# Seasonality and Distribution of Marine Birds in Saanich Inlet, Vancouver Island, B.C.

by
K.H. Morgan, R. Hay and K. Vermeer
Canadian Wildlife Service

Institute of Ocean Sciences
Department of Fisheries and Oceans
Sidney, B.C. V8L 4B2

1987

**Canadian Technical Report of Hydrography and Ocean Sciences No. 95**

Fisheries and Oceans   Pêches et Océans

Canada

## Canadian Technical Report of Hydrography and Ocean Sciences

These reports contain scientific and technical information of a type that represents a contribution to existing knowledge but which is not normally found in the primary literature. The subject matter is generally related to programs and interests of the Ocean Science and Surveys (OSS) sector of the Department of Fisheries and Oceans.

Technical Reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report will be abstracted in Aquatic Sciences and Fisheries Abstracts. Reports are also listed in the Department's annual index to scientific and technical publications.

Technical Reports are produced regionally but are numbered and indexed nationally. Requests for individual reports will be fulfilled by the issuing establishment listed on the front cover and title page. Out of stock reports will be supplied for a fee by commercial agents.

Regional and headquarters establishments of Ocean Science and Surveys ceased publication of their various report series as of December 1981. A complete listing of these publications and the last number issued under each title are published in the *Canadian Journal of Fisheries and Aquatic Sciences,* Volume 38: Index to Publications 1981. The current series began with Report Number 1 in January 1982.

## Rapport technique canadien sur l'hydrographie et les sciences océaniques

Ces rapports contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles mais que l'on ne trouve pas normalement dans les revues scientifiques. Le sujet est généralement rattaché aux programmes et intérêts du service des Sciences et Levés océaniques (SLO) du ministère des Pêches et des Océans.

Les rapports techniques peuvent être considérés comme des publications à part entière. Le titre exact figure au-dessus du résumé du chaque rapport. Les résumés des rapports seront publiés dans la revue Résumés des sciences aquatiques et halieutiques et les titres figureront dans l'index annuel des publications scientifiques et techniques du Ministère.

Les rapports techniques sont produits à l'échelon régional mais sont numérotés et placés dans l'index à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page de titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Les établissements des Sciences et Levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports depuis décembre 1981. Vous trouverez dans l'index des publications du volume 38 du *Journal canadien des sciences halieutiques et aquatiques,* la liste de ces publications ainsi que le dernier numéro paru dans chaque catégorie. La nouvelle série a commencé avec la publication du Rapport n° 1 en janvier 1982.

CANADIAN TECHNICAL REPORT OF
HYDROGRAPHY AND OCEAN SCIENCES
NO. 95

1987

# SEASONALITY AND DISTRIBUTION OF MARINE BIRDS IN SAANICH INLET, VANCOUVER ISLAND, B.C.

K.H. Morgan, R. Hay and K. Vermeer
Canadian Wildlife Service

Institute of Ocean Sciences
Department of Fisheries & Oceans
Sidney, B. C.     V8L 4B2

Cat. No. Fs 97-18/95   ISSN 0711-6764

Correct citation for this publication:

Morgan,K.H., R. Hay and K.Vermeer. 1987. Seasonality and distribution of marine birds in Saanich Inlet, Vancouver Island, B.C. Can. Tech. Rep. Hydrogr. Ocean Sci. No. 95: iii + 53p.

## ABSTRACT

Morgan, K.H., R. Hay and K. Vermeer. 1987. Seasonality and distribution of marine birds in Saanich Inlet, Vancouver Island, B.C. Can. Tech. Rep. Hydrogr. Ocean Sci. No. 95: iii + 53p.

Seasonal changes in species and populations of marine birds were monitored in Saanich Inlet, Vancouver Island, British Columbia from March to mid-December 1986. Highest population levels and species richness occurred during November and December, largely due to the influx of migrants. In contrast, the number of birds in July declined to less than 10% of the winter population. Shallow bays and areas with extensive intertidal habitats supported the largest and richest avifauna, whereas deep open waters and areas off rocky shorelines had far fewer species and lower densities.

The distribution and foraging activities of many birds, especially those species that fed in the exposed intertidal zone, appeared to be strongly linked to tidal cycles.

Key words: marine birds, seasonality, Saanich Inlet, SE Vancouver Island

## RÉSUMÉ

Morgan, K.H., R. Hay and K. Vermeer. 1987. Seasonality and distribution of marine birds in Saanich Inlet, Vancouver Island, B.C. Can. Tech. Rep. Hydrogr. Ocean Sci. No. 95: iii + 53p.

De mars à la mi-décembre 1986, on a noté les variations saisonnières des espèces et de l'abondance d'oiseaux marins fréquentant l'inlet Saanich, sur l'île de Vancouver (Colombie-Britannique). Les plus grandes richesses spécifique et abondance démographique ont été observées en novembre et décembre quand les migrateurs sont arrivés. Par contre, le nombre d'oiseaux présents à cet endroit en juillet se situait à moins de 10% de l'abondance hivernale. L'avifaune la plus abondante et la plus diversifiée fréquentait es baies peu profondes et les régions englobant d'importants habitats intertidaux. Par contre, les eaux libres profondes et les eaux au large de côtes rocheuses étaient fréquentées par moins d'espèces en nombre moins élevé.

La répartition et les activités de recherche de la nourriture d'un grand nombre d'oiseaux, surtout les espèces qui s'alimentent dans la zone intertidale exposée, semble être étroitement liées au cycle des marées.

Mots-clés: oiseaux marins, caractère saisonnier, inlet Saanich, sud-est de l'île de Vancouver

## INTRODUCTION

It is well documented that marine birds in coastal waters display spatial and seasonal patterns of abundance and distribution (Manuwal et al. 1979, Stott and Olson 1982, Vermeer 1983). Spatial patterns are largely due to the variety of foraging habitats (food type and availability) produced by the complex geomorphology of coastlines. The seasonality of migration and breeding periods is likely related to cycles of prey abundance.

In aerial surveys of the marine birds of the southeast coast of Vancouver Island and adjacent Gulf Islands, Vermeer et al. (1983) observed a great diversity of bird species and densities were found to be as high as 255 birds/km. Unfortunately, Saanich Inlet, the largest fjord along the east coast of Vancouver Island, was not censused at that time. To the best of our knowledge, there have been no published reports of the distribution, abundance or seasonal occurrence of marine birds in this inlet.

The purpose of this study was therefore to characterize the populations of such birds from the mouth of Saanich Inlet to Finlayson Arm. Our objectives were to monitor the spatial and temporal patterns of distribution and abundance and to identify habitat types and geographic areas of importance to marine birds.

## DESCRIPTION OF STUDY AREA

The following description of Saanich Inlet is based on the work of Herlinveaux (1962), Woods and Shaw (1981) and Juniper and Brinkhurst (1984). The inlet is a 24km-long fjord-like embayment, oriented in a north-south direction (Fig. 1). The maximum width, between Patricia Bay and Mill Bay, is 7.2km. The deepest point of the inlet (228m) occurs off Sheppard Point. A shallow sill (75m) at the mouth severely restricts deep-water circulation. Unlike the case of the "classic" fjord, there is no significant source of freshwater at the head of Saanich Inlet. Instead, most freshwater entering the inlet comes from the Cowichan River to the north. Peak discharge from the Cowichan occurs in December, while the minimum is usually in August. The fluctuations in discharge create large variations in the surface salinities at the mouth of Saanich Inlet. Water movement in the inlet is characterized by a net inflow along the Hatch Point side and a net outflow on the Moses Point side.

At Patricia Bay, the average annual precipitation is 81.5cm. Maximum precipitation occurs in December (13.7cm), while the minmum (1.8cm) takes place in July.

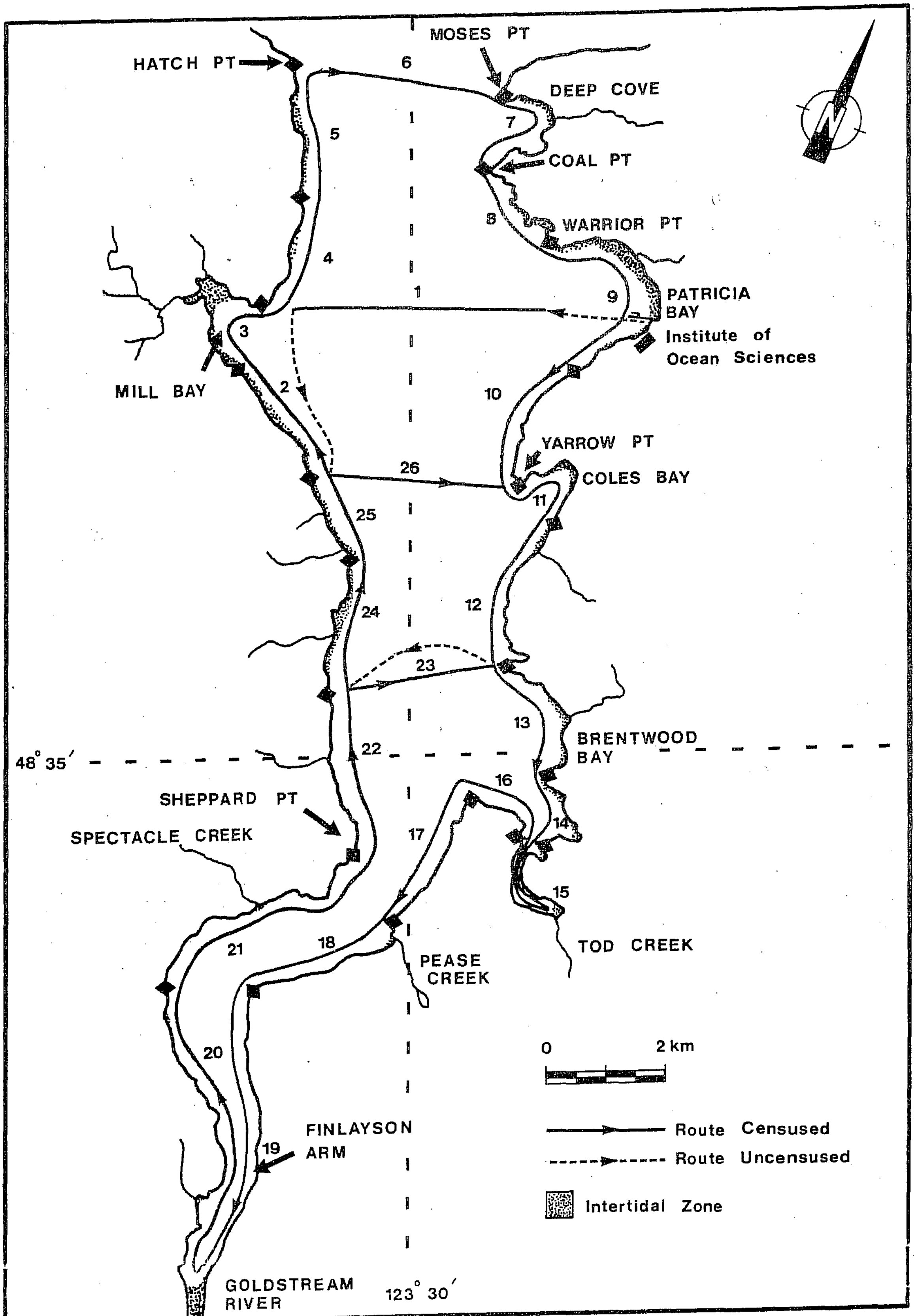



Figure 1. Saanich Inlet, showing the survey route and the location of each transect. Transect numbers are shown along the survey routes.

# METHODS

## Bird Censusing

Saanich Inlet: Censusing of marine birds took place at approximately 2-week intervals, from 11 March 1986 to 15 December 1986. Surveys were conducted from an 8.2m launch. As each census took between 5 and 7 hours, a wide range of tide levels occurred during each survey.

The study area was divided into twenty-two subsections (transects), according to shoreline features. In addition, four open-water transects cut across the inlet. By subdividing the inlet in this manner, we were able to accurately position the location of all birds. During each census, the launch track paralleled the coastline, approximately 150m offshore. All species of birds associated with fresh- or salt-water habitats were tallied. In addition, we made note of all birds roosting on manmade structures.

The data were tabulated both by month and by season. The following dates (modified from Manuwal et al. 1979) were used to define the seasons.
Spring: April 1 - May 15: migration of birds into and through the study area occurred.
Summer: May 16 - August 31: the population consisted primarily of summer residents, non breeders of species that nest elsewhere and a few migrants.
Fall: September 1 - October 31: the majority of southbound migrants passed through the area.
Winter: November 1 - project end: the population consisted of winter residents plus a few late southbound migrants.

Patricia Bay: The marine birds of Patricia Bay were censused from the Institute of Ocean Sciences dock, approximately every 2 weeks from 3 April 1986 to 16 December 1986. The dock extends approximately 380m into the bay, affording an uninterrupted view of the study area. By using highly visible, permanent landmarks, we divided the bay into twelve sectors (Figure 2), again to assist in positioning the location of each bird. Binoculars and a 60-power spotting scope aided in species identification.

During each census, all birds were tallied and their approximate positions were transferred to a hydrographic chart. In addition, all birds observed on shore or in flight were counted (by sector). The activity of every bird was categorized as follows: a)feeding, b)swimming/walking, c)resting or d)flying. As with Saanich Inlet, the data were tabulated by month and by season.

## Habitat Analysis

Saanich Inlet: Each transect was placed into one of four general categories: a)open-water, b)shallow bays, c)rocky shorelines including steep fjord walls, or d)areas (other than bays) characterized by extensive beaches and/or intertidal zones. Very few transects followed exclusively one habitat type. However, we did feel that using the dominant type was an acceptable compromise.

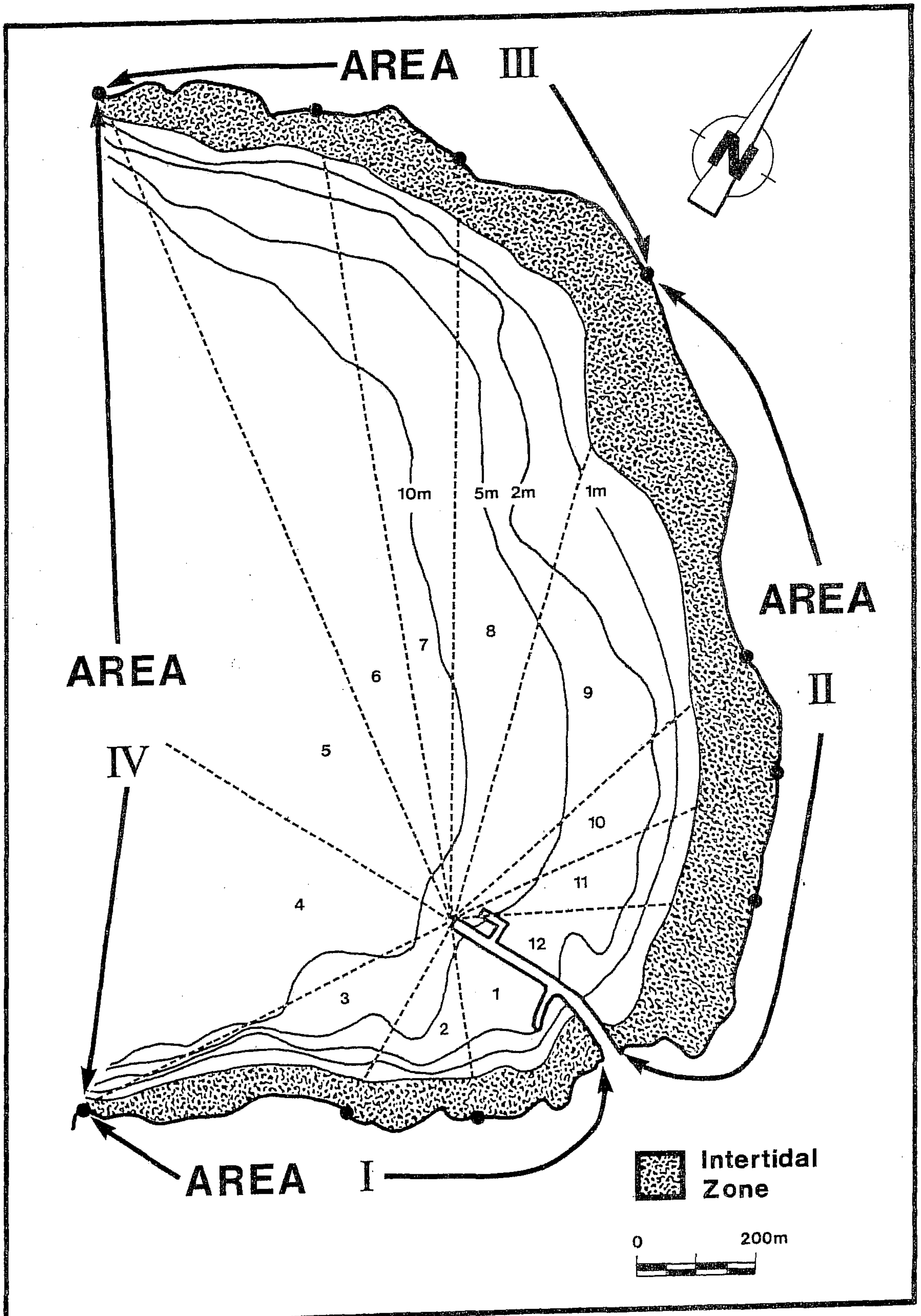



Figure 2. Patricia Bay, showing the location of each sector (1 - 12) and the 4 major habitat areas (I - IV).

Patricia Bay

Intertidal (Areas I,II,III): While it was found convenient to divide Patricia Bay into twelve sectors for the bird censusing, we recognized only four distinct areas (Fig. 2). After examining areas I, II and III at low tide, a permanent reference point was marked (in each area) on an immovable object on the shore.

