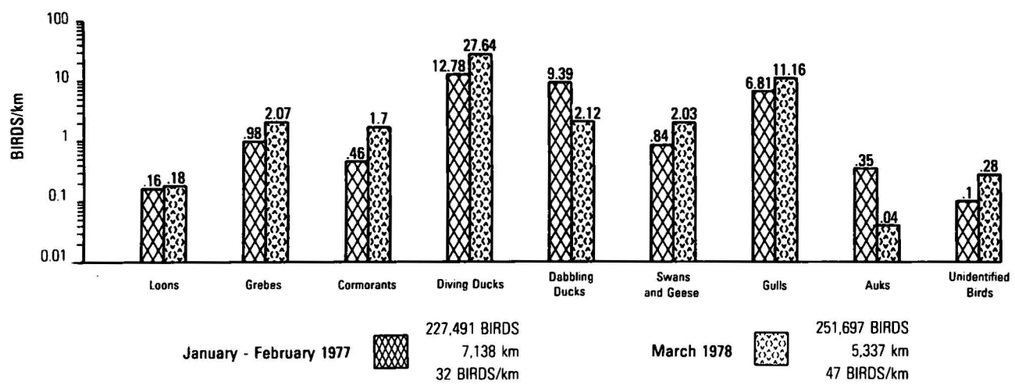


Figure 13. Comparison of overall bird densities as observed by airplane along the Canadian west coast between January - February 1977 and March 1978.

Table 2. Distribution of bird densities in various inshore waters of Canada's west coast as observed by airplane, January - February 1977 and March 1978.

Location	January - February 1977			March 1978		
	No. birds	No. km surveyed	Birds/km	No. birds	No. km surveyed	Birds/km
Vancouver Island						
East Coast (Str. of Georgia)	42,546	250	170.2	42,619	167	255.2
Gulf Island Area	37,397	589	63.5	42,162	195	216.2
West Coast Inlets	31,608	690	45.8	76,811	486	158.0
N.E. Coast (Queen Charlotte Str.)	4,593	155	29.6	2,663	147	18.1
S.W. Coast	4,374	185	23.6	4.026	187	21.5
West Coast	4,774	312	15.3	4,754	341	13.9
Vancouver Is. Density	125,271	2,181	57.3	173,035	1,523	113.6
Mainland						
Fraser River Estuary	14,937	102	146.4	15,302	75	204.0
St. of Georgia Coast	6,496	137	47.4	7,283	153	47.6
St. of Georgia and Johnstone Strait Inlets	11,173	515	21.7	12,626	1,042	12.1
Queen Charlotte Sound and Hecate Strait Inlets	47,784	2.479	19.3	15,235	1,261	12.1
Queen Charlotte Sound and Hecate Strait Coast	8,901	821	10.8	20,537	908	22.6
Mainland Density	89,291	4,054	22.0	70,983	3,439	20.6
Queen Charlotte Islands						
Inlets	9,219	310	29.7	4,786	121	39.5
North Coast	--	--	--	2,336	100	23.4
East Coast	3,403	469	7.3	557	59	9.4
West Coast	293	125	2.3	--	--	--
Queen Charlotte Isl. Density	12,915	904	14.3	7,679	280	27.4
Overall Bird Density	227,491	7,138	31.9	251,697	5,337	47.1

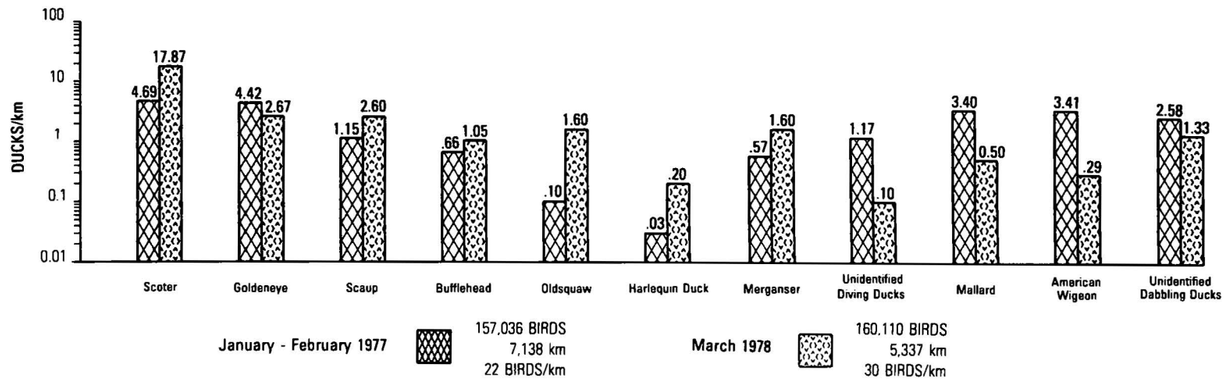


Figure 14. Comparison of overall duck densities as observed by airplane along the Canadian west coast between January - February 1977 and March 1978.

Distribution and Relative Density of Loons, Grebes and Cormorants

The Arctic Loon breeds (Campbell et al. 1982) and visits British Columbia in large flocks during spring, winter and fall. Tens of thousands migrate northward along the west coast of Vancouver Island in May (Vermeer and Vermeer, 1975), and frequently congregate in waters with strong tidal currents such as Active Pass (Edwards, 1964; Vermeer 1977). They were the most frequently observed loon in all coastal surveys and were particularly numerous along the eastern and northern shores of the Strait of Georgia in autumn and spring (Map 8) and at eastern Moresby Island (Map 13A) in autumn. The Common Loon, a resident, occurs singly and in small flocks in sheltered coastal waters, and is seen offshore less frequently than the Arctic Loon. The inconspicuous Red-throated Loon is next in abundance to the Common Loon, and breeds on small British Columbia coastal lakes. It forages in the lakes as well as in nearby marine waters (Reimchen and Douglas, 1980).

The Western Grebe is the most numerous grebe and winters by the tens of thousands in the Gulf Islands (Map 8). The sheltered waters and inlets of the Strait of Georgia and those of adjacent Puget Sound constitute the world's major wintering area for that species. The Red-necked Grebe, which occurs singly and in small loose groups in winter was the most abundant grebe at eastern Moresby Island (Map 13A). The Horned Grebe, another common winter visitor, forages close to sheltered shores and was one of the most abundant grebes observed in Chatham Sound. The Pied-billed Grebe is least common on the British Columbia coast and is more frequently found in fresh water.

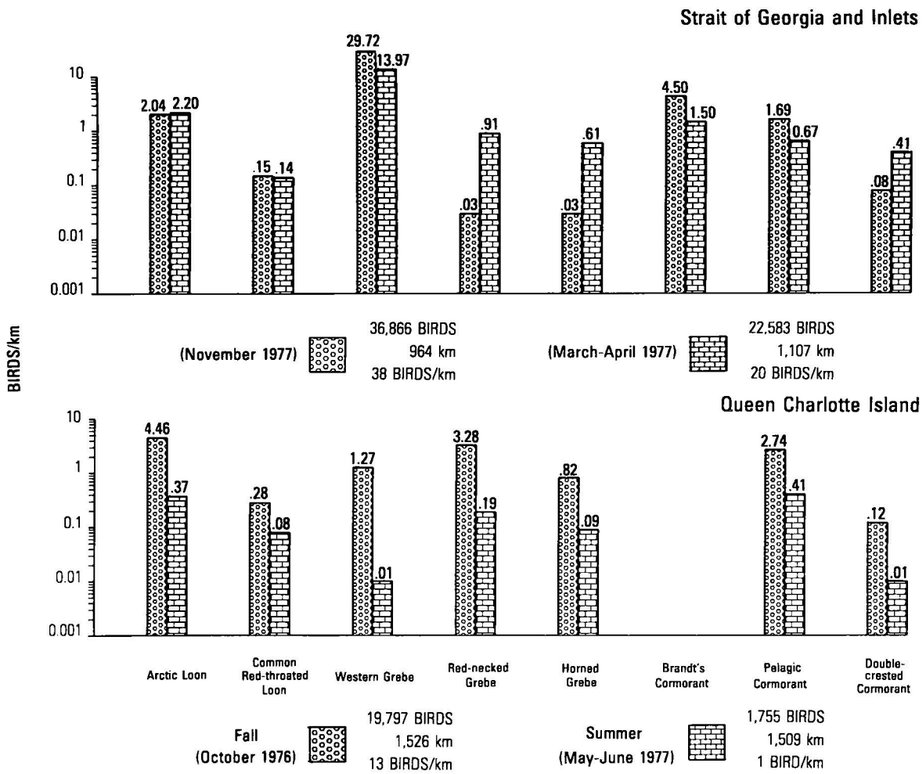


Figure 15. Comparison of overall loon, grebe and cormorant densities as observed by boat between the Strait of Georgia and the Queen Charlotte Islands.

The Pelagic Cormorant is the most widespread and abundant cormorant along the coast. The Brandt's Cormorant, a species which visits the Gulf Islands in large flocks (Map 8) is one of the few species which shows reverse migration. It travels north in autumn and returns to its southern nesting grounds in spring (Vermeer 1977). The Double-crested Cormorant is the least numerous cormorant and occurs more commonly in shallow waters than the other two species.

The overall densities of loons, grebes and cormorants in the Strait of Georgia and the Queen Charlotte Islands are compared in Fig. 15. The Western Grebe reached the highest density in the Strait. Arctic Loons and Pelagic Cormorants showed moderate densities at both locations. The Brandt's Cormorant was the most numerous cormorant in the Strait of Georgia and the Pelagic Cormorant was most numerous around the Queen Charlotte Islands.

Distribution and Relative Density of Gulls and Auks

Gulls

Of the eleven gull species, the Glaucous-winged Gull was the most frequently observed. It is the only gull that nests on numerous marine islets (Drent and Guiguet 1960). The Herring Gull breeds on British Columbia lakes and is a common visitor to the coast (Campbell 1982). Bonaparte's Gull, an interior tree nester, and the Mew Gull, which nests on coastal lakes (Campbell 1970b), are numerous spring and autumn migrants to the Strait of Georgia (Vermeer, 1977). Mew and Glaucous-winged Gulls congregate by the tens of thousands to feed upon herring and spawn in the spring. The Bonaparte's Gulls arrive too late to make much use of that food source.

California and Ring-billed Gulls chiefly breed on prairie lakes in western Canada (Vermeer, 1970). One nesting colony of those gulls has been found in interior British Columbia (Merilees 1974). The California Gulls arrive on the British Columbia coast in July to September on their way to California and western Mexico (Vermeer, 1970). Ring-billed Gulls arrive at the same time from the prairies, but are less common, because the main population follows a more interior route to the United States west coast (Vermeer, 1970). In 1972, California Gulls were the most numerous marine birds along the exposed west coast of Vancouver

Table 3. Comparison of numbers and densities of birds observed during an aerial survey of 413 km along the west coast of Vancouver Island, August 12 and 13, 1972 (condensed from Robertson, 1974).

Species	Exposed waters		Sheltered waters	
	No. birds	No. birds/km	No. birds	No. birds/km
California Gull	18,670	45.2	812	2.0
Glaucous-winged Gull	8,335	20.2	1,033	2.5
Cormorants	1,895	4.6	38	0.09
Common Murre	876	2.1	20	0.05
Other birds	976	2.4	718	1.7

Island (Table 3).

Thayer's, Glaucous and Sabine's Gulls are arctic nesters. The Thayer's Gull is a frequent visitor from October to April at which time it may make up from 10 to 20% of the mixed flocks of Glaucous-winged, Thayer's and Herring Gulls. The Glaucous Gull is infrequently seen while the Sabine's Gull migrates offshore from the Arctic to the west coast of South America where it winters, passing through the coastal waters of Vancouver Island in autumn (Fig. 9).

The Black-legged Kittiwake, which breeds in Alaska (see Sowls et al. 1978), migrates and feeds upon small pelagic fishes along the exposed west coast. It was one of the common larids observed in the Queen Charlotte Islands (Maps 14A and B). Because the Kittiwake is pelagic, it was rarely seen in the Strait of Georgia (Fig. 16).

The dark-coloured Heermann's Gull regularly visit southern Vancouver Island in late summer and early fall. They chiefly breed on Rasa Island in the Gulf of Mexico. (Anderson et al., 1976).

Several terns, close relatives of the gulls, visit our coast in spring and early autumn. Most numerous are the Common and Arctic Terns, but Caspian Terns are also occasiunally seen in the south.

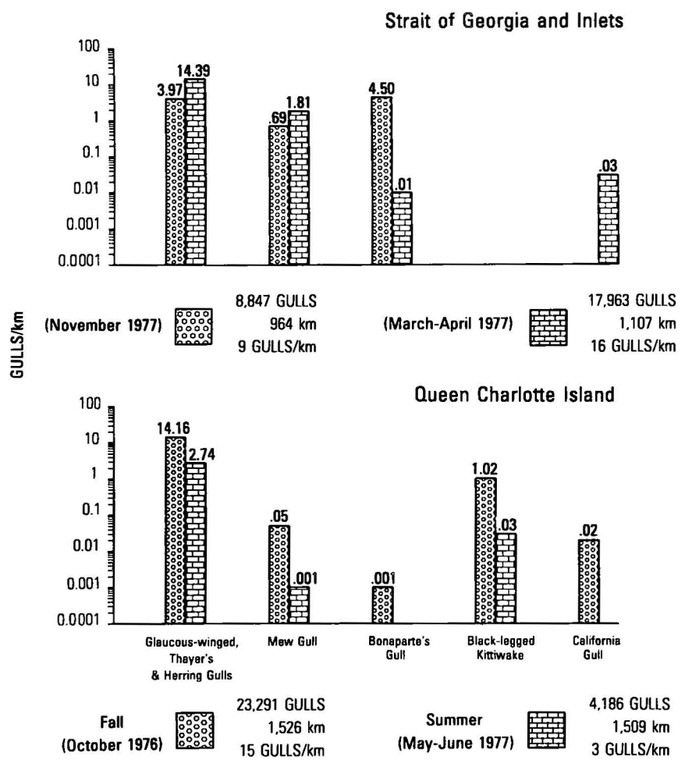


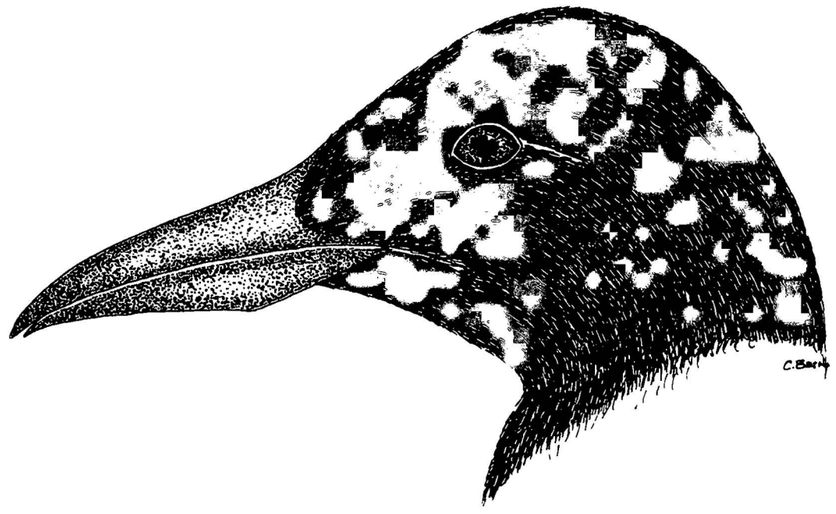
Figure 16. Comparison of overall gull densities as observed by boat between the Strait of Georgia and the Queen Charlotte Islands.

Auks

The Cassin's Auklet, Ancient Murrelet, Common Murre, Rhinoceros Auklet, Pigeon Guillemot, Tufted and Horned Puffin nest and feed in British Columbia waters. The Cassin's Auklet mainly feeds on the copepod, Calanus cristatus, and euphausiids in summer (Vermeer, 1981a), the Ancient Murrelet on euphausiids and fish (Sealy, 1975), while the remaining auks are primarily fish feeders (Drent, 1965; Sealy, 1975; Vermeer, 1979, 1980). The Pigeon Guillemot and the Marbled Murrelets forage inshore and the others offshore.

In the Strait of Georgia, the Common Murre was the most common auk along exposed shores and the Marbled Murrelet in fjords and inlets (Map 10). Marbled Murrelets, which are solitary breeders in trees and on hill slopes (Harris, 1971; Simons, 1980), presumably nest commonly along the Strait. Parents with young birds have been frequently observed there.

The Common Murre was also the dominant species at eastern Moresby Island in the Queen Charlotte Islands in the fall (Map 15A). Murre numbers declined considerably in the spring as they left for their breeding grounds. Only a few murres breed in the Queen Charlotte Islands. Ancient Murrelet sightings increased significantly in the spring in the Queen Charlotte Islands (Maps 15A and B), perhaps as the species is one of the most abundant breeding auks there (Map 17). Increases in the numbers of Marbled Murrelets and Pigeon Guillemots in the spring might also relate to an influx of breeders. The Cassin's Auklet, one of the two most numerous breeding auklets, was not observed in large numbers on the water. That is not surprising because the Cassin's Auklet generally does not feed inshore. Another auk frequently encountered in the Queen Charlotte Islands was the Rhinoceros Auklet (Maps 15A and B). There is only one known large colony of approximately 10,000 breeding pairs on Anthony Island, at the southern tip of the archipelago (Campbell and Carrioch, 1979). Many Rhinoceros Auklets seen in the Queen Charlottes may also visit from Forrester Island, a colony of at least 40,000 pairs, near the southern tip of Alaska (Sowls etal. 1978).



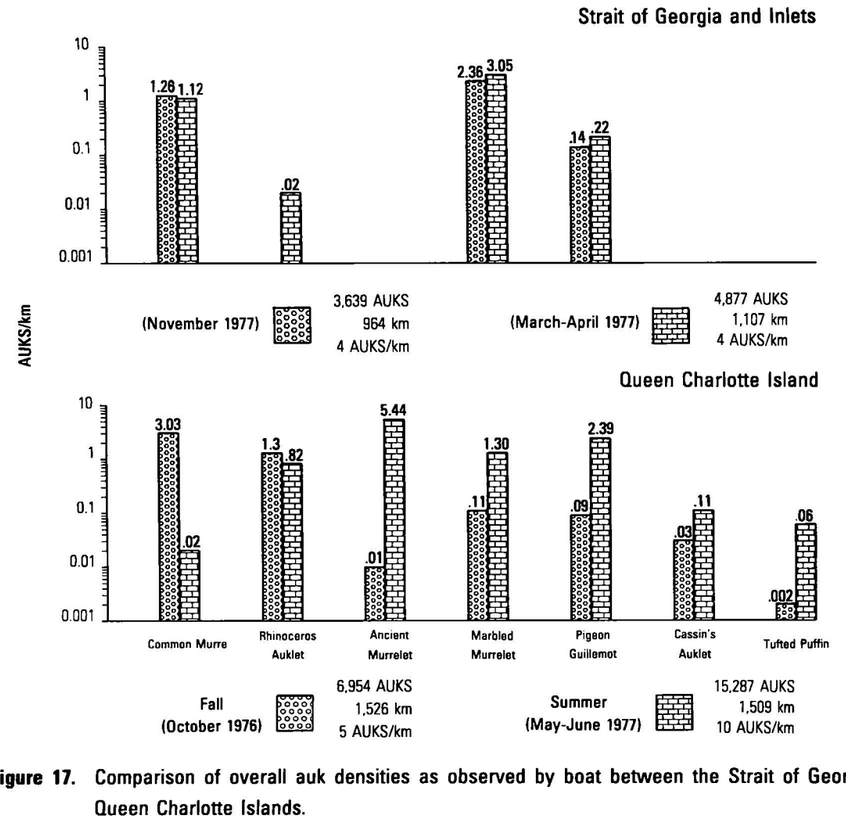


Figure 17. Comparison of overall auk densities as observed by boat between the Strait of Georgia and the Queen Charlotte Islands.

Distribution and Relative Density of Waterfowl

Swans and Geese

Two species of swans, the Whistling and Trumpeter visit the coast. The Whistling Swan appears in small flocks in south coastal regions in the fall, while the Trumpeter Swan is a regular winter visitant at estuarine marshes. About 800 adult and immature Trumpeter Swans use the saltwater estuaries of Vancouver Island in winter (Smith and Blood, 1972; McKelvey 1979). The Mute Swan has been introduced from Europe and is now a local breeder. It may be seen in estuarine marshes along Vancouver Island's southeast coast.

Of the geese frequenting our coast, the Canada, Snow and Brant are common visitors, while White-fronted Geese are less frequently observed. The Canada Goose is the only natural breeding goose in British Columbia, and in the winter its numbers are augmented by migrants from Alaska. A population of about 10,000 Snow Geese winters on the Fraser Delta foreshore where they forage on marsh plants. Brant congregate at Boundary Bay and at beaches with eelgrass along eastern Vancouver Island during spring, while only a few hundred spend the winter in the Queen Charlotte Islands. For a detailed review on the occurrence, migratory routes, breeding and summering ranges of the different species and races of geese visiting the British Columbia coast, the reader is referred to Taylor (1973).

Dabbling Ducks

Most of the North American dabbling duck species occur on the coast outside of summer, where they usually associate with estuarine habitat. The January-February, 1977 survey along the whole British Columbia coast showed that dabbling ducks had high densities (Map 3), but their numbers declined considerably in March (Fig. 13, Map 4). Perhaps many had migrated to the breeding territories. Of the dabblers, the Mallard and American Widgeon were most common (Fig. 14). The Mallard is the most common dabbler in winter in marshes of the inlets, while the American Widgeon concentrates by the thousands from October to December near streams and estuaries around the Strait of Georgia. There they forage on algae and feed in adjacent agricultural fields.

Diving Ducks

About a dozen diving duck species are common or numerous in British Columbia. They can be divided into seaducks, which are found both in sheltered and exposed waters, and bay ducks which are mostly confined to bays and sheltered shores. Seaducks by this definition are Surf, White-winged and Black Scoters, Oldsquaw and Harlequin Ducks. Bay ducks are Barrow's and Common Goldeneyes, Bufflehead, Greater Scaup and the three species of merganser: Common, Red-breasted and Hooded. Some less frequently occurring bay ducks, mostly associated with estuarine habitat, are the Lesser Scaup, Canvasback and Ruddy Duck and the occasional Redhead, Ring-necked and Tufted Duck.

Seaducks

Scoters feed close to the shore and over coastal banks. The Surf Scoter had the highest density of all ducks along the coast (Fig. 14, Maps 3 and 11, Vermeer, 1981b). In March they feed on herring spawn in inlets on the west coast of Vancouver Island and among the Gulf Islands (Map 4) and abandon their staple diet of mussels (Vermeer 1981b). The White-winged Scoter had the highest density on the eastern coast of Moresby Island (Map 16A) where large flocks occurred near shore as well as 15 km from shore in 15 fathoms of water (Savard, 1979). The Black Scoter, the least common scoter, was abundant at certain locations on the eastern coast of Vancouver Island, e.g., near Comox, in March.

Of all ducks, the Oldsquaw was seen farthest from shore in sheltered as well as exposed water. Hirsch (1980) also reported that among duck species, Oldsquaws were most distant from shore in the Strait of Juan de Fuca and Northern Puget Sound, Washington. Oldsquaw may also occur in large flocks in close proximity to shore; for example, thousands of them were seen feeding upon herring spawn at Ganges Harbour in the Gulf Islands in March (Vermeer, 1981b), as well as at Atrevida Reef on the east coast of the Strait of Georgia (Map 11).

Harlequin Ducks feed in shallow areas with rocky substrates, in boulder-strewn and frequently surf-exposed waters and in kelp beds. They were seen more frequently in the Queen Charlotte Islands than in the Strait of Georgia (cf. Fig. 18, Maps 16A and B).

Bay Ducks

The Barrow's Goldeneye occurs mostly along rocky shores and in fjords, while the Common Goldeneye is found in that habitat as well as over sand and mud substrates and in estuaries. Barrow's Goldeneyes share the inlets with Surf Scoters in the fjords (Fig. 14 and Map 11) where the diet of both

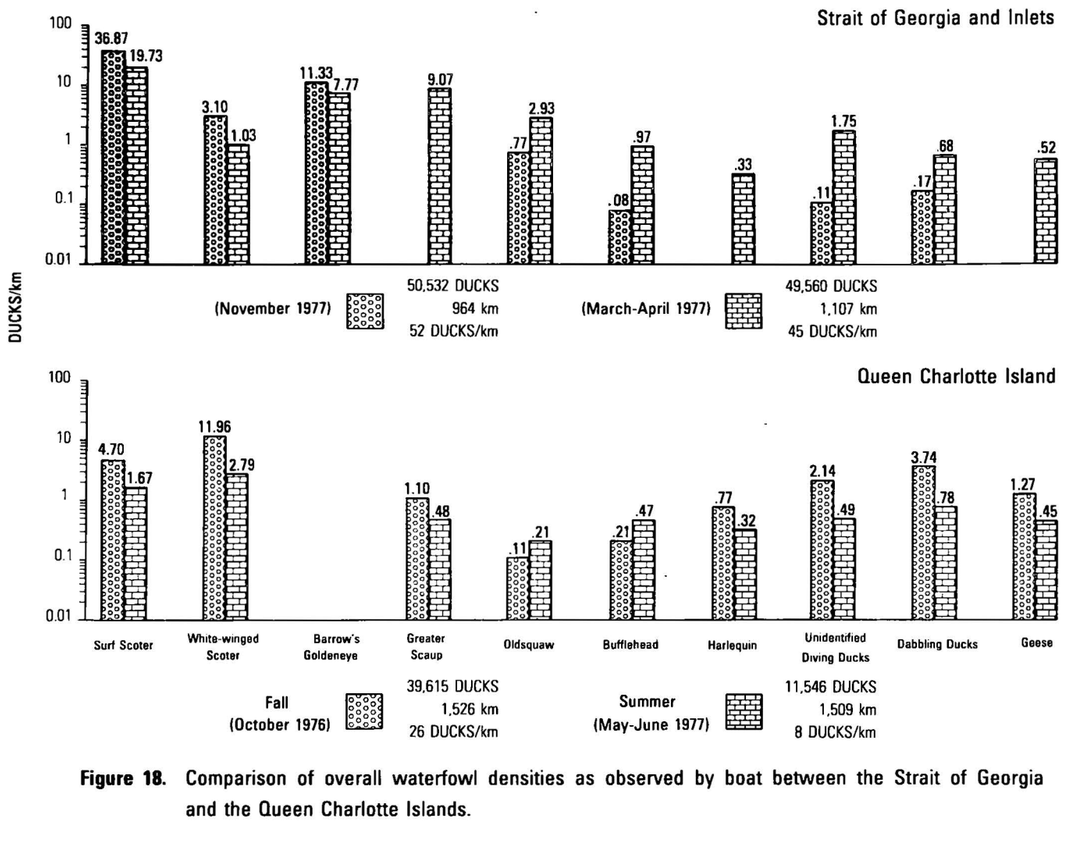


Figure 18. Comparison of overall waterfowl densities as observed by boat between the Strait of Georgia and the Queen Charlotte Islands.

species consists chiefly of mussels (Vermeer, 1981b). The Barrow's Goldeneye appears to be one of the most numerous wintering ducks on the coast. Barrow's Goldeneyes are mostly restricted to northwestern North America (Bellrose, 1976), and the fjords and inlets of British Columbia's mainland coast contain the world's major known wintering population of that species (Vermeer, 1982).

The Bufflehead, closely related to the goldeneye, feeds close to rocky shores as well as in sheltered bays. It did not show up in large numbers in most surveys, as Bufflehead are late migrants and generally do not arrive on the coast until October (Vermeer, 1982). It was second in abundance to Surf Scoters among ducks observed in the Gulf Islands in the winter of 1978 (Vermeer, 1982). The Bufflehead was also the most numerous diving duck in marine waters off adjacent Washington during the winters of 1978 and 1979 (Hirsch, 1980).

The Greater Scaup, another numerous visitor to the coast (Fig. 18, Maps. 6 and 11), forages mostly over shallow sand and mud bottoms. It occurs in particularly large numbers in the spring on the east coast of Vancouver Island (Map 6) and in the fall and winter in Boundary Bay (Vermeer and Levings, 1977).

Mergansers occur mostly in sheltered waters. The Common Merganser commonly occurs in estuaries and frequents areas of upwelling in late winter and early spring (e.g. Active Pass). The Red-breasted Merganser is the most common merganser seen along coastal shores and Hooded Mergansers the least common. They are found close to rocky shores in sheltered waters, but may prefer fresh water environments.

Breeding Distribution

Canadian West Coast

Auks are the most numerous of the marine birds that breed on the coast. Most nest in the Queen Charlotte Islands and near northern Vancouver Island (Map 17). The Cassin's Auklet is most abundant, followed by the Ancient Murrelet (Table 4). Those two species account for 68% of the nesting marine bird populations on the coast. Triangle Island with 720,000 Cassin's Auklets, based on a 1977 survey, contains 40% of the world's known breeding population (Vermeer et al. 1979). Ancient Murrelets nest on the northern part of the coast with the Queen Charlotte Islands as their largest known breeding concentration in British Columbia (Campbell and Carrioch, 1979). Rhinoceros auklets are concentrated on Pine Island in the Queen Charlotte Strait and on Lucy Island in the Chatham Sound, while 78% of the Tufted Puffins nest on Triangle Island. Pigeon Guillemots are semi-colonial nesters in rock crevices and cavities on islands along the whole coast. Common Murres primarily breed on the Scott Islands. Small numbers of Horned Puffins nest in rock cavities in the Queen Charlotte Islands (Campbell et al. 1979). Marbled Murrelets nest solitarily on the ground or in trees (Simons, 1980). Although that species is numerous on our coastal waters, few nests have been found in trees (Harris, 1971; Savile, 1972).

Storm-Petrels account for 16% of the marine bird breeding population, with most of them in the Queen Charlotte Islands (Map 17). The Glaucous-winged Gull is our only nesting marine gull. They are most numerous in the Strait of Georgia, where their numbers have increased 3.5 times between 1928 and 1974 (Butler et al. 1980), perhaps resulting from an increase in human refuse on which they feed (Drent and Guiguet, 1961; Vermeer, 1963). Of the three cormorants, the Pelagic Cormorant is the most common breeding species. The Double-crested Cormorant nests only in the southern portion of the Strait of Georgia, while Brandt's Cormorants breed in small numbers at a few locations on the west coast of Vancouver Island.

Comparisons in Northeastern Pacific

Three species of auks, the Cassin's Auklets, the Ancient Murrelets and the Rhinoceros Auklets breed in larger numbers in Canada than elsewhere in the northeastern Pacific (Table 5). All three species are nocturnal nesters, which is presumably an adaptation to reduce predation. Northern Alaska, with its constant daylight in summer may not be optimal nesting habitat for the nocturnal species. Common Murres are most abundant in Alaska, followed by large populations in Washington, Oregon and California. Perhaps the reason that murres are not numerous nesters on the Canadian west coast is because of lack of suitable nesting habitat. They prefer to nest on cliffs and steep rocky islets which are more common along the Pacific coastline to the north and south of Canada. Tufted Puffins occur in far greater numbers in Alaska than elsewhere in the northeastern Pacific, perhaps because of the presence in Alaska of many treeless islands with suitable soil for nest burrowing (Vermeer, 1979). Horned Puffins, which nest primarily in rock crevices, are chiefly restricted to Alaska. Fork-tailed Storm-Petrels are relatively scarce in Oregon and California, perhaps because they prefer to feed in cold water (Martin and Myres, 1969). Leach's Storm-Petrels are numerous everywhere in the northeastern Pacific. Of the cormorants, the Double-crested is least abundant in the northeastern Pacific, perhaps because it is chiefly a shallow water feeder, which also breeds commonly on lakes in the North American interior (Vermeer, 1973). Pelagic Cormorants are widespread in the northeastern Pacific, while the Brandt's Cormorants breed mostly in Oregon and California. Glaucous-winged Gulls are most numerous in Alaska and British Columbia, while in Oregon and California they are replaced by the Western Gull.

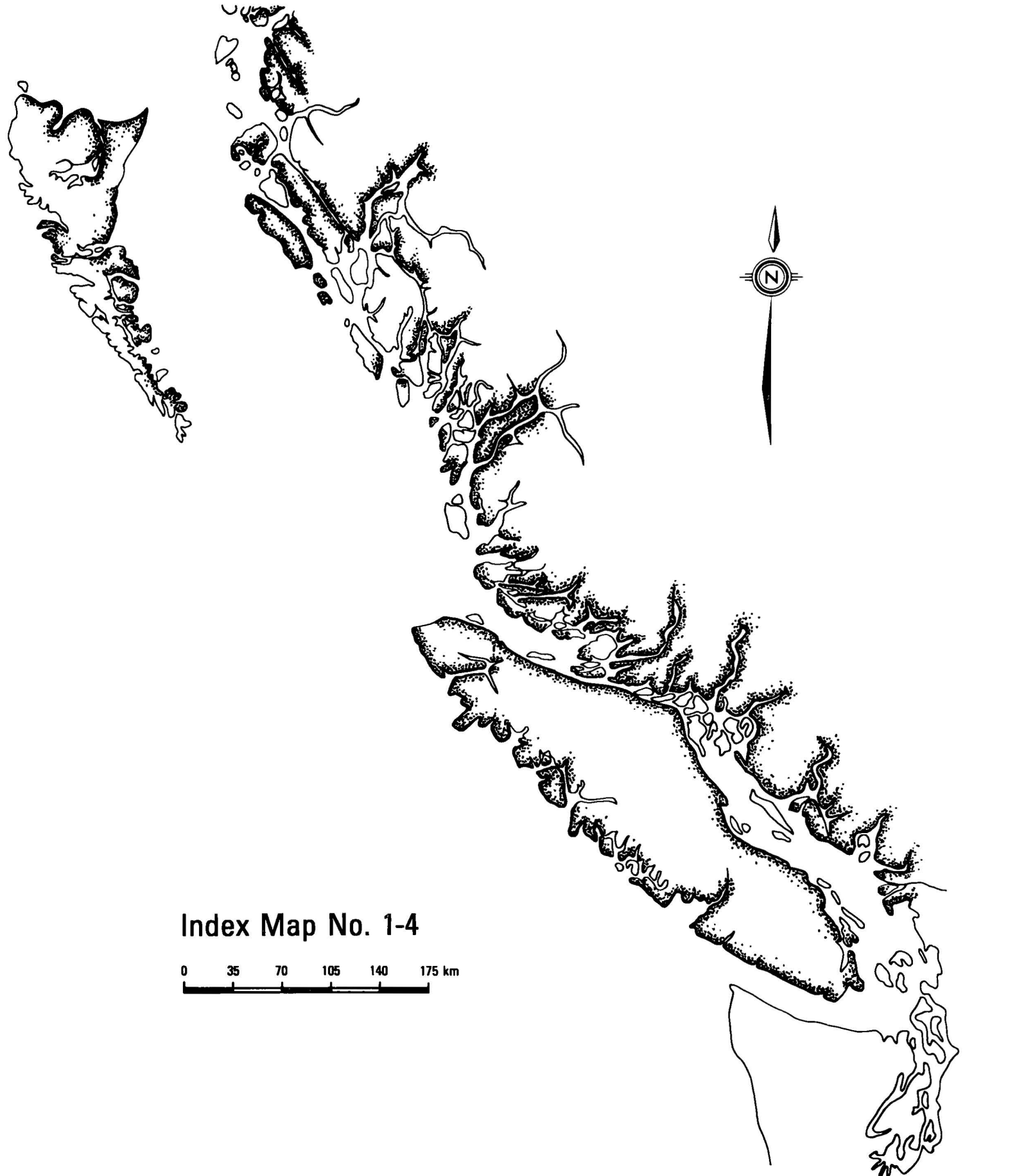
Table 4. Comparison of breeding numbers and percentages of marine birds, British Columbia.

