# A STUDY OF THE DISTRIBUTION OF SOME MEMBERS OF THE NYROCINAE WINTERING ON THE COASTAL WATERS OF SOUTHERN BRITISH COLUMBIA

by

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## ABSTRACT

From September, 1951, until March 1952, field work was carried on to determine the distribution of wintering diving ducks on the coastal waters of southern British Columbia, and an attempt was made to discover and evaluate the factors causing distribution and movement.

Diving ducks are influenced by the availability of food and other factors related to this availability. These factors include salmon and herring spawning, grain elevators, sewer outfalls, and changing tides. Local movements result from courtship activity, diel periodicity and disturbing agencies.

Mortality factors, including hunting, oiling, predation and lead poisoning did not cause serious inroads in the wintering diving duck population during the study.

Lake, and bay and estuarine habitats were found to be less important wintering areas than habitats along protected and unprotected coastline. All species of diving ducks showed preference for certain habitats and regions in the study area, and were absent or uncommon in others.

During the winter, the drakes and hens of most species were distributed non-randomly because of the preponderance of males and their tendency to flock together. In early spring the sexes were distributed non-randomly due to pair formation and predominance of drakes. A differential sex migration was evident in most species of ducks during late fall and early spring.

Only a small percentage of juveniles of all species were wintering on the study area, indicating that they possibly winter in other localities.

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# INTRODUCTION

The diving, bay or sea ducks have, for many years been recorded as transients on the Pacific seabord during spring and fall migrations, and as residents during the winter. The records of Munro and Cowan (1947) show that all the species of Nyrocinae, with the exception of the eiders and lesser scaup duck (Nyroca affinis), winter on the marine waters adjacent to southern British Columbia. Munro (1939, 1941, 1942), in his studies on the American golden-eye (Glaucionetta clangula americana), Barrow's golden-eye (Glaucionetta islandica), greater scaup duck (Nyroca marila), lesser scaup duck and buffle-head (Charitonetta albeola), observed these ducks on their coastal wintering grounds and made conclusions regarding their distribution and movement. Until September, 1951, when the present study was initiated, little attempt had been made to systematically observe diving ducks throughout the entire winter period on an area suitably large and ecologically varied to include all species of Nyrocinae wintering in this latitude.

In winter, most species of diving ducks live on the coastal marine waters. In the study area, the ducks showing this habit were greater scaup duck, American golden-eye, Barrow's golden-eye, bufflehead, harlequin (Histrionicus histrionicus), white-winged scoter (Melanitta deglandi), surf scoter (Melanitta

perspicillata), American scoter (Oidemia americana), and, to a lesser degree, canvas-back (Nyroca valisineria).

During the study, an attempt was made to observe all existing shore line within the study area. This was not possible owing to limited time and transportation facilities available. However, the shoreline and lakes observed represent the varied array of ecological habitats that exist.

When it is impractical to mark a sufficiently large number of animals for recognition at a later date, all conclusions regarding seasonal and daily movement must be made by analysing a series of observational data on the species, rather than the individual. This method has been used in the present study. Because the many factors influencing the wintering ducks could not be controlled, it has been necessary to indicate the effects of these factors rather than draw definite conclusions.

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## DESCRIPTION OF STUDY AREA, HABITATS, AND OBSERVATIONAL AREAS

The waters of the Strait of Georgia, Burrard inlet, and Howe sound adjacent to the coast of southern British Columbia, and the inland lakes in this region, are probably the most northerly coastal wintering grounds of the redhead (Nyroca americana), ring-necked duck (Nyroca collaris), canvas back, and lesser scaup duck. To the greater scaup duck, American golden-eye, Barrow's golden-eye, buffle-head, harlequin, white-winged scoter, and surf scoter, these waters are the approximate mid-points of their coastal winter ranges. During September, October and November large numbers of diving ducks arrive on these wintering grounds from their more northerly breeding range. According to Munro and Cowan (1947), some species, such as the harlequin and non-breeding white-winged scoters, surf scoters, and American scoters summer in small numbers on the British Columbia coast.

The salt water study area is bounded on the west by the east coast of Vancouver island, and extends from Oyster bay in the north, southeast to Victoria. The eastern boundary is formed by the mainland coast line and extends from the 49th parallel north to McNab creek, Howe sound.

The freshwater lakes included in the study are St. Mary lake, Salt Spring island, and Langford, Elk, Durrance, Sooke,

Wolf, Quamichan, Somenos lakes, and in part, Cowichan and Comox lakes, Vancouver island. On the mainland, observations were made at Beaver lake and Lost Lagoon, Vancouver.

The study region is characterized by mild winters and high precipitation. At Comox, near the northern boundary of the study area, the lowest temperature recorded (Meteorological Division, Department of Transport) in January 1952, was 7°F. The lowest recorded temperature at Victoria was 18°F., and at Vancouver, 14°F. Highest precipitation occurs during December, and the average monthly precipitation during this month at Cumberland (41 years' observations) is 10.87 inches, at Victoria (58 years' observations), 4.67 inches, and at Vancouver (41 years' observations), 8.76 inches. The marine waters seldom freeze over except in the marshy areas, and some protected bays. Even here the ice soon rots or is broken up by wind and wave action. Freshwater lakes usually freeze over completely or partially during the latter part of December and early January.

On the Pacific coast, three major factors operate to determine the distribution of shore invertebrates. These have been described by Ricketts and Calvin (1939), as the degree of wave shock, the type of shore bottom, and the tidal exposure. These factors suggested the classification of habitats used by these workers, and a similar but modified system has been adopted for the present study.

Cottam (1939), has shown, and the results of the food analysis made by the author indicate, that many species of

invertebrates are utilized as food by diving ducks. It is reasonable to assume then, that those factors which influence invertebrate distribution also affect the distribution of diving ducks.

The classification of marine habitats adopted is based on the exposure of the shoreline to high winds and wave shock, and the type of bottom, whether rocky or sandy. The effect of wave shock is considered negligible in the freshwater habitat, and no distinction between different types of bottom has been made.

Considering degree of exposure and type of bottom, the following generalizations can be made:

Unprotected coast: The shoreline in this region, because of its position and exposure to frequent strong winds, is subjected to heavy surf. Many gradient stages occur and occasionally, a strip of unprotected beach is broken by a projecting point or pier which provides protection to the leeward shoreline. However, the majority of shoreline in this category is pervaded by a high degree of wave shock.

Protected coast: Wave shock is minimized in this region because of natural and artificial obstruction to heavy waves and strong winds. Again, many gradient stages of wave shock exist, but heavy surf on this shore is uncommon.

Sandy shore and rocky shore: Along a strip of coast line, much intergradation of types of bottom exist, ranging from muddy, muddy-sandy, to rocky. In the Greater Vancouver area,

much of the bottom is sandy, due to the deposition of silt by the Fraser river. Often, rocks are present on the sandy bottom, and a change from a sandy, sandy-rocky, to a rocky bottom occurs almost imperceptibly. The author has attempted classification after determining which element, whether rock or sand, was predominant, and has established observational areas to coincide approximately with these bottom types.

Bay and estuarine: The shoreline in this habitat is almost completely protected from surf, and the water salinity, because of the influence of rivers and streams, is lower than in other regions. In the Greater Vancouver area, only one such habitat exists, and, occurring at the mouth of the North arm of the Fraser river, includes the waters from the H. R. McMillan booming ground north to West Point Grey and west to the Iona Island jetty.

The shore is protected from heavy wave action by the jetty, and the many log booms which are present. The combined effect of these two factors results in quiescent waters. The majority of bottom consists of sand and mud, although some rocks are present, especially at the northern end in the vicinity of West Point Grey. At low tide, vast expanses of shore are exposed limiting the diving ducks to the narrow dredged channel just east of the jetty.

Lake: The only lake intensively studied was St. Mary lake, Salt Spring island. Small alder (Alnus sp.), willows (Salix sp.), and western spiraea (Spiraea douglassi Hook), are

present along the shoreline, and sedges (*Carex* sp.) and water lobelia (*Lobelia dortmanna* L.) grow in the water near the shore. Low-lying wooded hills on all sides serve to protect the lake from strong winds.

The shoreline in the Greater Vancouver area can be classified into four habitats, viz;

I. Unprotected coast-sand bottom,

II. Unprotected coast-rock bottom,

III. Protected coast-rock bottom,

IV. Bay and estuarine-mud-sand bottom.

The first two habitats are represented by three individual and separate units of shore (Figures 1-5). Habitats three and four are represented by one unit of shoreline each (Figures 6-7) and the lake habitat, is typified by St. Mary lake, Salt Spring island.

The separate units of shoreline representing the unprotected-sandy and unprotected-rocky habitats are quite distant from one another, and it was not possible to cover all these units on the same day. For this reason each of the three units of shore within these two habitats was established as an observational area. The observational areas in each type and their size and location is as follows:

| Observational Area | Habitat | Size (Miles) | Location |
|---|---|---|---|
| 1 | I | 3.5 | West of jetty, North arm of Fraser river, |
| 2 | I | 3.9 | West Point Grey to the Royal Vancouver Yacht Club, |
| 3 | I | .4 | Kitsilano beach, |
| 4 | II | 1.2 | Royal Vancouver Yacht Club to Kitsilano beach, |
| 5 | II | .7 | English Bay beach, |
| 6 | II | 1.8 | Second beach to Siwash rock, |
| 7 | III | 2.6 | Prospect point to Coal harbour, |
| 8 | IV | 3.5 | North arm of Fraser river, |
| 9 | V | 1.6 | St. Mary lake. |

Photographic Surveys Ltd.

Figure 1. Aerial photograph of Vancouver and adjacent waters. Note the sandy shore at the Iona Island jetty (lower right corner) and West Point Grey (lower left).

Figure 2. Low tide at Observational Area 3, Kitsilano beach. Unprotected-sandy habitat.

Figure 3. Low tide at Observational Area 4, Jericho beach. Unprotected-rocky habitat.

Figure 4. Low tide at Observational Area 5, English Bay beach. Unprotected-rocky habitat.

Figure 5. Low tide at Observational Area 6, Second beach. Unprotected-rocky habitat.

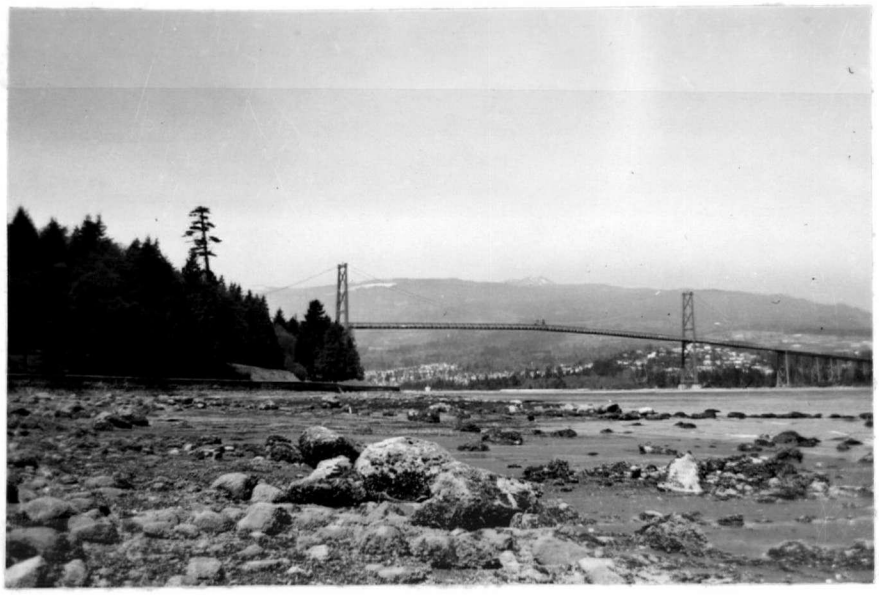


Figure 6. Low tide at Observational Area 7, Prospect point. Protected-rocky habitat.

Figure 7. Low tide at Observational Area 8, North arm of Fraser river. Bay and estuarine habitat.

## PROCEDURE

In the majority of cases, all counts were made with binoculars and a twenty-power telescope. Observers in the field were supplied with pocket-sized census books in which pertinent data such as species, numbers present, sex and age of the diving ducks were recorded. Place, time, weather, wind velocity, condition of water and distance from shore were also noted, and in each case an attempt was made to determine the activity of all birds observed. Those diving continuously were recorded as feeding, whether or not food material could actually be seen in the bill. Those ducks sitting on the water, showing little or no movement were recorded as resting or loafing. Other activities noted were flying, displaying and courting, and attempts at coitus.

Observations were made by walking along the beaches, driving along roads in close proximity to the shore, and travelling by open boat and motor launch. When observing by boat, every attempt was made to avoid disturbing the ducks in order to insure against counting the same ducks repeatedly.

To determine how the numbers and species of ducks changed or varied, arbitrary time periods were established. Each month contained two time periods, viz. from the first day of the month to the fifteenth, inclusive, and from the

sixteenth day to the last day of the month, inclusive. It is seen that unless a month has exactly thirty days, the time periods will vary slightly in length. However, it is felt that this introduces no bias to the observations because all time periods consist of fourteen to sixteen days. Only the records for those habitats on which observations have been made repeatedly throughout the winter are used to draw comparisons regarding habitat preference and relative abundance, although counts made on all shoreline covered are used to determine overall distribution and sex and age structure of the various species.

An attempt was made to obtain data at least onceevery two weeks on observational areas one to nine, and whenever possible, at least four observational areas were covered on the same day.

# FACTORS INFLUENCING SEASONAL DISTRIBUTION AND MOVEMENT

## CLIMATE

The winter climate in the Strait of Georgia, already mentioned, can be described as mild with high precipitation. Temperatures normally fall below freezing during December and January, and many of the small shallow lakes on Vancouver island and the mainland freeze over. Ice may form on small areas of calm salt water, but this temporary condition in no way prevents the ducks from feeding, nor does it act to delimit their available feeding area.

During late December, 1951, and early January, 1952, Somenos and Quamichan lakes were completely frozen and supported no diving ducks. St. Mary lake was partially frozen, but this condition did not affect the feeding activity of the small population of ducks wintering there.

Kortright (1943), demonstrated that the greater scaup duck, American golden-eye, Barrow's golden-eye, buffle-head, harlequin, old-squaw (Clangula hyemalis), and the three species of scoters, commonly winter north of the study area. This would indicate that the temperature extremes in the Strait of Georgia

are within the limits of tolerance of these ducks. Although no definite data are available, it would seem that low temperatures may limit the northern winter distribution of the redhead, ring-necked duck, canvas-back and lesser scaup duck.

## LAND AND SHORE TOPOGRAPHY

It is conceivable that only a small number of diving ducks would winter on southern British Columbian waters if the coastline was regular and not protected from heavy surf by the outlying islands. However, the shoreline is very irregular and characterized by numerous bays, sounds and inlets, and the juxtaposition of the many smaller islands and Vancouver island with the mainland results in a high degree of wind and wave protection. Large waves similar to those occurring on the west coast of Vancouver island are not experienced in the strait.

Field observations indicate that enough shoreline is available to offer sanctuary to all ducks during storms.

## FOOD AVAILABILITY AND PREFERENCE

### Invertebrates

It was not possible to obtain quantitative and qualitative data on the distribution of invertebrates in the study area. However, a rich supply of many species of invertebrates occurs in the inter-tidal zone. Ricketts and Calvin (1939),

have shown how invertebrates are distributed in the tidal zones on the Pacific coast, and Parizeau (1941), working on the east coast of Vancouver island, found the greatest wealth and variety of invertebrate fauna occurred in the lower half of the tidal zone. Invertebrates are influenced by the type of shore and exposure, with the result that an uneven distribution occurs over a large and varied coastline.