The distance between zero and maximum high tides was measured in areas I,II and III. A rope, stretched between the reference point and the zero water mark, was used to position fifteen evenly spaced sampling points. The following method was repeated at each sampling point. A 6m line was centred (parallel to the water) at the sampling point. Every species of macroscopic plant and epifauna along this line was noted. Unknowns were collected and fixed with formalin. If pebbles occurred along the line, the 5 nearest the sampling point were measured. When sand was encountered, five holes (spaced at 0.5m intervals along the line) were dug to an approximate depth of 10cm. The sand was coarse-sieved (mesh width 0.5cm) and all infauna was identified or collected. All invertebrate nomenclature used in this report follows Austin (1985).

The vertical distance between successive sampling points was determined by using a sighting level and a surveying rod. After all fifteen sampling points were completed, the five most abundant animals were determined. At the midrange of each of these species, the number per unit area was determined. At the midpoint of the distribution of sand, a 300-500g sample was taken from the upper 10cm and fixed in formalin.

For each area, the total vertical "drop" in the intertidal zone was subdivided to form three subunits (upper, mid and lower intertidal).

Subtidal (Areas I,II,III): By use of SCUBA, the sampling line was extended beyond the zero tide mark to a water depth of approximately 4m. Divers followed the line noting, at 50m intervals, the plants and animals that they observed. A sand sample (top 10cm) was collected midway along each 50m interval. This sample was later fixed with formalin.

Laboratory Sample Processing

Each sand sample was kept separate. The sand was emptied into a sorting pan and all organisms larger than 1mm were removed, counted and identified. In addition, all wood and algal fragments were removed. The remaining material was dried at 200° C and sieved through 2.00mm and 0.06mm stacking sieves. The three fractions were weighed and the proportions of gravel/shell fragments, sand and mud were used to classify the substrate according to Shepard (1954).

Statistical Analysis

Saanich Inlet: Using the habitat categories (open-water, bays etc.) we determined the percent of birds present (in one habitat type) out of the total number observed throughout the inlet during each tide class. The arcsine transformation (Zar 1974) was used on all percentage values. We regressed the transformed data against the tide level.

The total number of birds/km over the entire study period was calculated for each of the twenty-six transects. These values were subjected to a single-linkage weighted (by arithmetic mean) pair group cluster analysis using the complement of the Bray-Curtis coefficient (Romesburg 1984). This allowed us to determine which transects were most similar in bird species composition and densities.

Patricia Bay: The intertidal and subtidal communities from areas I,II and III were tested for similarities using the Jaccard Coefficient of Community (Brower and Zar 1979).

In each of the four areas, the total number of birds/$km^2$ (by species) was calculated. The data was subjected to a single-linkage weighted pair group cluster analysis. This enabled us to determine which areas were most similar.

For each species, the percentage of feeding birds out of the total number present was regressed against the tide level and the time of day.

For each species of bird, we attempted to determine the preferred foraging habitat by examining the proportions feeding in each of four categories: a)exposed intertidal, b)shallow water (less than 2m deep), c)mid-water depth (2-5m) and d)deep water (greater than 5m). The surface area of the four categories was estimated for each of the twelve sectors using a planimeter (Keuffel and Esser) and a hydrographic chart (no. 3441). For each sector, the number of birds by preferred foraging habitat was regressed against the surface area of the respective habitat category.

Sources of Error

Census data of marine birds seldom accurately reflect actual population levels, and consequently are an unavoidable source of error. Environmental conditions have significant effects on the numbers of birds censused because they not only affect the birds' behaviour and their observability, but also influence the observer. There is also considerable variation between observers in experience, visual acuity and ability to estimate flock size and distance (Manuwal et al. 1979).

The habitat analysis was likely another source of error. Sampling from only three locations, undoubtedly ignored substrate variability. Free swimming fauna are poorly represented in the list of intertidal and subtidal species encountered. In spite of several netting attempts, most of these organisms eluded capture. Restricting the sampling to only once (late May) during the entire study was likely a minor source of error. Nyblade (1978) observed that in intertidal areas of the Strait of Juan de Fuca with numerous species (i.e. high species richness), there was only a slight decline in the number of species over the winter. It has been observed in New Jersey (Botton 1984) and in California (Quammen 1984) that during periods of high gull and shorebird densities, the number of intertidal fauna was not significantly reduced.

## RESULTS AND DISCUSSION

### Saanich Inlet

All common and Latin names of birds noted in this paper are listed in Appendix 1. In addition, bird code names (used in several tables and figures) are presented in Appendix 1.

The densities (birds per km of transect) for each species found in Saanich Inlet (averaged over the entire study period) are shown in Appendix 2. We identified 48 species of marine birds between March and December. The seasonal changes in the average number of birds, the average number of species and the average density (birds/km) are listed in Table 1. Figure 3 illustrates the variations that we observed. These changes primarily reflected the two peak migration periods and the breeding season activities. Manuwal et al. (1979) reported similar population and richness trends.

The highest population and the greatest number of species occurred in November and December, due primarily to the influx of winter residents. Total population and species richness were lowest in the summer. The July population consisted mostly of birds that breed either in or near Saanich Inlet (e.g. Pelagic and Double-crested cormorant, Pigeon Guillemot, Common Merganser, Great Blue Heron, Glaucous-winged Gull and possibly Marbled Murrelet); a few nonbreeding White-winged Scoter, Common Goldeneye and Pacific Loon also were present at this time.

The highest average density of birds in Saanich Inlet (93.7 birds/km) was far less than the 255 birds/km Vermeer (1981) observed in aerial surveys of the east coast of Vancouver Island and adjacent Gulf Islands during March. Vermeer stated that large flocks of cormorants, loons, grebes, gulls and diving ducks, had been attracted to the spawning of Pacific Herring (*Clupea harengus pallasi*) in Ganges Harbour, Saltspring Island. While in the past herring have spawned in Saanich Inlet, there presently are no spawning populations (Woods and Shaw 1981). This may account for much of the differences in observed densities.

Table 2 shows how species density and richness changed over the study period in each transect. With few exceptions, peak densities occurred during the winter. Many of the exceptions can be attributed to the occurrence of large numbers of Western Grebes. Rafts varying between 100 and 3800 birds were observed, primarily in deep water. However, a flock of approximately 2100 birds was found in Mill Bay in the early spring. Vermeer (1983) observed that this species reached the Strait of Georgia, from their interior nesting colonies, in early autumn. Its numbers rose during the winter before departing after the spawning of Herring in March.

Table 3 displays the extent of different water habitat types in Saanich Inlet. Open-water and rocky shores accounted for over 80% of the available habitat.

Table 1. Average number of birds, average number of species and average density (birds/km) in Saanich Inlet by month.

| Month | No. of Birds | No. of Species | Density |
|---|---|---|---|
| March | 3991 | 33 | 50.6 |
| April | 4786 | 33 | 60.7 |
| May | 1333 | 24 | 16.9 |
| June | 610 | 15 | 7.7 |
| July | 491 | 12 | 6.2 |
| August | 1000 | 19 | 12.7 |
| September | 1218 | 20 | 15.4 |
| October | 4953 | 27 | 62.8 |
| November | 5918 | 36 | 75.1 |
| December | 7386 | 36 | 93.7 |

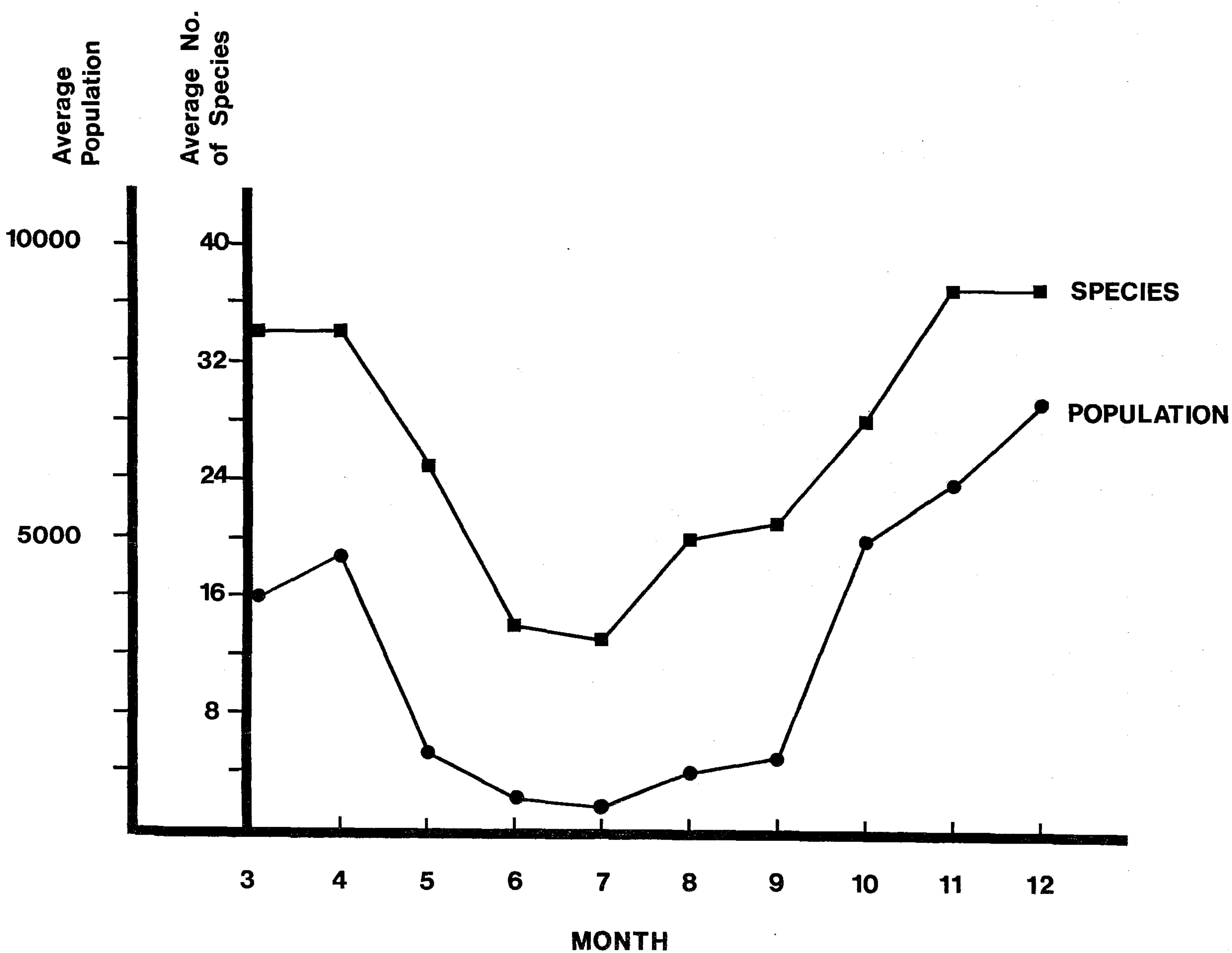



Figure 3. Average total monthly population and average number of species of marine birds observed in Saanich Inlet.

Table 2. Average density (birds/km) (D) and average number of species (R) by season in each of the 26 Saanich Inlet transects. Transect numbers are listed along the left margin. Letters in parentheses refer to habitat type.

| | Spring | | Summer | | Fall | | Winter | |
|---|---|---|---|---|---|---|---|---|
| | D | R | D | R | D | R | D | R |
| 1(o) | 38.5 | 6.0 | 5.0 | 4.0 | 208.5 | 7.5 | 164.6 | 6.6 |
| 2(i) | 37.1 | 12.7 | 16.2 | 5.0 | 25.6 | 10.5 | 84.2 | 15.0 |
| 3(b) | 404.7 | 15.3 | 20.3 | 6.8 | 69.5 | 11.0 | 374.8 | 19.0 |
| 4(r) | 26.9 | 10.3 | 9.2 | 4.0 | 12.8 | 6.0 | 42.4 | 14.8 |
| 5(i) | 26.2 | 8.3 | 21.6 | 4.4 | 29.8 | 10.3 | 70.9 | 14.4 |
| 6(o) | 3.5 | 4.0 | 2.5 | 3.2 | 16.1 | 7.8 | 8.8 | 7.6 |
| 7(b) | 64.5 | 16.7 | 16.4 | 6.4 | 40.4 | 12.0 | 77.4 | 17.4 |
| 8(r) | 92.2 | 17.7 | 20.0 | 7.0 | 36.3 | 11.8 | 110.6 | 16.4 |
| 9(b) | 223.6 | 21.7 | 35.4 | 8.8 | 94.6 | 15.3 | 282.5 | 22.0 |
| 10(r) | 35.5 | 14.7 | 9.2 | 4.4 | 40.4 | 11.8 | 76.9 | 16.2 |
| 11(b) | 82.8 | 13.3 | 8.8 | 3.6 | 22.1 | 7.3 | 68.9 | 11.2 |
| 12(r) | 19.4 | 12.7 | 3.6 | 3.0 | 13.9 | 8.0 | 30.3 | 11.8 |
| 13(b) | 33.6 | 14.3 | 5.5 | 3.8 | 15.5 | 6.8 | 37.4 | 13.6 |
| 14(b) | 53.9 | 7.7 | 52.3 | 2.6 | 40.9 | 4.3 | 70.6 | 12.2 |
| 15(b) | 72.8 | 10.7 | 14.6 | 3.6 | 25.8 | 6.3 | 81.9 | 10.8 |
| 16(r) | 5.6 | 2.0 | 2.1 | 1.0 | 3.8 | 1.8 | 12.8 | 6.4 |
| 17(r) | 12.0 | 6.3 | 6.0 | 1.4 | 5.5 | 3.0 | 17.0 | 9.8 |
| 18(r) | 7.4 | 3.0 | 1.4 | 2.0 | 3.4 | 2.8 | 11.3 | 7.0 |
| 19(r) | 22.5 | 11.7 | 10.2 | 4.2 | 6.2 | 5.8 | 73.9 | 15.0 |
| 20(r) | 10.8 | 7.3 | 5.5 | 3.8 | 8.9 | 6.3 | 26.7 | 12.6 |
| 21(r) | 7.5 | 6.7 | 1.5 | 2.2 | 5.2 | 4.5 | 16.6 | 8.0 |
| 22(r) | 6.2 | 5.7 | 2.6 | 1.4 | 6.6 | 2.8 | 64.2 | 10.8 |
| 23(o) | 2.4 | 2.0 | 1.9 | 1.6 | 2.5 | 3.0 | 10.9 | 4.2 |
| 24(i) | 27.5 | 10.7 | 8.7 | 3.4 | 47.0 | 9.3 | 54.1 | 14.6 |
| 25(i) | 61.5 | 11.0 | 13.5 | 3.4 | 31.7 | 8.8 | 62.4 | 13.8 |
| 26(o) | 13.1 | 4.3 | 1.1 | 2.2 | 75.4 | 3.8 | 24.0 | 6.0 |

Habitat Type Codes: b = shallow bay
i = extensive beach/intertidal
o = open-water
r = rocky shoreline

Table 3. Extent of different water habitat types in Saanich Inlet.

| Habitat Type | Area ($km^2$) | Percent of Total Area |
|---|---|---|
| Bay | 7.93 | 12.3 |
| Beach/Intertidal | 2.77 | 4.3 |
| Rocky Shoreline | 11.20 | 17.4 |
| Open-water | 42.60 | 66.0 |

Table 4 demonstrates that shallow bays, followed by areas with extensive intertidal normally had the highest bird densities, while open-water and rocky shore habitats supported far fewer birds. Manuwal et al. (1979) and Wahl and Speich (1983) noted that the highest bird densities were usually observed in shallow bays; whereas the lowest numbers occurred in deep waters.

Species of birds that are either closely related, or exploit a resource in a similar manner, were combined into groupings (or guilds). Appendix 1 lists the guilds that each species belonged to. Figures 4a to 4j show that, with the exception of loons and sea ducks, the average number of birds present in the inlet peaked during the winter. Pacific Loons are frequently observed in very large flocks along the southern B.C. coast during spring and fall (Vermeer et al. 1983). A flock of 350 birds, present briefly during October, created the fall peak of loons. A spring peak in sea ducks has been reported elsewhere (Vermeer 1981, Vermeer et al. 1983). It was suggested by Vermeer (1981) that this peak was largely due to the influx of White-winged and Surf scoters from the United States west coast en route to their northern breeding grounds.

Table 5 lists the average number of birds/km of the 28 most common species, by habitat type. Where each species reached its highest density may suggest a preferred habitat type. The following species groupings refer to Table 5.

