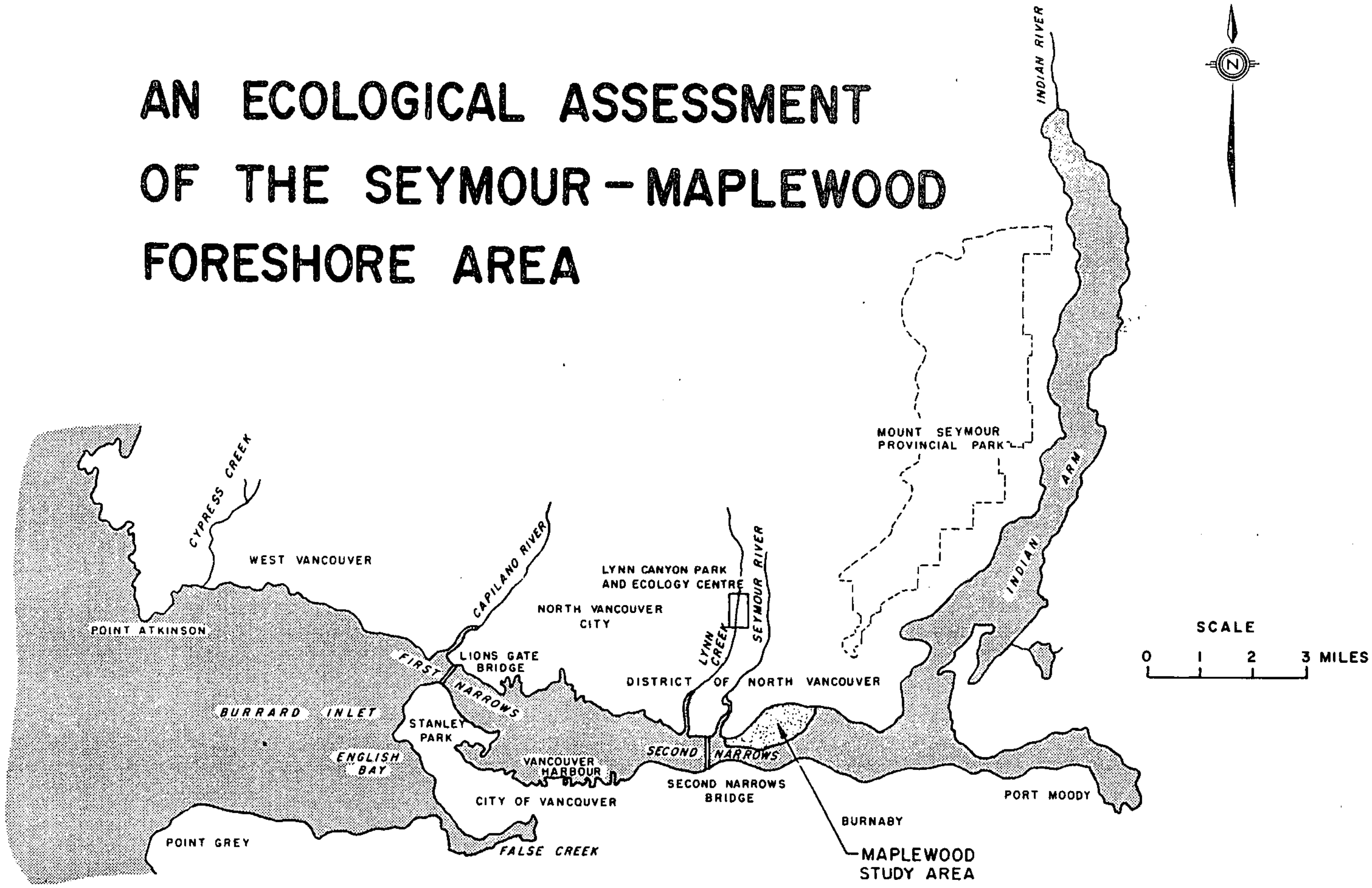
ENVIRONMENT CANADA

# AN ECOLOGICAL ASSESSMENT OF THE SEYMOUR - MAPLEWOOD FORESHORE AREA




DECEMBER, 1975

An ecological assessment of the Seymour-Maplewood foreshore area

| DATE | ISSUED TO |
| --- | --- |

TD
194.5
H69

An ecological assessment of the Seymour-Maplewood foreshore area

EBS

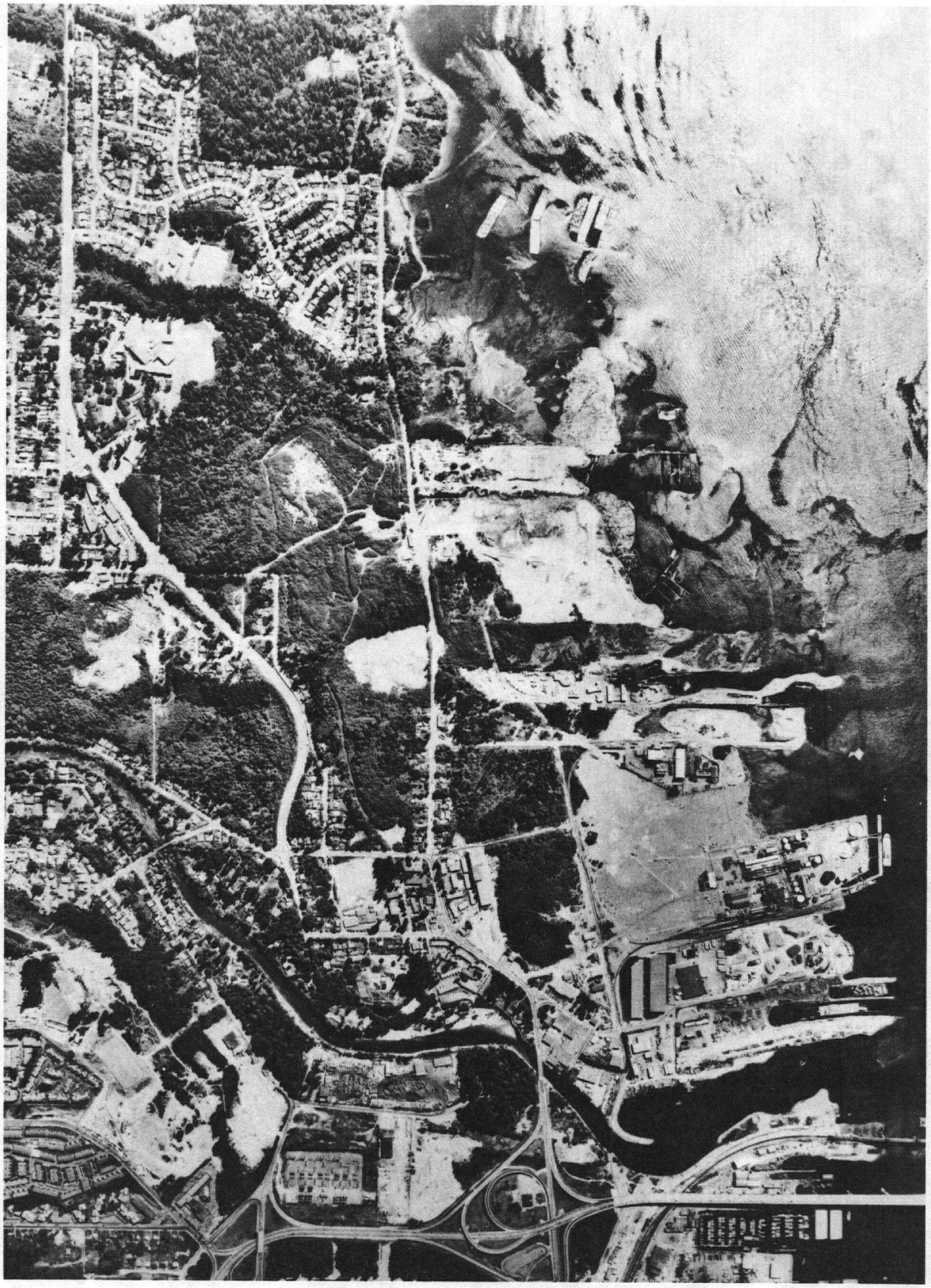
# AN ECOLOGICAL ASSESSMENT OF THE SEYMOUR-MAPLEWOOD FORESHORE AREA

DEPARTMENT OF THE ENVIRONMENT
CANADA



COMPILED BY
HOWARD PAISH AND ASSOCIATES LTD.
ENVIRONMENTAL AND RESOURCE MANAGEMENT CONSULTANTS

DECEMBER, 1975



The Seymour-Maplewood Area, May 2, 1974. Photo by Pacific Survey Corp. Reprinted with permission of the District of North Vancouver by B. Fox, Western Forest Products Laboratory, Canadian Forestry Service, Environment Canada, Vancouver, B.C.

# ABSTRACT

An assessment is made of the ecological significance of the last remaining area of intertidal marsh and mudflats on the north shore of Burrard Inlet. Wildlife surveys show that approximately 8,000 waterbirds (mainly ducks and gulls) are dependent upon the area, particularly in winter. Fishery studies also indicate that the area is a valuable rearing habitat for anadromous fish species which spawn in rivers and streams entering Burrard Inlet. An assessment is also made of the effects of past and present urban developments on the ecology of Burrard Inlet. It is recommended that the integrity of the remaining fish and wildlife habitat be preserved.

## SUMMARY OF MAIN CONCLUSIONS AND RECOMMENDATIONS

### CONCLUSIONS

1. The Seymour-Maplewood area is the remainder of a common estuary of the Seymour River, McCartney, Unnamed and Taylor creeks.

2. The District of North Vancouver is the planning authority for the area under study. The National Harbours Board owns and leases a significant amount of land in the area (Map 4) and controls the use of Burrard Inlet up to the high tide line.

3. The area under study includes a 16-acre remnant of what once was about 350 acres of intertidal marshland along the whole north shore of Burrard Inlet of which about 108 acres were in the Seymour-Maplewood area.

4. The marshland losses have been due to dredging and filling operations carried out for industrial and commercial purposes.

5. Estuaries in general are now known to be important rearing areas for anadromous species of fish on their seaward migration.

6. Important fish species such as juvenile chum, chinook and coho salmon are known to feed in the Seymour-Maplewood estuary. This being the largest estuary system in the inlet, takes on a special importance for the fishery resource. This importance is further increased because of stock enhancement activities (Capilano hatchery, possible Indian River hatchery and possible restorative measures on other streams).

7. More than 83,000 birds from 53 species were sighted in the Maplewood area during the 1972-73 surveys. Eighty-four (84%) percent of these were waterbirds. Most of the waterbirds were ducks using the area as a wintering habitat. It is estimated that about 10,800 wintering birds depend on the Seymour-Maplewood area, with about half of these dependent on the mudflats specifically.

8. The migratory birds using the area are part of the Pacific Flyway and are protected and managed under international agreement.

9. The numbers of waterfowl in Burrard Inlet are probably much reduced in comparison with the time prior to foreshore development. They have been relying to a progressively greater extent on the Maplewood area which has the largest remaining remnants of marsh habitat in Burrard Inlet. The Maplewood marsh comprises about 75% of existing intertidal marshland along the north shore and represents about 5% of the marshland which originally existed.

10. Log storage and debris disposal are currently the most environmentally damaging activities affecting the Seymour-Maplewood foreshore area. There are potential hazards from accidental spills from nearby chemical based industries.

11. Further development in the area involving only the upland zone would not have to be seriously restricted to protect fish and wildlife in the estuary, provided adequate air and water pollution control measures were implemented, and stream flows maintained.

RECOMMENDATIONS

12. Grassy areas created with any uplands development would provide useful waterfowl habitat.

13. The existing intertidal marshland and mudflats along the Seymour-Maplewood foreshore should be protected from further alteration or development.

14. The most compatible uses of the area are limited access recreation and education (walking, sport fishing, nature study).

15. The watersheds of McCartney, Unnamed and Taylor creeks should be protected from adverse changes in water quality, discharge patterns and stream channels.

16. Log storage and debris disposal in the intertidal and immediately adjacent subtidal areas should be phased out.

17. Future barge berth extensions in the industrialized part of the area should be on pilings rather than new landfill.

# TABLE OF CONTENTS

## LIST OF MAPS, FIGURE AND TABLES

Page

### Maps



### Figure



### Tables

## INTRODUCTION

The area immediately east of Second Narrows on the north shore of Burrard Inlet has been the site of a variety of proposals for development in recent years. Some new developmental activity has taken place and some is going on as this report is being prepared. These activities, past and present, have included filling and 'reclamation' of intertidal marshes and mudflats which provide habitat for migratory waterfowl, shorebirds and fish. A major town centre development with apartment blocks, shops, office buildings and a marina, tentatively suggested for the area locally known as the Maplewood Mud Flats, prompted the Department of Environment to initiate studies of the area by the Canadian Wildlife Service and the Fisheries and Marine Service, in order to document its importance to wildlife and fish. Howard Paish and Associates were contracted by the Environmental Management Service of the Department of Environment to combine the data and interpretations obtained by the Services into this single report assessing the ecological significance of the Seymour-Maplewood area to wildlife and aquatic life. The Department of Environment has responsibility, both by statute and by international treaty, for the protection of migratory birds, fish and their habitat.

On its part the District of North Vancouver has recognized the need to obtain information on the natural values of the area before land use decisions are made. A policy statement released by the District early in February, 1974 stated:

> *"6.4 No specific plans for residential or other uses be contemplated for the Maplewood Mudflats area until after receipt of the Environment Canada studies and appropriate decisions have been made upon that study."*

This report has been prepared to put collected resource data into the most meaningful context for future planning, pointing out some of the obvious resource use values of the area to enable the District and others with controlling interests in the area to take into account fish, wildlife, recreational, educational and aesthetic values in future land use decisions.

The history of land development in the area is described in the report, and some assessment is made of the impacts past development has had on the ecology of the Seymour-Maplewood area. Potential impacts of proposed developments are described and mitigation measures are outlined, where appropriate, together with measures for enhancing natural values.

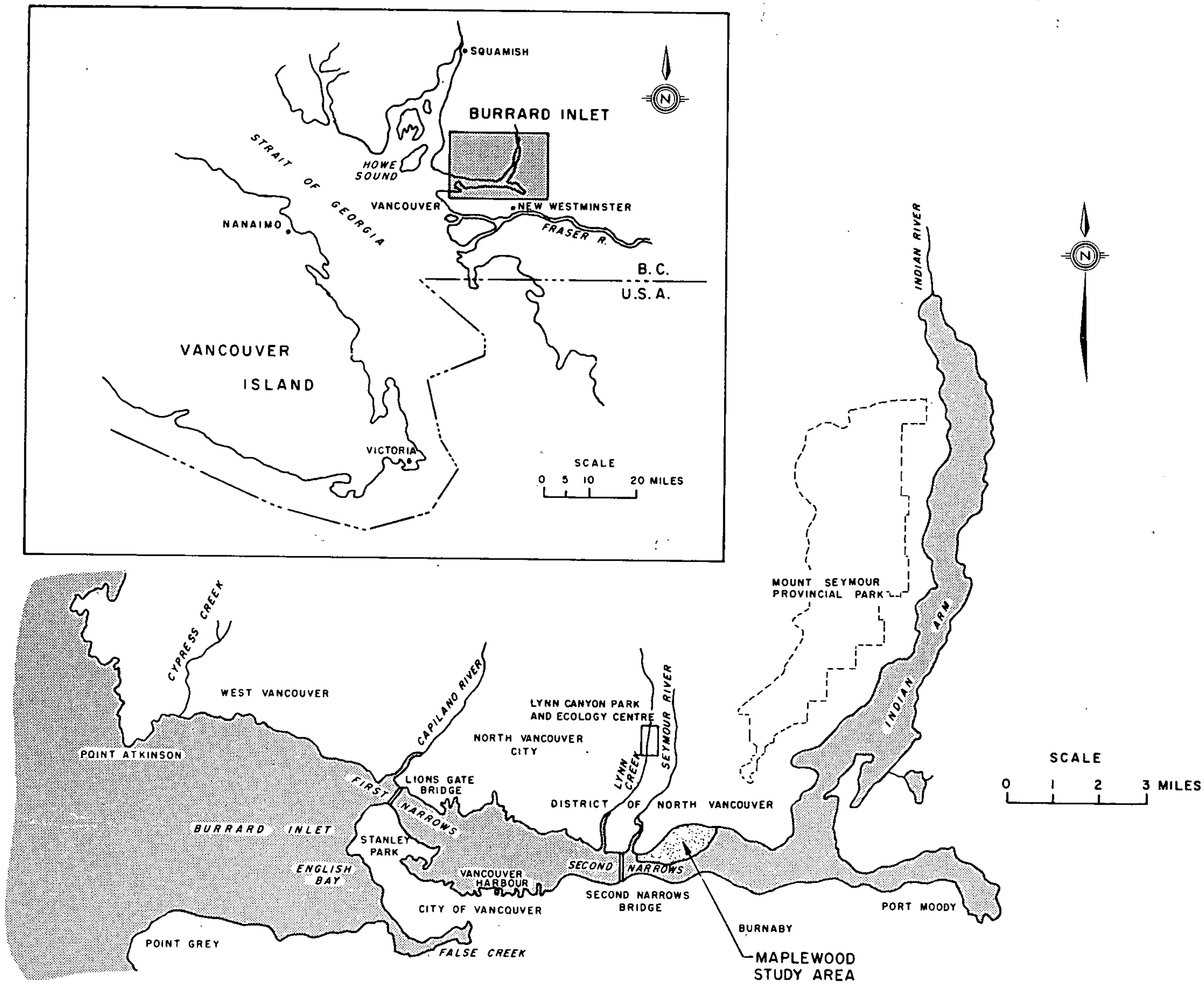
## SCOPE AND METHODS

Geographically the study area, which we have called the Seymour-Maplewood area, is bounded on the north by the Dollarton Highway, on the west by the Second Narrows Bridge, on the south by the open waters of Burrard Inlet, and on the east by Taylor Creek. Its general location is shown on Map 1.

The report is based on information provided by the Canadian Wildlife Service and the Fisheries and Marine Service of the Department of the Environment.

Marine biologists of the Pacific Environment Institute sampled invertebrates on the Mud Flats in February and March, 1974 (Levings and McDaniel, 1974). Methods involved are given in detail in Appendix 1. Biologists of the Fisheries and Marine Service also sampled invertebrates adjacent to the mouth of the Seymour River in November, 1974.

Migratory bird surveys were conducted for the Canadian Wildlife Service once a week between October 1, 1972 and May 15, 1973 (Vaudry and Land, 1973). These data were supplemented with additional published and unpublished information where available. Mammals were recorded at the same time as the bird surveys. Sampling methods are given in more detail in Appendix 2.




MAP 1. Burrard Inlet and location of Seymour - Maplewood estuary.

A survey of plant species present in the marsh at Maplewood Mud Flats was conducted during the fall of 1972 (Forbes, 1972), and further vegetation surveys were carried out by the Canadian Wildlife Service in the summers of 1973 and 1974.

An initial draft and interpretation of wildlife and vegetation data was prepared by D. Trethewey, Canadian Wildlife Service.

Limited sampling to determine fish species present in the study area was carried out by the Fisheries and Marine Service during three periods in 1973. Methods involved are given in detail in Appendix 3. An initial draft and interpretation of these data was prepared by D. Goodman, Fisheries and Marine Service.

The history of the alienation of marshland habitat for industrial purposes was traced with the aid of nautical charts dating from 1859-60 to the present, in the files of the Canadian Hydrographic Service, Fisheries and Marine Service, Environment Canada, Victoria, B.C. (representative charts are included in Appendix 4). Data regarding sizes of presently-remaining marshes in the study area were estimated from aerial photographs taken in 1971 and 1973 which are on file at the Canadian Wildlife Service, Delta, B.C. Estimates of acreages were calculated with the aid of a 100 dot per square inch Bruning No. 4849 Aeragraph dot grid.

In accordance with the terms of reference for report preparation, no new fieldwork for basic data collection was undertaken by Howard Paish and Associates. However, the consultants have drawn on professional judgment and past experience with similar estuarine situations in including their assessment of the significance of the data provided, and in assisting with formulating recommendations.

## THE SEYMOUR-MAPLEWOOD AREA

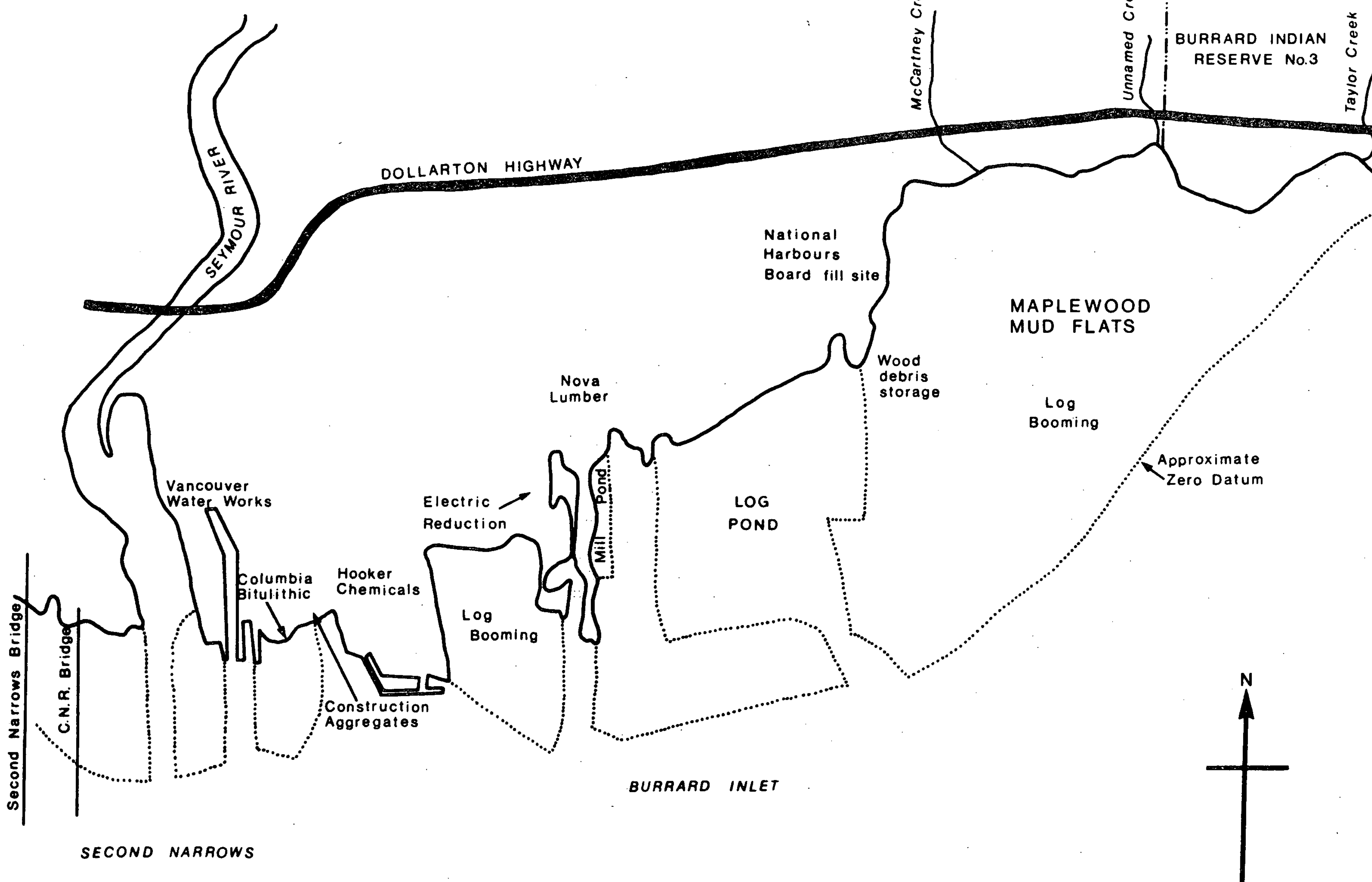
The study area is presently zoned primarily for industrial use and has been put to a variety of industrial uses by several private and public owners (see Map 2). In spite of this zoning and use, the area maintains an ecological identity, and it is the purpose of this report to place the area in a broad ecological perspective, to describe its natural characteristics, and to comment on probable impacts from past and projected developments.