Cottam (1939), has shown that diving ducks eat a variety of invertebrates and plant food, but usually there is one food that is taken in greater quantities than others. The ducks probably have a preference for a certain food and will gorge themselves with this food when it is available. When non-available, other more available foods are eaten in greater quantities. The food study made by Cottam (1939) has shown that 44.07% of the food eaten by 819 white-winged scoters consisted of clams, oysters and pectens, and 11.98% blue mussels (Mytilus edulis). For 168 surf scoters, 13.04% of the food was clams and 28.74% was blue mussels. This would indicate that white-winged scoters showed a preference for clams, oysters and pectens, whereas the surf scoters preferred blue mussels. The former invertebrates are most commonly found on sandy bottom, while the mussels are most abundant on rocky bottom.

If it is true that these two species of diving ducks do show preference for certain foods, it should be expected they would be most common in areas where these foods were available. In order to test this, the numbers of white-winged

scoters and surf scoters were compared on two areas which showed differences in type of bottom, and presumably contained different quantity and variety of invertebrates. One of these areas extends from Qualicum river to Courtenay, Vancouver island. There are several commercial oyster beds in this area, and probably oysters and clams are generally abundant. The second area extends from Gibsons, Howe sound, north to McNab creek and south along the west side of Anvil, Gambier and Keats islands. Most of the shoreline is rocky and abrupt (Figure 8) and blue mussels are very abundant.

Figure 8. South end of Anvil island, Howe sound, showing abrupt and rocky shore typical of this region.

In two observations, 15.4 white-winged scoters per mile and 4.4 surf scoters per mile were seen from Qualicum river to Courtenay. The two observations in Howe sound showed that 0.61 white-winged scoters per mile and 19.75 surf scoters per mile were feeding here. These observations indicate that

invertebrate distribution and waterfowl preference for these food organisms is a factor affecting the distribution of wintering diving ducks.

Availability of food, discussed in the following sections, also affects distribution. Moffitt (1938), found that canvas-backs in the Suisun area, California, fed in the marshes during the fall, and when the food supply became exhausted, moved to the open bays to consume animal food.

A small sample of gizzards, obtained during the winter, was examined and the percentage volume of food eaten by the nine species of diving ducks considered, is presented in Table I. No conclusions can be drawn from such an inadequate sample, but the results indicate that the canvas-back is predominantly a plant feeder. Undoubtedly, the presence of plant food affects the distribution of these ducks. They were most common in bay and estuarine habitat where an abundant supply of plant food is found. The greater scaup duck, American golden-eye, buffle-head, old-squaw, harlequin duck, white-winged scoter, surf scoter and American scoter are predominantly animal feeders. All areas on which these ducks were seen feeding have an abundant supply of this preferred animal food. The results also indicate that surf scoters show a preference for blue mussels, and that clams and crustaceans are preferred by white-winged scoters. This is substantiated by Cottam (1939) in his diving duck food study.

The presence of more white-winged scoters on the east

Table I. Food, by volume percentages, taken by nine species of diving ducks during period September 1951 to March 1952.

| | Canvas-back | Greater scaup duck | American golden-eye | Buffle-head | Old Squaw | Har-le-quin duck | White-winged scoter | Surf Scoter | American Scoter |
|---|---|---|---|---|---|---|---|---|---|
| Number of gizzards examined | 6 | 3 | 1 | 4 | 2 | 2 | 5 | 8 | 1 |
| **Plant food** | | | | | | | | | |
| Pondweeds | | | | | | | | | |
| *Potomogeton pectinatus* | | 2.78 | | | | | | | |
| *Potomogeton* sp. | 100.00 | 15.97 | | T | | | | | |
| Sedges | | | | | | | | | |
| "Cyperaceae" | T | .69 | | T | | | | | |
| *Scirpus* sp. | | T | | 10.00 | | | | | |
| *Carex* sp. | T | T | | T | | | | | |
| Smartweeds | | | | | | | | | |
| *Polygonum* sp. | T | T | | T | | | | | |
| Crowfoot | | | | | | | | | |
| *Ranunculus* sp. | | T | | | | | | | |
| Dock | | | | | | | | | |
| *Rumex* sp. | | T | | | | | | | |
| Rose | | | | | | | | | |
| *Rosa* sp. | | | | T | | | | | |
| Algae | | | | | | | T | T | |

Table I. Cont'd. Food, by volume percentages, taken by nine species of diving ducks during period September 1951 to March 1952.

| | Canvas-back | Greater scaup duck | American golden-eye | Buffle-head | Old-squaw | Har-le-quin duck | White-winged scoter | Surf scoter | American scoter |
|---|---|---|---|---|---|---|---|---|---|
| Animal food | | | | | | | | | |
| Mollusca | | | | | | | | | |
| Blue mussel, Mytilus edulis | | | | | 50.00 | | | 77.75 | |
| Clam, Protothaca staminea | | | | | | | 1.48 | | |
| Clam, Protothaca sp. | | | | | 50.00 | | 15.74 | T | |
| Clam, undetermined | | | | | | 30.73 | 35.58 | | 38.90 |
| Pecten, Pecten hindsii | | | | | | | 17.22 | | |
| Snail, Callistoma costatum | | | | | | | 2.22 | | |
| Snail, Callistoma sp. | | | | | | | | | 5.56 |
| Snail, Thais sp. | | | | | | | 3.52 | | |
| Snail, Littorina sp. | | 3.47 | T | 30.00 | | 3.07 | | .65 | |
| Snail, Certhiopsis sp. | | | | | | | | | 55.54 |
| Snail, Odostomia sp.(?) | | T | | | | | | | |
| Snail, undetermined | | | | | | | 2.59 | | |
| Arthropoda | | | | | | | | | |
| Crustacea | | | | | | | | | |
| Crab, Hemigrapsus nudus | | 77.09 | 100.00 | 40.00 | | | | | |

Table I. Cont'd. Food, by volume percentages, taken by nine species of diving ducks during period September 1951 to March 1952.

| | Canvas-back | Greater scaup duck | American golden-eye | Buffle-head | Old-squaw | Har-le-quin duck | White-winged scoter | Surf scoter | American scoter |
|---|---|---|---|---|---|---|---|---|---|
| Animal Food | | | | | | | | | |
| Arthropoda | | | | | | | | | |
| Crustacea | | | | | | | | | |
| Crab, *Hemigrapsus* sp. | | | | | | 66.20 | 7.03 | | |
| Hermit Crab, *Pagurus* sp. | | | | 20.00 | | | | | |
| Crab, *Oregonia gracilis* | | | | | | | 3.52 | | |
| Amphipoda | | T | | | T | | | | |
| Insecta, *Aphrosylus* sp.(?) | | T | | | | | | | |
| Diptera | | | | T | | | | | |
| Coelenterata | | | | | | | | | |
| Hydrozoa, *Abietenaria* sp.(?) | | | | | | | T | | |
| Chordata | | | | | | | | | |
| Pisces, *Clupea pallasi* | | | | | | | | 21.60 | |
| Undetermined | | | | | T | T | 11.10 | | |
| Lead shot | T | | T | | | | | T | |

coast of Vancouver island than in Howe sound, and the reverse situation with surf scoters, may be, as already mentioned, due to this preference.

Diving ducks were usually observed feeding in water depths of from six to eight fathoms. Depth data were obtained by estimating the distance from shore at which the ducks were feeding, and then calculating depth by means of Hydrographic maps. Schorger (1947), reports that old-squaws have been taken in gill nets at from 12 to 27 fathoms, but all birds seen during the study were either feeding in waters not deeper than six to eight fathoms, or resting on deeper water in close proximity to land.

The literature and field observations indicate that a rich invertebrate fauna is present on the inter-tidal shores within the study area.

Salmon Spawn

Salmon ova, which become available in the coastal streams in October, appear to have a definite bearing on the winter distribution of some species of diving ducks. Although the author was unable to find evidence of this in the winter of 1951-52, Munro (1923) found that Barrow's golden-eyes were feeding extensively on the spawn of sockeye salmon (Oncorhynchus nerka). This food formed the principal food during November and December.

Evidence has also been obtained by Munro (1939) that

salmon eggs form the main food for the American golden-eye during December and January. A similar situation has been reported by Wright (1944), who has observed American golden-eyes eating sockeye spawn in October, November, and December on Flathead lake, Montana.

Greater scaup ducks have been recorded by Munro (1941) feeding on salmon ova and the rotted flesh of dead salmon at this season. Mr. A. A. Sherman, (personal communication) reports very few golden-eyes and mergansers on the Cowichan river over the winter period 1951-52, and, as stated earlier, no evidence of diving ducks utilizing salmon ova has been obtained during the present study.

The literature indicates that some species, namely the golden-eyes and greater scaup ducks, do feed on salmon ova and consequently their distribution is influenced by the presence of this food.

Herring Spawn

The ova of the Pacific herring (Clupea pallasii), form the seasonal food for many species of diving ducks wintering in the Strait of Georgia, as shown by Munro and Clemens (1931) in their study of the relation of waterfowl to herring spawn in British Columbia. These authors found that the American golden-eyes, old-squaws, harlequin ducks, white-winged scoters, surf scoters and American scoters were utilizing herring spawn as food, and as a result, moving to areas of spawn abundance to

feed.

In two separate studies, Munro (1939, 1941) found that herring ova were consumed by Barrow's golden-eyes and perhaps formed the most important seasonal food of the greater scaup duck. One surf scoter shot and examined by the author at Ganges harbour, Salt Spring island on March 26, 1952, had fed entirely on herring ova. The stomach and gizzard contained 19 c.c. of this food.

Observations show that in March, when herring spawning is at its peak, large numbers of diving ducks concentrate over areas of spawn abundance. This influx and concentration of ducks was seen in two localities during the study. Mr. D. J. Robinson (letter) on March 22, 1952, observed and estimated 2,800 to 3,400 greater scaup ducks and a smaller number of golden-eyes, white-winged scoters and surf scoters at Nanoose bay, Vancouver island. The total number of diving ducks was estimated to be between 4,000 and 5,000. In this same area, from November, 1951 to early March, 1952, only 225 diving ducks per observation were seen.

A parallel situation was observed at this bay by Munro (1941) on March 12, 1934. On this date a raft of several thousand greater scaup ducks and smaller flocks of white-winged scoters and surf scoters were feeding on herring ova. Again, on March 26, 1936, Munro (1941) estimated 3,000 greater scaup ducks together with a smaller number of white-winged scoters and American scoters feeding in this bay.

Additional evidence showing that herring spawn

influences waterfowl distribution is presented by Mr. K. Racey (personal communication), who recorded the numbers of diving ducks seen between Fort Rupert and Port Hardy, Vancouver island, from October, 1950, to May, 1951. Throughout the fall and winter American golden-eyes, Barrow's golden-eyes, white-winged scoters, surf scoters and American scoters were present, but not common in this area. During late March and April, when herring spawn was available, large concentrations of golden-eyes and scoters, as well as a few greater scaup ducks were seen feeding on herring ova in Hardy bay. Later in May when no ova were available, only a few diving ducks were present and feeding in the area.

Although this flocking habit may be characteristic of these ducks prior to spring migration, it is believed that the presence of herring spawn is an important factor influencing waterfowl distribution and movement.

Grain Elevators

Diving ducks are also influenced by the presence of grain pool elevators in Vancouver harbour. This influence is related to the factor of food availability and appears to affect greater scaup ducks, American golden-eyes and Barrow's golden-eyes more than the other species of diving ducks.

At the No. 1 Pool Elevator on November 23, 1951, a large raft of approximately 150 greater scaup ducks and 150

American golden-eyes and Barrow's golden-eyes were seen actively diving, and, presumably feeding. H. D. Mulligan (personal communication), observed these species in smaller numbers on December 13, 1951, feeding on grain chaff.

Cottam (1939), states that grains of various kinds are taken by American golden-eyes at bait stations where these foods are consumed in preference to most natural foods because of availability.

There are only a few pool elevators in Vancouver harbour and probably only a few ducks are influenced by this source of food. However, the available grain chaff does affect distribution of a small percentage of greater scaup ducks and golden-eyes.

Sewer Outfalls

Several other factors were found to influence seasonal distribution and movement of diving ducks.

In the Greater Vancouver area, many sewer outfalls are located in English bay, False creek, Vancouver harbour and Burrard inlet. During the study greater scaup ducks, American golden-eyes and surf scoters, in association with gulls, were seen many times in compact rafts scavenging over the Brockton point and Jericho beach sewer outfalls.

Cottam (1939), has observed lesser scaup ducks feeding in similar situations on the eastern seaboard, and his stomach

analyses further indicate that these birds were consuming sewage material. He also cites the case (p.40) of lesser scaup ducks concentrating over the sewer outfalls in Santa Barbara, California, in order to feed on sewage.

Four large rafts of greater scaup ducks of 700, 375, 350, and 200 birds, approximately, and many smaller rafts, were seen between Vancouver harbour and the Second Narrows bridge, Burrard inlet on February 24, 1952. Eight sewer outfalls are located in this area, and the ducks, rafted and diving over these positions, were presumably feeding on the sewer flotsam.

On December 9, 1951, approximately 500 greater scaup ducks were seen feeding over the several sewer outfalls east of the Second Narrows bridge, and presumably, were feeding on sewage at that time. Mr. A. Dzubin (personal communication) reports a similar situation was observed on January 5, 1952, at which time an unestimated number of greater scaup ducks were seen between Second Narrows bridge and Vancouver harbour.

A comparable situation was observed at Clover point, Victoria, on March 15, 1952. In this locality approximately 250 greater scaup ducks, 35 surf scoters and a few American golden-eyes were actively feeding over the sewer outfall in this area. C. J. Guiguet (personal communication) has seen large rafts of diving ducks in this area at numerous times during the winter. R. Webb (letter) observed approximately 300 greater scaup ducks, and a smaller number of surf scoters and gulls feeding around Clover point on February 7, 1952.

The foregoing observations would seem to indicate that greater scaup ducks, and to a lesser degree, surf scoters and American golden-eyes, commonly feed on sewage, and consequently, spend much of their time in the vicinity of sewer outfalls. The distribution of sewers in the Vancouver and Victoria areas probably directly influences the distribution of these species.

In considering all the foregoing factors which influence seasonal distribution and movement, it can be concluded that food availability and preference appear to be the two chief factors governing this distribution and movement. Cottle (1949), drew similar conclusions in his study of the feeding behaviour of dabbling ducks in the lower Fraser valley, and Cottam (1939), states that food availability and preference are the two prime factors responsible for diving duck distribution.

## FACTORS INFLUENCING DAILY DISTRIBUTION AND MOVEMENT

As mentioned earlier, an attempt was made to determine the activity of all ducks seen during the study, and, when possible, to draw conclusions regarding the reasons for this manifestation of movement. The following factors, most of which are related to food availability, are considered responsible for daily movement and distribution.