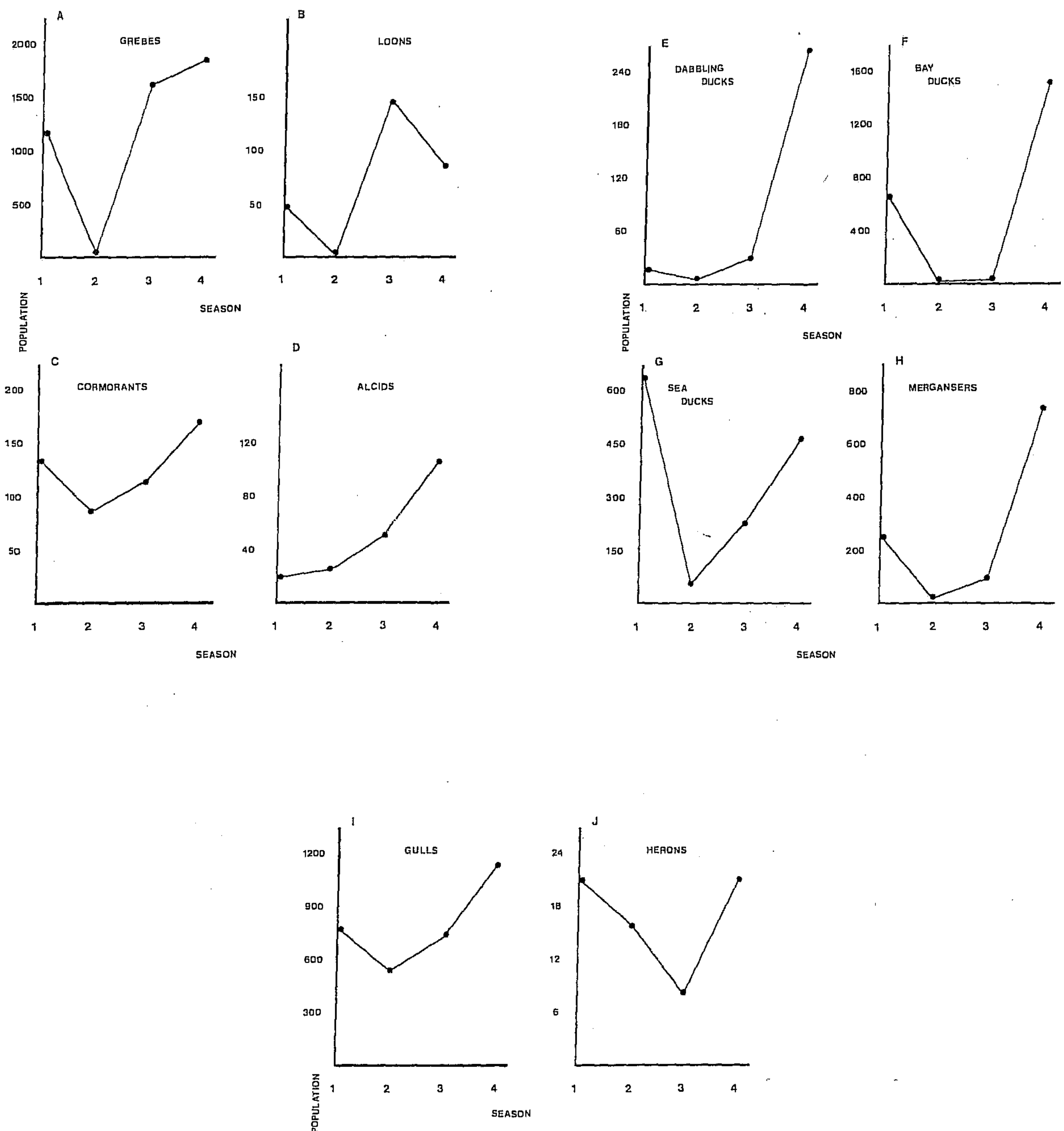
Open-water Species: Pacific Loon, Western Grebe and Common Murre were usually found in open-water habitats. According to Angell and Balcomb (1982) and Trethewey (1985), these 3 species normally feed either in open-waters (especially over reefs) or in the deep entrances of bays and estuaries. Areas with strong tidal rips are reported to be favoured by Pacific Loon and Common Murre (Manuwal et al. 1979, Angell and Balcomb 1982, Vermeer et al. 1983). However, when fishing is good these species will move into shallow waters where they capture a variety of fish including Pacific Herring, Shiner Sea Perch (*Cymatogaster aggregata*), salmon, sculpin and blennies (Phillips and Carter 1957, Angell and Balcomb 1982, Petersen 1983). They will also occasionally take crabs, shrimp, polychaetes, and gammarid amphipods

Shallow Bay Species: Common Loon, Horned Grebe and Red-necked Grebe forage for fish, crabs, shrimp and amphipods, both offshore and nearshore. However, they show a preference for sheltered bays, estuaries and entrance channels (Manuwal et al. 1979, Vermeer et al. 1983).

Double-crested and Pelagic cormorants were more abundant in shallow bays than in other habitats. Both species feed primarily upon fish and shrimp. Double-crests are reported to use shallow water estuaries and bays, especially those that have flat bottoms (Morrison et al. 1978, Manuwal et al. 1979, Ainley et al. 1981, Nysewander 1983a, Vermeer 1983). Pelagic Cormorants also utilize shallow waters, feeding in the intertidal zone (Dow 1964, Vermeer et al. 1983). However, according to Robertson (1974), Manuwal et al. (1979), Ainley et al. (1981) and Nysewander (1983a) this species usually forages in waters along rocky shores or in the surf beside steep cliffs.

Table 4. Average number of birds/survey and average bird density/survey in Saanich Inlet. Numbers in parentheses are standard deviations. Data were averaged over the entire study period (n=17 surveys).

| Habitat Type | Average No. Birds/Survey | Average No. Birds/km/Survey |
|---|---|---|
| Bay | 336.5 (240.5) | 73 2 (52.4) |
| Beach/Intertidal | 143.7 (13.4) | 42 6 (12.3) |
| Rocky Shoreline | 86.6 (69.8) | 21.7 (17.5) |
| Open-water | 189.3 (245.4) | 36.4 (47.2) |




Figures 4a - j. Average seasonal populations of birds in Saanich Inlet by guilds ( 1 = spring, 2 = summer, 3 = fall, 4 = winter).

Table 5. Average densities (birds/km) for the 28 most common species of birds by habitat type. Where each species reached its highest density is indicated by *. Numbers in parentheses are standard deviations.

| Species | Open | Bay | Intertidal | Rocky |
|---|---|---|---|---|
| Pacific Loon | 1.29(2.17)* | 0.31(0.39) | 0.16(0.12) | 0.46(0.67) |
| Western Grebe | 35.16(46.99)* | 8.65(14.69) | 0.30(0.47) | 0.06(0.06) |
| Common Murre | 0.75(0.60)* | 0.02(0.03) | 0.02(0.03) | 0.05(0.08) |
| Common Loon | 0.11(0.11) | 0.69(0.55)* | 0.39(0.25) | 0.16(0.14) |
| Horned Grebe | 0.09(0.16) | 4.59(3.97)* | 1.66(1.46) | 0.99(0.86) |
| Red-necked Grebe | 0.12(0.07) | 1.41(1.30)* | 0.56(0.52) | 0.35(0.28) |
| Double-crstd Cormorant | 0.16(0.12) | 1.70(0.65)* | 0.77(0.47) | 0.38(0.11) |
| Pelagic Cormorant | 0.18(0.12) | 1.45(0.49)* | 0.44(0.33) | 0.76(0.61) |
| Great Blue Heron | 0.01(0.01) | 0.55(0.39)* | 0.14(0.09) | 0.09(0.02) |
| Mallard | 0.00 | 0.16(0.13)* | 0.06(0.05) | 0.05(0.04) |
| White-winged Scoter | 0.15(0.10) | 7.16(7.69)* | 0.59(0.88) | 0.66(0.74) |
| Surf Scoter | 0.11(0.09) | 5.81(4.54)* | 1.33(1.52) | 0.63(0.67) |
| Oldsquaw | 0.04(0.08) | 0.09(0.16)* | 0.02(0.04) | 0.04(0.06) |
| Common Goldeneye | 0.00 | 2.22(3.79)* | 0.97(1.67) | 0.49(0.84) |
| Bufflehead | 0.00 | 5.62(9.36)* | 1.47(2.55) | 0.55(0.96) |
| Common Merganser | 0.00 | 0.40(0.31)* | 0.25(0.23) | 0.22(0.27) |
| Red-breasted Merganser | 0.22(0.23) | 3.61(4.37)* | 1.48(1.69) | 1.22(1.63) |
| Hooded Merganser | 0.00 | 0.30(0.09)* | 0.00 | 0.03(0.03) |
| Mew Gull | 0.15(0.11) | 2.29(2.54)* | 1.53(0.68) | 0.76(0.39) |
| Glaucous-winged Gull | 1.04(0.09) | 14.25(4.27)* | 8.25(3.64) | 3.82(0.98) |
| Pigeon Guillemot | 0.03(0.02) | 0.20(0.08)* | 0.11(0.09) | 0.08(0.05) |
| American Wigeon | 0.03(0.05) | 0.73(1.19) | 0.98(0.69)* | 0.21(0.24) |
| Barrow's Goldeneye | 0.00 | 1.86(3.11) | 2.19(3.79)* | 1.10(1.88) |
| Bonaparte's Gull | 0.41(0.31) | 0.99(0.86) | 1.53(1.79)* | 0.54(0.57) |
| California Gull | 0.14(0.17) | 0.46(0.39) | 2.73(2.47)* | 0.29(0.31) |
| Marbled Murrelet | 0.05(0.05) | 0.13(0.02) | 0.24(0.05)* | 0.09(0.05) |
| Harlequin Duck | 0.00 | 0.08(0.11) | 0.02(0.04) | 0.16(0.13)* |
| Rhinoceros Auklet | 0.01(0.01) | 0.01(0.01) | 0.01(0.01) | 0.06(0.02)* |

Great Blue Herons were most frequently observed either foraging on beaches and in the shallow intertidal, or roosting on rocks and trees around shallow bays. Krebs (1974) noted that herons preyed heavily on Staghorn Sculpin (*Leptocottus armatus*), Starry Flounder (*Platichthys stellatus*), Shiner Sea Perch and Penpoint Gunnel (*Apodichthys flavidus*), species that frequently occur near eelgrass beds and pilings in estuaries and shallow bays (Eschmeyer et al. 1983).

Nine species of ducks reached their highest densities in bay habitats. In marine environments, Mallards feed primarily on plant material, notably eelgrass and various species of algae that grow in the high intertidal. They will however also take small crustaceans and molluscs and scavenge on dead salmon and salmon eggs (Bent 1962a, Angell and Balcomb 1982). These foods are often abundant along the sand and gravel shores of shallow bays and estuaries.

Shallow bays also supported the highest densities of White-winged and Surf Scoters. According to Vermeer and Bourne (1984) Surf Scoters are generally more numerous in B.C. than are White-winged Scoters. In Saanich Inlet, the reverse occurred, with White-winged Scoters being more abundant.

Numerous authors report that White-winged Scoters forage in shallow waters, feeding primarily on bivalves and gastropods and to a lesser extent on crustaceans, polychaete worms and fish (Cottam 1939, Bent 1962b, Forsell and Gould 1981, Stott and Olson 1982, Sanger 1983, Vermeer 1983, Sanger and Jones 1984, Vermeer and Bourne 1984). This species is primarily a benthic feeder, taking clams and snails either from the top or from within the substrate. While White-winged Scoters can dive to depths of at least 12m (Cottam 1939), they usually feed in water less than 5m deep. Because of their preference for benthic feeding, they are scarce along the continuous rocky shores of deep fjords (Vermeer and Bourne 1984).

Surf Scoters are reported to be most abundant along the steep rock walls of deep fjords. In such locations, they feed primarily upon Blue Mussels (*Mytilus edulis*) (Vermeer et al.1983, Vermeer and Bourne 1984). Molluscs, especially bivalves make up the bulk of their diet (Cottam 1939, Bent 1962b, Vermeer and Levings 1977, Sanger 1983). Depending on the location, and therefore on prey availability, Surf Scoters will also feed on polychaetes, barnacles, crabs, fish, sea urchins, sand dollars and starfish taken from waters usually shallower than 9m (Cottam 1939, Dow 1964, Bent 1962b, Sanger 1983).

In this study we did not find Surf Scoters to be abundant along rocky shorelines. Instead, the highest densities occurred in shallow bays. This has been observed along both Pacific (Grosz and Yocom 1972, Scott-Brown 1976, Manuwal et al. 1979) and Atlantic coastlines (Stott and Olson 1982). Stott and Olson reported that there was a decrease in density as the proportion of rocky substrate increased and in their opinion, the tendency to associate Surf Scoters with fjord walls and rocky headlands was erroneous. They claimed that the scoters must pass through these areas en route to shallow bays, their preferred foraging areas. Shallow bays and extensive intertidal zones are typically scarce or absent in most fjords. Consequently, Surf Scoters must forage along the fjord walls. Blue Mussels are often the most abundant intertidal organism attached to these steep walls.

Oldsquaws are considered by many authors to be generalists, well distributed over all habitat types (Bent 1962b, Stott and Olson 1982, Sanger 1983, Johnson 1984). Showing no clear habitat preferences, this species will: glean food along the edge of the beach (Bent 1962b); feed on epibenthic prey in shallow water (Krasnow and Sanger 1982, Johnson 1984); or feed in open water habitats, regularly diving to depths of 20m or more (Angell and Balcomb 1982). Their diet consists of a wide range of prey including gammarid amphipods, bivalves, gastropods, isopods, copepods, polychaetes, fish and fish eggs (Cottam 1939, Krasnow and Sanger 1982, Stott and Olson 1982, Sanger 1983, Vermeer 1983, Sanger and Jones 1984). Johnson (1984) found a close relationship between the relative volume of major invertebrates in Oldsquaw stomachs and in the epibenthos, indicating that this bird species is an opportunistic feeder. Although Oldsquaw were never very abundant in the inlet, they occurred in all habitat types. However, they were most frequently observed in shallow bays.

Common Goldeneyes were also most frequently encountered in shallow bays. This species forages in a broad range of habitats: diving in waters up to 5m deep, in search of molluscs and crustaceans (Dow 1964, Angell and Balcomb 1982) or dabbling in shallow areas near shore, feeding on crabs, isopods, barnacles, gastropods, polychaetes and eelgrass seeds (Bent 1962b, Olney and Mills 1963). Stott and Olson (1982) observed, along the east coast, a preference for rocky areas over sandy beaches. Similarly, Vermeer et al. (1983) stated that Common Goldeneye were common along rocky shores, in fjords, above sand and mud substrates and in estuaries.

Another species that was most abundant in shallow bays was the Bufflehead. Erskine (1972) stated that Bufflehead prefer to forage in shallow water (usually less than 3m deep), feeding mostly during low tides. Off New Hampshire, this species used harbours and bays more readily than the coastline (Stott and Olson 1982). However, when Bufflehead were observed along the coast, they appeared to prefer rocky areas rather than sandy beaches. Vermeer et al. (1983) observed that along the B.C. coast this species occurred close to rocky shores and in sheltered bays. The diet of Bufflehead includes amphipods, shrimp, crabs, isopods, barnacles, bivalves, gastropods, polychaetes, small fish and small quantities of vegetation (Cottam 1939, Bent 1962b, Erskine 1972).

All three species of mergansers were most numerous in shallow bays. Munro and Clemens (1932) stated that Common Mergansers foraged in shallow waters, often very close to shore. Trethewey (1985) observed that this species was most abundant near the mouths of rivers. While primarily a fish eater, they will also take mussels and other molluscs, crabs, shrimp, isopods and polychaetes (Munro and Clemens 1932, Bent 1962a). We found that Common Mergansers were only slightly more abundant in bays than along rocky shores. The highest overall densities occurred (in descending order) near the mouths of Tod Creek, Goldstream River, Spectacle Creek and Pease Creek (Fig. 1). This supports Trethewey's (1985) observations that Common Mergansers were abundant near river mouths.

Red-breasted Mergansers have been reported to be more common close to rocky shores than to sandy areas (Stott and Olson 1982, Vermeer et al. 1983). In contrast, Bent (1962a) and Brattstrom (1965) claimed that this species primarily exploits shallow bays, tidal estuaries and shallows off sandy beaches. These authors also stated that this species usually forages in water less than 1m deep, searching for fish and, rarely, crustaceans and molluscs. Our results suggested that shallow bays were the preferred foraging sites.

Hooded Mergansers were abundant only during the early winter. Vermeer et al. (1983) stated that they were most often observed near rocky shores in sheltered bays. It is suggested that throughout the year, Hooded Mergansers prefer fresh water over marine environments (Bent 1962a, Vermeer et al. 1983). Their diet consists of fish, isopods and amphipods, as well as eelgrass seeds and small amounts of algae (Bent 1962a). We encountered Hooded Mergansers most often between Deep Cove and Yarrow Point.

Mew and Glaucous-winged gulls were also most abundant in sheltered bays. Along the coast, Mew Gulls forage along beaches and mudflats, concentrating especially on kelp and eelgrass beds. They also frequently settle in shallow waters over tidal flats, dipping for edible flotsam at the edge of the beach (Angell and Balcomb 1982, Nysewander 1983b). Crustaceans and fish appear to be the most important components of their diet, although they frequently take polychaetes, gastropods, bivalves and flies (Sanger 1983).

Glaucous-winged Gulls were the most abundant gull throughout the entire study. This species forages in a wide range of habitats, although it favours shallow waters nearshore and along tide rips (Baird 1983, Vermeer 1983). We frequently observed these gulls foraging during low tides on mud flats and rocky intertidal areas. Large numbers of this species often congregated at communal roost sites. Glaucous-winged Gulls are opportunistic feeders, foraging on isopods, crabs, shrimp, barnacles, periwinkles, limpets, chitons, clams, mussels, sea urchins, starfish, polychaetes, fish, fish eggs and plants (Trapp 1979, Baird 1983, Sanger 1983).

A significant increase in the number of gulls took place in Finlayson Arm and the Goldstream estuary during the latter half of November. We observed as many as 750 gulls (85% Glaucous-winged) in less than $3km^2$ . The large numbers coincided with the spawning of salmon. This sudden increase in a rich food supply attracted in unprecedented numbers not only gulls, but also Mallard, White-winged Scoter, Barrow's Goldeneye, Bufflehead, Common and Red-breasted mergansers, Common Murre and Rhinoceros Auklet.

Pigeon Guillemots were the most common alcid in shallow bays. However, they invariably occurred in the deeper waters of the bays. Krasnow and Sanger (1982) described Pigeon Guillemots as the most neritic of all the alcids, feeding almost exclusively on epibenthic prey. This species is an opportunist, feeding on shrimp, crabs, gammarid amphipods, polychaetes, bivalves and many small fish (Krasnow and Sanger 1982, Angell and Balcomb 1982, Sanger 1983). The highest concentration of Guillemots occurred between Deep Cove and Coles Bay.

Species Occurring Off Extensive Beaches: Vermeer et al. (1983) stated, that along the B.C. coast, American Wigeon concentrate near streams and estuaries. They feed on or near the surface by either dabbling in the substrate, or by tipping up in shallow water. Their diet consists almost entirely of plants, especially the seeds and roots of eelgrass, but also ulva and other species of algae (Bent 1962a, Angell and Balcomb 1982). We found Wigeon most often along extensive beaches or against the shores of sheltered bays.

Barrow's Goldeneye were more abundant off extensive beach habitats than elsewhere. According to Vermeer (1982,1983), this species is most common along rocky shores and in fjords. In contrast, Angell and Balcomb (1982) claimed that Barrow's Goldeneye prefer to feed off tidal flats and estuaries, and in protected harbours. Our results more or less agreed with both statements, as the transects with the highest densities were a beach, a bay and a rocky habitat (Appendix 2).