According to Armstrong (1956), the Seymour-Maplewood area, generally, is underlain by marine deltaic deposits of gravel up to 50 feet thick resting on glacial till or bedrock. These deposits were formed by mountain streams and presently are covered by relatively thin layers of fine-grained sediments consisting mainly of silt and sand but with some gravel components.

Much of the present upland west of Maplewood Mud Flats was created by the filling of intertidal marshes for industrial purposes.

Immediately west of Maplewood Mud Flats is located a "log pond" (Map 2) formed during the late 1950's and early 1960's by gravel excavations. Based on Canadian Nautical Chart 3483, the size of the log pond was estimated at 60 acres, but its size currently is being reduced as a result of National Harbours Board fill operations. The only portions of the Seymour-Maplewood area that have not undergone a considerable amount of alteration due to dredging and filling are the Maplewood Mud Flats, a narrow strip of marsh immediately east of Nova Lumber, and the lower intertidal portions of the western part of the study area (Map 2).

Water movements on the study area are influenced mainly by the tides. Burrard Inlet is subject to a mixed mainly diurnal tidal regime, which usually provides two complete tidal oscillations daily with marked inequalities in heights of successive high and low waters (Canadian Hydrographic Service, 1975). Flood tides flow onto the Seymour-Maplewood area from the west through Second Narrows and ebb tides move across the area from the east. Two large tidal eddies, one flowing counterclockwise during flood tides and another flowing clockwise during ebb tides, occur at Maplewood Mud Flats (Tabata, 1973). Fresh water flows into the intertidal area from the Seymour River, McCartney Creek, Unnamed Creek and Taylor Creek.




MAP 2. General land use; Seymour – Maplewood estuary (Nov., 1975).

Scale: 1 in. = 1000 ft.

## 1. Characteristics of an Estuary

To understand the ecological workings of the Seymour-Maplewood area well, it is important to recognize that the area, although altered by past development, is a functioning estuary fitting the classical definition. Actually, it is an estuary system within a larger estuary, Burrard Inlet. In physical terms, an estuary has been described as "*a semi-enclosed body of water which has a free connection with the open ocean and within which seawater is measurably diluted with freshwater derived from land drainage*" (Cameron and Pritchard, 1963). In more ecological terms, an estuary can be described as an integrated and interacting system, consisting of identifiable upland, intertidal and subtidal zones, and fresh and salt water bodies. Translated into more familiar terms, these components are:

| | | |
|---|---|---|
| Upland | - | forest, woodland, true grassland (above tidal reach) |
| Freshwater | - | rivers and streams |
| Intertidal | - | marshland (upper intertidal) and mud flats (lower intertidal) |
| Subtidal | - | below low tide |
| Saltwater | - | ocean, inlet, bay. |

In general, the biological productivity of an estuary is tied to an interdependent and rather inflexible set of physical and chemical conditions, to which plants and animals have adapted in rather specific and intricate ways. Within the estuary system the kinds and abundance of plants and animals can be seen to differ quite markedly in the different components, usually as the result of basic differences in elevation, substrate, salinity and nutrient supply. These factors, along with the size and shape of the estuary components, are fixed by the general topographic, geologic and hydrologic features of the area, although often they are altered by man-made developments. The key element to understand as far as biological production is concerned, is the importance of the interaction and interdependence among the estuarine components. Physically and chemically the estuarine components are linked through the transitional nature of the zones, one usually blending gradually into the next, and by water movements: fresh water flowing seaward, carrying nutrients and forming a freshwater gradient outward across the intertidal zone; salt water flowing shoreward by currents, tides and wave action, carrying nutrients, and forming a saltwater gradient inwards across the intertidal zone. It is this shifting of fresh and salt waters across the shallow intertidal zone, carrying their nutrient loads, that is the very essence of the generally high biological productivity of estuaries. Factors influencing the water flows also affect the kinds and abundance of plants and animals produced by an estuary.

Aside from the obvious link plants and animals have with their physical and chemical environments, they are also linked with each other to form what is termed a "food web" or "chain". This is shown graphically in Figure 1, which illustrates the major dependent food relationships.

Clearly, modification of one element of the food web can affect others, and where this phenomenon has been documented in the past, the cause often has been physical alteration to some component of the estuary. For example, a landfill on the marshland would reduce production of vascular plants, which in turn would affect detritus, benthic invertebrates, fish and birds.

However, an estuary must offer more than food; it must also offer shelter or a space to live which makes up an organism's "habitat". The food-space relationship for an organism is complex, but where food is not a limiting factor, the availability of suitable space or shelter can determine an organism's overall abundance. Therefore, in an estuarine system, modification to the physical size (or some other controlling characteristic) of any component can result in changes in abundance of plants and animals, through a reduction in the available or acceptable living space.

Modification can be direct, as in the case of a landfill infringing on the intertidal zone, or indirect, as in the case of the alteration of water flows, which can in turn cause salinity changes and result in altered species composition according to saltwater tolerance.

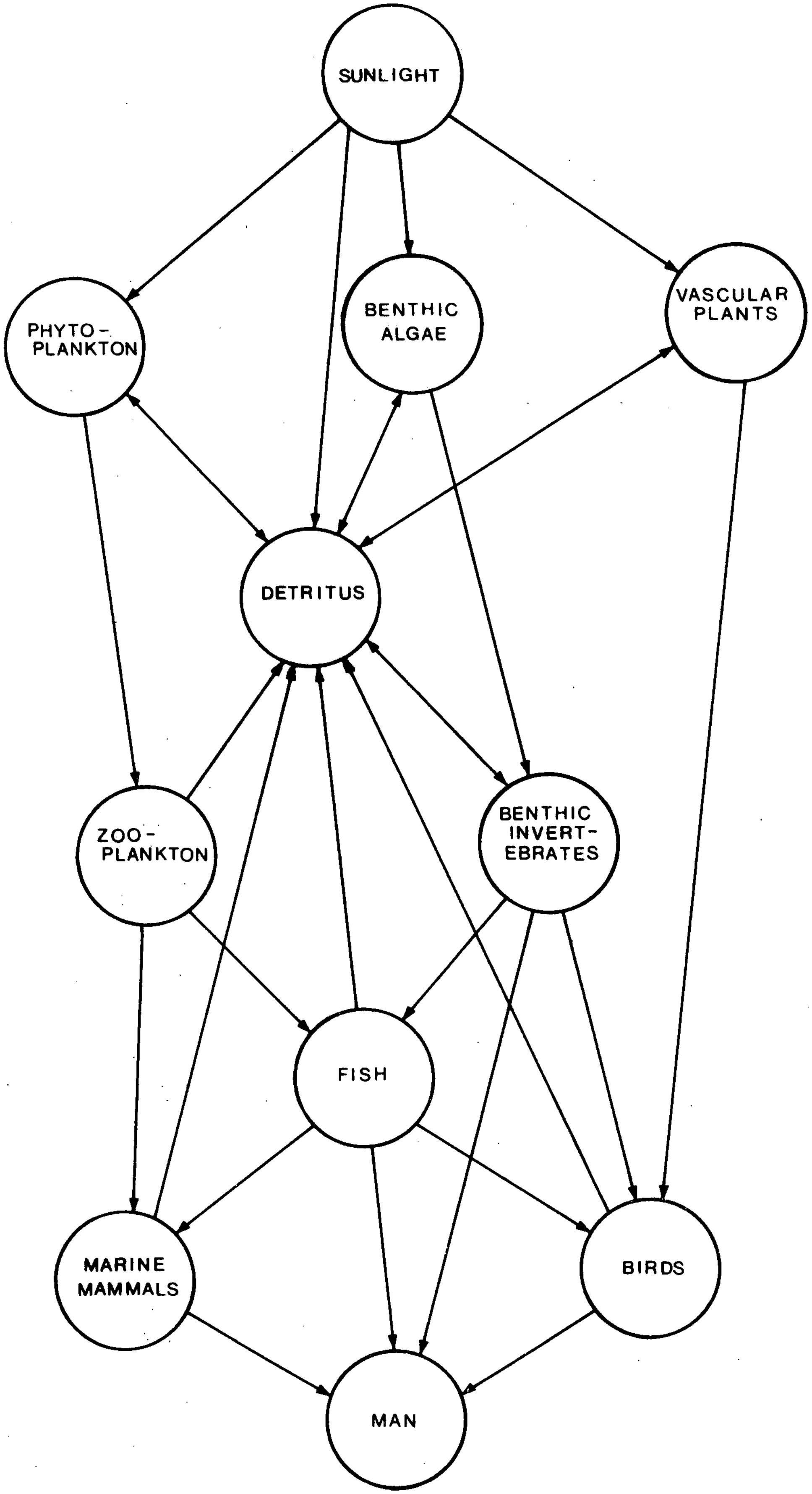



FIGURE 1. Typical estuary food web or food chain.

## 2. Components and Vegetation of Seymour-Maplewood Estuary

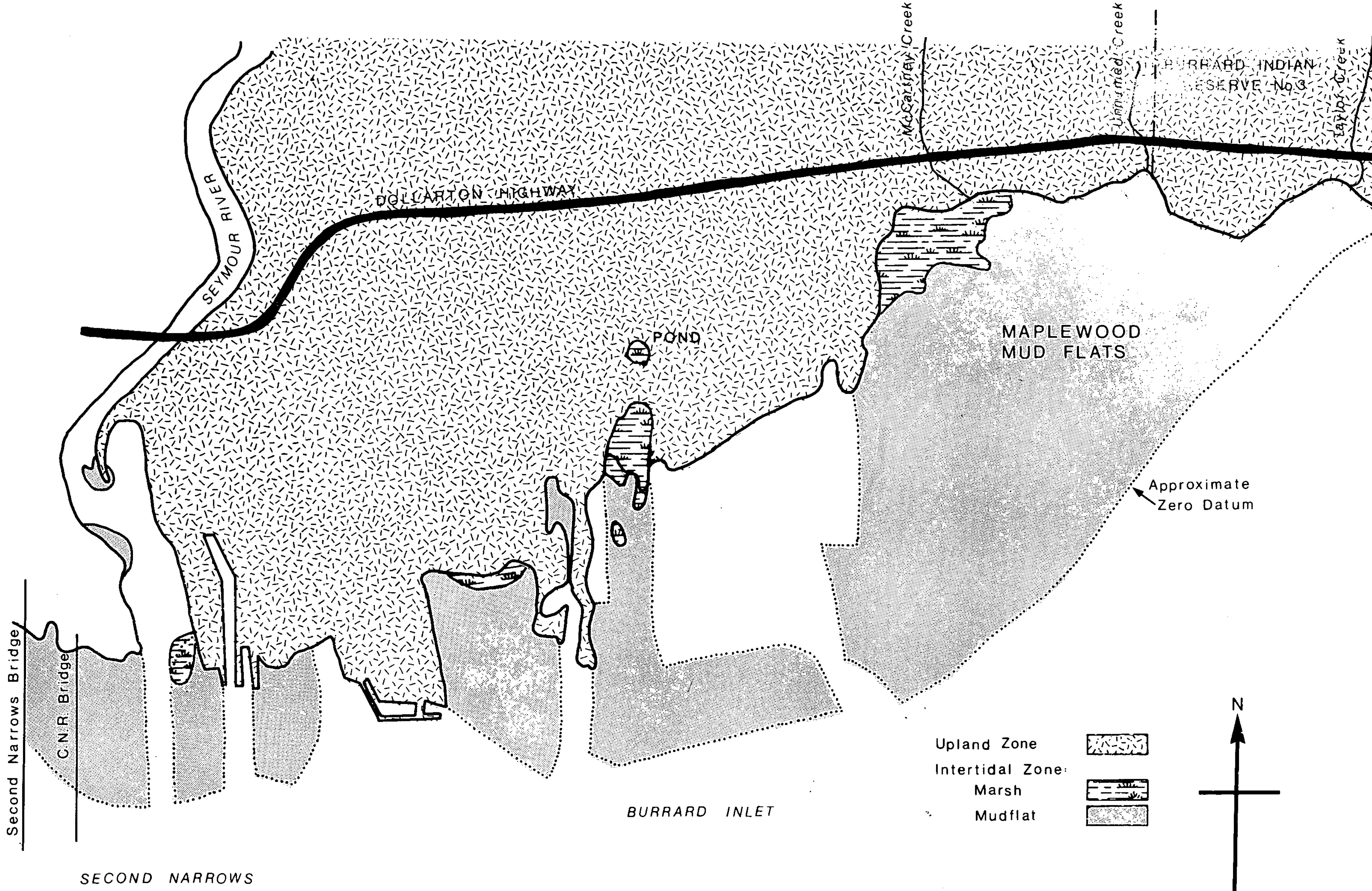
Precise boundaries are difficult to place on estuaries as their component zones are by nature transitional. An additional complexity in the case of the Seymour-Maplewood area is the fact that it is in reality a multiple estuary, comprising the freshwater input from the Seymour River, McCartney Creek, Unnamed Creek and Taylor Creek, but sharing a common intertidal zone (a situation much more obvious before development on the foreshore). In addition, this multiple estuary lies within yet another estuary, Burrard Inlet (Tabata, 1973).

It is most meaningful to consider the four estuaries of Seymour River, McCartney Creek, Unnamed Creek and Taylor Creek, as one. Pre-development marine charts (Fig. 1 of Appendix 4) show a continuous marsh zone from a point west of the Second Narrows Bridge east to beyond McCartney Creek, suggesting that the area at that time probably functioned as a single estuary. It would not be justifiable, therefore, to divide the area into discrete units according to subsequent developments, as there are likely to be some ecological factors that still function in a continuous fashion across the width of the area. Portions of the lower intertidal zone remain almost continuous, and it is apparent that some waterfowl (diving ducks mainly) and some fish are distributed across the width of the area. It is important therefore to discuss resource values, impacts and mitigation in terms of the total estuary area, regardless of some of the development intrusions which have already been made.

The Seymour-Maplewood estuary area as described above therefore consists of the following component areas (Map 3):

| | | |
|---|---|---|
| Upland | - | Watershed areas of Seymour River, McCartney, Unnamed and Taylor creeks down to high tide line. |
| Freshwater | - | Seymour River, McCartney Creek, Unnamed Creek, Taylor Creek and, to some degree, Fraser River. |
| Intertidal | - | Marshlands currently existing at the mouths of McCartney Creek and Unnamed Creek, and three other small areas between Seymour River and the log pond. |
| | | Mud flats seaward of marsh areas, fill areas, or steep uplands. |
| Subtidal | - | Seabed below lower low water line (-0.3 ft.). |
| Saltwater | - | Burrard Inlet, influenced by Fraser River. |

These components are described below according to their approximate boundaries, their major vegetation types (usually the most visible characteristic distinguishing upland and intertidal zones), and the relative importance of these components to the estuary as a whole. The invertebrates, and major fish and wildlife species, some of which range over several component zones, are described in a separate section following.




MAP 3. Major components of the Seymour - Maplewood estuary (Nov., 1975).

a) Upland Component

The entire watershed areas of contributing streams are important in determining freshwater flows and water quality delivered to the intertidal zone; however, this report will consider only the lower portions of these watersheds, from the Dollarton Highway south to the high tide mark. This upland area is mainly zoned "industrial" and since 1930, has been expanded by landfill to about 92 acres for industrial use. Major landowners are Electric Reduction Company of Canada Ltd., Hooker Chemicals, Nova Lumber Co. Ltd., L & K Lumber Ltd., Greater Vancouver Water District, National Harbours Board, Corporation of the District of North Vancouver and Burrard Indian Band.

The upland zone presently has a variety of vegetative types, ranging from grasses to coniferous forest. Most of the original plant communities have been altered by man's activities, and the present vegetation pattern generally reflects the development "age" of the various parts of the upland area. Second-growth coniferous forest is found along much of the upland zone immediately south of the Dollarton Highway. Generally, the coniferous forest is fringed on its seaward side and along the stream courses with a mixture of deciduous trees and shrubs. This deciduous fringe is important ecologically as it supports a variety of birds and small mammals, and it is important to the maintenance of aquatic life in the streams.

A small freshwater pond located east of Nova Lumber is fringed with cat-tail, arrowgrass and deciduous shrubs and trees. This pond occasionally is used by dabbling ducks.

b) Freshwater Component

Primary freshwater sources to the estuary include the Seymour River, and McCartney, Unnamed and Taylor creeks. In addition, some fresh water (actually brackish water) is contributed by Burrard Inlet.

The river and streams are important to estuarine productivity as they carry into the intertidal zone organic nutrients from their watersheds and, along with tides and currents, aid in distributing estuarine nutrients and food organisms across the intertidal zone. They also contribute to the estuary food organisms produced in the streams.

The water from these streams is important to intertidal production as it creates a freshwater/saltwater gradient across this zone, with different plants and animals being distributed according to their particular tolerances.

These streams, along with the adjacent upland areas, provide very diverse and rich plant and animal communities or "ecotones", which are of considerable value not only biologically, but aesthetically as well.

Salmon and steelhead spawn in Seymour River and some salmon are believed to spawn in McCartney Creek. No such fish use has been found for Unnamed or Taylor creeks, however, conditions appear suitable at least in their lower reaches.

The Seymour River has been much altered in the past with a storage dam on its upper reaches, dyking and channeling in its lower reaches, and almost total elimination of the marshland at its mouth. This dam likely has resulted in a greatly reduced sediment and nutrient load to the estuary, and the channeling and dyking has undoubtedly increased water velocities at the mouth with probable altered sedimentation and salinities as a result. The loss of marshland is a direct loss of valuable fish and wildlife habitat.

McCartney, Unnamed and Taylor creeks do not appear to have been much altered in the past except for culverting at the Dollarton Highway, and they can probably be considered as "natural streams".

c) Intertidal Component

Intertidal lands have been reduced by industrial landfill and dredging operations from approximately 500 acres in 1930 to approximately 300 acres at present. Most of the presently remaining intertidal area is under the control of National Harbours Board. Several road end corridors under District of North Vancouver control extend across the large Maplewood Mud Flats area.

The vegetation of any ecosystem is critical. Collectively the plant species, as primary producers, form the base of the food web. Plants transform the sun's energy into a form usable by other living things, and in an estuarine ecosystem this primary production, drawing from fresh and salt water nutrient sources, is carried out to a large extent by emergent and submergent plants of the intertidal zone. Although the intertidal zone extends from the lowest low water level to the highest high water level, there are distinct vegetational differences within this zone — mainly due to elevation and salinity — which characterize two major subzones: marshlands and mudflats.

Marshlands: The marshland vegetative community is found in the upper intertidal region, and occupies several small pockets in the Seymour-Maplewood area (Map 3). The largest, and likely the most productive and important of these, is the approximately 10-acre marsh at the mouth of McCartney Creek. A marsh of somewhat smaller size, about 3 acres, is adjacent to Nova Lumber and another, of less than 1 acre, is at the mouth of Unnamed Creek, at the western boundary of Burrard Indian Reserve No. 3. These three marshes, because of their freshwater inputs are probably correctly termed "*brackish water marshes*". The remaining marshland areas, east of the Hooker Chemicals plant, and at the mouth of the Seymour River, are remnants of the outer fringe of the original marsh complex. The former of these has been largely cut off from freshwater sources and, as a result, contains only the saltwater marsh component.

These marshes are not completely flooded by every high tide, and the plant species composition reflects the relationship between individual species' salt tolerances and the degree of saltwater inundation received from each flood tide. This is particularly evident in the marshes at the mouth of McCartney Creek and east of Nova Lumber. The outer, or seaward portions have the lowest elevation, are subject to the greatest tidal inundation and are typified by the more salt tolerant species such as glasswort (*Salicornia sp.*) and saltgrass (*Distichlis spicata*). The inner portions have the higher elevations, are only occasionally flooded by the highest tides, and are typified by plants with lower salt tolerances such as water plantain (*Alisma plantago-aquatica*) and cat-tail (*Typha latifolia*). Between these two extremes are plants with intermediate tolerances to salt, dominated by the Lyngby's sedge (*Carex lyngbyei*). A more complete list of intertidal plant species identified on the Seymour-Maplewood estuary is provided in Appendix 2.

Some marsh plants have been shown to be of direct value to waterfowl. The more important of these are:

Seaside arrowgrass (*Triglochin maritimum*)

- Potential important food source (seeds) for wintering dabbling ducks.

Seashore saltgrass (*Distichlis spicata*)

- Potentially important food source year-round for ducks and geese.

Lyngby's sedge (*Carex lyngbyei*)

- Seeds are probably an important food source for wintering dabbling ducks.

Glasswort (*Salicornia sp.*)

- Normally, glassworts play a small role in the diet of wintering waterfowl, but due to their abundance in the Seymour-Maplewood marshes, they are a potentially valuable food source, particularly in adverse weather conditions, when other food may not be available.

<u>Mudflats</u>: The mudflat vegetation is restricted to several species of algae. During the late summer and fall, green algae such as sea lettuce (*Ulva sp.*), green confetti (*Enteromorpha sp.*) and *Ulothrix sp.* are abundant over the entire mudflat area, extending to the margin of the marsh. These algae virtually disappear in December and January, possibly due to low temperatures, and reappear the following summer. Other unidentified green algae and the brown alga, rockweed (*Fucus, sp.*), are also fairly common on the mudflats and in some cases on the rest of the intertidal zone as well.

Along the seaward fringe of the intertidal zone (approximating the one foot tide line and seaward) is a zone of eelgrass. Its seaward limit is unknown, but it extends at least to lower low water (-0.3 foot tide as defined by Canadian Nautical Chart 3483). Some unidentified brown algae also were noted mixed with the eelgrass and extending into deeper water.

Several of these species are known to have direct value to fish and waterfowl, including the following:

Sea lettuce ( *Ulva lactuca*)

- Potentially valuable food for wintering wigeon.

Rockweed (*Fucus gardneri*)

- Herring spawning areas.

Eelgrass (*Zostera marina*)

- Potentially valuable food source for all waterfowl.
- Food and cover for prey species of diving birds and fish.
- Herring spawning (in other estuaries).

d) Subtidal Component

Little is known of the subtidal zone and its importance to the estuarine ecology. This zone beyond the lowest low tide (-0.3 ft. tide) supports an unmeasured extension of the eelgrass bed, as previously described for the intertidal zone, and provides plankton and nutrients which are carried over the intertidal zone for use by plants and animals there.

e) Saltwater Component

Burrard Inlet provides the saltwater component to the Seymour-Maplewood estuary, although in reality Burrard Inlet is considered brackish or somewhat less than a true marine body of water (Tabata, 1973).