### WEATHER

Severe weather and very rough water, sometimes experienced in the Strait of Georgia, appears in some instances to force numbers of ducks from the exposed feeding grounds to calmer waters. This was indicated by two separate counts made from Cowichan bay, Vancouver island, to Ganges harbour, Salt Spring island, immediately before and after a storm on January 13, 1952. The total diving duck count on January 12, when the water was very calm and there was no appreciable wind, exceeded 900 ducks. On January 14, following a severe storm, the same area was covered. In this second count, only 535 diving ducks were seen. Quite probably some ducks were overlooked because of the rough condition of the water. Nevertheless, it is

believed that fewer ducks were actually present at this time. No definite conclusions could be drawn regarding where the ducks had gone, but presumably they had left the area for quieter waters.

It has been observed, that large numbers of diving ducks feed and rest in Hammond bay, Vancouver island. This bay is protected during most stormy weather, and on February 9, 1952, when water conditions on the east coast of Vancouver island were very rough, 655 ducks were seen here. On January 17, 1952, when water conditions were generally calm, only 42 diving ducks were observed in this bay. Counts made on the same days at the more exposed Departure bay, a few miles to the south, showed that fewer birds were using this area during stormy weather, although the difference does not appear too significant.

Although in some instances waterfowl are disturbed by rough water and seek more sheltered waters, observations infer that these conditions do not always result in movement. Perhaps the degree of storminess is the operative factor determining the response of the waterfowl, for on December 21, 1951, a raft of approximately 200 surf scoters were observed feeding at the entrance to Horseshoe bay, Howe sound. At this time, a moderately strong northerly wind was sending large breakers into the bay.

Another set of data are presented which also show that diving ducks are not affected by moderate wave action. At Jericho beach, on March 17, 1952, 437 diving ducks were seen feeding, apparently unaffected by the driving rain and rough

water. Two days later, when the waters were extremely calm 434 diving ducks were counted on the same area. Evidently the conditions of the former day did not affect the ducks or cause them to shift to calmer waters.

The above observations infer that although waterfowl are ordinarily unaffected by stormy weather, there are instances where severe storms cause movement to protected bays.

## TIDES

Fluctuating tides have, on several occasions, appeared to be a factor causing duck movement and flocking in the vicinity of the Iona Island jetty. This is probably due to the turbulence caused by the river water, which is at a higher level than the salt water at this time, pouring over the north end of the jetty on the out-going tide.

On November 3, 1951, at 1 p.m., G. W. Smith (personal communication) observed an estimated 3,500 waterfowl, mostly diving ducks, feeding vigorously at a distance of 500 yards west of the jetty. These ducks, forming a long dense raft parallel to the shore, were feeding in what appeared to be a zone of drift material resulting from the receding tide and turbulent waters. Surf scoters formed the greatest part of this raft, while white-winged scoters, American scoters, buffle-heads, greater scaup ducks, and some pond ducks (baldpate (Mareca

americana)), were also present. One week later, at 2 p.m. on November 9, only 21 diving ducks were seen in this area. At this time the tide was high and there was no evidence of turbulence or rushing water. It is possible that many invertebrates are dislodged from the bottom when the Fraser river water is pouring over the jetty and the ducks at such times congregate here to utilize the available food.

Griscom (1945), reports that American golden-eyes are affected by tides in Newburyport harbour, Massachusetts where, two hours after high tide, these ducks move in to feed at the mouth of the sewer.

## DISPLAY AND COURTSHIP

A great amount of sexual activity is displayed by the diving ducks after the courtship has begun in early spring. Munro (1939), and Munro and Clemens (1931), have described the displays of the golden-eyes during courtship in February and March. American golden-eyes and Barrow's golden-eyes were seen in courtship activity in January in the Vancouver area, and on February 22, 1952, a male American golden-eye was seen attempting coitus with a female of the same species which had been previously swimming at his side with body low in the water and neck outstretched.

Several groups of three males and one female harlequin duck were seen actively courting on February 10, 1952, at Big

Qualicum river, Vancouver island. The males quickly flew after the female when she took flight, and followed her when she dived into the water.

Old-squaws were seen courting in the North Arm of the Fraser river in late February. No flights were made by the two males and one female, but much diving activity was shown. In the same area on March 14, 1952, three male buffle-heads were displaying before a hen. Munro (1942) describes the courtship behaviour of the buffle-head on the coast and states that this activity, reaching its greatest intensity on the interior breeding ground in April, is initiated on the wintering grounds in late January and early February.

Surf scoter drakes were seen vigorously displaying before a hen on March 15, 1952, at Oak bay, Vancouver island. At this time the males appeared very hostile towards one another.

Redheads, ring-necked ducks, canvas-backs, greater scaup ducks, and white-winged scoters were not seen displaying during the study. However, ducks of these species were seen paired during most of the winter. If the pairing in early spring was a true sexual association, it is feasible that courtship had taken place. The pairing seen in October, November and December may have been the result of chance association which had taken place in the interior breeding areas where post-breeding males often associate with moulting females. This association has been reported by Munro (1942), who states that moulting adult and yearling female buffle-heads are joined in August and

September by flying young and a few adult males and second year males in adult plumage. Munro (1939), has observed the association of male and female American golden-eyes during late fall, and states that at this time the adult males, accompanying females, young of the year, and a few yearlings, appear in the interior of British Columbia.

With the advancement of spring, courtship was seen to be prevalent in some species of diving ducks, and appeared to be an important factor causing local movements and shifts of courting individuals.

## DIEL PERIODICITY

Allee, et al (1949), state that the majority of animals have a diel periodicity in their general behaviour, and mention that most animals show a well defined diurnal period of relative activity and nocturnal period of relative inactivity.

It was not possible to study the nocturnal habits of the diving ducks during the study, or determine their activity at this time, but observations at Pasley island on November 17 and 18, 1951, showed that a great amount of waterfowl movement occurred at dawn and dusk. The juxtaposition of Pasley island, Popham island, and Golby island (Figure 9) forms an area of water which is almost completely protected from wind.

Courtesy G. W. Anderson.

Figure 9. Aerial photograph of the Pasley island group. The protected inter-island area offers sanctuary to diving ducks at night.

A large concentration of surf scoters, Barrow's golden-eyes, buffleheads, and white-winged scoters was seen in this inter-island area on the evening of November 17. The following morning at dawn this concentration was again observed, and at this time, many groups of from five to thirty ducks were starting to depart in a south-easterly direction. A few birds flew and swam to the nearby islands and began feeding. At 8 a.m. this large raft of ducks had completely disappeared. Later that day, at about 4 p.m., groups of the same species of ducks began flying into this area in small flocks of from two to fifty. By 4:30 p.m. an estimated 800 ducks were again resting approximately midway between these islands. The water depth at this position varied from 13 to 25 fathoms.

Although no definite conclusions can be drawn from these observations, it can be speculated that these ducks were returning to this protected area to rest during the night. No feeding activity was noted, and the deepness of the water would indicate that the scoters and golden-eyes could not feed here. Perhaps those birds flying southeast from this area in the early morning were dispersing to their feeding grounds in the Greater Vancouver area.

A return visit to these islands on February 27, 1952, showed that Barrow's golden-eyes and surf scoters were resting there in a similar fashion. The following day, at 2 p.m. no ducks were present.

Similar diel periodicity may exist locally in all

species of waterfowl, but remained undetected during the study.

## DISTURBANCES

Many agencies operate to disturb and move diving ducks off their feeding grounds. All instances of disturbance noted were related to human presence in the vicinity. Commonly, they are forced to fly or dive to avoid motor launches and fish boats. Frequently, when feeding close to the shore, the ducks take wing when approached by persons on the beach.

Illegal hunting was seen to cause rapid dispersion of ducks in the North Arm of the Fraser river. At this time, three gunners on the bow of a fish boat were seen shooting indiscriminantly into flocks of white-winged scoters and surf scoters, and ducks of these species were flying out of the locality in all directions. Most disturbing agencies are harmless, however, and only cause small movements in the form of short flights or rapid dives.

# FACTORS OF MORTALITY

The agencies responsible for diving duck mortality on the wintering grounds were found to be hunting, and oiling. These factors vary in their relative importance from year to year, and, during the present study, an attempt was made to evaluate their combined effects on the diving duck population.

## HUNTING

Some species of diving ducks, such as the redhead, ring-necked duck, canvas-back, and scaups, are considered to be choice game birds and are heavily hunted. The golden-eyes and scoters are believed to be unpalatable and "fishy" by many hunters and for this reason are not shot. Table II shows the number and kinds of diving ducks killed by hunters during the open seasons 1949 to 1951, at the Delta Municipality and checked at the bag checking stations.

Only 291 diving ducks of all species were killed during three years of hunting. This is a small number compared to the 7,585 mallards (Anas p. platyrhynchus) shot in this same area during the same period. Additional ducks are killed by fishermen after the hunting season has closed, but it is believed

Table II. Delta Municipality bag check of diving ducks shot by hunters during open seasons, 1949 - 1951.

| Species | Number shot | | | |
|---|---|---|---|---|
| | 1949 | 1950 | 1951 | Total |
| Redhead | | 1 | 1 | 2 |
| Ring-necked duck | | 1 | | 1 |
| Canvas-back | 25 | 14 | 9 | 48 |
| "Scaup" | 31 | 61 | 21 | 113 |
| "Golden-eye" | 7 | 11 | 1 | 19 |
| Buffle-head | 31 | 49 | 16 | 96 |
| Old-squaw | | | 1 | 1 |
| "Scoter" | | 6 | 5 | 11 |
| Total | 94 | 143 | 54 | 291 |

that only a small number of diving ducks are killed in this manner.

The habit of flocking on open water prevents many hunters from shooting diving ducks, and this probably is an important reason for so few ducks being shot. It is conclusive that hunting is not an important factor causing diving duck mortality.

OILING

On February 17, and 24, 1952, the debris line on the Boundary Bay beach was sampled and all dead birds and the cause of death were recorded. The sample included two miles of beach. Table III shows the results of this sampling.

Table III. Number of dead birds found on a two mile sample of beach at Boundary bay, February 7 and 24, 1952.

| Species | Cause of Mortality | | | |
|---|---|---|---|---|
| | Oiled | Shot | Unknown | Total |
| "Scaup" | | | 3 | 3 |
| American golden-eye | 1 | | | 1 |
| Buffle-head | 3 | | 3 | 6 |
| Old-squaw | 1 | | | 1 |
| White-winged scoter | 3 | 4 | 1 | 8 |
| Dabbling duck | | 1 | 9 | 10 |
| Black brant | | | 3 | 3 |
| "Gull" | 2 | 2 | 3 | 7 |
| Common loon | | | 1 | 1 |
| Western grebe | 1 | | 1 | 2 |
| Eared grebe | | | 2 | 2 |
| Total | 11 | 7 | 26 | 44 |

During the study only 11 birds were found dead as a result of oiling. It appears that oiling has not been as serious a factor of mortality as in previous years.

The effect of oil pollution varies each year. In 1947, Mr. K. Racey (personal communication) made observations on February 12, 16, and 18, at the shoreline of West Point Grey, Vancouver. The following species of birds were found dead as a result of oiling: greater scaup duck, buffle-head, old-squaw, surf scoter, American scoter, pintail (Dafila acuta tzitzihoa), red-breasted merganser (Mergus serrator) and horned grebe (Colymbus auritus). No actual count was made, but mortality was especially great among the American scoters and old-squaw ducks.

Lincoln (1936), in reviewing the effect of oil pollution on waterfowl, cites examples of large numbers of ducks being killed indirectly by oil at many localities on the Atlantic and Pacific coasts, and Racey (1930), found 14 oiled dead birds at Crescent beach in May, 1929, on a quarter mile sample of beach. He concludes that much damage is done to local water birds by oil.

Undoubtedly many birds are killed each winter as a result of oiling, and this is probably an important factor of mortality in some years. Oiling did not appear to be as serious in the study area during the winter of 1951-52, as it has been in other localities in other years. The total number of deaths by this cause could not be determined.

## LEAD POISONING

No evidence of lead poisoning was found during the study. The very nature of their feeding habits and preference for open water probably accounts for only small quantities of lead shot being ingested by diving ducks. The gizzard of one canvas-back examined contained two lead pellets, and an American golden-eye and surf scoter examined each had one pellet in the gizzard. The effect of lead shot could not be determined, but probably it is an unimportant factor in diving duck mortality.

## PREDATION

On several occasions a bald eagle (Haliaeetus leucocephalus) was seen making stoops at diving ducks at the Iona Island jetty. When approached by the eagle, the ducks would dive, and although the eagle made numerous attempts, it was unable to catch any ducks. In other situations some ducks are probably killed by eagles, but this is probably an unimportant factor of mortality on the wintering grounds.

## DISTRIBUTION OF THE SPECIES

The data obtained during the winter on Observational Areas 1 to 9, were analysed in order to determine if different species of diving ducks showed preference for certain habitats. In Figure 10 and 11 for each species, the percentage of the total number counted per observational mile on each habitat over the winter period is shown. The cumulative totals of the average number counted by species on all habitats (Observational Areas 1 to 9) during the study is shown in Figure 12.

General distribution over the entire study area, by species, is discussed in the following sections, and distribution and density (average number seen per observation) are shown in Figure 19 and 20.

### REDHEAD (Nyroca americana)

Only a few ducks of this species were wintering in the study area, and all birds, with one exception, occurred on lake habitat. One pair of redheads were counted at Elk lake, Victoria, in March 1952, but the greatest number occurred at St. Mary lake, where in January, 11 birds were observed at one time.

One drake was seen flying over the Iona Island jetty in November, 1951, but this was the only time this species

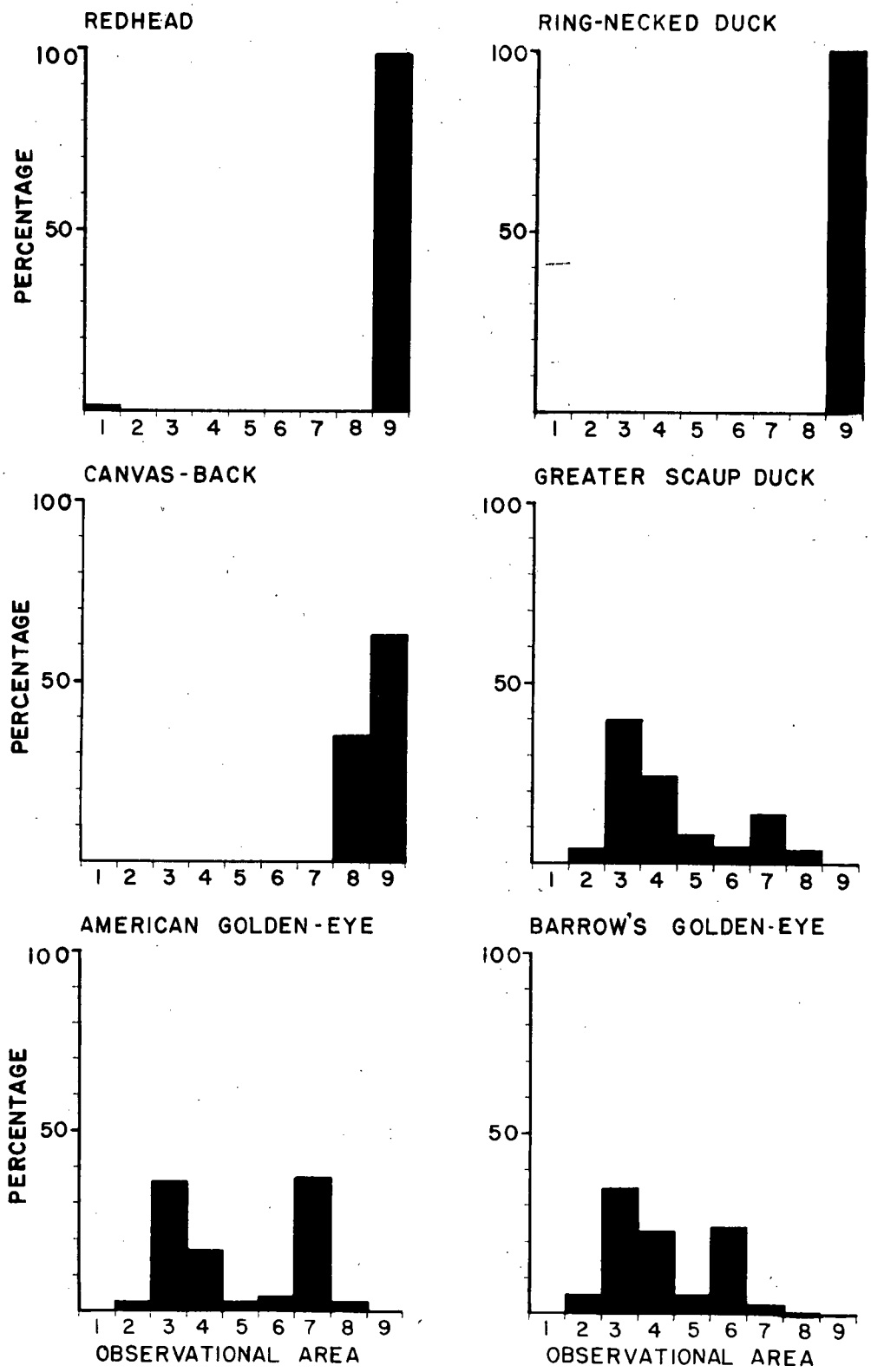



Figure 10. Percentage number of diving ducks counted per observational mile on individual habitats during period September 1951 to March 1952.