	(A) West Coast Queen Charlotte Isl.		(B) East Coast Queen Charlotte Isl.		(C) Mainland Coast, Hecate St.		(D) Mainland Coast, Queen Charlotte Sd.		(E) Scott Islands		(F) Queen Charlotte Strait		(G) West Coast Vanc. Isl.		(H) Strait Georgia		All Regions	
Species	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Fork-tailed Storm-Petrel	42100	31.5	59320	44.4	--	--	1000	0.7	--	--	30500	22.8	810	0.6	--	--	133730	6.1
Leach's Storm-Petrel	72400	33.0	30000	13.7	--	--	12000	5.5	400	0.2	78300	35.8	25900	11.8	--	--	219000	10.1
Brandt's Cormorant	--	--	--	--	--	--	--	--	60	29.4	--	--	144	70.6	--	--	204	T
Double-crested Cormorant	--	--	--	--	--	--	--	--	--	--	--	--	--	--	825	100.0	825	T
Pelagic Cormorant	500	6.1	370	4.5	260	3.2	100	1.2	200	2.4	250	3.0	2500	30.4	4040	49.2	8220	0.4
Glaucous-winged Gull	2400	5.5	1500	3.4	1800	4.1	3000	6.9	1000	2.3	50	0.1	14000	32.0	20000	45.7	43750	2.0
Common Murre	300	3.6	--	--	--	--	--	--	8000	96.2	--	--	16	0.2	--	--	8316	0.4
Pigeon Guillemot	990	15.3	940	14.5	50	0.8	1240	19.1	400	6.1	600	9.2	1070	16.5	1200	18.5	6490	0.3
Ancient Murrelet	173100	41.0	234660	55.6	--	--	14000	3.3	--	--	--	--	--	--	--	--	421760	19.4
Cassin's Auklet	263220	24.8	52140	4.9	--	--	18100	1.7	720000	67.7	9100	0.9	640	T	--	--	1063200	48.9
Rhinoceros Auklet	3450	1.7	600	0.3	50000	24.1	7800	3.7	32300	15.6	112000	54.0	1300	0.6	--	--	207450	9.5
Tufted Puffin	7000	11.0	50	0.1	--	--	200	0.3	50000	78.8	--	--	6200	9.8	4	T	63454	2.9
Horned Puffin	50	100.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	50	T
Total	565510	--	379580	--	52110	--	57440	--	812360	--	230800	--	52580	--	26069	--	2176449	100.0

Table 5. Comparison of breeding populations of 13 marine bird species on Canada's west coast with those elsewhere in the northeastern Pacific.*

Species	Alaska (Sowls et al. 1978)		Canada's west coast (this paper)		Washington (Manuwal et al. 1979,Speich pers.comm.)		Oregon (Varoujean et al. 1979[b])		California (Sowls et al. 1980		Total Pacific Northeast	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Fork-tailed Storm-Petrel	1148500	88.8	133730	10.3	10000	0.8	1000	0.1	310	Tra.	1293540	10.8
Leach's Storm-Petrel	1709600	81.0	219000	10.4	30000	1.4	136000	6.4	18304	0.8	2112904	17.6
Brandt's Cormorant	11	Tra .	204	0.3	180	0.2	16200	20.0	64210	79.5	80805	0.7
Double-crested Cormorant	4701	43.8	825	7.7	1620	15.1	1700	15.8	1884	17.6	10730	0.1
Pelagic Cormorant	40888	53.7	8220	10.8	4640	6.1	6560	8.6	15870	20.8	761788	0.6
Glaucous-winged Gull	229022	77.2	43750	14.8	23800	8.0	--	--	--	--	296572	2.5
Common Murre	1690584	65.2	8316	0.3	22000	0.8	512000	19.7	363154	14.0	2596054	21.6
Pigeon Guillemot	40571	57.9	6490	9.3	3980	5.7	4260	6.1	14724	21.0	70025	0.6
Ancient Murrelet	113302	21.2	421760	78.8	--	--	--	--	--	--	535062	4.4
Cassin's Auklet	319140	20.2	1063200	67.1	70000	4.4	240	Tra.	131170	8.3	1583750	13.2
Rhinoceros Auklet	112618	29.8	207450	54.9	57600	15.2	200	Tra.	362	0.1	378230	3.1
Tufted Puffin	2108535	95.7	63455	2.9	25160	1.1	6600	0.3	250	Tra.	2204000	18.4
Horned Puffin	768111	100.0	50	Tra.	--	--	--	--	--	--	768161	6.4
Total	8285583		2176450		248980		684760		610238		12006011	100.0

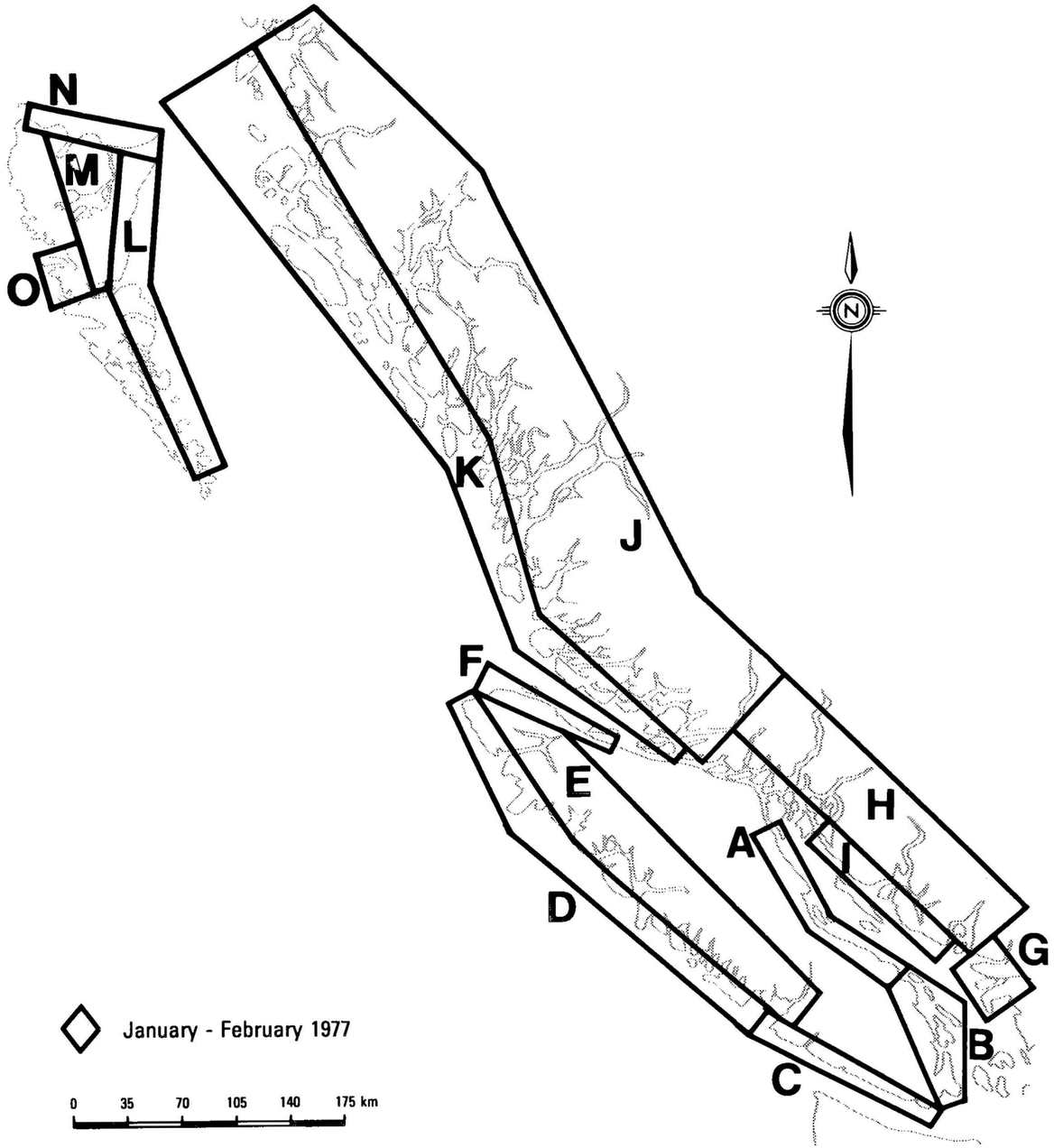
*Data are conservative. Actual breeding populations are estimated in many instances to be twice as large (especially in Alaska) as indicated here.

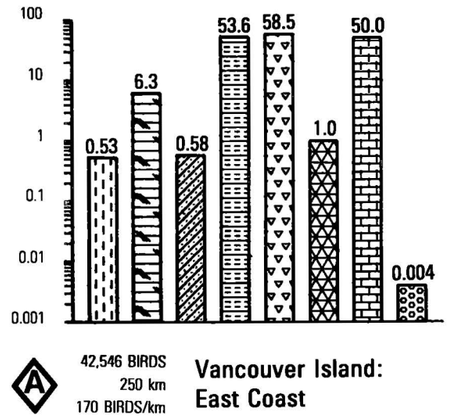


Index Map No. 1-4

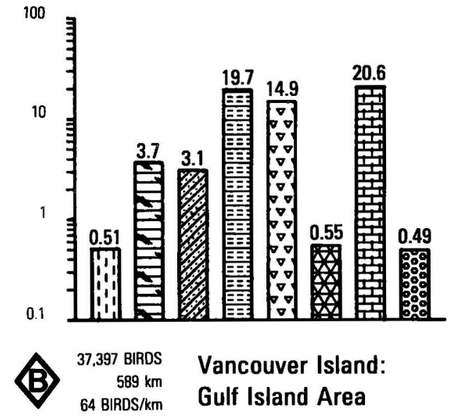
0 35 70 105 140 175 km

Map 1. Distribution and densities of birds along the Canadian west coast as observed by airplane, January – February 1977.

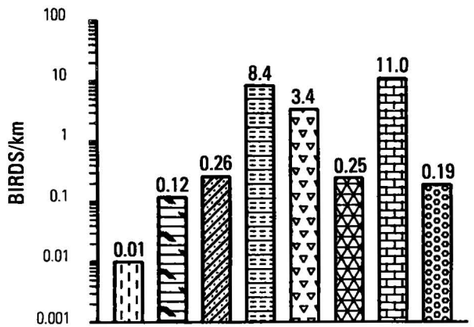




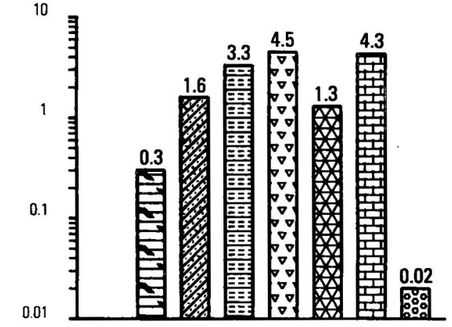
A — 42,546 BIRDS, 250 km, 170 BIRDS/km — Vancouver Island: East Coast



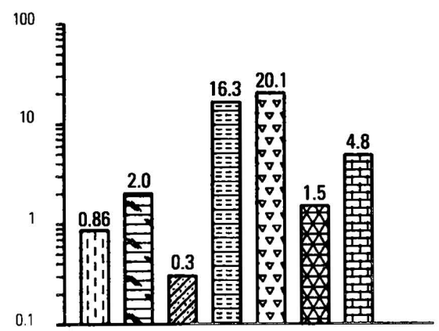
B — 37,397 BIRDS, 589 km, 64 BIRDS/km — Vancouver Island: Gulf Island Area



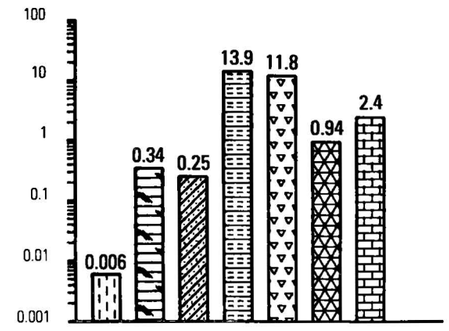
C — 4,374 BIRDS, 185 km, 24 BIRDS/km — Vancouver Island: S.W. Coast



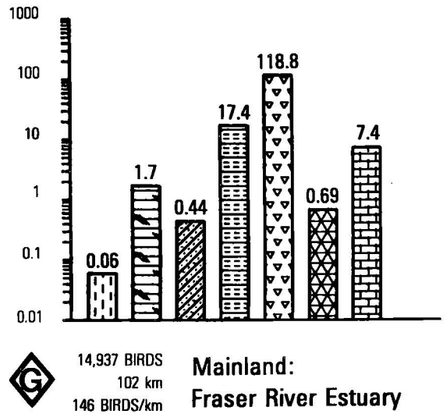
D — 4,774 BIRDS, 312 km, 15 BIRDS/km — Vancouver Island: West Coast



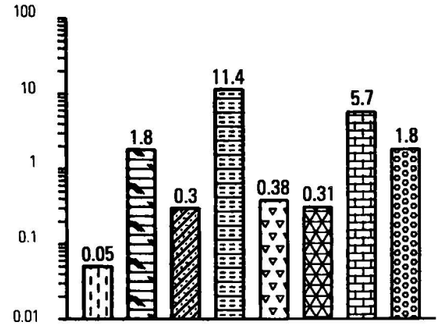
E — 31,608 BIRDS, 690 km, 46 BIRDS/km — Vancouver Island: West Coast Inlets



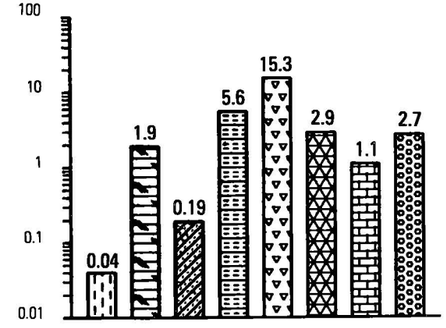
F — 4,593 BIRDS, 155 km, 30 BIRDS/km — Vancouver Island: N.E. Coast



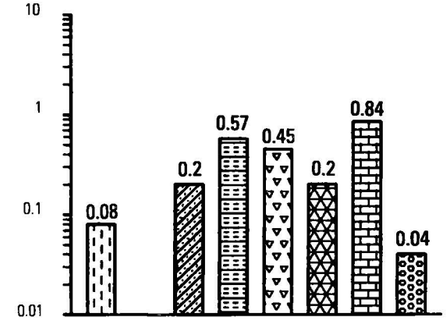
G — 14,937 BIRDS · 102 km · 146 BIRDS/km — **Mainland: Fraser River Estuary**



H — 11,173 BIRDS · 515 km · 22 BIRDS/km — **Mainland: St. of Georgia & Johnstone Strait Inlets**

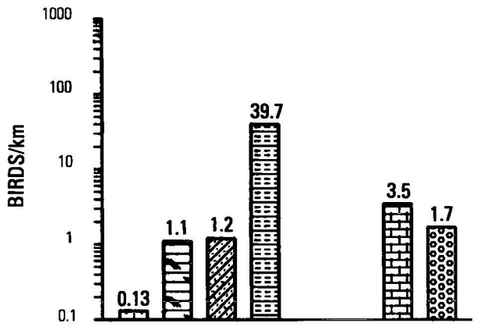


M — 9,219 BIRDS · 310 km · 30 BIRDS/km — **Queen Charlotte Islands: Inlets**

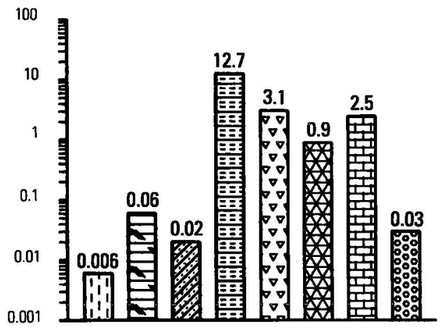


O — 293 BIRDS · 125 km · 2 BIRDS/km — **Queen Charlotte Islands: West Coast**

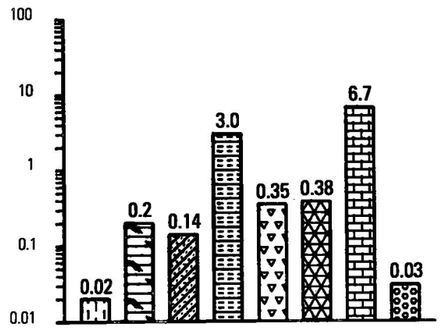
Note: Area N – Queen Charlotte Islands: North Coast was not surveyed this season.



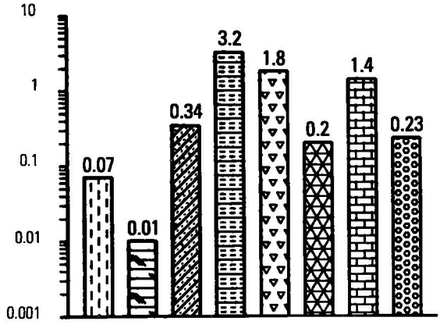
I — 6,496 BIRDS · 137 km · 47 BIRDS/km — **Mainland: St. of Georgia Coast**



J — 47,784 BIRDS · 2,479 km · 19 BIRDS/km — **Mainland: Queen Charlotte Sound & Hecate Strait Inlets**



K — 8,901 BIRDS · 821 km · 11 BIRDS/km — **Mainland: Queen Charlotte Sound & Hecate Strait Coast**



L — 3,403 BIRDS · 469 km · 7 BIRDS/km — **Queen Charlotte Islands: East Coast**

Loons

Grebes

Cormorants

Diving Ducks

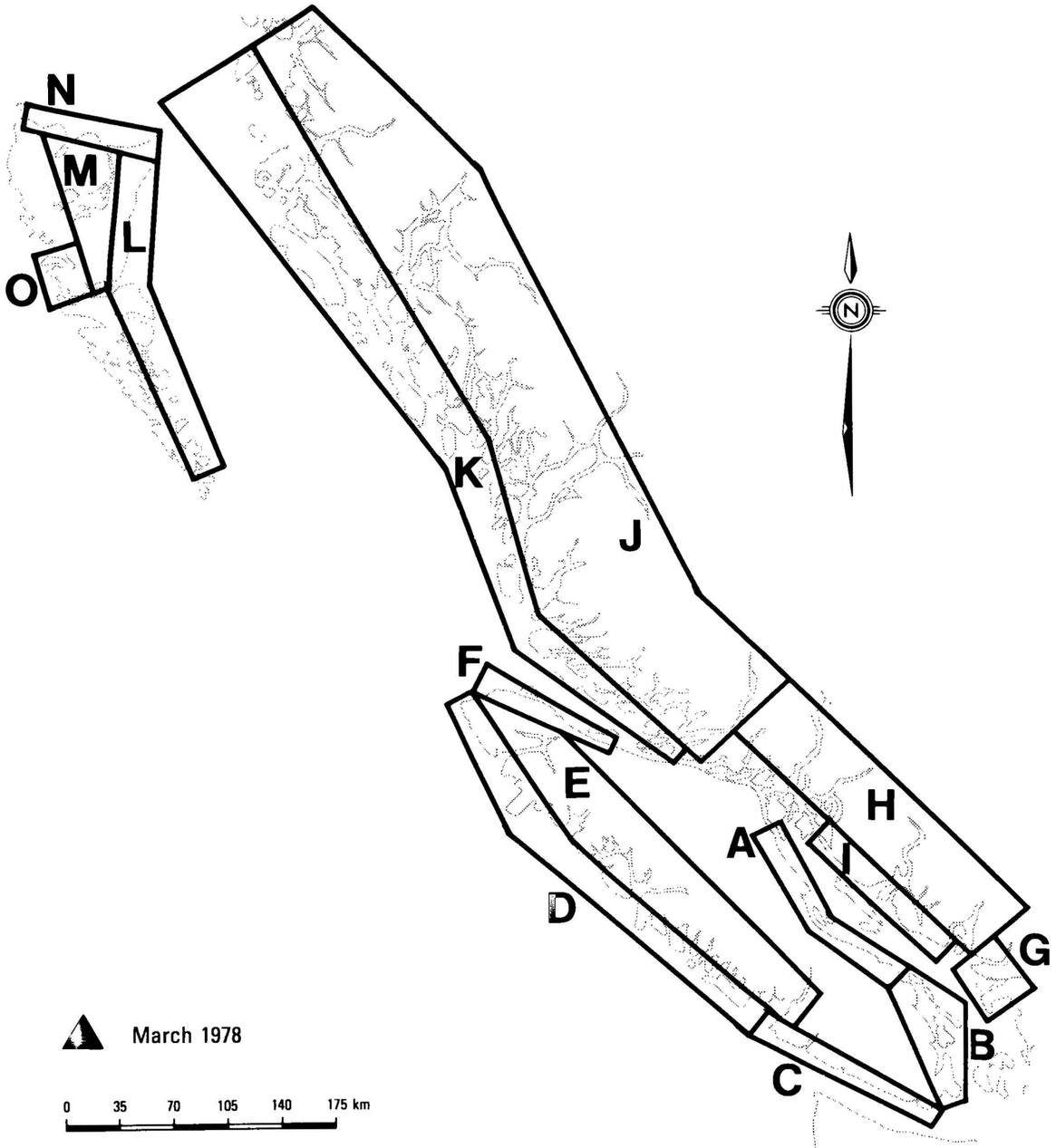
Dabbling Ducks

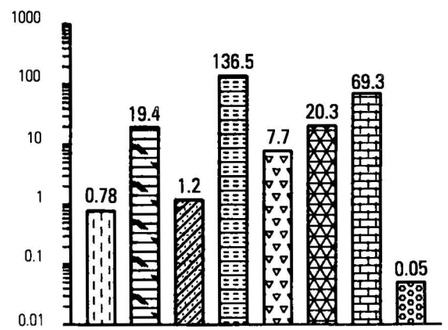
Swans & Geese

Gulls

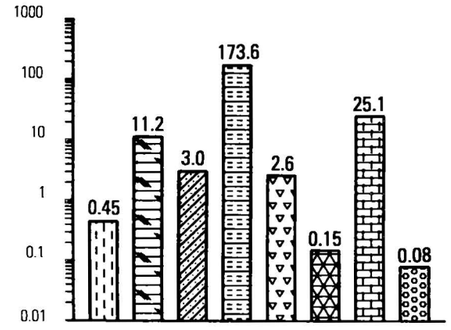
Auks

Map 2. Distribution and densities of birds along the Canadian west coast as observed by airplane, March 1978.

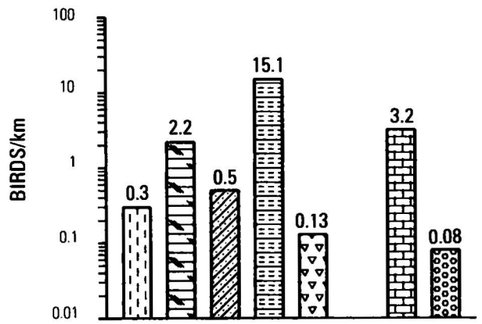




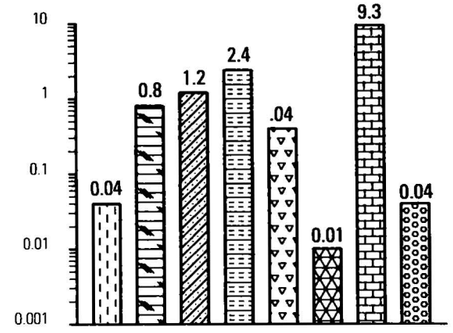
A — 42,619 BIRDS; 167 km; 255 BIRDS/km — Vancouver Island: East Coast



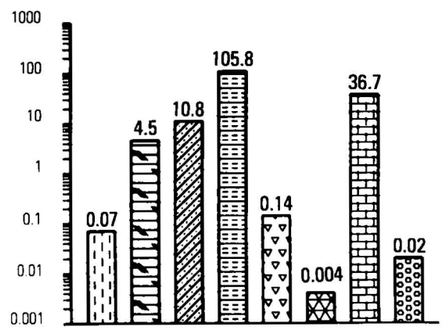
B — 42,162 BIRDS; 195 km; 216 BIRDS/km — Vancouver Island: Gulf Island Area



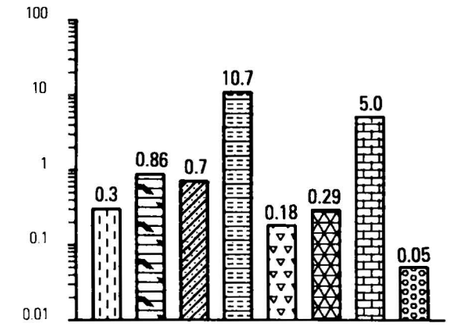
C — 4,026 BIRDS; 187 km; 22 BIRDS/km — Vancouver Island: S.W. Coast



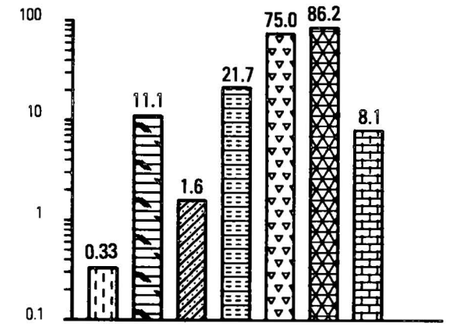
D — 4,754 BIRDS; 341 km; 14 BIRDS/km — Vancouver Island: West Coast



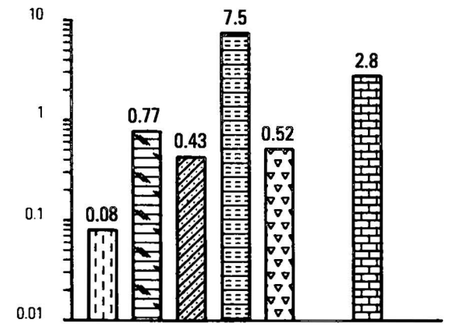
E — 76,811 BIRDS; 486 km; 158 BIRDS/km — Vancouver Island: West Coast Inlets



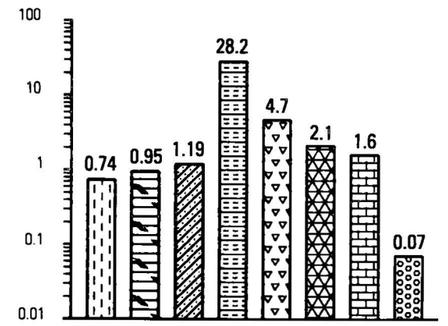
F — 2,663 BIRDS; 147 km; 18 BIRDS/km — Vancouver Island: N.E. Coast



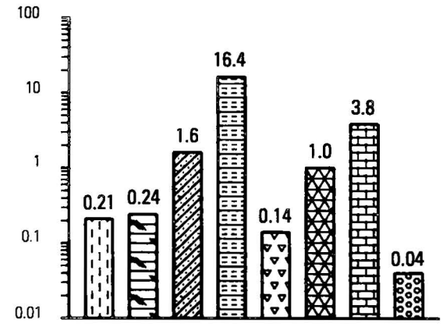
G — 15,302 BIRDS · 75 km · 204 BIRDS/km — **Mainland: Fraser River Estuary**



H — 12,626 BIRDS · 1042 km · 12 BIRDS/km — **Mainland: St. of Georgia & Johnstone Strait Inlets**

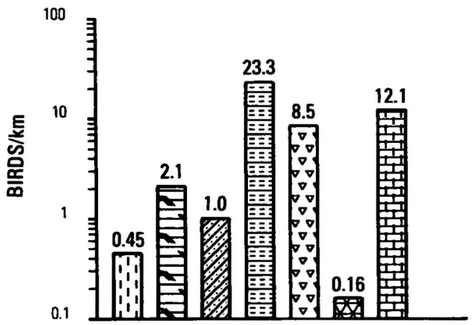


M — 4,786 BIRDS · 121 km · 40 BIRDS/km — **Queen Charlotte Islands: Inlets**

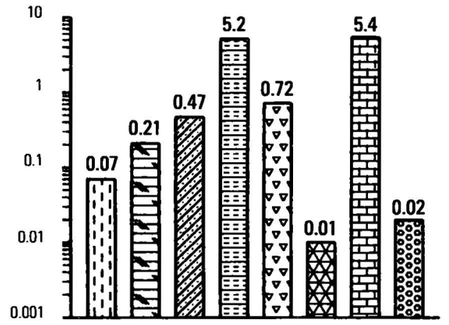


N — 2,336 BIRDS · 100 km · 23 BIRDS/km — **Queen Charlotte Islands: North Coast**

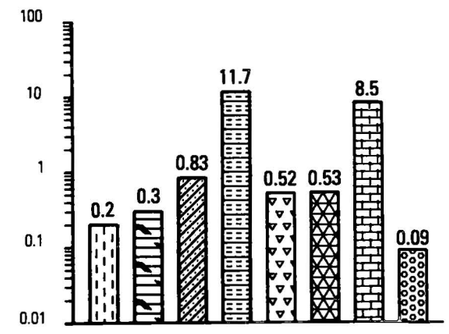
Note: Area O – Queen Charlotte Islands: West Coast was not surveyed this season.



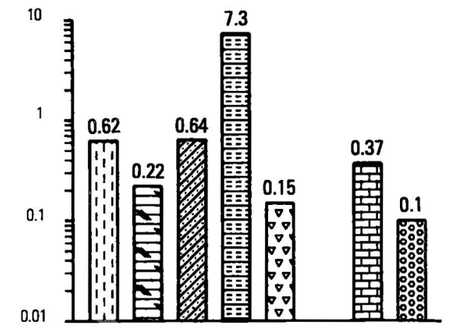
I — 7,283 BIRDS · 153 km · 48 BIRDS/km — **Mainland: St. of Georgia Coast**



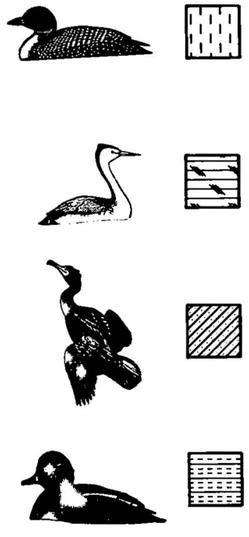
J — 15,235 BIRDS · 1261 km · 12 BIRDS/km — **Mainland: Queen Charlotte Sound & Hecate Strait Inlets**



K — 20,537 BIRDS · 908 km · 23 BIRDS/km — **Mainland: Queen Charlotte Sound & Hecate Strait Coast**



L — 557 BIRDS · 59 km · 9 BIRDS/km — **Queen Charlotte Islands: East Coast**

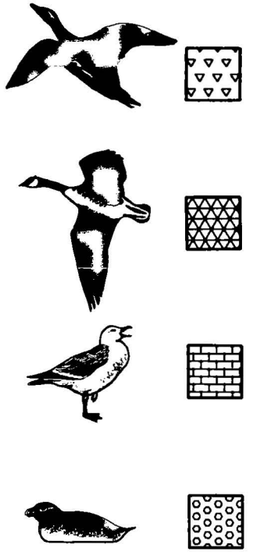


Loons

Grebes

Cormorants

Diving Ducks



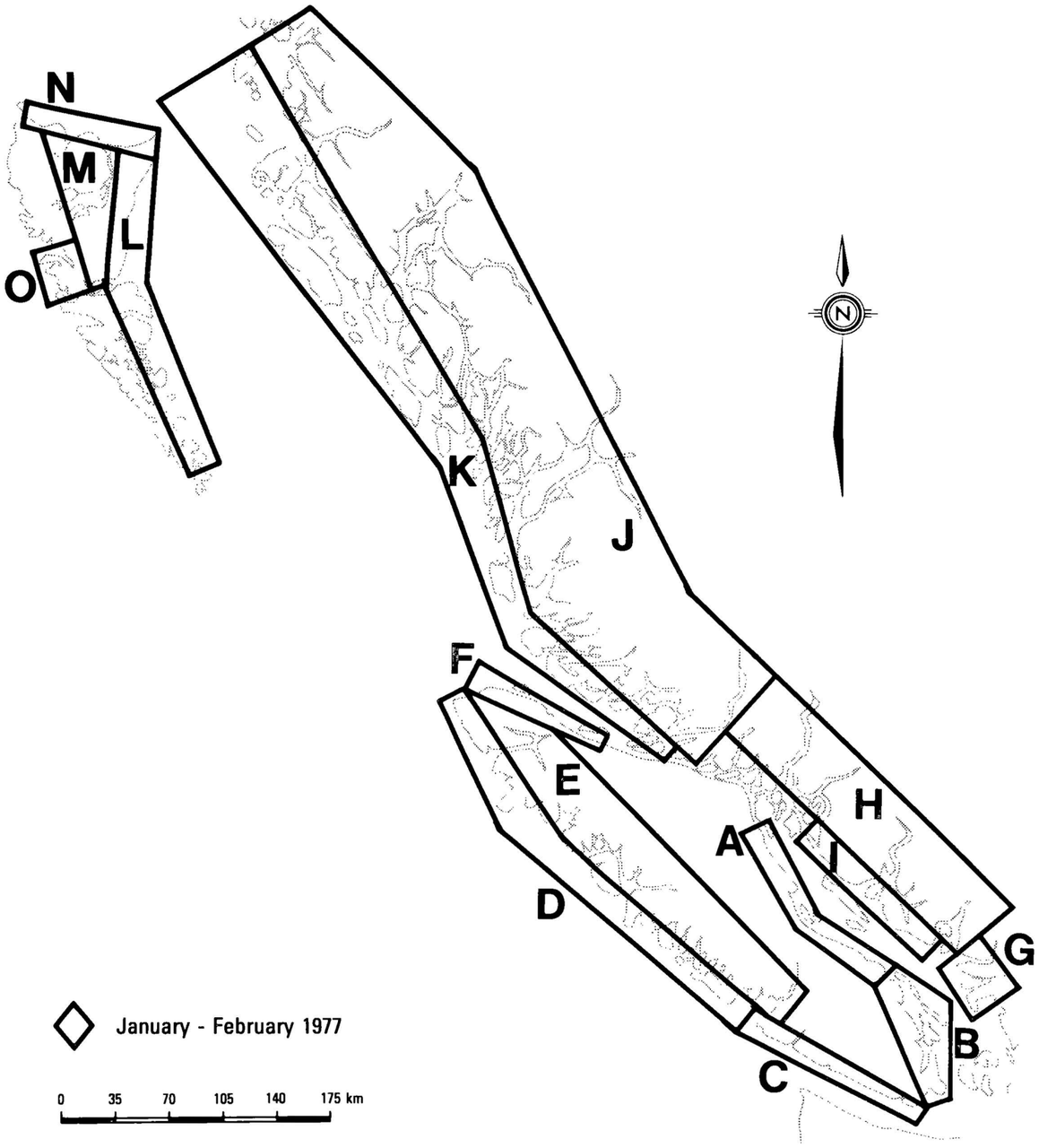
Dabbling Ducks

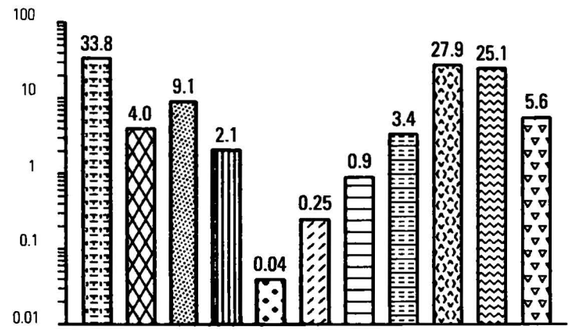
Swans & Geese

Gulls

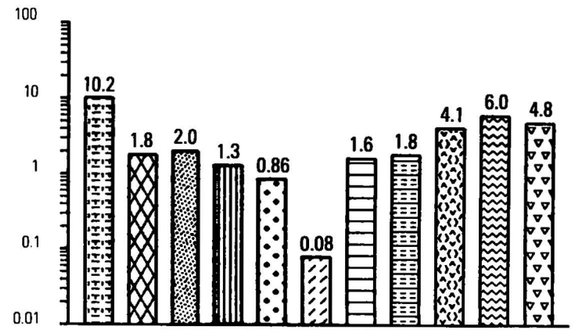
Auks

Map 3. Distribution and densities of ducks along the Canadian west coast as observed by airplane, January – February 1977.

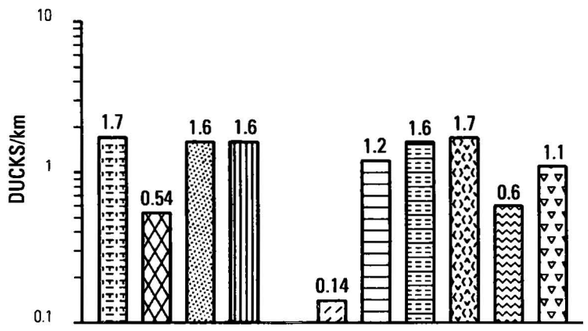




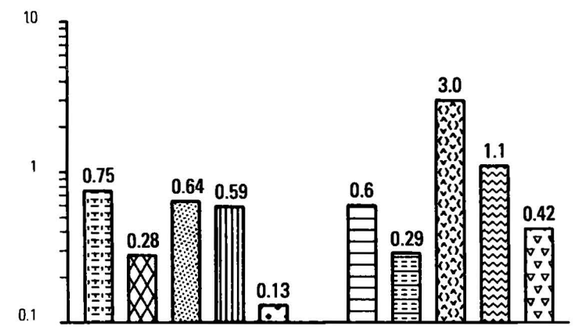
A — 28,042 DUCKS; 250 km; 112 DUCKS/km — Vancouver Island: East Coast



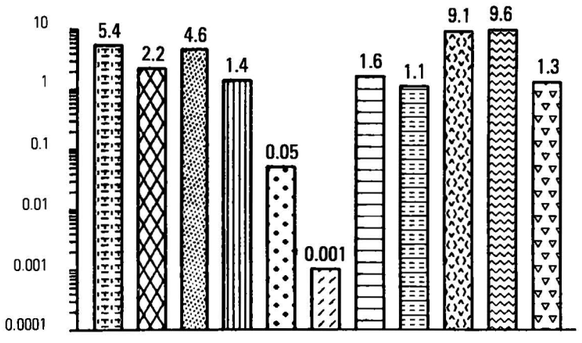
B — 20,361 DUCKS; 589 km; 35 DUCKS/km — Vancouver Island: Gulf Island Area



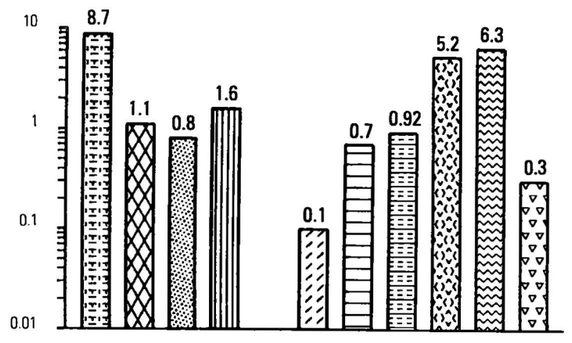
C — 2,178 DUCKS; 185 km; 12 DUCKS/km — Vancouver Island: S.W. Coast



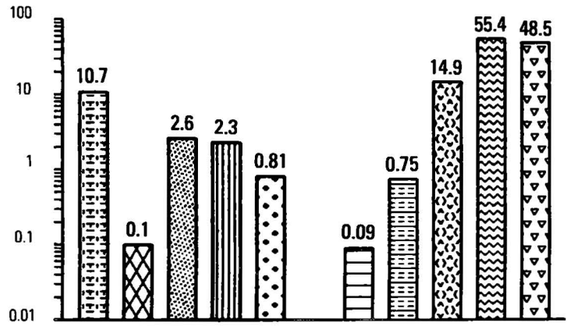
D — 2,430 DUCKS; 312 km; 8 DUCKS/km — Vancouver Island: West Coast



E — 25,108 DUCKS; 690 km; 36 DUCKS/km — Vancouver Island: West Coast Inlets

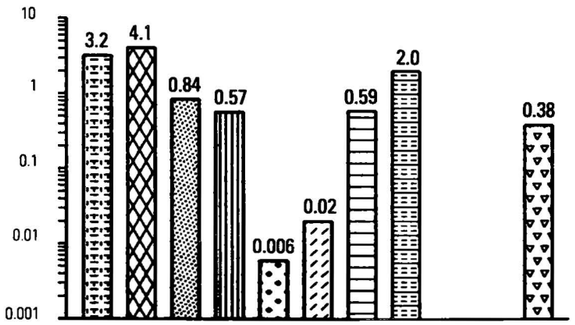


F — 3,979 DUCKS; 155 km; 26 DUCKS/km — Vancouver Island: N.E. Coast



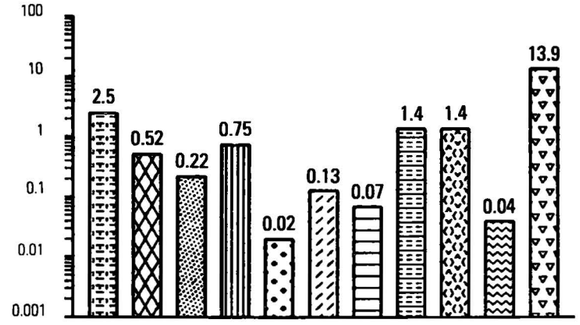
13,889 DUCKS
102 km
136 DUCKS/km

Mainland:
Fraser River Estuary



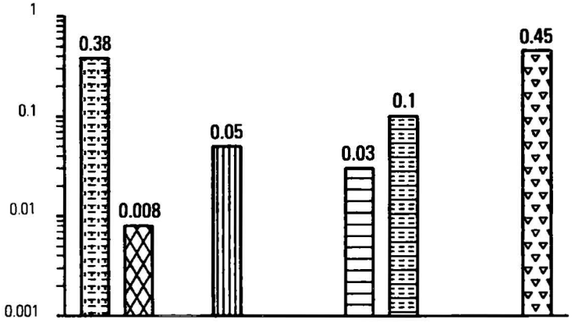
6,034 DUCKS
515 km
12 DUCKS/km

Mainland:
St. of Georgia & Johnstone Strait Inlets



6,475 DUCKS
310 km
21 DUCKS/km

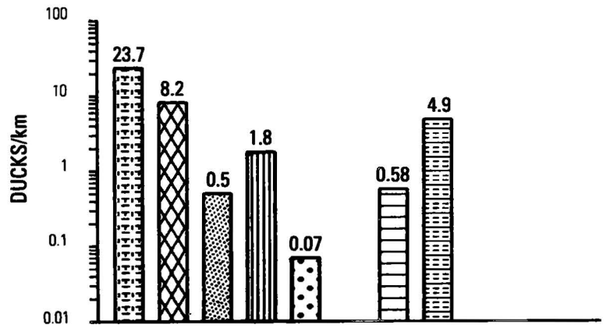
Queen Charlotte Islands:
Inlets



127 DUCKS
125 km
1 DUCK/km

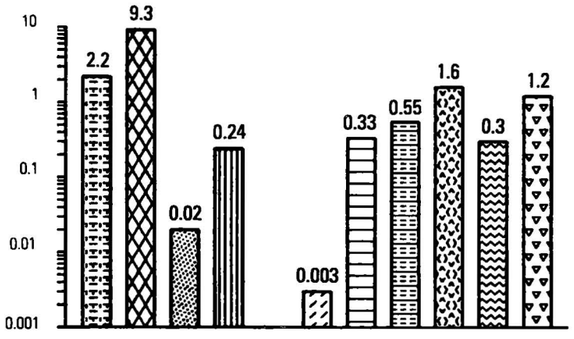
Queen Charlotte Islands:
West Coast

Note: Area N – Queen Charlotte Islands: North Coast was not surveyed this season.