## 3. Fauna of Seymour-Maplewood Estuary

### a) Invertebrates

Invertebrate organisms produced in an estuary generally make up a significant proportion of the diet for estuarine fish and in some cases birds as well. Shellfish and crustaceans are also of some recreational and economic value where they are taken for human consumption.

Department of Environment studies of invertebrate organisms in the Seymour-Maplewood estuary were restricted to sampling in three locations: the intermediate and lower intertidal zone of Maplewood Mud Flats, seaward from McCartney, Unnamed and Taylor creeks; the subtidal zone along the outer margin of the Mud Flats at the zero datum line (Fig. 1 of Appendix 1); and the intermediate and upper intertidal zone adjacent to the mouth of the Seymour River (Table 4 and Fig. 5 of Appendix 1).

The kinds and abundance of invertebrate organisms living in the bottom sediments were found to vary according to the texture of the bottom, depth and salinity (Tables 1 and 2 of Appendix 1). For example, in the case of the larger organisms, lugworms and soft-shelled clams were dominant in muddy sand areas, while mussels and barnacles with many shore crabs were prominent on gravel-sand. In the areas of highest elevation, near the high tide mark, beach hoppers were very abundant, particularly where vegetation or debris provided cover.

Large numbers of insect larvae, which generally have a low salt tolerance, were found in areas most heavily influenced by fresh water. Sediments adjacent to the scrap log dump contained much wood debris and few organisms (Table 2 of Appendix 1).

The amount of chlorophyll *a* in the bottom sediments was measured as an indication of algal biomass. The total amount found decreased with distance from the freshwater marsh at McCartney Creek, indicating an inverse relationship with salinity (Table 4 and Figs. 2 and 3 of Appendix 1). This was independent of sediment type, although sandy substrates tend to have less chlorophyll (Tietjen, 1968). Organisms which feed on algae (detritus feeders, including aquatic insect larvae) therefore have more food available near fresh water. This relationship is important for other detritus eaters such as amphipods, which are usually found associated with the marshland vegetation and which form a large part of the diet of fish and some birds in other estuaries studies, i.e. Squamish estuary (Goodman and Vroom, 1972). This has not been found to be the case in the Seymour-Maplewood estuary, as no large concentrations of these organisms were found, and they did not form a large part of the fish diet. This was possibly due to the small size of marsh remaining, or perhaps to insufficient sampling.

The subtidal sampling showed a predominance of annelid worms and molluscs in the sediments along the zero tide line (Table 3 of Appendix 1). These sediments were mostly sand mixed with shell and gravel. Eelgrass was obtained in 4 out of the 6 bottom samples in this zone, and although crabs were not obtained in the samples, they are known to occur in this area and are taken for sale by a commercial crab fisherman and are also captured by local residents for home consumption.

The intertidal benthic invertebrates described for the area by the Pacific Environment Institute studies did not appear in significant numbers in the diet of the fish examined by the Fisheries and Marine Service, however, the fish sampling was admittedly light.

Estuarine invertebrates are a common food source for several species of birds, including shorebirds such as sandpipers on the exposed mudflats, and for diving birds such as diving ducks, loons, grebes, cormorants, and alcids in the deeper water areas. However, this food utilization was not documented for the Maplewood estuary.

The apparently large population of soft-shelled clams represents a significant potential resource for recreational clam digging. The area is presently closed for this activity due to sewage pollution.

Investigations conducted at the intertidal area between the mouth of the Seymour River and the District of North Vancouver barge berth indicate that this area also is highly productive of food organisms for both fish and waterbirds (Table 4 and Fig. 5 of Appendix 1).

b) Birds

More than 83,000 birds representing 53 species were recorded during the Canadian Wildlife Service bird surveys of the Seymour-Maplewood area conducted between October, 1972 and May, 1973 (Table 1) (Table 3 of Appendix 2).

Waterbirds made up 84% of all sightings, while marshbirds and shorebirds comprised 8% and songbirds 7% (Table 1). Almost half of the individual bird sightings (45%) were on the Maplewood Mud Flats, seaward of McCartney, Unnamed and Taylor creeks, signifying the importance of this area as wintering habitat for a variety of birds.

Based on maximum counts during the survey it was estimated that approximately 10,800 birds used the entire Seymour-Maplewood area and about 5,300 birds used Maplewood Mud Flats for winter habitat (Table 2). These estimates are minimal because there is no way of knowing the turnover of birds during the migratory periods.

A brief description of habitat requirements for the more numerous of the migratory birds — the waterfowl — is given below, so that in later descriptions of the various bird groups some attention can be given to those features of the estuary which are of greatest importance to these birds.

TABLE 1. Total numbers of birds in main bird groups recorded in each sub-area of the Maplewood study area during 33 visits to the study area October 1, 1972 - May 15, 1973.

| Bird Groups | Numbers of birds seen in each sub-area[1] Maplewood Mud Flats | N.H.B. East | N.H.B. West | H.C. East | H.C. West | Number of birds seen on the entire Maplewood study area |
|---|---|---|---|---|---|---|
| **Waterbirds** | | | | | | |
| Loons | 6 (15.4)[2] | 1 (2.6) | —— | 18 (46.1) | 14 (35.9) | 39 (100) |
| Grebes | 338 (23.8) | 189 (13.3) | 572 (40.4) | 140 (9.9) | 178 (12.6) | 1,417 (100) |
| Cormorants | 47 (5.7) | 15 (1.8) | 159 (19.2) | 292 (35.3) | 314 (38.0) | 827 (100) |
| Geese | 1 (10.0) | 1 (10.0) | —— | 6 (60.0) | 2 (20.0) | 10 (100) |
| Dabbling ducks | 13,390 (70.6) | 353 (1.9) | 2,322 (12.2) | 2,504 (13.2) | 394 (2.1) | 18,963 (100) |
| Diving ducks | 9,324 (31.5) | 4,487 (15.1) | 9,344 (31.5) | 2,453 (8.3) | 4,029 (13.6) | 29,637 (100) |
| Gulls[3] | 6,371 (34.7) | 720 (3.9) | 2,033 (11.1) | 2,262 (12.3) | 6,980 (38.0) | 18,366 (100) |
| Coots | 252 (29.2) | 253 (29.3) | 272 (31.5) | 12 (1.4) | 74 (8.6) | 863 (100) |
| Alcids[4] | 4 (25.0) | —— | 1 (6.2) | 4 (25.0) | 7 (43.8) | 16 (100) |
| Sub-total | 29,733 (42.4) | 6,019 (8.6) | 14,703 (21.0) | 2,691 (11.0) | 11,992 (17.0) | 70,138 (100) |
| **Marsh and Shorebirds** | | | | | | |
| Great blue herons | 120 (88.2) | 3 (2.2) | 11 (8.1) | —— | 2 (1.5) | 136 (100) |
| Small shorebirds[5] | 3,147 (50.0) | 370 (5.9) | 1,085 (17.3) | 1,688 (26.8) | 1 (0) | 6,291 (100) |
| Sub-total | 3,267 (50.8) | 373 (5.8) | 1,096 (17.1) | 1,688 (26.3) | 3 (0) | 6,427 (100) |
| **Birds of Prey (Bald eagle)** | 1(100) | —— | —— | —— | —— | 1 (100) |
| **Songbirds** | | | | | | |
| Crows | 3,914 (70.0) | 565 (10.1) | 833 (14.9) | 96 (1.7) | 185 (3.3) | 5,593 (100) |
| Others[6] | 20 (36.4) | 25 (45.4) | 9 (16.4) | —— | 1 (1.8) | 55 (100) |
| | 3,934 (69.7) | 590 (10.4) | 842 (14.9) | 96 (1.7) | 186 (3.3) | 5,648 (100) |
| **Other Birds** | | | | | | |
| Rock doves | —— | 25 (16.9) | 40 (27.0) | 57 (38.5) | 26 (17.6) | 148 (100) |
| Starlings | 480 (62.2) | 15 (1.9) | —— | 277 (35.9) | —— | 772 (100) |
| Sub-total | 480 (52.2) | 40 (4.3) | 40 (4.3) | 334 (36.3) | 26 (2.9) | 920 (100) |
| Total Birds | 37,415 (45.0) | 7,022 (8.4) | 16,681 (20.1) | 9,809 (11.8) | 12,207 (14.7) | 83,134 (100) |

[1] see Figure 1 of Appendix 2 for description of sub-areas.

[2] Numbers in parentheses indicate for each bird group the percentage of the total number of birds recorded that were seen in each sub-area.

[3] Includes terns.

[4] Murrelets, guillemots and auklets.

[5] Sandpipers, plovers, etc.

[6] Miscellaneous small passerine species. For convenience also includes kingfishers.

Table 2. Estimated minimum numbers of birds dependent on the Maplewood study area, Burrard Inlet, B.C., based on observations October, 1972 to May, 1975.

| Bird Groups | Numbers of Birds: Entire Seymour-Maplewood Area | Maplewood Mud Flats Only |
|---|---|---|
| Waterbirds | | |
| Loons | 7 | 2 |
| Grebes | 275 | 52 |
| Cormorants | 59 | 8 |
| Geese | 5 | 1 |
| Dabbling Ducks | 2,101 | 1,463 |
| Diving Ducks | 2,613 | 1,097 |
| Gulls | 2,460 | 650 |
| Coots | 54 | 24 |
| Alcids | 4 | 2 |
| Total Waterbirds | 7,578 | 3,299 |
| Marshbirds and Shorebirds | 2,035 | 1,023 |
| Birds of Prey | 1 | 1 |
| Songbirds | 892 | 766 |
| Other Birds | 290 | 200 |
| Total Birds | 10,796 | 5,289 |

North American waterfowl generally are considered as migratory, and are managed by international agreement with the U.S.A. under the Migratory Birds Treaty of 1916. These birds generally nest in the higher latitudes, returning to more southerly areas in fall and winter to escape the freezing temperatures which would otherwise eliminate their feeding. British Columbia is included in the Pacific Flyway, a major migratory route, and annually about four million waterfowl migrate along the coast, using open marshes along the way for resting and feeding. Some of these birds remain in B.C.'s coastal marshes for the winter before returning north in the spring. Some remain to nest, and could be considered as resident waterfowl. Freezing temperatures and ice-covered feeding areas can be as much a problem to migratory birds along the B.C. coast as in more northern latitudes. Consequently, those coastal marshes which, because of their saltwater influence and resulting lower freezing point, remain ice-free throughout most freezing periods can be considered as important emergency feeding grounds during these times of extreme stress.

Depending on the species, waterfowl requirements for food may include plant or animal matter, or both. The general factors governing food production have been described in an earlier section dealing with the general estuary. This also included a graphic representation of a typical estuary food web (figure 1).

In terms of offering the most acceptable conditions to overwintering or resting waterfowl, that portion of the Seymour-Maplewood area termed the "Maplewood Mud Flats", together with the adjacent marshlands, is the most significant.

A summary of the bird survey data follows, in which the major bird groups are described according to numbers (Mud Flats vs. entire area), habitat preference, species composition, seasonal use and feeding. Graphic and tabular presentations of these data are provided in Appendix 2 and in Tables 1 and 2 in the text.

Waterbirds: The Maplewood area is especially favoured as wintering habitat by waterbirds. This group comprised 41 of the 53 species of birds identified on the Seymour-Maplewood area (Table 3 of Appendix 2).

Waterfowl (ducks and geese) were the most numerous, comprising 69% of the total number of waterbirds and 58% of all birds seen (Table 1).

Of the waterfowl, diving ducks (those ducks which dive under the water to feed) were most numerous, with an estimated 2,600 divers dependent on the Seymour-Maplewood area, of which 1,000 to 1,100 were dependent on the Maplewood Mud Flats (Table 2).

Scaup were the most numerous of the diving ducks, comprising about half of the divers seen on both the entire Seymour-Maplewood area and on the Mud Flats (Table 3 of Appendix 2).

Diving ducks feed chiefly on animal matter and during the study were seen most often in areas of deeper water west of the Mud Flats, with only about a third (32%) of the sightings on the Mud Flats (Table 1).

Of the diving ducks, bufflehead appeared to be most dependent on the Maplewood Mud Flats with 83% of the sightings of this species on the Mud Flats (Fig. 2 of Appendix 2).

Table 3 and Figure 2 of Appendix 2 provide a comparison of the numbers of scaup, goldeneye, bufflehead, scoters and mergansers seen on Maplewood Mud Flats with those seen on the entire Seymour-Maplewood area.

Dabbling ducks (those ducks which feed by "tipping up" or dabbling in shallow water) were the second most numerous waterfowl (Table 1). The number of dabblers dependent on the Seymour-Maplewood area was estimated to be at least 2,100 of which 1,400 to 1,500 were dependent on the Mud Flats (Table 2).

American wigeon and mallards were the most abundant dabbler species on the study area, comprising 57% and 25% respectively (Table 4 of Appendix 2). Green-winged teal ranked a distant third in abundance at 8% while gadwall, pintail, European wigeon, northern shoveler and unidentified dabblers comprised the rest.

Based on monthly mean numbers of birds seen, dabblers appeared to be most numerous in October and gradually declined until most had left the study area the following May (Fig. 4 of Appendix 2).

Most (71%) of the dabbling ducks, unlike the diving ducks, showed a preference for the Mud Flats (Table 1), and those dabblers not seen on the Mud Flats were generally seen at or near one or more of the other remnants of marsh in the western part of the Seymour-Maplewood area (Figs. 9 and 10 of Appendix 2). However, of the five most numerous species of dabblers only wigeon, pintail and gadwall were dependent mainly on Maplewood Mud Flats with 88%, 81% and 73% respectively of these three species seen there (Table 5 of Appendix 2). Thirty-nine percent of the mallards, the second most numerous dabbler species seen on the study area, were seen on the Mud Flats. Green-winged teal appeared to favour the Mud Flats only slightly over the rest of the Seymour-Maplewood area.

Mallards have been reported by local residents to use the small freshwater marsh east of Nova Lumber, particularly during migratory periods. Dabbling ducks generally feed on vegetation and the main attraction for dabblers appeared to be the remnant marshes and extensive algal growth on the Mud Flats. When the intertidal flats were flooded, most dabblers used the marshes. However, during lower tidal stages, many dabblers left the marshes to feed at the tide line. This latter feeding activity was most prevalent among the wigeon on the Mud Flats, but some dabblers also fed in this manner on the intertidal area immediately east of Hooker Chemicals.

The Seymour-Maplewood area is of particular value to dabblers at certain times of the migration and wintering period. For example, during the period October to December, 1972, between 900 and 1,000 dabblers regularly used Maplewood Mud Flats. Of these, about 800 to 900 apparently fed on the lush growth of green algae growing on the Mud Flats. Numbers of wigeon using the Mud Flats decreased considerably following the disappearance of this green algae during the latter part of December, 1972.

The Seymour-Maplewood area was particularly important to dabblers during times of crisis such as during prolonged periods of below freezing weather. At such times (for example, the first two weeks of December, 1972 and the first two weeks of January, 1973) numbers of dabblers in the study area increased substantially (Fig. 3 of Appendix 2). It was on December 8, 1972, during the first of these two cold periods that the one-day maximum number of 1,828 dabblers was seen on the Seymour-Maplewood area. This was likely due to the freezing of other marsh areas in the vicinity (particularly freshwater marshes) and subsequent concentrations of dabblers on the few remaining ice-free marshes, the intertidal marshes. Most of the extra dabblers forced to use the Seymour-Maplewood area during periods of cold weather did not use the Maplewood Mud Flats, rather, they utilized the smaller remnants of marsh to the west, particularly the area between the log pond and Nova Lumber.

Seasonal use and mean monthly counts of dabbling ducks are provided in Table 3 and Figure 4 of Appendix 2.

Geese and swans are also classed as waterfowl, but during the study geese were seen on the study area infrequently and swans not at all. One snow goose, probably a stray from the large flocks that use the Fraser estuary marshes, was seen near the Maplewood Mud Flats on October 27, 1972 and from two to five Canada geese, probably from the Stanley Park flock, occasionally were seen near the mouth of the Seymour River during April and May, 1973. Local residents reported that up to 12 Canada geese occasionally were seen on the Mud Flats in June, 1973, and 7 were seen feeding on marsh vegetation on July 20, 1974 by Canadian Wildlife Service officers.

Gulls ranked third in total numbers of waterbirds seen during the 1972-73 surveys (Table 1). Six species of gulls were identified, including glaucous, glaucous-winged, herring, California, mew and Bonaparte's. Gulls were most abundant in the Seymour-Maplewood area from December, 1972 to February, 1973, and on the Mud Flats during February (Fig. 5 of Appendix 2). Gulls, like the diving ducks, were most numerous on the western portion of the Seymour-Maplewood area with only 35% of all gulls seen on the Mud Flats (Table 1). One-day maximum numbers of gulls observed on the entire Seymour-Maplewood area and on the Maplewood Mud Flats were 2,460 and 650 birds respectively.

Taken together, waterfowl and gulls represented nearly 96% of all waterbirds seen and 80% of all birds seen in the Seymour-Maplewood area (Table 1).

Diving birds such as loons, grebes, cormorants and alcids comprised 3% of all waterbirds seen in the Seymour-Maplewood area (Table 1). Because these species typically dive after small fish and invertebrates most were in areas of deeper water in the western part of the Seymour-Maplewood area, with only 17% of these diving birds seen on the Maplewood Mud Flats.

The remaining 1% of the waterbirds were coots, of which only 29% were seen on the Mud Flats (Table 1) (Fig. 5 of Appendix 2). Most coots were seen along the outer edges of National Harbours Board debris stored in the log pond immediately west of the Mud Flats.

Most waterbirds had migrated out of the study area by May. However, a few waterfowl apparently remained to breed in the vicinity. One brood of three mallards and 2 broods of mergansers, containing six and seven young, respectively, were observed on the area by Canadian Wildlife Service personnel during May and June, 1973. A second brood of six mallards was reported on Maplewood Mud Flats by local residents.

Marshbirds and shorebirds: This group of birds accounted for 8% of all birds seen in the Maplewood area. Of these, approximately 50% were sighted on the Mud Flats (Table 1) (Fig. 6 of Appendix 2).

Great blue herons, the only species of heron seen, were most abundant during January and February, particularly on the Mud Flats where 88% were sighted (Table 1) (Fig. 6 of Appendix 2). The maximum number of herons seen at one time was 18 at Maplewood Mud

Flats January 23, 1973. During low tides, herons usually fed actively on small fish in the tidepools of the mudlfats or in shallow water near the tide line. At high tide when the Mud Flats were covered with water, herons usually loafed on nearby log booms. The nearest known heronries are located in Stanley Park, at Port Coquitlam and at the University Endowment Lands.

During the study period, small shorebirds also fed on the intertidal portions of the Seymour-Maplewood area whenever tidal conditions permitted. Although a few small shorebirds were seen in the Seymour-Maplewood area all winter, their numbers, like those of the dabbling ducks, increased considerably during the prolonged periods of cold weather (Fig. 6 of Appendix 2). In early December, 1972 a one-day maximum of 2,017 birds was seen. During the sub-freezing weather of the first part of January, 1973, numbers of small shorebirds in the Seymour-Maplewood area did not increase appreciably. However, shorebirds are very mobile and their constant shifting from area to area makes counting difficult. Therefore, it is possible that because the Seymour-Maplewood area was surveyed only once weekly, potential high concentrations of birds during this period might have been missed. A second build-up of small shorebirds was noted during February and early March, 1973 due probably to northward spring migration. Because the study was initiated in October, most of the southward migrating shorebirds had already passed through the area and therefore were not recorded. Of the smaller shorebirds identified on the study area, probably the only species remaining to nest is the killdeer.

Birds of prey: One bird of prey species, the bald eagle, was observed in the Seymour-Maplewood area. Only one eagle was seen during the regular bird surveys, although two eagles were seen during other investigations in the summer of 1973.

Songbirds: Crows made up 99% of the passerine birds seen in the Seymour-Maplewood area and at Maplewood Mud Flats and 70% of all crows seen were on the Mud Flats (Table 1). Miscellaneous species of small songbirds were seen infrequently but most (64%) were seen other than on the Mud Flats.

Other Birds: The total number of non-indigenous species such as rock doves and common starlings seen was not large, although flocks of up to 260 starlings occasionally were seen on the intertidal area when the tide was low (Table 3 of Appendix 2).

### c) Fish

Information regarding fish in the Seymour-Maplewood estuary complex is limited to Fisheries and Marine Service sampling during three periods in 1973, and periodic observations, mainly by local anglers. Fisheries and Marine Service salmon and steelhead spawning escapements for Burrard Inlet rivers and streams provide evidence of the likely sources of juvenile salmon taken during the 1973 sampling.

Fish found or observed in the estuary included chum, chinook and coho salmon, herring, smelt, sculpin, flounder, stickleback, lemon sole and anchovy, all taken in the 1973 netting program, and cut-throat trout observed by anglers.

Some understanding of the general life history and ecological requirements for the various kinds of fish found in the estuary may be gained from the following notes:

(i) <u>Anadromous fish - Salmon, steelhead trout, coastal cut-throat trout.</u>

These species spend the greater part of their growing and adult life in the ocean, returning to streams and rivers to spawn. The young, after spending several weeks to several years (depending on the species) in fresh water, return to sea. On this seaward migration they generally remain in the estuary of their native stream, or perhaps a more productive one nearby, for varying periods of time up to several months, again depending on the species.

The value of the estuary to these seaward migrating fish is recognized as twofold.
It provides a transition zone for the acclimation from fresh to salt water and also provides a high protein food source for rapid growth. It has been shown that survival of anadromous fish in the sea is directly related to the size that individual fish attain upon leaving the parent stream or estuary. Therefore food production and fish growth in the stream and estuary is critical.

Estuarine residence for these fish is predominantly during the spring months, and for some species well into summer. Food sources in the estuary are generally plankton, benthic (bottom) organisms, and other fish.

ii) Other migratory fish - herring, smelt, and anchovy.

These species could be classed as anadromous in a sense as they will spawn along the shores in somewhat brackish conditions. Herring young, at least, remain near shore for a period of time, feeding and growing before returning to sea.

iii) Non-migratory or resident fish - sculpin, flounder, stickleback, sole

These species occur generally in shallow water along much of the B.C. coast. They are not considered 'estuary' residents in any specific way, however, they will obviously utilize the abundant estuary food sources.

Netting in the late spring and summer of 1973 (Fig. 1 of Appendix 3) resulted in the capture of a total of 705 fish, of which 63.1% were herring, 28.8% smelts, 2% salmon and the remaining 6.1% sole, stickleback, sculpin and anchovy. It should be noted that about 50 chum salmon fry escaped the net in the May sampling and were not counted (Table 1 of Appendix 3).

Of the salmon, chum were caught in the May and June sampling while chinook and coho were taken only in the June sampling period. No salmon were captured in August. This pattern appears consistent with other estuaries studied by the Fisheries Service, e.g. the Squamish and Fraser (Goodman and Vroom, 1972; Hoos and Packman, 1974). Unfortunately, no sampling was carried out earlier in the year to further corroborate this.

Pink salmon, steelhead trout and coastal cut-throat trout are other anadromous species known to inhabit Burrard Inlet and its tributaries, however, no young of these species were caught in any of the net samples. It does not necessarily follow that they do not use this estuary at some time as the sampling program was not designed to provide a comprehensive evaluation of total fish use (or their numbers).