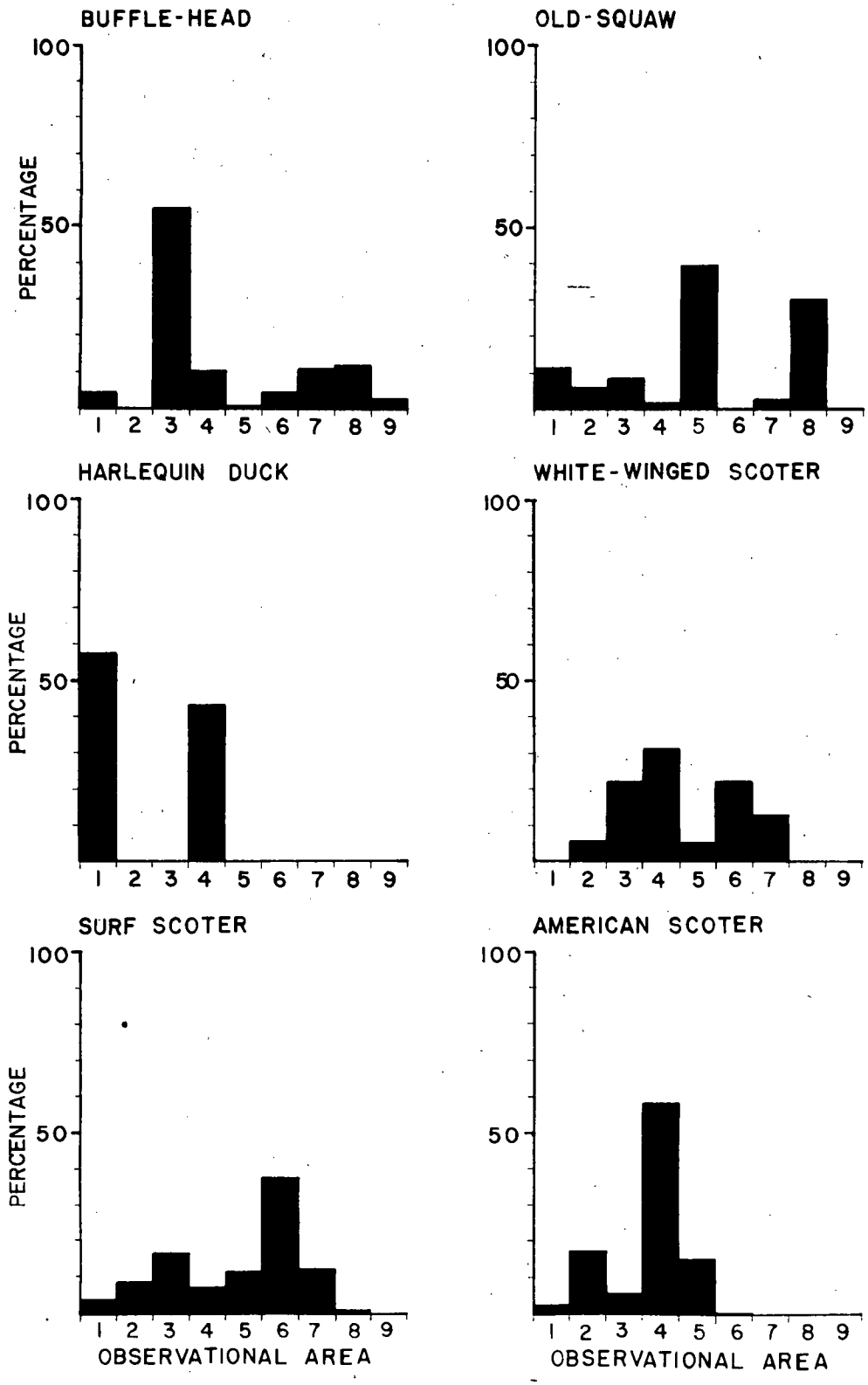



Figure 11. Percentage number of diving ducks counted per observational mile on individual habitats during period September 1951 to March 1952.

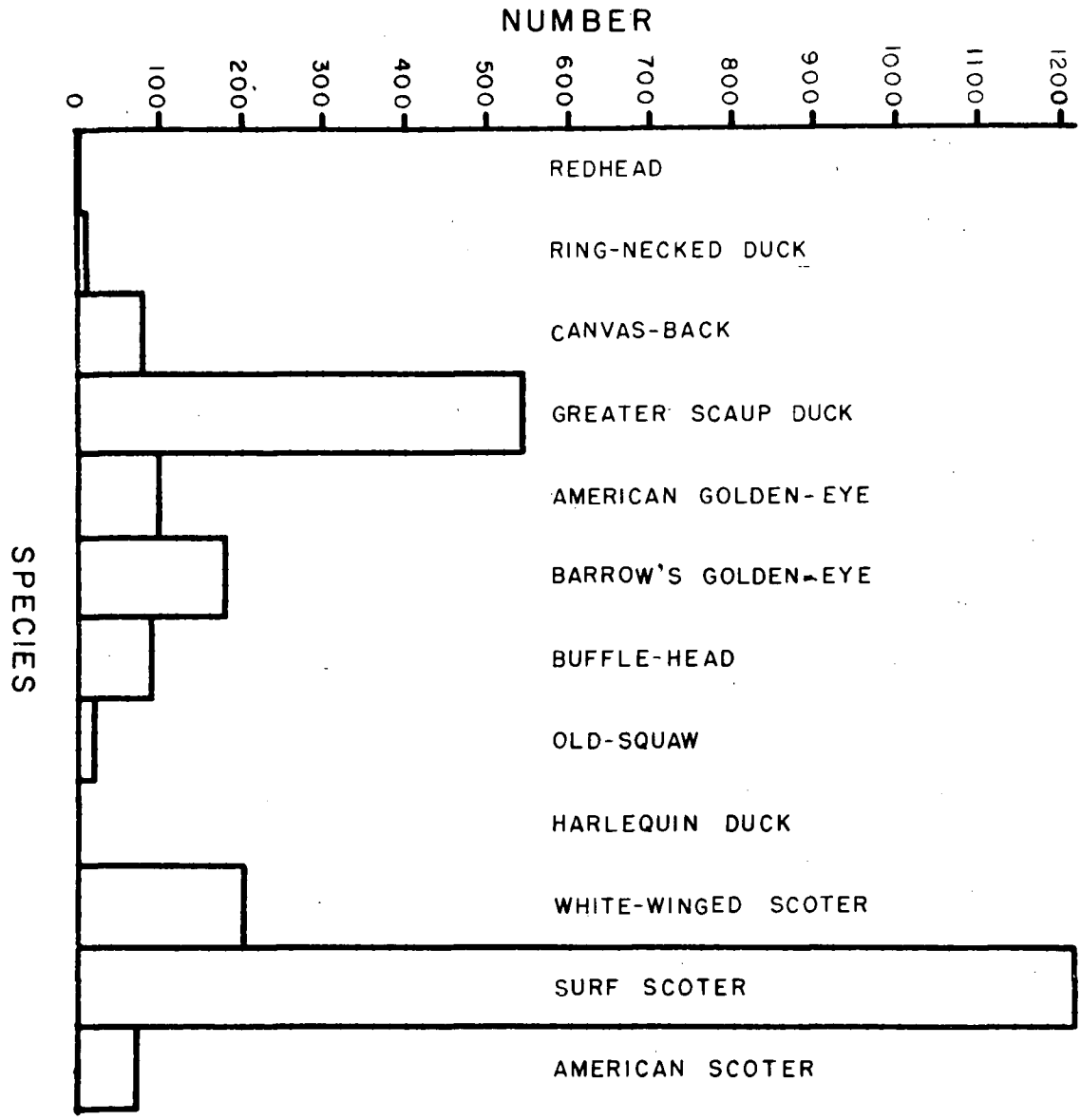



Figure 12. Total number of diving ducks counted, by species, on Observational Areas 1 - 9 during period September 1951 to March 1952. (Representing cumulative totals of average number counted per observation during this period.)

occurred on salt water habitat.

Redheads were the least abundant diving duck on the study area. It showed a definite preference for lake habitat and was not observed feeding on salt water areas. This preference for lake habitat is shown in Figure 10, where over 98% of the birds observed per mile were on St. Mary lake.

RING-NECKED DUCK (Nyroca collaris)

These birds did not occur on salt water areas, and were seen only on St. Mary lake. In December, 1951, the largest raft was observed and consisted of 22 males and 19 females. Very often, these ducks were feeding and resting in association with greater scaup ducks.

It was not determined why these birds did not occur at Elk lake, or other lakes in the Victoria region, where presumably, food availability is similar to that found at St. Mary lake.

CANVAS-BACK (Nyroca valisineria)

Ducks of this species were not generally distributed over the study area, but appeared to prefer St. Mary lake and the bay and estuarine habitat in the North arm of the Fraser

river. The only other localities where they were seen was at the mouth of the Koksilah and Cowichan rivers, Vancouver island, and at the Gorge near Victoria. They were observed only to rest on St. Mary lake where the greatest number counted at one time was 58. At the North arm of the Fraser river, canvas-backs were usually feeding, but no more than 41 were seen at one time.

Canvas-backs showed definite preference for wind-protected waters of low salinity. They were not seen feeding along any strip of unprotected shoreline in the study area.

GREATER SCAUP DUCK (Nyroca marila)

These ducks were generally distributed over the study area, but localities of greatest abundance were English bay, Vancouver harbour, Nanoose bay, Cowichan bay, Ganges harbour and Victoria. Sewer outfalls and abundant herring spawn, resulting in a high degree of food availability were the factors responsible for heavy concentrations in these localities.

Greater scaup ducks were present on all observational areas in the Vancouver area, but were most abundant at Jericho beach (Observational Area 4) and Kitsilano beach (Observational Area 3). A small population of from three to ten birds wintered on St. Mary lake, and groups of two and three birds were seen at Elk lake, Victoria, and Beaver lake, Vancouver. Occasionally

a large raft of 100 to 200 birds were observed at Lost lagoon, Vancouver, and Langford lake, Vancouver island, but these did not occur in these localities during the entire study period.

Food availability greatly influences the distribution of greater scaup ducks, for those areas not having sewer outfalls or available herring ova, such as Howe sound and Indian arm, are not characterized by an abundance of this species. On the east coast of Vancouver island between Qualicum river and Courtenay, this species was second in abundance.

LESSER SCAUP DUCK (Nyroca affinis)

No birds of this species were seen on the study area during the winter. Evidence that small numbers of these birds are present during fall migration and early winter has been obtained by Munro (1947), who counted a total of 81 lesser scaup ducks on Burnaby lake during September, October and November, 1946. Munro (1941), states that it seems fairly well established that the lesser scaup duck is a scarce winter visitant in British Columbia. Farther south in the Portland region, Oregon, this bird is the most abundant of the wintering diving ducks, but in southern British Columbia, it is rarely seen in winter.

AMERICAN GOLDEN-EYE (Glaucionetta clangula americana)

Ducks of this species were seen on all observational areas and did not show a marked preference for any one habitat type, although more were present in the protected-rocky than other habitats. American golden-eyes were most abundant on the east coast of Vancouver island and the Victoria area. Almost all the golden-eyes in these localities were of this species.

In the Greater Vancouver area and in Howe sound and Indian arm, this species is far outnumbered by Barrow's golden-eye.

Lake habitat is not preferred to marine habitats, and only a small number of these birds were seen on St. Mary lake during early spring.

BARROW'S GOLDEN-EYE (Glaucionetta islandica)

The distribution of Barrow's golden-eye and American golden-eye is similar in the study area, but many regions with large numbers of one species is characterized by a paucity of the related species. Examples of this situation were cited above, but can be emphasized again. In two counts between Qualicum river and the city of Courtenay, only five Barrow's golden-eyes were seen, whereas the number of American golden-eyes was more than fifty times greater. In Howe sound,

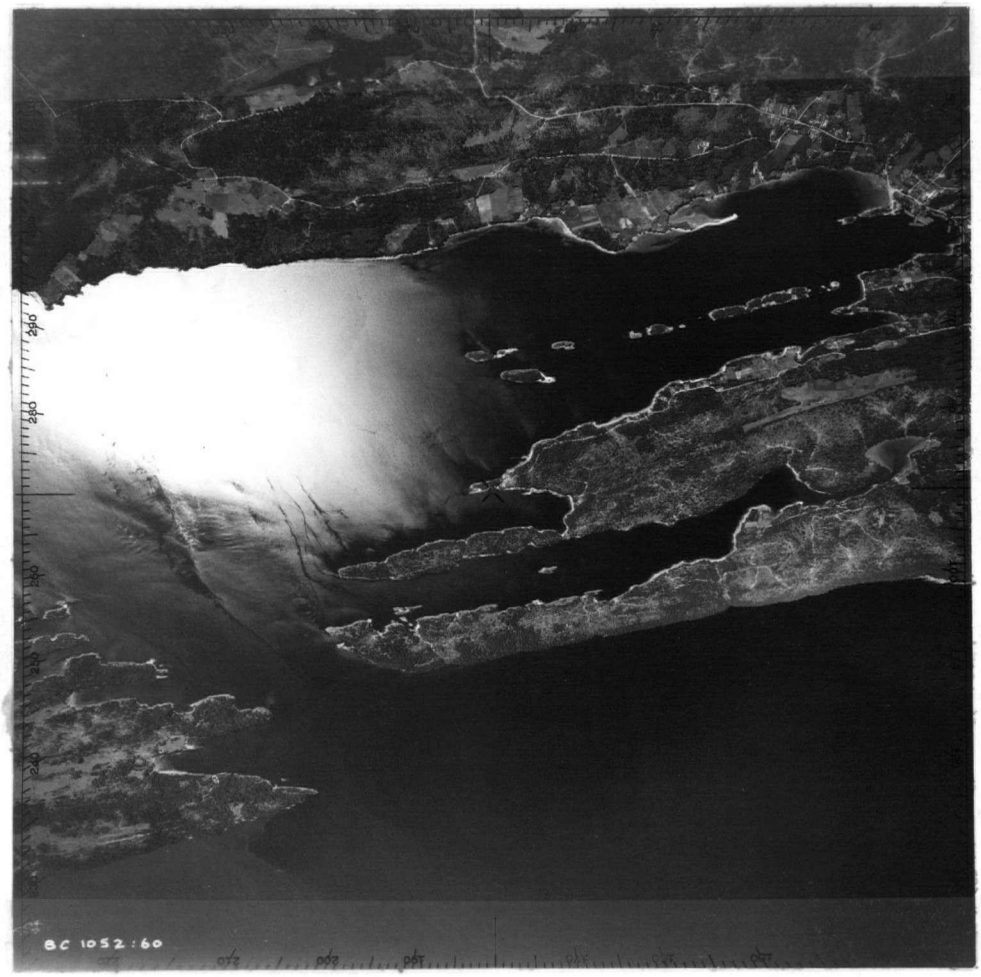
Barrow's golden-eyes were found to be almost twenty times as numerous, and during one observation at Indian arm, only eight American golden-eyes as opposed to 311 Barrow's golden-eyes were seen. This species is not commonly seen in the Victoria area.