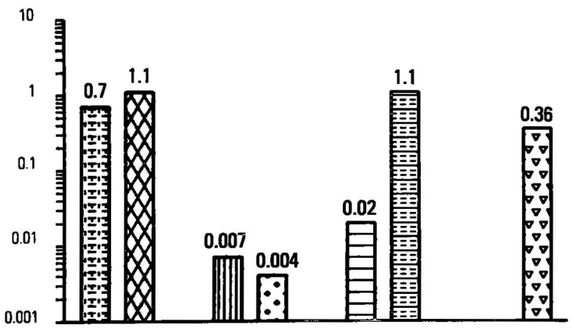
5,443 DUCKS
137 km
40 DUCKS/km

Mainland:
St. of Georgia Coast



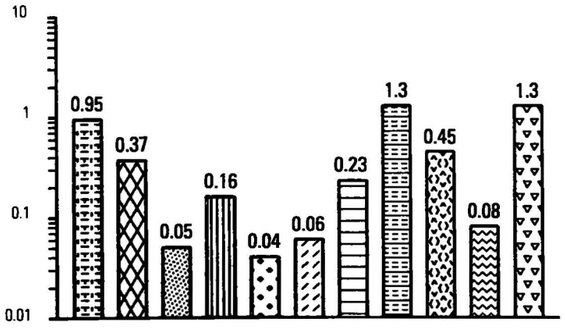
39,124 DUCKS
2,479 km
16 DUCKS/km

Mainland:
Queen Charlotte Sound & Hecate Strait Inlets



2,732 DUCKS
821 km
3 DUCKS/km

Mainland:
Queen Charlotte Sound & Hecate Strait Coast



2,354 DUCKS
469 km
5 DUCKS/km

Queen Charlotte Islands:
East Coast

Scoters

Harlequin

Goldeneyes

Mergansers

Scaup

Other & Unidentified Diving Ducks

Bufflehead

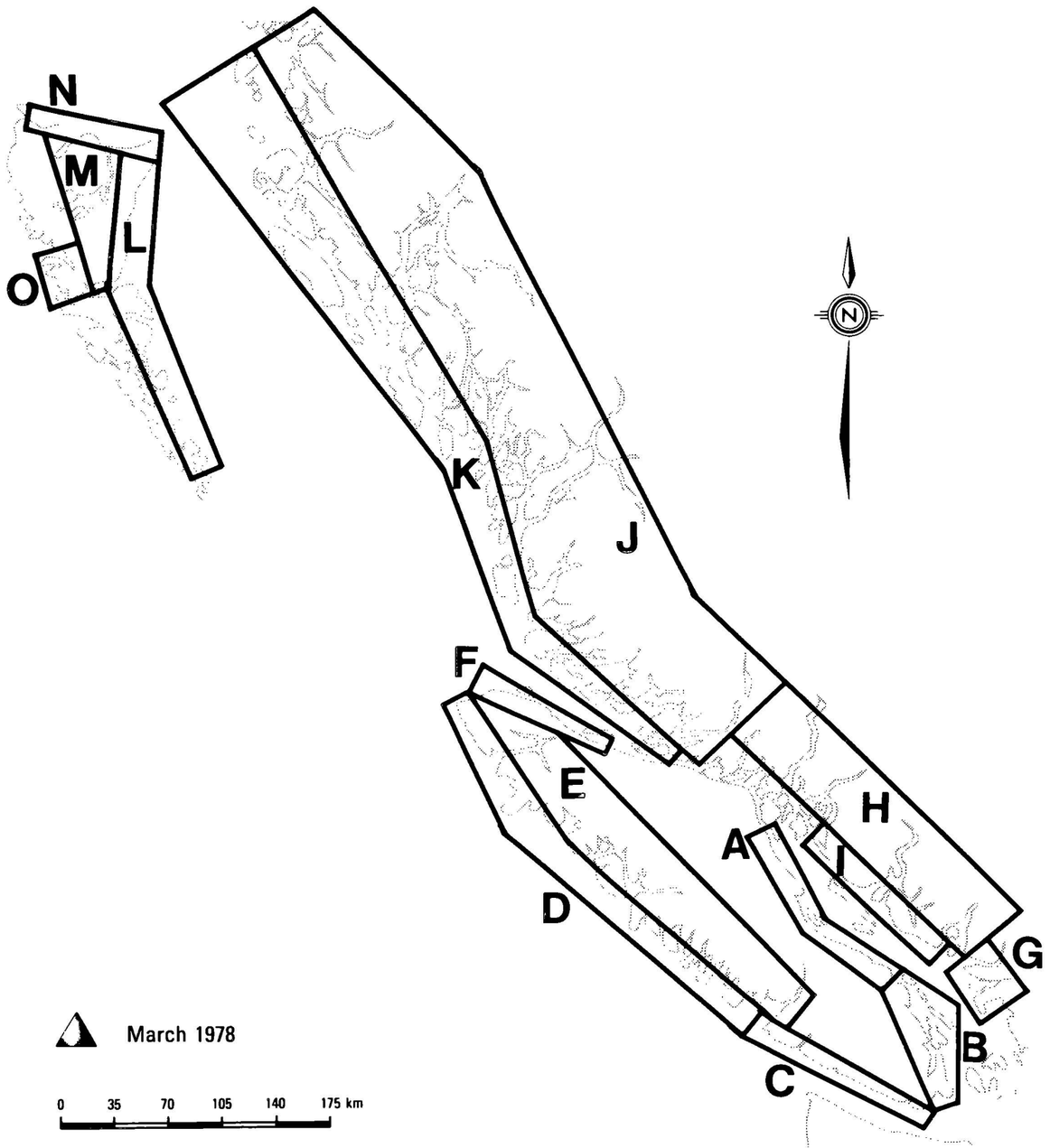
Mallard

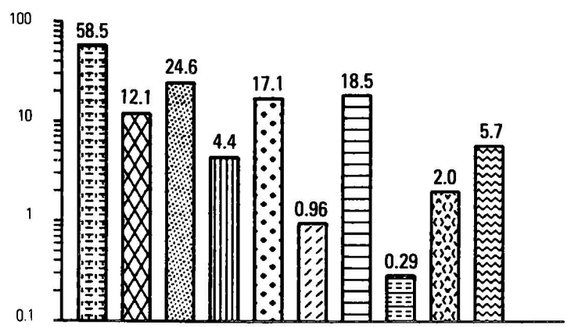
Oldsquaw

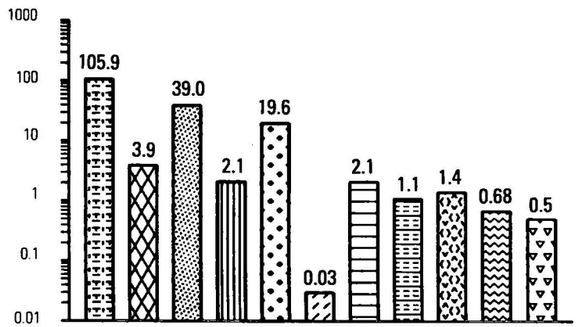
American Widgeon

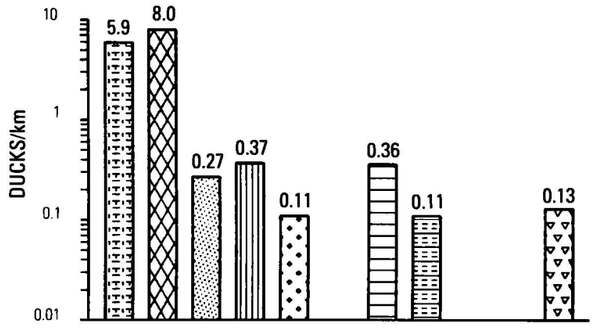
Other & Unidentified Dabbling Ducks

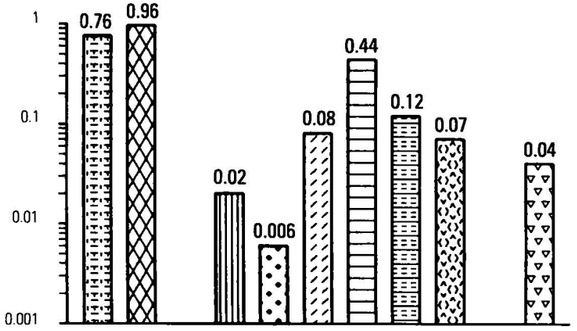
Map 4. Distribution and densities of ducks along the Canadian west coast as observed by airplane, March 1978.

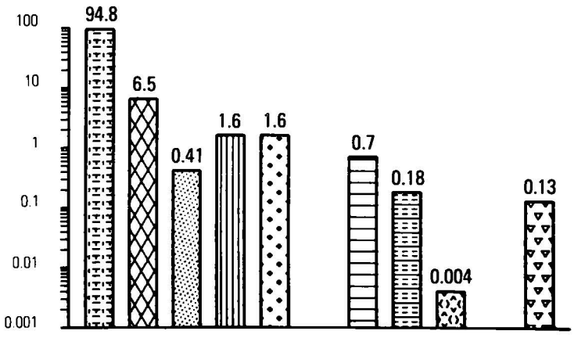


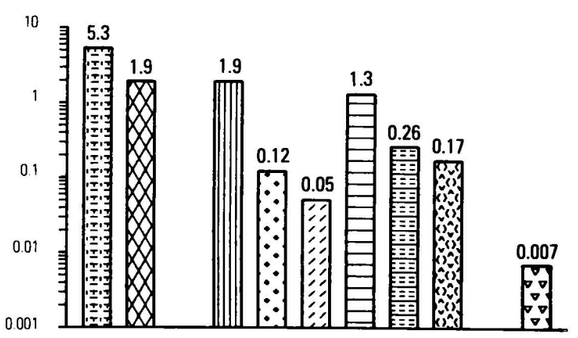


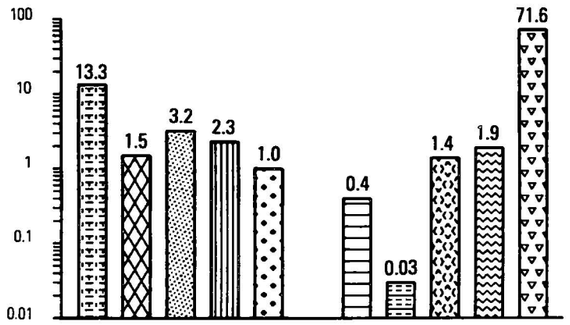




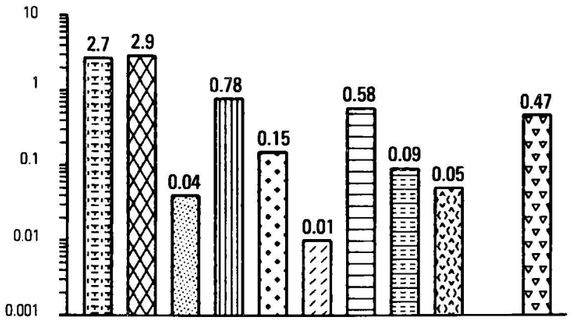




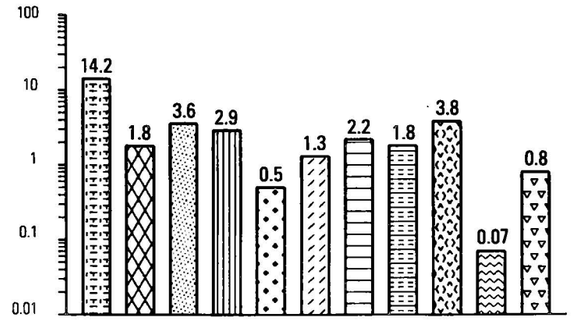




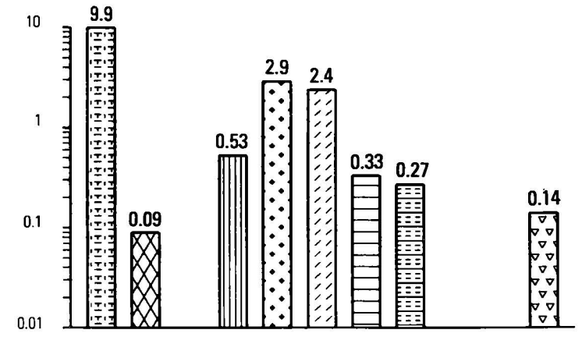
G 7,256 DUCKS · 75 km · 97 DUCKS/km — **Mainland: Fraser River Estuary**



H 8,325 DUCKS · 1042 km · 8 DUCKS/km — **Mainland: St. of Georgia & Johnstone Strait Inlets**

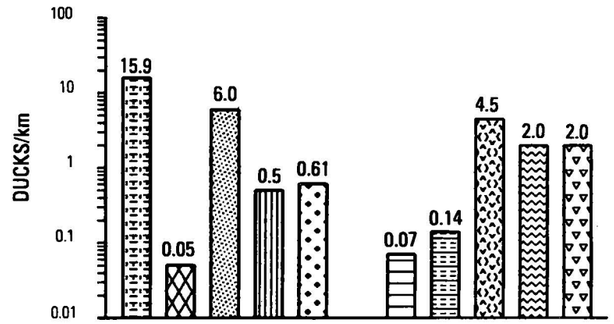


M 3,975 DUCKS · 121 km · 33 DUCKS/km — **Queen Charlotte Islands: Inlets**

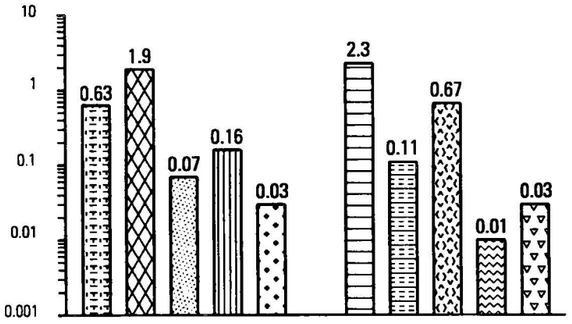


N 1,655 DUCKS · 100 km · 17 DUCKS/km — **Queen Charlotte Islands: North Coast**

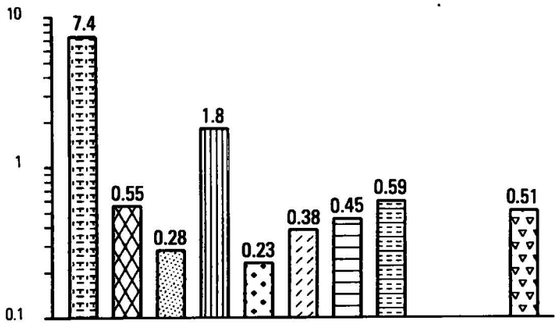
Note: Area O – Queen Charlotte Islands: West Coast was not surveyed this season.



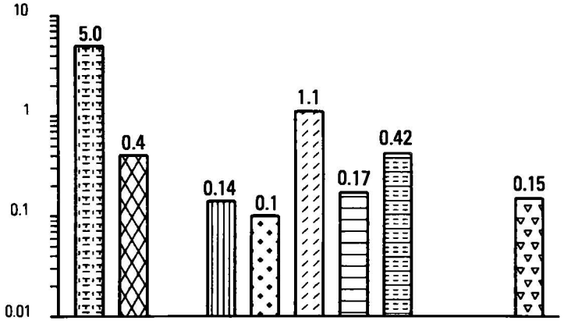
I 4,862 DUCKS · 153 km · 32 DUCKS/km — **Mainland: St. of Georgia Coast**



J 7,440 DUCKS · 1261 km · 6 DUCKS/km — **Mainland: Queen Charlotte Sound & Hecate Strait Inlets**



K 11,068 DUCKS · 908 km · 12 DUCKS/km — **Mainland: Queen Charlotte Sound & Hecate Strait Coast**



L 441 DUCKS · 59 km · 7 DUCKS/km — **Queen Charlotte Islands: East Coast**

Scoters

Harlequin

Goldeneyes

Mergansers

Scaup

Other & Unidentified Diving Ducks

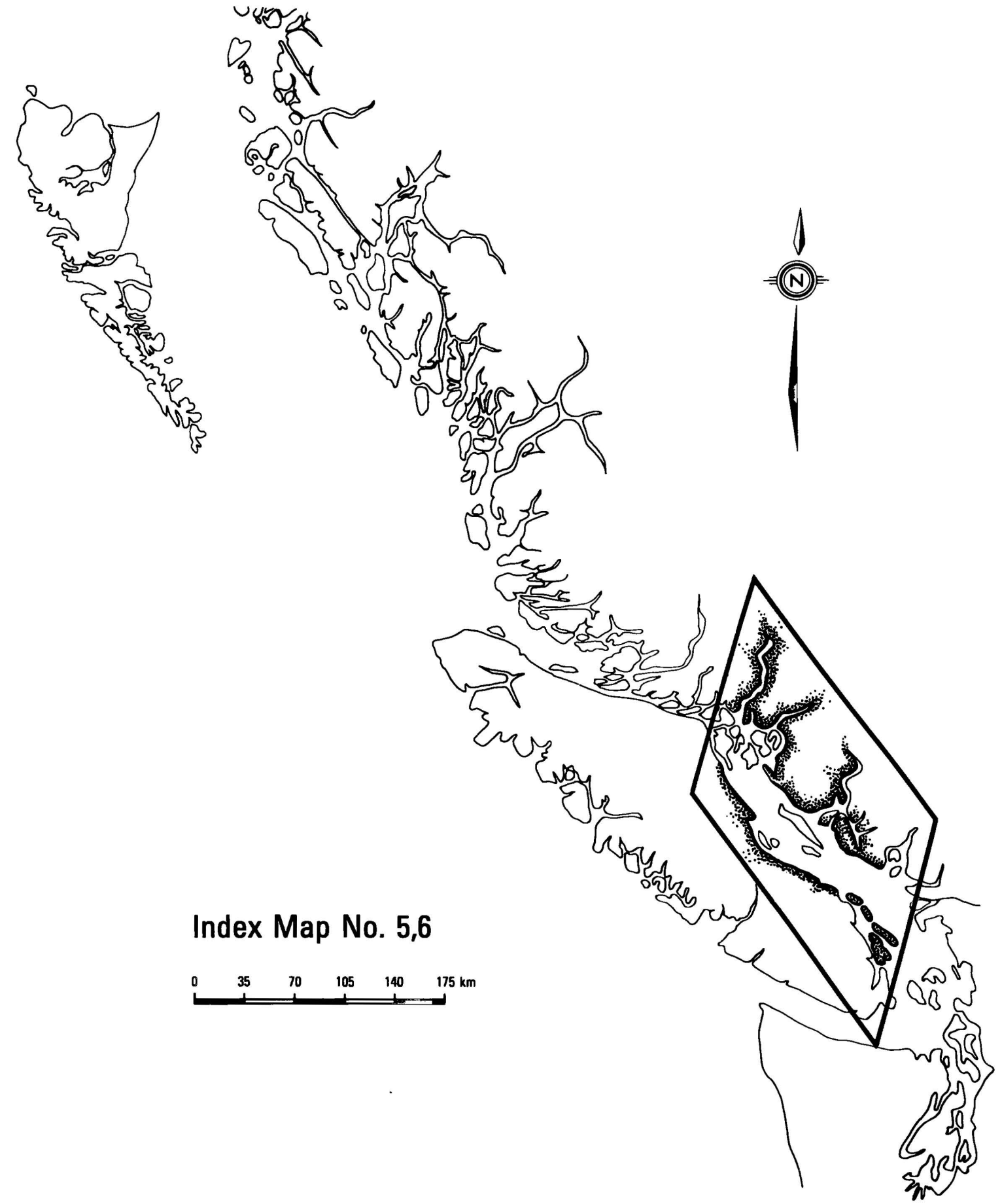
Bufflehead

Mallard

Oldsquaw

American Widgeon

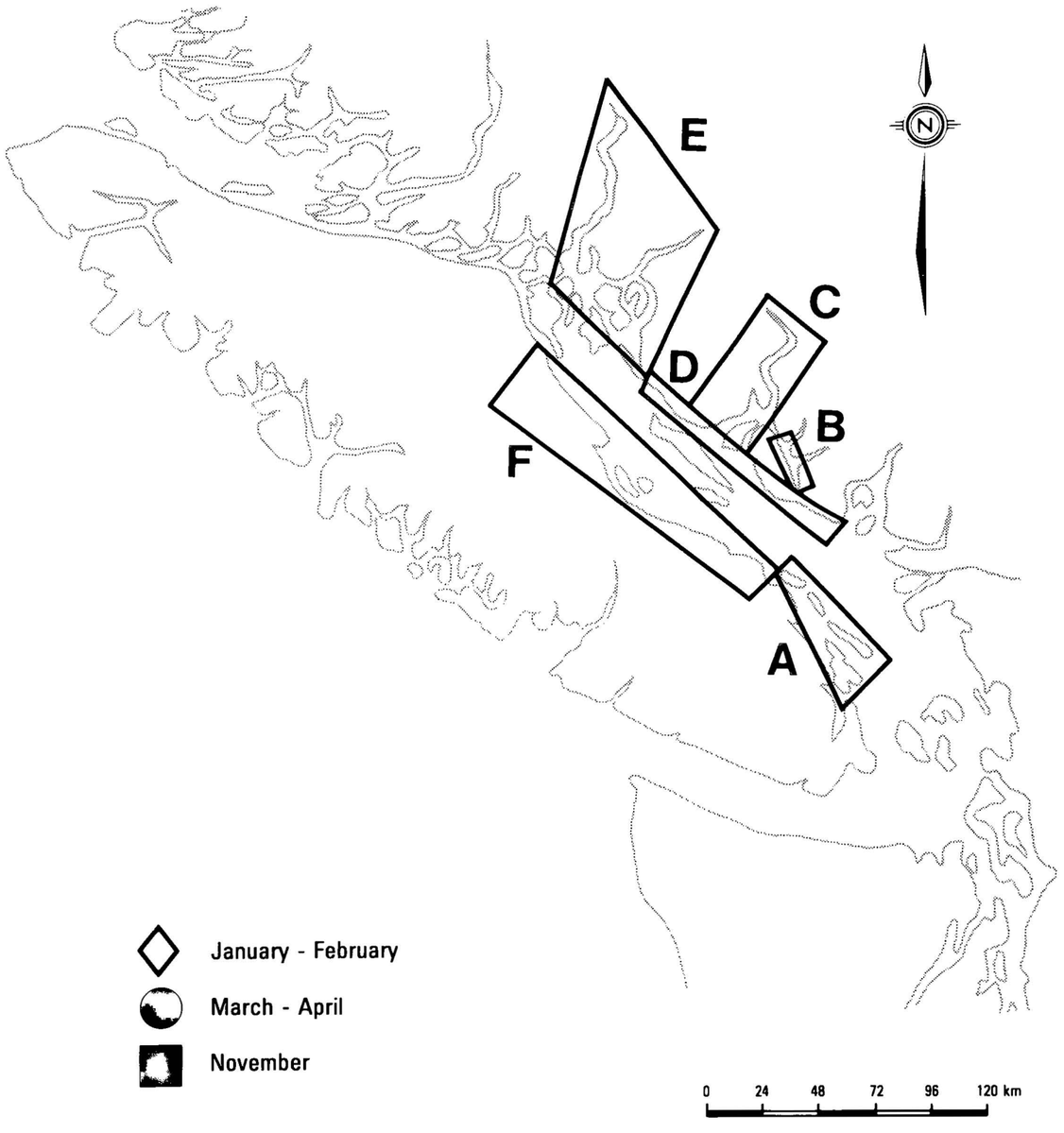
Other & Unidentified Dabbling Ducks

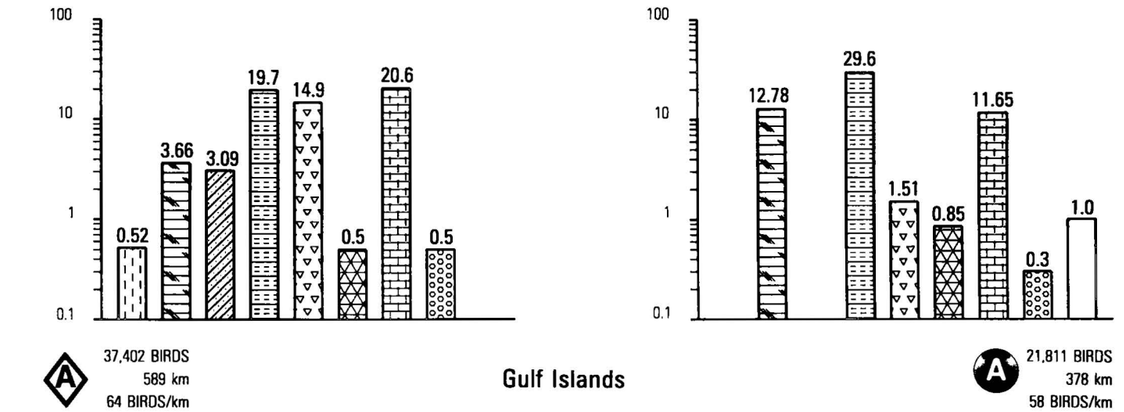


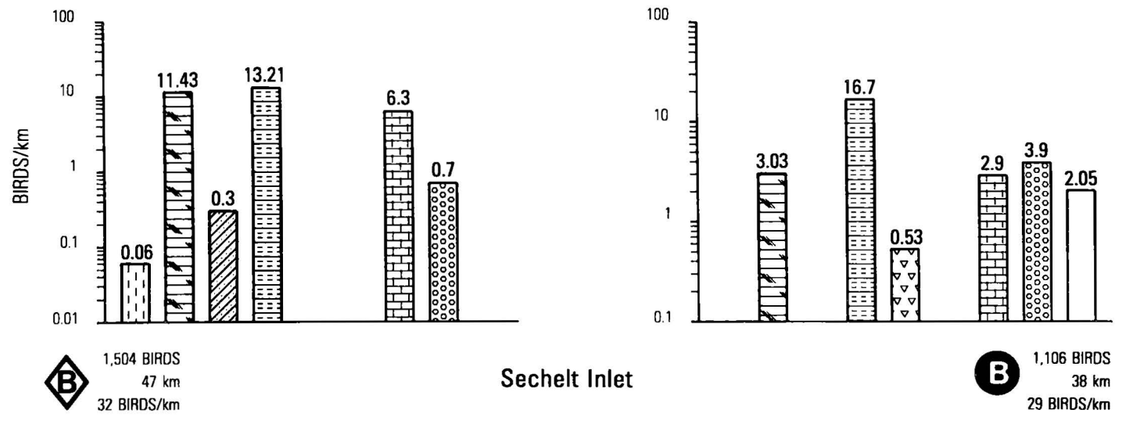
Index Map No. 5,6

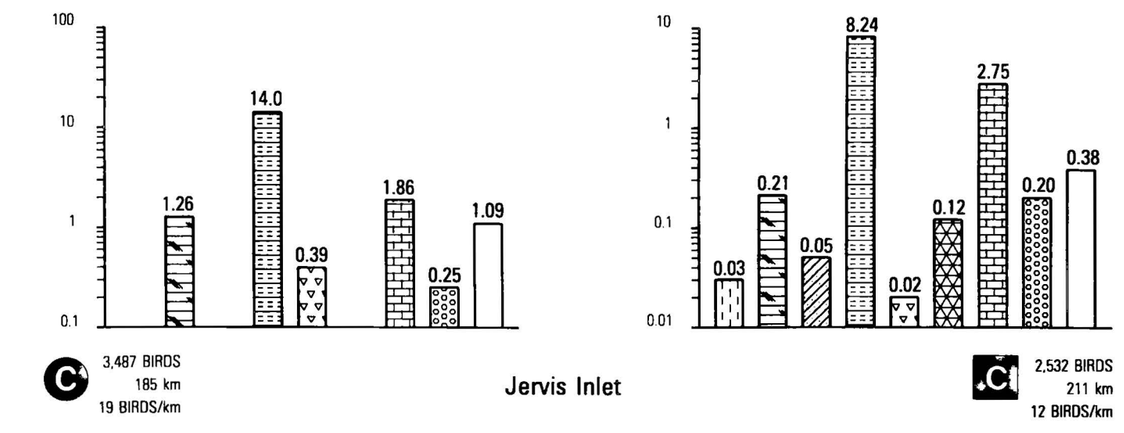
0 35 70 105 140 175 km

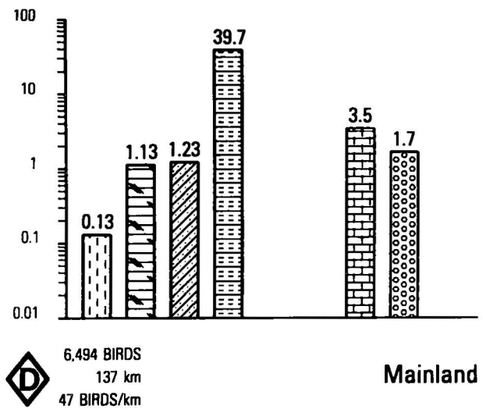
Map 5. Distribution and densities of birds along the shores of the Strait of Georgia and adjacent fjords as observed by airplane, January – February, March – April, and November 1977.





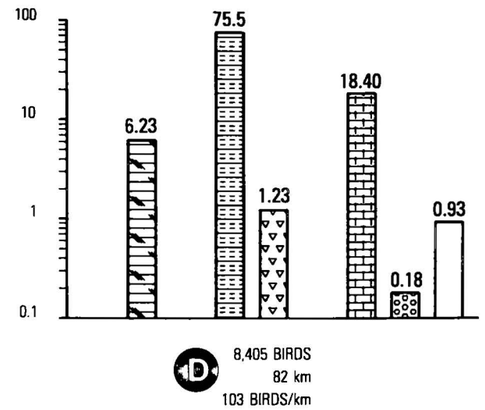




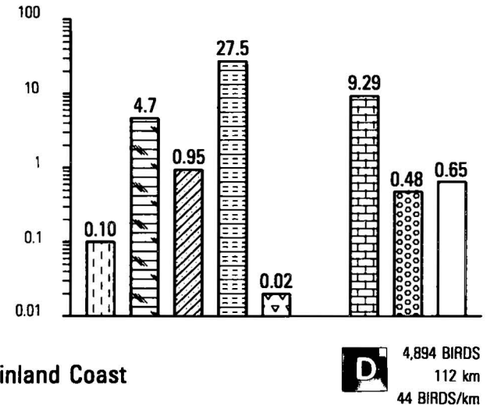


6,494 BIRDS
137 km
47 BIRDS/km

Mainland Coast

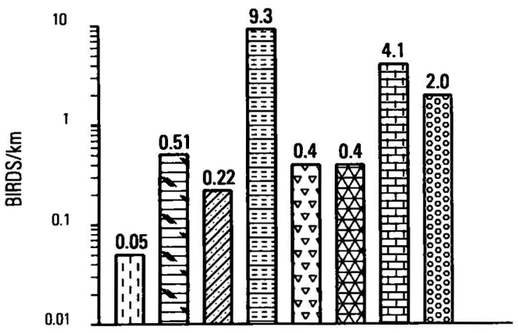


8,405 BIRDS
82 km
103 BIRDS/km



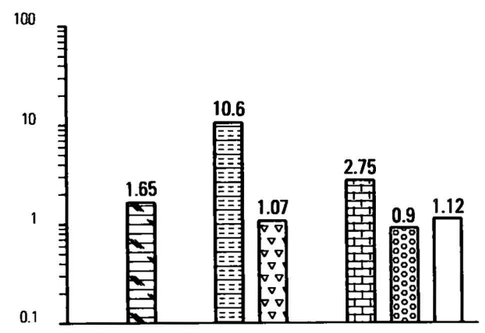
Mainland Coast

4,894 BIRDS
112 km
44 BIRDS/km

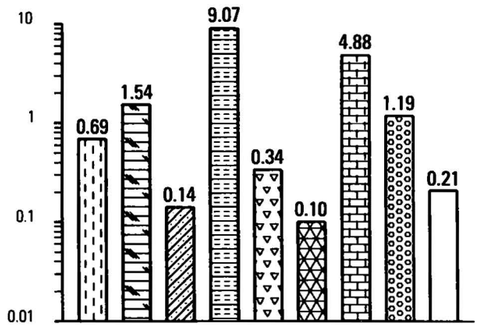


7,446 BIRDS
438 km
17 BIRDS/km

Bute & Toba Inlets

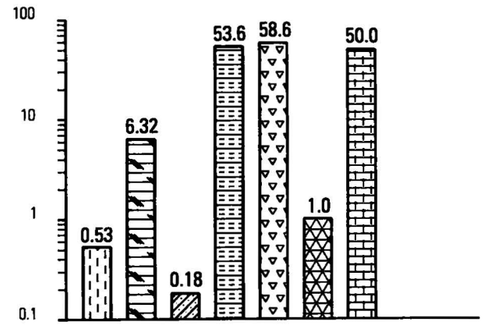


6,607 BIRDS
365 km
18 BIRDS/km



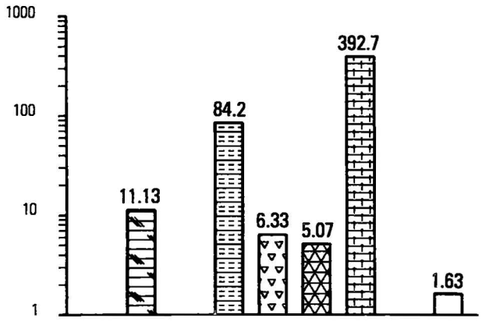
Bute & Toba Inlets

7,250 BIRDS
399 km
18 BIRDS/km

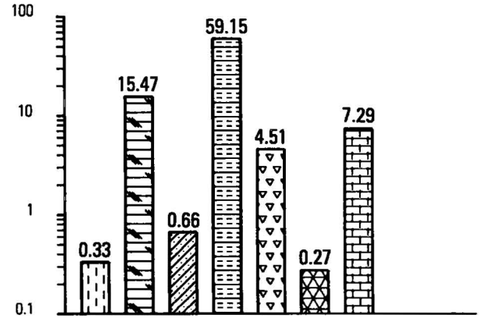


42,500 BIRDS
250 km
170 BIRDS/km

East Coast: Vancouver Island

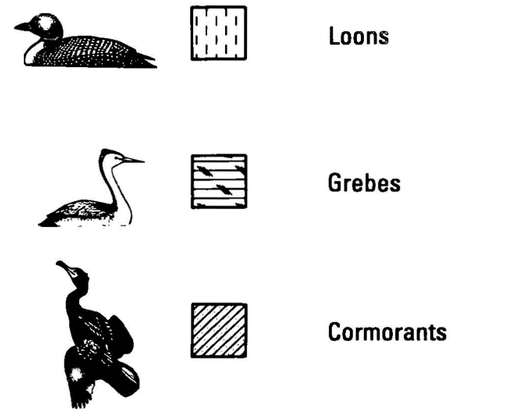


71,643 BIRDS
143 km
501 BIRDS/km



East Coast: Vancouver Island

16,312 BIRDS
186 km
88 BIRDS/km



Loons

Grebes

Cormorants

Diving Ducks

Dabbling Ducks

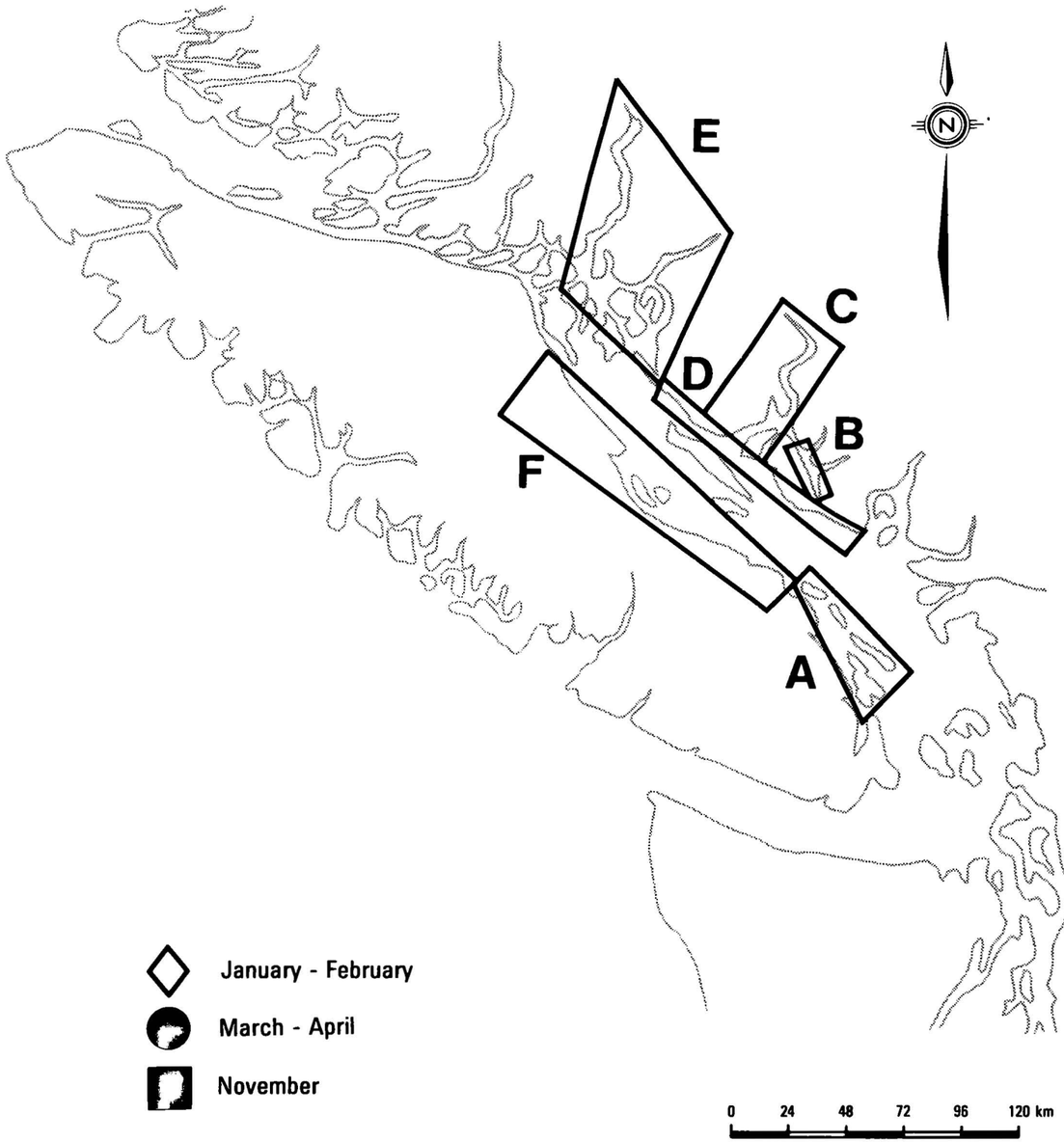
Swans & Geese

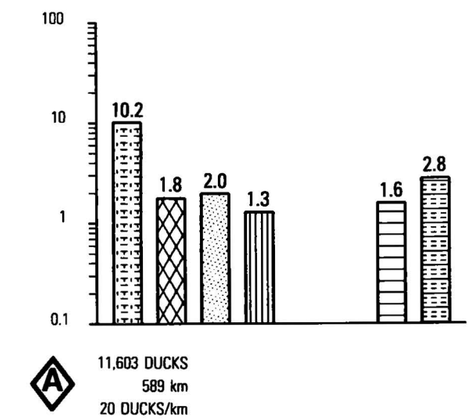
Gulls

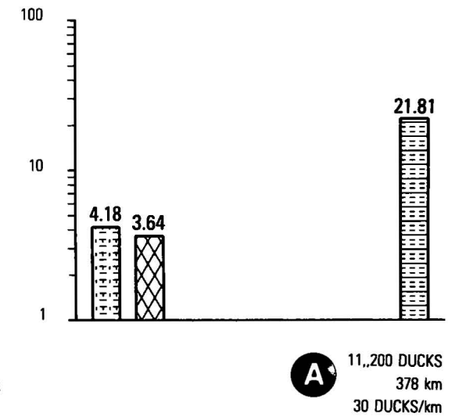
Auks

Unidentified Species

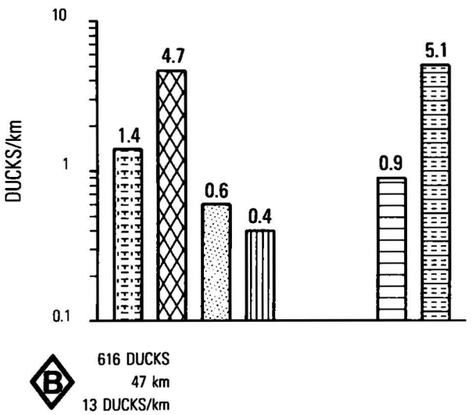
Map 6. Distribution and densities of diving ducks along the shores of the Strait of Georgia and adjacent fjords as observed by airplane, March – April and November 1977.