When found along fjord walls, Barrow's Goldeneye feed almost exclusively on Blue Mussels (Vermeer 1982, 1983). Koehl et al. (1984) observed that when Barrow's were feeding along fjord walls during high tides, they fed predominantly on mussels (with attached barnacles and periwinkles). However, at low tide, when the mussels were exposed and therefore unavailable, the goldeneye ate other bivalves, gastropods and crabs. Cottam (1939) stated that they will also eat amphipods, isopods, polychaetes, starfish, sea urchins and fish. Koehl et al. (1984) believed that Barrow's Goldeneye minimize their diving effort by feeding on prey that are available at a given tide level. We suggest that by being a generalist, (rather than specializing only on mussels), Barrow's Goldeneye can exploit a wide range of prey in a variety of habitats.

Bonaparte's and California gulls were far more abundant along those transects with extensive beaches than along any others. Bent (1963) described the Bonaparte's Gull as largely insectivorous, feeding over rafts of drifting seaweed. By plunging headfirst into the water or by probing the edges of beaches for edible flotsam, they capture shrimp, gammarid amphipods and small fish (Bent 1963, Angell and Balcomb 1982, Sanger 1983, Vermeer et al. 1987). California Gulls are opportunistic feeders, scavenging beaches and the exposed intertidal for a variety of organisms including crabs, amphipods, isopods and molluscs. They also feed on small surface swimming fish (Bent 1963). According to Manuwal et al. (1979) extensive gravel and sand beaches are important roost sites at low tides for several gull species, including Bonaparte's and California. We suggest that it was the presence of roost sites that attracted these species to areas with extensive foreshores.

Marbled Murrelets were also more abundant in waters off areas with extensive foreshores. This species is reported to prefer foraging away from shore, off entrance channels, rocky shores and over reefs (Angell and Balcomb 1982, Krasnow and Sanger 1983). The literature suggests that Marbled Murrelet feed throughout the entire water column, capturing small schooling fish, mysids, euphausiids and gammarid amphipods (Angell and Balcomb 1982, Sanger 1983). Manuwal et al. (1979) reported that this species often forages in tidal convergences. Typical of most of the areas with extensive beaches was a steep dropoff below the intertidal zone. We suggest that this feature may at times create increased turbulence or upwelling. Such an enriched environment would likely support greater numbers of prey.

Rocky Shore Species: Harlequin Ducks are opportunistic feeders, often foraging in shallow, turbulent waters along rocky shores (Bent 1962b, Manuwal et al., Dzinbal and Jarvis 1984). Their diet includes crabs, gammarid amphipods, limpets, chitons, mussels, and occasionally fish and eelgrass (Cottam 1939, Bent 1962b, Dzinbal and Jarvis 1984). In Saanich Inlet, Harlequins were only slightly more abundant along rocky shores. Never numerous, they were observed in only 8 transects. The area between Coal Point and Warrior Point, which features many small islets and rocky points consistently had the highest number of Harlequins.

Rhinoceros Auklet was another species that was more abundant along rocky shores. Angell and Balcomb (1982) reported that in coastal waters this species feeds in estuaries and in entrance channels especially over reefs diving for a variety of fish including Pacific Herring and Pacific Sand Lance (*Ammodytes hexapterus*). In this study, Rhinoceros Auklets were often observed along the rock walls of Finlayson Arm. They also occasionally occurred at the mouth of the inlet east of Hatch Point. These locations fit the description by Angell and Balcomb of preferred foraging habitats. This species was never abundant in Saanich Inlet. Between March and mid-November, we observed on average 1 Rhinoceros Auklet per month. However, from mid-November until the end of the study, there were as many as 13 auklets present. The increase, mostly in Finlayson Arm, was likely related to the salmon spawning in Goldstream River.

## Influence Of Tide Level On Bird Distribution

The proportion of birds within each habitat type during a given tidal interval (out of the total number present in the entire inlet), were regressed against the mid-point of each interval (Table 6). The proportion of birds present off beach habitats and off rocky shores showed no significant association with the tide level. In contrast, the bird populations in bays and in open-waters appeared to be strongly correlated with tidal level. As the level rose, bays supported a decreasing percentage of birds (Fig. 5a). We interpret this to indicate that during low water, there were greater opportunities for feeding, loafing or roosting. We also suggest that the increase in the proportion of birds in open-water habitats as the tide rose (Fig. 5b) was largely a result of birds leaving the bays.

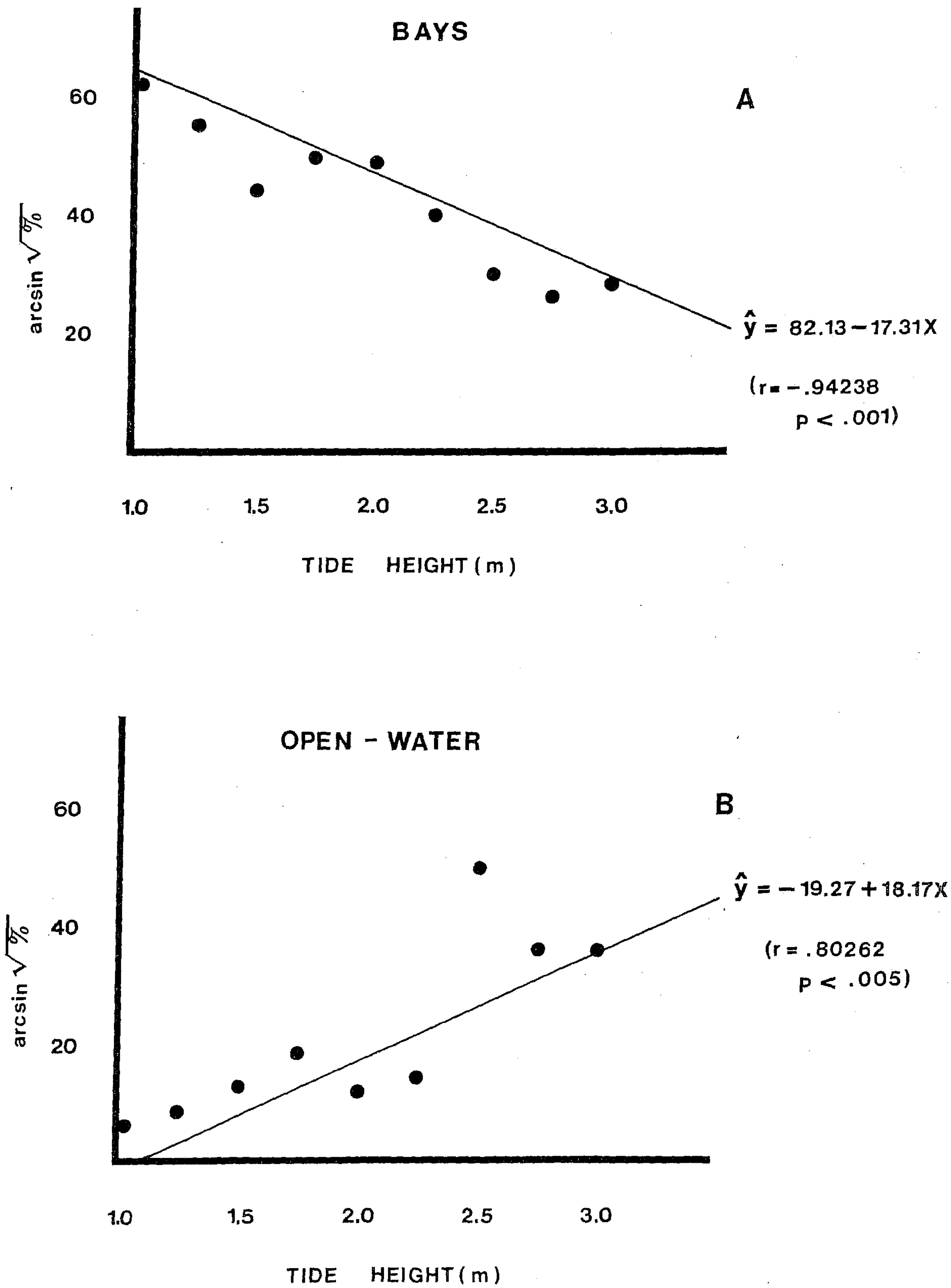
## Transect Density Similarities

Figure 6 displays the results of the cluster analysis of the bird species densities in each transect. Out of thirteen pair combinations, nine were of the same habitat type. Apparently, like habitats were exploited by similar bird species in similar densities. In several cases, the clustering occurred either between adjacent transects or between transects on opposite sides of the inlet, regardless of habitat type. This suggested several

Table 6. Number of birds observed within each habitat type by tide interval. The proportion within each habitat type were regressed against the mid-point of each tide interval. Regression analysis results are presented beneath each habitat type.

| | Habitat Type | | | | |
|---|---|---|---|---|---|
| Tide Interval (meters above zero water level) | Beach | Rocky | Bay | Open | Total |
| 1.00-1.25 | 316 | 877 | 4883 | 79 | 6155 |
| 1.26-1.50 | 202 | 310 | 1187 | 39 | 1738 |
| 1.51-1.75 | 216 | 342 | 593 | 60 | 1211 |
| 1.76-2.00 | 772 | 1322 | 4095 | 682 | 6871 |
| 2.01-2.25 | 44 | 907 | 1308 | 94 | 2353 |
| 2.26-2.50 | 751 | 905 | 1339 | 172 | 3167 |
| 2.51-2.75 | 715 | 754 | 2519 | 5901 | 9889 |
| 2.76-3.00 | 1814 | 1222 | 1361 | 2399 | 6796 |
| 3.01-3.25 | 1142 | 3456 | 3005 | 4820 | 12423 |
| | r=.3493 | r=.0895 | r=-.9420 | r=.8026 | |
| | ns | ns | p<.001 | p<.005 | |

ns = non-significant




Figures 5a and 5b. Percentage of birds (of total Saanich Inlet population) present in bays and open-water habitats relative to tide height. Regression analysis results are also presented.

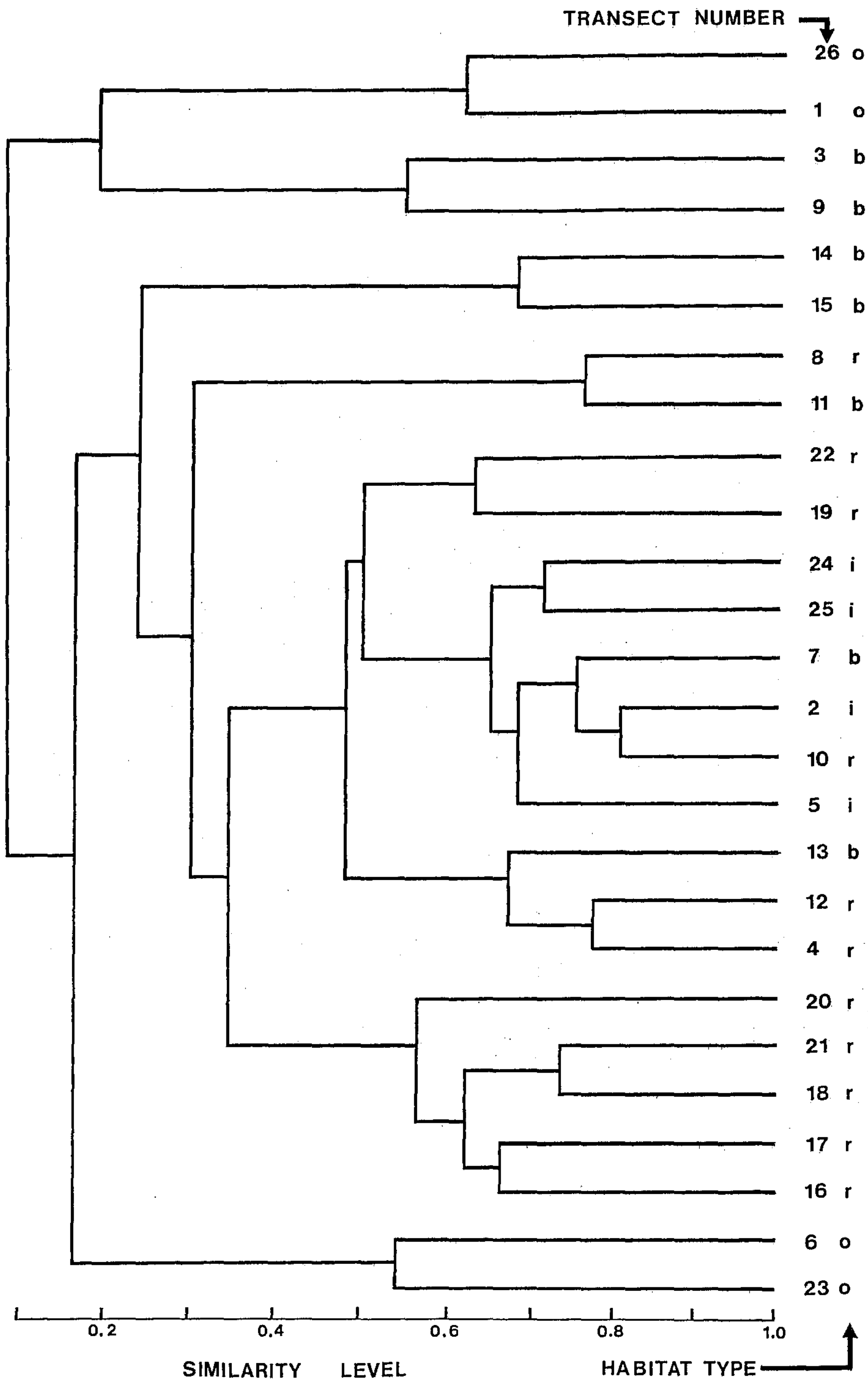



Figure 6. Dendrogram of the cluster analysis of species densities in each of the 26 transects. A high similarity level indicates a greater number of shared species and similar population densities. See Table 2 for habitat-type codes.

possibilities: 1)some transects had been incorrectly labelled, 2) the actual habitat differences between some transects were only minor and had little impact on the birds, and 3) many species of marine birds have wide habitat tolerances, allowing them to exploit a variety of situations. We believe that each of these suggestions is partially correct.

Patricia Bay

Appendix 3 lists all of the species identified from the habitat sampling, as well as providing a brief description of areas I,II and III.

Table 7 (summary of Appendix 3) shows that area I had the highest species richness. Nyblade (1978) observed that in the Strait of Juan de Fuca species richness was highest in the rocky intertidal, while exposed sand and gravel areas had the fewest species. Our results were similar. By using the Jaccard Coefficient of Community Similarity, we calculated how the intertidal and subtidal communities differed between the three areas. This coefficient ranges from 0 (no species common to both communities) to 1.0 (all species common to both communities) (Brower and Zar 1979). The values listed in Table 8 show that while areas II and III were most similar, the degree of overlap (ie. shared species) was quite low. This suggests that, at least on the basis of species presence/absence, the three areas were fairly distinct.

Figure 7 illustrates the monthly changes in the average number of birds and the average number of species in Patricia Bay. The relationships followed closely those observed in Saanich Inlet (Fig. 3).

Table 9 lists the bird species densities observed in each area during the entire study period. Area II supported the greatest number of species (34) and more species reached their maximum density there than in the other areas. While the second highest species richness occurred in area III, only two species reached their peak density there. As would be expected for a deep water habitat, area IV had the lowest species richness.

Foraging habitat is likely to be more crucial to a species of bird than is (for example) a roost site. Table 10 shows the feeding densities in each sector of the 20 most common bird species. Area I appeared to be the most frequently used foraging location of Common Loon, Horned Grebe, Pelagic Cormorant, Barrow's Goldeneye and Bufflehead. All but Pelagic Cormorants foraged in the shallower waters of this area, Pelagics foraged more often in slightly deeper waters.

Double-crested Cormorant, White-winged Scoter, Surf Scoter, Common Goldeneye and Marbled Murrelet foraged most heavily in the shallow waters of area II, close to shore. Great Blue Heron, Glaucous-winged Gull and Mew Gull also foraged more in area II, hunting either in the exposed intertidal or in the extreme shallows at the water's edge. Mallards and American Wigeon usually fed during low tide, on the extensive beds of eelgrass and algae (especially Ulva sp. and Enteromorpha sp.) as well as along the water's edge.

Western Grebe, Red-necked Grebe and Red-breasted Merganser foraged more

Table 7. Summary of Appendix 3, listing the number of intertidal and subtidal species found in Patricia Bay by area. Also listed are the average densities of the most common intertidal organisms and the average number of molluscs found in the subtidal sediment samples.

| | Area | | |
|---|---|---|---|
| | I | II | III |
| Number of species of: | | | |
| Plants | 16 | 8 | 11 |
| Annelida | 18 | 16 | 9 |
| Crustacea | 40 | 30 | 22 |
| Mollusca | 32 | 25 | 23 |
| Echinodermata | 10 | 3 | 6 |
| others | 14 | 8 | 8 |
| Total | 130 | 90 | 79 |
| Intertidal | | | |
| Average density (no./$m^2$) | | | |
| Barnacles | 34000 | 16000* | 38000 |
| Periwinkles | 8500 | 2000* | 5500 |
| Mussels | 400 | 2400* | 500 |
| Limpets | 400 | 1300* | 1900 |
| Subtidal Molluscs | | | |
| Average density/ kg of sediment (dry weight) | | | |
| Gastropods | 15 | 25 | 17 |
| Bivalves | 30 | 60 | 35 |

* note: these densities apply to rock surfaces only. As there were very few rocks in area II, the overall density of these organisms was extremely low.