Only one or two birds were seen occasionally on fresh-water lakes, which indicates that this habitat is not preferred as feeding or resting grounds. In the Vancouver area they were more abundant on unprotected and protected shoreline than in bay and estuarine habitat.

BUFFLE-HEAD (Charitonetta albeola)

These ducks were observed on all observational areas in the Vancouver region except at Spanish banks and English Bay beach (Observational Areas 2 and 5). They were common on the east coast of Vancouver island, in the Victoria region, and in Howe sound, but only one drake was observed in Indian arm.

Buffle-heads were not seen feeding in heavy surf, and appeared to prefer protected areas. More than 400 were observed in two counts at Ganges harbour and Prevost island, where they congregate to feed in the narrow protected bays (Figure 13). One or two birds were present on each small lake and pot-hole examined in the Victoria region, and often these were the only ducks using these feeding areas.




Department of Lands and Forests.

Figure 13. Aerial photograph of Ganges harbour, Salt Spring island, and the northwest end of Prevost island. The narrow inlets on Prevost island are favourite feeding areas for buffle-heads and golden-eyes. This region is an important herring spawning ground.

OLD-SQUAW (Clangula hyemalis)

These ducks were most abundant in the Victoria region and Salt Spring island. None was seen during two counts on the east coast of Vancouver island from Qualicum river to Courtenay, nor in Howe sound, and only one drake was seen in Indian arm.

Salt water areas are used extensively by this species and none was seen on lake habitat. In the Vancouver region, old-squaws were most numerous in bay and estuarine habitat. On March 23, 1952, thirteen pairs were seen at English Bay beach--an area where none had been seen previously. This flocking may be concomitant with their habit of moving in closer to the coastline as spring advances. A similar situation was seen at Ganges harbour, where in March, 1952, the number of old-squaws had increased fourfold since January.

HARLEQUIN DUCK (Histrionicus histrionicus)

Only nine harlequin ducks were seen in the Vancouver region during the study, and these were observed along unprotected shoreline at Jericho beach and the Iona Island jetty (Observational Areas 4 and 1). Areas of greatest abundance were in the Victoria region, between Qualicum river and Courtenay, and at Salt Spring island.

Lake habitat was not used by this species, and none was seen in Indian arm. Only three pair were observed during

two counts in Howe sound.

These ducks prefer to feed along unprotected coastline and preferred areas were the Gulf islands and the east coast of Vancouver island.

WHITE-WINGED SCOTER (Melanitta deglandi)

The east coast of Vancouver island, and the Gulf islands are the areas of greatest white-winged scoter abundance. In the Victoria region, this species is more abundant than the surf scoter. They were present on all regions except Indian arm, and only 39 were seen in two counts in Howe sound.

In the Vancouver region, they utilized all habitat types except bay and estuarine habitat in the North arm of the Fraser river. Although no white-winged scoters were observed on lake habitat during the winter, they did occur on St. Mary lake several times during September, 1951, and March, 1952.

SURF SCOTER (Melanitta perspicillata)

This species did not occur on lake habitat during the study, but was very common on all other areas. Indian arm, Howe sound, and the Vancouver region, where white-winged scoters were not abundant, were the regions of greatest surf scoter concentration. On the east coast of Vancouver island, and at

Victoria, the reverse situation was seen where the population of surf scoters was much smaller than the white-winged scoter population.

In the Vancouver region, surf scoters were abundant on all habitats except bay and estuarine, and they showed the tendency to aggregate in large flocks on these habitats.

AMERICAN SCOTER (Oidemia americana)

All ducks counted in the Vancouver region were seen between the mouth of the Fraser river and English Bay beach. They were not observed in the protected waters between Prospect point and Coal harbour, nor did they occur on any lake habitat.

Only a small population wintered in the Victoria region and the east coast of Vancouver island, and in two counts at Ganges harbour, only three American scoters were seen. They did not occur in Howe Sound or Indian arm during the winter, and this is taken to indicate that for some undetermined reason, these areas are unpreferred. The greatest number occurred along the unprotected shoreline in the Vancouver region.

In order to determine relative use, by all species, of the five habitats in the Vancouver region, the average number of all diving ducks counted per observational mile for each habitat was calculated and presented graphically in Figure 14.

The differences between the numbers of ducks using

the unprotected-sandy, unprotected-rocky, and protected-rocky habitats are not great considering the great variety in counts from month to month, so that it is doubtful if much significance can be attached to these differences. In the case of bay and estuarine and lake habitats, the number of ducks vary greatly from those in the first three habitats. This is taken to indicate that these two habitats are less desirable wintering areas.

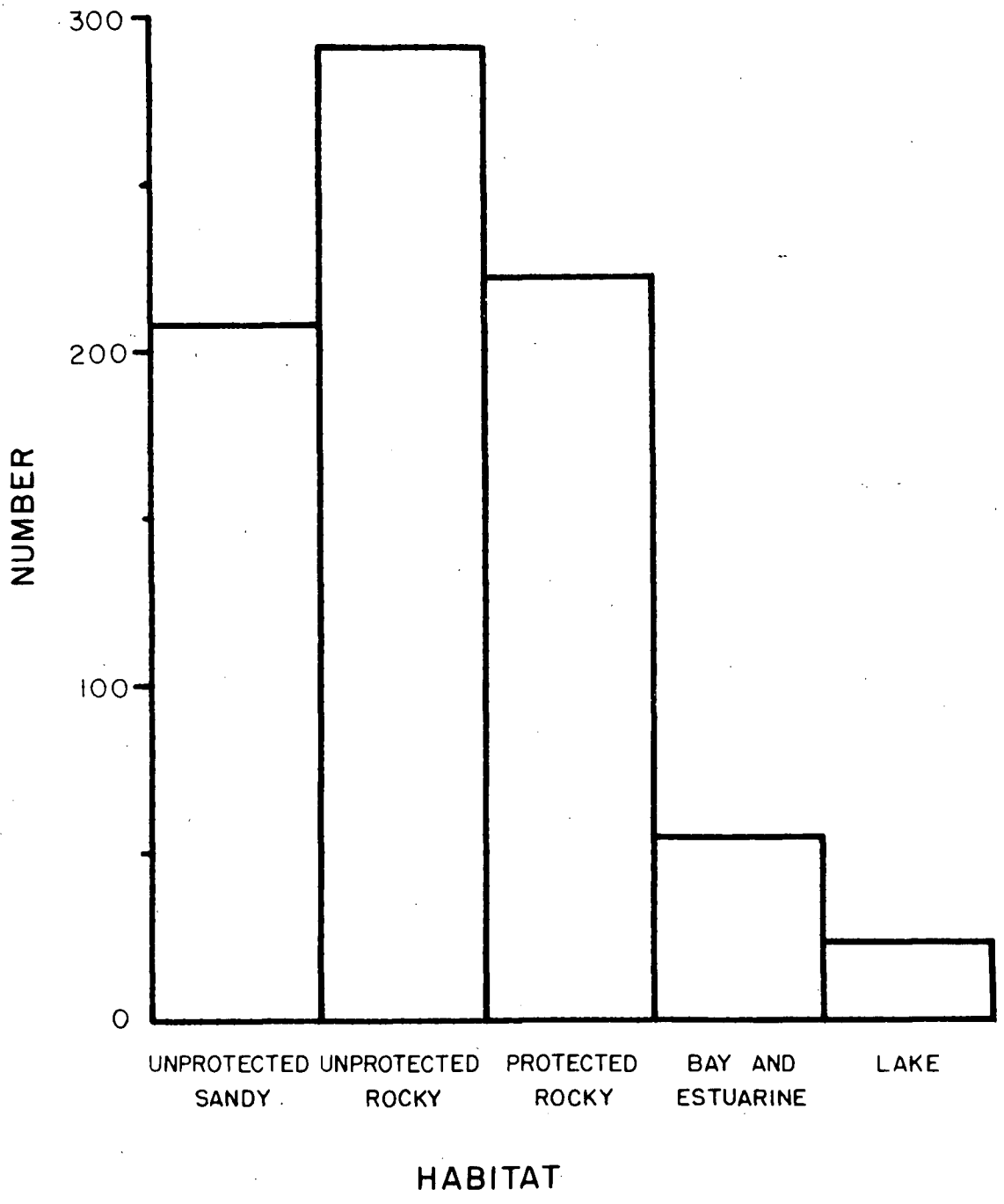



Figure 14. Average number of all species of diving ducks counted per observational mile by habitats during period September 1951 to March 1952. (Representing cumulative totals of average number counted per observational mile during this period.)

# STRUCTURE OF THE POPULATION

## SEX STRUCTURE

All data obtained during the study were analysed by the 2 × n Chi-square test adopted from Snedecor (1946), in order to draw definite conclusions regarding distribution of the sexes.

Provided that the method of sampling introduces no bias, then a Chi-square test that gives either a very high or very low probability value indicates a departure from the amount of variation expected, in sex ratios, resulting from chance factors alone. For example: for American scoter in November 1951, 303 birds were counted and the total counts were 202 males to 101 females. This represents a significant departure from a 1:1 sex ratio (Chi-square = 33.67) and the probability that this sample was drawn from a 1:1 sex ratio population is less than five chances in one hundred.

Each individual group or sub-sample of ducks observed was used in the analyses of the data.

Chi-square tests of this kind measure deviation from a theoretical standard in which thereis complete uniformity (i.e. no variation) in the sub-samples. If the birds aggregate in groups at random, with respect to sex, one would expect

considerable variation in the sex ratios of the sub-samples (i.e. variations about the average). Thus Chi-square would assume an intermediate value and the corresponding probability value (i.e. the probability that the samples were drawn from a population in which all the sexes were always arranged in a fixed proportion) would lie between 0.95 and 0.05.

If the birds were arranged in groups with a particular sex ratio very frequently (i.e. if variation in the sub-samples was small), then Chi-square would be low, and the corresponding probability value would be greater than 0.95. This would indicate a high probability that the sub-samples were taken from a population in which the birds grouped in particular sex ratios.

Similarly, if the birds are grouping in such a way that males congregate, then the sub-sample sex ratios will show wide variations and Chi-square will be high. The corresponding probability value will be less than 0.05. This would indicate that the population was not distributed at random with respect to sex.

The various values of Chi-square might of course reflect more complicated situations than those suggested. For example, the last case of a high Chi-square value might result from a combination of limited flock size with gregarious behaviour of males or non-gregarious tendencies of the females. It could also result from a differential seasonal migration of the two sexes, or a differential distribution on the study area.

In the following account of sex structure, conclusions have been drawn on the basis of the analyses, the results of which are summarized in Table IV. Significant values are those in which the probability value is greater than 0.95 or less than 0.05, and the meaning of these values is based on observations on life history and behaviour.

In order to determine differential sex migration, the sex ratios in October and November and in March were compared (2 x 2 Chi-square test) with the true winter sex ratio occurring in December, January and February. A significant difference between the sex ratios in October and November, and the true winter sex ratio is interpreted to mean that one sex was more abundant earlier in the winter as a result of differential sex migration. A significant difference in sex ratios could occur because of a differential distribution on the two sexes on the study area, but it has been assumed that both sexes are randomly distributed over the study area. In other words, a significant difference in sex ratio in October and November and in the three winter months, is taken to mean that one sex is an earlier fall migrant than the other, or, in the case where there is an increased preponderance of the sex which was preponderant in early fall, one sex continues to immigrate into the study area as winter advances.

A further assumption is made regarding the change in sex ratios, viz., if one sex is more abundant in the three

Table IV. Probability values for uniformity of distribution with respect to sex and sex ratio during period September 1951 - March 1952.

| Species | October | | November | | December | | January | | February | | March | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | A | B | A | B | A | B | A | B | A | B |
| Redhead | | | | | | | >.99 | .3-.5 | | | | |
| Ring-necked duck | | | | | >.99 | .5-.7 | .8-.9 | .02*-.05 | | | .90-.95 | .8-.9 |
| Canvas-back | | | | | | | <.01 | <.01* | .1-.2 | .7-.8 | .05-.1 | .05-.1 |
| Greater scaup duck | .1-.2 | .02*-.05 | <.01 | <.01* | <.01 | <.01* | <.01 | <.01* | <.01 | <.01* | .05 | <.01* |
| American golden-eye | <.01 | <.01** | .5-.7 | <.01* | .2-.3 | <.01* | >.99 | <.01* | >.99 | <.01* | .5 | <.01* |
| Barrow's golden-eye | .01-.02 | <.01* | <.01 | <.01* | .5 | .05-.1 | >.99 | .05-.1 | .5 | .5-.7 | >.99 | .05-.1 |
| Buffle-head | .90-.95 | .01*-.02 | .5 | <.01* | .3-.5 | <.01* | .2 | <.01* | .98 | <.01* | >.99 | .8-.9 |
| Old-squaw | | | | | | | .8-.9 | <.01* | >.99 | .5-.7 | >.99 | .2-.3 |
| Harlequin duck | | | | | | | .98-.99 | <.01 | >.99 | .1-.2 | >.99 | .1-.2 |

Table IV. Cont'd. Probability values for uniformity of distribution with respect to sex and sex ratio during period September 1951 - March 1952.

| Species | October | | November | | December | | January | | February | | March | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | A | B | A | B | A | B | A | B | A | B |
| White-winged scoter | .7-.8 | <.01* | .05-.10 | <.01* | .2-.3 | .05-.1 | >.99 | <.01* | >.99 | .5 | >.99 | .1-.2 |
| Surf scoter | <.01 | <.01* | <.01 | <.01* | .02-.05 | <.01* | >.99 | <.01* | <.01 | <.01* | >.99 | <.01* |
| American scoter | .2-.3 | <.01* | .3-.5 | <.01* | .7-.8 | .01-.02** | .3-.5 | .5-.7 | >.99 | .05-.1 | .5-.7 | .05-.1 |

A - Probability of uniformity of distribution.

B - Probability that sample was taken from a 1:1 sex ratio population.

*Indicates a significant preponderance of males.