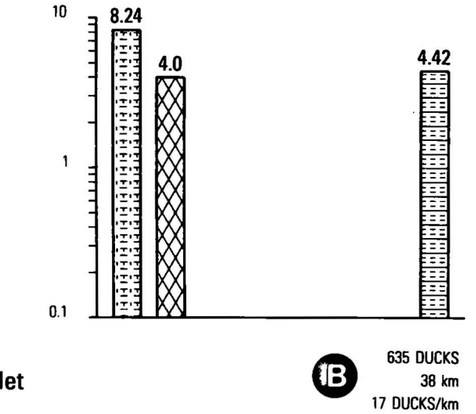




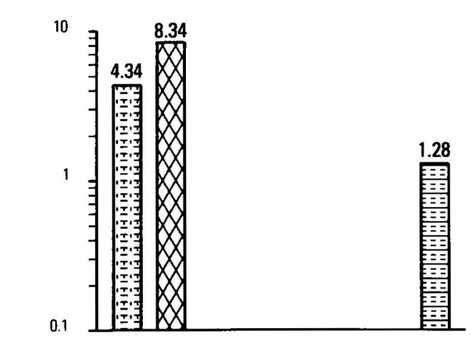


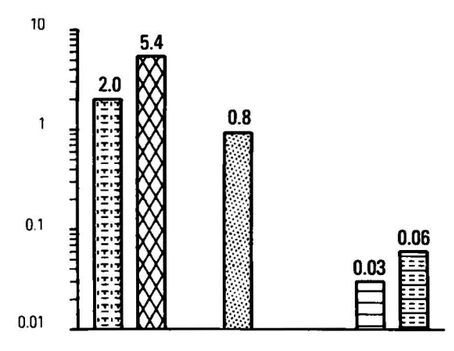
Gulf Islands



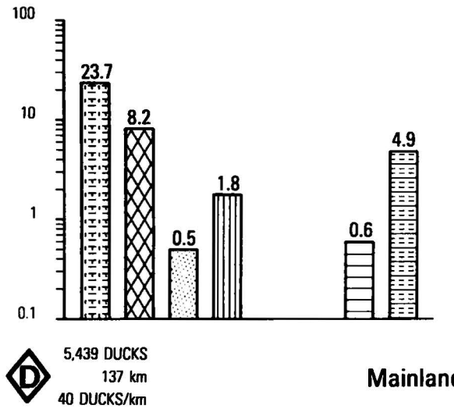


Sechelt Inlet



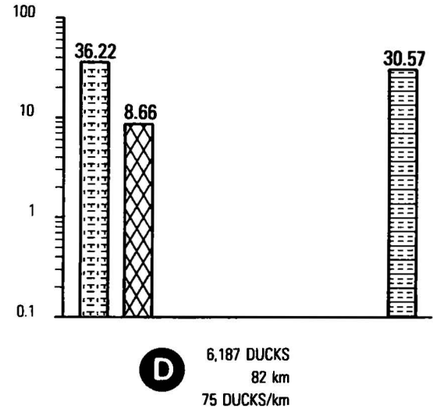


Jervis Inlet

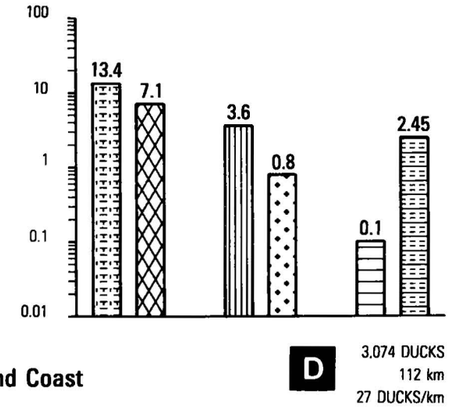


D 5,439 DUCKS
137 km
40 DUCKS/km

Mainland Coast

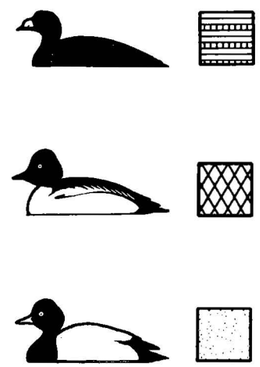


D 6,187 DUCKS
82 km
75 DUCKS/km



Mainland Coast

D 3,074 DUCKS
112 km
27 DUCKS/km



Scoters

Goldeneyes

Scaup

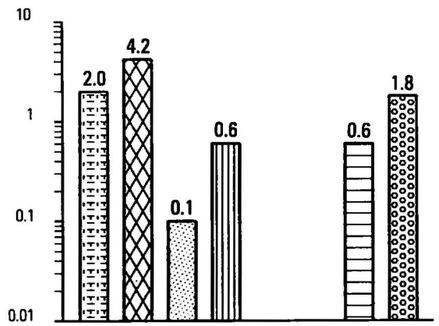
Bufflehead

Oldsquaw

Harlequin

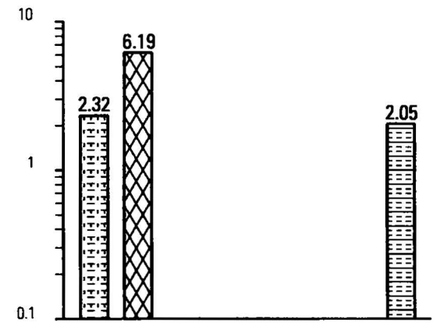
Mergansers

Other &
Unidentified
Diving Ducks

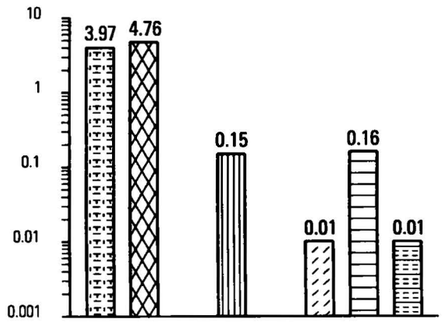


E 4,073 DUCKS
438 km
9 DUCKS/km

Bute & Toba Inlets

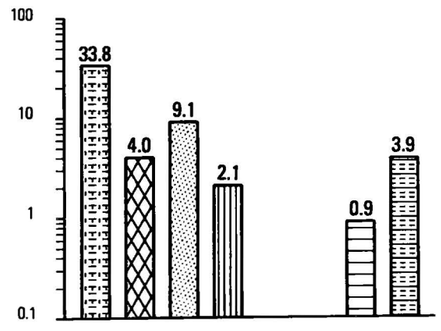


E 3,854 DUCKS
365 km
11 DUCKS/km



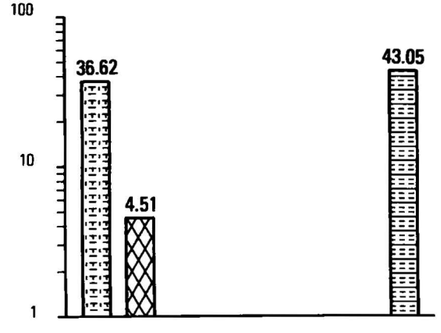
Bute & Toba Inlets

E 3,615 DUCKS
399 km
9 DUCKS/km

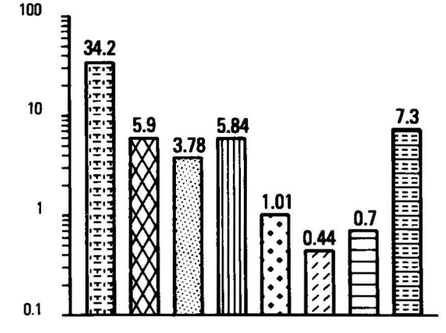


F 13,450 DUCKS
250 km
54 DUCKS/km

East Coast: Vancouver Island

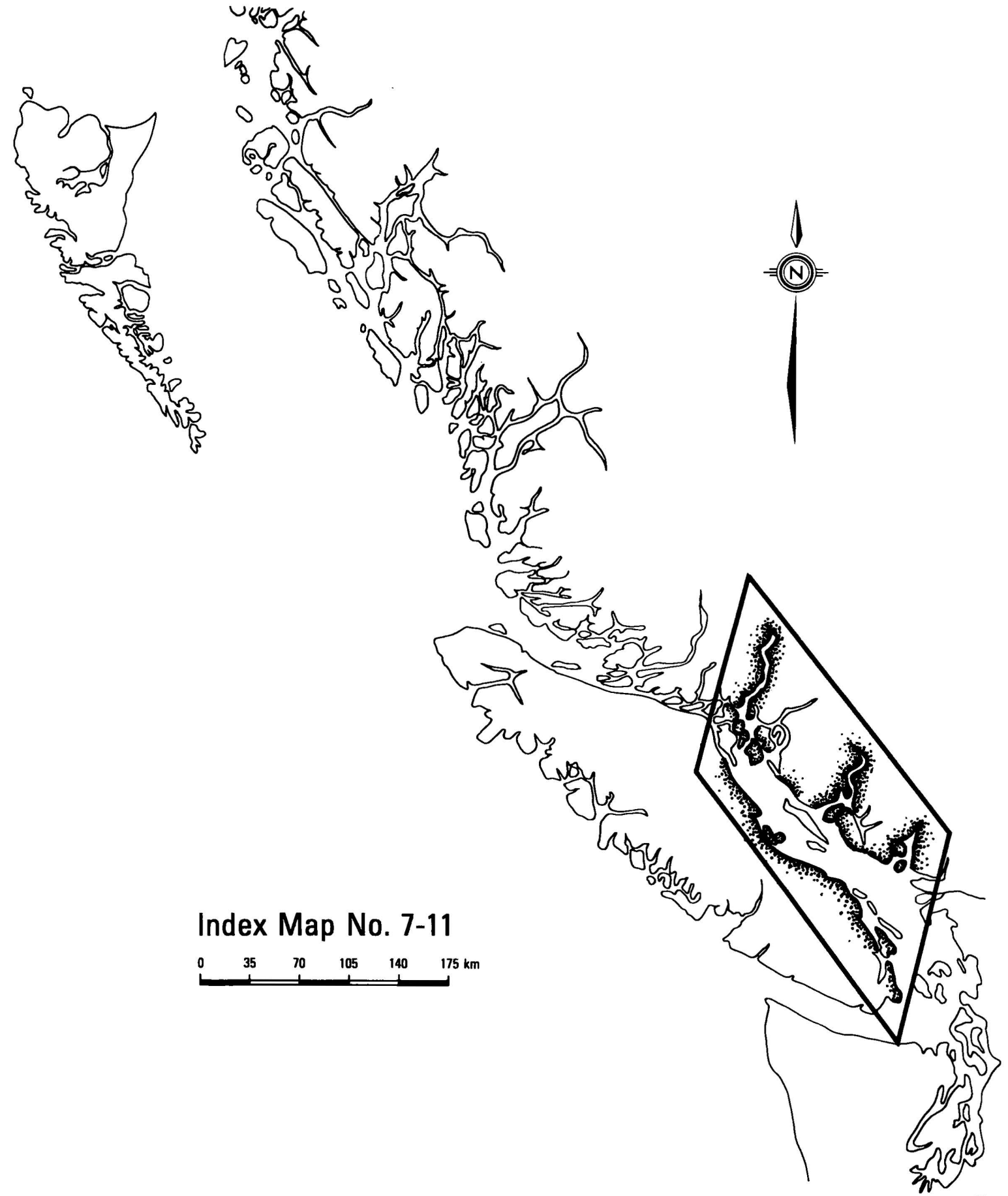


F 12,038 DUCKS
143 km
84 DUCKS/km

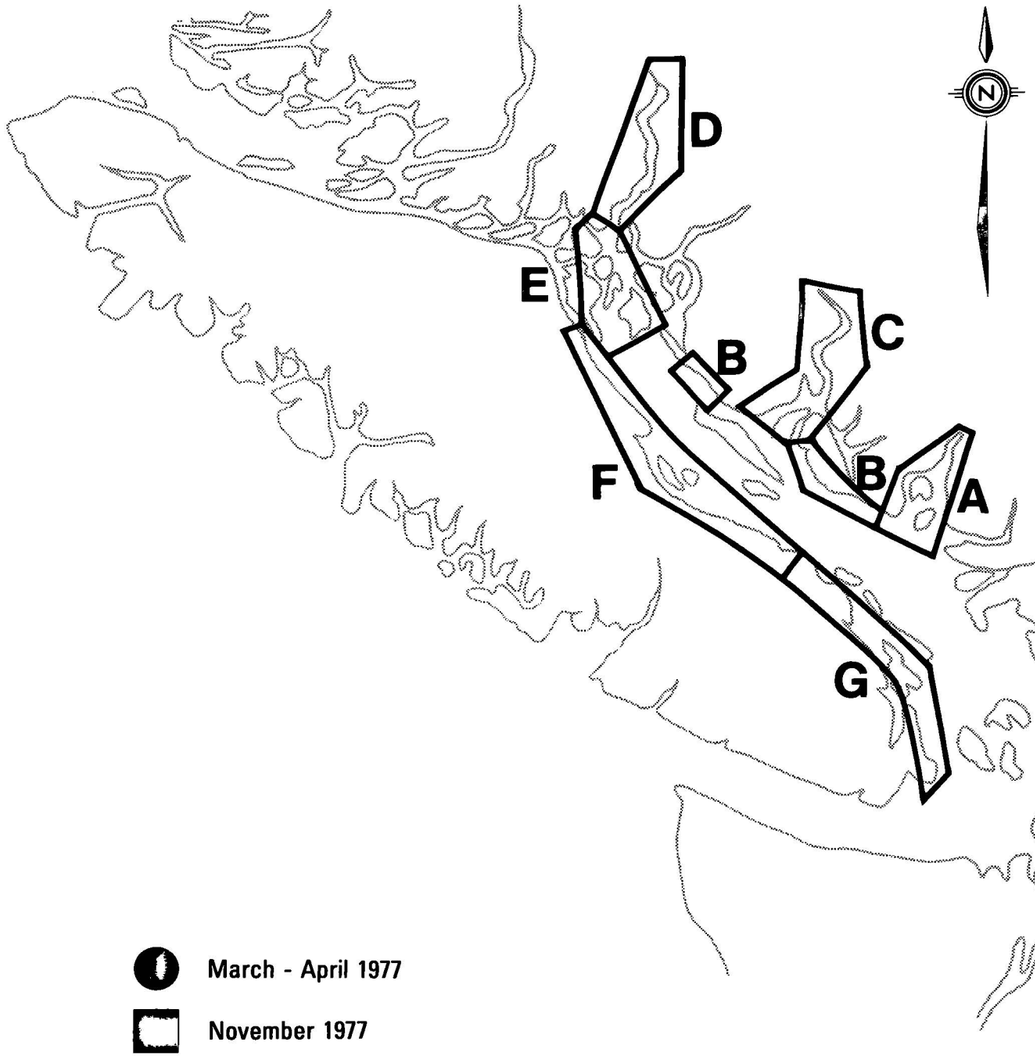


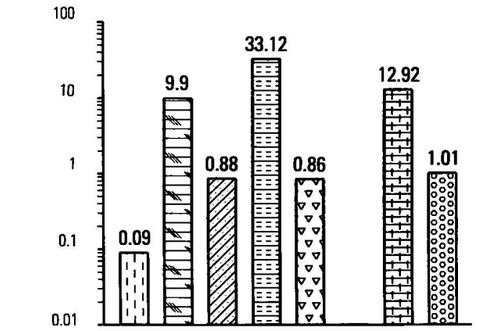
East Coast: Vancouver Island

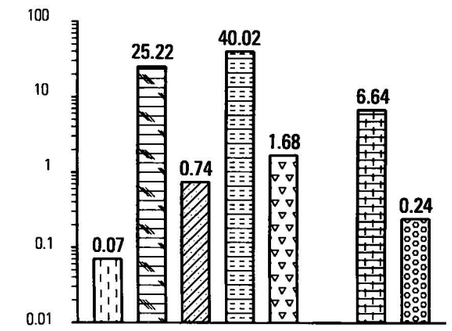
F 11,006 DUCKS
186 km
59 DUCKS/km


N
Index Map No. 7-11
0 35 70 105 140 175 km

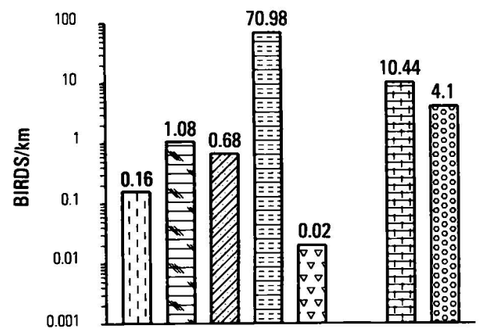
Map 7. Distribution and densities of birds along the shores of the Strait of Georgia and adjacent fjords as observed by boat, March – April and November 1977.

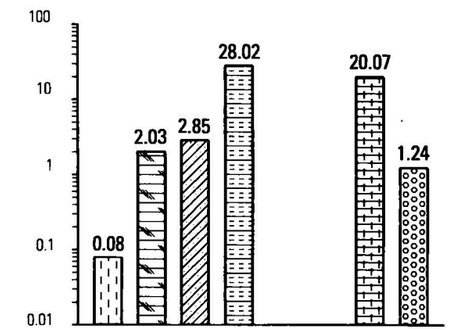




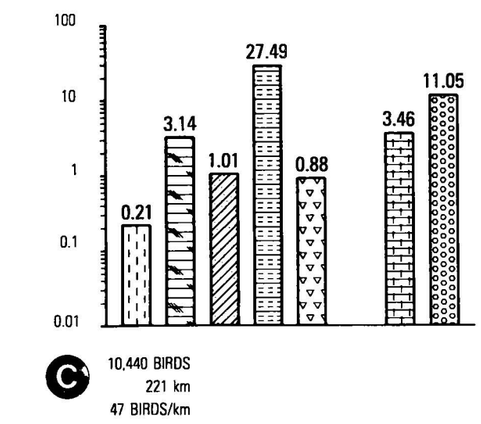


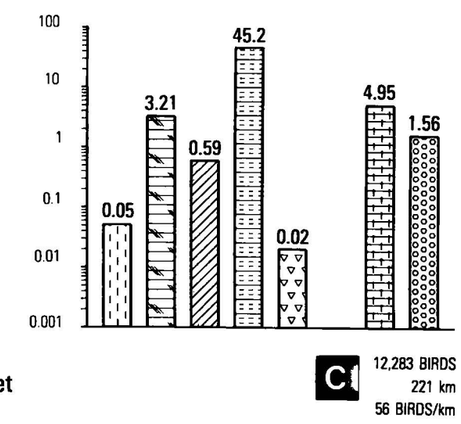
Howe Sound



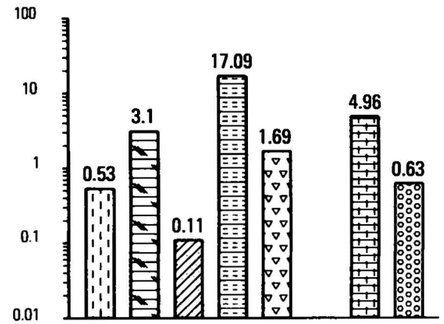


Mainland Coast

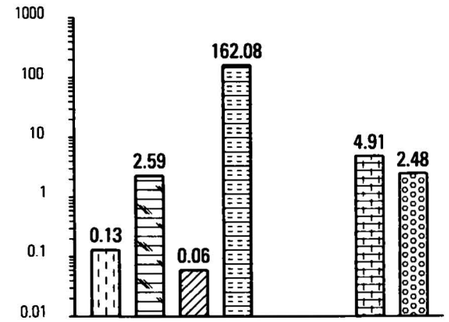




Jervis Inlet

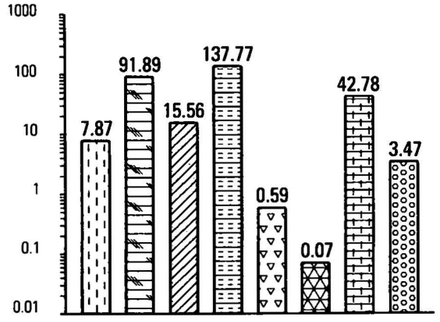


D 4,076 BIRDS
145 km
28 BIRDS/km

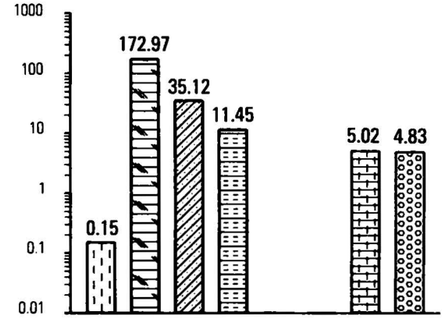


D 24,976 BIRDS
145 km
172 BIRDS/km

Bute Inlet

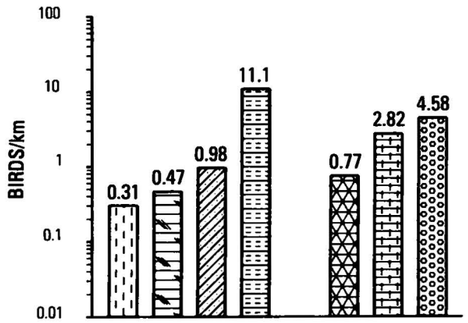


G 39,900 BIRDS
133 km
300 BIRDS/km

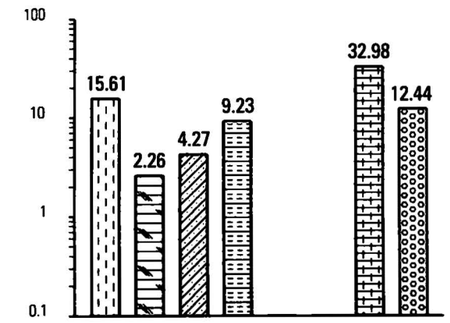


G 30,529 BIRDS
133 km
230 BIRDS/km

Victoria Neck Pt.

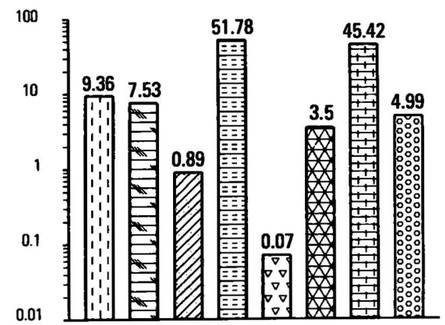


E 3,239 BIRDS
154 km
21 BIRDS/km

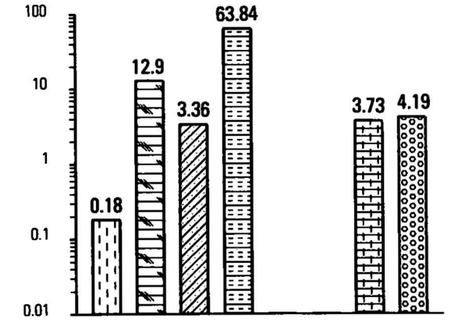


E 9,983 BIRDS
130 km
77 BIRDS/km

N. Georgia Strait

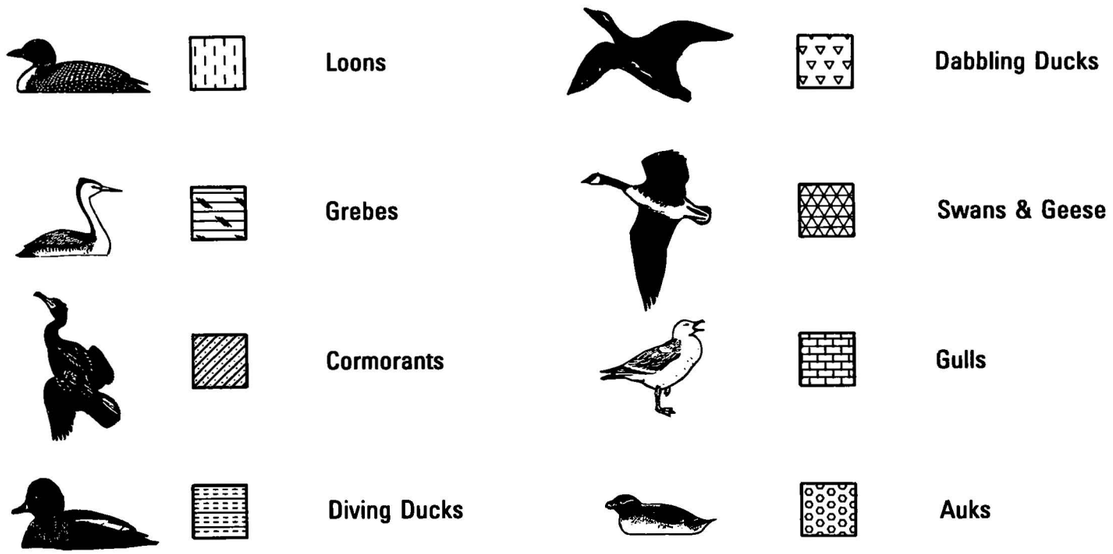


F 17,543 BIRDS
142 km
124 BIRDS/km

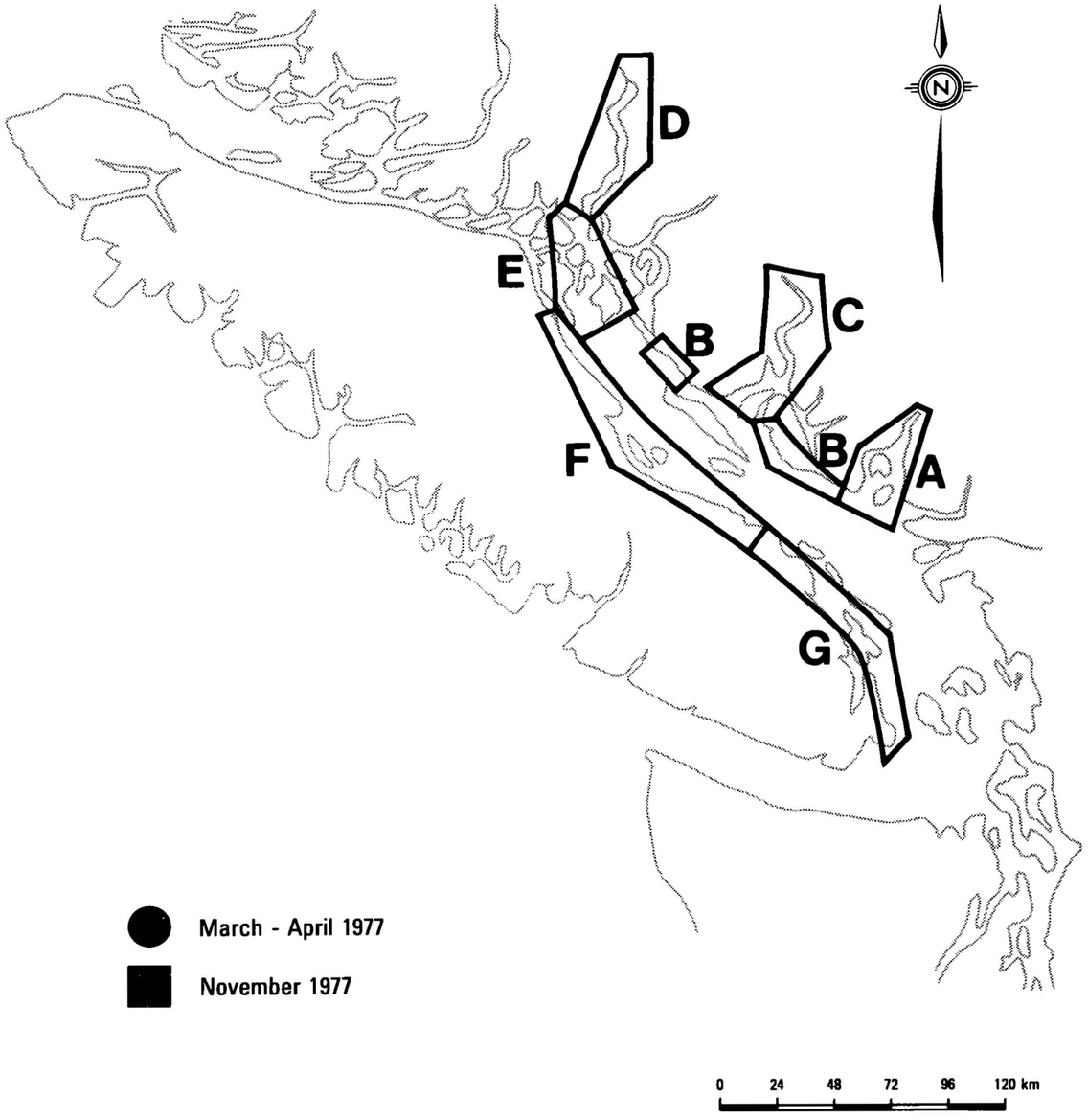


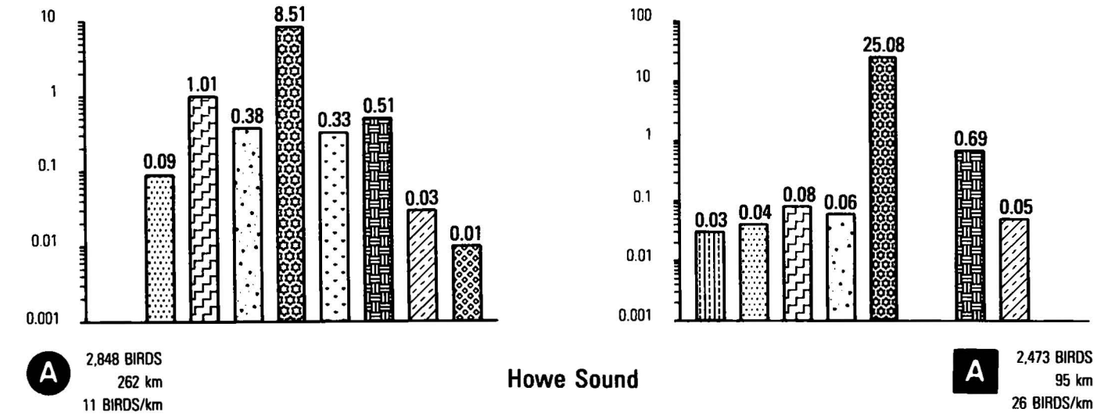
F 12,524 BIRDS
142 km
88 BIRDS/km

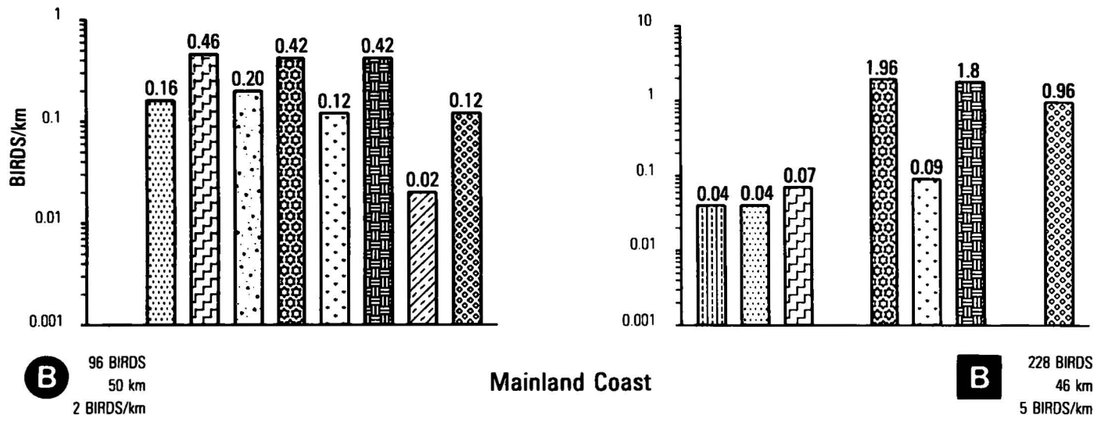
Neck Pt. Campbell R.

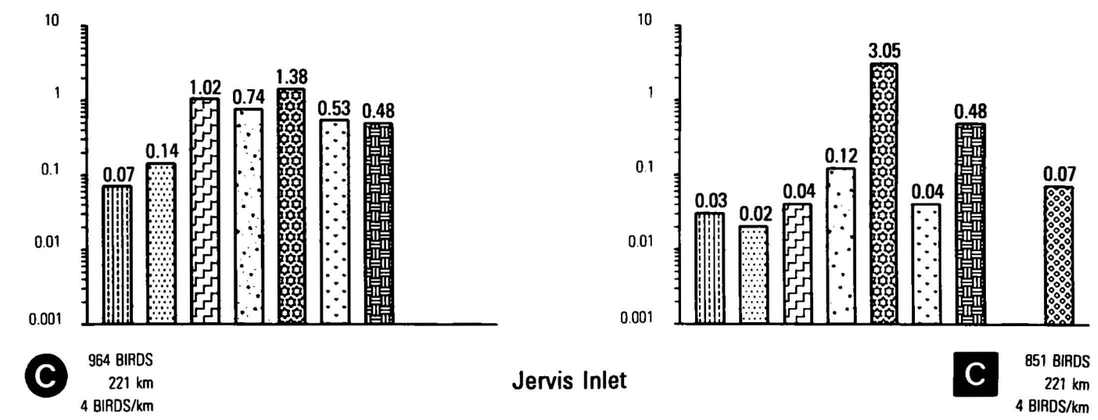


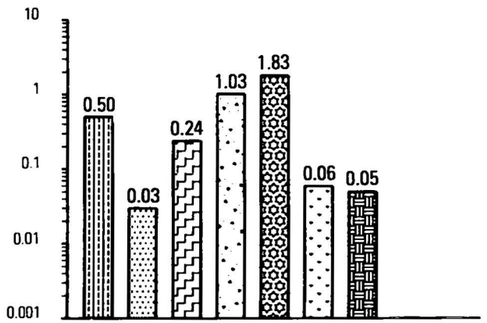
Map 8. Distribution and densities of loons, grebes and cormorants along the shores of the Strait of Georgia and adjacent fjords as observed by boat, March – April and November 1977.



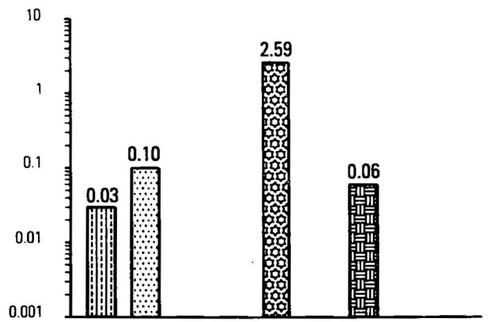






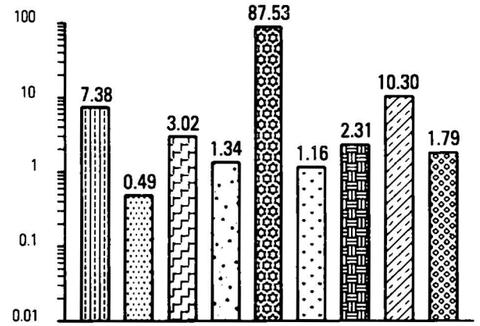


D 5,423 BIRDS
145 km
4 BIRDS/km

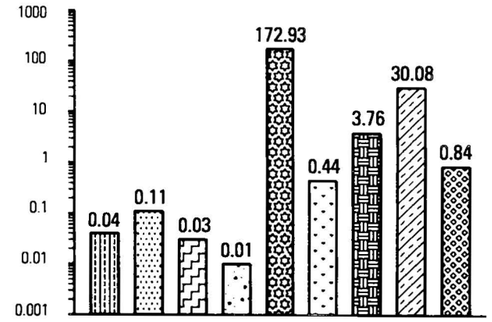


D 403 BIRDS
145 km
3 BIRDS/km

Bute Inlet

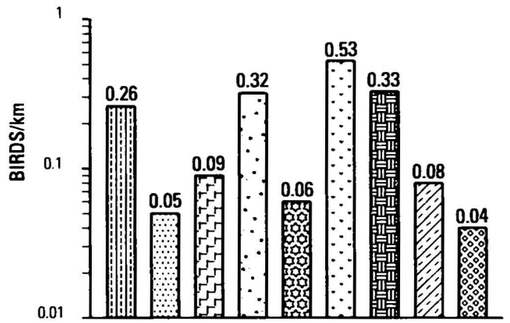


G 15,338 BIRDS
133 km
115 BIRDS/km

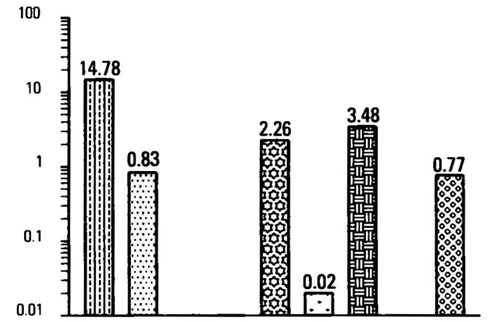


G 27,696 BIRDS
133 km
208 BIRDS/km

Victoria Neck Pt.

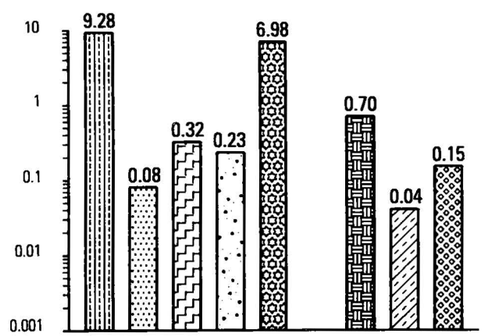


E 271 BIRDS
154 km
2 BIRDS/km

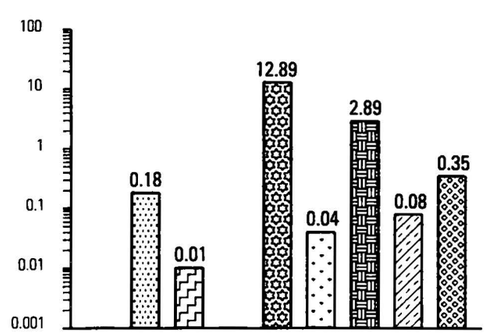


E 2,878 BIRDS
130 km
22 BIRDS/km

N. Georgia Strait



F 2,525 BIRDS
142 km
18 BIRDS/km



F 2,334 BIRDS
142 km
16 BIRDS/km

Neck Pt. Campbell R.