Herring were taken in the May and June periods but were absent in August. Only stickleback were taken in August. Sculpin, flounder, sole and anchovy were caught only in May, while smelt were taken only in June.

Subsequent analysis showed chinook and coho (captured in June) to be in their second year of life, while chum (June captures) were "fish of the year" or in their first year (Table 2 of Appendix 3). These age groups are consistent with those found in other estuaries (Goodman and Vroom, 1972).

Given the low frequency of sampling, the small number of sample stations and the low numbers caught, it was impossible to establish any pattern of fish abundance in the various parts of the intertidal zone.

Examination of the stomach contents of fish caught showed that chinook salmon ate primarily benthic (bottom) organisms, while coho and chum stomachs contained none of these organisms. Pelagic, or free swimming organisms formed almost the entire stomach contents of coho, herring and surf smelt, and were a significant item in the stomachs of chum salmon and longfin smelt. Other fish were eaten by coho, chum and chinook salmon (herring principally), and by herring and longfin smelt (unidentified species). Terrestrial organisms (insects) were eaten in significant numbers only by chum salmon. These data indicate that although estuarine benthic organisms are a food source for fish, other sources were available and used also, at least during the sampling periods (Tables 3 and 4 of Appendix 3). This appeared similar to other estuaries (Goodman and Vroom, 1972; Parker and Goodman, 1974).

The parental stream of the salmon and trout utilizing the Seymour-Maplewood estuary has not been clearly identified. There is no record of spawning salmon, steelhead or cut-throat trout in McCartney Creek, Unnamed Creek or Taylor Creek, which flow into the eastern side of the estuary; however, chum salmon fry have been sighted in McCartney Creek, suggesting that some spawning may take place there, at least by these species. Inspection has shown that all three streams appear suitable for salmon spawning and perhaps trout, in their lower reaches.

The most obvious source of young fish is Seymour River because of its proximity, however, other Burrard Inlet tributaries should not be discounted. Salmon and steelhead spawners are well documented in the Capilano, Seymour and Indian rivers, as well as Lynn Creek. Table 5 of Appendix 3 provides available spawner counts for these tributaries. By way of summary, the ten-year combined average counts in these tributaries (1963 to 1972) include over 57,000 pink salmon (odd years only), 11,000 chum salmon, 4,600 coho salmon and 180 steelhead trout. Chinook salmon spawning in Burrard Inlet tributaries up to 1972 has been negligible and was restricted to several dozen fish in 1971 and 1972. Ten-year average figures for these rivers and streams (Table 6 of Appendix 3) show substantial declines in most species since 1934. The production of coho, chinook and steelhead, however, has been increased considerably in the Capilano River since 1971 with the advent of the hatchery operation on that river, but it is not known to what extent these hatchery-released fish utilize the estuarine areas of upper Burrard Inlet.

Adult coastal cut-throat trout have been caught by anglers fishing in the intertidal zone of the mouth of McCartney Creek, principally from early April to mid-June, and from the beginning of September to the middle of November. It is not known if these fish spawn in tributaries in this end of Burrard Inlet.

The Fisheries and Marine Service is currently examining the feasibility and potential of a salmon hatchery development on the Indian River. The Seymour-Maplewood estuary is the only estuarine area of any significance between Indian River and the sea, and the possible use by these hatchery-released fish on their seaward migration should be considered as a potential future resource value of the estuary.

e) Mammals

The only mammal species seen on the study area was the harbour seal. However, deer and raccoon tracks were seen in the mud at the mouth of McCartney Creek and it is likely that other nocturnal mammals such as mink and river otters also frequent the area.

Summary

The above data show the strong preference of most bird species for the more "natural" (i.e. undisturbed) habitats found from the Second Narrows Bridge to the eastern end of the Maplewood Mud Flats. The specific habitat and food requirements described also point out the dependence of these species on the natural functioning of this area as an estuary, with attention focused on its component parts interacting as a system.

Although a significant number of birds were observed at times away from the more "natural" areas, it is highly likely that at least the waterfowl were nonetheless dependent on some elements of the marshes or mudflats for food and shelter.

There would appear to be sufficient numbers of salmon and steelhead produced in Burrard Inlet tributaries to warrant protection of estuarine areas necessary for these species' survival. The limited fish sampling carried out by the Fisheries and Marine Service suggests that the Seymour-Maplewood estuary area provides habitat for fish produced in a number of streams. Fish produced in the tributaries emptying into the estuary would most likely utilize the same estuary. These would include Seymour River fish, and possibly production from McCartney, Unnamed and Taylor creeks. The capture of chinook salmon, however, is suggestive, although by no means conclusive evidence that fish as far away as the Capilano River (the closest recorded spawning stream for chinook) may utilize the estuary. If this is the case, then the recently increased stocks of coho, chinook and steelhead in the Capilano River by hatchery production could place a greater emphasis on the Seymour-Maplewood estuary for these anadromous species.

## 4. Natural Resource Perspective

In some respects, descriptions of the natural resources of the estuary and the impacts which developments may have on them are more meaningful when considered within larger perspectives of time and space. From such a broad analysis, the values of resources and the significance of impacts can be ascribed on the basis of relative abundance and alternative habitats.

In the case of the Seymour-Maplewood estuary, this kind of analysis involves the consideration of both the past and present estimates of fish, wildlife and their habitats, and their relation to Burrard Inlet and the Lower Mainland as a whole. No specific studies have been carried out for such a "perspective analysis", however, with the aid of some limited data along with some professional judgment, some conclusions can be drawn.

### a) Habitat

Intertidal marshland is considered the most important habitat in the estuary in terms of food and shelter for the many species of fish and birds recorded for the area. Of the approximately 300 acres of intertidal zone of the Seymour-Maplewood estuary, only about 16 acres presently is marshland, 10 acres of which is located at the mouth of McCartney Creek, the other 6 acres divided among four smaller marsh areas. Although much reduced from pre-development years, the marshland of the Seymour-Maplewood estuary through the years has become the most significant marsh on the north shore of Burrard Inlet, from Capilano to Indian Arm (see below).

Approximate acreage of intertidal marsh

| Year | First Narrows to Second Narrows | Second Narrows to Taylor Creek | North Shore Total |
|---|---|---|---|
| 1930[a] | 242(100%)[b] | 108(100%) | 350(100%) |
| 1957[c] | 193( 80%)[b] | 73( 68%) | 266( 76%) |
| 1975[d] | 5( 2%) | 16( 15%) | 21( 6%) |

a. 1930 data arbitrarily used as baseline because little filling of North Shore marshes occurred prior to that time. Acreage estimates for 1930 based on Canadian Hydrographic Service Field sheets 2203-L and 2206-L (which were produced in 1927 and 1929, respectively, and which were used to update British Admiralty Chart 922 to 1930).

b. Numbers in parentheses represent percentages of original amount of marsh remaining in a particular part of the north shore in a given year.

c. 1957 estimates based on British Admiralty Chart 922 (updated to 1957).

d. 1975 estimates based on Canadian Nautical Charts 3482 and 3483 (updated to January 2, 1975; and aerial photographs taken in 1971 and 1973) on file at the Canadian Wildlife Service, Delta, B.C.

Refer to charts in Appendix 4.

Apart from the mouth of the Indian River, the only other significant marsh in Burrard Inlet is the less than 5-acre marsh fringe at the eastern end of Burrard Inlet at Port Moody, and Stanley Park, which is an artificially maintained habitat.

Productive intertidal mudflats are also scarce in Burrard Inlet, with the Seymour-Maplewood Mud Flats comprising the largest single area, about 286 acres. Other large areas of any significance include Coal Harbour and Port Moody.

b) Birds

On a "birds per acre" basis, using the Canadian Wildlife Service 1972 to 1973 maximum counts, the original Seymour-Maplewood intertidal marsh of 108 acres may have directly supported somewhere between 7,500 to 14,000 dabbling ducks (Fig. 11 of Appendix 2), compared to 2,100 at present and indirectly, perhaps a somewhat lower multiple of diving ducks and other waterbirds. There is no way of knowing the original populations of waterbirds supported by the total Burrard marshland of about 350 acres before any development, however, it is likely that these populations were several times the present numbers.

There are unfortunately, no reliable data on present bird numbers in all of Burrard Inlet such as exist for the

Seymour-Maplewood area. The "Christmas Bird Count" program, an annual count in the Lower Mainland done by various naturalists groups and individuals provides fairly complete coverage of Burrard Inlet. However, the information based on one day counts has questionable quantitative value, as the Canadian Wildlife Service Seymour-Maplewood weekly surveys suggested there could be a substantial variability between single counts. However, the Christmas Bird Counts show that the Seymour-Maplewood area has maintained over the past few years a greater diversity of bird species than many other areas, probably reflecting the diversity of habitats offered.

To carry this perspective one step further, that is, the Seymour-Maplewood bird population in relation to the Lower Mainland, brings into focus the Pacific Flyway and the total habitat available in the Lower Mainland to support these birds. Many of the migratory waterfowl (ducks and geese) seen on the Seymour-Maplewood estuary are part of the much larger populations of the Pacific Flyway. Of the Flyway's approximately 4 million birds in total, about one million annually stop in the Lower Mainland (Burgess, 1970; Halladay and Harris, 1972) and of these over 200,000 overwinter in the marshes and other intertidal areas of the Fraser and other Lower Mainland estuaries (Taylor, 1974), including the Seymour-Maplewood estuary. This is the largest wintering waterfowl population in Canada.

Protection of the waterfowl is an obligation the Canadian Government has assumed with the U.S.A. as a signator of the Migratory Birds Treaty of 1916. This agreement was founded on the understanding that the birds are an international resource. Land use or other decisions which affect these birds or their habitat in either country will also affect the birds and their values in both countries. A parallel situation exists with shorebirds. Over one million plovers, snipe, sandpipers and other shorebirds overwinter in the Lower Mainland (Hallady and Harris, 1972), particularly along the foreshore areas of the Fraser and other Lower Mainland estuaries, including the Seymour-Maplewood estuary.

The critical role that intertidal marshland plays in the provision of food and shelter for these migratory birds is now recognized and the recent recognition of the dramatic losses of this habitat to development practices such as filling, dredging and dyking has lead to increased government opposition and control over land use practices which would remove or degrade the remaining productive marshland. In the Fraser estuary, it has been estimated that only 9,000 acres remain of an original 45,000 acres of marshland (Taylor, 1974). The 21 acres remaining of an original 350 acres of marshland on the north shore of Burrard Inlet does not appear an unusual pattern, although no measurements of other Lower Mainland estuaries are available. In view of this reduction in critical habitat, the maintenance of the waterfowl of the Pacific Flyway and the shorebirds which stop or overwinter in the Lower Mainland will depend on the success of measures taken to protect the remaining habitat, including that found in the Seymour-Maplewood estuary.

Alternative habitats do not exist for these bird populations, and normally all habitats would be considered as used to capacity by animals already there. The loss of habitat would result in a reduction in the numbers of birds that the destroyed habitat supported.

The fractional contribution that the birds of the Seymour-Maplewood area make to the larger populations of the Pacific FLyway does not detract from the value they have in terms of local and district recreational, aesthetic and educational uses. The fact that these birds are present, in whatever numbers there may be, is important to a number of people who currenlty use and value the area for recreational and aesthetic purposes, as well as to some who recognize the educational opportunities this area provides.

c) Fish

There are no reliable estimates of numbers of fish using either the Seymour-Maplewood area or Burrard Inlet. However, there is some general information on several species found in Burrard Inlet which suggest some relevance to the Seymour-Maplewood estuary. The species found in the Maplewood sampling, in the Burrard Inlet sampling as part of the Department of Environment "Third Crossing

Studies", and as recorded in annual spawning escapement estimates for Burrard Inlet tributaries, include several important species known in other areas to depend on estuarine habitat for food and shelter.

Of major concern are several salmon species, steelhead trout and herring, of both commercial and recreational importance.

These species' dependence on the Seymour-Maplewood area has not been measured, but the fact that this area provides most of the remaining vestiges of true estuary conditions found in Burrard Inlet places a singular importance on this area.

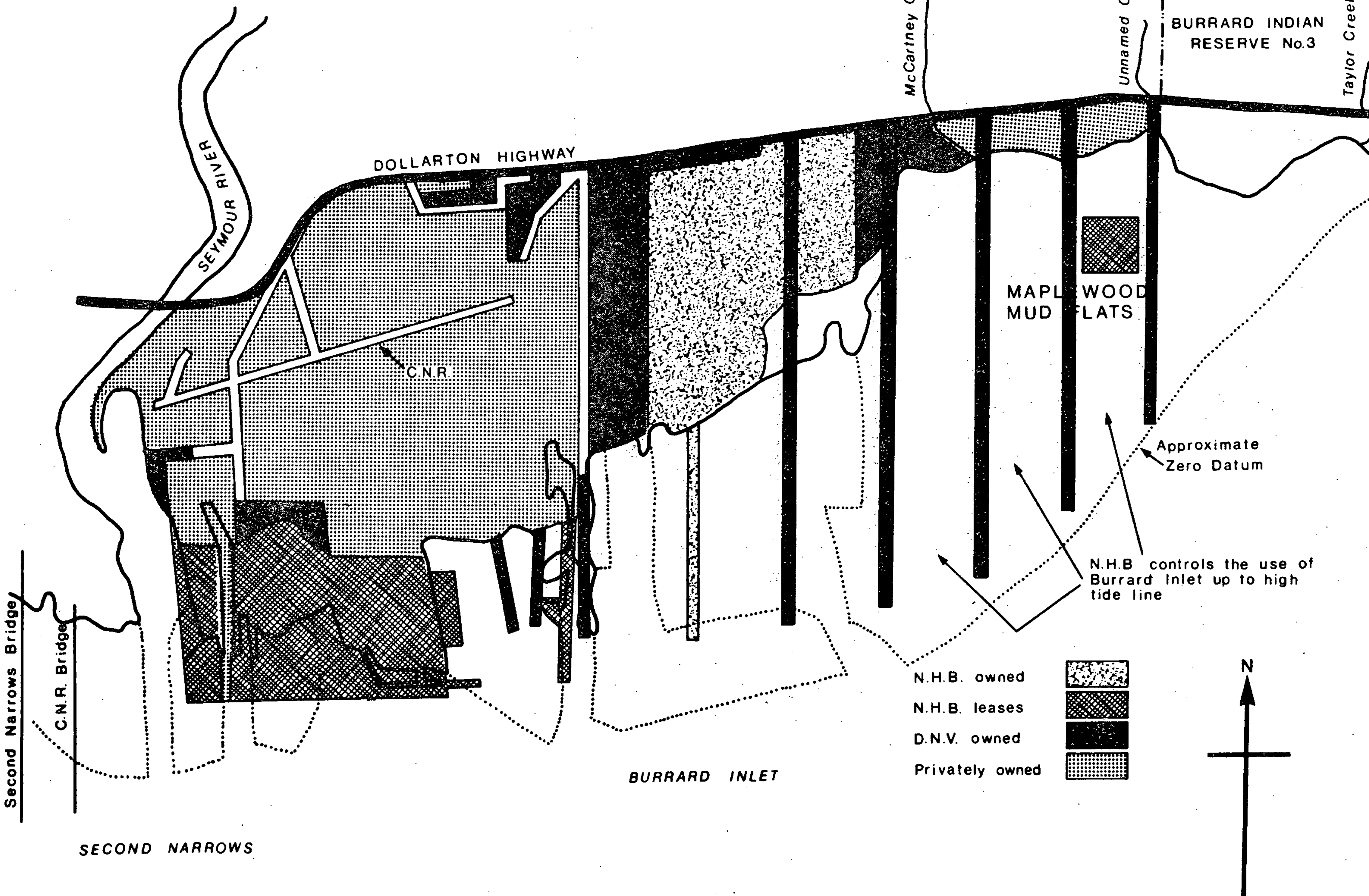
The salmon and steelhead spawner populations in Burrard Inlet tributaries have been decreasing since first records were kept ( Table 6 of Appendix 3). This is thought to be the result of a combination of overfishing and habitat loss — including loss of estuarine habitat. The restoration of these runs (such as is already taking place with the hatchery on the Capilano River, the possible future hatchery development on the Indian River, and possibly other restorative measures on other rivers and streams) will result in a greater number of young salmon and steelhead being fed into Burrard Inlet whose capacity to provide food and shelter through productive estuarine habitat may be already severely limited. It seems imperative therefore to protect what little estuarine habitat still exists in order to maintain options for future restoration or enhancement.

Herring, although not recorded as spawning in Burrard Inlet, have been found in substantial numbers along both the north and south shorelines as far east as Second Narrows by the Fisheries and Marine Service sampling program for the "Third Crossing" study. No sampling for this program was carried out east of Second Narrows, and no relative abundance estimate can be made for the Seymour-Maplewood area.

The Fisheries and Marine Service Maplewood sampling identified herring as a user of the Seymour-Maplewood estuary, and it is apparent that these fish, along with the substantial numbers found in the rest of Burrard Inlet, are part of the general Lower Mainland herring population which probably spawn in Boundary Bay but use Burrard Inlet as one of their rearing areas.

## 5. Land Ownership and Present Use

Current major landowners in the Seymour-Maplewood upland and foreshore area are: Electric Reduction Company of Canada Ltd. (ERCO Industries Ltd.), Hooker Chemicals - Division of Canadian Occidental Petroleum Ltd., Nova Lumber Company Ltd., L & K Lumber, Ltd., Greater Vancouver Water District, National Harbours Board, the Corporation of the District of North Vancouver and the Burrard Indian Band (Map 4).




MAP 4. General land ownership of Seymour – Maplewood estuary area (Nov.,1975). Boundaries are approximate, taken from District of North Vancouver Ownership Map 13, March, 1975 and N.H.B. data.

The intertidal portion of Maplewood Mud Flats is mainly under the control of the National Harbours Board, but several corridors of intertidal land belonging to the District of North Vancouver extend across Harbours Board property to the outer limits of the Mud Flats.

Log boom storage is presently the main use made of the Maplewood Mud Flats, except on its outermost western edge where the Harbours Board stores floating debris cleared from Vancouver harbour. Log booms and harbour debris are also stored at the log pond. However, the National Harbours Board has, for the past 1-1/2 to 2 years, been systematically burying the driftwood in the northernmost part of the log pond under landfill. A small amount of intertidal land was filled between ERCO and Nova Lumber during 1974. In addition, proposed developments by Columbia Bitulithic and Construction Aggregates Ltd. would result in the alteration or destruction of about 3-2/3 acres of intertidal lands between Hooker Chemicals and the mouth of the Seymour River (Map 2).

## DEVELOPMENT IMPACTS

The biological productivity of an estuary can be affected by alteration of any one of a multitude of interacting factors. Typical changes brought about by development range from the direct reduction of available habitat that results from dredging and filling, to the frequently more subtle and less easily discerned alterations in freshwater flow, salinity, or water quality. Development activities that traditionally have resulted in adverse impacts on estuarine ecology include:

Landfill on upland or intertidal areas, which directly and proportionately reduces productive habitat.

Dyking, which alters normal freshwater dispersal over upland and intertidal areas, or seawater dispersal over intertidal areas, affecting sedimentation, availability of nutrients and salinity. Dykes are also landfills.

Dredging, which alters bottom composition and depth, and effectively intrudes the subtidal zone onto the more productive intertidal zone. Disposal of dredged material may also create a landfill problem.

Industrial Operations, which can result in poorer water quality, air pollution, noise and disturbance, as well as directly displacing habitat.

The most profound and immediate impacts of estuary development concern loss of habitat, which will be reflected in at least proportional losses of the plants and animals originally occupying the disturbed area.

1. Past Development Impacts

a) Dredging and landfill

Most of the past development activities in the Seymour-Maplewood area have taken the form of dredging and landfill on the intertidal zone, or a combination of the two. The net result of these operations has been the outright loss of approximately 92 acres (85%) of the original marshes within the study area, and the alteration of approximately 105 acres of intertidal gravel-and-mud flats.

The filling of the marshes is an irreversible act which has destroyed considerable waterfowl habitat. Dabbling ducks, because of their greater dependence as a group on marsh habitat, probably were the birds which suffered most. One can only guess at the numbers of dabbling ducks (and perhaps even geese and swans) that once utilized the marshes of the Seymour-Maplewood area. On the basis of 1972-73 estimates of maximum numbers of dabblers dependent on the small amount of marsh remaining in the study area, the numbers of dabblers dependent on the original 108 acres may have been in the range of 7,500 to 14,000 birds.

In addition to dabbling ducks, a number of other bird species commonly associated with marshes of southwestern British Columbia may also have been hard hit by destruction of the marsh. Such common marsh birds as the red-winged blackbird and the marsh wren were not seen at Maplewood during this study.

The other main groups of birds that were observed on the study area generally utilize food from a greater variety of sources than dabbling ducks, consequently, the total direct impact of marsh destruction on them potentially was less than on dabbling ducks.

Dredging of the intertidal mudflats potentially had less impact on birds than the destruction of the marshes. Whereas the filling in and paving over of the marshes is irreversible, dredged areas will, in time, be recolonized by marine organisms if no further disturbance takes place. However, a dredged area may be subject to constant scouring by prop-wash from boats, and by repeated dredging to maintain an open channel.

Dredging on the study area has undoubtedly reduced the amount of intertidal area available to those groups of birds such as dabbling ducks, shorebirds, herons, gulls, crows, etc. — which must feed in shallow water or on dry land. Diving ducks, known to feed to depths of at least 6 to 8 fathoms (36 to 48 feet) (Mitchell, 1952), potentially could regain use of dredged out feeding areas, provided the areas were left undisturbed to be recolonized by marine vegetation and prey species. Even so, changing the water's depth might alter the composition of the species which recolonized, and thus the composition of the bird species dependent on them for food.

The largest and most conspicuous dredged area is the log pond in the central part of the study area. This pond, which is conspicuous only during low tides, was created mainly as a result of gravel excavation between 1957 and 1965, although a narrow barge channel had been dredged across the area to the shore during the 1920's. The log pond occupies an area of about 60 acres including approximately 12 acres which has been filled by the National Harbours Board. The dredging of the log pond resulted in the destruction of perhaps 5 to 10 acres of the total amount of marsh lost to development.

To date, Maplewood Mud Flats has almost totally escaped the destruction of dredging and filling. A small pond apparently dredged for use as a sawmill pond is located near the northern shore of the Mud Flats, just east of McCartney Creek. However, the mill has ceased operation and the pond apparently has been recolonized by marine organism. Ducks, particularly bufflehead, often were seen in this small pond at low tide.

### b) Log storage and driftwood disposal

Log storage has left many sunken logs scattered over the surface of Maplewood Mud Flats. These "sinkers", well past the point of being salvageable for lumber, are gradually being absorbed into the ecological system of the Mud Flats. Most have been invaded by teredos, small wood-boring molluscs whose disused burrows provide homes for many small marine organisms as well as hastening the decay of the wood by allowing the more rapid penetration of bacteria into the heart of the log. The surfaces of the logs also serve as solid points of attachment for various species of marine algae and invertebrates such as mussels and barnacles (used for food by diving ducks) which normally are unable to inhabit muddy areas due to lack of solid attachment points.