**Indicates a significant preponderance of females.

Significant values = 0.95 or larger; 0.05 or smaller.

winter months than in October and November, it is assumed that this results from an influx of the less abundant sex, and not as a result of efflux of the sex which was more abundant earlier in the fall.

The percentage of paired individuals, by species, for each month has been calculated and confidence limits at the 0.95 level of significance have been applied in each case. It has been considered that a pair is any two ducks, one of which is a male and the other a female, which are detached from other ducks or are closely associated when with other ducks. Hochbaum (1944), states that in all species, courtship displays are infrequent, or cease entirely immediately following the formation of the pair. During this period of non-display, pairs are gregarious. Males do not show belligerence to one another until courtship is resumed on the breeding grounds. For this reason, any group of birds seen in the field in which the sex ratio was exactly 1:1 was considered to consist of paired birds. The data for the percentage paired for each species is presented in Figures 15 and 16.

The percentage of males in each species for each month has been calculated in a similar manner, (Figures 17 and 18) and fiducial limits at the 0.95 level of confidence have been applied to these percentages. Significant and non-significant changes in percentages can be readily found by comparing the ranges of the fiducial limits for each month. If one set of fiducial limits does not overlap another set of limits, then

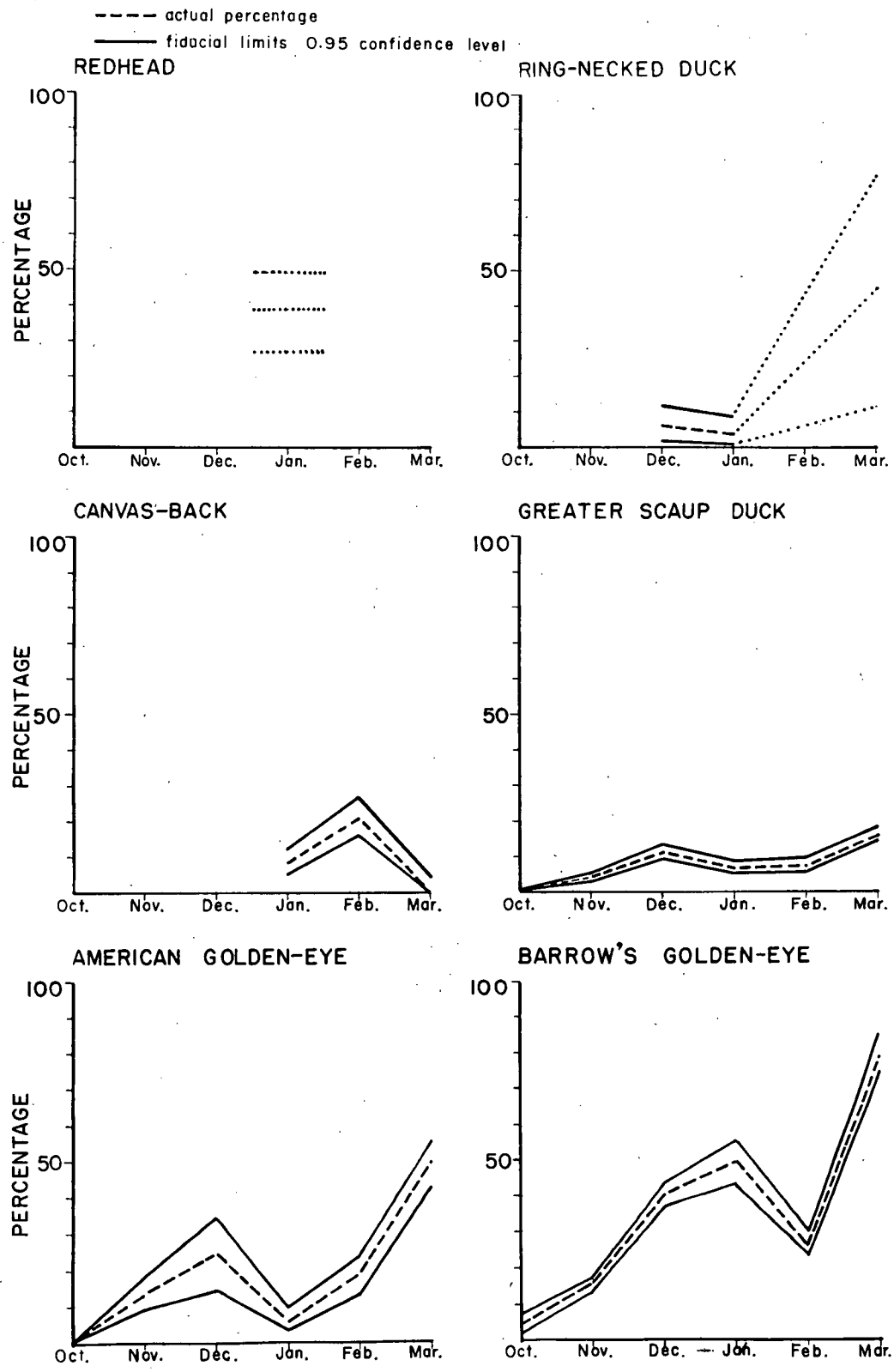



Figure 15. Percentage paired, by species, observed in study area during period September 1951 to March 1952.

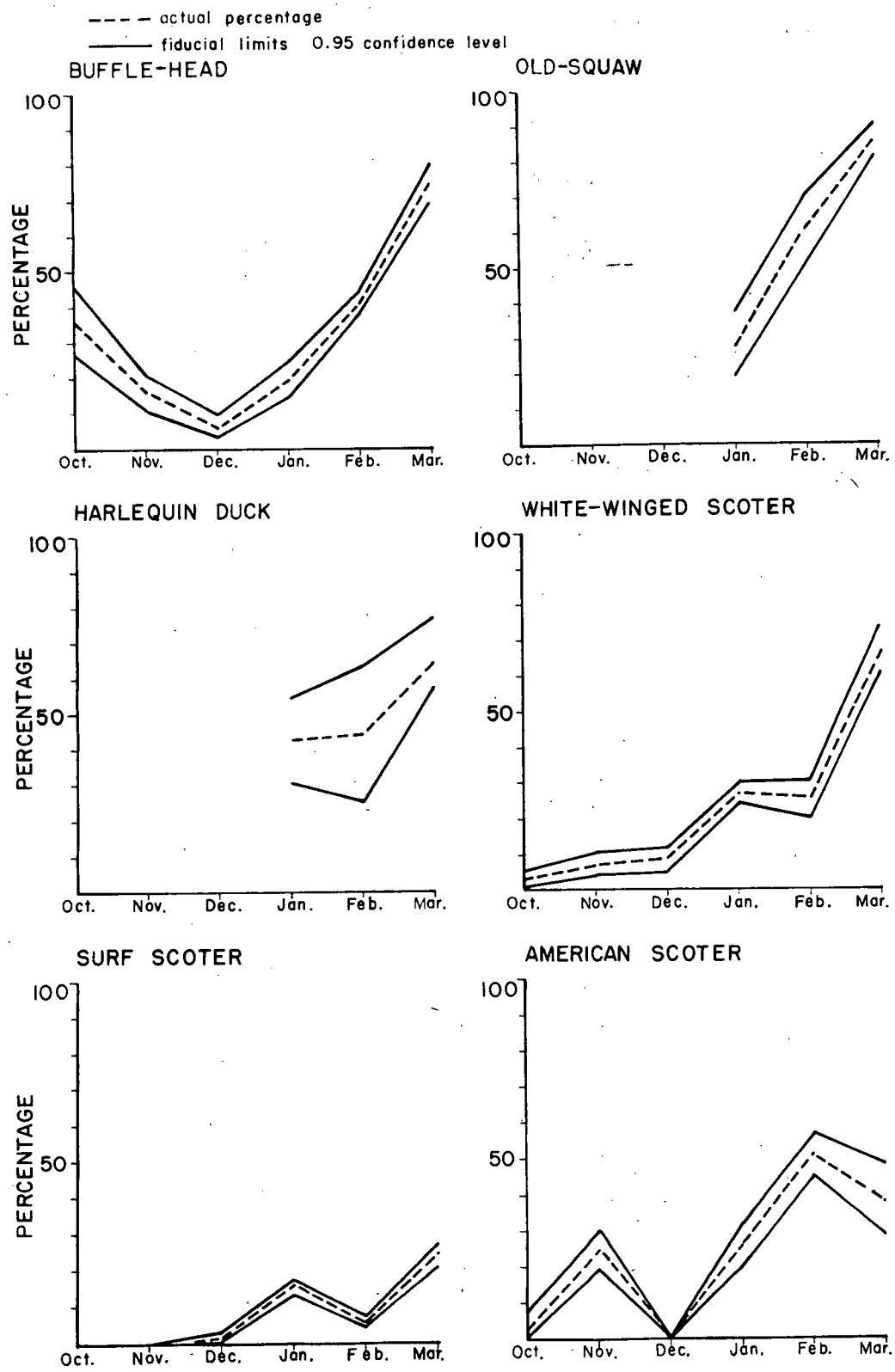



Figure 16. Percentage paired, by species, observed in study area during period September 1951 - March 1952.

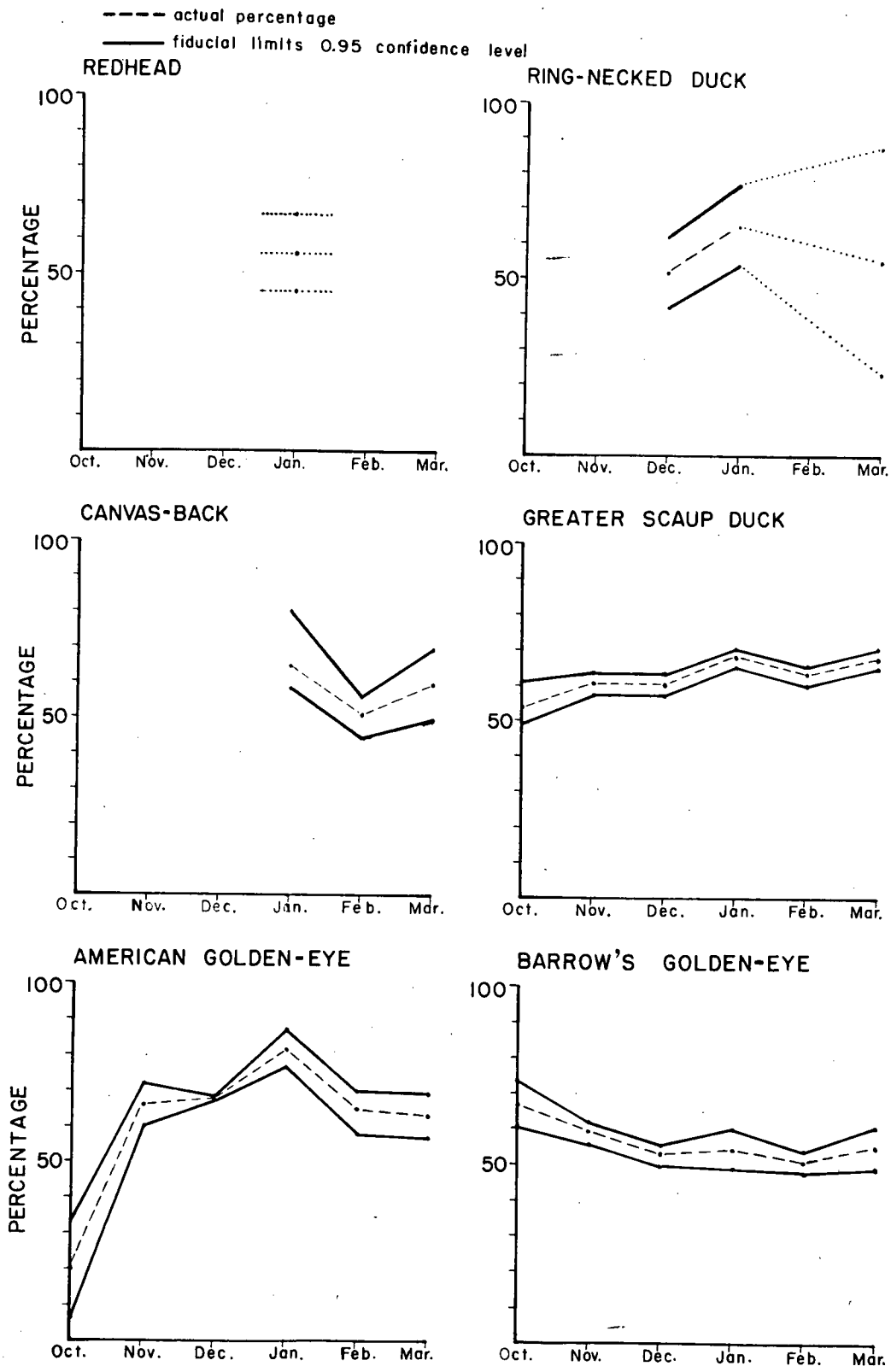



Figure 17. Percentage males, by species, observed in study area during period September 1951 - March 1952.

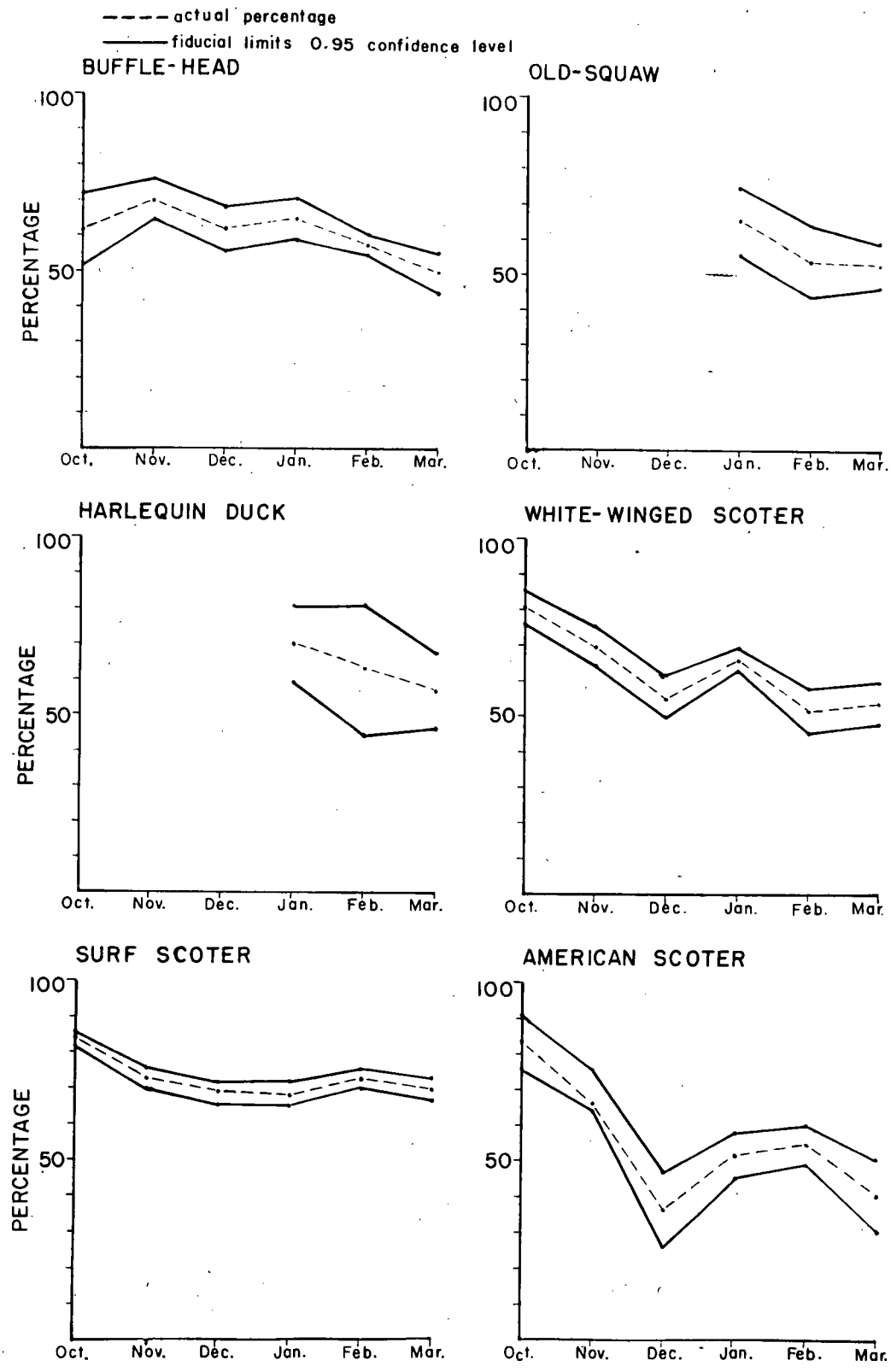



Figure 18. Percentage males, by species, observed in study area during period September 1951 - March 1952.

it can be assumed with reasonable accuracy, that the two percentages are significantly different.