Arctic Loon

Other &
Unidentified Loons

Red-necked
Grebe

Horned Grebe

Unidentified
Cormorants

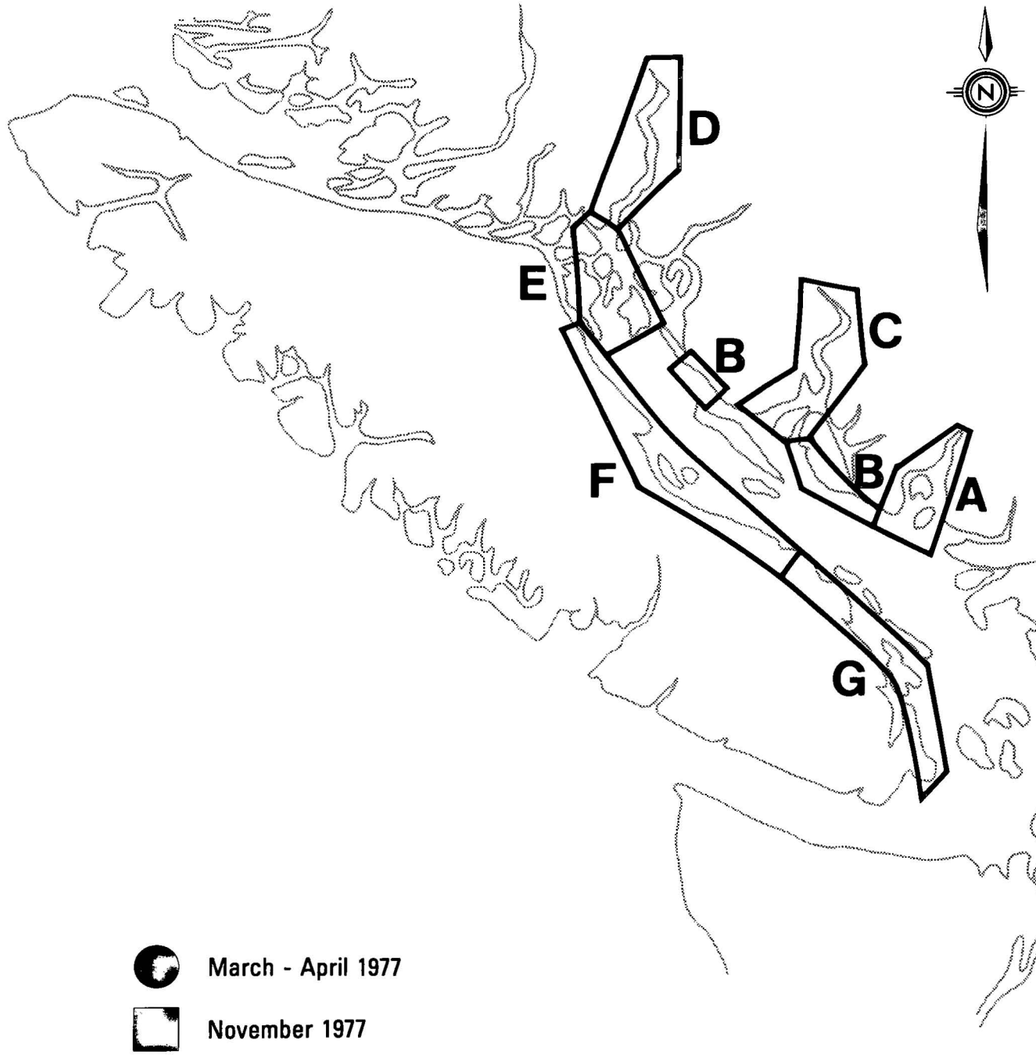
Western Grebe

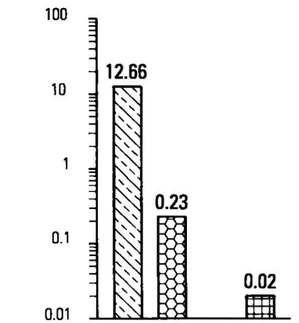
Double-crested
Cormorant

Pelagic
Cormorant

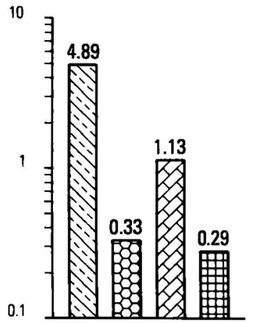
Brandt's
Cormorant

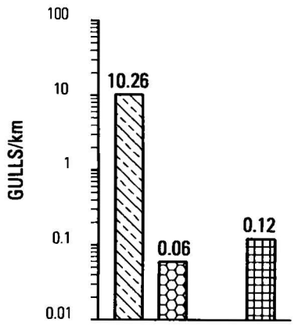
Map 9. Distribution and densities of gulls along the shores of the Strait of Georgia and adjacent fjords as observed by boat, March – April and November 1977.



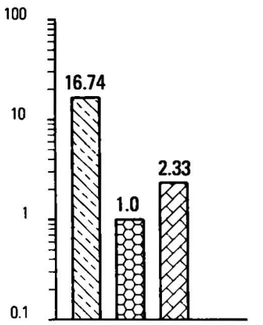


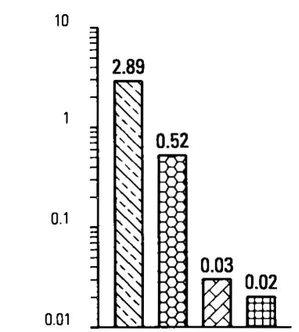
Howe Sound



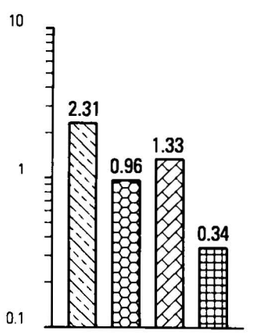


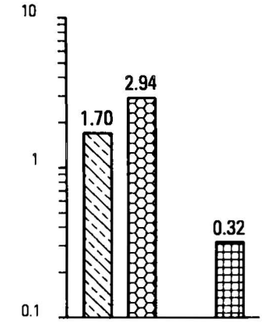
Mainland Coast



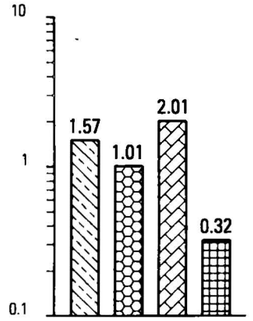


Jervis Inlet



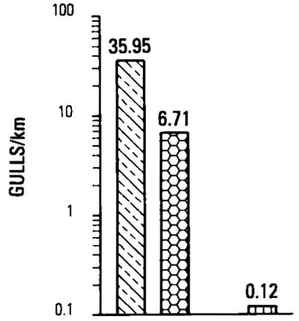


D 719 GULLS
145 km
5 GULLS/km

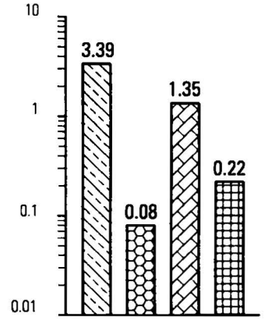


D 712 GULLS
145 km
5 GULLS/km

Bute Inlet

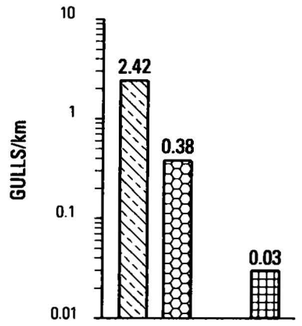


G 5,690 GULLS
133 km
43 GULLS/km

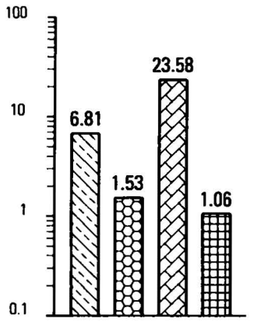


G 670 GULLS
133 km
5 GULLS/km

Victoria Neck Pt.

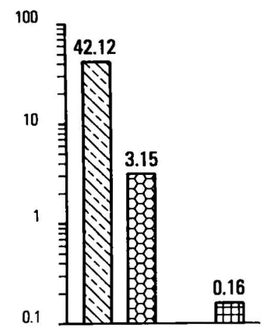


E 436 GULLS
154 km
3 GULLS/km

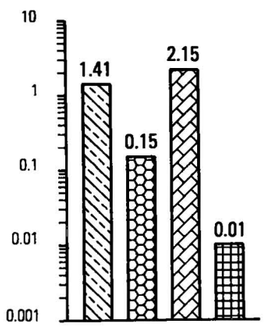


E 429 GULLS
130 km
33 GULLS/km

N. Georgia Strait



F 6,451 GULLS
142 km
45 GULLS/km



F 528 GULLS
142 km
4 GULLS/km

Neck Pt. Campbell R.

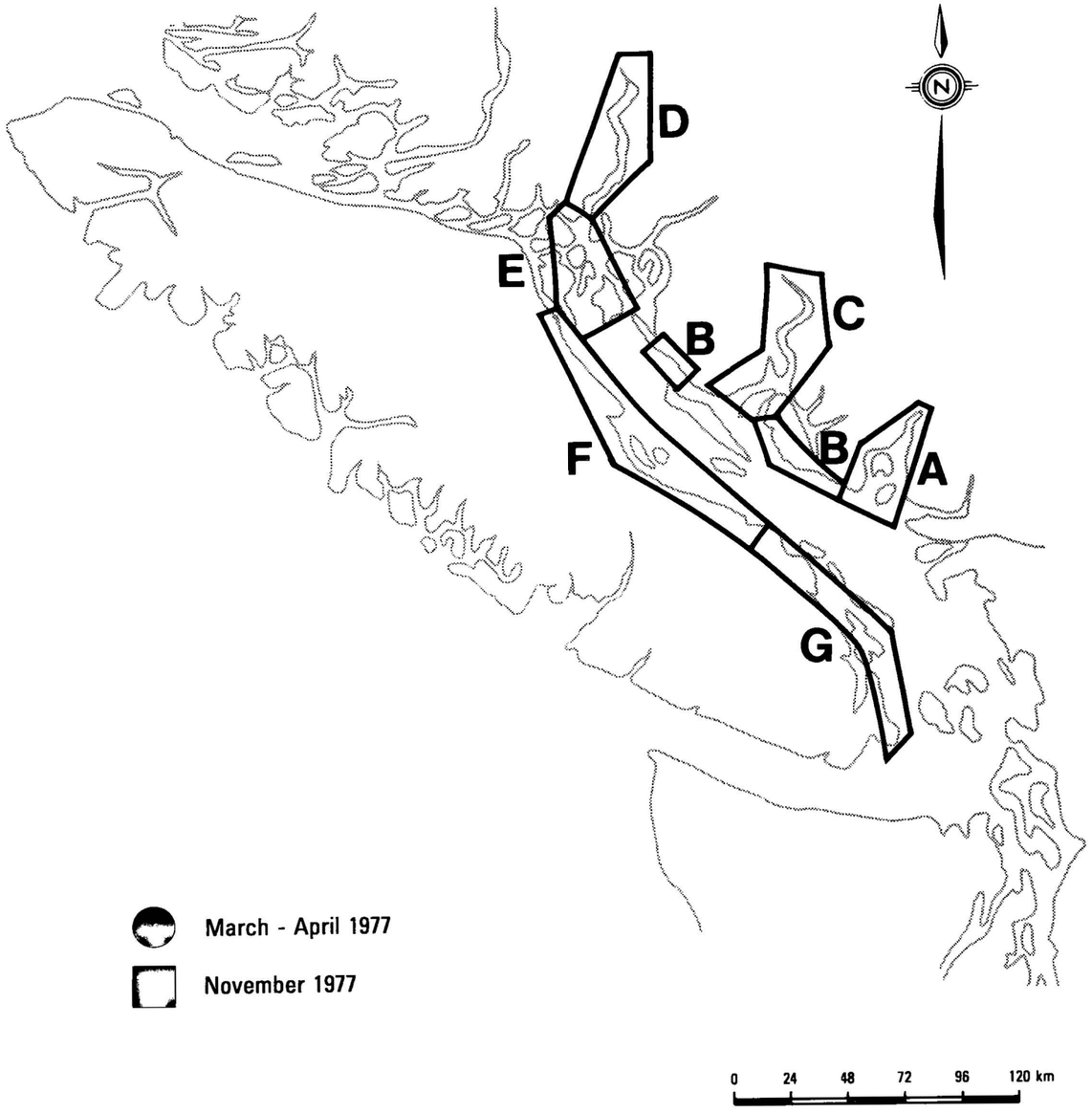
Glaucous- winged Gull

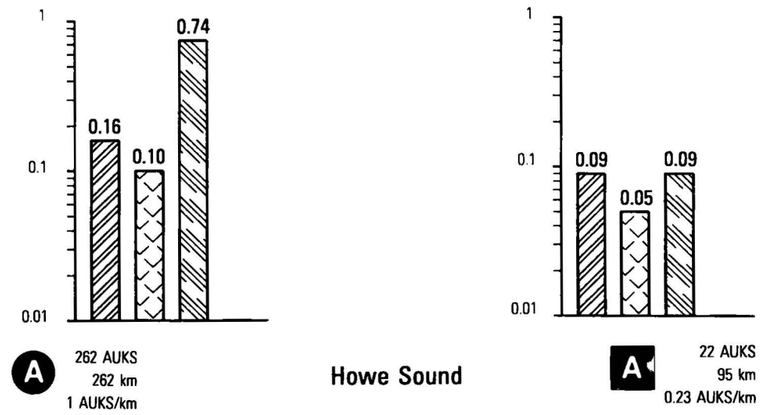
Mew Gull

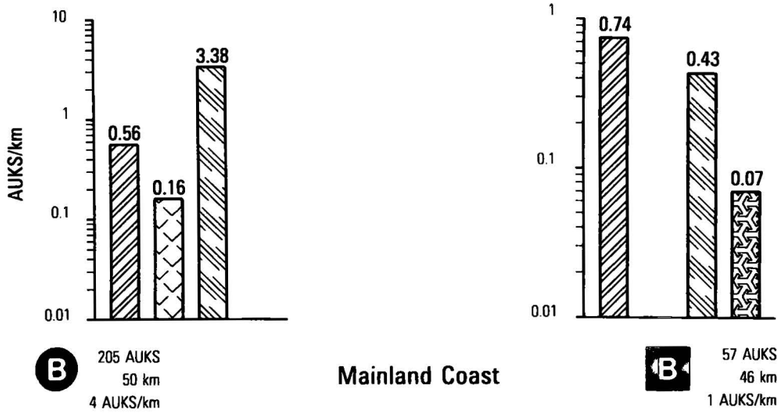
Bonaparte's Gull

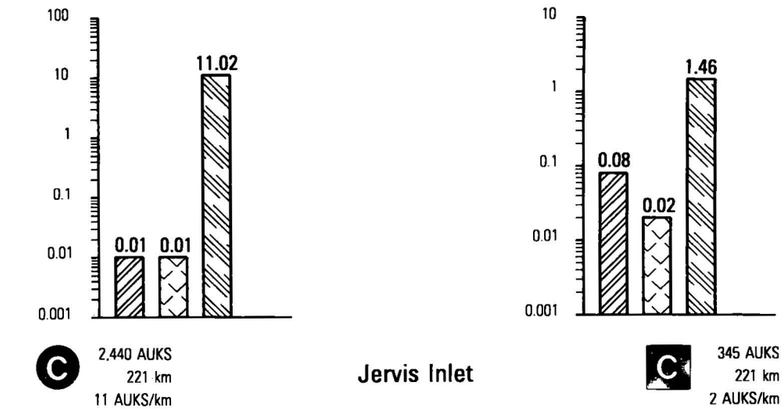
Other &
Unidentified
Gulls

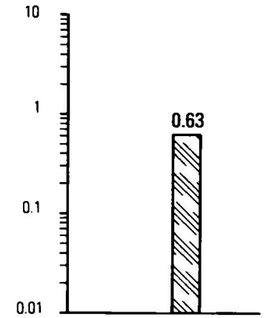
Map 10. Distribution and densities of auks along the shores of the Strait of Georgia and adjacent fjords as observed by boat, March – April and November 1977.



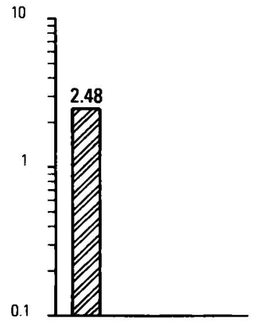






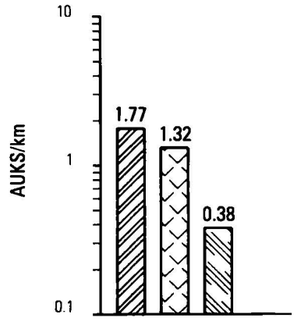


D 91 AUKS
145 km
0.63 AUKS/km

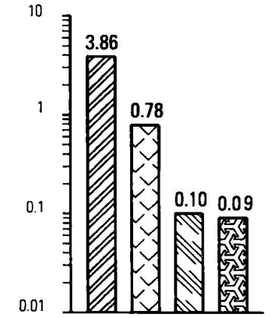


D 360 AUKS
145 km
2 AUKS/km

Bute Inlet

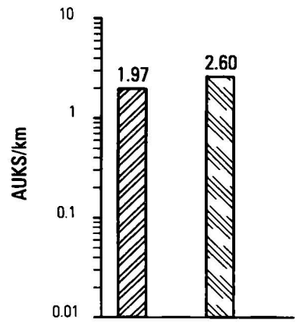


G 461 AUKS
133 km
3 AUKS/km

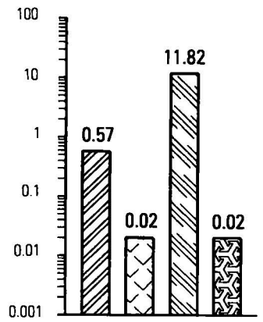


G 642 AUKS
133 km
5 AUKS/km

Victoria Neck Pt.

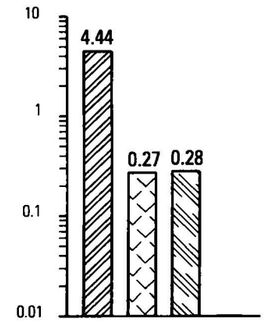


E 704 AUKS
154 km
5 AUKS/km

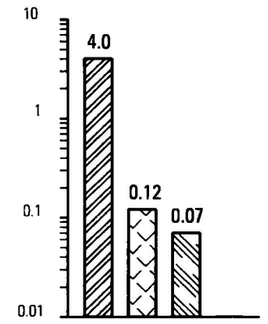


E 1,616 AUKS
130 km
12 AUKS/km

N. Georgia Strait



F 709 AUKS
142 km
5 AUKS/km



F 595 AUKS
142 km
4 AUKS/km

Neck Pt. Campbell R.

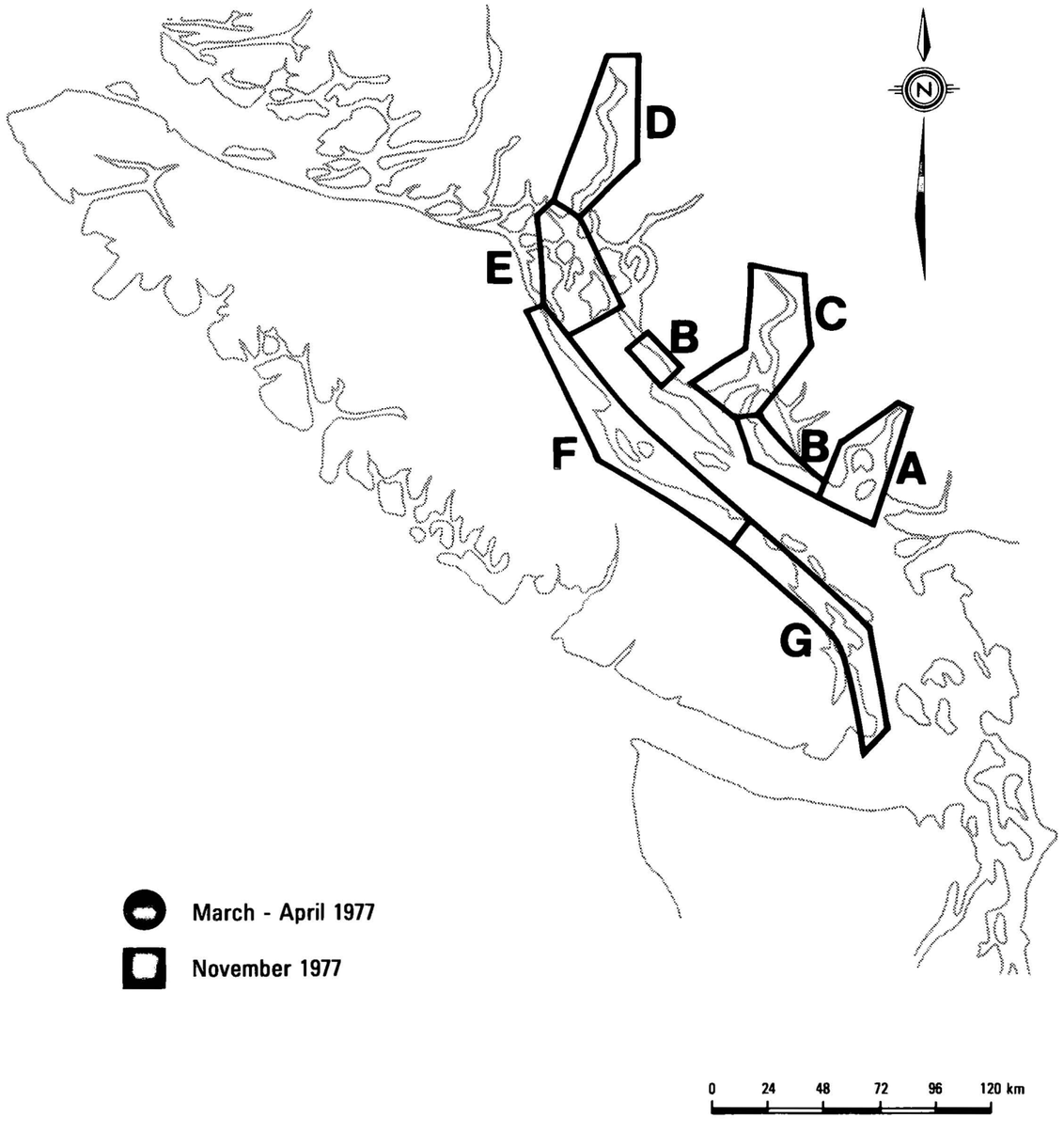
Common Murre

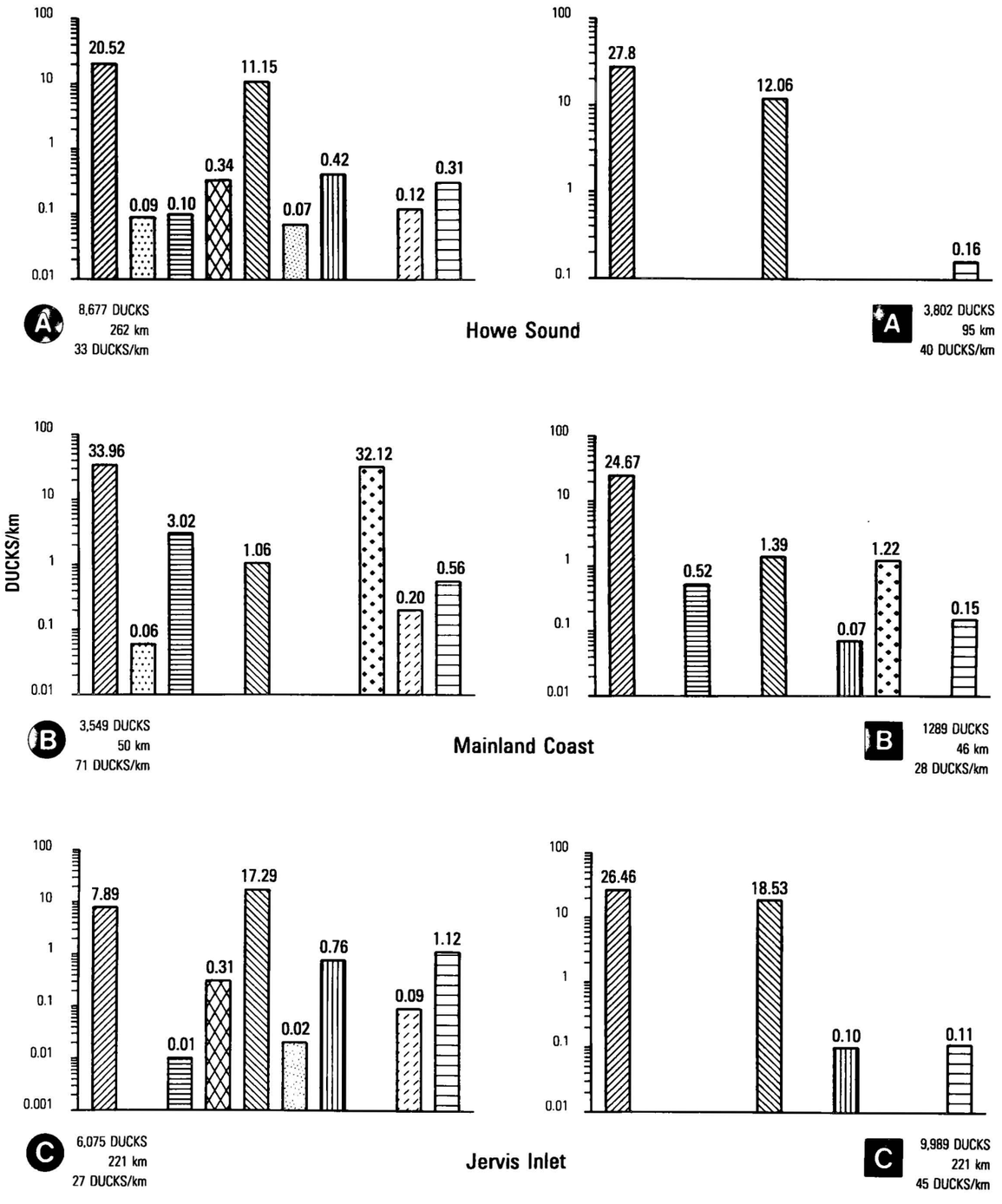
Pigeon Guillemot

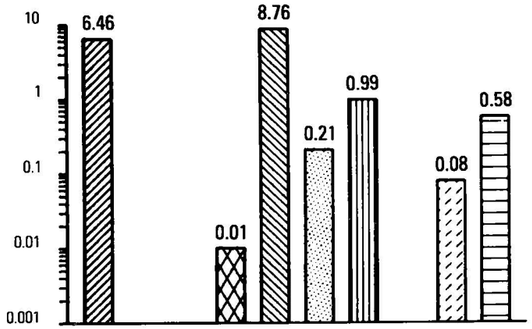
Marbled Murrelet

Rhinoceros Auklet

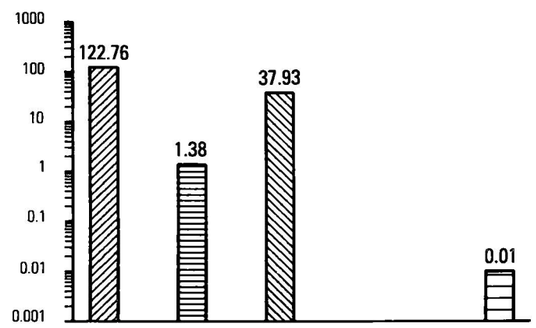
Map 11. Distribution and densities of diving ducks along the shores of the Strait of Georgia and adjacent fjords as observed by boat, March – April and November 1977.





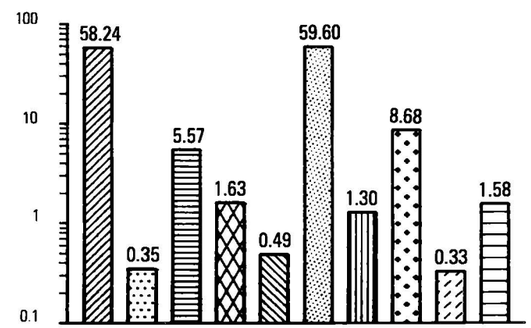


D 2,478 DUCKS
145 km
17 DUCKS/km

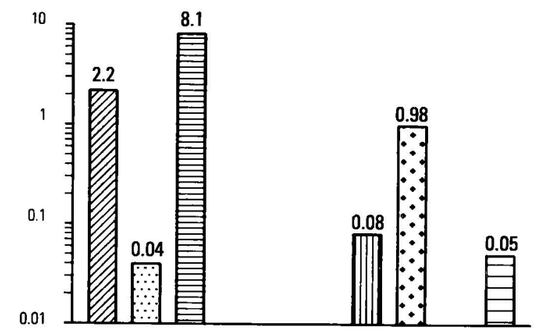


D 23,501 DUCKS
145 km
162 DUCKS/km

Bute Inlet

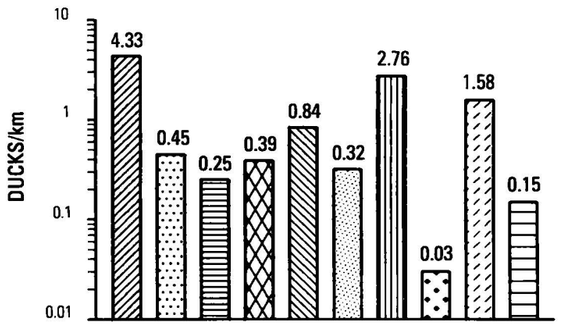


G 18,323 DUCKS
133 km
138 DUCKS/km

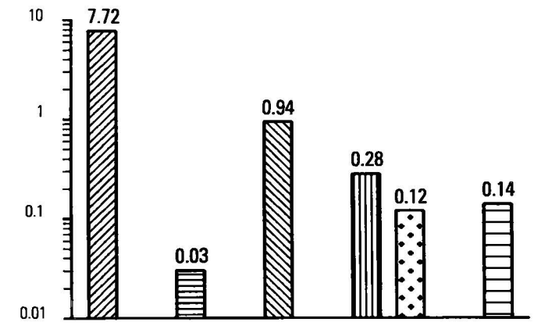


G 1,523 DUCKS
133 km
11 DUCKS/km

Victoria Neck Pt.

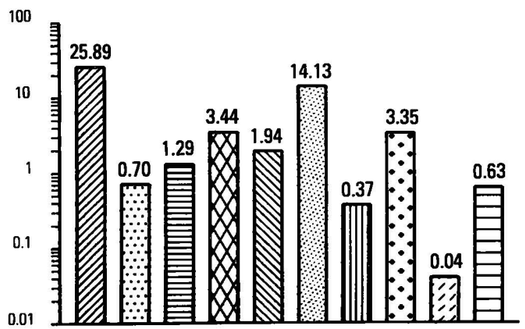


E 1709 DUCKS
154 km
11 DUCKS/km

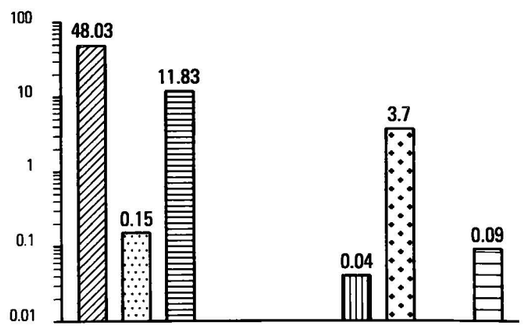


E 1,200 DUCKS
130 km
9 DUCKS/km

N. Georgia Strait



F 7,353 DUCKS
142 km
52 DUCKS/km



F 9,065 DUCKS
142 km
64 DUCKS/km

Neck Pt. Campbell R.

Surf Scoter

Scaup

Black Scoter

Bufflehead

White- winged Scoter

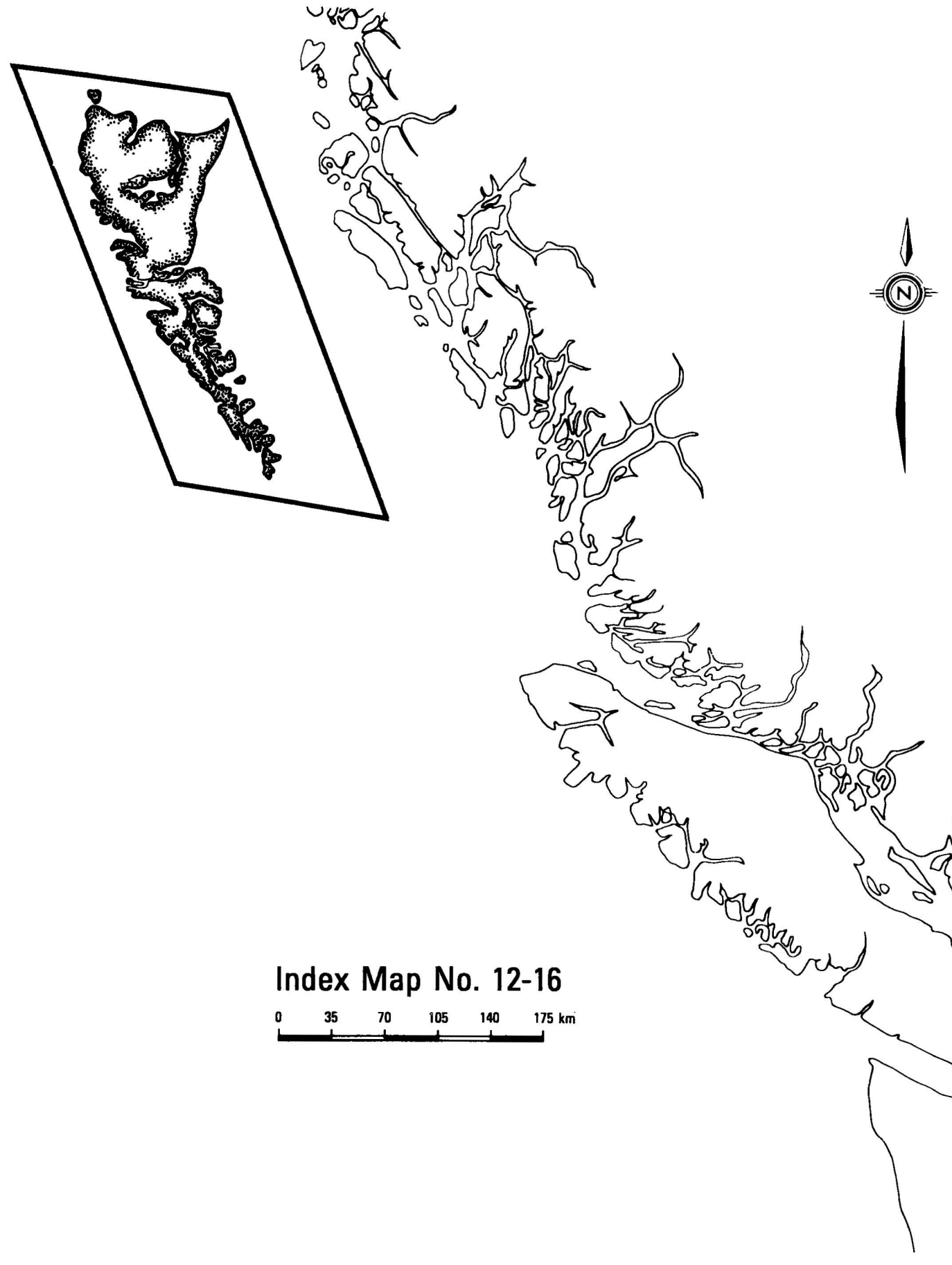
Oldsquaw

Common Goldeneye

Harlequin

Barrow's Goldeneye

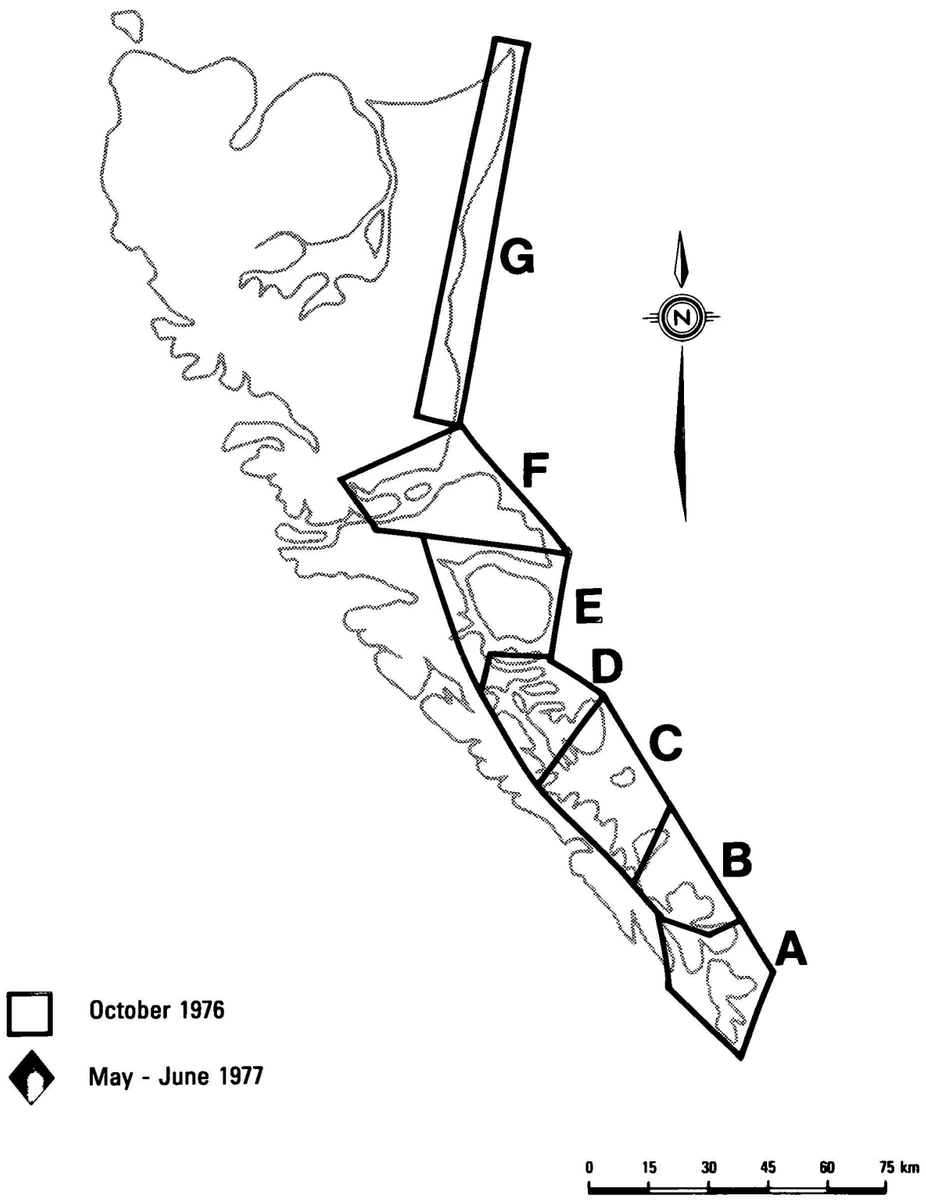
Mergansers

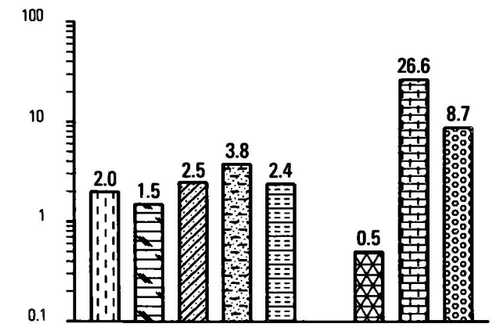


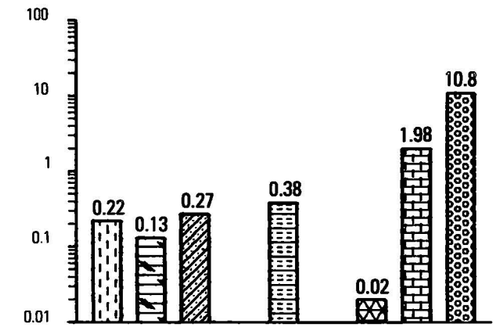
Index Map No. 12-16

0 35 70 105 140 175 km

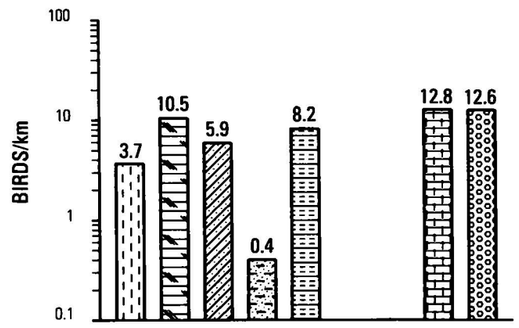
Map 12A. Distribution and densities of birds along the Queen Charlotte Island coast as observed by boat, October 1976 and May – June 1977.