## 2. Present Land Use Impacts

The value to wildlife (particularly dabbling ducks) of the once extensive marshes in the western part of the study area was eliminated when they were "reclaimed" for industrial purposes. However, waterfowl (particularly diving ducks), other waterbirds (such as gulls and grebes), and crows may be seen in relatively large numbers in appropriate habitat around the periphery of the industrial area. Apparently the present daily industrial activity has little effect on most of the birds. Boat traffic associated with the industries temporarily displaces waterbirds but they usually return to their original location once the disturbance has passed.

At the time of the Canadian Wildlife Service inventories, Electric Reduction Company (ERCO) discharged 30°C (86°F) fresh water at the rate of about 300 gallons per minute into a small cooling pond in the upper intertidal zone adjacent to ERCO property. This pond was flushed with the cooler waters of Burrard Inlet at each high tide. The warm water did not seem to inhibit use of the pond and an adjacent fringe of saltmarsh by dabbling ducks. In fact, during periods of cold weather when the freshwater portions of the other marshes on the study area were covered with ice or snow, this small pond remained ice-free and received much use by dabblers (particularly green-winged teal).

The greatest hazard to wildife and fish from the existing industrialization of the Seymour-Maplewood estuary is the potential for accidental spillage of toxic substances from the chemical-based industries, or of oil from ships servicing this area and points farther east on Burrard Inlet. An oil spill in the Maplewood vicinity during the fall or winter could be disastrous to thousands of waterbirds. Two tidal eddies (one flowing counterclockwise during flood tides and another flowing clockwise during ebb tides) occur in the vicinity of Maplewood Mud Flats (Tabata, 1973). Consequently, oil spilled in this area probably would be trapped by these eddies, resulting in the oiling of many birds and most of the extensive intertidal marsh and mud flats.

The main industrial use made of the presently existing intertidal portions of the Mud Flats is for the storage of logs. Although log booms (particularly the boomsticks) are used by birds regularly for loafing, it is believed that at Maplewood the destruction of feeding habitat outweighs any benefits the booms provide as loafing habitat. Log booms are generally detrimental to wildlife habitat in several ways, all inhibiting the growth of marine plants and animals beneath the booms:

i) Pieces of bark and wood shed from the logs become waterlogged, sink and form a smothering blanket of debris on the bottom.

ii) Decomposition of the debris can cause localized problems of deoxygenation, and production of hydrogen sulphide and perhaps other chemicals toxic to aquatic and benthic life.

iii) The substrate is abraded by log booms at low tide; and

iv) Log booms reduce the amount of sunlight which reaches bottom-dwelling vegetation and, thus, reduces its productivity.

At Maplewood there also is evidence of striations across the mudflats, apparently where towboat activity is greatest. These striations probably are the result of the propeller wash of boats engaged in booming activities, or they may be the result of logs being dragged across the mud at lower water. Whatever their cause, the striations reduce the productivity of the flats.

The log pond and Maplewood Mud Flats are also used for the storage of floating debris swept from Burrard Inlet by the National Harbours Board because it constitutes a navigational hazard. Formerly this debris was hauled onto the adjacent upland, allowed to dry, and then was burned. Present air pollution standards no longer allow this practice, so the debris has been gradually accumulating in its present location. The effects of this debris on wildlife habitat basically are the same as for the log booms. The debris stored on Maplewood Mud Flats covers, and probably was temporarily eliminated, about 2 to 3 acres of the outer fringes of the saltmarsh.

The National Harbours Board for the past one and a half years has been systematically burying the driftwood under landfill in the northernmost part of the log pond. The area when completed would yield about 12 acres of usable "reclaimed" land which was formerly valuable fish and wildlife habitat.

If the driftwood debris were removed from Maplewood Mud Flats and log booming discontinued throughout the rest of the study area, the portions presently degraded by those activities would, in time, become more productive habitat.

Apparently, the method currently used for disposal of harbour sweepings was embarked upon without considering the environmental implication. From the fish and wildife standpoint, the burial of such a large amount of wood might result in future environmental complications as the wood begins to decay and ground water leaches toxic substances ("leachates") into adjacent intertidal areas. These substances may be directly harmful to birds or fish, and may indirectly affect them by inhibiting the growth and productivity of food species. Because the wood will decompose under anaerobic (without oxygen) conditions, the rate of decomposition will be slowed, and potentially the production of leachates will be prolonged over a number of years. From the wildlife standpoint, it is preferable that all such areas of fill be constructed almost entirely of non-toxic mineral soil containing a minimum of organic matter.

The current methods of disposing of driftwood obviously can be only interim measures at best, because the driftwood problem is continuous. It is realized that the National Harbours Board is faced with a complex problem in this respect, but from the wildlife standpoint it is preferable not to contain the wood in large booms in shallow intertidal areas, nor to bury it where leachates will contaminate wildlife habitat. Probably the method of disposal most acceptable to all concerned would be some form of smokeless combustion, or the utilization of the driftwood as fuel. Clearly, more investigation of these latter approaches is warranted.

3. Future Development

Any future development involving the destruction or degradation of marsh or mudflat habitat in the Maplewood area will result in further reductions in the numbers of migratory birds and fish using the area, and probably will adversely affect overall biological productivity of the estuary. On the other hand, any development confined to the present upland portions of the area should have little or no impact on most of the waterbird species or fish dependent on this area, provided adequate watershed protection and pollution control measures are implemented. Development of the upland will disrupt songbird habitat. However, because no songbird data currently exist for the upland portion of the Seymour-Maplewood area, and because the extent of this disruption will depend on the location and type of development undertaken, it is impossible to predict at this time the impact of such development on songbirds.

A possible exception to the foregoing generalization about development of the upland area concerns a small (about one-acre) freshwater pond and surrounding alder swamp on municipal property adjacent to Nova Lumber's lumber storage yard (Map 3). No data exist in Canadian Wildlife Service files regarding the use of this pond by waterfowl, but local residents report that it is used by dabbling ducks, and it should be considered an integral part of the waterfowl habitat remaining in the area. Indeed, it is only about 150 to 200 yards from the three-acre remnant of intertidal marsh which presently fronts municipal property west of the log pond, and which is used by a maximum of about 300 to 350 dabbling ducks (mostly mallards). Because the pond and the intertidal marsh are connected by low swampy ground, a minimum of effort probably would be required to convert them into one 6-to-7 acre unit of prime waterfowl habitat.

Without specific plans for developments in the Seymour-Maplewood area, it is impossible to predict impacts other than in general terms. Because the species and numbers an area supports are directly related to the quantity and quality of the habitat available, the total impact on the fish and wildlife in the area would depend on the amount and quality of the habitat removed for development.

Two specific proposals for developments involving sections of the intertidal lands adjacent to the mouth of the Seymour River were examined by the Canadian Wildlife Service and the Fisheries and Marine Service. Columbia Bitulithic proposed to fill 2.64 acres for gravel storage and Construction Aggregates, on behalf of the District of North Vancouver, proposed to fill 0.5 acre and dredge an additional 0.5 acre to provide a barge berth. A joint report released by the two Services in March, 1975 said in summary:

> *"Both proposals, as originally presented, would irreversibly destroy important feeding habitat for wintering waterbirds and seaward migrant salmonids. Because the construction of the barge berth would require less area of fill than the Columbia Bitulithic proposal, it would have less impact on fish and waterbird habitat than the Columbia Bitulithic proposal. However, the environmental impact of the District of North Vancouver's barge berth proposal should be minimized by locating the loading ramp on the existing upland behind the present high water mark."*

The report recommended rejection of Columbia Bitulithic's proposed extension of operations, and recommended the barge berth proposal should be accepted only if it could be shown there was no alternative site possible.

The District of North Vancouver town centre proposal for Maplewood has remained at the 'concept' stage and has not been laid down in specifics. However, it is clear that such a development, involving the introduction of a very large human population, even if physically sited entirely on the upland zone, must have a profound effect ecologically on the whole area.

At one extreme exists the possibility of total development of the entire intertidal zone of the Seymour-Maplewood area. In that case, all of the birds dependent on shallow water or dry beach for feeding would be displaced. Of the waterbird species, only diving birds and gulls might remain, and even their numbers would probably be reduced drastically. Similarly, fish habitat would be eliminated to the extent landfill occurred, or would be altered drastically by dredging. Changes would occur throughout the food web.

At the other extreme, the option exists of declaring a moratorium on all future development of the remaining intertidal portions of the Seymour-Maplewood area, and of relocating elsewhere all log booms and driftwood presently stored on the area. Acceptance of this option would at least maintain winter bird populations at their present levels, and as areas presently degraded by log booming and driftwood storage gradually recovered, the numbers of birds and fish using the areas would be expected to increase.

The Maplewood area is biologically significant for the following reasons:

i) The few remaining acres of intertidal marsh at Maplewood represent nearly all that is left of extensive intertidal marshes that once existed on the north shore between Maplewood Mud Flats and the mouth of the Capilano River.

ii) The Maplewood area represents the last remaining natural marsh-and-mudflat ecological complex on the north shore that has not been irreparably altered by development;

iii) The areas of marsh remaining, and the extensive growth of algae which occurs on Maplewood Mud Flats, attract large concentrations of dabbling ducks through the winter. The only other places in Burrard Inlet where large numbers of dabblers may be seen are the man-made duck ponds and grassy areas of Stanley Park and Ambleside Park, and at Port Moody. The area also provides important habitat for diving ducks, shorebirds, gulls and numerous other groups of birds.

The points listed suggest that the option not to develop the area further could serve more than a conservation purpose. The value of retaining a small area of virtually untouched yet accessible foreshore on the predominantly developed shores of Burrard Inlet should not be overlooked. The existence of such pockets of 'wild' land in the urban area becomes increasingly rare, and the remaining natural areas increasingly valuable as a result. They can serve recreational needs by providing opportunity for urban man to renew his contact with nature as relief from the artificial environment he has built around himself, and the kinds of recreation they best provide — walking, looking, nature study — require little or no capital investment or upkeep out of the public purse.

Such natural areas can serve science and education as well as recreation. Maplewood Mud Flats presents the only opportunity existing to study the "last remaining natural marsh and mudflat ecological complex on the North Shore", as we have described it, a place to learn the workings of a natural ecosystem, so far only slightly altered by human activity, and much of the alteration capable of being restored. The area, accessible and conveniently near at hand, would appear to offer a great deal to local schools and Capilano College for field studies.

Finally, the "no development" option would serve an aesthetic purpose, providing the relief of natural features and open space in an industrialized area.

## CONCLUSIONS AND RECOMMENDATIONS

### 1. Summary Conclusions

(1) The Seymour-Maplewood area is the remainder of a common estuary of the Seymour River and McCartney, Unnamed and Taylor creeks.

(2) This estuary is a remnant of what was once a nearly continuous estuarine system extending across the north side of Burrard Inlet from Capilano River to Taylor Creek. Of an estimated 350 acres of intertidal marshland in this north shore estuary system, that existed prior to development, about 21 acres remain.

(3) The Seymour-Maplewood area was originally comprised of 108 acres of marsh but this has been reduced to only 16 acres.

(4) The losses to marshlands along with similar reductions to intertidal mudflats have resulted from landfills and dredging for industrial and commercial purposes.

Invetebrates

(5) Invertebrate organisms important as food for fish and birds were found in the mudflats and subtidal zone. The abundance of these organisms in various places appeared to be related to natural features such as substrate type, salinity and depth, but apparently was also affected by bottom disturbances and presence of debris.

(6) The intertidal zone supports a large population of soft-shelled clams, a potential recreational resource. At present the area is closed to clam digging due to sewage pollution.

(7) Crabs are found in abundance in conjunction with the eelgrass beds in the subtidal zone and are of commercial and recreational value.

## Birds

(8) More than 83,000 birds of 53 species were observed in the 1972 to 1973 surveys; 84% of these were waterbirds, 8% were marshbirds and shorebirds, and 7% songbirds.

(9) Based on maximum counts, about 10,800 wintering birds used the Seymour-Maplewood area; 5,300 of them used the Maplewood Mud Flats specifically. Most of the waterbirds were present for the winter months only.

(10) Waterfowl (primarily ducks) made up the majority of the waterbirds observed, with slightly more diving ducks recorded than dabbling ducks. Diving ducks were mainly scaup, goldeneye and scoters, while dabbling ducks were mainly American wigeon, mallards and green-winged teal.

(11) Dabbling ducks were more closely associated with the marsh and mudflat habitats than the divers. This association is believed to be largely a reflection of species feeding habits. Diving ducks, however, derive a portion of their food supply from estuarine sources.

(12) Marsh habitat was of particular importance to dabbling ducks in periods of sub-freezing weather.

(13) Diving birds (diving ducks, loons, grebes, cormorants and alcids) were sighted mainly in subtidal areas, except for a few on the mudflats at high tide.

(14) Of the total number of marshbirds and shorebirds seen, one half were found on Maplewood Mud Flats. With the exception of killdeer and great blue herons, most apparently had migrated from the area by spring.

(15) Those bird species most dependent on marshland habitat, i.e. waterfowl, were probably present in much larger numbers in Burrard Inlet before foreshore development. With the encroaching developments, these species have had to rely to a progressively greater extent on the Seymour-Maplewood area, which has the largest remaining remnants of marsh habitat in Burrard Inlet.

(16) The birds in the Seymour-maplewood area have an intrinsic value in terms of the recreational, aesthetic and educational opportunities their presence in the area offers not only to local residents but elsewhere on the Pacific Flyway.

Fish

(17) Limited sampling showed several important fish species using the intertidal areas, including juvenile chum, chinook and coho salmon, as well as herring, anchovy, smelt, stickleback, and several other largely bottom-dwelling fish. Adult cut-throat trout have also been observed.

(18) Stomach analyses indicated some dependence by most fish on estuarine produced food.

(19) As the largest estuary system in Burrard Inlet, the Seymour-Maplewood estuary probably plays an important role in the rearing of the young of anadromous fish (salmon, steelhead and cut-throat trout) which spawn in a number of Burrard Inlet tributaries and which typically require an estuary habitat for a period of time on their seaward migration. Enhancement of these fish stocks (Capilano hatchery,

possible Indian River hatchery, possible restorative measures on other streams) places a proportionately greater emphasis on the ecological value of the Seymour-Maplewood estuary.

(20) The anadromous species (salmon and steelhead and cut-throat trout) along with herring are migratory to the Seymour-Maplewood estuary, and as parts of larger populations outside of the area and Burrard Inlet, have resource values which are national and international in scope, being parts of commercial and recreatonal fisheries.

Development Impacts: Past

(21) Development activities which typically have adverse effects on estuarine ecology include landfill, dyking, dredging and operations which remove habitat and degrade water and air quality.

(22) In the past, landfill and dredging have resulted in a loss of 92 acres or 85% of the Seymour-Maplewood marshland, and the alteration of approximately 105 acres of intertidal gravel and mudflats.

(23) These losses and alterations may have resulted in a proportionate loss of birds such as dabbling ducks, which are dependent on marshland habitat. Other birds would have been affected to a lesser extent.

(24) With respect to the effect of loss of marshlands on fish, a substantial loss of food organisms for most fish would be expected.

(25) Dredging of the mudflats has probably been less destructive to birds and fish than the filling of marshland, however, there would have been some loss of food production from the original dredging, maintenance dredging and prop wash scouring.

(26) Dredged areas are or have been made to be subtidal and, as such, will likely be colonized with different organisms from the original intertidal habitat.

## Development Impacts: Present

(27) Aside from the ongoing alienation of productive habitats by industrial landfills and dredging, the current log storage and debris disposal are perhaps the most damaging environmental impact factors. Adverse impacts arise from bark and wood litter smothering areas of the bottom, localized degradation of water quality from decomposing wood, substrate abrasion at low tide, and reduced sunlight to the plants on the bottom. Bottom scouring from towboat propeller wash is also suspected. In addition, the present practice of log debris burial with earth fill could result in the leaching of toxic materials into surrounding waters.

(28) The greatest hazard to wildlife and fish from present industrial use of the area is the potential for accidental spillage of toxic substances from the chemical-based industries, or of oil from ships and boats servicing this area and points farther east on Burrard Inlet. The Burrard Inlet Working Group has been established among the three levels of government and industry in order to respond quickly to emergency situations.

(29) The operation of the ERCO cooling pond apparently has no ill effects on fish and wildlife and, in fact, the warmer water may be beneficial to bird use of the area during very cold period when other marshes are frozen. This benefit was even greater prior to the filling of the small amount (one-plus acres) of adjacent marsh during 1974.

Development Impacts: Future

(30) Any additional landfills or dredging in the intertidal zone will further reduce the productive habitats of the estuary for birds and fish, with further destruction of marshland having the greatest impact. With so little marsh remaining, any further reduction could eliminate some birds from the area completely.

(31) Further development involving only the upland zone could have little or no impact on birds or fish in the estuary, provided adequate watershed protection and air and water pollution control measures were implemented.

(32) As originally proposed, the planned Columbia Bitulithic landfill, and the proposed District of North Vancouver barge berth adjacent to it, would reduce intertidal habitat for birds and fish. However, in the case of the barge berth, alternate plans might be feasible using upland areas or pilings.

(33) A town centre proposal for the Maplewood Mud Flats, although not past the concept stage, appears incompatible with protection of the intertidal marshland and mudflat habitats. The presence of a large number of people using this specific area in an uncontrolled way would itself have a profound ecological effect on the area.

(34) Acceptance of the option for no further development on the intertidal marshes and mudflats, along with relocation of present log storage and debris disposal, would at least maintain present numbers of wintering birds, and as areas affected by log and debris storage recovered, the numbers of birds and fish using the areas could be expected to increase.

(35) The option of no further development on the intertidal marshes and mudflats would serve more than a biological protection purpose. Preservation would also serve science, education and recreation by offering this last substantial remnant of natural estuary on the North Shore to research and observation for Capilano College and local schools, and to limited access recreation for those interested in viewing what is in reality a pocket of "wilderness" in an urban setting. It would also help protect the commercial fishery.

## 2. The Framework of Assessments and Planning

Assessment of the ecological significance to wildlife and fish of the Seymour-Maplewood area must take into account certain realities and constraints which cannot be ignored. Firstly, it must be recognized that the Government of Canada, operating through the Department of the Environment, is legally obliged to protect migratory birds and fish that occur in the area. The fact that the few remaining acres of intertidal marsh and marsh-and-mudflat complex are virtually last remnants on the North Shore of valuable habitat types, not only increases their intrinsic value to fish and wildlife, but also lays a heavier responsibility on the agencies involved to ensure their protection.

Secondly, government agencies generally are not acting on their own behalf or on behalf of the resources. They are acting on behalf of the people to retain recognized economic, social, recreational and educational values that exist in the natural resources of the Seymour-Maplewood area. All of those values are enhanced by reason of their location adjacent to contrasting developed areas, and their easy accessibility to an urban population.

Thirdly, planning for the future of the Seymour-Maplewood area is complicated by a confusion of landownerships and jurisdictions and is constrained to some degree by industrial zoning over most of the area.

Fourthly, the Burrard Indian Reserve No. 3 is not within the zoning jurisdiction of the District of North Vancouver, and land and resource uses on the Reserve do not necessarily conform to those on adjacent lands.

Finally, successful planning to protect fish and wildlife (especially migratory birds) and the ecological integrity of the area, cannot be achieved by any single agency acting unilaterally, but can only come about through consultation and cooperation between all the interested and affected parties.

The following recommendations are made with these realities and constraints in mind:

## 3. Recommendations

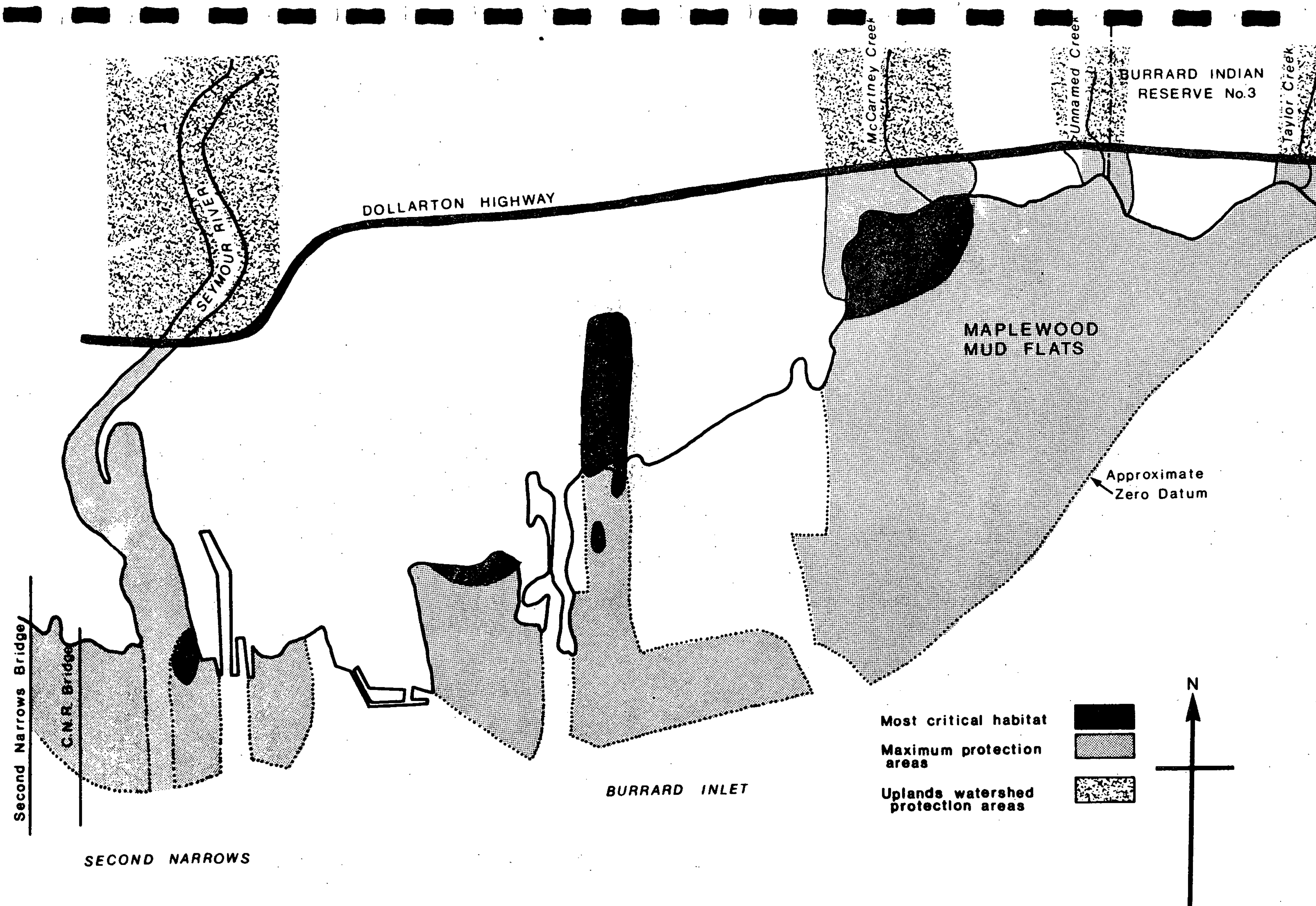
### (1) Priority Areas for Protection

For maximum protection of fish and wildlife, the general aim should be to preserve all remaining marshland and intertidal mudflats.