Thus in the graph for percentage males for the American golden-eye, it is seen that the percentage males in November is significantly greater than the percentage in October. The percentage in January is significantly different from that in all other months, and the percentage males in November is not significantly different from that in December, February and March. A trend is indicated in which the percentage of males increases from October to November; does not show significant increase again until January; and then shows a significant reduction in February and March. Significant differences on all other graphs showing fiducial limits can be obtained in the same manner.

Redhead

There are not sufficient data to draw conclusions regarding the sex ratio of the sub-samples, nor can differential seasonal migration be determined.

The one probability value obtained in January (Table IV), indicates a non-random distribution of males and females resulting from pair formation with the species. The sex ratio of January's population was 1.26 males to 1.00 female, which shows moderate variation from a 1:1 sex ratio.

Ring-necked Duck

Sufficient data are also lacking for this species, but a non-random distribution of the sexes occurred in December (probability value greater than 0.99) as a result of pair formation. There was a preponderance of males in January (Figure 17) and the winter sex ratio was 1.28 males to 1.00 female.

No evidence was obtained to show that migration began in March, but if migration had started, then the drakes and hens had left in equal numbers.

Canvas-back

In January there was a significant preponderance of males in the study area (1.82 males to 1.00 female), and these showed the tendency to flock together (Figure 17) with the result that the sexes were not randomly distributed. The winter sex ratio was 1.42 males to 1.00 female and did not change significantly in March. The percentage of paired individuals remained low throughout the winter (Figure 15), and in March, only a small percentage of the population consisted of paired birds. This, and the fact that there was no significant change in the percentage of males in March, indicates that if spring migration had begun, only paired ducks had left the wintering grounds.

Greater Scaup Duck

In all months, there was a departure from a 1:1 sex ratio resulting from a preponderance of males (Figure 17). The distribution of the sexes was significantly non-random from November to February due to the preponderance of males and their tendency to flock together. The sex ratio in October and November (1.44 males to 1.00 female) indicates more males than females on the study area. The preponderance of males increased until, during the winter months, the ratio was 1.77 males to 1.00 female. This indicates that more males than females were moving into the area as winter advanced.

The percentage of paired ducks increased in March (Figure 15), but no evidence was obtained to indicate that spring migration had started.

American Golden-eye

In all months there was a significant departure from a 1:1 sex ratio resulting from a preponderance of females in October, and a preponderance of males during the remainder of the winter (Figure 17). The distribution of the sexes was non-random in October due to the flocking tendencies of the females, and in January and February, distribution was non-random because many of the birds had started to pair. In March, distribution of the sexes was random and, because there was a significant change in the sex ratio at this time (1.72 males to 1.00 female

in winter), it is construed that either many males had left the study area for the breeding grounds, or more paired ducks had arrived in the study area from more southerly wintering grounds.

There is a significant increase in the number of paired ducks in March (Figure 15). The sex ratio in October (0.25 males to 1.00 female) differs from the winter sex ratio (2.68 males to 1.00 female), and a differential fall migration is indicated where females arrived on the wintering grounds before the bulk of the males arrived. After October, the proportion of males became increasingly greater until January, indicating a later migration of the drakes.

Barrow's Golden-eye

In October and November there was a departure from a 1:1 sex ratio resulting from a preponderance of males (Figure 17). During the remainder of the winter there was only a small preponderance of drakes. The sex ratio in October (2.04 males to 1.00 female) shows that females remain longer on the interior lakes and are the last to arrive on the wintering grounds. This is further indicated during the winter when the number of females became proportionately greater (winter sex ratio: 1.09 males to 1.00 female). In November the males tended to flock together, but this became less evident in December. The situation in January when there was a preponderance of males in most sub-samples, changed the

following month when the sexes were randomly distributed, i.e. showed more variation from a 1:1 sex ratio. In March, the sexes were distributed non-randomly due to the preponderance of paired individuals (Figure 15).

Throughout the winter there was a preponderance of males in the study area, and in March, this preponderance became even greater (1.25 males to 1.00 female). This indicates that either more males had arrived in the study area, or the population which had left the study area consisted of approximately equal numbers of males and females, thus leaving a population on the coast in which there was an even greater preponderance of males.

Buffle-head

During the winter the sexes were distributed at random, except in March when there was a high proportion of paired ducks on the study area (Figure 16). There was a marked preponderance of drakes in all months except March (Figure 18) when presumably there was an influx of paired ducks from more southerly wintering grounds or an efflux of more drakes than hens from the study area.

The preponderance of males in October (1.63 males to 1.00 female) became even larger in November (2.30 males to 1.00 female). This is not so marked in December (1.65 males to 1.00 female) when, it is believed, more females arrived in

the study area.

The data indicate that males are the first to arrive on the wintering grounds, and they form the bulk of the population of early spring migrants.

Old-squaw

Sufficient data are lacking for this species to indicate trends in distribution and sex ratio during the entire study. However, in January the sexes were distributed at random, when considerable variation occurred in the sex ratio of the sub-samples. In February and March, a non-random distribution occurred as a result of pair formation (Figure 16). At this time more than 75% of the sub-samples were paired ducks.

There was a preponderance of drakes in January (1.95 males to 1.00 female) when most sub-samples contained more males than females (Figure 18). However, the proportion of males during January and February (1.51 male to 1.00 female) did not show a significant change in March (1.15 males to 1.00 female). This indicates that if spring migration began in March, it was not a differential sex migration, but one where both males and females had left in equal numbers.

Harlequin duck

Early winter data are also lacking for this species and it is seen that the probability values for sex ratio and distribution of the sexes are very similar to those for

old-squaws. (Table IV)

In January the sexes were distributed non-randomly owing to the presence of more drakes than hens in all sub-samples (Figure 18). The sexes were distributed non-randomly in February and March, but this was due to pair formation (Figure 16). At this time, 55% of the sub-samples were paired ducks.

A preponderance of drakes occurred in January (2.33 males to 1.00 female) when there were more males than females in all sub-samples. However, the proportion of males during January and February (2.13 males to 1.00 female) did not significantly change in March, when the sex ratio was 1.32 males to 1.00 female. This indicates that if spring migration began in March, both drakes and hens had left the wintering grounds in equal numbers.

White-winged Scoter

During October there was a high proportion of drakes in the study area (Figure 18) when the sex ratio was 4.45 males to 1.00 female. This proportion decreased in November (2.91 males to 1.00 female) and December (1.24 males to 1.00 female), indicating that a differential sex migration from the breeding grounds had taken place, and the males were the first to arrive on the coastal waters.

In October, November and December, the sexes were

distributed at random in the sub-samples. Non-random distribution occurred after December due to the preponderance of males in most of the sub-samples, and in March, non-randomness resulted because more than 50% of the sub-samples were paired ducks (Figure 16).

The winter sex ratio in the study area was 1.48 males to 1.00 female, and no significant change from this ratio occurred in March (1.18 males to 1.00 female). This indicated that spring migration had not started in March, or if it had, then the majority of the emmigrating ducks were paired and the majority of the migrants arriving from the south were also paired.

Surf Scoter

During the entire study, the wintering population consisted of a preponderance of males (Figure 18). The greatest preponderance of drakes occurred in October, when the sex ratio was 5.46 males to 1.00 female. The proportion of females became progressively greater until, in January, the sex ratio was 2.19 males to 1.00 female. A differential sex migration is indicated here, where the first fall migrants are predominantly males, and the bulk of the female population arrives in the study area during November and December.

A non-random distribution of the sexes occurred in October, November and December when the drakes showed the

tendency to flock together. In January, most of the sub-samples showed a sex ratio of from 2 males to 1 female, to 4 male to 1 female. The proportion of males in the sub-samples was greater in February (32 males to 1 female, to 1 male to 1 female) as a result of non-random distribution. In March, most sub-samples were either paired ducks or courting parties resulting in a non-random distribution.

No significant change from the winter sex ratio (2.44 males to 1.00 female) occurred in March (2.31 males to 1.00 female). This indicates that spring migration had not yet started, or if it had, the majority of ducks which left the study area were paired and the majority arriving in the study area from the south were also paired.

American Scoter

During all winter months, except February, the sexes in the sub-samples were distributed at random. In February, non-random distribution occurred because most of the sub-samples consisted of paired individuals (Figure 16).

There was a preponderance of drakes in October (5.15 males to 1.00 female) which became progressively smaller until in December (Figure 18), the sex ratio was 0.58 males to 1.00 female. This indicates that the early fall migrants were predominantly drakes which preceded the hens to the wintering grounds. The preponderance of females in December cannot be explained unless there were actually more females in the

wintering population. This seems unlikely, however, because the winter sex ratio was 1.06 males to 1.00 female. Possibly differential distribution of the two sexes occurred on the study area, although this was not detected during the study.

No significant change in sex ratio occurred in March, indicating that if migration had started, the drakes and hens had departed in equal numbers, and similarly, the migrants arriving from the south were predominantly paired ducks.

It seems likely that some paired ducks had started migrating because there was no increase in the percentage of paired American scoters on the study area during March (Figure 16). Before this time, a significant increase had occurred each month after December.

AGE STRUCTURE

Within the diving duck group, many species, such as the scoters, golden-eyes, buffleheads, harlequin ducks, and old-squaws, do not mature and assume adult plumage during the first year, with the result that several age classes are present on the wintering grounds. It was very difficult during the study to correctly identify juveniles and yearling birds, and no attempt was made to sex the birds identified as juveniles.

The descriptions of the species presented by Kortright (1943), were used to distinguish juveniles from adults, but these descriptions were not always sufficiently complete to include all plumage patterns encountered. Error is also introduced because of the manner in which juvenile birds, which closely resemble the adult female of the species early in the fall, gradually change their appearance during the winter. More accuracy could have been obtained if all birds had been observed at close range, but often it was necessary to speciate, sex and age birds with binoculars at distances exceeding 400 yards.

With as much accuracy as could be obtained in the field, the percentage of juveniles seen each month for each species have been tabulated, and fiducial limits at the 0.95 level of confidence have been applied (Table V).

The percentage juveniles in most species remained low

Table V. Percentage juveniles, by species, observed during period, September 1951 - March 1952.

| | October | November | December | January | February | March |
|---|---|---|---|---|---|---|
| Redhead | - | - | 0 | 0 | 0 | 0 |
| Ring-necked duck | - | - | 0 | 0 | 0 | 0 |
| Canvas-back | - | - | - | 0 | 0 | 0 |
| Greater scaup duck | 0 | 0.8 | 0.1 | 0.3 | 1.0 | 0 |
| American golden-eye | 0 | 6.7 | 0 | 2.7 | 3.7 | 2.9 |
| Barrow's golden-eye | 0 | 0.4 | 9.0 | 2.1 | 4.0 | 1.9 |
| Buffle-head | 0 | 0.3 | 0.5 | 1.0 | 0 | 1.3 |
| Old-squaw | - | - | - | 0 | 0 | 0 |
| Harlequin duck | - | - | 0 | 0 | 0 | 0 |
| White-winged scoter | 4.7 | 23.0 | 5.6 | 8.5 | 6.4 | 4.0 |
| Surf scoter | 2.2 | 9.5 | 10.4 | 5.5 | 5.0 | 1.6 |
| American scoter | 0 | 0.7 | 0 | 0.5 | 1.8 | 17.2 |

throughout the winter, and juveniles of the redheads, ring-necked ducks, canvas-backs, old-squaws and harlequin ducks were not seen. No significant increase or decrease in percentages of juveniles each month was noted in the greater scaup duck, American golden-eye, buffle-head and old-squaw species. There

was a significant increase in Barrow's golden-eye juveniles in December, and white-winged scoters in November. There was a significant increase in the number of surf scoter juveniles in November and December, and after this time, the percentage decreased each month. From October to February, only eight juvenile American scoters were seen. In March, a sudden influx of juveniles occurred, and 17.2% of the population consisted of young birds. This may be the result of spring immigration into the area and represent the beginning of migration.

Field observations indicate that only a small percentage of juveniles of all species were present on the study area during the winter. This suggests that possibly, the bulk of the juvenile populations concentrate in other localities throughout the winter.

# DISCUSSION

This investigation was made in order to determine the distribution of wintering ducks on the coastal waters of southern British Columbia. During the study, an attempt was made to discover and evaluate the factors causing distribution and duck movement. Although distribution has been determined throughout the entire study area, the main emphasis has been placed on distribution on the five ecological habitats in the vicinity of Vancouver and Salt Spring island.

A study of the factors influencing seasonal distribution of the diving ducks showed that the winter climate in the area can be tolerated by most species of ducks. The scarcity of redheads, ring-necked ducks, canvas-backs and lesser scaup ducks may be due to lower tolerance to freezing temperatures.

The irregular coastline and juxtaposition of the many small islands in the Strait of Georgia results in numerous areas which are protected from strong winds. There are a sufficient number of these protected areas to offer sanctuary to all ducks during storms, although not all waterfowl leave the open waters at such times.

Observations indicated that diving ducks are influenced by the distribution of their preferred food. It was found that white-winged scoters are most abundant on the east coast of Vancouver island where there is a rich supply of their

preferred food, viz. clams and oysters. In Howe sound, white-winged scoters are uncommon, but surf scoters, which feed extensively on the rich fauna of blue mussels, are very abundant. Few surf scoters are found on the east coast of Vancouver island, probably because their preferred food--blue mussels--are not too abundant there.

Other factors, related to food availability, operate to influence seasonal distribution of the diving ducks. During the sockeye salmon and Pacific herring spawning periods, large numbers of greater scaup ducks, American golden-eyes, Barrow's golden-eyes, white-winged scoters, surf scoters and American scoters concentrate in areas of spawn abundance in order to feed on the available ova.

Grain elevators were found to affect the distribution of the greater scaup duck, American golden-eye, and Barrow's golden-eye in Vancouver harbour, and concentrations of greater scaup ducks, American golden-eyes and surf scoters were seen many times feeding over sewer outfalls.