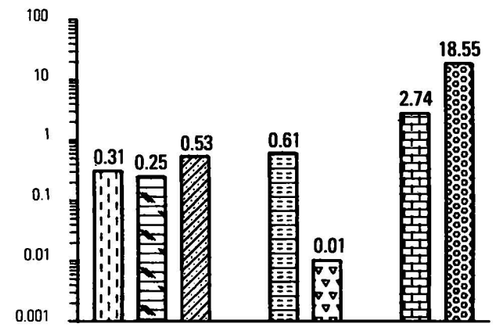




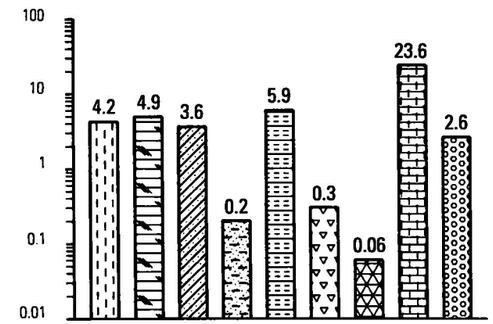


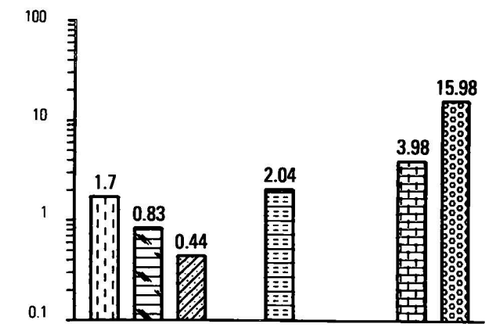
Houston Stewart Channel



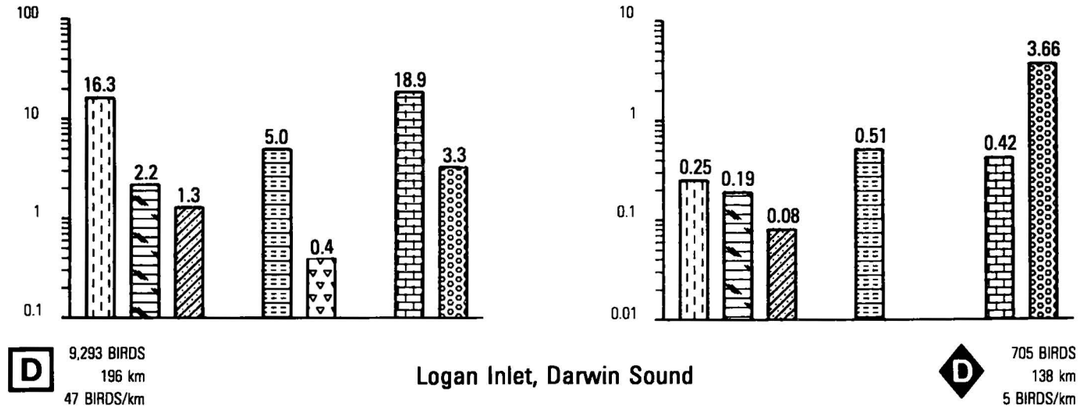


Skincuttle Inlet





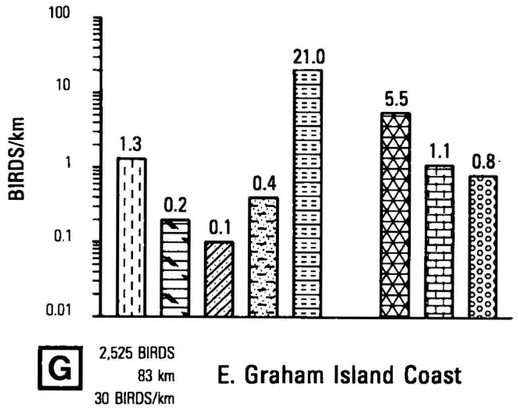
Juan Perez Sound



D 9,293 BIRDS 196 km 47 BIRDS/km

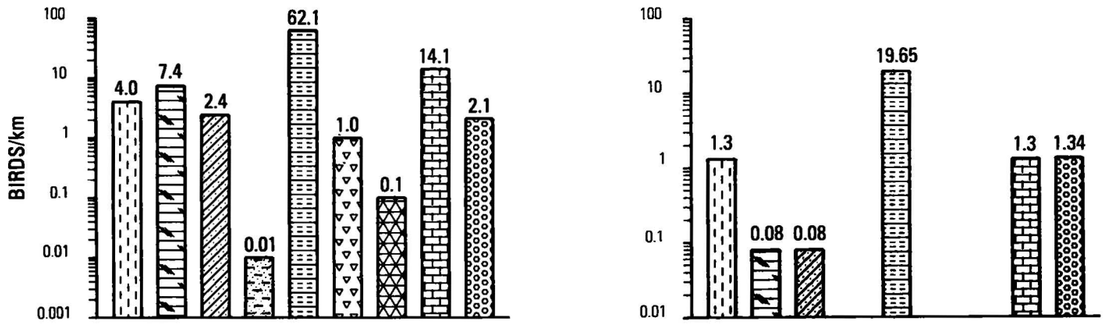
Logan Inlet, Darwin Sound

D 705 BIRDS 138 km 5 BIRDS/km



G 2,525 BIRDS 83 km 30 BIRDS/km

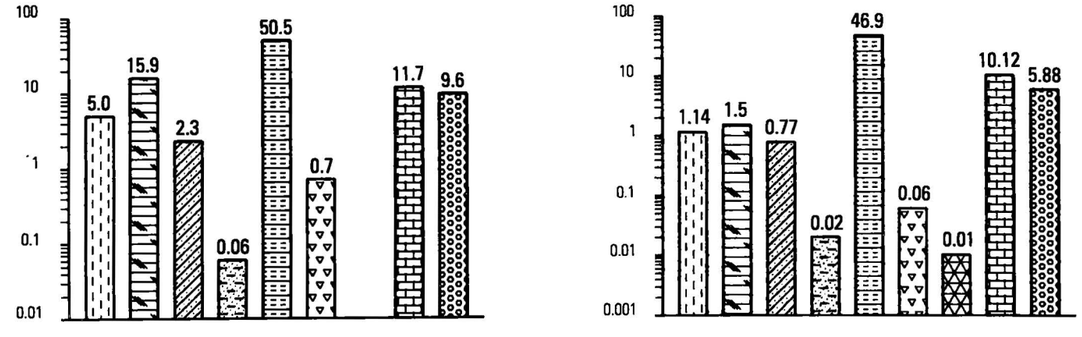
E. Graham Island Coast



E 19,005 BIRDS 204 km 93 BIRDS/km

Cumshewa Inlet, Selwyn Inlet

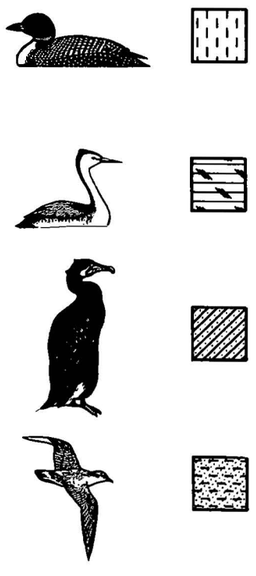
E 2,118 BIRDS 89 km 24 BIRDS/km



F 15,233 BIRDS 159 km 96 BIRDS/km

Skidegate Inlet

F 7,636 BIRDS 115 km 66 BIRDS/km



Loons

Grebes

Cormorants

Shearwaters

Diving Ducks

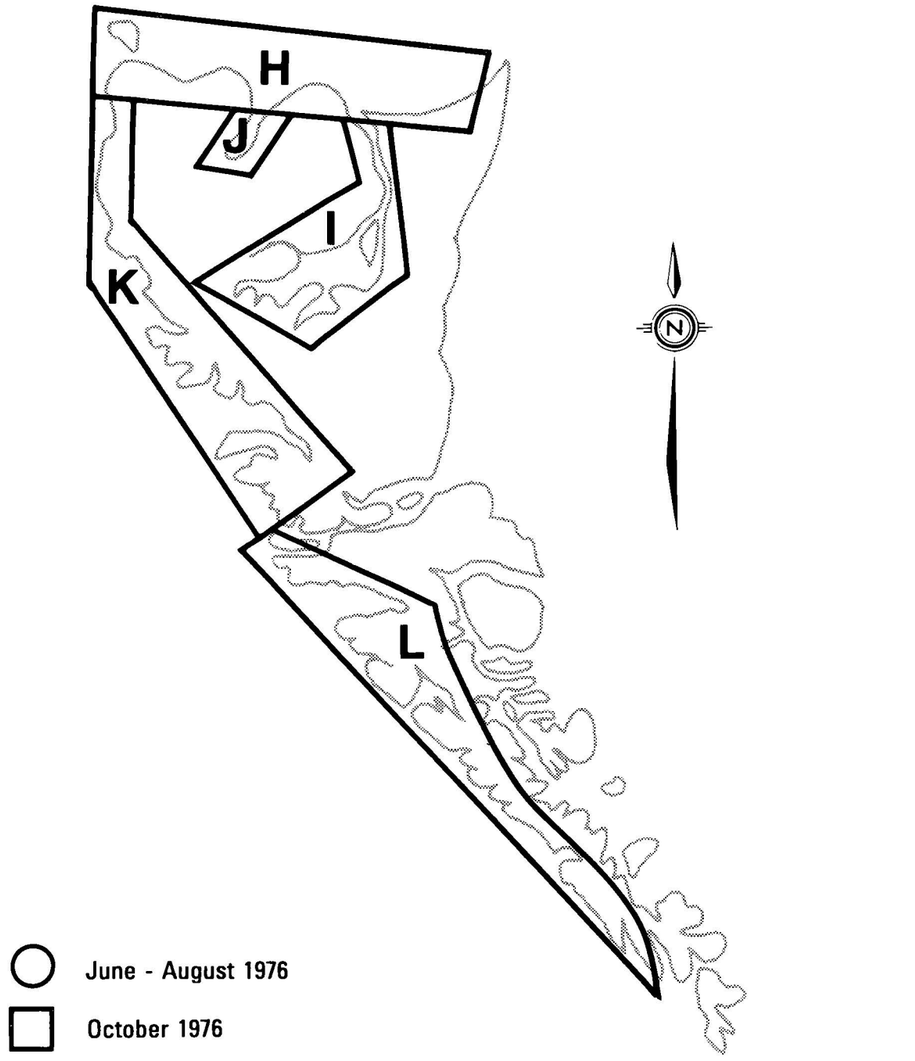
Dabbling Ducks

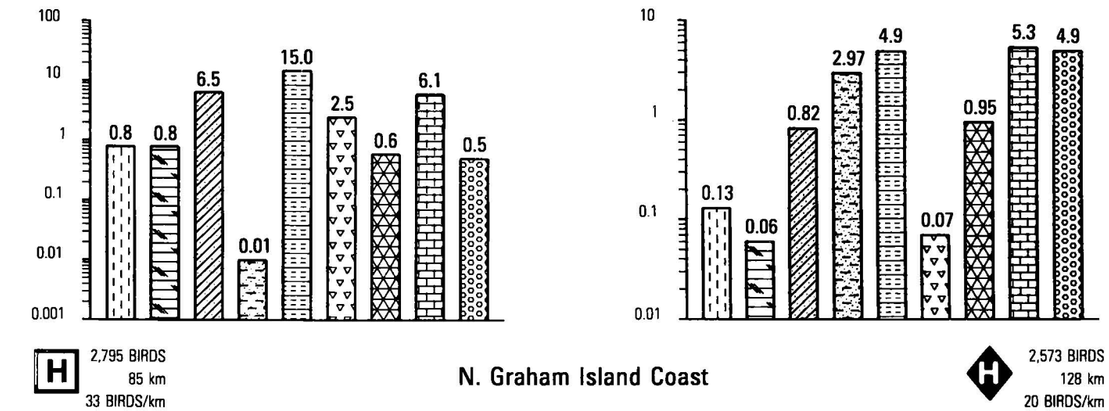
Swans & Geese

Gulls

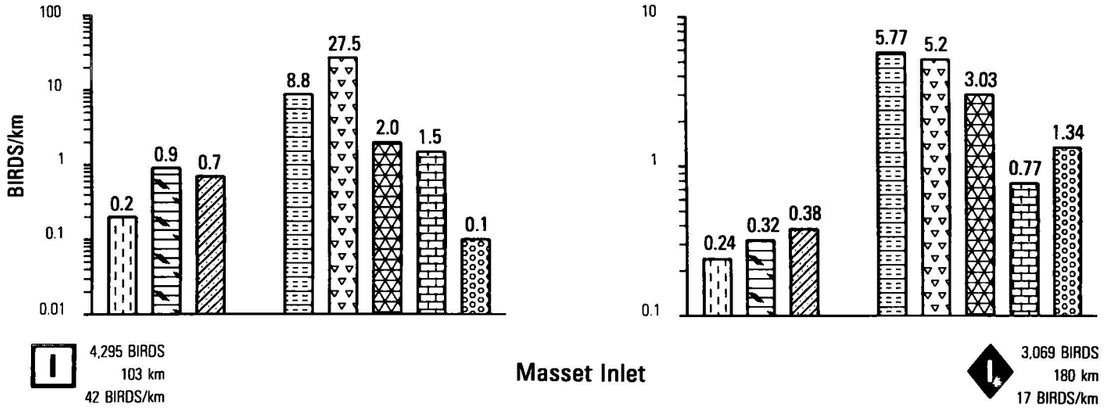
Auks

Map 12B. Distribution and densities of birds along the Queen Charlotte Island coast as observed by boat, June – August 1976, October 1976 and May – June 1977.

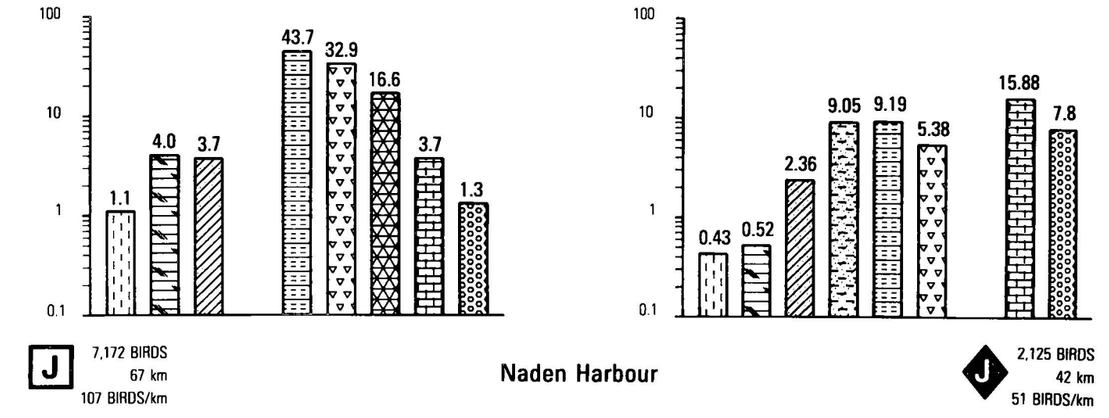




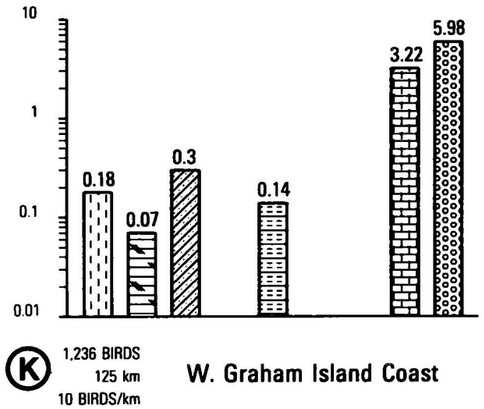
N. Graham Island Coast



Masset Inlet

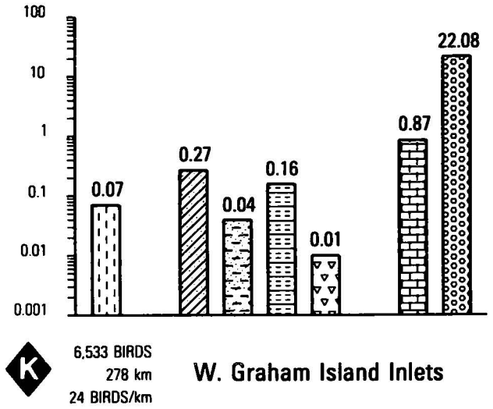


Naden Harbour



K 1,236 BIRDS
125 km
10 BIRDS/km

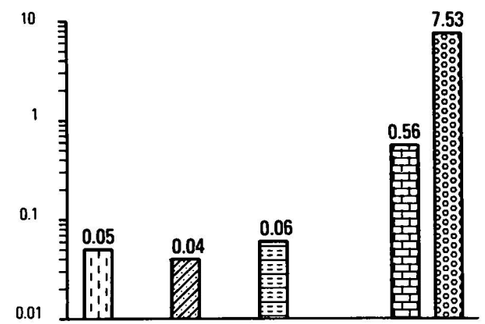
W. Graham Island Coast



K 6,533 BIRDS
278 km
24 BIRDS/km

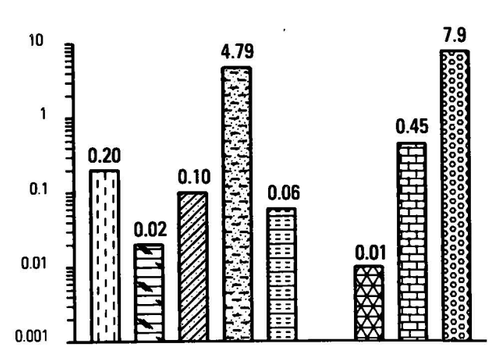
W. Graham Island Inlets

BIRDS/km



L 1,112 BIRDS
135 km
8 BIRDS/km

W. Moresby Island Coast



L 2,192 BIRDS
162 km
14 BIRDS/km

W. Moresby Island Inlets

Loons

Grebes

Cormorants

Shearwaters

Auks

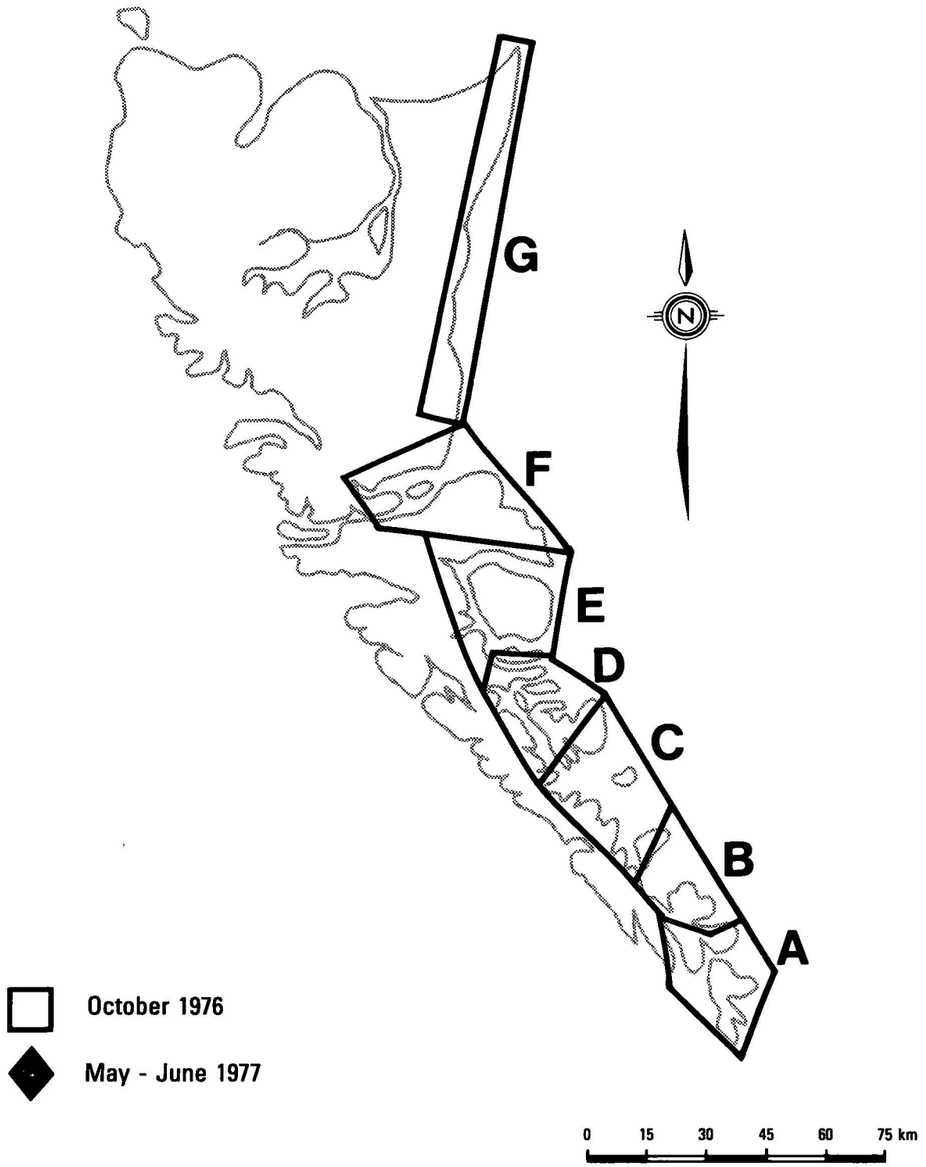
Diving Ducks

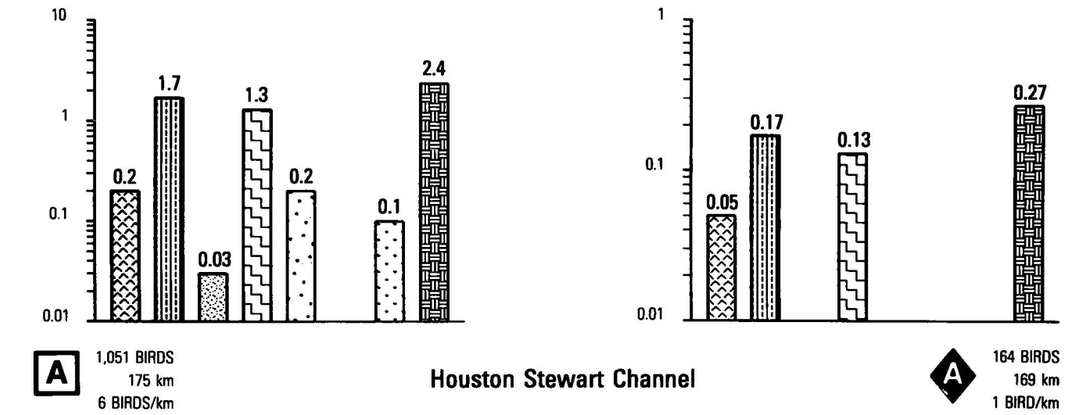
Dabbling Ducks

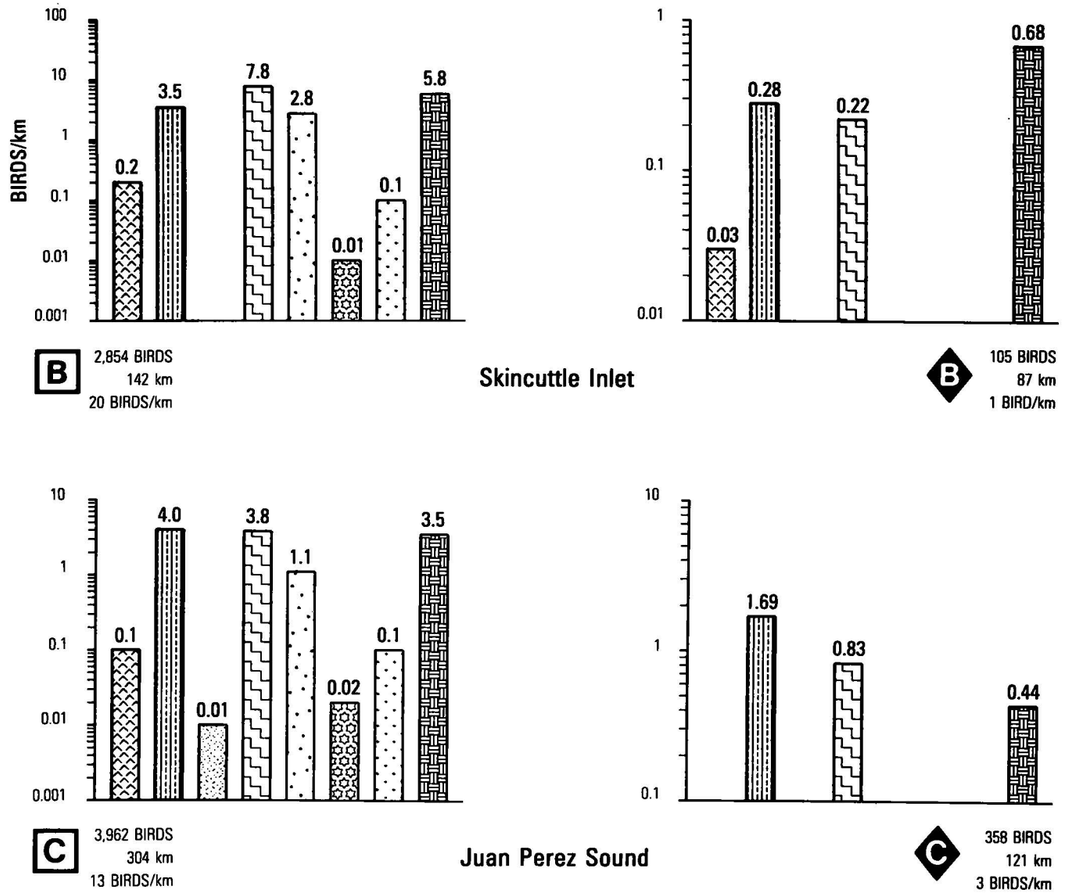
Swans & Geese

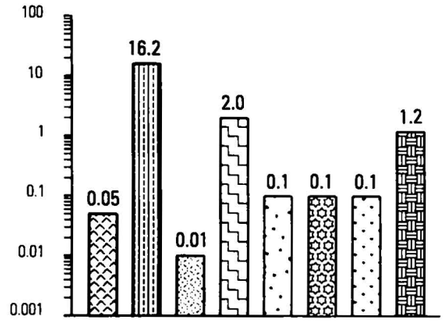
Gulls

Map 13A. Distribution and densities of loons, grebes and cormorants along the Queen Charlotte Island coast as observed by boat, June – August 1976, October 1976 and May – June 1977.

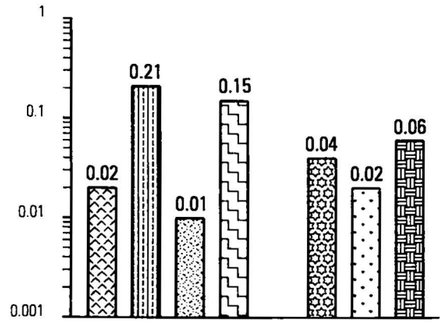






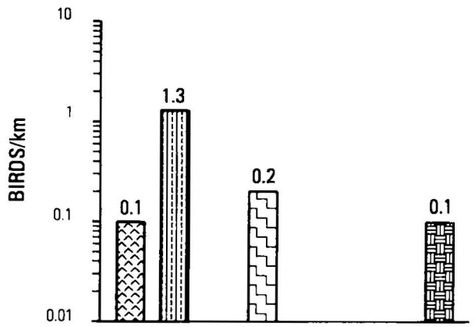


D 3,881 BIRDS
196 km
20 BIRDS/km



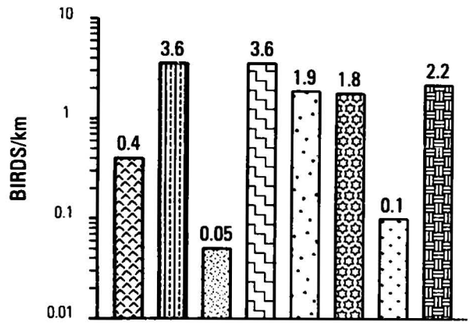
D 70 BIRDS
138 km
0.51 BIRDS/km

Logan Inlet, Darwin Sound

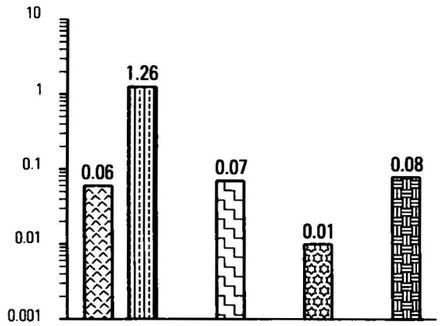


G 133 BIRDS
67 km
2 BIRDS/km

E. Graham Island Coast

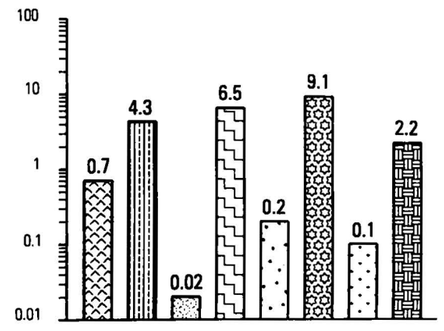


E 2,816 BIRDS
204 km
14 BIRDS/km

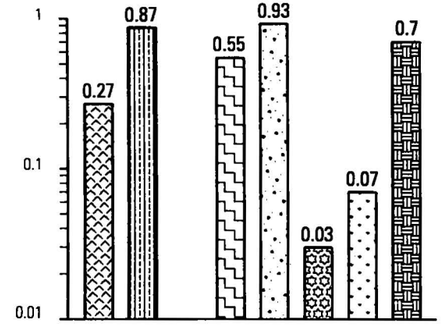


E 132 BIRDS
89 km
1 BIRD/km

Cumshewa Inlet, Selwyn Inlet



F 3,689 BIRDS
159 km
23 BIRDS/km



F 393 BIRDS
115 km
3 BIRDS/km

Skidegate Inlet

Common Loon

Horned Grebe

Arctic Loon

Western Grebe

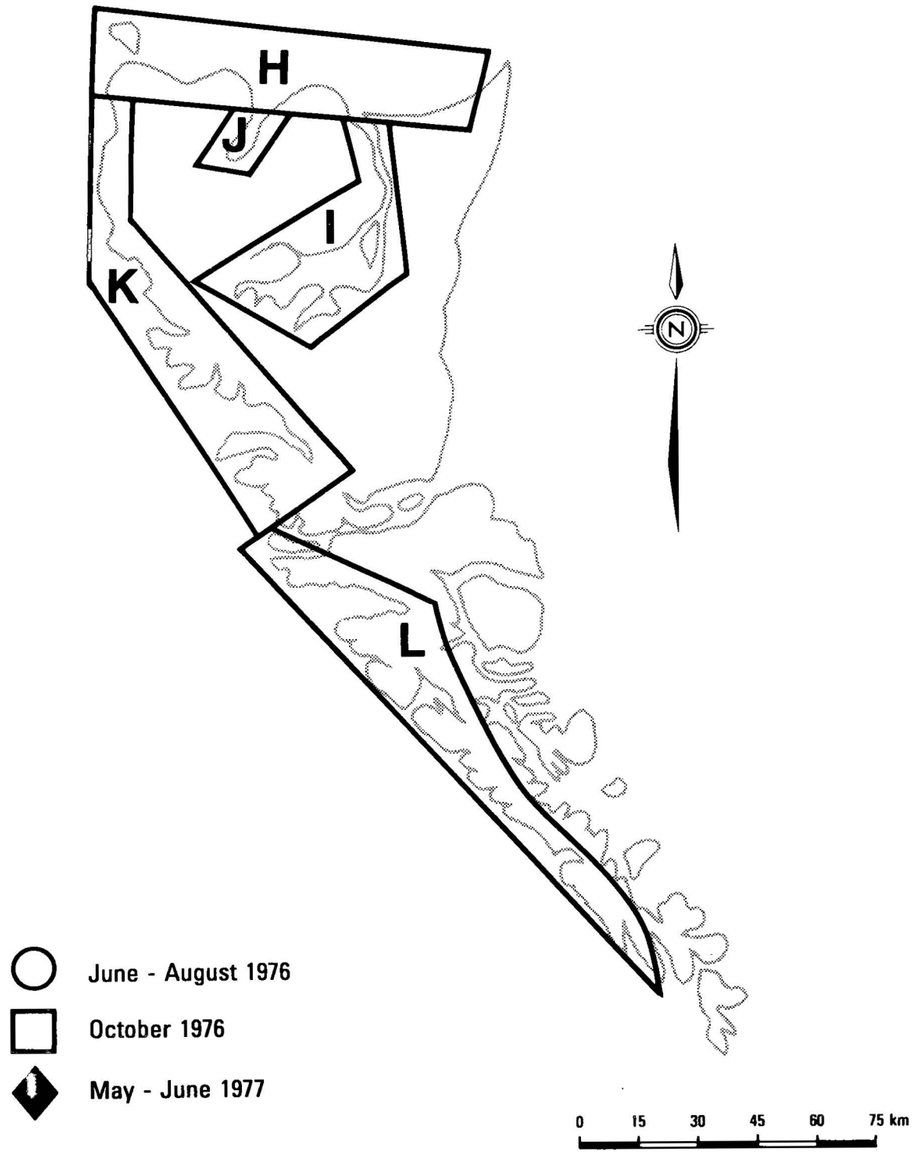
Red-throated Loon

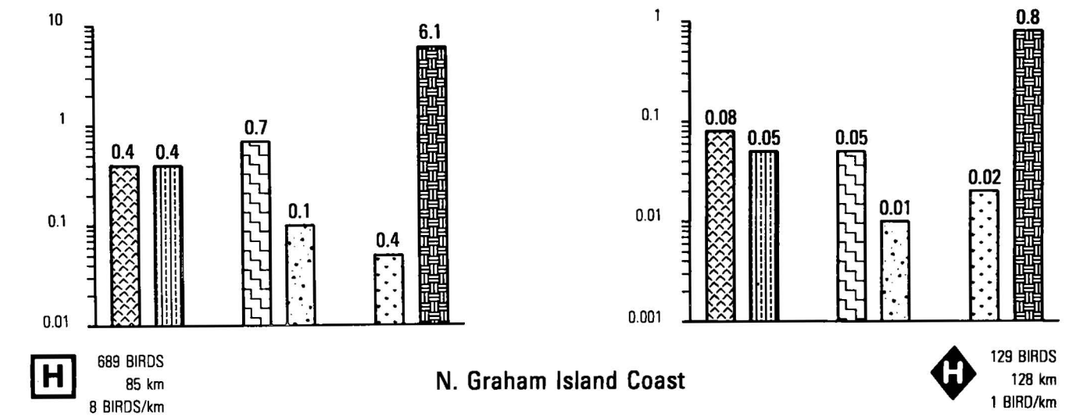
Double-crested Cormorant

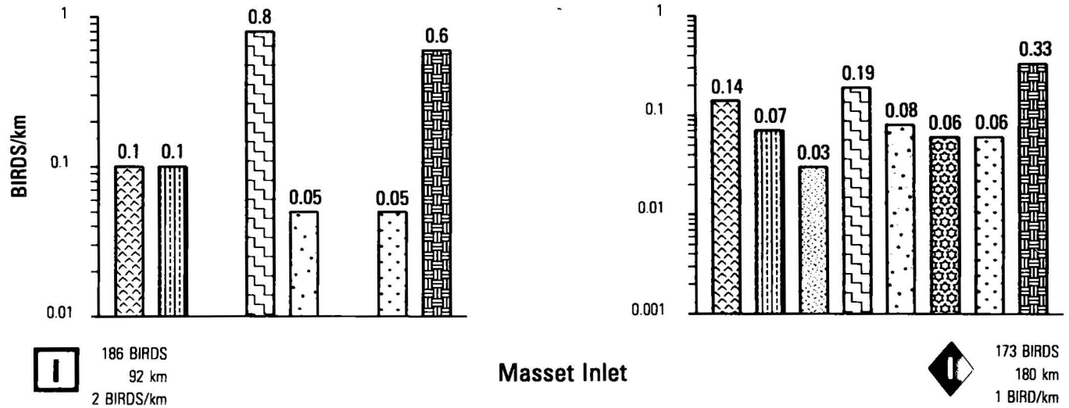
Red-necked Grebe

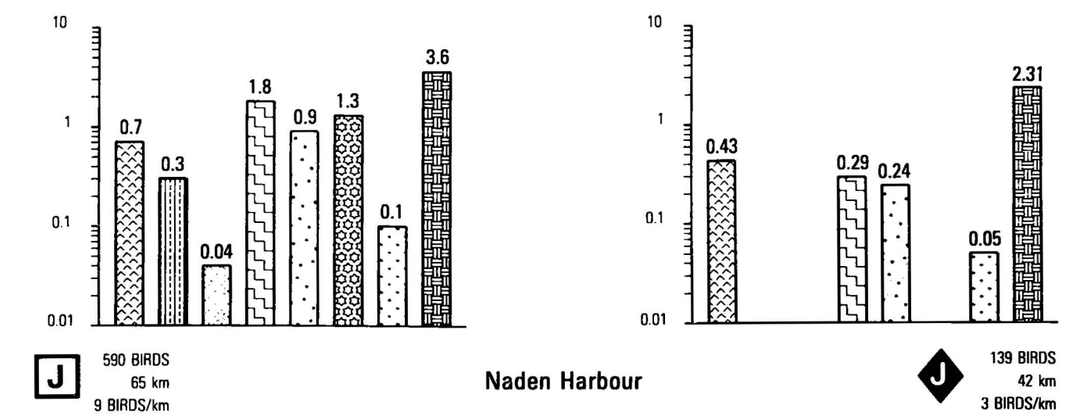
Pelagic Cormorant

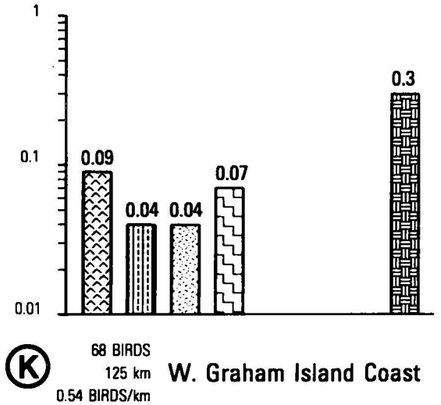
Map 13B. Distribution and densities of loons, grebes and cormorants along the Queen Charlotte Island coast as observed by boat, June – August 1976, October 1976 and May – June 1977.