Table 8. Similarities between the intertidal and subtidal communities of areas I,II and III (Patricia Bay) using the Jaccard Coefficient.

| | Area I-Area II | Area I-Area III | Area II-Area III |
|---|---|---|---|
| Jaccard Coefficient | .3949 | .4247 | .4444 |

$$\text{Jaccard Coefficient} = \frac{C}{S1+S2-C}$$

where: C is the number of species common to both communities and S1 and S2 are the total number of species in communities 1 and 2 respectively

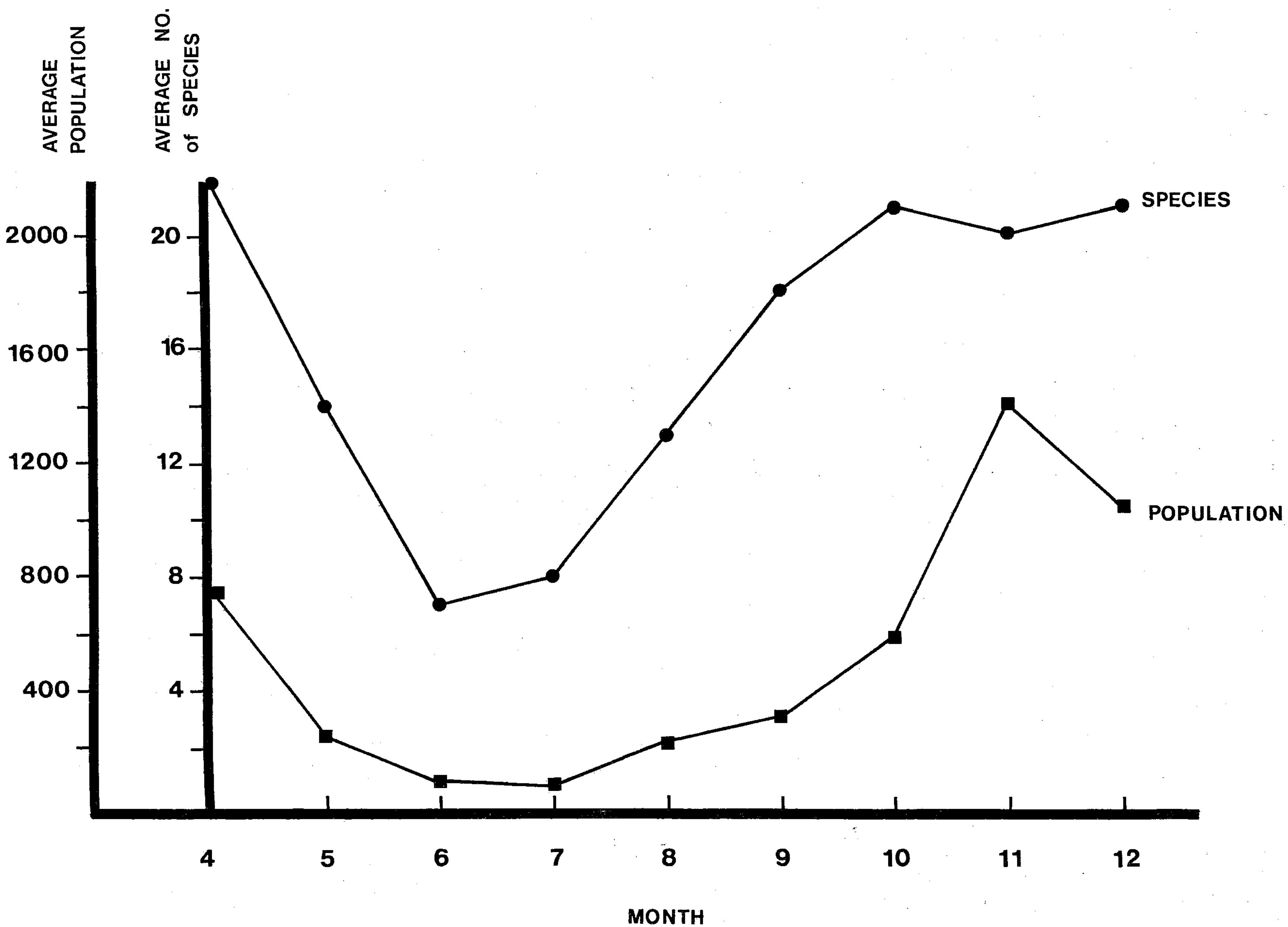



Figure 7. Average monthly population and average number of species of marine birds observed in Patricia Bay.

Table 9. Species densities (birds/km$^2$) for each area of Patricia Bay (entire study period). The area in which a species reached its maximum density is indicated by *.

| Species | Area I | Area II | Area III | Area IV |
|---|---|---|---|---|
| Common Loon | 151.63* | 98.16 | 74.98 | 50.12 |
| Pacific Loon | 12.13 | 6.69 | 17.41 | 36.85* |
| Red-throated Loon | 0.00 | 2.23* | 0.00 | 0.00 |
| Western Grebe | 0.00 | 22.31 | 44.19* | 4.42 |
| Red-necked Grebe | 181.95 | 149.48 | 239.68* | 128.24 |
| Horned Grebe | 934.01* | 760.77 | 740.47 | 63.38 |
| Eared Grebe | 30.33* | 11.16 | 2.68 | 0.00 |
| Pied-billed Grebe | 0.00 | 2.23* | 1.34 | 0.00 |
| Double-crested Cormorant | 103.11 | 116.01 | 60.26 | 364.08* |
| Pelagic Cormorant | 54.59 | 24.54 | 24.10 | 100.23* |
| Brandt's Cormorant | 0.00 | 2.23* | 0.00 | 0.00 |
| Great Blue Heron | 48.52* | 42.39 | 8.03 | 2.95 |
| Canada Goose | 42.46* | 2.23 | 0.00 | 0.00 |
| Mallard | 30.33 | 127.17* | 37.49 | 0.00 |
| Green-winged Teal | 0.00 | 8.92* | 0.00 | 0.00 |
| Blue-winged Teal | 0.00 | 20.08* | 0.00 | 0.00 |
| American Wigeon | 236.54 | 310.11* | 258.43 | 5.89 |
| Northern Pintail | 0.00 | 11.16* | 0.00 | 0.00 |
| Greater Scaup | 0.00 | 249.87* | 29.46 | 0.00 |
| Black Scoter | 0.00 | 22.31* | 1.34 | 0.00 |
| White-winged Scoter | 278.99 | 1885.19* | 283.87 | 17.69 |
| Surf Scoter | 163.76 | 785.31* | 376.26 | 224.05 |
| Oldsquaw | 18.19* | 0.00 | 8.03 | 2.95 |
| Barrow's Goldeneye | 260.79* | 66.93 | 53.56 | 0.00 |
| Common Goldeneye | 242.60* | 187.40 | 133.90 | 20.48 |
| Bufflehead | 412.42 | 588.98* | 295.92 | 2.95 |
| Common Merganser | 54.59* | 0.00 | 5.36 | 0.00 |
| Red-breasted Merganser | 248.67 | 294.49 | 435.18 | 496.74* |
| Hooded Merganser | 24.26 | 37.93* | 4.02 | 0.00 |
| Bonaparte's Gull | 30.33 | 44.62* | 44.19 | 7.37 |
| Mew Gull | 60.65 | 374.81* | 89.71 | 23.58 |
| California Gull | 0.00 | 33.47* | 5.36 | 0.00 |
| Thayer's Gull | 0.00 | 0.00 | 1.34* | 0.00 |
| Western Gull | 0.00 | 2.23* | 0.00 | 0.00 |
| Glaucous-winged Gull | 648.96 | 992.79* | 263.78 | 69.28 |
| Common Tern | 0.00 | 0.00 | 0.00 | 26.53* |
| Common Murre | 0.00 | 0.00 | 2.68 | 14.74* |
| Pigeon Guillemot | 12.13 | 11.16 | 16.07 | 20.64* |
| Marbled Murrelet | 12.13* | 11.16 | 4.02 | 1.47 |
| Total species observed | 25 | 34 | 31 | 23 |

Table 10. Average feeding densities (birds/km$^2$) for the twenty most common species of birds in Patricia Bay. Densities were averaged over the entire study period. See Appendix 1 for species codes.

| | Area I | | | Area IV | | Area III | | | Area II | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| COLO | 161 | 165 | 89 | 39 | 25 | 37 | 64 | 51 | 50 | 105 | 63 | 142 |
| PALO | 0 | 0 | 13 | 19 | 51 | 6 | 5 | 4 | 4 | 15 | 0 | 0 |
| WEGR | 0 | 0 | 0 | 0 | 3 | 46 | 16 | 0 | 25 | 35 | 16 | 0 |
| RNGR | 121 | 275 | 114 | 105 | 42 | 31 | 354 | 166 | 71 | 15 | 78 | 142 |
| HOGR | 484 | 1651 | 380 | 62 | 11 | 176 | 370 | 1093 | 454 | 690 | 516 | 568 |
| DCCO | 60 | 55 | 51 | 4 | 65 | 9 | 32 | 38 | 21 | 105 | 63 | 90 |
| PECO | 40 | 0 | 76 | 19 | 3 | 3 | 21 | 17 | 4 | 15 | 0 | 26 |
| GBHE | 40 | 0 | 38 | 0 | 0 | 0 | 5 | 13 | 21 | 30 | 0 | 116 |
| MADU | 60 | 0 | 13 | 0 | 0 | 37 | 0 | 0 | 0 | 255 | 375 | 361 |
| AMWI | 121 | 138 | 63 | 0 | 0 | 243 | 370 | 0 | 121 | 0 | 0 | 516 |
| WWSC | 101 | 578 | 190 | 19 | 3 | 243 | 32 | 234 | 937 | 150 | 735 | 1627 |
| SUSC | 161 | 110 | 114 | 47 | 181 | 299 | 171 | 145 | 287 | 90 | 954 | 736 |
| BAGO | 81 | 303 | 228 | 0 | 0 | 37 | 32 | 47 | 42 | 0 | 63 | 52 |
| COGO | 20 | 110 | 114 | 0 | 0 | 117 | 48 | 85 | 54 | 15 | 31 | 232 |
| BUFF | 383 | 826 | 114 | 8 | 0 | 182 | 279 | 315 | 396 | 705 | 360 | 736 |
| RBME | 81 | 83 | 317 | 97 | 169 | 330 | 0 | 315 | 316 | 135 | 109 | 155 |
| MEGU | 20 | 0 | 0 | 8 | 0 | 3 | 0 | 17 | 162 | 120 | 172 | 39 |
| GWGU | 242 | 413 | 203 | 0 | 3 | 31 | 59 | 102 | 192 | 180 | 438 | 387 |
| PIGU | 0 | 0 | 12 | 27 | 8 | 14 | 5 | 4 | 10 | 0 | 0 | 0 |
| MAMU | 0 | 0 | 25 | 0 | 0 | 3 | 0 | 4 | 12 | 30 | 0 | 0 |

frequently in area III. Red-necked Grebe and Red-breasted Merganser were most often observed diving very close to shore, whereas Western Grebe generally hunted in the deepest waters of this area.

Only 2 species (Pacific Loon and Pigeon Guillemot) foraged primarily in area IV. While several authors state that Pigeon Guillemots forage in shallow waters of bays and along beaches (Angell and Balcomb 1982, Sanger 1983, Vermeer 1983), this was not the case in Patricia Bay.

Figure 8 shows the results of the cluster analysis of the bird species densities from the 4 areas. Areas I and III, which appeared quite similar physically (ie. rocky shorelines), shared the highest number of species (75% overlap). As mentioned earlier, areas I and II had more intertidal fauna in common. The analysis therefore suggests that the birds may have been responding more to broad habitat features, than to variations in the abundance of intertidal prey. As expected, area IV had fewer bird species in common with the other 3 areas (35% overlap).

Table 11 lists the results of the regression analyses between the proportion of birds feeding and tide height, and time of day. Seven species showed significant negative associations between the proportion feeding and the tide height. Birds that forage in the exposed intertidal and in shallow waters at the edge of the beach (Great Blue Heron, Mallard, American Wigeon, Mew Gull and Glaucous-winged Gull) were most negatively correlated with tide level. White-winged Scoter and Barrow's Goldeneye also fed less with increasing tide height. These negative correlations may have been related to a greater availability of benthic prey at low tide. Nyblade (1978) noted that the richness and diversity of invertebrates increased with decreasing tide height. Common Goldeneye was the only species that showed a significant positive association with increasing tide height. This species feeds heavily on crab, shrimp and amphipods (Cottam 1939, Olney and Mills 1963). Such prey may either be more active (and therefore more easily detected) on flooding tides, or they may be more abundant in the upper intertidal.

For three species of birds, the proportion feeding decreased significantly with the time of day. Energy requirements are at their highest in the morning, possibly explaining why many species feed more heavily at this time. Double-crested Cormorant was the only species that showed a significant positive correlation with time of day. We can offer no explanation for this result.

Although the feeding proportions of Surf Scoters and White-winged Scoters followed very similar patterns with the time of day, they did peak at different time intervals during the afternoon (Figure 9a). This may demonstrate a way of reducing food competition between two closely-related species.

Figures 9b and 9c show the percentage of Mallard and American Wigeon feeding versus the time of day. Bent (1962a) stated that Wigeon feed mostly in the early morning and again in the late afternoon. Figure 9b suggests that Mallard were also more active feeders in the early and late hours of the day.

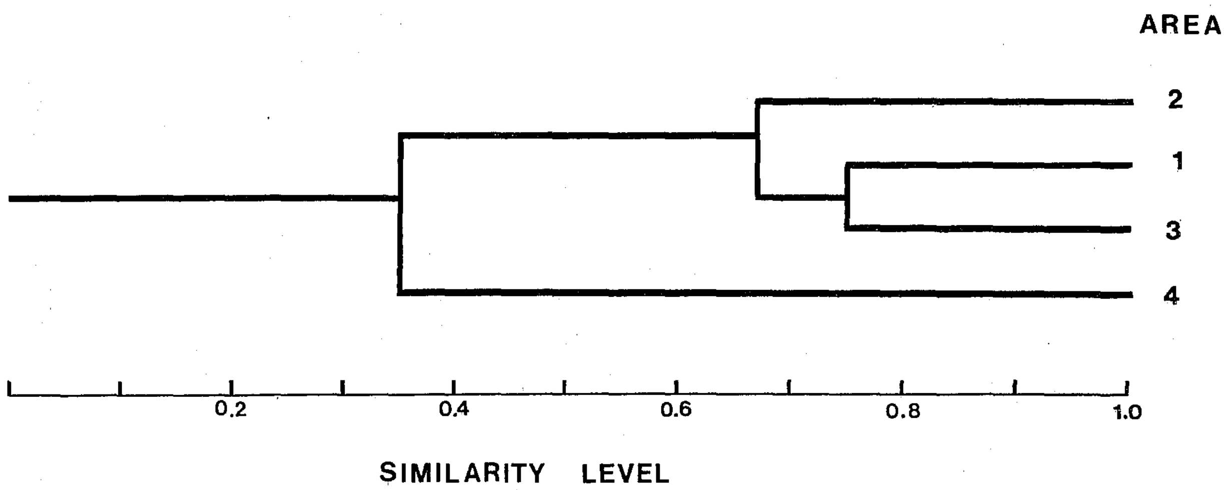



Figure 8. Dendrogram of cluster analysis of population densities in the 4 major areas of Patricia Bay.

Table 11. Results of regression analyses between the percent of birds feeding (arcsine transformed) and the tide height and the time of day. Only the densities of the twenty most common species were analyzed. See Appendix 1 for species codes. Numbers in parentheses are the number of tide or time intervals used in the analysis.

| | Tide | | Time of Day | |
|---|---|---|---|---|
| | r | significance | r | significance |
| Species | | | | |
| COLO | -.4248(11) | ns | -.4320(8) | ns |
| PALO | * | | -.4432(6) | ns |
| WEGR | +.5341(6) | ns | * | |
| RNGR | -.2905(10) | ns | -.5829(8) | ns |
| HOGR | -.3051(11) | ns | -.2926(9) | ns |
| DCCO | -.3953(11) | ns | +.8463(7) | p<.005 |
| PECO | -.2208(11) | ns | +.1066(8) | ns |
| GBHE | -.9262(6) | p<.005 | -.4644(7) | ns |
| MADU | -.9512(6) | p<.0025 | -.6165(9) | ns |
| AMWI | -.8567(6) | p<.025 | -.3416(5) | ns |
| WWSC | -.6894(9) | p<.025 | -.0471(8) | ns |
| SUSC | -.5816(8) | ns | +.3900(8) | ns |
| BAGO | -.8008(8) | p<.01 | -.3410(7) | ns |
| COGO | +.7443(10) | p<.01 | -.2631(8) | ns |
| BUFF | -.0096(9) | ns | -.7429(8) | p<.025 |
| RBME | -.4956(8) | ns | +.7067(7) | ns |
| MEGU | -.8571(11) | p<.0005 | -.7151(9) | p<.025 |
| GWGU | -.8447(11) | p<.001 | -.9012(9) | p<.001 |
| PIGU | -.3977(9) | ns | -.1541(8) | ns |
| MAMU | -.2043(8) | ns | * | |