Daily movement is caused by changes in weather conditions, although not all waterfowl appear to be affected to the same degree. A count immediately before and after a storm at Ganges harbour, Salt Spring island, indicated that an emmigration from the area had taken place during the adverse weather conditions. Surf scoters appear least affected by stormy weather.

In some localities, viz. the Iona Island jetty, tides

appear to increase the availability of food, and this in turn affects distribution of waterfowl. Turbulent waters at the jetty during the outgoing tides possibly dislodge invertebrates from the bottom. This increased availability of food may be the reason for diving duck concentration at this time.

Local movements resulting from courtship activity are commonly seen during early spring. During this time, the drakes rapidly pursue the hen when she takes wing, and the males appear belligerent towards one another.

Observations at Pasley Island indicate that duck movement is caused by diurnal-nocturnal rhythm. This diel periodicity apparently causes changes in local distribution, as many ducks were seen to concentrate on protected waters at night, and depart from these waters in early morning--only to return the following evening. No definite conclusions can be drawn, but it is possible that a similar flocking and dispersion of species of diving ducks takes place at night and morning in other areas.

Disturbing agencies cause frequent local movements and dispersion of waterfowl flocks. This is especially true in the vicinity of Vancouver, where boats, and persons on the beach disturb the ducks.

Bag-check records from the Delta Municipality indicate that hunting is not a serious factor causing diving duck mortality. This is probably due to the small degree of hunter-effort, and the open water flocking habit of the ducks.

Oil on the surface of the water, discarded by ships at sea, appears to kill many birds in some years. Eleven birds were found dead as a result of oiling on a two-mile sample of beach at Boundary bay in February, 1952. Mortality appeared to be greatest among old-squaws and American scoters in the Vancouver area in 1947.

No evidence of death as a result of lead poisoning was found during the study. Probably little lead shot is ingested because of the deep water feeding habits of the diving ducks.

Predation does not appear to be a serious factor of mortality in the study area during the winter.

Relative use of five habitats by all species of diving ducks was determined, and no significant difference in use was seen on unprotected-sandy, unprotected-rocky and protected-rocky habitats. Bay and estuarine, and lake habitats appear less important as wintering areas. The total number counted by species on all five habitats during the study was determined, and it was seen that surf scoters and greater scaup ducks are the most abundant species on these habitats. The percentage of the total number counted by species on each habitat is presented graphically. Greater scaup ducks, American golden-eyes, and buffle-heads were found on all habitats. Redheads, ring-necked ducks, canvas-backs, Barrow's golden-eyes, old-squaws, harlequin ducks, white-winged scoters, surf scoters and American scoters, were conspicuously absent from some habitats.

The data obtained on Observational Areas 1 to 9, representing five habitat types, were analysed in order to determine if the different species of diving ducks showed a preference for certain habitats. It was found that only a small population of redheads and ring-necked ducks winter in the study area, and were seen only on lake habitat. Canvas-backs were not abundant, but were observed on lake and bay and estuarine habitats. Greater scaup ducks were abundant on all habitats, but were not common in Howe sound and Indian arm. No lesser scaup ducks were seen wintering in the study area, although one author cited has reported small numbers present during early winter at Burnaby lake in 1946. American golden-eyes were common on all habitats except lakes during the winter, and were not common in Howe sound or Indian arm. Although the distribution of Barrow's golden-eye is somewhat similar to that of the American golden-eye, these birds were not so abundant on the east coast of Vancouver island. However, they were very common in Howe sound and Indian arm; two areas where American golden-eyes are not common.

Protected areas appear to be the preferred habitats for buffle-heads. These birds were common in all areas except Indian arm. Old-squaws were not abundant during the winter and were most commonly seen in bay and estuarine habitat and along unprotected rocky shores at Ganges harbour. Harlequin ducks were also common at Ganges harbour and along the east coast of Vancouver island from Qualicum river to Courtenay,

but only a small population was wintering in the study area.

White-winged scoters and surf scoters were generally distributed over the entire area, although their density varies in local areas. White-winged scoters were abundant in all localities except Howe sound and Indian arm. Surf scoters were, on the other hand, very abundant in these two inlets, but not as abundant as on the east coast of Vancouver island.

American scoters were most common in the Vancouver area, and were seen only in the unprotected coast habitats.

All data were analysed to determine the distribution of the sexes for each species. The interpretation of the probability values obtained for the species is based on observations on life history and behaviour. Sufficient data are lacking for redheads, ring-necked ducks, canvas-backs, old-squaws, and harlequin ducks to indicate trends over the entire winter.

After December, most species showed significant non-randomness in the distribution of males and females. This occurred as a result of the preponderance of males in the canvas-back ducks, and a preponderance of paired ducks in the other species.

A differential sex migration during the fall was evident in most species studied. The males of Barrow's golden-eye, buffle-head, white-winged scoter, surf scoter and American scoter formed the bulk of the early fall migrants. The reverse situation was seen in American golden-eye, where

the females were the predominant early fall migrants.

During March, it is believed that some species had started to migrate to the breeding grounds. It was found that, if migration had actually started, only paired individuals had emigrated in the ring-necked duck, canvas-back, old-squaw, harlequin duck, white-winged scoter, surf scoter and American scoter species. The data indicate that the bulk of the buffle-head spring migrants are males. A similar situation occurs in the American golden-eye species, where either drakes had left the study area first or only paired ducks had arrived from the south. In the Barrow's golden-eye species, it was indicated that only paired ducks had left the study area, or only drakes had arrived from the more southerly wintering grounds. The data did not indicate that greater scaup ducks had started to emigrate in March.

The percentage of juveniles in each species remained low throughout the winter, and redhead, ring-necked duck, canvas-back, old-squaw and harlequin duck juveniles were not seen. No upward or downward trends in the percentage of juveniles was evident in the greater scaup duck, American golden-eye, buffle-head and old-squaw. Significant increases and decreases in the percentages of juveniles are seen in Barrow's golden-eye, white-winged scoter, surf scoter and American scoter.

The data indicate that possibly juvenile birds concentrate in other localities outside the study area during the winter.

# CONCLUSIONS

1. The low winter temperatures in the study area are within the tolerance limits of most species of diving ducks. The study area is probably the northern limit of the winter ranges of redheads, ring-necked ducks and canvasbacks.
2. Not all species of diving ducks are affected by adverse weather conditions.
3. Abundance and availability of food appear to be the two chief factors influencing diving duck distribution. Salmon and herring spawning, grain elevators and sewer outfalls influence seasonal distribution of greater scaup ducks, American golden-eyes, Barrow's golden-eyes, white-winged scoters, surf scoters and American scoters.
4. Factors responsible for daily movement and distribution are weather, tides, diel periodicity, disturbances and courtship activity.
5. The combined effects of all agencies of mortality does not cause serious inroads in the wintering diving duck population.
6. All species of diving ducks showed differences in their general distribution on the study area, and the data indicate that they differ in their habitat preference.

7. The sex and age structure differed in each species, and juveniles comprised only a small percentage of the wintering population.

8. A differential sex migration occurs in the fall when the bulk of the migrants are males in the Barrow's golden-eye, buffle-head, white-winged scoter, surf scoter and American scoter species. The early fall American golden-eye migrants are predominantly females.

9. If spring migration commences in March, then the majority of migrants of the ring-necked duck, canvas-back, Barrow's golden-eye, old-squaw, harlequin duck, white-winged scoter, surf scoter and American scoter species are paired ducks. The data for the American golden-eye and buffle-head in March, indicate that either the drakes had left the study area in greater numbers than the hens, or there had been a large influx of paired ducks of these species into the study area.

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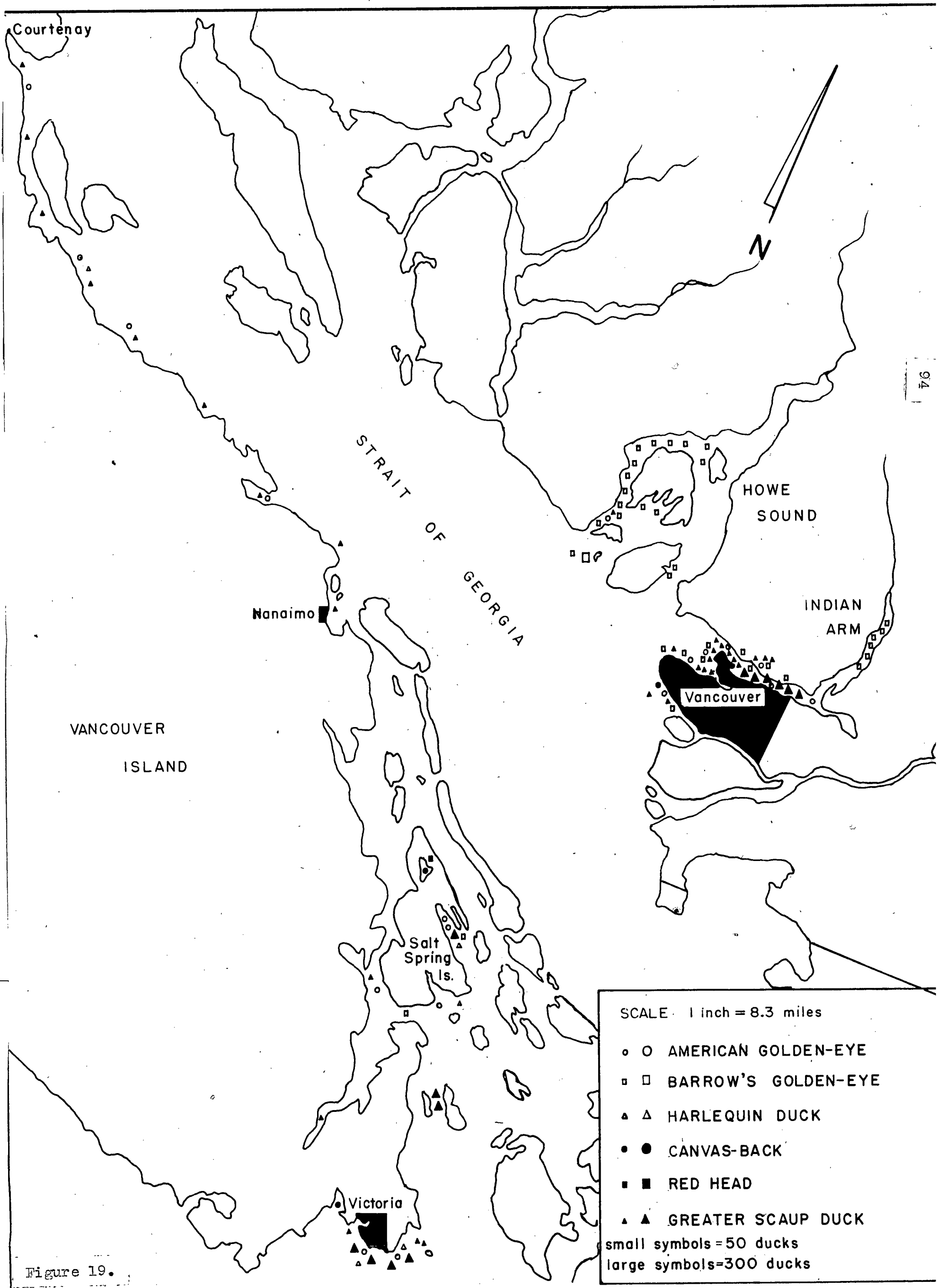


Figure 19.

DISTRIBUTION AND DENSITY OF WINTERING DIVING DUCKS IN STUDY AREA, SOUTHERN BRITISH COLUMBIA

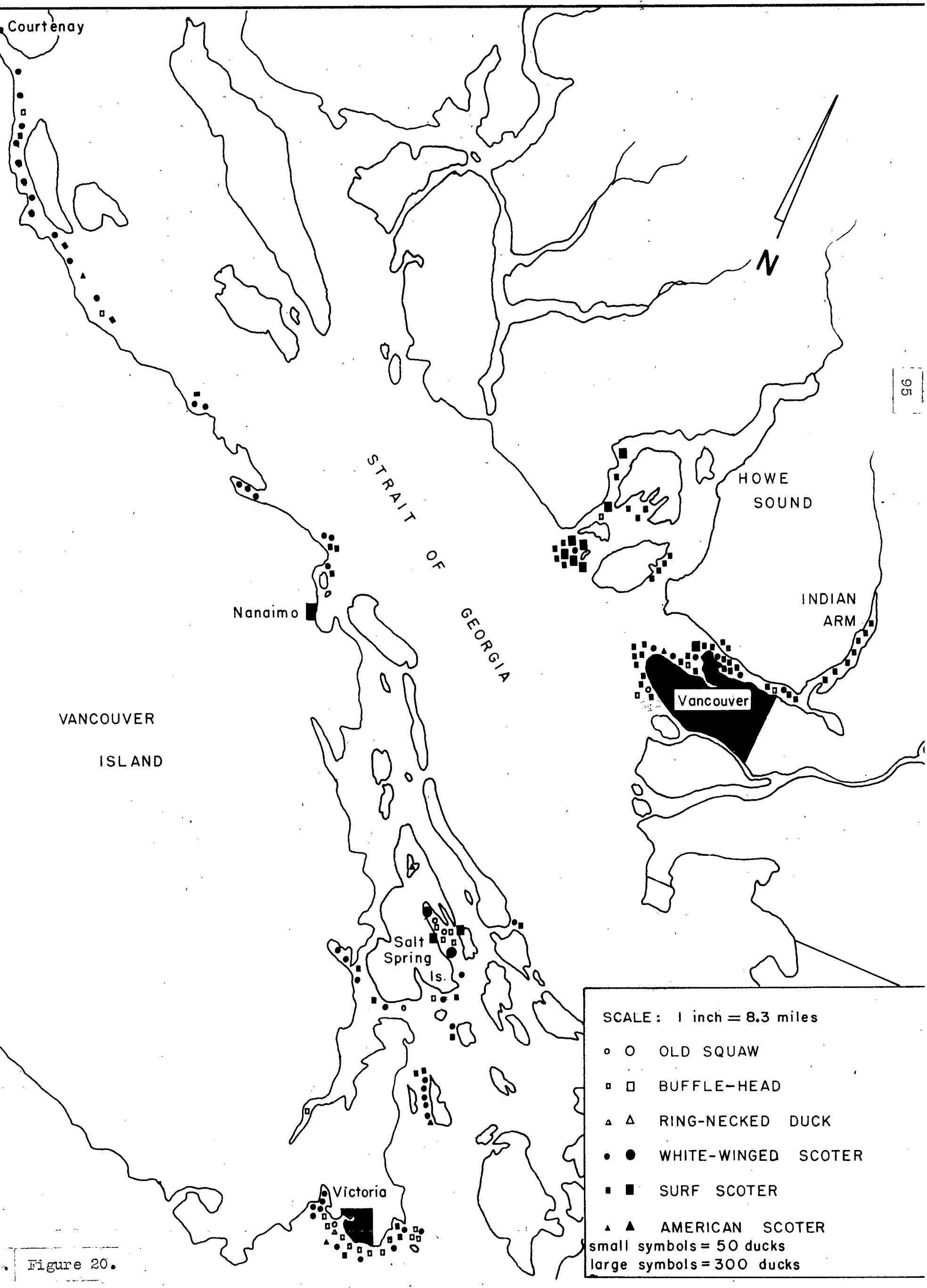


Figure 20.

DISTRIBUTION AND DENSITY OF WINTERING DIVING DUCKS IN STUDY AREA, SOUTHERN BRITISH COLUMBIA