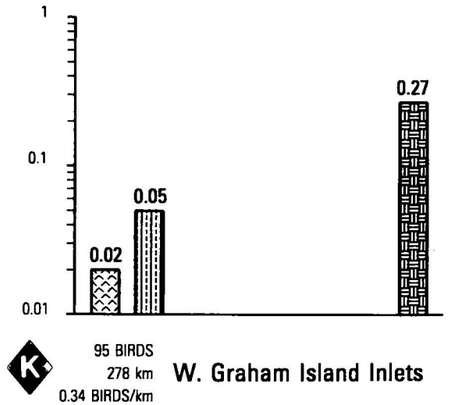






68 BIRDS
125 km
0.54 BIRDS/km

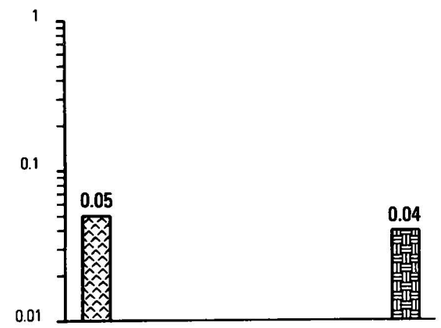
W. Graham Island Coast



95 BIRDS
278 km
0.34 BIRDS/km

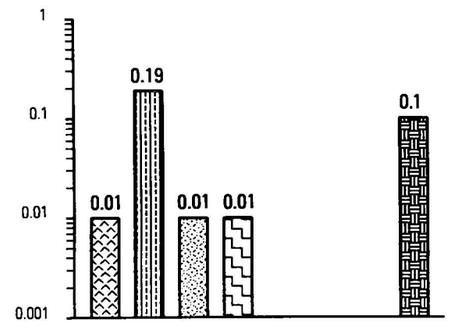
W. Graham Island Inlets

BIRDS/km



12 BIRDS
135 km
0.09 BIRDS/km

W. Moresby Island Coast



52 BIRDS
162 km
0.32 BIRDS/km

W. Moresby Island Inlets

Common Loon

Arctic Loon

Red-throated Loon

Red-necked Grebe

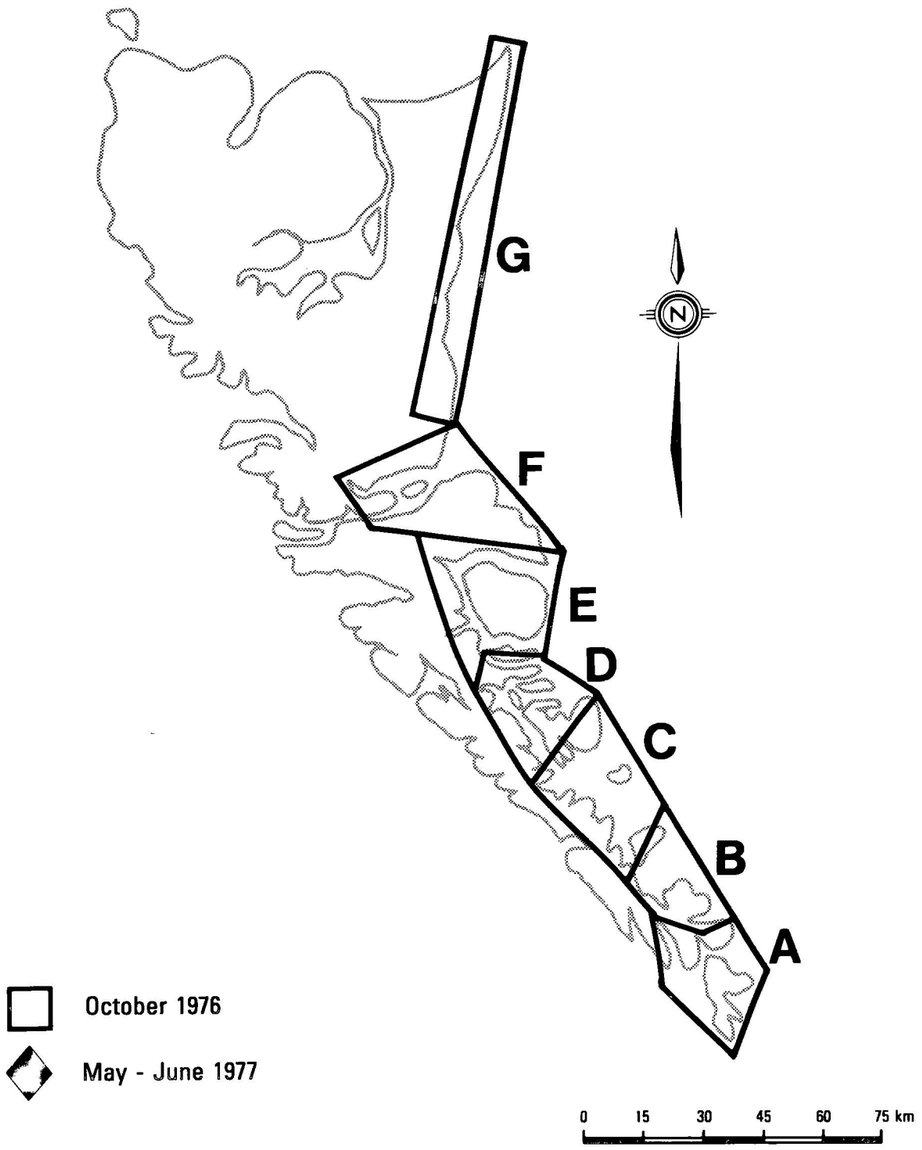
Horned Grebe

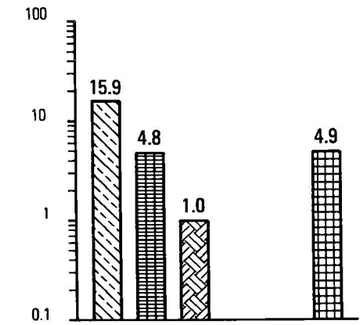
Western Grebe

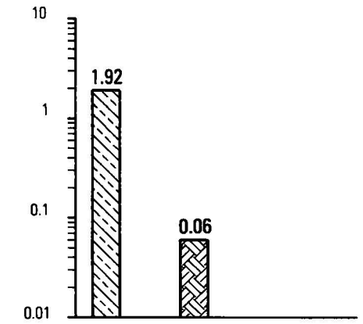
Double-crested Cormorant

Pelagic Cormorant

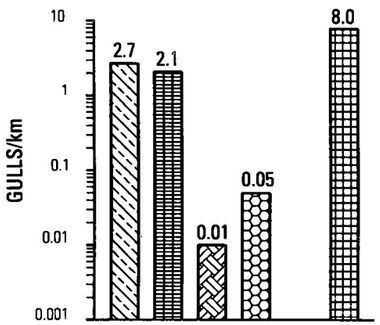
Map 14A. Distribution and densities of gulls along the Queen Charlotte Island coast as observed by boat, October 1976 and May – June 1977.

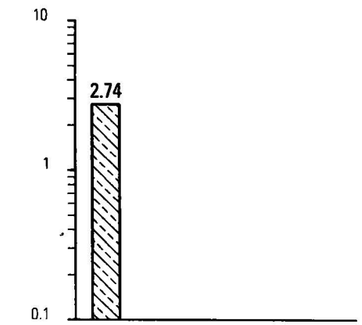




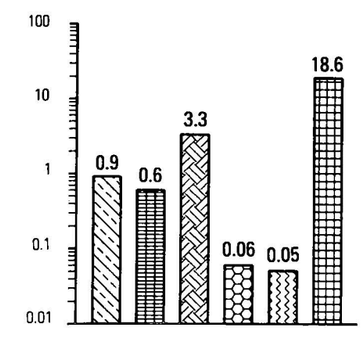


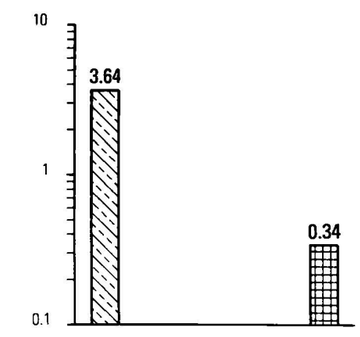
Houston Stewart Channel



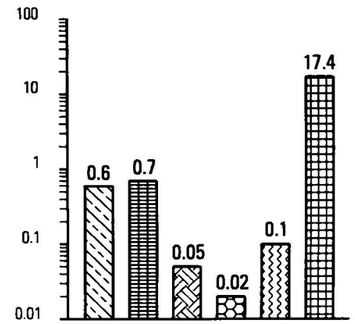


Skincuttle Inlet

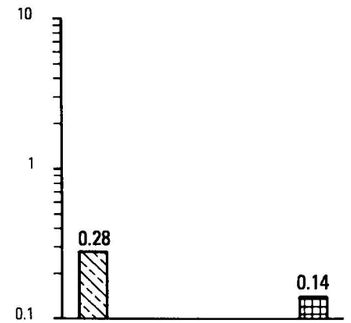




Juan Perez Sound

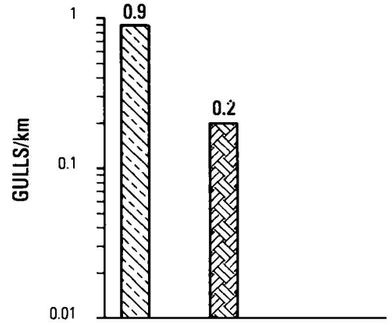


D 3,704 GULLS
196 km
19 GULLS/km



Logan Inlet, Darwin Sound

◆D 58 GULLS
138 km
0.42 GULLS/km



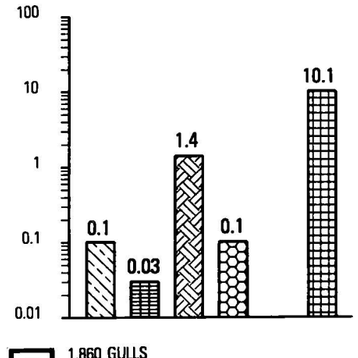
G 91 GULLS
83 km
1 GULL/km

E. Graham Island Coast

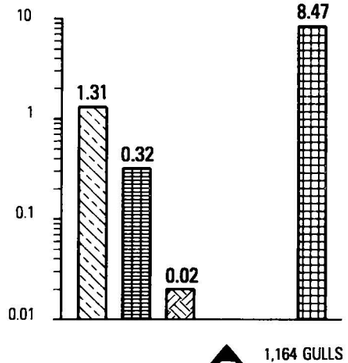
E 2,876 GULLS
204 km
14 GULLS/km

Cumshewa Inlet, Selwyn Sound

◆E 112 GULLS
89 km
1 GULL/km



F 1,860 GULLS
159 km
12 GULLS/km



Skidegate Inlet

◆F 1,164 GULLS
115 km
10 GULLS/km

Glaucous- winged Gull

Herring/Thayer's Gull

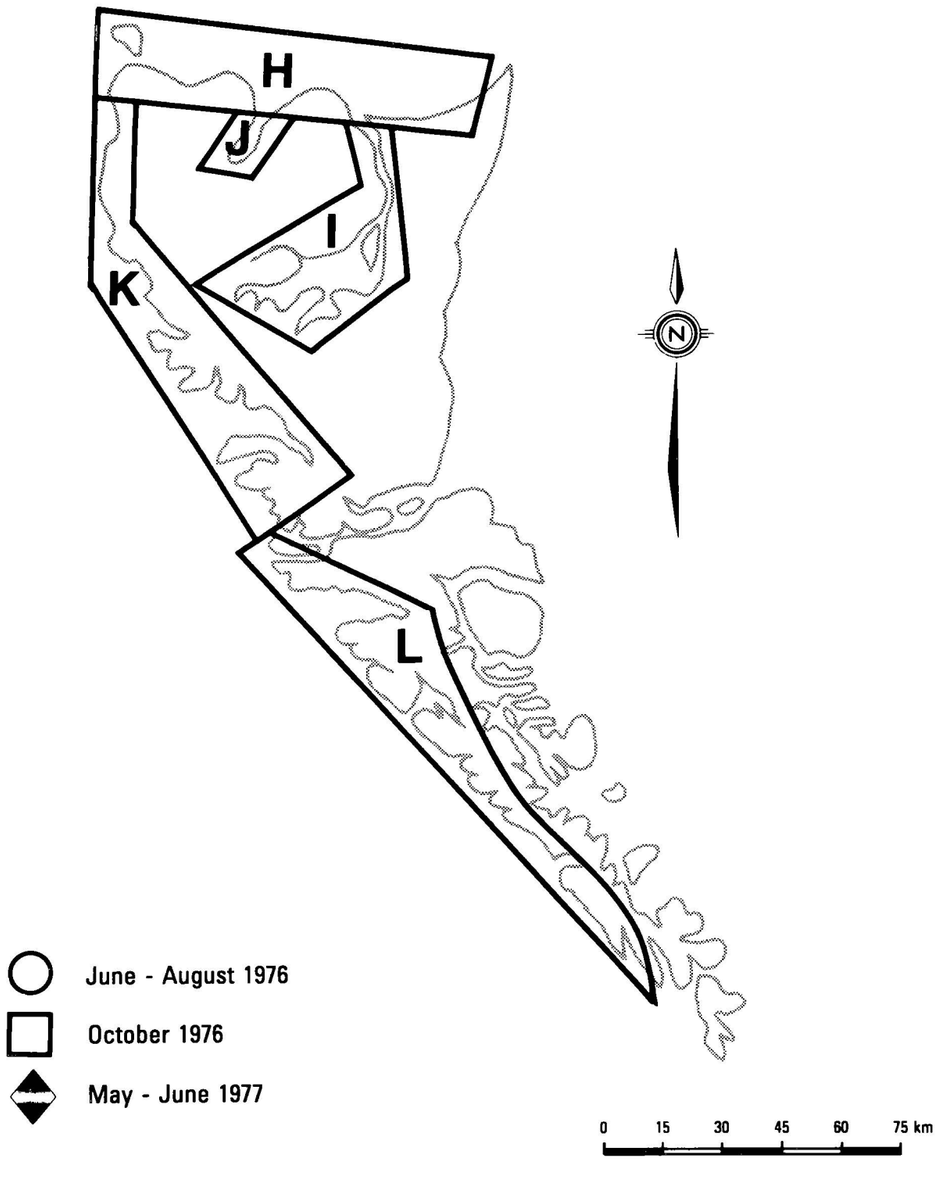
Black-legged Kittiwake

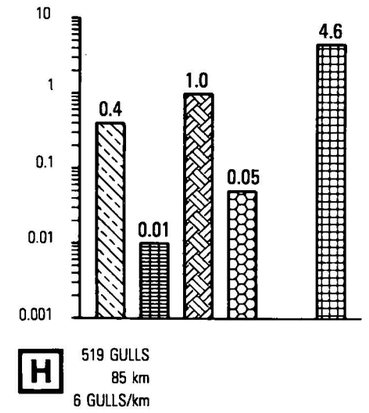
Mew Gull

California Gull

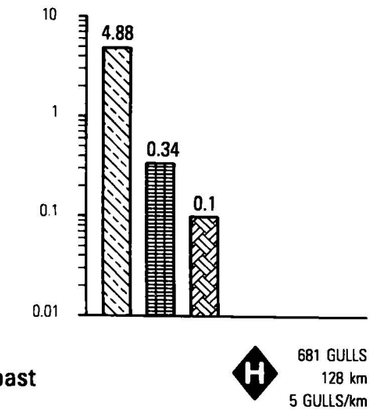
Other &
Unidentified
Gulls

Map 14B. Distribution and densities of gulls along the Queen Charlotte Island coast as observed by boat, June – August 1976, October 1976 and May – June 1977.



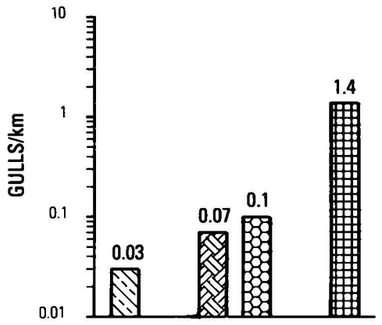


H
519 GULLS
85 km
6 GULLS/km

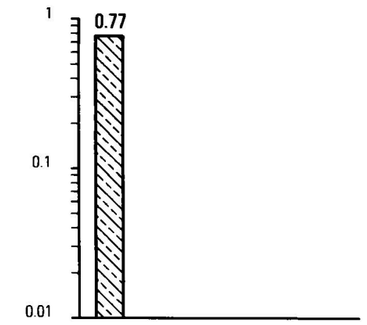


H
681 GULLS
128 km
5 GULLS/km

N. Graham Island Coast

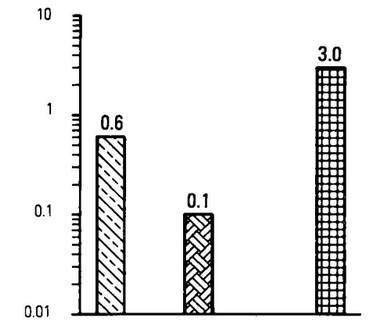


I
155 GULLS
103 km
2 GULLS/km

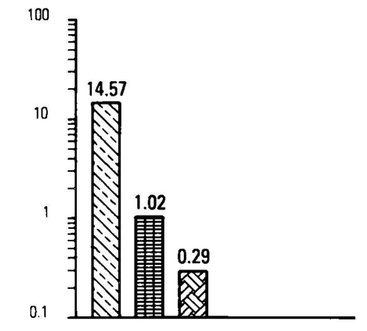


I
139 GULLS
180 km
0.77 GULLS/km

Masset Inlet



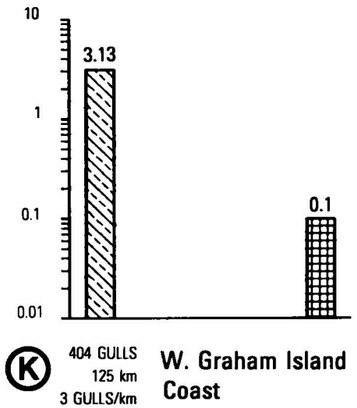
J
248 GULLS
67 km
4 GULLS/km



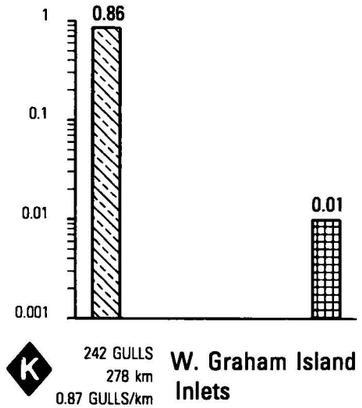
J
667 GULLS
42 km
16 GULLS/km

Naden Harbour

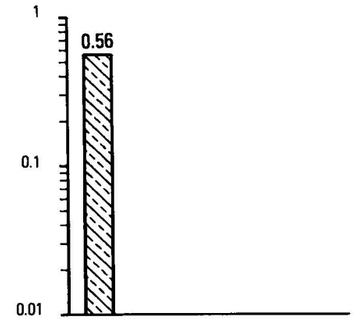
GULLS/km



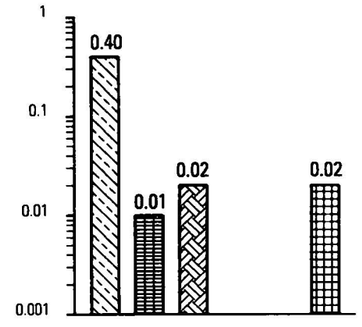
404 GULLS
125 km
3 GULLS/km
W. Graham Island
Coast



242 GULLS
278 km
0.87 GULLS/km
W. Graham Island
Inlets



76 GULLS
135 km
0.56 GULLS/km
W. Moresby Island
Coast



73 GULLS
162 km
0.45 GULLS/km
W. Moresby Island
Inlets

Glaucous-winged Gull

Herring/Thayer's Gull

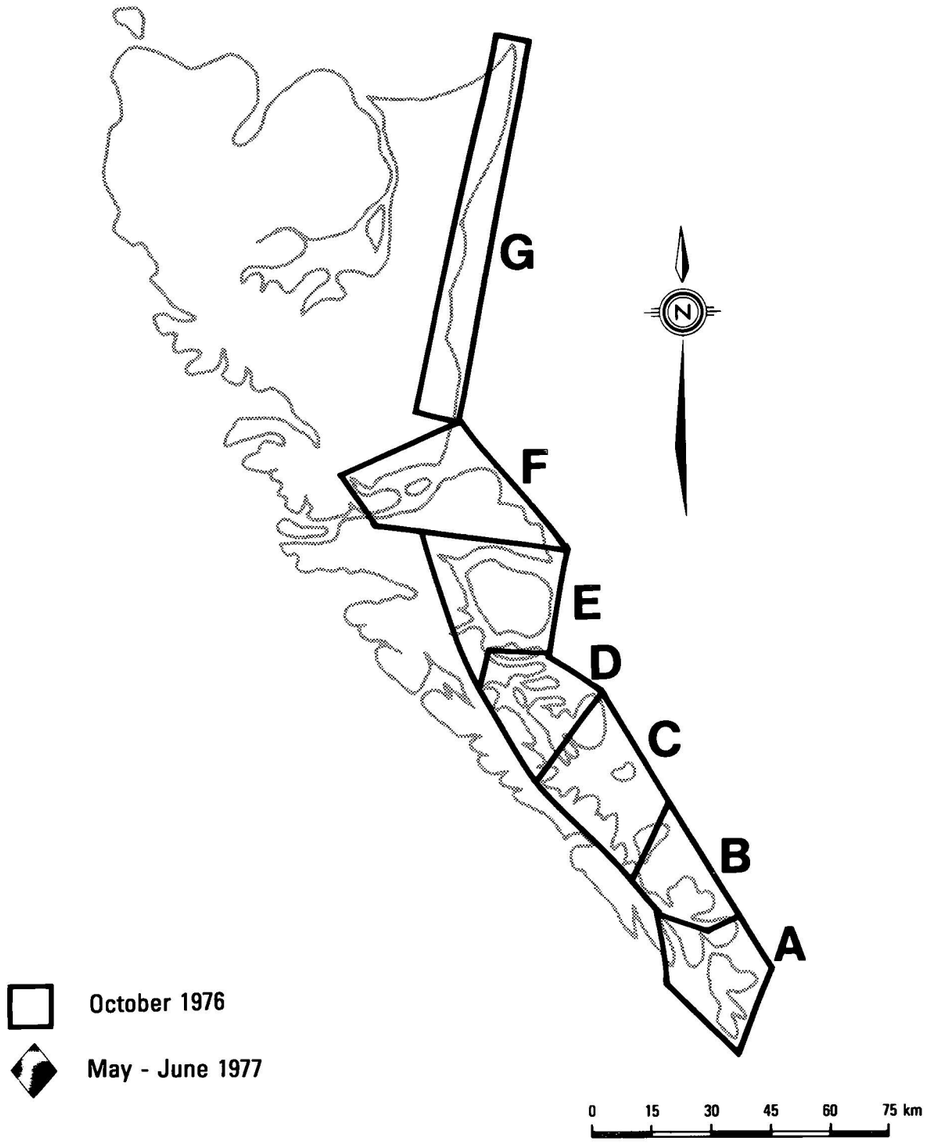
Black-legged Kittiwake

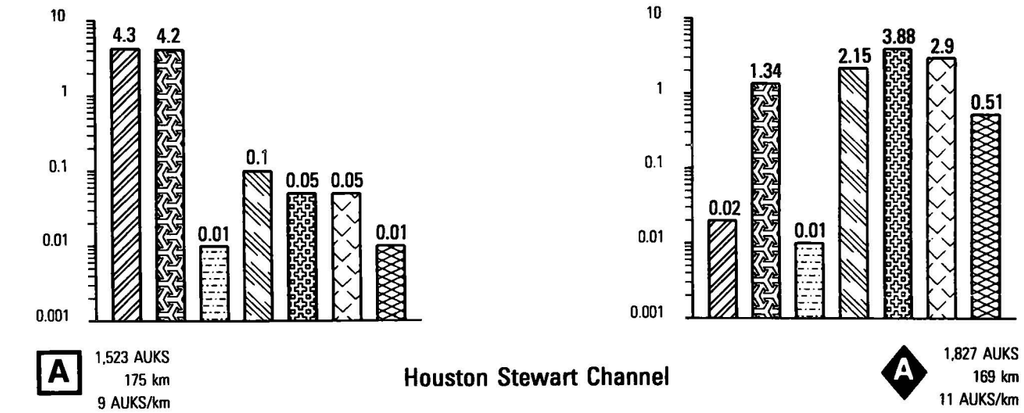
Mew Gull

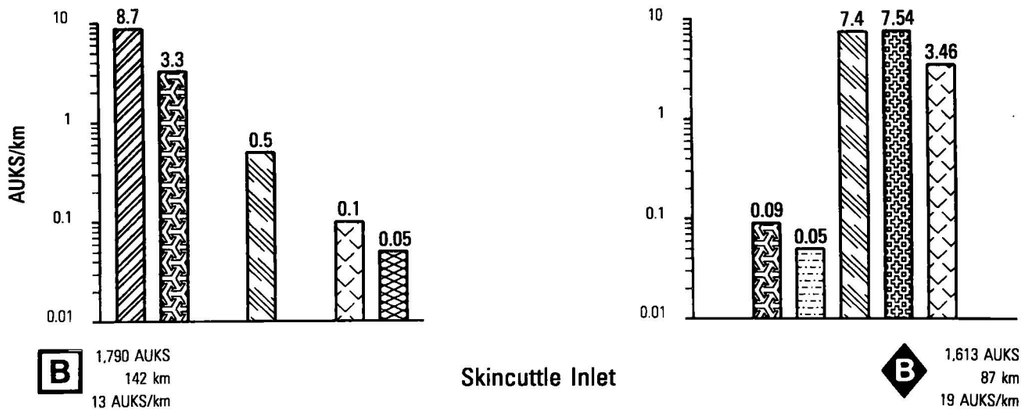
California Gull

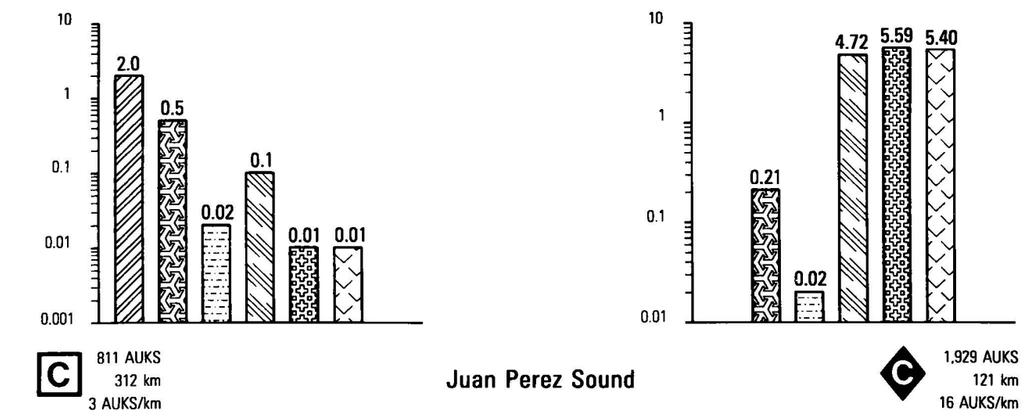
Other &
Unidentified
Gulls

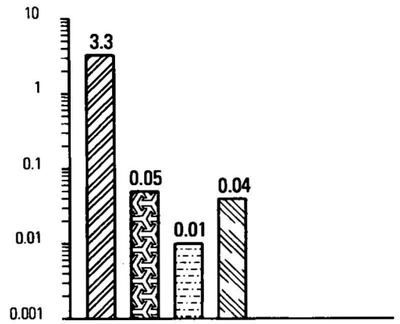
Map 15A. Distribution and densities of auks along the Queen Charlotte Island coast as observed by boat, October 1976 and May – June 1977.



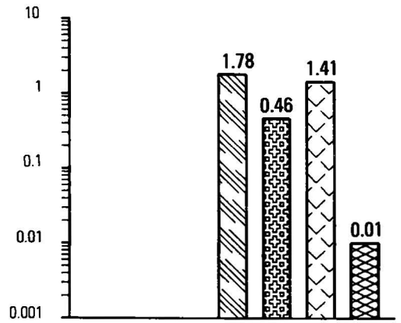






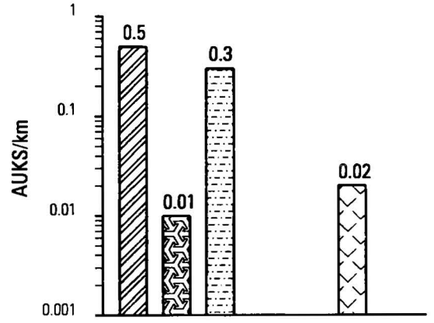


D 647 AUKS
196 km
3 AUKS/km



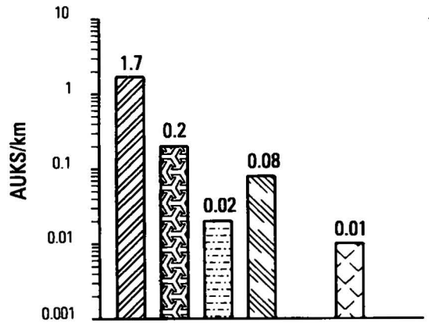
D 505 AUKS
138 km
4 AUKS/km

Logan Inlet, Darwin Sound

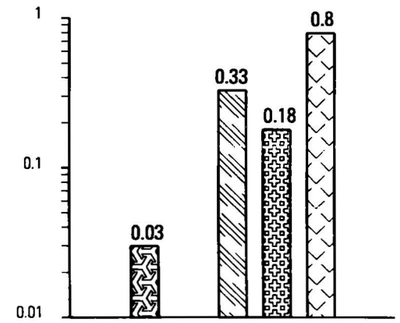


G 66 AUKS
83 km
0.8 AUKS/km

E. Graham Island Coast

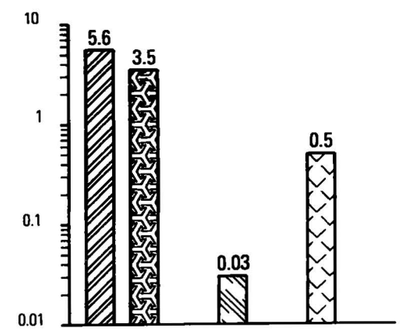


E 428 AUKS
204 km
2 AUKS/km

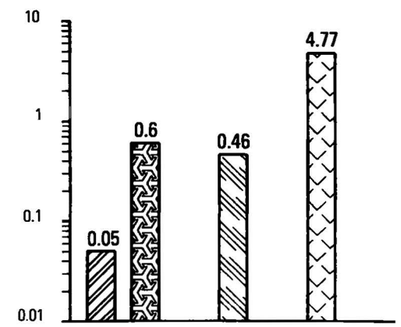


E 119 AUKS
89 km
1 AUK/km

Cumshewa Inlet, Selwyn Sound



F 1,526 AUKS
159 km
10 AUKS/km



F 676 AUKS
115 km
6 AUKS/km

Skidegate Inlet

Common Murre

Marbled Murrelet

Rhinoceros Auklet

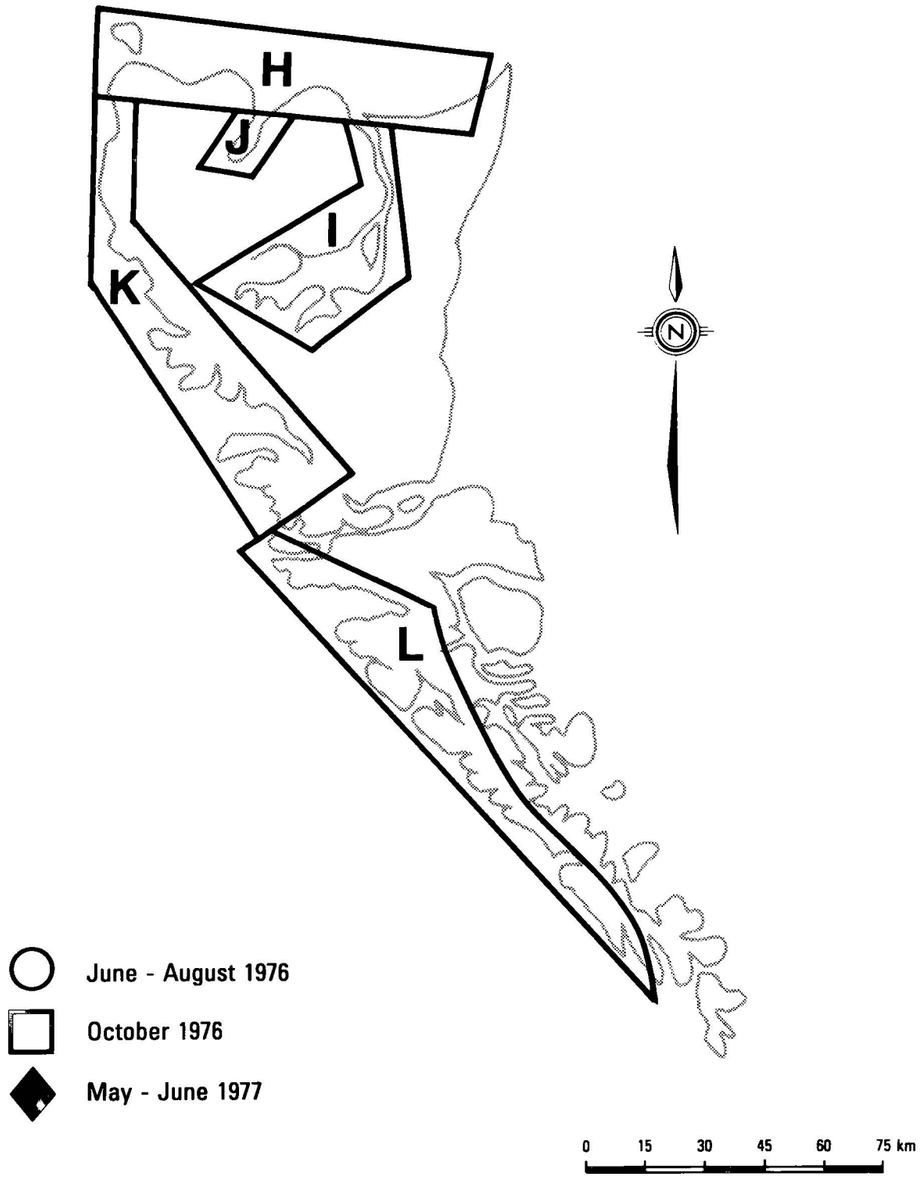
Ancient Murrelet

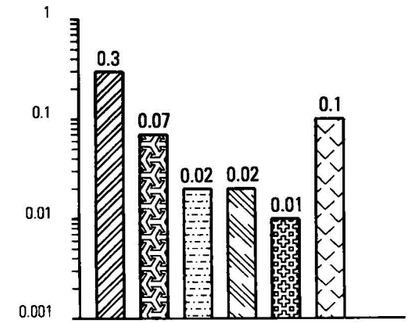
Cassin's Auklet

Pigeon Guillemot

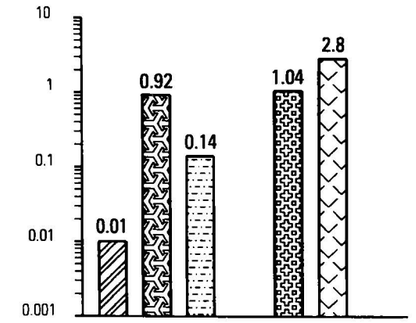
Tufted Puffin

Map 15B. Distribution and densities of auks along the Queen Charlotte Island coast as observed by boat, June – August 1976, October 1976 and May – June 1977.