* = insufficient intervals for analysis
ns = non-significant

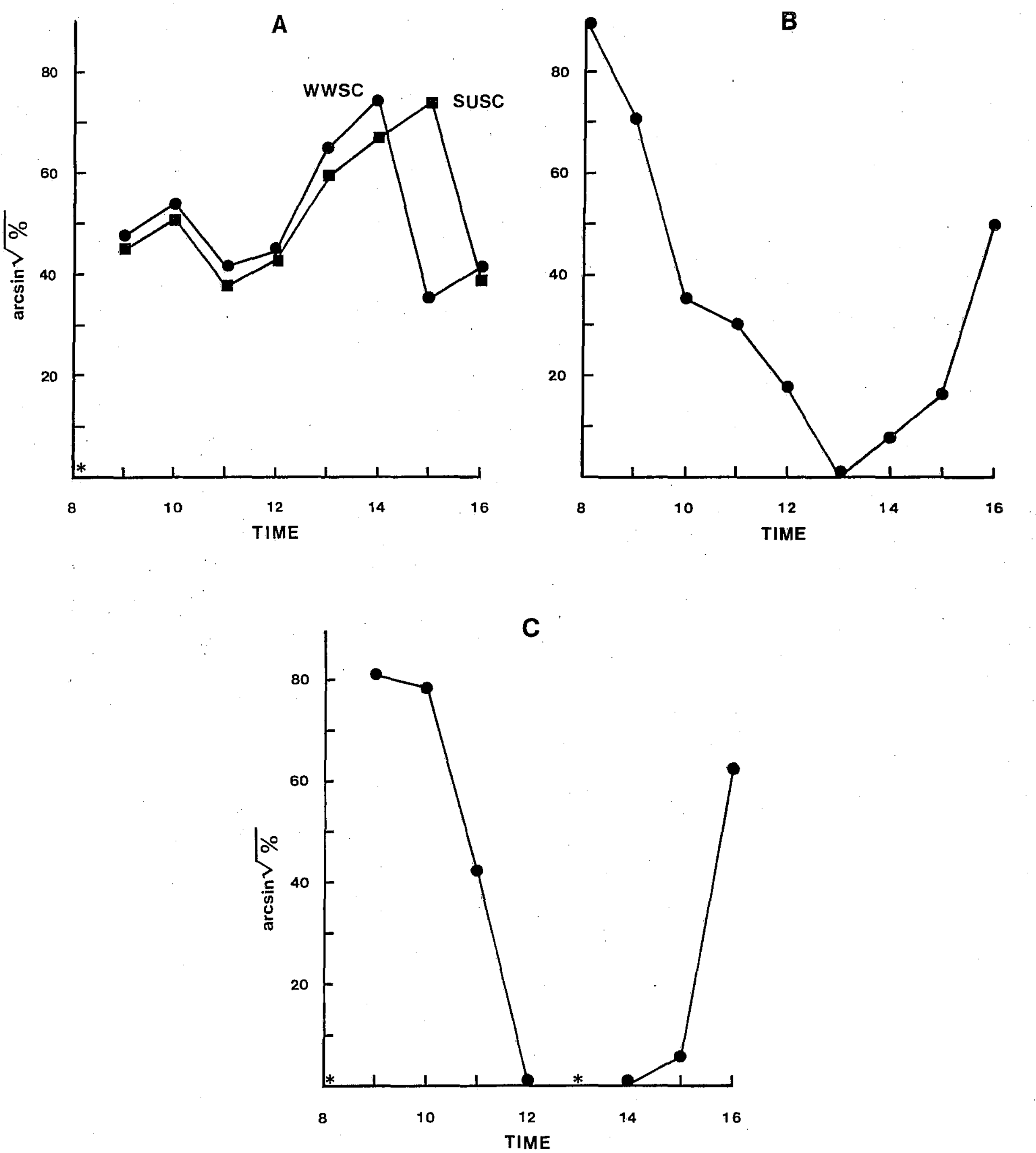



Figure 9a - c. Relationship between time of day and the percentage of birds feeding. 9a = White-winged Scoter (WWSC) and Surf Scoter (SUSC), 9b = Mallard, 9c = American Wigeon. Species absent during a given time interval is indicated by *.

Trethewey (1985) stated that "the greater the area of the intertidal zone and the adjacent subtidal zone out to at least 15m, the potentially better the habitat for waterfowl." Progressing from Trethewey's statement, we tested for a relationship between the surface areas of the intertidal zone and the number of birds the area supported. Table 12 shows the apparent preferred foraging locations of 29 species of birds. The total number of intertidal feeders observed within each sector was regressed against the surface area of the intertidal zone in each sector. The same method was applied to the relationships between shallow water, mid-depth and deep water feeders and the surface area of the appropriate habitats. Table 13 shows the results of the regression analyses. With the exception of those species that foraged primarily in mid-depth water, there were highly significant correlations between the surface areas of the preferred habitat type, and the total number of birds present.

## Roost Sites in Saanich Inlet

Manuwal *et al*. (1979) stated that roost sites were an important aspect of the life histories of marine birds. These authors identified a variety of roosts including: the surface of the water, isolated rocks, islands, spits, beaches, log booms, buoys, docks, boats, pilings and buildings. We investigated the importance of manmade structures as roost sites and found that only 11 species used these surfaces. Table 14 lists the average percentage roosting on artificial surfaces, out of the total inlet population. Several species rarely used manmade roosts. However, to species such as Common Tern, Pelagic Cormorant, Double-crested Cormorant and Glaucous-winged Gull ,the importance of manmade structures is obvious. The locations that consistently supported the highest number of birds roosting on artificial surfaces were Mill Bay, Patricia Bay, Deep Cove and Brentwood Bay. The presence of numerous roosts likely accounts in part for the rich avifauna observed in the shallow bays of Saanich Inlet.

Table 12. Water habitat types where each species most frequently foraged (in Patricia Bay).

| Intertidal | Shallow Water <2m | Mid-depth 2-5m | Deep Water >5m |
|---|---|---|---|
| Mallard | Common Loon | Pelagic Cormorant | Pacific Loon |
| Northern Pintail | Red-necked Grebe | Bonaparte's Gull | Western Grebe |
| Blue-winged Teal | Horned Grebe | | Common Murre |
| Mew Gull | Eared Grebe | | Pigeon Guillemot |
| California Gull | Double-crested Cormorant | | |
| Glaucous-winged Gull | Great Blue Heron | | |
| | American Wigeon | | |
| | Greater Scaup | | |
| | White-winged Scoter | | |
| | Surf Scoter | | |
| | Oldsquaw | | |
| | Barrow's Goldeneye | | |
| | Common Goldeneye | | |
| | Bufflehead | | |
| | Red-breasted Merganser | | |
| | Hooded Merganser | | |
| | Marbled Murrelet | | |

Table 13. The approximate surface area ($m^2$) of the four feeding habitats within Patricia Bay and the population of birds in each. The number of birds was determined by summing the totals of the appropriate species listed in Table 12 (eg the number of beach feeding birds observed on beaches).

| Sector | Surface Area | Beach Feeders | Surface Area | Shallow Water Feeders | Surface Area | Mid-Depth Feeders | Surface Area | Deep Water Feeders |
|---|---|---|---|---|---|---|---|---|
| 1 | 14750 | 36 | 17900 | 103 | 16600 | 7 | 400 | 0 |
| 2 | 10600 | 23 | 9150 | 214 | 10000 | 0 | 6650 | 0 |
| 3 | 16800 | 50 | 17050 | 243 | 11850 | 7 | 33250 | 4 |
| 4 | | | | | | | 256450 | 16 |
| 5 | | | | | | | 354000 | 36 |
| 6 | 45500 | 116 | 15950 | 63 | 27400 | 33 | 235700 | 12 |
| 7 | 21200 | 57 | 22850 | 520 | 21800 | 28 | 120900 | 11 |
| 8 | 80200 | 100 | 45300 | 965 | 44000 | 15 | 65600 | 2 |
| 9 | 103800 | 363 | 65000 | 1117 | 30300 | 17 | 40900 | 6 |
| 10 | 28250 | 73 | 16400 | 252 | 14700 | 5 | 7300 | 1 |
| 11 | 33250 | 106 | 17000 | 432 | 11200 | 4 | 2500 | 0 |
| 12 | 47150 | 164 | 15000 | 706 | 14750 | 15 | 650 | 0 |
| | $r = +.86542$ $p<.001$ | | $r = +.81851$ $p<.0025$ | | $r = +.55083$ ns | | $r = +.93792$ $p<.0005$ | |

note: Sectors 4 and 5 had negligible amounts of beach, shallow and mid-depth water habitats.

Table 14. Bird species that were observed roosting on manmade structures, and the average proportion of the total number present in Saanich Inlet (entire study period).

| Species | Total Number of Birds | % Roosting |
|---|---|---|
| Common Tern | 186 | 64.6 |
| Double-crested Cormorant | 1331 | 60.2 |
| Pelagic Cormorant | 1220 | 56.6 |
| Glaucous-winged Gull | 10491 | 33.4 |
| California Gull | 604 | 25.6 |
| Common Merganser | 466 | 17.9 |
| Mew Gull | 2038 | 16.8 |
| Great Blue Heron | 314 | 10.3 |
| Bonaparte's Gull | 1002 | 9.2 |
| Mallard | 344 | 1.0 |
| Hooded Merganser | 378 | 0.3 |

## SUMMARY

The results of this study showed that in Saanich Inlet the greatest number of marine birds and the highest number of species occurred during the winter. During December, we found a total of nearly 7400 birds made up of 37 species. In contrast, during June there were as few as 500 birds (14 species) in all of Saanich Inlet. These changes dramatically illustrated the influence the fall migration period had on the breeding season population.

Shallow bays consistently supported the largest and richest avifauna, followed by those areas with extensive beaches and intertidal zones. Waters off rocky shores and open-water reaches supported the fewest species and the lowest number of birds.

With increasing tide heights, bays supported significantly fewer birds, whereas there were proportionately more birds in open-water habitats.

Species of birds that feed in the exposed intertidal zone and in the shallows at the edge of the beach fed significantly less with increasing tide height.

We observed a strong positive correlation between the number of birds that prefer to forage within a given habitat type and the surface area of their preferred habitat.

Deep water habitats along steep rock walls did not support the highest densities of Surf Scoters. Instead, they reached their peak abundance in shallow bays.

## RECOMMENDATIONS FOR FURTHER STUDIES

1) The effects of tide level and time of day on the foraging behaviour of marine birds needs to be investigated.
2) The possible association between the number of birds that forage in a particular habitat type and the extent of that habitat should be examined.
3) Detailed studies of the preferred prey and foraging habitats (and how these change seasonally) should be undertaken for at least the most common species of marine birds.
4) The role that manmade roosts play in determining the composition, distribution and abundance of marine birds needs further study.

## ACKNOWLEDGEMENTS

The authors of this paper gratefully acknowledge the staff of the Marine Bird Studies Job Development Project (T.Hooper, J.Naydiuk, I.Szabo) for their exuberant and capable help in the censusing of marine birds. We also thank the staff of Ships Division, Institute of Ocean Sciences, Sidney for its constant support. A special thanks goes to B.Simmons for his artful handling of the motor launch "SQUAMISH". L.Giovando (of I.O.S.) and S.Morgan kindly reviewed this manuscript. S.Lipscomb, J.Naydiuk, T.Michalski and R.Woods generously volunteered to conduct the subtidal sampling of Patricia Bay by SCUBA. W.Austin of Khoyatan Marine Lab, P.Shaw of U.B.C. and R.Woods were invaluable in their identification of marine organisms. We are also grateful to S.Cross of Aquametrix Research Ltd., for his suggestions and guidance throughout the statistical analysis of the data.

REFERENCES

Ainley,D.G., D.W. Anderson and P.R. Kelly. 1981. Feeding ecology of marine cormorants in southwestern North America. Condor 83:120-131.

Angell,T. and K.C. Balcomb,III. 1982. Marine birds and mammals of Puget Sound. Washington Sea Grant Program, University of Washington. 45pp.

Austin,W.C. 1985. An annotated checklist of marine invertebrates in the cold temperate northeast Pacific. Khoyatan Marine Laboratory. 682pp.

Baird,P.A. 1983. Glaucous-winged Gull (Larus glaucescens). in: Baird,P.A. and P.J. Gould (eds.). The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. Dept. Commer., NOAA, OCSEAP Final Rep. 45 (1986): 237-277.

Bent,A.C. 1962a. Life histories of North American wild fowl. Part 1. Dover Publications Inc., New York. 244pp.

Bent,A.C. 1962b. Life histories of North American wild fowl. Part 2. Dover Publications Inc., New York. 314pp.

Bent,A.C. 1963. Life Histories of North American gulls and terns. Dover Publications Inc., New York. 337pp.

Botton,M.L. 1984. Effects of Laughing Gull and shorebird predation on the intertidal fauna at Cape May, New Jersey. Estuarine, Coastal and Shelf Science 18:209-220.

Brattstrom,B.H. 1965. Cooperative feeding behaviour in Red-breasted Mergansers. Auk 82:639.

Brower,J.E. and J.H. Zar. 1979. Field and laboratory methods of general ecology. W.C. Brown Co. Publishers, Iowa. 194pp.

Cottam,C. 1939. Food habits of North American diving ducks. U.S. Dept. Agric., Washington, D.C. Technical Bulletin No. 643. 140pp.

Dow,D.D. 1964. Diving times of wintering water birds. Auk 81:556-558.

Dzinbal,K.A. and R.L. Jarvis. 1984. Coastal feeding ecology of Harlequin Ducks in Prince William Sound, Alaska, during summer. in: Nettleship,D.N., G.A. Sanger and P.F. Springer (eds.). Marine birds: their feeding ecology and commercial fisheries relationships. Canadian Wildlife Service for the Pacific Seabird Group: 6-10.

Erskine,A.J. 1972. Buffleheads. Canadian Wildlife Service, Dept. Envir. Monograph Series no. 4. 240pp.

Eschmeyer,W.N., E.S. Herald and H. Hammann. 1983. A field guide to

Pacific coast fishes of North America. Houghton Mifflin Co., Boston. 336pp.

Forsell,D.J. and P.J. Gould. 1981. Distribution and abundance of marine birds and mammals wintering in the Kodiak area of Alaska. U.S. Fish and Wildlife Service, Washington, D.C. FWS/OBS-81/13. 81pp.

Grosz,T, and C.F. Yocom. 1972. Food habits of the White-winged Scoter in northwestern California. Journal of Wildlife Management 36:1279-1282.

Herlinveaux,R.H. 1962. Oceanography of Saanich Inlet in Vancouver Island, B.C. Journal of Fisheries Research Board of Canada 19:1-37.

Johnson,S.R. 1984. Prey selection by Oldsquaws in a Beaufort Sea lagoon, Alaska. in: Nettleship,D.N., G.A. Sanger and P.F. Springer (eds.). Marine birds: their feeding ecology and commercial fisheries relationships. Canadian Wildlife Service for the Pacific Seabird Group: 12-19.

Juniper,S.K. and R.O. Brinkhurst (eds.). 1984. Proceedings of a multidisciplinary symposium on Saanich Inlet, 2nd Feb. 1983. Institute of Ocean Sciences, Dept. Fisheries and Oceans. Canadian Technical Report of Hydrography and Ocean Sciences No. 38. 104pp.

Koehl,P.S., T.C. Rothe and D.V. Derksen. 1984. Winter food habits of Barrow's Goldeneyes in southeast Alaska. in: Nettleship,D.N., G.A. Sanger and P.F. Springer (eds.). Marine birds: their feeding ecology and commercial fisheries relationships. Canadian Wildlife Service for the Pacific Seabird Group: 1-5.

Krasnow,L.D. and G.A. Sanger. 1982. Feeding ecology of marine birds in the nearshore waters of Kodiak Island. in: Baird, P.A. and P.J. Gould (eds.). The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. Dept. Commer., NOAA, OCSEAP Final Rep. 45 (1986):505-630.

Krebs,J.R. 1974. Colonial nesting and social feeding as strategies for exploiting food resources in the Great Blue Heron. Behaviour 51:99-131.

Manuwal,D.A., T.R. Wahl and S.M. Speich. 1979. The seasonal distribution and abundance of marine bird populations in the Strait of Juan de Fuca and northern Puget Sound in 1978. U.S. Dept. Commer., NOAA technical memorandum ERL MESA-44. 391pp.

Morrison,M.L., R.D. Slack and E. Shanley,JR. 1978. Age and foraging ability relationships of Olivaceous Cormorants. Wilson Bulletin 90:414-422.

Munro,J.A. and W.A. Clemens. 1932. The American Merganser in British Columbia. Bulletin of the Biological Board of Canada 55:1-50.

Nyblade,C.F. 1978. Intertidal and shallow subtidal benthos of the Strait of Juan de Fuca, Spring 1976-Winter 1977. U.S. Dept. Commer., NOAA technical memorandum ERL MESA-26. 156pp.

Nysewander,D.R. 1983a. Cormorants (Phalacrocorax spp.). in: Baird,P.A.

and P.J. Gould (eds.). The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. Dept. Commer., NOAA, OCSEAP Final Rep. 45 (1986):207-236.

Nysewander,D.R. 1983b. Mew Gull (Larus canus). in: Baird,P.A. and P.J. Gould (eds.). The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. Dept. Commer., NOAA, OCSEAP Final Rep. 45 (1986):277-294.

Olney,P.J. and D.H. Mills. 1963. The food and feeding habits of Goldeneye *Bucephala clangula* in Great Britain. Ibis 105:293-300.

Petersen,M.R. 1983. Murres (Uria spp.). in: Baird,P.A. and P.J. Gould (eds.). The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. Dept. Commer., NOAA, OCSEAP Final Rep. 45 (1986):381-400.

Phillips,R.E. and G.D. Carter. 1957. Winter foods of Western Grebes. Murrelet 38:5-6.

Quammen,M.L. 1984. Predation by shorebirds, fish and crabs on invertebrates in intertidal mudflats: an experimental test. Ecology 65:529-537.

Robertson,I. 1974. The food of nesting Double-crested and Pelagic Cormorants at Mandarte Island, B.C., with notes on feeding ecology. Condor 76:346-348.

Romesburg,H.C. 1984. Cluster analysis for researchers. Lifetime Learning Publications, California. 334pp.

Sanger,G.A. 1983. Diets and food web relationships of seabirds in the Gulf of Alaska and adjacent marine regions. in: Baird,P.A. and P.J. Gould (eds.). The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. Dept. Commer., NOAA, OCSEAP Final Rep. 45 (1986):631-771.

Sanger,G.A. and R.D. Jones. 1984. Winter feeding ecology and trophic relationships of Oldsquaws and White-winged Scoters on Kachemak Bay, Alaska. in: Nettleship,D.N., G.A. Sanger and P.F. Springer (eds.). Marine birds: their feeding ecology and commercial fisheries relationships. Canadian Wildlife Service for the Pacific Seabird Group:20-28.

Scott-Brown,J.M. 1976. Factors affecting the habitat selection of three species of diving ducks along the Stanley Park coastline during the winter season. Unpublished B.Sc. Thesis. University of British Columbia.

Shepard,F.P. 1954. Nomenclature based on sand-silt-clay ratios. Journal of Sedimentology and Petrology 24:151-158.