(a) Areas indicated as high priority habitat on Map 5 should be completely protected from alteration or development. These include all of the remaining marsh habitat and important intertidal zone.

(b) The whole of the Maplewood Mud Flats east of the existing National Harbours Board fill should be reserved from further industrial or commercial development.

(c) The watersheds of McCartney, Unnamed and Taylor creeks should be protected to assure high water quality, continuance of normal discharge patterns and retention of natural stream channels. This protection must be a part of planning for urban development




MAP 5. Seymour - Maplewood estuary, priority protection areas.

Scale: 1 in. = 1000 ft.

in the area above the Dollarton Highway as well as below. Retention of the several channels McCartney Creek follows below the Highway would ensure that nutrients carried by the stream are dispersed over a wide area of the marsh to maintain freshwater vegetation, which is believed to be a large contributor to continued fertility of the area.

(2) Compatible Uses

Uses compatible with the maintenance of the ecological integrity of the area, and specifically with maintenance of bird and fish habitat equal to or better in quality than the existing habitat, are few. As indicated above, all of the intertidal portions of the area should be reserved from further industrial or commercial development. More particularly, it should be reserved from the dredge and fill operations likely to precede and accompany industrial or commercial expansion; moreover, it would be highly desirable to phase out the current log booming activity.

The most compatible uses of the area are casual and limited access recreation (walking, sport fishing, nature study) and education, since they would require little, if any, physical alteration of the area. Removal of accumulated garbage — old washing machines, hosepipe, wire rope, bits of plastic, etc. — would improve the area aesthetically. Little more need be done to make the area suitable for recreation and educational uses. The area reserved for these purposes will serve conservation requirements at the same time.

West of the National Harbours Board fill area, it is recognized that well established industrial operations will continue at least at present levels. Maintenance dredging required to sustain them is tolerable, but expansion should be discouraged. Present industrial use of the area would be more compatible with retention of natural values if the following steps were taken:

(a) Filled areas, where possible, should be graded to the lowest possible angle where they meet the water. This would, in effect, increase the area of biologically productive shallow intertidal zone, improving habitat for both birds and fish.

(b) Erosion of filled areas should be arrested by rip-rapping or placement of steel pilings along the shoulder of the fill. Stabilizing the shoulder would encourage colonization by invertebrates of the sea bottom around the periphery of the fill.

(c) Any further fill material used in the area, even over existing fill, should be of a character not to leach toxic materials into the surrounding water.

(d) If any expansion of barge berths or other shipping facilities is undertaken, pilings should be employed as a base, rather than new landfill.

(e) Further industrial or commercial development in the filled areas should incorporate a plan for aesthetic enhancement, particularly on areas adjacent to the water. This would not only benefit North Vancouver residents and all who view the area, and the workers at these sites, but would also provide an opportunity to revegetate some areas with plants of use to wildlife. For example, grassy areas can provide useful habitat for wigeon, particularly in colder winter periods and, shrubs and trees would support songbird populations.

## 3. Habitat Improvement

Several of the measures suggested above for fish and wildlife protection and compatible uses can be considered "improvements". Other steps include the following:

(a) Major habitat improvement would be achieved by ending log booming and driftwood disposal (storage) in the area.

(b) The potential hazard to water quality posed by leaching of toxic materials from buried logs in the National Harbours Board fill area should be monitored. Should the hazard be shown to be high, consideration should be given to construction of an impervious containment dyke to confine the leachates.

* * *

# BIBLIOGRAPHY


Armstrong, J.E. 1956. Surficial geology of Vancouver area, British Columbia. Geol. Surv. Can. Paper 55-40. Dept. Energy, Mines and Res. Ottawa. 16 pp. plus map and table.

Burgess, T.E. 1970. Foods and habitat of four anatinids wintering on the Fraser Delta tidal marshes. M.Sc. Thesis, Dept. of Zool., U.B.C. 124 pp.

Cameron, W.M. and D.W. Pritchard. 1963. In "The sea. Ideas and observations on the progress in the study of the seas." Inter-science Publishers. John Wiley and Sons. Vol. 2, Chapter 15 "Estuaries", pp. 306-322.

Canadian Hydrographic Service. 1975. Canadian tide and current tables, Vol. 5, Juan de Fuca and Georgia Straits. Marine Sciences Directorate, Dept. Environ., Ottawa. 90 pp.

Forbes, R.D. 1972. A floral description of the Maplewood Mud Flats and Nanaimo River estuary, British Columbia. Unpub. Rept. prepared for the Can. Wildl. Serv., Vanc., B.C. 101 pp.

Goodman, D. and P.R. Vroom. 1972. Investigations into fish utilization of the inner estuary of the Squamish River. Fish. Serv. Tech. Rept. (1972-12). 52 pp.

Halladay, D.R. and R.D. Harris. 1972. A commitment to the future — a proposal for the protection and management of the Fraser wetlands. B.C. Fish and Wildl. Br. and Can. Wildl. Serv. 17 pp.

Hoos, L.M. and G.A. Packman. 1974. The Fraser River estuary — status of environmental knowledge to 1974. Estuary Working Grp., Reg. Bd. Pac. Reg., Dept. Environ., Spec. Estuary Series No. 1, pp. 101-125.

Levings, C.D. and N.R. McDaniel. 1974. Invertebrates at the Maplewood Mud Flats, a rare habitat in Vancouver Harbour. Fish. Res. Bd. Can. Manus. Rept. Series No. 1314. 22 pp.

Mitchell, G.L. 1952. A study of the distribution of some members of the Nyrocinae wintering on the coastal waters of southern British Columbia. M.A. Thesis, Dept. of Zool., U.B.C. 93 pp.

Parker, R.R. and D. Goodman. 1974. A discussion of the impact of the proposed Nanaimo Harbour development on the aquatic environment and its fishery resource. Appendix IV In "An environmental assessment of Nanaimo port alternatives." Dept. Environ., Lands Direct., Ottawa.

Tabata, S. 1973. A brief oceanographic description of the waters of Burrard Inlet and Indian Arm. Appendix D In "The Burrard Inlet-Howe Sound area (preliminary description of existing environmental conditions)." Dept. Environ., Vancouver, B.C.

Taylor, E.W. 1974. The Vancouver International Airport expansion proposals and possible impact on wildlife of the Fraser River estuary. Can. Wildl. Serv., Delta, B.C. 54 pp.

Tietjen, J.F. 1968. Chlorophyll and pheopigments in estuarine sediments. Limnol. Oceanogr. 13: 189-132.

Vaudry, A. and J. Land. 1973. A migratory bird survey of the Maplewood Mud Flats and Maplewood area October, 1972-May, 1973. Unpubl. Rept. prepared for the Can. Wildl. Serv., Vanc., B.C. 91 pp.

# APPENDIX 1

## INVERTEBRATES OF THE SEYMOUR-MAPLEWOOD AREA

a) Levings, C.D., and N.R. McDaniel. 1974

Invertebrates at the Maplewood Mudflats, a rare habitat in Vancouver Harbour. Fisheries Research Board of Canada, Manuscript report Series No. 1314.

b) Canadian Wildlife Service and Fisheries and Marine Service, 1975. A report on the environmental impact of proposed industrial developments adjacent to the Seymour River estuary, Burrard Inlet. Environment Canada, Vancouver.

Contents: (in order)

## FIELD METHODS

Intertidal sampling was carried out on the low tide of February 28, 1974. Station locations (Fig. 1: stn. A to T) were chosen with the following procedure: an engineering transit was set up in the middle of the flats, near the high tide line (Fig. 1). Using a random number table, 20 horizontal angles and ranges were chosen (Table 1) and these positions were used as station locations. Personnel were guided to the stations using radio communications. Organisms are zoned on tidal shores and the locations of communities within these zones is determined by the elevation at each site. In this study, the elevation at each site was referred to chart datum using water levels and a tide book.

Qualitative sampling was accomplished by digging frequently in the sediment to determine if burrowing macrofauna were present. These locations were not accurately positioned.

At each quantitative station, the sediments and organisms within a 0.25 $m^2$ quadrat were collected. Sediments were scraped with a trowel to a depth of 2 cm. The samples were washed through a 0.5 mm screen and preserved in 10% formalin.

Samples for plant pigments (chlorophyll) in sediments were also obtained, because these data provide a rough estimate of the food supply available for benthic organisms. Adjacent to each quadrat, a sediment sample for chlorophyll analysis was obtained by inverting a test tube onto the sediment surface and collecting about 5 ml of the surficial material. It was not possible to collect a chlorophyll sample at Station A, because a pool with thick grass in it was located at this site. The sediment samples were frozen within 6 hours of collection.

A small hole about 5 cm deep was dug adjacent to the quadrat, and the water drained into it was collected for salinity determination. Temperature was measured by pushing a thermometer into the sediment surface and the thermometer was read after a standard time interval.

Sublittoral sampling was completed on March 1, 1974. Van Veen grab samples (0.1 $m^2$) were obtained during high tide from six stations (MW-1 to MW-6) along the zero tide level of the flats, as shown in Figure 1. Depths were obtained from a depth sounder aboard the Fisheries Research Vessel ACTIVE LASS, and stations were located using radar. An estimate of the volume recovered by the grab was recorded, and a small sediment sample was removed and frozen. The remainder of each sample was sieved through 1 mm and 0.5 mm box sieves and these fractions were fixed in 10% formalin.

## LABORATORY PROCEDURES

After subsampling by wet weight, the intertidal samples were placed in white plastic trays, and large organisms such as mussels and barnacles were removed. The remaining material was placed in petri dishes and sorted under a microscope of 12X magnification. The majority of the subtidal samples contained sand, so an elutriation apparatus was used to float soft-bodied organisms from the sediment. After elutriation, the remaining sediment was spread thinly on white plastic trays and examined for shelled organisms, such as gastropods and bivalves. Sorting was then completed by microscope.

Owing to time and personnel limitations, only 13 samples from the intertidal area were examined. These restraints also prevented detailed identification of the fauna from all samples, and only a few organisms were identified to the species level.

Within two weeks of sampling, chlorophyll was extracted by the following method (adapted from Anon, 1966): 6 ml of 90% acetone was added to the sample, which was then wrapped in aluminum foil and thoroughly shaken. The samples were placed in a cool dark location for twenty hours. 9 ml of 90% acetone were then added, and the samples were gravity filtered through a 0.45 μ membrane

(GFC) filter. Samples were then run in a Carey spectrophotometer, where absorbance was measured at the following wavelengths: 663 nm (total chlorophyll *a*), 645 nm (active chlorophyll *a*) and 480 nm (carotenoids).

Salinity was determined using a Hytech inductive salinometer.

Table 1: Angles and ranges used in locating intertidal quadrats at Maplewood Mudflats, February 28 1974. Angles and ranges were obtained from the transit position shown in Figure 1. Temperature, salinity, elevations, and sediment data are also given.

| Station | Horizontal Angle | Distance (m) | Temp. ($^oC$) | Salinity ($^o/oo$) | Sediment | Elevation (O.D.,m) |
|---|---|---|---|---|---|---|
| A | 161 | 309 | 6.5 | 3.908 | Grass-Mud | 3.6 |
| B | 140 | 68 | 6.9 | 7.583 | Mud | 2.0 |
| C | 127 | 231 | 7.0 | 17.260 | Mud | 2.3 |
| D | 126 | 472 | 7.0 | 16.343 | Mud-Sand-Wood | 2.3 |
| E | 118 | 441 | 7.0 | 15.379 | Mud-Sand-Wood | 2.1 |
| F | 126 | 36 | N/A | 0.021 | Mud | 2.0 |
| G | 110 | 18 | 7.0 | 14.561 | Mud-Sand-Wood | 2.3 |
| H | 90 | 594 | 7.0 | 22.828 | Sand-Shell | 2.1 |
| I | 80 | 402 | 7.1 | 22.743 | Mud-Sand | 1.8 |
| J | 74 | 411 | 7.0 | 21.399 | Mud-Sand | 1.0 |
| K | 67 | 365 | N/A | 20.899 | Mud | 1.0 |
| L | 64 | 347 | 7.0 | 17.872 | Sand | 1.0 |
| M | 39 | 305 | 6.5 | 16.869 | Sand | 1.3 |
| N | 30 | 271 | 6.8 | 14.787 | Sand | 0.9 |
| O | 29 | 259 | 7.0 | 12.886 | Sand-Wood | 0.8 |
| P | 15 | 356 | 7.1 | 19.346 | Sand-Shell | 0.8 |
| Q | 13 | 285 | 7.1 | 15.106 | Mud-Sand | 0.8 |
| R | 7 | 249 | 6.9 | 18.038 | Mud | 1.1 |
| S | 21 | 157 | 6.9 | 16.076 | Mud | 1.0 |
| T | 50 | 55 | 6.9 | 17.865 | Mud | 2.1 |

Table 2: Abundance (number $m^{-2}$) of benthic invertebrates at Maplewood mudflats.

| Station | B | C | D |
|---|---|---|---|
| Time (Feb. 28'74) | 1330 | 1350 | 1405 |
| Sediment Temp. ($^{o}$C) | 6.9 | 7.0 | 7.0 |
| Sediment Sal. ($^{o}$/oo) | 7.58 | 17.26 | 16.34 |
| Sediment Type (visual) | mud | mud | mud-sand-chips |
| Elevation (m,O.D.) | 3.6 | 2.5 | 2.3 |
| Nematoda | 4416 | 1856 | 192 |
| Insect larvae | 2432 | 19168 | 64 |
| Nemertea | -- | -- | -- |
| *Eteone longa* | 1472 | 448 | -- |
| *Manayunkia aestuarina* | 47936 | 38208 | 896 |
| Polychaeta unk. | -- | -- | 128 |
| Oligochaeta unk | -- | -- | -- |
| *Corophium* sp. | 3072 | 4000 | 320 |
| *Anisogammarus* sp. | 704 | 448 | 256 |
| *Orchestoidea* sp. | -- | -- | -- |
| Tanaidacea | 3776 | 1280 | -- |
| Cumacea | 9088 | 1952 | 256 |
| Harpacticoid copepoda | 1920 | 1792 | -- |
| *Gnorimosphaeroma* sp. | -- | -- | -- |
| *Hemigrapsus oregonensis* | -- | -- | -- |
| Paguridae | -- | -- | -- |
| *Balanus glandula* | -- | -- | -- |
| *Mya arenaria* | -- | -- | -- |
| *Mytilus edulis* | -- | -- | 64 |
| *Clinocardium nutalli* | -- | -- | -- |
| Lamellibranchia unk | 128 | 96 | -- |
| *Acmea* sp. | -- | -- | -- |
| Gastropoda unk | -- | -- | -- |
| Mollusc eggs (unk) | 832 | 384 | -- |

Table 2: Abundance (number $m^{-2}$) of benthic invertebrates at Maplewood mudflats.

| Station | F | G | I |
|---|---|---|---|
| Time (Feb. 28'74) | 1430 | 1440 | 1515 |
| Sediment Temp. ($^{o}$C) | N/A | 7.0 | 7.1 |
| Sediment Sal. ($^{o}$/oo) | <1.0 | 14.56 | 22.74 |
| Sediment Type (visual) | mud | mud-sand-chips | mud-sand |
| Elevation (m,O.D.) | 1.9 | 2.3 | 1.8 |
| Nematoda | 1472 | 256 | 512 |
| Insect larvae | 1504 | 6016 | 256 |
| Nemertea | -- | -- | -- |
| *Eteone longa* | 1056 | 640 | -- |
| *Manayunkia aestuarina* | 15616 | 768 | -- |
| Polychaeta unk. | 256 | -- | 384 |
| Oligochaeta unk | 64 | -- | -- |
| *Corophium* sp. | 376 | 3200 | 1280 |
| *Anisogammarus* sp. | 416 | 3968 | -- |
| *Orchestoidea* sp. | -- | -- | -- |
| Tanaidacea | 2048 | 2048 | 128 |
| Cumacea | 4576 | 256 | 18432 |
| Harpacticoid copepoda | 832 | -- | 384 |
| *Gnorimosphaeroma* sp. | -- | -- | -- |
| *Hemigrapsus oregonensis* | -- | -- | -- |
| Paguridae | -- | -- | -- |
| *Balanus glandula* | -- | -- | -- |
| *Mya arenaria* | 1184 | -- | -- |
| *Mytilus edulis* | -- | -- | -- |
| *Clinocardium nutalli* | -- | -- | -- |
| Lamellibranchia unk | -- | -- | 768 |
| *Acmea* sp. | -- | -- | -- |
| Gastropoda unk | -- | -- | -- |
| Mollusc eggs (unk) | 1344 | -- | -- |

Table 2: Abundance (number $m^{-2}$) of benthic invertebrates at Maplewood mudflats.

| Station | J | L | P |
|---|---|---|---|
| Time (Feb. 28'74) | 1525 | 1545 | 1618 |
| Sediment Temp. (°C) | 7.0 | 7.0 | 7.1 |
| Sediment Sal. (°/oo) | 21.39 | 17.87 | 19.34 |
| Sediment Type (visual) | mud-sand-chips | sand | sand |
| Elevation (m,O.D.) | 1.0 | 1.0 | 0.8 |
| Nematoda | 11648 | 18624 | 2784 |
| Insect larvae | 128 | 192 | 864 |
| Nemertea | -- | -- | 1056 |
| *Eteone longa* | -- | -- | -- |
| *Manayunkia aestuarina* | -- | 128 | 48 |
| Polychaeta unk. | -- | 1984 | -- |
| Oligochaeta unk | -- | -- | -- |
| *Corophium* sp. | 3072 | 8060 | 528 |
| *Anisogammarus* sp. | 512 | 3392 | 48 |
| *Orchestoidea* sp. | -- | -- | -- |
| Tanaidacea | -- | -- | -- |
| Cumacea | 58112 | 31936 | 144 |
| Harpacticoid copepoda | 3200 | 1984 | 96 |
| *Gnorimosphaeroma* sp. | 512 | -- | 1824 |
| *Hemigrapsus oregonensis* | 128 | -- | 1536 |
| Paguridae | -- | -- | 3456 |
| *Balanus glandula* | -- | -- | 18192 |
| *Mya arenaria* | -- | -- | -- |
| *Mytilus edulis* | 5760 | -- | 6384 |
| *Clinocardium nutalli* | -- | -- | 48 |
| Lamellibranchia unk | 4480 | 2860 | 384 |
| *Acmea* sp. | -- | -- | 1152 |
| Gastropoda unk | 256 | -- | 576 |
| Mollusc eggs (unk) | 128 | -- | 288 |

Table 2: Abundance (number $m^{-2}$) of benthic invertebrates at Maplewood mudflats.

| Station | Q | R | S |
|---|---|---|---|
| Time (Feb. 28'74) | 1630 | 1635 | 1445 |
| Sediment Temp. (°C) | 7.1 | 6.9 | 6.9 |
| Sediment Sal. (°/oo) | 15.10 | 18.03 | 16.07 |
| Sediment Type (visual) | mud-sand | mud | mud |
| Elevation (m,O.D.) | 0.8 | 1.0 | 1.0 |
| Nematoda | 2176 | 4736 | 3840 |
| Insect larvae | 384 | 128 | -- |
| Nemertea | -- | -- | -- |
| *Eteone longa* | 128 | 256 | 256 |
| *Manayunkia aestuarina* | 256 | 512 | 5376 |
| Polychaeta unk. | -- | -- | -- |
| Oligochaeta unk | -- | -- | -- |
| *Corophium* sp. | 2560 | 1152 | 6400 |
| *Anisogammarus* sp. | -- | 1152 | 384 |
| *Orchestoidea* sp. | -- | -- | -- |
| Tanaidacea | -- | -- | 128 |
| Cumacea | 57856 | 32896 | 31360 |
| Harpacticoid copepoda | -- | 128 | 256 |
| *Gnorimosphaeroma* sp. | -- | -- | 128 |
| *Hemigrapsus oregonensis* | -- | -- | 128 |
| Paguridae | -- | -- | -- |
| *Balanus glandula* | -- | -- | 72 |
| *Mya arenaria* | -- | -- | -- |
| *Mytilus edulis* | 768 | -- | 32 |
| *Clinocardium nutalli* | -- | -- | -- |
| Lamellibranchia unk | 32 | -- | 5504 |
| *Acmea* sp. | -- | -- | -- |
| Gastropoda unk | -- | -- | -- |
| Mollusc eggs (unk) | | | |

Table 2: Abundance (number $m^{-2}$) of benthic invertebrates at Maplewood mudflats.

| | |
|---|---|
| Station | Transit site |
| Time (Feb. 28'74) | 1705 |
| Sediment Temp. ($^{o}$C) | N/A |
| Sediment Sal. ($^{o}$/oo) | N/A |
| Sediment Type (visual) | Gravel |
| Elevation (m,O.D.) | 2.5 |
| Nematoda | -- |
| Insect larvae | 16 |
| Nemertea | -- |
| *Eteone longa* | -- |
| *Manayunkia aestuarina* | -- |
| Polychaeta unk. | -- |
| Oligochaeta unk | 88 |
| *Corophium* sp. | -- |
| *Anisogammarus* sp. | -- |
| *Orchestoidea* sp. | 48 |
| Tanaidacea | -- |
| Cumacea | -- |
| Harpacticoid copepoda | -- |
| *Gnorimosphaeroma* sp. | -- |
| *Hemigrapsus oregonensis* | -- |
| Paguridae | -- |
| *Balanus glandula* | -- |
| *Mya arenaria* | -- |
| *Mytilus edulis* | -- |
| *Clinocardium nutalli* | -- |
| Lamellibranchia unk | -- |
| *Acmea* sp. | -- |
| Gastropoda unk | -- |
| Mollusc eggs (unk) | -- |