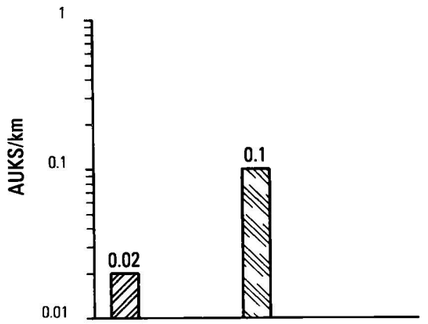


H
43 AUKS
85 km
0.5 AUKS/km

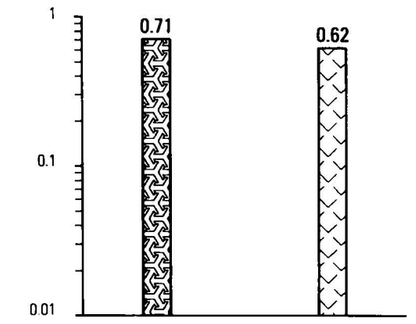


H
628 AUKS
128 km
5 AUKS/km

N. Graham Island Coast

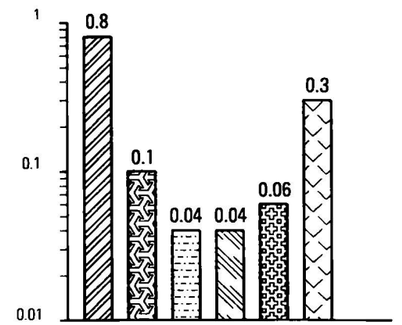


I
10 AUKS
103 km
0.1 AUK/km

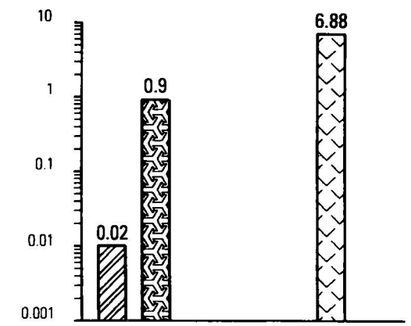


Masset Inlet

I
239 AUKS
180 km
1 AUK/km

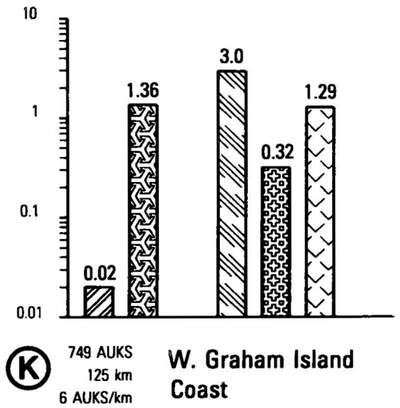


J
87 AUKS
67 km
1 AUK/km

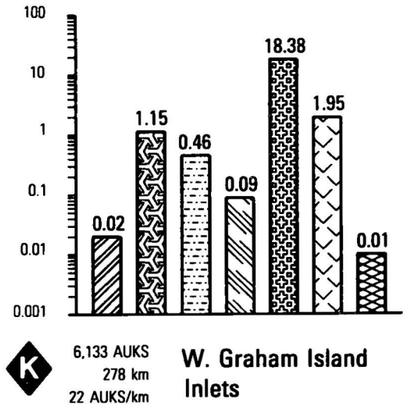


Naden Harbour

J
328 AUKS
42 km
8 AUKS/km

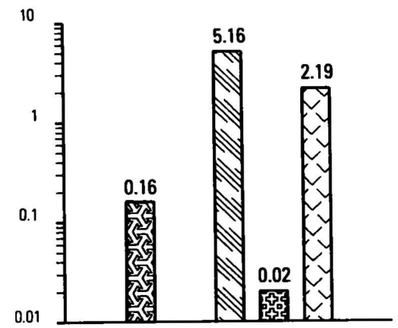


K 749 AUKS 125 km 6 AUKS/km **W. Graham Island Coast**

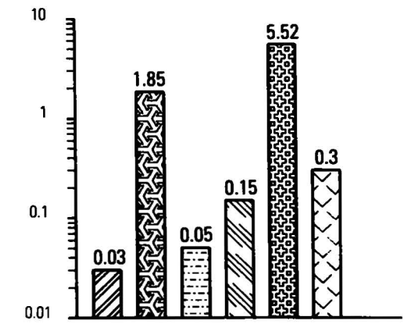


K 6,133 AUKS 278 km 22 AUKS/km **W. Graham Island Inlets**

AUKS/km



L 1,017 AUKS 135 km 8 AUKS/km **W. Moresby Island Coast**



L 1,280 AUKS 162 km 8 AUKS/km **W. Moresby Island Inlets**

Common Murre

Marbled Murrelet

Rhinoceros Auklet

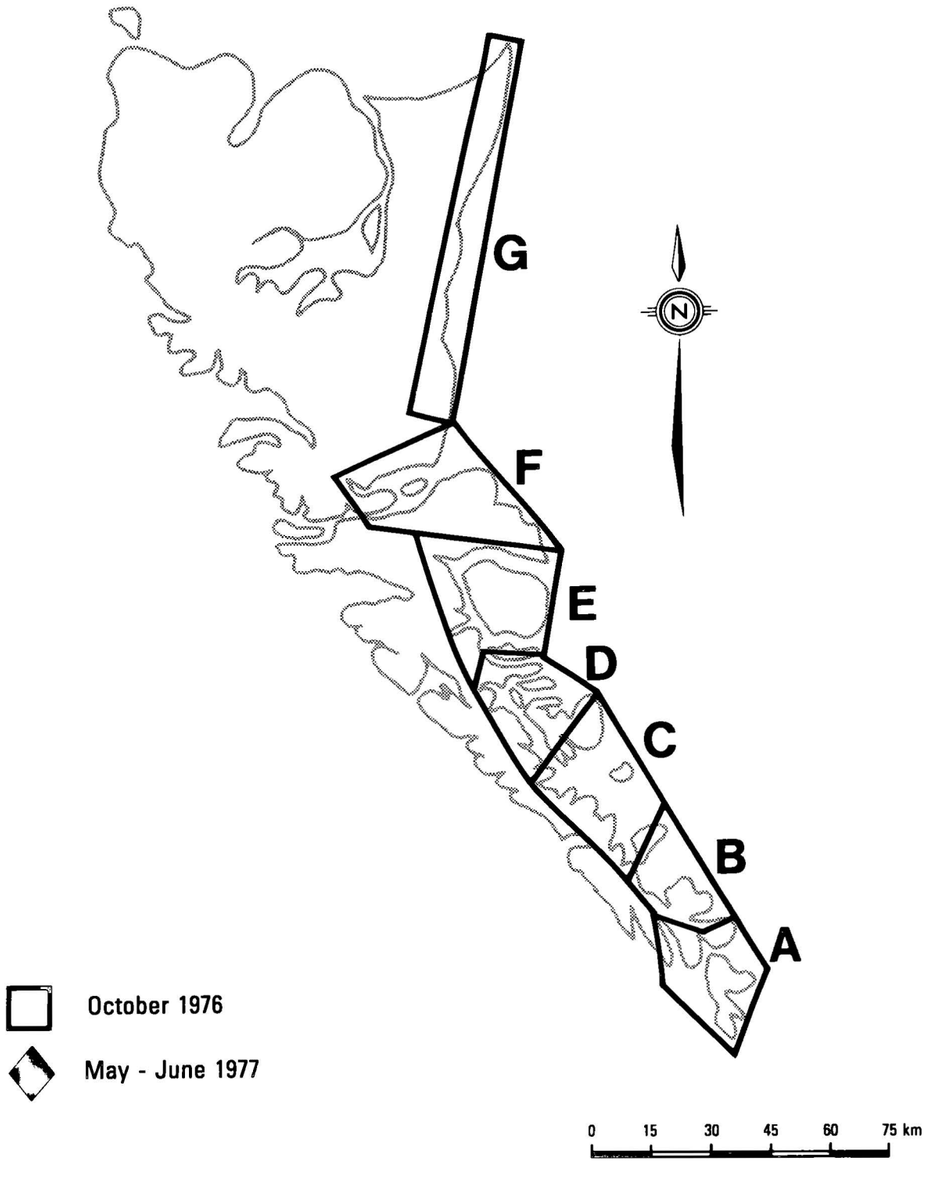
Ancient Murrelet

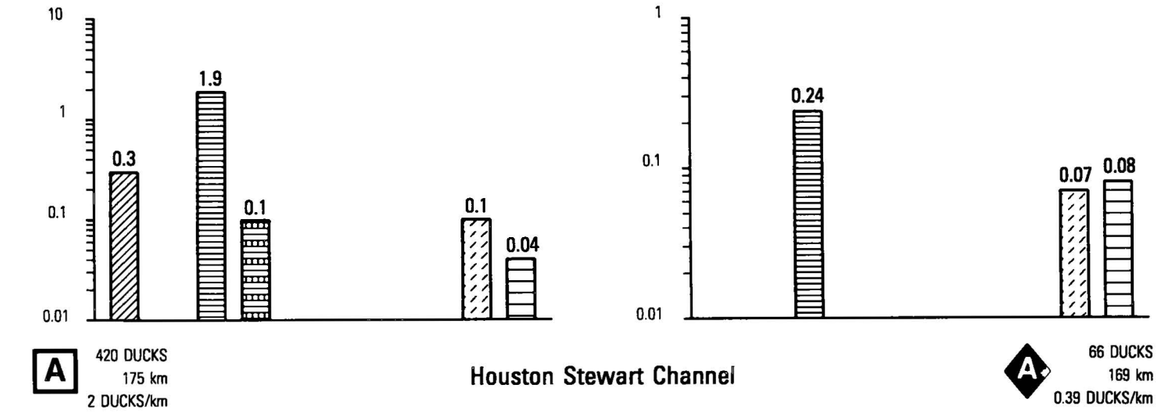
Cassin's Auklet

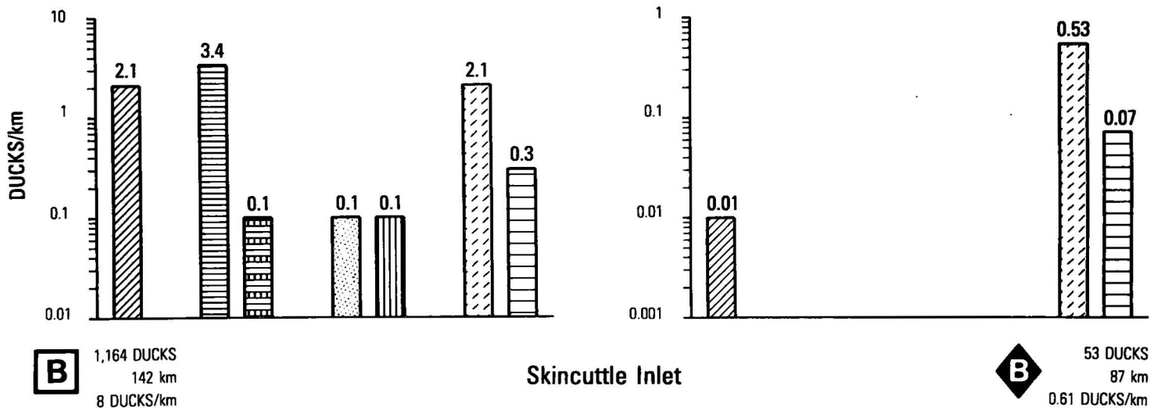
Pigeon Guillemot

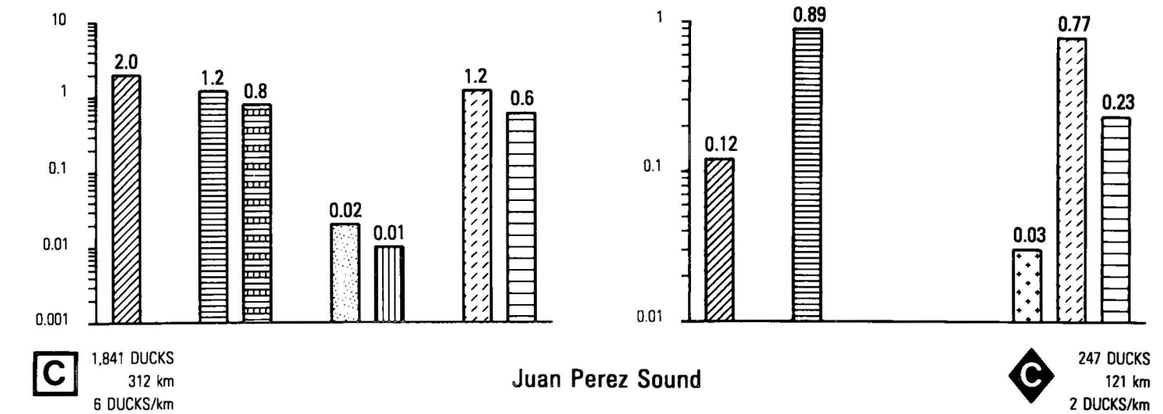
Tufted Puffin

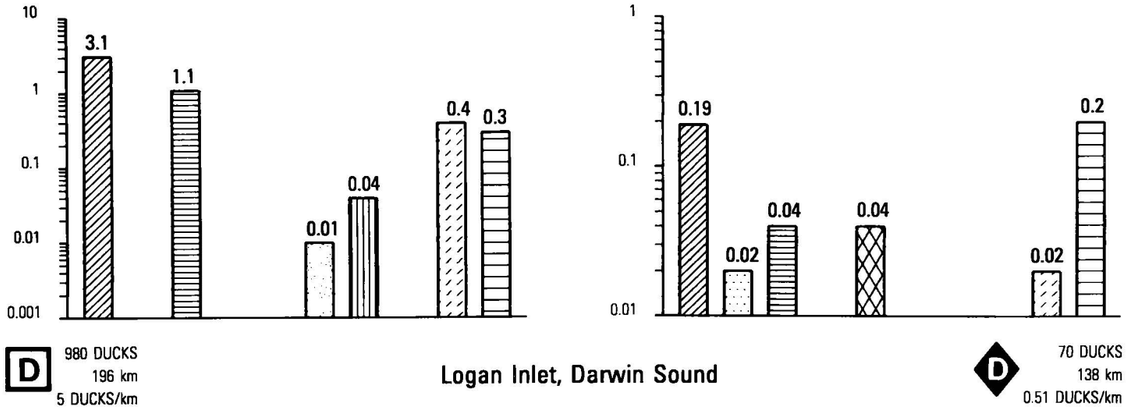
Map 16A. Distribution and densities of diving ducks along the Queen Charlotte Island coast as observed by boat, October 1976 and May – June 1977.







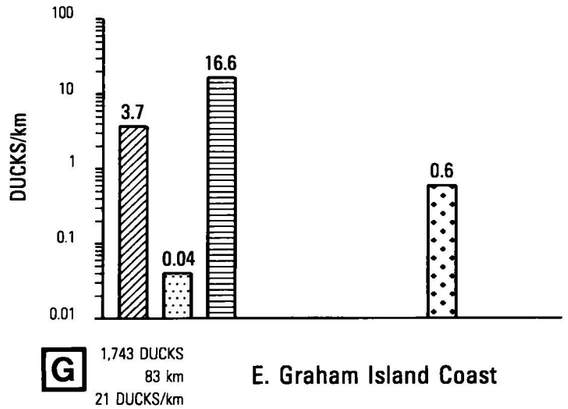




D 980 DUCKS 196 km 5 DUCKS/km

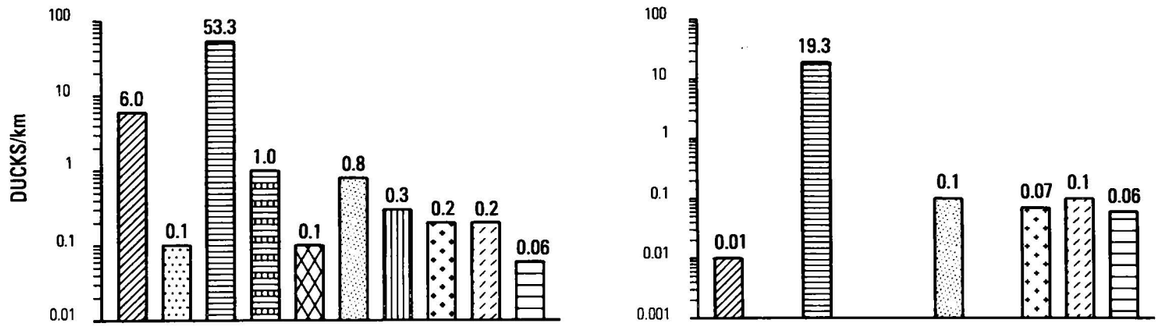
Logan Inlet, Darwin Sound

D 70 DUCKS 138 km 0.51 DUCKS/km



G 1,743 DUCKS 83 km 21 DUCKS/km

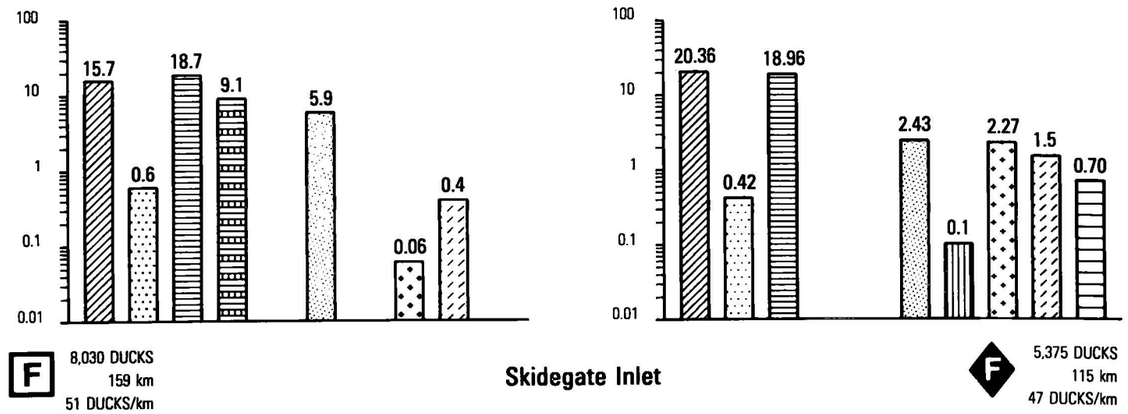
E. Graham Island Coast



E 12,668 DUCKS 204 km 62 DUCKS/km

Cumshewa Inlet, Selwyn Sound

E 1,748 DUCKS 87 km 20 DUCKS/km



F 8,030 DUCKS 159 km 51 DUCKS/km

Skidegate Inlet

F 5,375 DUCKS 115 km 47 DUCKS/km

Surf Scoter

Greater Scaup

Black Scoter

Bufflehead

White-winged Scoter

Oldsquaw

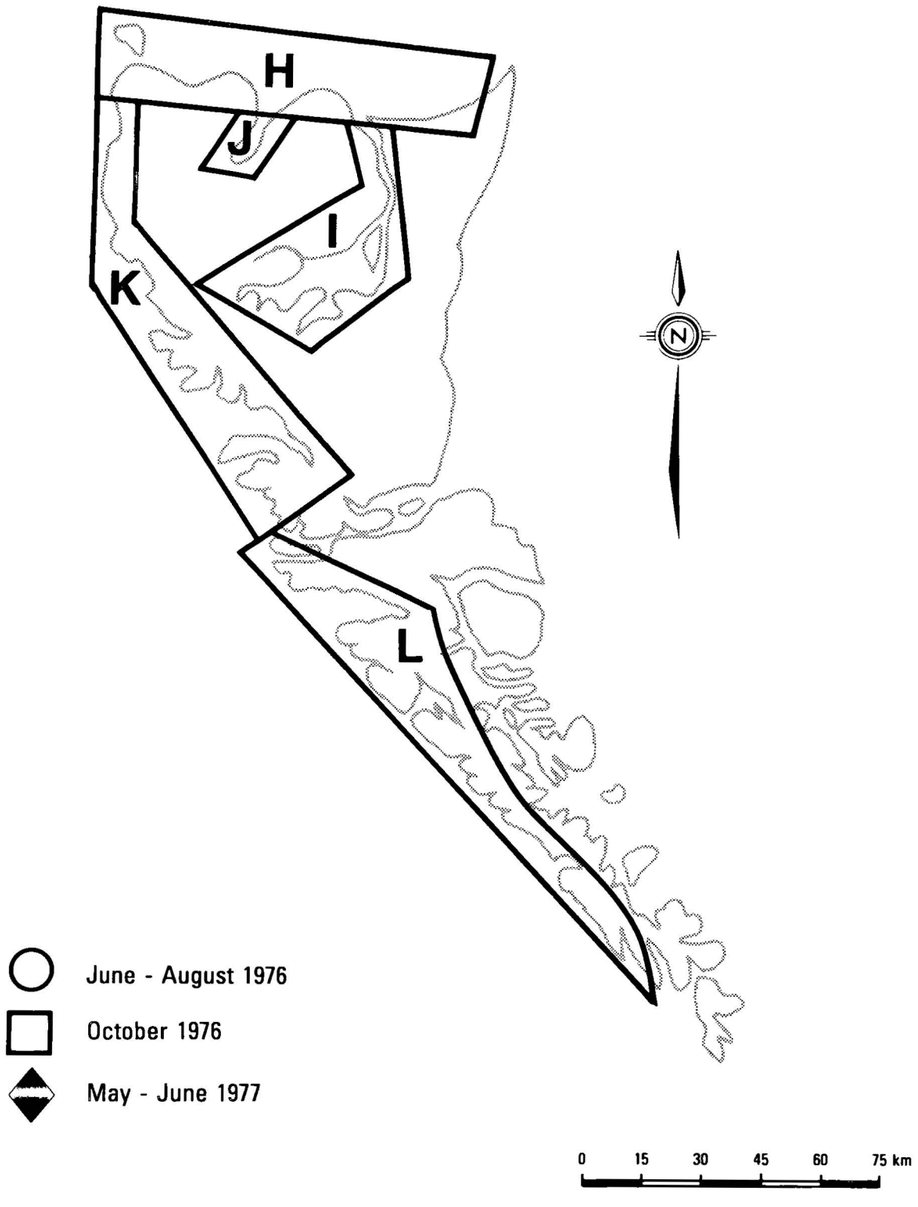
Unidentified Scoters

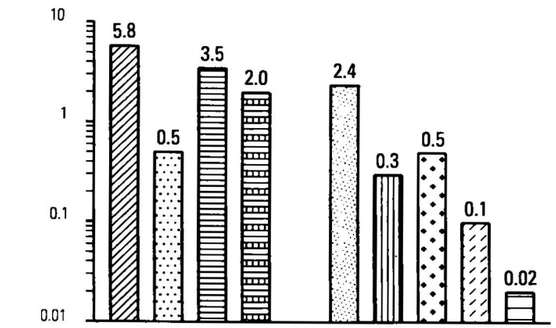
Harlequin

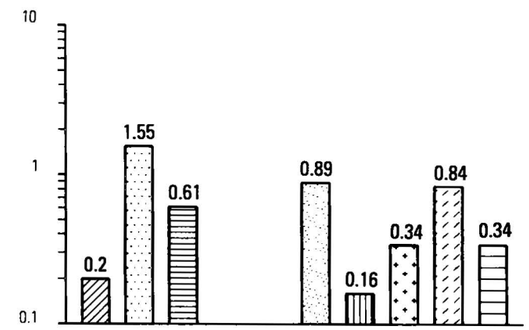
Common Goldeneye

Mergansers

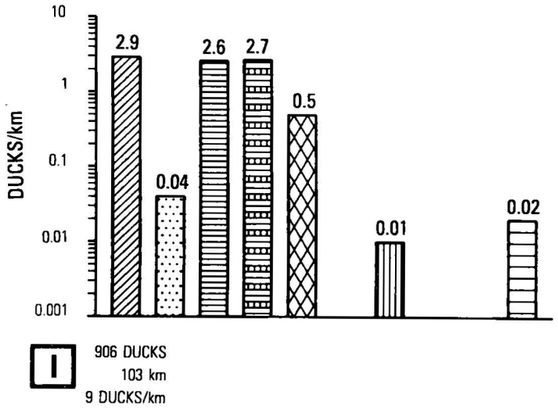
Map 16B. Distribution and densities of diving ducks along the Queen Charlotte Island coast as observed by boat, June – August 1976, October 1976 and May – June 1977.

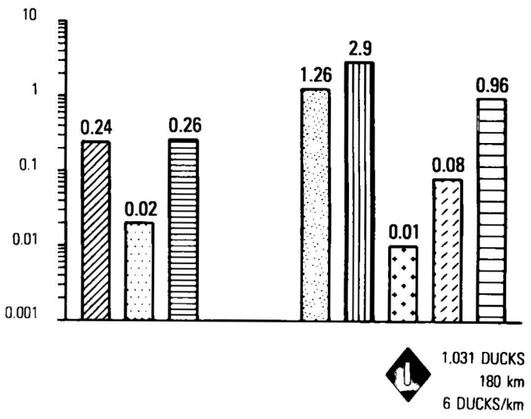




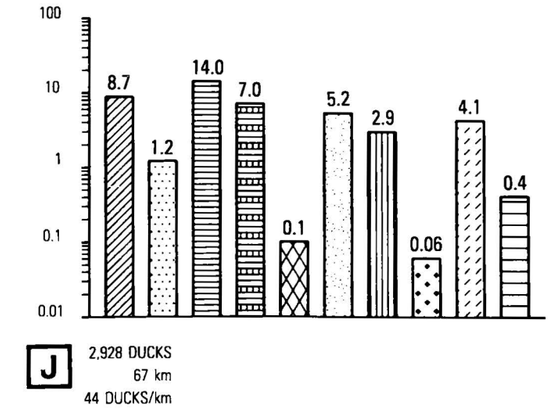


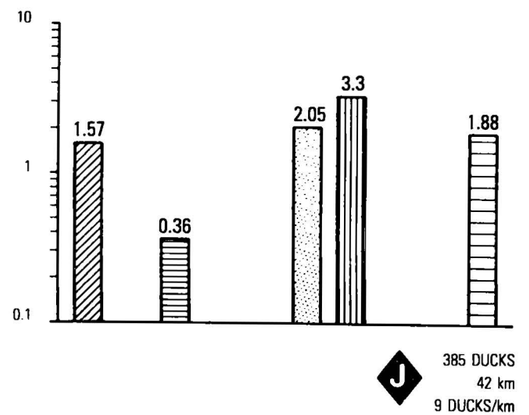
N. Graham Island Coast



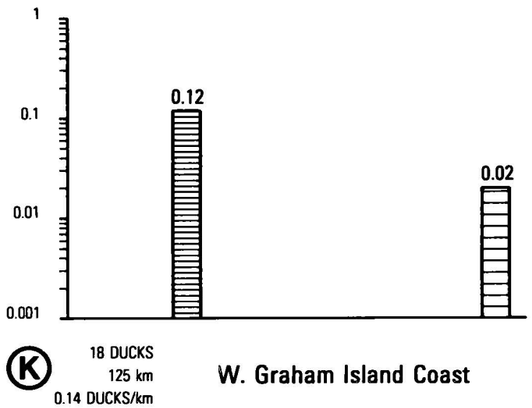


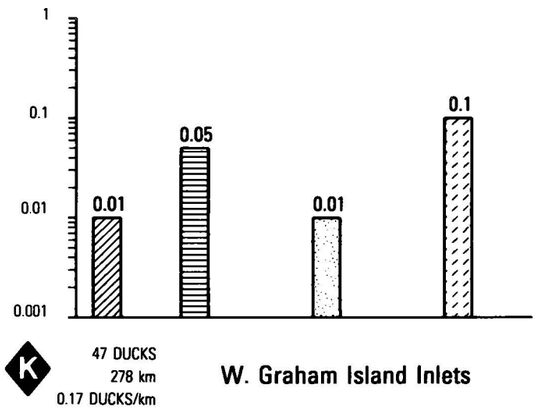
Masset Inlet



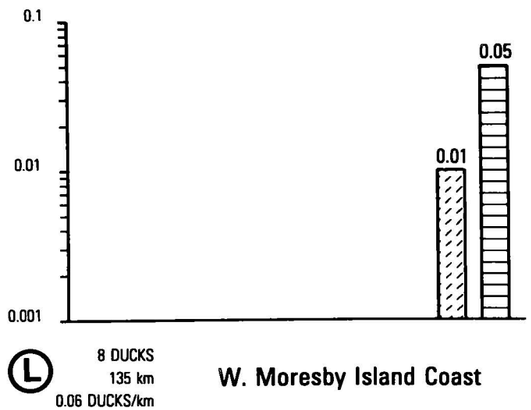


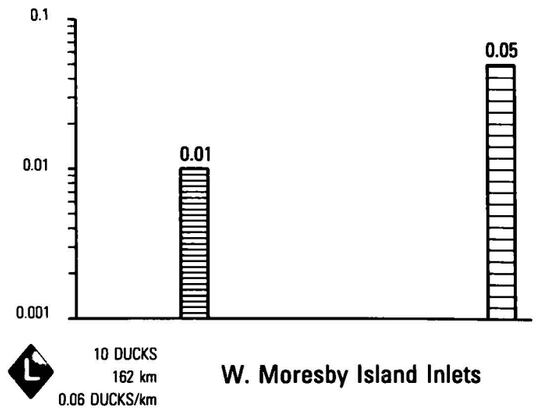
Naden Harbour

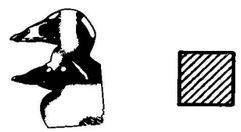


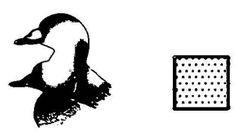


DUCKS/km






Surf Scoter


Black Scoter


White-winged Scoter


Unidentified Scoters


Common Goldeneye


Greater Scaup

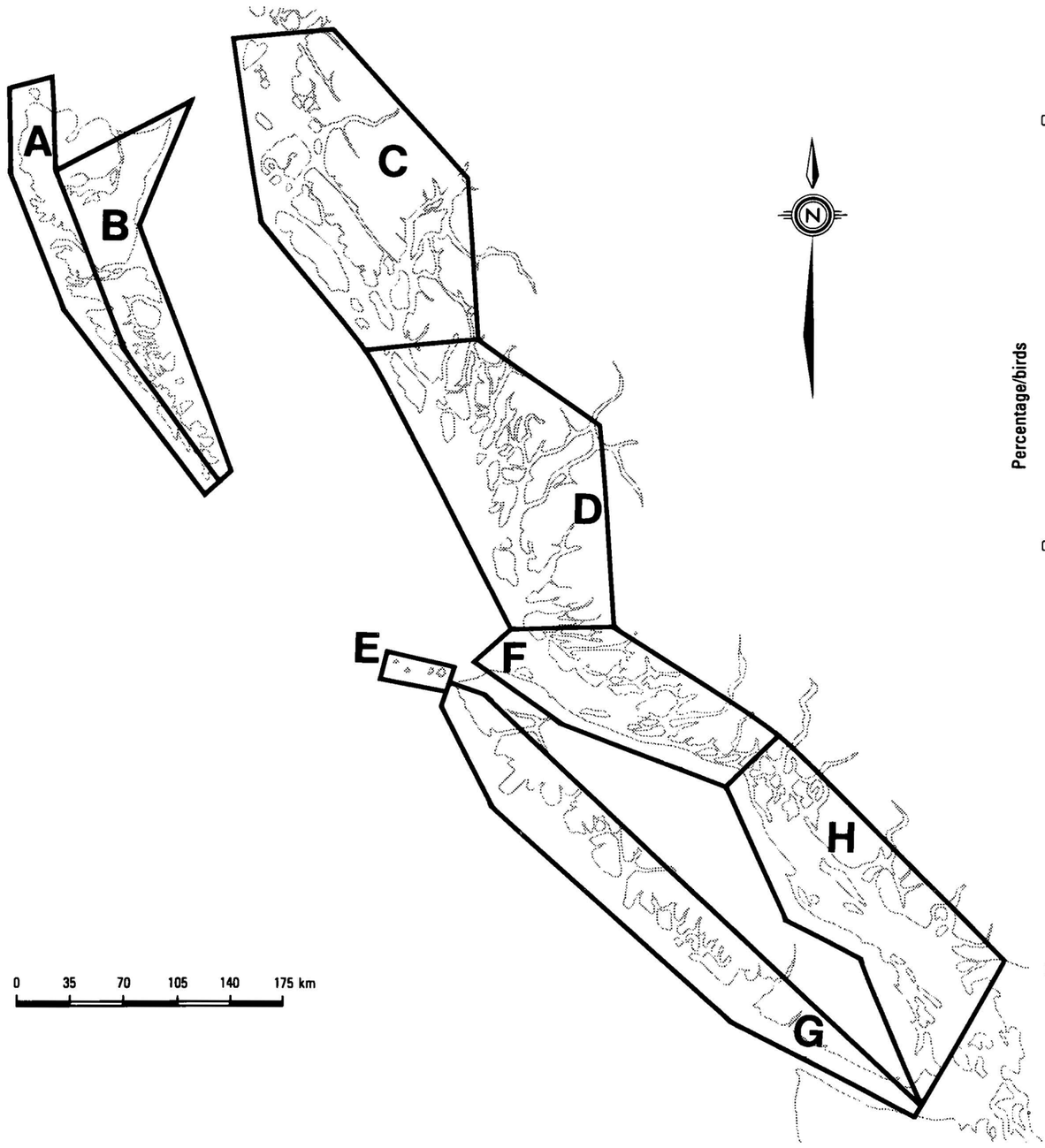

Bufflehead

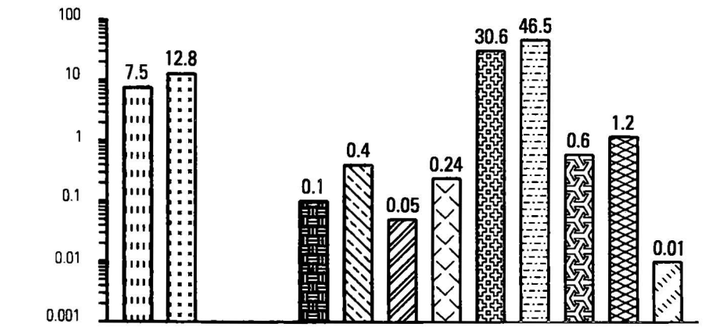

Oldsquaw


Harlequin

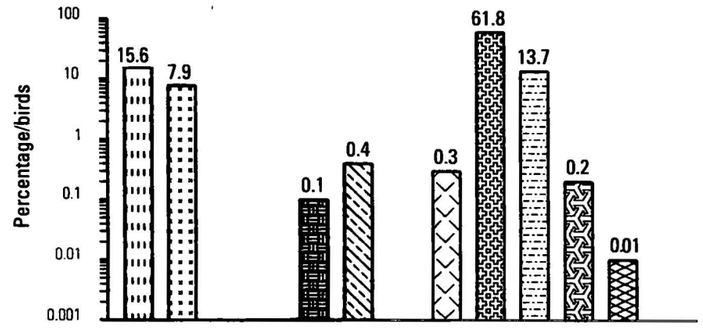

Mergansers

Map 17. Distribution of marine breeding bird numbers on the Canadian west coast as observed from nest counts, 1970-1978.

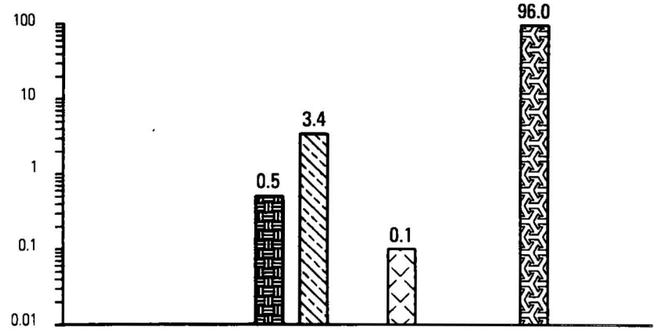




A Queen Charlotte Islands: West Coast
565,510 Birds



B Queen Charlotte Islands: East Coast
379,580 Birds



C Mainland Coast: Hecate Strait
52,110 Birds

Fork-tailed Storm-Petrel

Leach's Storm-Petrel

Brandt's Cormorant

Double-crested Cormorant

Pelagic Cormorant

Glaucous-winged Gull

Common Murre

Pigeon Guillemot

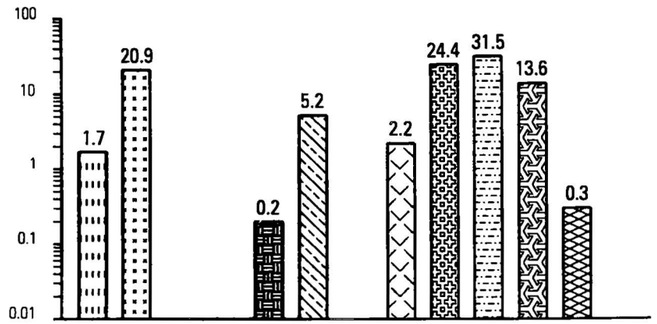
Ancient Murrelet

Cassin's Auklet

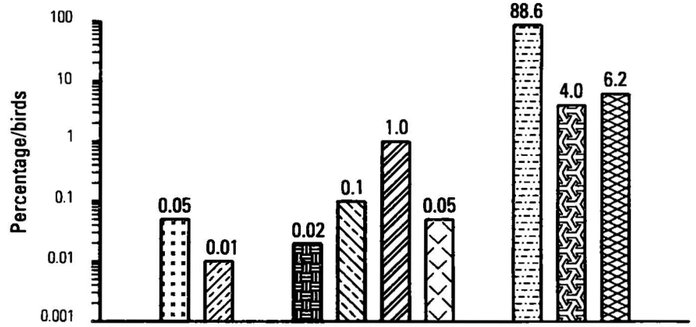
Rhinoceros Auklet

Tufted Puffin

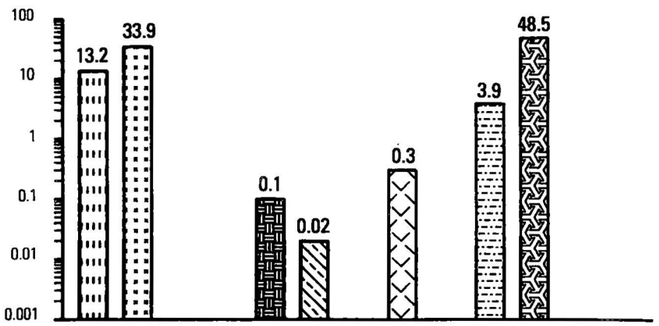
Horned Puffin



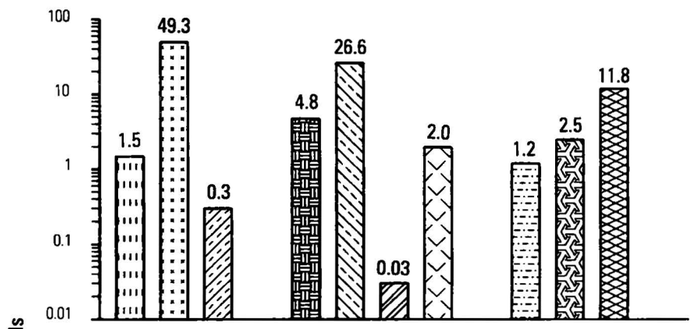
D Mainland Coast: Queen Charlotte Sound
57,440 Birds



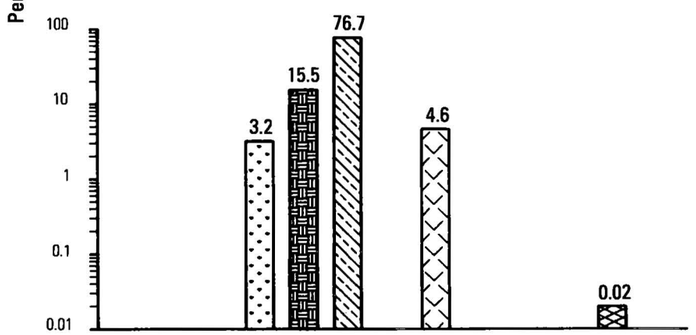
E Scott Islands
812,360 Birds



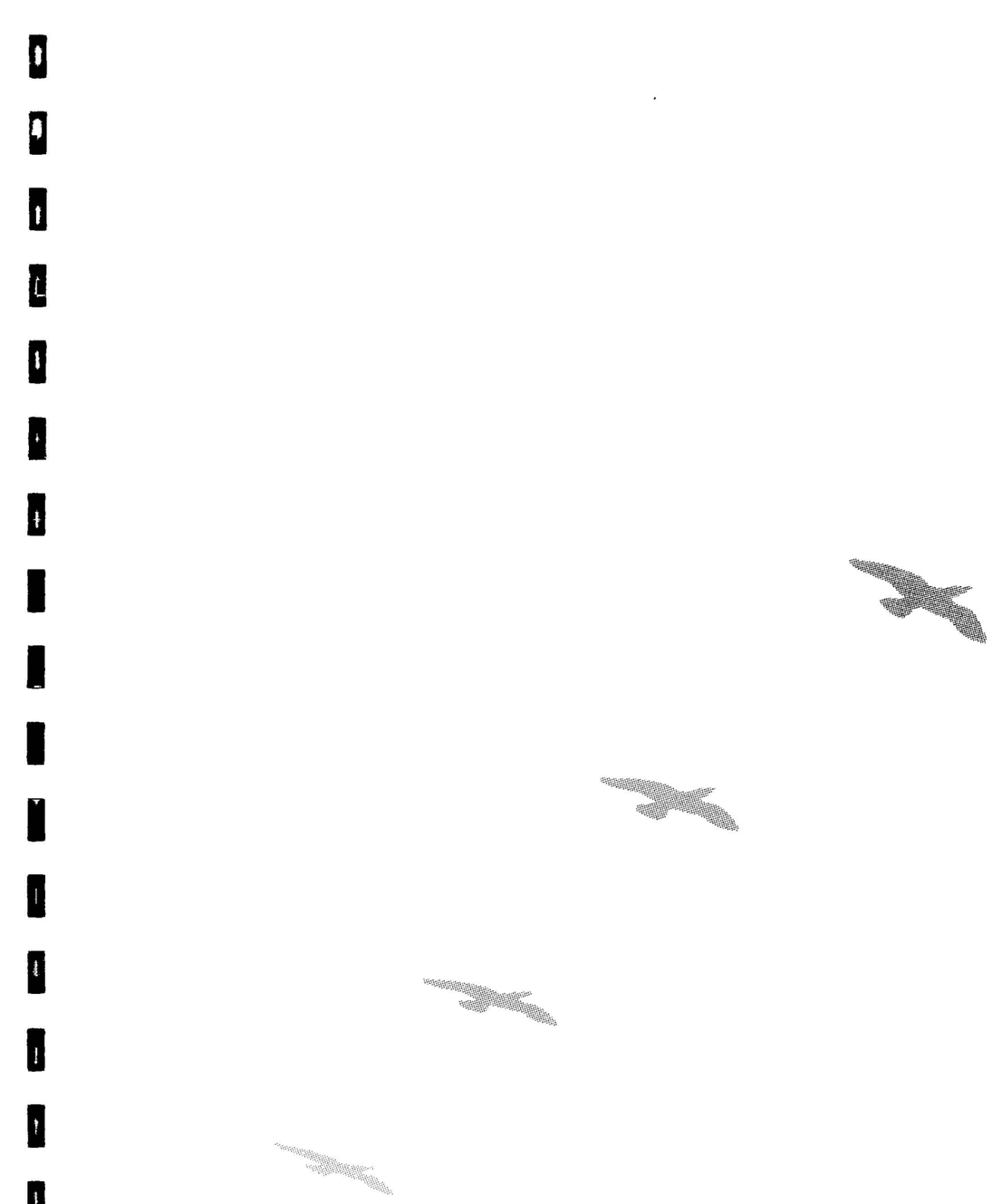
F Queen Charlotte Strait
230,800 Birds

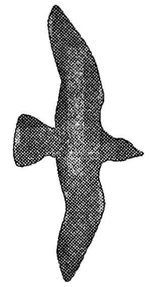


G Vancouver Island: West Coast
52,580 Birds



H Strait of Georgia
26,069 Birds





Conclusion

Canada's Pacific waters support several million marine birds throughout the season. A few million birds occur within a few kilometers of the Canadian Pacific coastline from January to April. Although coastal surveys in autumn were restricted, data from the Queen Charlotte Islands and the Strait of Georgia suggest a similar or even larger population occurring on the coast at that time. At least two million birds are found in breeding colonies in summer. Another million birds may occur in any season on the open water of the Continental Shelf. For example, Manuwal et al. (1979) reported 240,000 Common Murres from open waters of the outer Strait of Juan de Fuca in September, 1978.

One of the greatest threats to marine birds in the northern hemisphere has proved to be oil spillage (Vermeer and Vermeer, 1974 and 1975). There are now applications to establish a tanker terminal either on the west coast of Canada or adjacent Washington State. A moratorium on offshore drilling on the Canadian Pacific Shelf may soon be lifted. Present information is insufficient to delineate with certainty where marine bird numbers will be most at hazard from oil spillage on the coast. Our data indicate that marine bird numbers, species and distribution vary drastically between seasons of the year. One can only generalize where, which species and what bird numbers will be threatened by oil. For instance, from the information shown here we can deduce that large auk populations will be much at hazard from spills in the Queen Charlotte Islands and northern Vancouver Island in summer; loons, cormorants and grebes in the Gulf Islands from autumn to spring, and ducks along the whole coastline of the Strait of Georgia from September to April. At least two years of surveys conducted on a monthly basis along the whole coastline as well as in adjacent waters of the Shelf are necessary to establish minimal baseline information for judgment on terminal locations and offshore drilling operations. We therefore fervently hope that such decisions will be delayed until at least that information has been gathered.

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