Stott,R.S. and D.P. Olson. 1982. Food-habitat relationship of sea ducks on the New Hampshire coastline. in: Ratti,J.T., L.D. Flake and W.A. Wentz (eds.). Waterfowl ecology and management: selected readings. The Wildlife Society:816-832.

Trapp,J.L. 1979. Variation in summer diet of Glaucous-winged gulls in the western Aleutian Islands: an ecological interpretation. Wilson Bulletin 91:412-419.

Trethewey,D.E.C. 1985. Bird use of the Squamish Estuary. Canadian Wildlife Service, Pacific and Yukon Region. 65pp.

Vermeer,K. 1981. Food and populations of Surf Scoters in British Columbia. Wildfowl 32:107-116.

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

Vermeer,K. 1983. Marine bird populations in the Strait of Georgia; comparison with the west coast of Vancouver Island. Canadian Technical Report of Hydrography and Ocean Sciences 19. 18pp.

Vermeer,K. and C.D. Levings. 1977. Populations, biomass and food habits of ducks on the Fraser Delta intertidal area, British Columbia. Wildfowl 28:49-60.

Vermeer,K., I. Robertson, R.W. Campbell, G. Kaiser and M. Lemon. 1983. Distribution and densities of marine birds on the Canadian west coast. Environment Canada, Canadian Wildlife Service. 73pp.

Vermeer,K. and N. Bourne. 1984. The White-winged Scoter diet in British Columbia waters: resource partitioning with other scoters. in: Nettleship,D.N., G.A. Sanger and P.F. Springer (eds.). Marine birds: their feeding ecology and commercial fisheries relationships. Canadian Wildlife Service for the Pacific Seabird Group:30-38.

Vermeer,K., I. Szabo and P. Greisman. 1987. The relationship between plankton-feeding Bonaparte's and Mew Gulls and tidal upwelling at Active Pass, British Columbia. Journal of Plankton Research 9:483-501.

Wahl,T.R. and S.M. Speich. 1983. First winter survey of marine birds in Puget Sound and Hood Canal, December 1982 and February 1983. M.Sc. draft, University of Washington. 29pp.

Woods,S.M. and D.P. Shaw. 1981. Hatch Point marine environment assessment: biological oceanography. Dobrocky Seatech Ltd. for Chevron Canada. 134pp.

Zar,J.H. 1974. Biostatistical analysis. Prentice Hall, New Jersey. 620pp.

APPENDIX 1. List of all species of birds encountered in this study. Latin names, code names and guild affiliations are also presented.

| Bird Species | | Code | Guild |
|---|---|---|---|
| Common Loon | Gavia immer | COLO | Loon |
| Yellow-billed Loon | G. adamsii | YBLO | Loon |
| Pacific Loon | G. pacifica | PALO | Loon |
| Red-throated Loon | G. stellata | RTLO | Loon |
| Western Grebe | Aechmophorus occidentalis | WEGR | Grebe |
| Red-necked Grebe | Podiceps grisegena | RNGR | Grebe |
| Horned Grebe | P. auritus | HOGR | Grebe |
| Eared Grebe | P. nigricollis | EAGR | Grebe |
| Pied-billed Grebe | Podilymbus podiceps | PBGR | Grebe |
| Leach's Storm-petrel | Oceanodroma leucorhoa | LESP | Pelagic Seabird |
| Double-crested Cormorant | Phalacrocorax auritus | DCCO | Cormorant |
| Brandt's Cormorant | P. penicillatus | BRCO | Cormorant |
| Pelagic Cormorant | P. pelagicus | PECO | Cormorant |
| Great Blue Heron | Ardea herodias | GBHE | Heron |
| Mute Swan | Cygnus olor | MUSW | Swan/Geese |
| Canada Goose | Branta canadensis | CAGO | Swan/Geese |
| Brant | B. bernicla | BRAN | Swan/Geese |
| Mallard | Anas platyrhynchos | MADU | Dabbling Duck |
| Green-winged Teal | A. crecca | GWTE | Dabbling Duck |
| American Wigeon | A. americana | AMWI | Dabbling Duck |
| Eurasian Wigeon | A. penelope | EUWI | Dabbling Duck |
| Northern Pintail | A. acuta | NOPI | Dabbling Duck |
| Blue-winged Teal | A. discors | BWTE | Dabbling Duck |
| Greater Scaup | Aythya marila | GRSC | Bay Duck |
| Lesser Scaup | A. affinis | LESC | Bay Duck |
| Black Scoter | Melanitta nigra | BLSC | Sea Duck |
| White-winged Scoter | M. fusca | WWSC | Sea Duck |
| Surf Scoter | M. perspicillata | SUSC | Sea Duck |
| Harlequin Duck | Histrionicus histrionicus | HADU | Sea Duck |
| Oldsquaw | Clangula hyemalis | OLDS | Sea Duck |
| Barrow's Goldeneye | Bucephala islandica | BAGO | Bay Duck |
| Common Goldeneye | B. clangula | COGO | Bay Duck |
| Bufflehead | B. albeola | BUFF | Bay Duck |
| Common Merganser | Mergus merganser | COME | Merganser |
| Red-breasted Merganser | M. serrator | RBME | Merganser |
| Hooded Merganser | Lophodytes cucullatus | HOME | Merganser |
| American Coot | Fulica americana | AMCO | Coot |
| Bonaparte's Gull | Larus philadelphia | BOGU | Gull/Tern |
| Mew Gull | L. canus | MEGU | Gull/Tern |
| Herring Gull | L. argentatus | HEGU | Gull/Tern |
| California Gull | L. californicus | CAGU | Gull/Tern |
| Thayer's Gull | L. thayeri | THGU | Gull/Tern |
| Western Gull | L. occidentalis | WEGU | Gull/Tern |

Appendix 1 continued.

| Bird Species | | Code | Guild |
|---|---|---|---|
| Glaucous-winged Gull | L. glaucescens | GWGU | Gull/Tern |
| Common Tern | Sterna hirundo | COTE | Gull/Tern |
| Common Murre | Uria aalgae | COMU | Alcid |
| Pigeon Guillemot | Cepphus columba | PIGU | Alcid |
| Marbled Murrelet | Brachyramphus marmoratus | MAMU | Alcid |
| Ancient Murrelet | Synthliboramphus antiquus | ANMU | Alcid |
| Rhinoceros Auklet | Cerorhinca monocerata | RHAU | Alcid |

APPENDIX 2. Densities (birds/km) of all species observed in Saanich Inlet, averaged over entire study period. Where each species reached its maximum density is indicated by a *. See Appendix 1 for species codes.

| | Transect Number | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| COLO | 2.5 | 12.7 | 19.4 | 6.6 | 5.3 | 1.2 | 14.5 | 16.1 | 29.4* | 5.1 | 12.8 | 4.4 | 8.2 |
| YBLO | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4* | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| PALO | 6.9 | 0.4 | 0.9 | 3.1 | 2.5 | 3.5 | 27.2 | 2.4 | 4.9 | 45.5 | 0.5 | 7.3 | 0.7 |
| RTLO | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |
| WEGR | 1699.0* | 5.9 | 912.9 | 0.9 | 4.1 | 35.0 | 35.1 | 1.2 | 1.1 | 0.3 | 1.5 | 0.3 | 0.0 |
| RNGR | 4.3 | 9.8 | 18.1 | 11.4 | 13.1 | 0.9 | 23.6 | 20.2 | 63.2* | 21.1 | 16.3 | 11.1 | 18.3 |
| HOGR | 3.2 | 67.4 | 84.5 | 21.9 | 25.8 | 4.7 | 72.8 | 134.7 | 265.4* | 71.7 | 81.6 | 19.6 | 30.9 |
| EAGR | 0.0 | 1.7 | 3.0 | 0.0 | 0.0 | 0.0 | 2.5 | 4.4 | 12.6* | 0.6 | 1.5 | 0.6 | 2.6 |
| PBGR | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1* | 0.0 | 0.0 | 0.0 | 0.8 |
| LESP | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4* |
| DCCO | 3.2 | 14.8 | 33.6 | 3.9 | 11.5 | 4.7 | 30.1 | 20.6 | 56.3* | 16.3 | 11.2 | 5.4 | 8.2 |
| PECO | 0.5 | 19.1 | 18.1 | 7.9 | 4.5 | 10.3 | 40.9 | 63.3* | 45.6 | 45.2 | 16.8 | 15.8 | 20.2 |
| BRCO | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.6 | 0.0 | 0.0 | 0.0 |
| GBHE | 0.0 | 4.7 | 17.2 | 4.4 | 2.1 | 0.3 | 4.7 | 5.7 | 5.2 | 1.8 | 1.5 | 0.9 | 3.4 |
| MUSW | 0.0 | 0.0 | 2.6 | 0.0 | 3.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CAGO | 0.0 | 0.0 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 11.5 | 0.0 | 0.0 | 0.0 | 0.8 |
| BRAN | 1.3* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MADU | 0.0 | 0.9 | 15 5 | 2.6 | 3.3 | 0.0 | 0.4 | 11.3 | 24.7* | 5.4 | 0.0 | 0.0 | 0.8 |
| GWTE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6* | 0.0 | 0.0 | 0.0 | 0.0 |
| AMWI | 0.0 | 39.4 | 87.5* | 10.9 | 86.9 | 0.0 | 3.9 | 9.7 | 63.5 | 31.3 | 10.2 | 2.2 | 0.8 |
| EUWI | 0.0 | 0.0 | 0.0 | 0.4* | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| GRSC | 0.0 | 0.0 | 11.2 | 0.0 | 0.0 | 1.5 | 1.8 | 4.4 | 53.3* | 0.0 | 5.6 | 0.0 | 0.0 |
| LESC | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.2* | 0.0 | 0.0 | 0.0 | 0.0 |
| BLSC | 0.0 | 0.0 | 2.2 | 0.0 | 0.0 | 0.0 | 1.8 | 1.2 | 12.6* | 0.3 | 0.0 | 0.0 | 0.8 |
| WWSC | 5.0 | 13.6 | 17.7 | 2.2 | 4.5 | 0.9 | 31.9 | 115.7 | 522.8* | 12.0 | 77.0 | 1.9 | 0.4 |
| SUSC | 3.4 | 23.3 | 219 4 | 18.9 | 16.4 | 2.9 | 23.6 | 101.2 | 283.5* | 17.5 | 103.6 | 6.9 | 8.6 |
| HADU | 0.0 | 0.0 | 2.6 | 3.5 | 1.2 | 0.0 | 3.3 | 16.9* | 4.9 | 8.7 | 0.0 | 0.0 | 0.0 |
| OLDS | 0.0 | 2.1 | 2.2 | 0.9 | 0.0 | 2.9 | 1.4 | 1.2 | 9.1 | 10.6* | 0.0 | 0.9 | 3.3 |
| BAGO | 0.0 | 97.5* | 96.9 | 72.8 | 47.5 | 0.0 | 55.8 | 35.1 | 74.2 | 80.1 | 32.6 | 54.1 | 21.6 |
| COGO | 0.2 | 40.3 | 111.6 | 25.0 | 34.4 | 0.3 | 33.3 | 80.2 | 155.2* | 43.1 | 29.6 | 16.8 | 36.9 |
| BUFF | 0.0 | 56.4 | 273.3 | 17.1 | 42.6 | 0.0 | 57.9 | 114.1 | 316.2* | 46.9 | 151.5 | 14.9 | 27.9 |
| COME | 0.4 | 5.1 | 3.0 | 0.0 | 2.9 | 0.0 | 0.0 | 1.6 | 4.4 | 0.3 | 1.0 | 3.5 | 4.1 |
| RBME | 6.3 | 88.9 | 96.9 | 44.3 | 114.3 | 2.7 | 112.7 | 93.5 | 253.6* | 79.5 | 62.2 | 43.4 | 35.4 |
| HOME | 0.0 | 6.4 | 6.5 | 4.4 | 2.5 | 0.0 | 26.8* | 23.8 | 15.7 | 8.7 | 4.1 | 3.5 | 5.6 |
| AMCO | 0.0 | 0.0 | 3.5* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BOGU | 1.6 | 9.7 | 15.5 | 7.0 | 15.9 | 10.6 | 30.1 | 14.9 | 19.8 | 3.3 | 0.5 | 4.8 | 8.9 |
| MEGU | 3.8 | 35.2 | 106.5* | 10.5 | 18.5 | 2.9 | 8.3 | 46.4 | 105 8 | 14.2 | 6.6 | 4.1 | 4.5 |
| HEGU | 0.2 | 0.0 | 1.3* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| CAGU | 0.5 | 4.2 | 9.5 | 26.8 | 70.5* | 3.8 | 1.1 | 6.9 | 18.7 | 0.9 | 2.0 | 0.6 | 0.8 |
| THGU | 0.0 | 0.4 | 3.0* | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| WEGU | 0.0 | 0.4 | 0.9* | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |

Appendix 2 continued.

| Species | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GWGU | 26.3 | 144.4 | 196.1 | 70.6 | 118.8 | 23.5 | 137.3 | 104.8 | 189.8 | 106.6 | 95.4 | 47.8 | 113.4 |
| COTE | 0.0 | 0.9 | 0.9 | 0.9 | 0.4 | 0.0 | 26.5* | 9.3 | 5.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| COMU | 24.6* | 1.3 | 0.9 | 1.8 | 1.2 | 10.6 | 1.8 | 0.4 | 0.6 | 3.9 | 0.0 | 6.3 | 0.0 |
| PIGU | 0.0 | 3.8 | 1.3 | 1.3 | 2.1 | 1.5 | 4.7 | 4.4 | 4.1 | 5.7* | 5.1 | 1.9 | 4.9 |
| MAMU | 1.1 | 5.5 | 6.0 | 6.6 | 3.7 | 6.2 | 6.5 | 2.8 | 0.3 | 4.2 | 1.5 | 4.4 | 3.4 |
| ANMU | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3* | 0.0 | 0.0 | 0.0 |
| RHAU | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |

Appendix 2 continued.

| Species | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COLO | 2.0 | 2.2 | 0.6 | 0.0 | 0.0 | 0.6 | 0.8 | 0.8 | 1.4 | 0.4 | 6.3 | 12.5 | 3.1 |
| YBLO | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PALO | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.4 | 1.4 | 0.7 | 0.0 | 1.1 | 4.2 | 3.8 | 68.8* |
| RTLO | 0.5* | 0.0 | 0.0 | 0.0 | 0.4 | 0.2 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| WEGR | 0.0 | 0.0 | 0.0 | 0.3 | 1.9 | 0.0 | 2.5 | 0.0 | 0.0 | 3.5 | 2.8 | 3.8 | 351.5 |
| RNGR | 17.3 | 4.9 | 5.8 | 3.4 | 1.5 | 4.3 | 3.5 | 3.0 | 1.8 | 0.7 | 10.6 | 20.6 | 2.8 |
| HOGR | 27.1 | 21.2 | 4.1 | 1.4 | 2.3 | 3.1 | 0.8 | 1.7 | 3.9 | 0.0 | 14.8 | 55.6 | 1.2 |
| EAGR | 1.0 | 2.2 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 |
| PBGR | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| LESP | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DCCO | 31.6 | 5.9 | 0.0 | 3.4 | 0.0 | 13.8 | 13.3 | 3.7 | 3.9 | 0.4 | 4.9 | 22.5 | 3.4 |
| PECO | 37.2 | 3.3 | 1.7 | 9.1 | 2.3 | 4.5 | 4.6 | 4.4 | 1.8 | 3.2 | 3.9 | 8.1 | 1.2 |
| BRCO | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 |
| GBHE | 5,9 | 34.2* | 0.0 | 1.4 | 1.9 | 3.5 | 2.1 | 0.7 | 2.2 | 0.0 | 3.2 | 2.5 | 0.0 |
| MUSW | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.5* | 2.2 | 0.2 | 0.0 | 0.0 | 0.7 | 1.3 | 0.0 |
| CAGO | 1.0 | 25.0* | 0.0 | 0.0 | 0.0 | 5.7 | 0.6 | 1.3 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 |
| BRAN | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MADU | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.1 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 1.3 | 0.0 |
| GWTE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| AMWI | 0.0 | 5.4 | 0.0 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 | 4.3 | 0.0 | 20.8 | 39.4 | 1.9 |
| EUWI | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| GRSC | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| LESC | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BLSC | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 |
| WWSC | 2.6 | 0.0 | 0.0 | 0.0 | 0.0 | 4.5 | 0.3 | 0.0 | 17.5 | 0.0 | 19.4 | 29.4 | 0.3 |
| SUSC | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 | 0.0 | 0.0 | 7.5 | 0.0 | 53.2 | 43.8 | 0.0 |
| HADU | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OLDS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BAGO | 38.8 | 43.4 | 4.7 | 19.6 | 16.7 | 11.6 | 38.1 | 26.5 | 25.4 | 0.0 | 41.9 | 37.5 | 0.0 |
| COGO | 20.4 | 22.3 | 1.7 | 16.2 | 6.4 | 18.7 | 3.5 | 2.8 | 7.9 | 0.0 | 17.9 | 25.0 | 0.0 |
| BUFF | 12.2 | 65.8 | 5.7 | 3.0 | 2.3 | 132.3 | 6.8 | 0.4 | 6.8 | 0.0 | 24.3 | 85.0 | 0.0 |
| COME | 5.6 | 32.1* | 6.6 | 5.7 | 7.6 | 31.3 | 7.4 | 10.9 | 4.9 | 1.1 | 4.2 | 0.0 | 0.0 |
| RBME | 18.4 | 65.2 | 19.8 | 13.5 | 10.9 | 11.8 | 2.7 | 15.9 | 9.9 | 1.8 | 31.3 | 36.9 | 0.6 |
| HOME | 3.1 | 6.5 | 4.1 | 0.0 | 0.8 | 1.4 | 0.9 | 0.0 | 1.1 | 0.0 | 0.0 | 3.1 | 0.0 |
| AMCO | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BOGU | 0.5 | 5.9 | 0.0 | 1.0 | 5.3 | 31.9 | 10.9 | 8.5 | 7.1 | 8.8 | 22.9 | 47.5* | 4.0 |
| MEGU | 5.6 | 3.8 | 2.3 | 6.4 | 7.9 | 25.4 | 30.2 | 17.4 | 21.4 | 21.1 | 34.5 | 23.8 | 4.0 |
| HEGU | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 |
| CAGU | 1.0 | 1.6 | 0.0 | 0.0 | 0.0 | 0.2 | 4.1 | 3.7 | 0.0 | 3.2 | 43.7 | 15.6 | 0.3 |
| THGU | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| WEGU | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| GWGU | 703.1* | 447.9 | 47.7 | 63.5 | 29.2 | 190.0 | 83.5 | 25.9 | 238.6 | 21.5 | 185.9 | 138.8 | 14.8 |
| COTE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 14.8 | 0.6 | 0.6 |
| COMU | 0.0 | 0.0 | 0.6 | 1.4 | 1.5 | 2.2 | 3.3 | 2.6 | 8.9 | 13.0 | 1.1 | 4.4 | 6.8 |
| PIGU | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.2 | 0.0 | 0.4 | 0.0 | 0.0 | 1.3 | 0.3 |
| MAMU | 3.1 | 0.0 | 1.2 | 0.7 | 0.0 | 0.9 | 0.2 | 1.1 | 1.4 | 0.7 | 1.8 | 10.1* | 0.6 |
| ANMU | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| RHAU | 0.5 | 0.0 | 0.0 | 0.7 | 0.0 | 0.2 | 3.2* | 1.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.3 |