Table: 3 Taxonomic composition of six Vanveen grab samples along the edge of Maplewood Flats, North Vancouver

| Station | MW-1 | MW-2 | MW-3 | MW-4 | MW-5 | MW-6 | |
|---|---|---|---|---|---|---|---|
| Time | 0845 | 0915 | 0935 | 0950 | 1010 | 1030 | |
| Depth (m) | 4 | 4 | 3 | 4 | 4 | 5 | |
| Substrate | sand, gravel | sand/ cobble | sand | sand/ cobble | sand | silt | |
| Volume (L) | 3 | 2.5 | 2.5 | 1 | 3 | 5 | Totals |
| Taxa | No. | | | | | | |
| Nematoda | 3 | - | 1 | - | 3 | - | 7 |
| Oligochaeta | 177 | 82 | 26 | | 111 | 185 | 581 |
| Polychaeta: | | | | | | | |
| Spionidae | 23 | 32 | 1 | 2 | 14 | 24 | 96 |
| Ophelidae | 65 | 19 | 21 | 13 | 10 | 7 | 135 |
| Glyceridae | 2 | 3 | 2 | 8 | 12 | 24 | 51 |
| Syllidae | 51 | 15 | - | - | - | - | 66 |
| Pectinariidae | 3 | - | - | - | - | 1 | 4 |
| Maldanidae | 2 | - | - | - | - | - | 2 |
| Sabellidae | - | - | - | - | 2 | - | 2 |
| Nereidae | 4 | 2 | - | 2 | - | 2 | 10 |
| Ampharetidae | 3 | - | - | 1 | 1 | 2 | 7 |
| Polynoidae | 18 | 3 | - | - | 5 | 17 | 43 |
| Phyllodocidae | - | 2 | - | - | 4 | 16 | 22 |
| Cirratulidae | 2 | - | - | - | - | 2 | 4 |
| Orbinidae | - | - | - | - | 18 | 12 | 30 |
| Arabellidae | - | 1 | - | - | - | 11 | 12 |
| Flabelligeridae | - | - | - | - | - | 1 | 1 |
| Nephtyidae | 3 | 1 | - | - | - | 2 | 6 |
| Unidentified polychaetes | 10 | 20 | - | - | - | 15 | 45 |
| Subtotal Polychaeta | 186 | 98 | 24 | 26 | 66 | 136 | 536 |
| Nemertina | 41 | 33 | - | - | - | 3 | 77 |
| Mollusca: | | | | | | | |
| Gastropoda | | 4 | - | 1 | 10 | 4 | 19 |
| Bivalvia | 18 | 23 | - | 12 | 38 | 94 | 207 |
| Polyplacophora | - | 1 | - | 1 | - | - | 2 |
| Crustacea: | | | | | | | |
| Cumacea | 2 | 1 | - | - | - | - | 3 |
| Isopoda | - | - | - | - | 1 | - | 1 |
| Amphipoda | 12 | - | - | 1 | 5 | - | 18 |
| Tanaidacea | 1 | 2 | - | - | - | - | 3 |
| Ostracoda | - | - | - | - | - | 1 | 1 |
| Paguridae | - | - | - | 1 | - | - | 1 |
| Natantia | - | - | - | 1 | - | - | 1 |
| Actiniaria | - | - | - | 2 | - | - | 2 |
| Echinodermata: | | | | | | | |
| Asteroidea | - | 1 | - | - | - | - | 1 |
| Holothuroidea | - | - | - | - | - | 1 | 1 |
| Ophiuroidea | - | - | - | - | - | 1 | 1 |
| Total Organisms | 440 | 244 | 51 | 45 | 234 | 425 | 1462 |
| Eelgrass (estimate) | some | none | none | little | much | some | |

Table 4: Plant pigments (chlorophyll, phaeopigments, carotenoids; $\mu g\ cm^{-3}$) in sediments at Maplewood mudflats, February 28, 1974.

| Station | Total chl a | Active chl a | phaeopig- ments | carotenoids |
|---|---|---|---|---|
| B | 24.43 | 12.17 | 20.90 | 3.03 |
| C | 23.13 | 12.57 | 18.10 | 30.30 |
| D | 23.32 | 7.60 | 15.61 | 30.60 |
| E | 20.50 | 11.21 | 15.69 | 23.25 |
| F | 8.87 | 4.43 | 7.50 | 10.26 |
| G | 16.87 | 8.54 | 14.20 | 34.20 |
| H | 12.08 | 5.07 | 11.90 | 17.20 |
| I | 10.70 | 3.20 | 12.65 | 16.34 |
| J | 13.59 | 7.32 | 10.61 | 20.50 |
| K | 20.62 | 10.14 | 19.65 | 36.60 |
| L | 7.07 | 3.60 | 5.76 | 7.47 |
| M | 13.56 | 8.01 | 9.61 | 14.40 |
| N | 8.89 | 6.62 | 3.47 | 12.70 |
| O | 9.78 | 3.20 | 11.00 | 12.70 |
| P | 9.17 | 2.64 | 11.29 | 28.35 |
| Q | 19.11 | 12.17 | 11.77 | 28.71 |
| R | 17.75 | 6.40 | 19.38 | 30.30 |
| S | 14.48 | 5.76 | 15.05 | 20.85 |
| T | 17.49 | 7.26 | 17.37 | 24.00 |

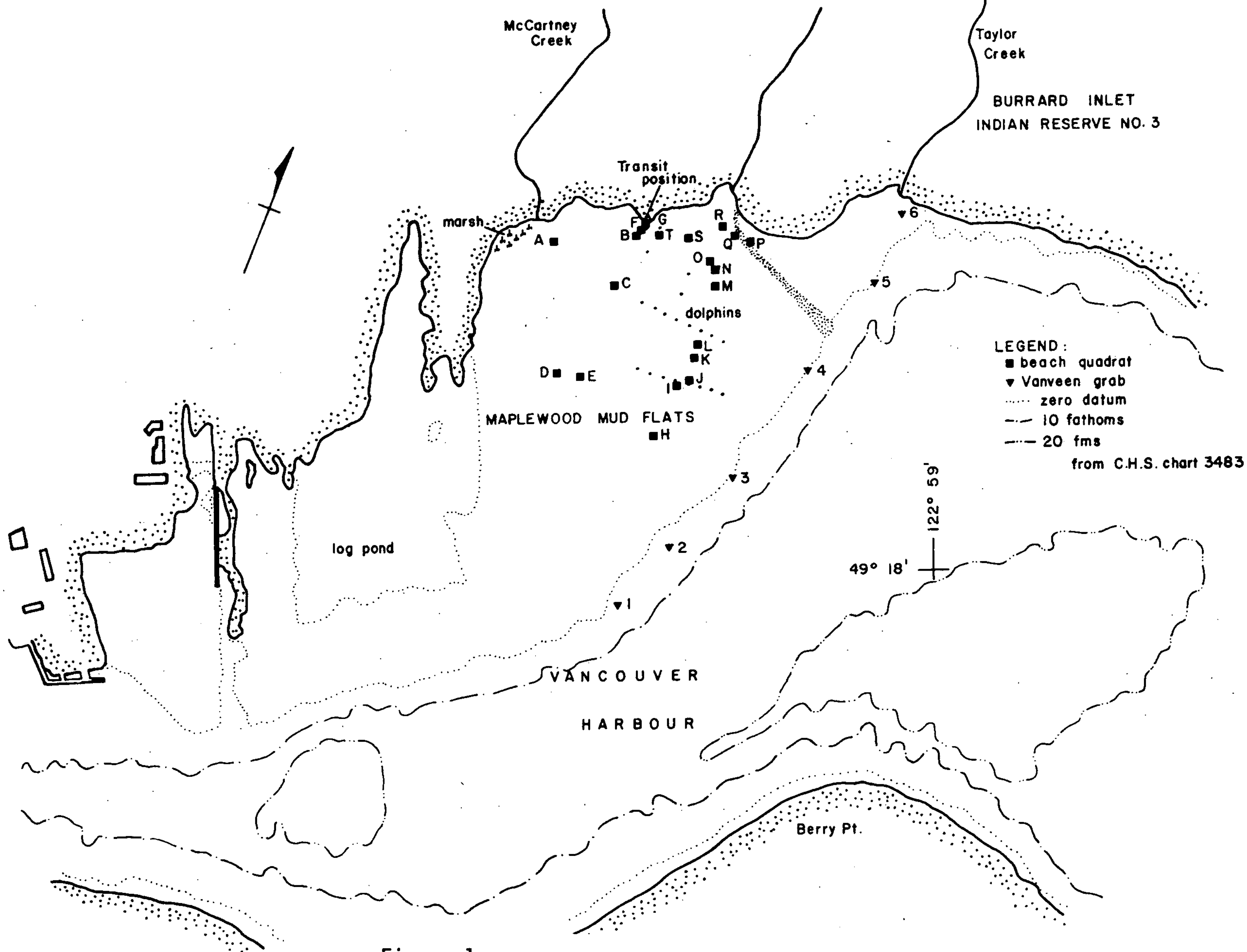



Figure 1
Station locations of intertidal quadrats and subtidal grab samples at the Maplewood mudflats. The transit position, where angles and ranges for quadrat station were measured from, is also shown.

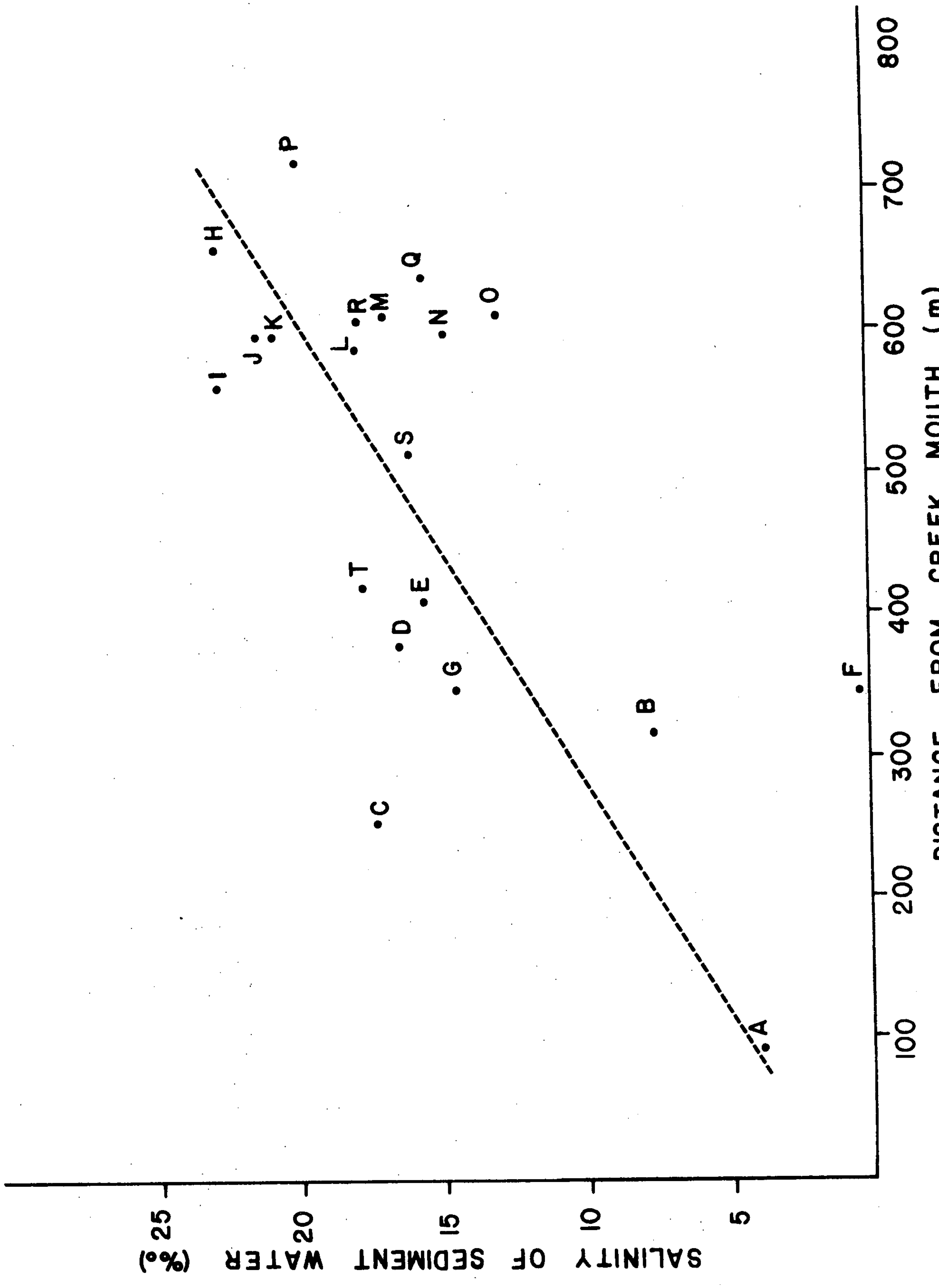



Figure 2. Relationship between salinity ($^{0}$/oo) of water in the surface of sediments at intertidal stations and distance (m) from the mouth of McCartney Creek. Lines fitted by eye.

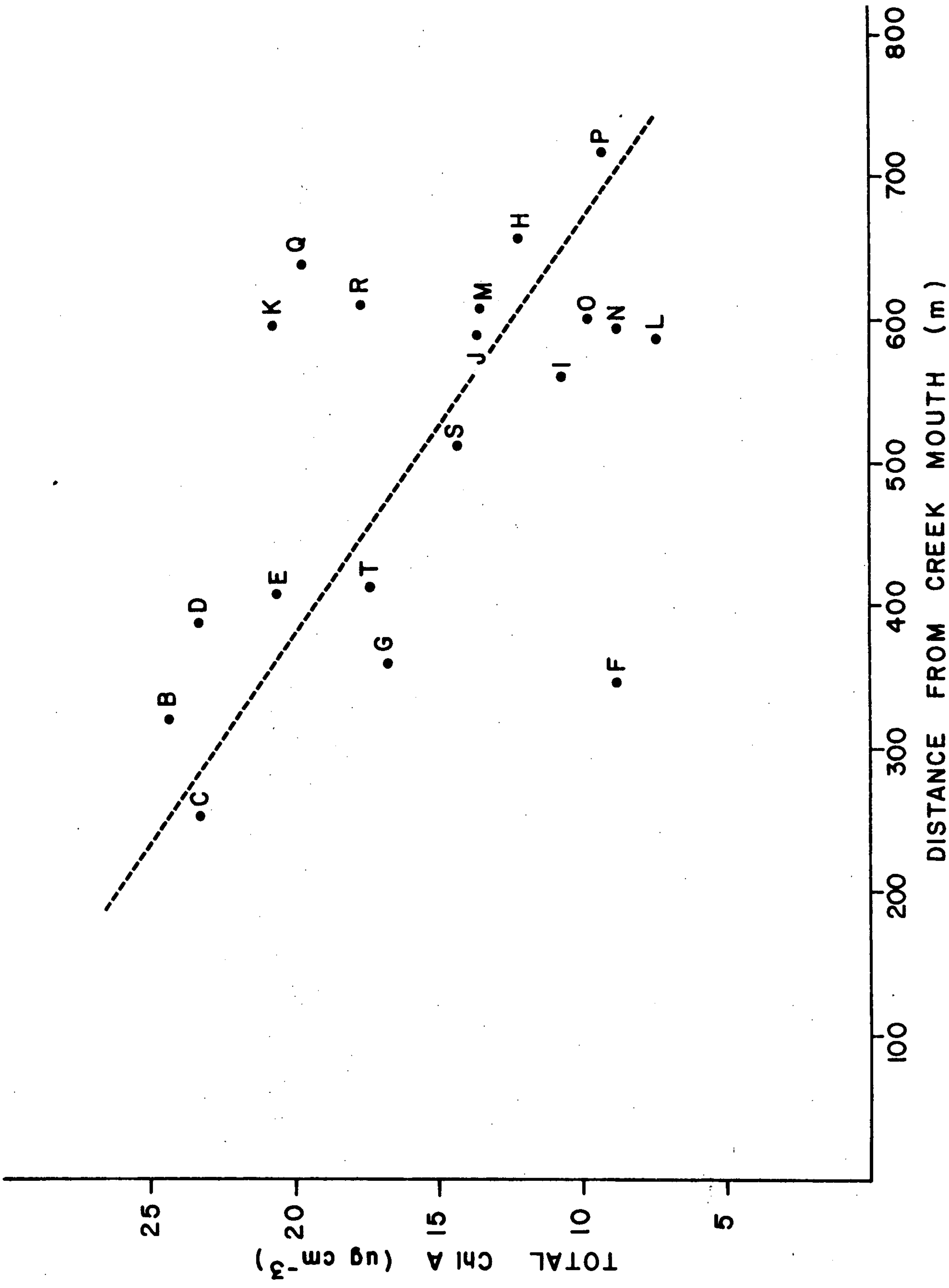



Figure 3. Relationship between total chlorophyll a ($\mu g\ cm^{-3}$) in the surface of sediments at intertidal stations and distance (m) from the mouth of McCartney Creek. Lines fitted by eye.

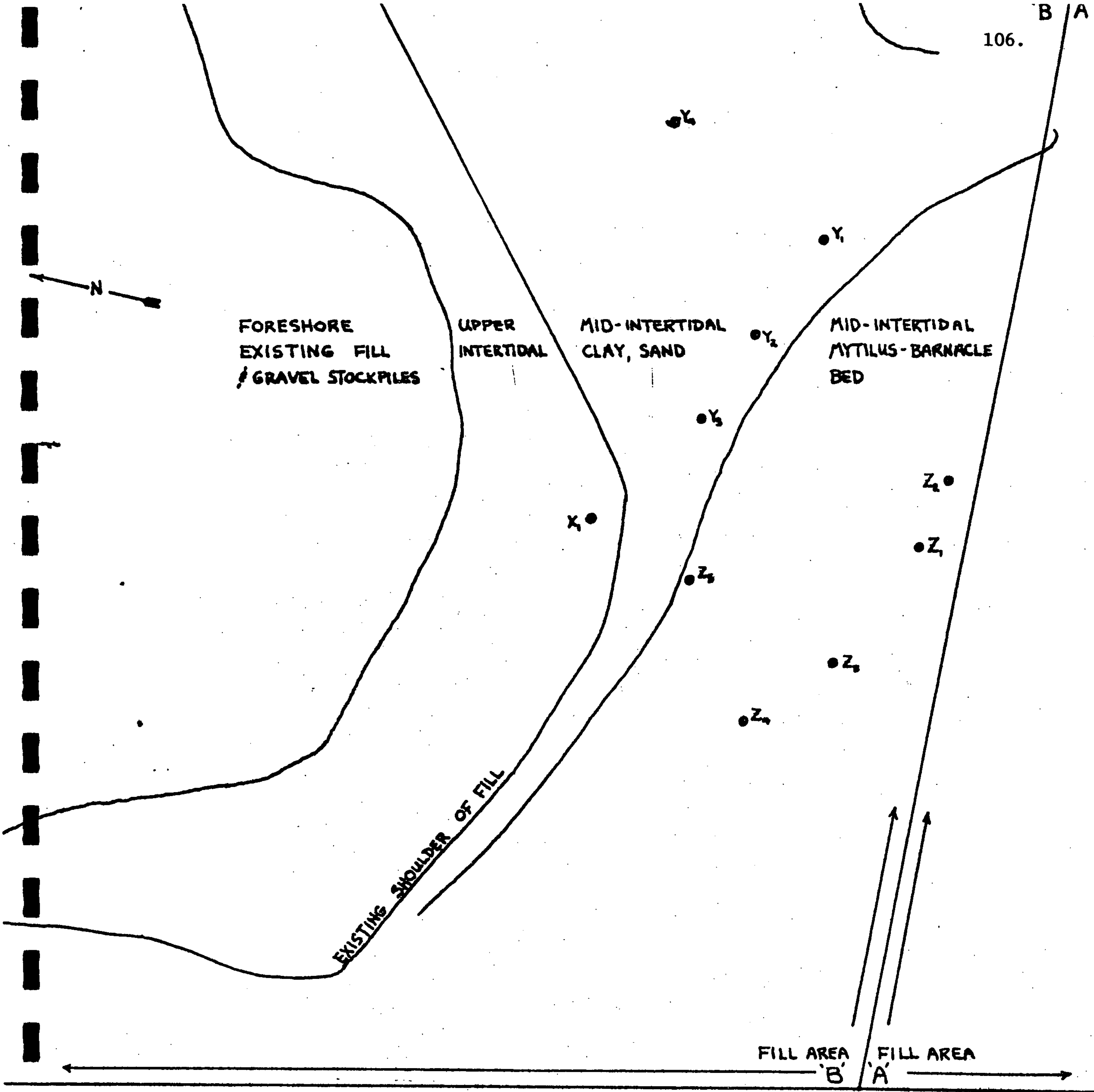



Figure 4. Locations of Fisheries and Marine Service invertebrate sampling stations (black dots), November 1974. Adapted from Columbia Bitulithic drawing #1434-16.

Table 5. Numbers and kinds of invertebrates identified by Fisheries and Marine Service at the proposed Columbia Bitulithic fill area, November, 1974.

| SAMPLE SITE | X1 | Y1 | Y2 | Y3 | Y4 | Z1 | Z2 | Z3 | Z4 | Z5 | Total no. of Organisms Present |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Organisms present: | | | | | | | | | | | |
| Amphipods | 00 | 3038 | 1328 | 3163 | 2661 | 637 | 89 | 1690 | 35 | 180 | 12,821 |
| Isopods | 00 | 23 | 16 | 8 | 4 | 77 | 21 | 381 | 1 | 16 | 547 |
| Copepods | 00 | 44679 | 32283 | 34213 | 10509 | 132 | 7172 | 9590 | 1457 | 1893 | 141,928 |
| Cumaceans | 00 | 8785 | 2771 | 6955 | 2090 | 37 | 288 | 74 | 4 | 247 | 21,251 |
| Polychaetes | 1 | 3501 | 1499 | 1462 | 234 | 357 | 639 | 46 | 60 | 673 | 8,472 |
| Nemerteans | 1 | 69 | 23 | 15 | 3 | ND | 64 | 146 | 2750 | 95 | 3,166 |
| Oligochaetes | 00 | 581 | 985 | 781 | 90 | ND | 2056 | 8803 | 886 | 3055 | 17,237 |
| Mytilus | 00 | 1 | 7 | 00 | 00 | 25 | 10 | 94 | 4 | 22 | 163 |
| Barnacle | 00 | 7 | 23 | 4 | 00 | 566 | 150 | 547 | 575 | 493 | 2,365 |
| Bivalve | 1 | 300 | 200 | 437 | 100 | 178 | 81 | 216 | 118 | 100 | 1,731 |
| Univalve | 00 | 27 | 1 | 18 | 20 | 150 | 76 | 152 | 59 | 80 | 593 |
| Chironomid | 00 | 00 | 8 | 00 | 00 | 432 | 35 | 547 | 200 | 00 | 1,222 |
| Hemigrapsus | 00 | 00 | 1 | 00 | 00 | 4 | 1 | 47 | 00 | 15 | 68 |
| Dipteran Larvae | 00 | 00 | 00 | 00 | 00 | 10 | 00 | 00 | 00 | 00 | 10 |
| Hermit Crabs | 00 | 00 | 1 | 00 | 00 | 1 | 00 | 4 | 00 | 00 | 6 |
| Total no. of Organisms/ $0.06m^2$ by site | 3 | 61011 | 39156 | 47056 | 15711 | 2606 | 10682 | 22337 | 6149 | 6869 | 211,580 |

ND = No data available

# APPENDIX 2

## BIRDS OF THE SEYMOUR-MAPLEWOOD AREA

a) Vaudry, A., and J. Land. 1973. A Migratory Bird Survey of the Maplewood Mud Flats and Maplewood Area — October, 1972 - May, 1973. Prepared for the Canadian Wildlife Service, unpublished.

b) Canadian Wildlife Service Previously unpublished data.

c) Canadian Wildlife Service and Fisheries and Marine Service, 1975. A report on the environmental impact of proposed industrial developments adjacent to the Seymour River estuary, Burrard Inlet. Environment Canada, Vancouver.

Contents: (in order)

From Vaudry & Land
Investigational Techniques
Figures 1-10 and Tables 1-5

From C.W.S.
Figure 11 and Table 6

From C.W.S. and F.M.S.
Tables 7 and 8

## INVESTIGATIONAL TECHNIQUES

We surveyed the numbers of birds present on the study area once a week, in a variety of weather and tidal conditions, from October, 1972 to mid-May, 1973. To facilitate the survey, the study area was divided into arbitrary sub-areas. Each sub-area was surveyed from one or more designated vantage points, which we believed gave the best possible view, before the next sub-area was surveyed (Fig. 1).

Although 7 x 50 mm binoculars and a spotting telescope (20X - 45X, zoom) aided in bird identification, some difficulties still occurred due to: extremely long distances, heat waves, the low winter sun reflecting off the water, rain, mist, white-caps, or a combination of these. When species could not be identified (for reasons stated above), only the general bird group to which the unidentified bird(s) belonged was used (e.g. dabblers).