APPENDIX 3. Species identified from the intertidal and subtidal sampling of Patricia Bay. Presence(+) or absence(-) is indicated for the four major zones (U = upper intertidal, M = middle intertidal, L = lower intertidal, S = subtidal). Identifications that have not been verified are indicated by *.

| Marine Flora | Area I | | | | Area II | | | | Area III | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | U | M | L | S | U | M | L | S | U | M | L | S |
| Chlorophyceae | | | | | | | | | | | | |
| Cladophora columbiana | - | + | - | - | - | - | - | - | - | - | - | - |
| C. sp. | - | - | + | - | - | - | - | - | - | - | - | - |
| Enteromorpha linza | + | + | + | - | - | + | + | - | - | - | + | - |
| Ulva sp. | - | + | + | + | - | + | + | + | - | - | + | + |
| Rhodophyceae | | | | | | | | | | | | |
| Corallina vancouveriensis* | - | + | - | - | - | - | - | - | - | - | - | - |
| Gigartina cristata | + | + | - | - | - | + | - | - | + | + | - | - |
| Gracilariopsis sjoestedtii | - | + | - | - | - | + | + | - | - | - | - | - |
| Odanthallia floccosa* | + | + | + | - | - | - | - | - | - | + | - | - |
| Petrocelis sp. | - | + | - | - | - | - | - | - | - | + | + | - |
| Polysiphona sp. | - | - | - | - | - | + | + | - | - | - | - | - |
| Rhodoglossum affine | - | - | + | - | - | - | - | - | - | - | - | - |
| Rhodomela larix | - | - | + | - | - | - | - | - | - | - | - | - |
| Phaeophyceae | | | | | | | | | | | | |
| Fucus distichus | + | + | + | - | - | - | - | + | + | + | + | - |
| Leathesia diformis | - | + | - | - | - | - | - | - | - | - | + | - |
| Ralfsia sp. | + | + | - | - | - | - | - | - | - | + | - | - |
| Sargassum muticum | - | + | + | - | - | - | + | - | - | - | + | + |
| Scytosiphon lomentaria | - | - | - | - | - | - | - | - | - | - | + | - |
| Flowering Plants | | | | | | | | | | | | |
| Zostera marina | - | + | + | + | - | + | + | + | - | - | + | + |
| **Marine Fauna** | | | | | | | | | | | | |
| Coelenterata | | | | | | | | | | | | |
| Anthopleura elegantissima | - | - | + | - | - | - | + | - | - | - | - | - |
| A. xanthogrammica | - | + | + | - | - | - | - | - | - | - | - | - |
| Pachycerianthus fimbriatus | - | - | - | - | - | - | - | - | - | - | - | + |
| Ptilosarcus gurneyi | - | - | - | + | - | - | - | - | - | - | - | - |
| Platyhelminthes | | | | | | | | | | | | |
| Polycladida | - | - | - | + | - | + | - | - | - | + | - | - |
| Nemertea | | | | | | | | | | | | |
| Cerebratulus sp. | - | - | + | + | - | - | + | - | - | - | - | - |

Appendix 3 continued.

| | | | |
|---|---|---|---|
| Tubulanus polymorphus | - - + - | - - - - | - - + - |
| Lineus ruber* | - - + + | - - - - | - - - - |
| Paranemertes peregrina | - - - - | - - - - | - - - + |
| **Nematoda** | | | |
| Adenophorea* | - - + + | - - - + | - - - + |
| **Annelida** | | | |
| Leitoscoloplos elongatus | - - - - | - - + - | - - - - |
| Paraonella platybranchia* | - - - + | - - - - | - - - - |
| Prionospio steestrupi | - - - - | - - - + | - - - - |
| P. sp. | - - - + | - - - - | - - - + |
| Magelona hobsonae | - - - - | - - - - | - - - + |
| Mesochaetopterus taylori | - - - - | - - + - | - - - - |
| Notomastus lineatus | - - - + | - - - - | - - - - |
| N. tenuis | - + + - | - + + - | - - + - |
| Axiothella rubrocincta | - - - - | - + + - | - - - - |
| Armandia brevis* | - - - - | - - - - | - - - + |
| Halosydna brevisetosa | - - + - | - - - - | - - - - |
| Harmothoe imbricata | - + - + | - - - - | - - - - |
| Pholoe caeca | - - - - | - - - + | - - - - |
| Ophiodromus pugettensis | - - - - | - - - + | - - - - |
| Syllis sp. | - - - + | - - - - | - - - - |
| Nereis procera | - - - + | - - - - | - - - - |
| N. vexillosa | - - - - | - - - - | + + - - |
| Platynereis bicanaliculata | - + - + | - - - + | - + - + |
| Glycera americana | - + - - | - - + - | + - - - |
| Nephtys californiensis | - - + - | - - + - | - - - - |
| N. cornuta franciscana | - - - + | - - - + | - - - - |
| Dorvillea pseudorubrovittata | - - - - | - - - + | - - - - |
| D. rudolphi | - - - + | - - - - | - - - - |
| Owenia fusiformis | - - - - | - - - + | - - - - |
| Amage anops | - - - - | - - - + | - - - - |
| Amphicteis mucronata | - - - + | - - - + | - - - - |
| Neoamphitrite robusta | - - + - | - - - - | - - + - |
| Eudistylia sp. | - - - + | - - - - | - - - - |
| Serpula vermicularis | - + + - | - - - + | - - + - |
| Tubificid oligochaete | - - - + | - - - - | - - - - |
| **Crustacea** | | | |
| Longipedia americana | - - - + | - - - - | - - - - |
| Ectinosomatidae | - - + - | - - - - | - - - - |
| Harpacticus sp. | - - + - | - - - + | - - - + |
| Dactylopodia vulgaris | - - - + | - - - - | - - - - |
| D. sp. | - - - + | - - - + | - - - + |
| Amphiascus minutus | - - - - | - - - + | - - - - |
| Robertgurneya sp. | - - - - | - - - + | - - - - |
| Typhlamphiascus sp. | - - - + | - - - + | - - - + |
| Heterolaophonte variabilis | - - + - | - - - - | - - - - |
| Chthamalus dalli | + - - - | + - - - | + + - - |
| Balanus glandula | + - - - | + + - - | + + - - |

Appendix 3 continued.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B. cariosus | + | + | - | - | + | + | - | - | - | + | - | - |
| B. nubilus | - | + | + | - | - | + | - | - | - | - | + | - |
| B. sp. | - | - | + | + | - | - | + | + | - | - | + | + |
| Cumella vulgaris* | - | - | + | - | - | - | + | - | - | - | + | - |
| Leptochelia dubia* | - | - | - | - | + | - | - | + | - | - | - | + |
| Gnorimosphaeroma oregonensis | - | + | - | - | - | - | - | - | - | + | - | - |
| Idotea resecata | - | - | - | - | - | - | + | + | - | - | - | - |
| I. wosnesenskii | + | + | - | - | - | - | - | - | - | - | - | - |
| Munna ubiquita* | - | - | - | + | - | - | - | + | - | - | - | - |
| Ampithoe simulans | - | + | - | - | - | + | - | - | - | + | - | - |
| A. valida | - | - | - | - | - | - | + | - | + | + | - | - |
| A. sp. | - | - | + | - | - | - | - | - | - | - | - | - |
| Allorchestes angusta | + | - | - | - | - | - | - | - | - | - | - | - |
| Aoroides intermedius | - | - | - | + | - | - | - | + | - | - | - | - |
| A. sp. | - | - | - | - | - | - | - | + | - | - | - | + |
| Corophium sp. | - | - | - | + | - | - | - | + | - | - | - | - |
| Guernea reduncans | - | - | - | + | - | - | - | - | - | - | - | - |
| Hyale plumosa | + | - | - | - | + | - | - | - | - | - | - | - |
| Photis brevipes | - | - | - | + | - | - | + | - | - | - | - | + |
| P. sp. | - | - | - | + | - | - | - | - | - | - | - | - |
| Foxiphalus obtusidens | - | - | - | + | - | - | - | - | - | - | - | - |
| Synchelidium shoemakeri | - | - | - | - | - | - | - | - | - | - | - | + |
| Hippolyte clarki | - | - | - | + | - | - | - | - | - | - | - | - |
| Heptacarpus brevirostrus | - | - | - | + | - | - | - | - | - | - | - | - |
| H. littoralis | - | - | - | + | - | - | - | - | - | - | - | - |
| H. paludicola | - | - | - | + | - | - | - | + | - | - | - | + |
| H. sitchensis | - | - | - | + | - | - | - | - | - | - | - | - |
| Crangon franciscorum franciscorum | - | - | - | + | - | - | - | + | - | - | - | - |
| Pagurus sp. | + | + | + | + | - | + | + | - | + | + | + | + |
| Petrolisthes eriomerus | - | - | + | - | - | - | - | - | - | - | - | - |
| Pugettia gracilis | - | - | + | - | - | - | + | - | - | - | - | - |
| P. producta | - | + | + | - | - | - | + | + | - | - | + | + |
| Telmessus cheiragonus | - | - | - | + | - | - | - | - | - | - | - | - |
| Cancer gracilis | - | - | - | - | - | - | - | + | - | - | + | + |
| C. magister | - | - | - | - | - | - | + | - | - | - | - | - |
| C. productus | - | + | + | + | - | - | + | + | - | - | + | + |
| Lophopanopeus leucomanus | - | - | + | - | - | - | - | - | - | - | - | - |
| Hemigrapsus sp. | + | + | + | + | + | + | - | + | + | + | + | - |
| Insecta | | | | | | | | | | | | |
| Cricotopus/Orthocladius sp. | - | - | + | - | - | - | - | - | - | - | - | - |
| Mollusca | | | | | | | | | | | | |
| Lepidozona mertensii | - | - | + | - | - | - | - | - | - | - | - | - |
| Mopalia ciliata | - | - | + | + | - | - | - | - | - | - | + | - |
| M. lignosa | - | - | + | - | - | - | - | - | - | - | - | - |
| Collisella pelta | - | + | - | - | - | + | - | - | - | + | + | - |
| C. digitalis | + | + | - | - | - | - | - | - | + | - | - | - |
| C. sp. | - | - | - | + | - | - | - | - | - | - | - | + |
| Notoacmea persona | - | - | - | - | + | + | + | - | + | + | + | - |
| N. scutum | + | + | - | - | + | + | - | - | - | - | - | - |

Appendix 3 continued.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Callistoma sp. | - | + | + | + | - | - | + | + | - | - | + | + |
| Margarites salmoneus | - | - | + | - | - | - | + | - | - | - | + | - |
| Tegula sp. | - | - | - | - | - | - | - | + | - | - | - | - |
| Littorina scutulata | + | + | - | - | + | + | - | - | + | + | + | - |
| L. sitkana | + | + | - | - | - | + | - | - | - | + | - | - |
| Bittium eschrichtii | - | - | + | - | - | - | - | - | - | - | + | + |
| Crepidula adunca | - | + | - | - | - | - | - | - | - | - | - | - |
| Polinices lewisii | - | - | - | - | - | - | - | - | - | - | - | + |
| Nucella lamellosa | - | + | - | - | - | - | - | + | - | - | + | - |
| Nassarius sp. | - | - | - | - | - | - | - | + | - | - | - | - |
| Haminoea vesicula | - | - | + | - | - | + | + | - | - | - | - | - |
| Phyllaplysia taylori | - | - | - | - | - | - | + | + | - | - | - | - |
| Acanthodoris brunnea | - | - | - | - | - | + | - | - | - | - | + | - |
| Anisodoris nobilis | - | - | + | + | - | - | - | - | - | - | - | + |
| Archidoris montereyensis | - | - | + | - | - | - | - | + | - | - | - | + |
| A. odhneri* | - | - | + | - | - | - | - | - | - | - | - | - |
| Diaula sandiegensis | - | - | - | - | - | - | - | - | - | - | - | + |
| Hermissenda crassicornis | - | - | - | + | - | - | - | - | - | - | - | + |
| Melibe leonina | - | - | - | + | - | - | - | + | - | - | - | - |
| Onchidoris bilamellata | - | + | - | - | - | - | - | - | - | - | - | - |
| Pododesmus macrochisma | - | + | + | - | - | - | + | - | - | - | + | + |
| Diplodonta orbella | - | - | + | + | - | - | - | - | - | - | - | - |
| Modiolus rectus | - | - | - | - | - | - | + | - | - | - | - | - |
| Mytilus edulis | + | + | - | - | - | + | + | - | + | + | + | - |
| Crassostrea gigas | - | - | - | - | - | + | + | - | + | + | + | - |
| Kellia laperousii* | - | - | + | - | - | - | - | - | - | - | - | - |
| Clinocardium nuttallii | - | - | + | - | - | - | + | + | - | - | - | - |
| Protothaca staminea | - | - | + | - | - | + | + | - | - | + | + | - |
| Saxidomus giganteus | - | - | + | - | - | - | + | - | - | - | + | + |
| Transennella tantilla* | - | - | + | - | - | - | - | - | - | - | - | - |
| Schizothaerus capax | - | - | + | - | - | - | + | + | - | - | - | + |
| Semele sp. | - | - | - | - | - | - | + | - | - | - | - | - |
| Tellina sp.* | - | - | + | - | - | - | - | - | - | - | - | - |
| Macoma nasuta | - | + | + | + | - | + | + | - | - | - | - | - |
| Echinodermata | | | | | | | | | | | | |
| Crossaster papposus | - | - | + | - | - | - | - | - | - | - | - | + |
| Solaster stimpsoni | - | - | - | - | - | - | - | + | - | - | - | + |
| Henricia leviuscula | - | - | + | - | - | - | - | - | - | - | - | + |
| Evasterias troschelii | - | + | + | + | - | + | - | + | - | - | + | + |
| Pisaster ochraceus | - | + | + | + | - | - | - | - | - | - | + | + |
| Dendraster excentricus | - | - | - | - | - | - | + | + | - | - | - | - |
| Ophiopholis sp.* | - | - | - | + | - | - | - | - | - | - | - | - |
| Cucumaria miniata | - | - | + | + | - | - | - | - | - | - | - | - |
| Eupentacta quinquesemita | - | - | + | + | - | - | - | - | - | - | - | - |
| Parastichopus californicus | - | - | + | + | - | - | - | - | - | - | - | + |
| Ascidia callosa | - | - | + | - | - | - | - | - | - | - | - | - |
| Cnemidocarpa finmarkiensis | - | - | + | - | - | - | - | - | - | - | - | - |
| Chordata | | | | | | | | | | | | |
| Hippoglossoides elassodon | - | - | + | + | - | - | + | + | - | - | - | + |

Appendix 3 continued.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Clinocottus acuticeps | - | - | - | - | - | - | + | - | - | - | - | - |
| Oligocottus maculosus | - | + | - | - | - | + | + | + | - | - | + | + |
| Gobiesox meandricus | - | - | + | - | - | - | - | - | - | - | - | - |
| Anoplarchus insignis | - | + | - | - | - | - | - | + | - | - | - | + |
| Ammodytes hexapterus | - | - | - | + | - | - | - | - | - | - | - | - |

Number of Species/Zone:

| | | | | | |
|---|---|---|---|---|---|
| Area I | U = 18 | Area II | U = 9 | Area III | U = 14 |
| | M = 44 | | M = 28 | | M = 23 |
| | L = 66 | | L = 43 | | L = 37 |
| | S = 57 | | S = 47 | | S = 43 |

Total number of Species/Area:

Area I = 130 Area II = 90 Area III = 79

## Brief Descriptions Of Areas I, II & III.

### Area I

This area extends south-west of the I.O.S. dock for approximately 1000m. As with areas II and III, there is almost no exposed beach at high tide. The substrate of this area (from supraintertidal to subtidal) is a mixture of pebble (0.4 - 6.4cm) and cobble (6.5 - 25.5cm) grading to cobble and boulder (>25.5cm) with large obtrusions of bedrock. The slope in this upper zone ranges between 5 and 8°. Lower down, the slope decreases to approximately 2° and the substrate is mostly bedrock with numerous tide pools and scattered patches of sand. Below the intertidal zone, the substrate rapidly changes to continuous sand with very few boulders.

### Area II

Area II extends north of the I.O.S. dock for nearly 1600m. There is a narrow (<10m) beach of cobble and pebbles grading to cobble with scattered boulders. The average slope here is 5°. Less than 20m from the upper limit of the beach, the substrate becomes almost entirely muddy sand with very few scattered boulders. The slope decreases here to between 1 and 3°.

### Area III

Area II intergrades into Area III. This section continues westward for almost 1100m until Warrior Point. The upper intertidal is mostly bedrock overlain with pockets of pebbles and small cobble. The upper slope averages 5°. Lower down, the substrate rapidly changes to sand with scattered rock islets. The average slope here is 3°.