Individual birds were counted whenever possible. We each estimated numbers of birds in large flocks and then recorded the average of the two estimates.

The total numbers of birds reported seen each day probably represented minimal estimates of the birds actually on the study area due to restricted vision, and the constant movement of birds into, out of and within the study area, and diving of birds.

To minimize error due to the aforementioned factors, the survey was conducted as quickly as possible. Also, since surveys were made only once a week it was not possible to document the exact usage of the study area by all species. Groups of birds using the area for only a short time (i.e. a few days or less) could easily have been overlooked. Consequently, only general trends are likely to be expressed in the results. With any survey of this type a certain degree of error is inevitable and the recorded figures must be considered with this in mind.

All birds and mammals seen on the study area were recorded in field notebooks and the data transferred at a later date to form sheets of daily counts and monthly summaries. The data obtained each month were summarized and discussed in monthly reports that were prepared from October, 1972 to March, 1973. These reports contain a more complete description of study methods as well as more detailed records of birds seen each day, and are on file in the Vancouver office of the Canadian Wildlife Service. Field data collected during April and May, 1973 were not summarized into monthly reports, as such, but were tabulated and incorporated directly into this final report.

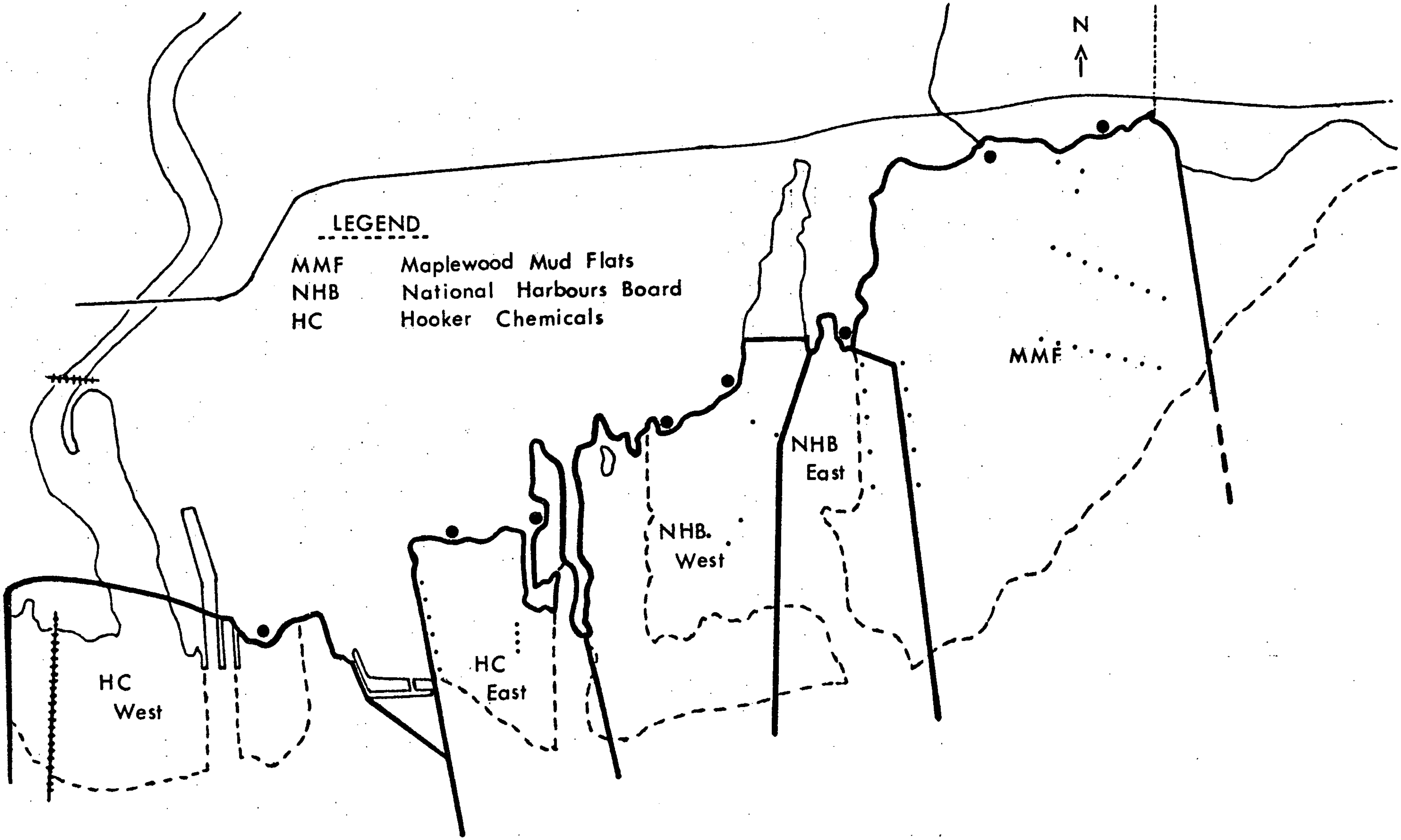



Figure 1. Map of the Seymour-Maplewood study area showing the various sub-areas into which the study area was arbitrarily divided. Vantage points, from which observations were made, are indicated by large solid black dots.

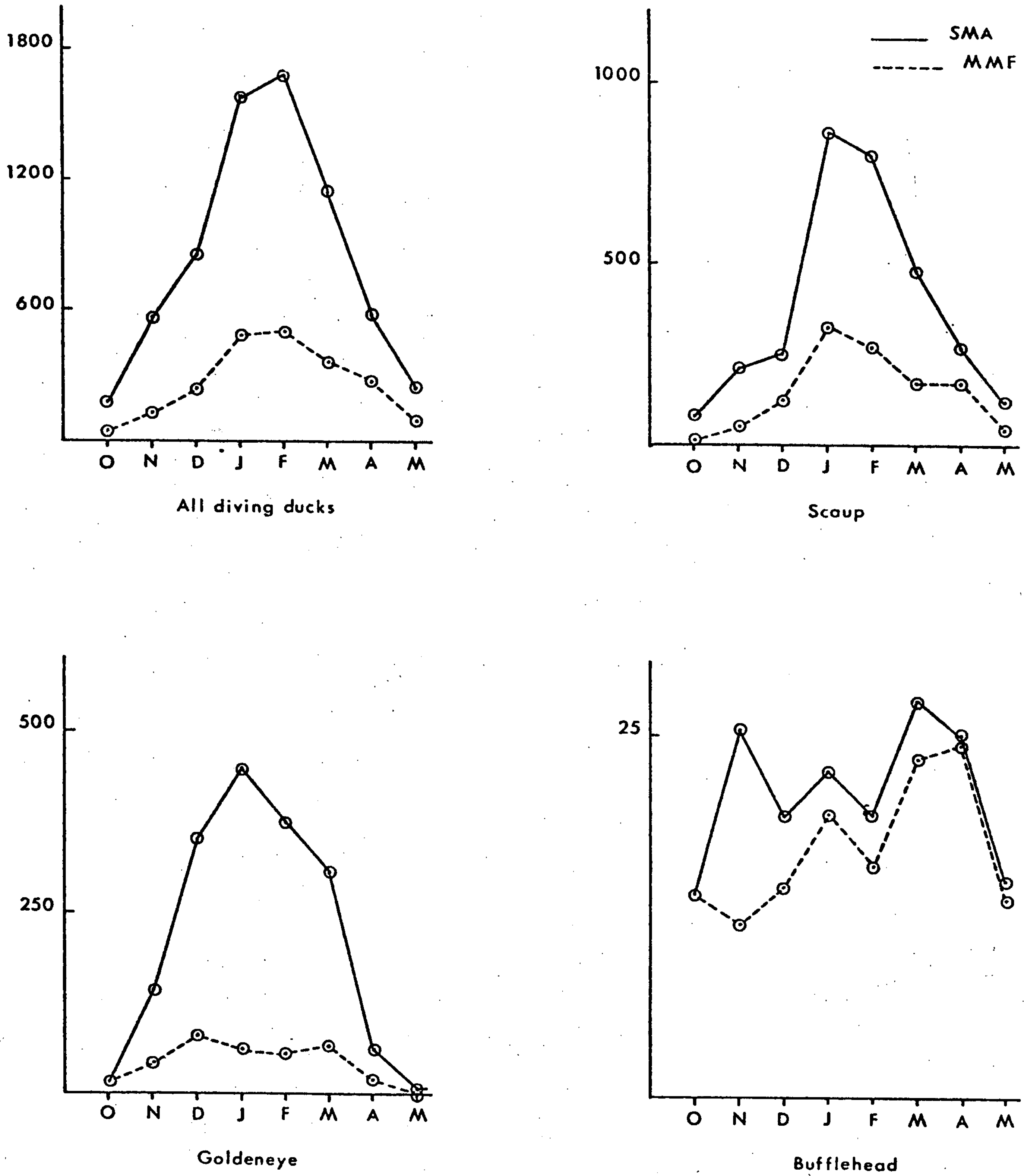



Figure 2. Monthly mean numbers of diving ducks seen per visit on the Seymour-Maplewood area (SMA) and Maplewood Mud Flats (MMF), October 1972 to May 1973.

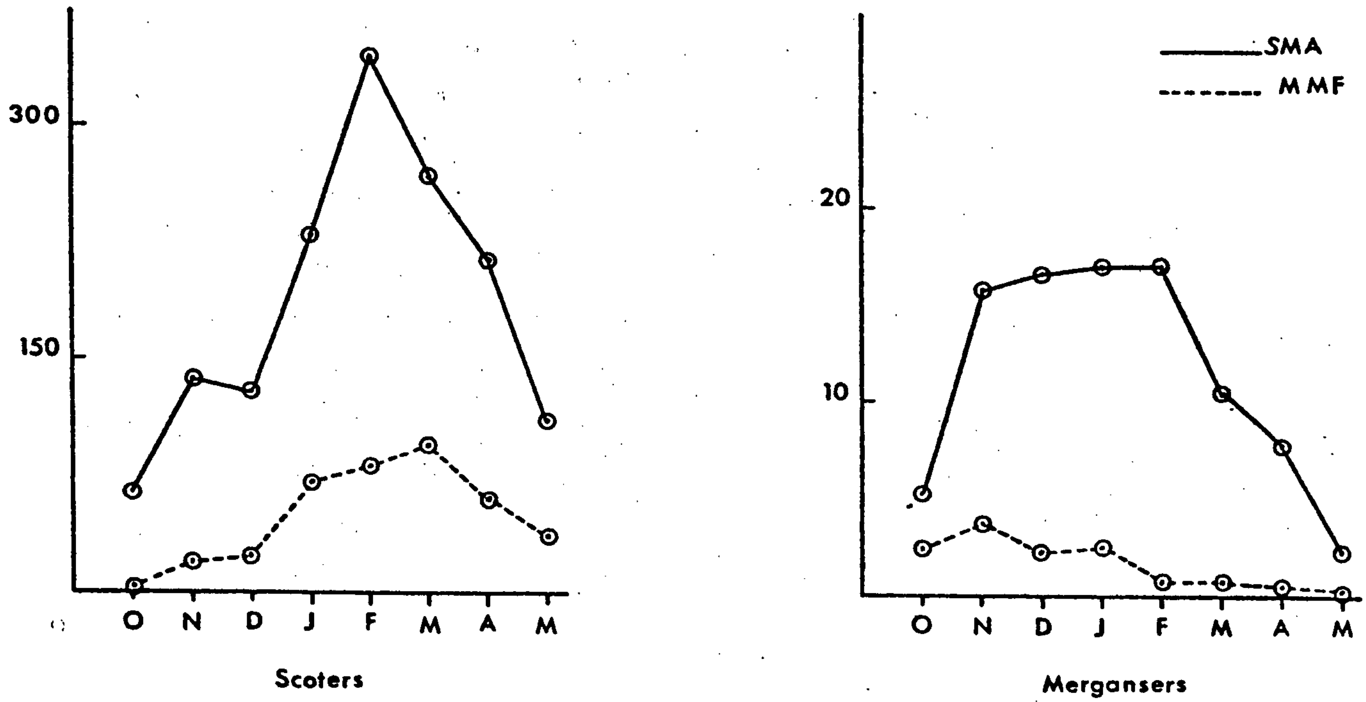



Figure 2. cont'd.

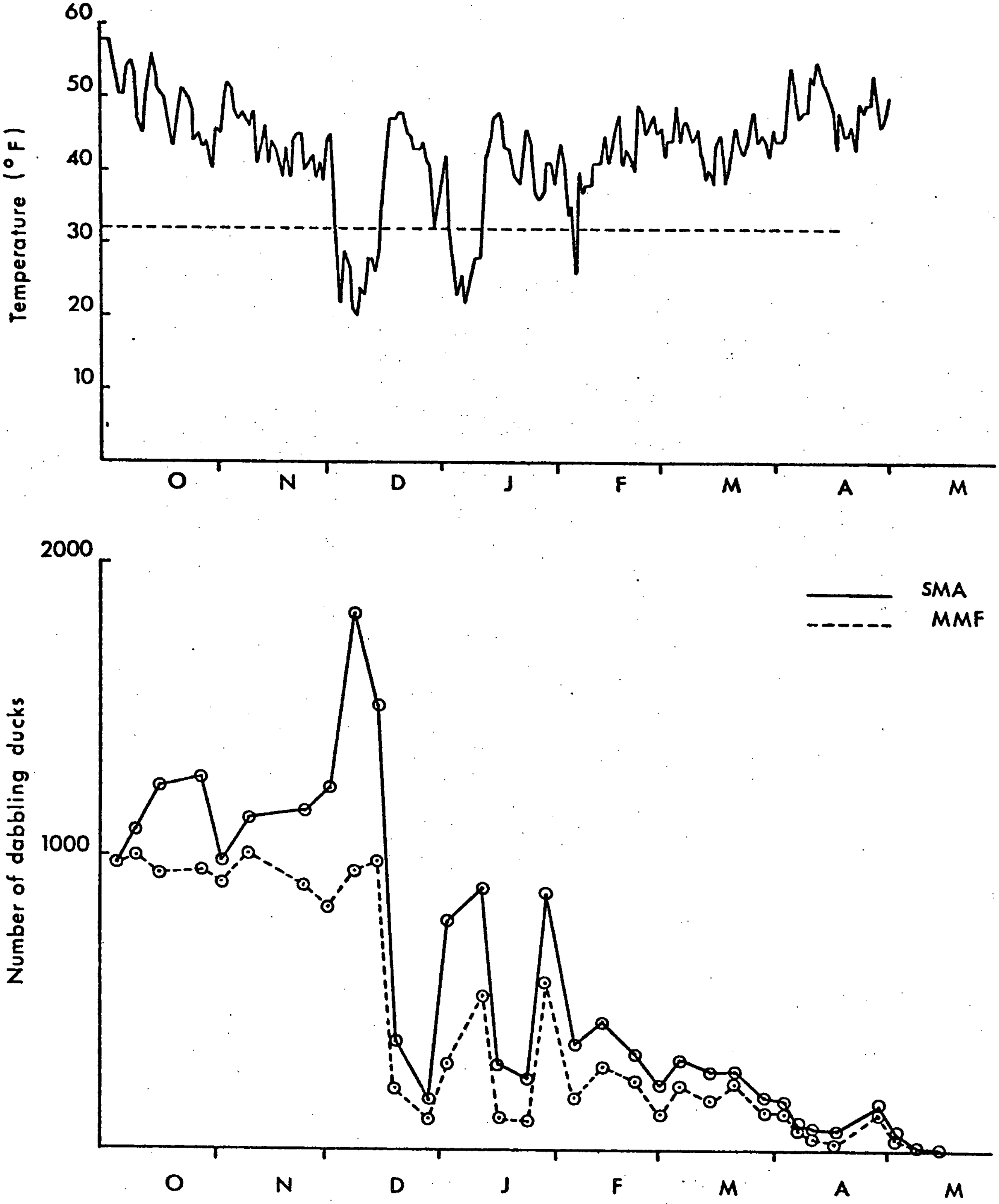



Figure 3. Mean daily temperature (F°) at North Vancouver, and numbers of dabbling ducks observed per visit on the Seymour-Maplewood area, October 1972 to May 1973.

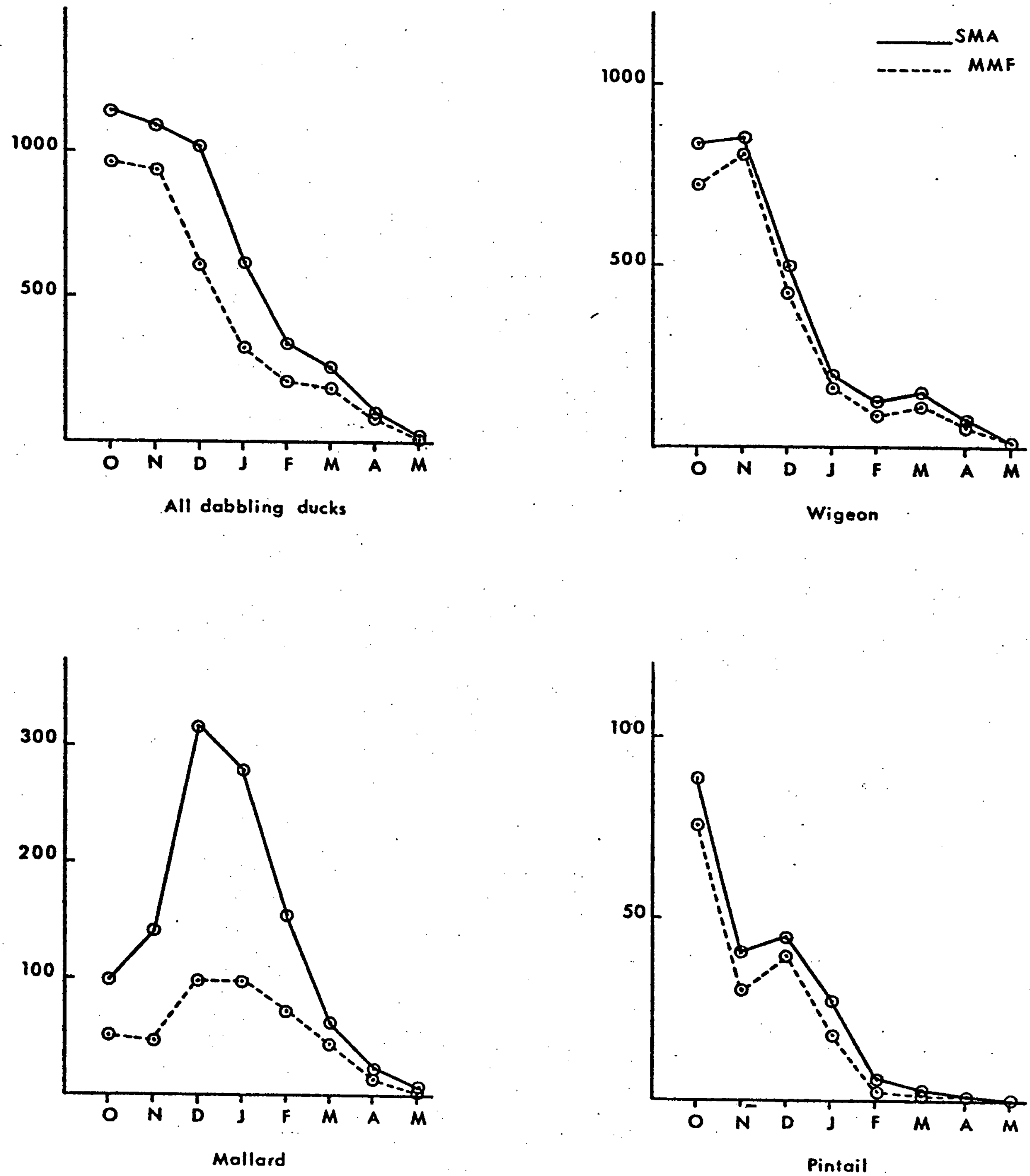



Figure 4. Monthly mean numbers of dabbling ducks seen per visit on the Seymour-Maplewood area (SMA) and Maplewood Mud Flats (MMF), October 1972 to May 1973.

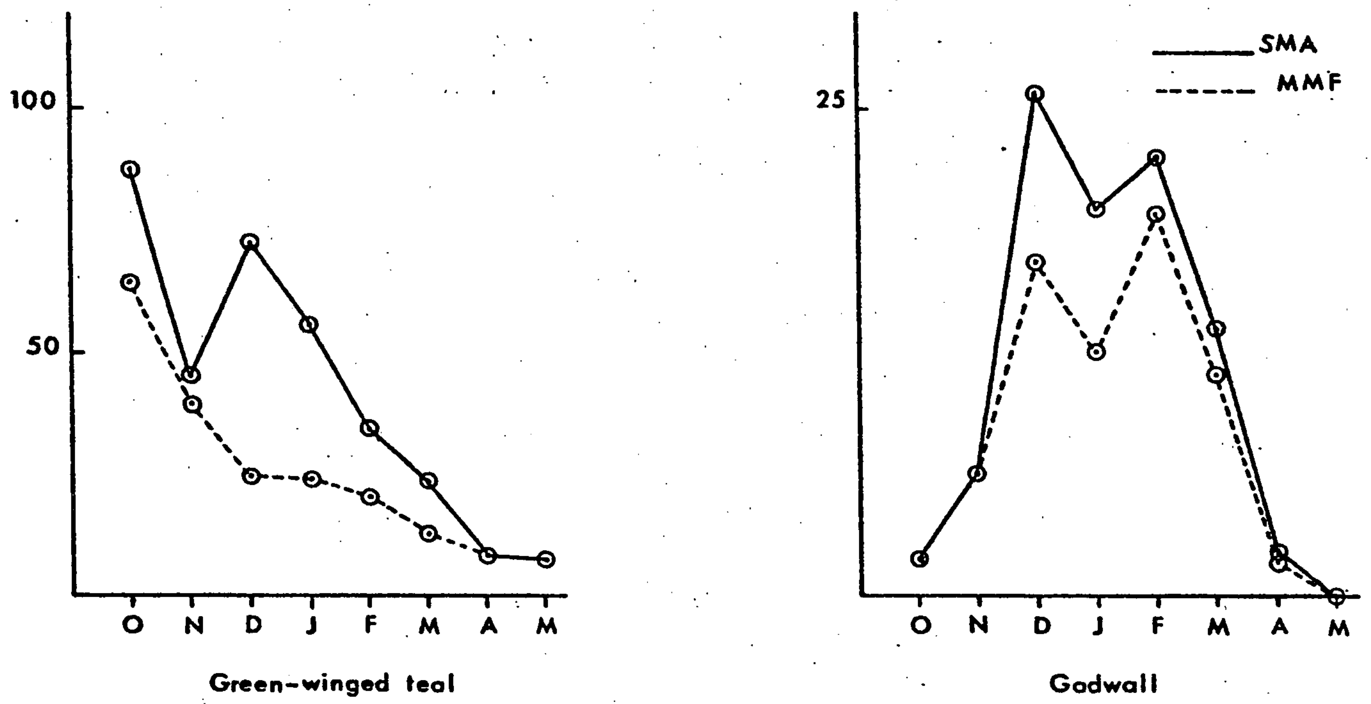



Figure 4. cont'd.

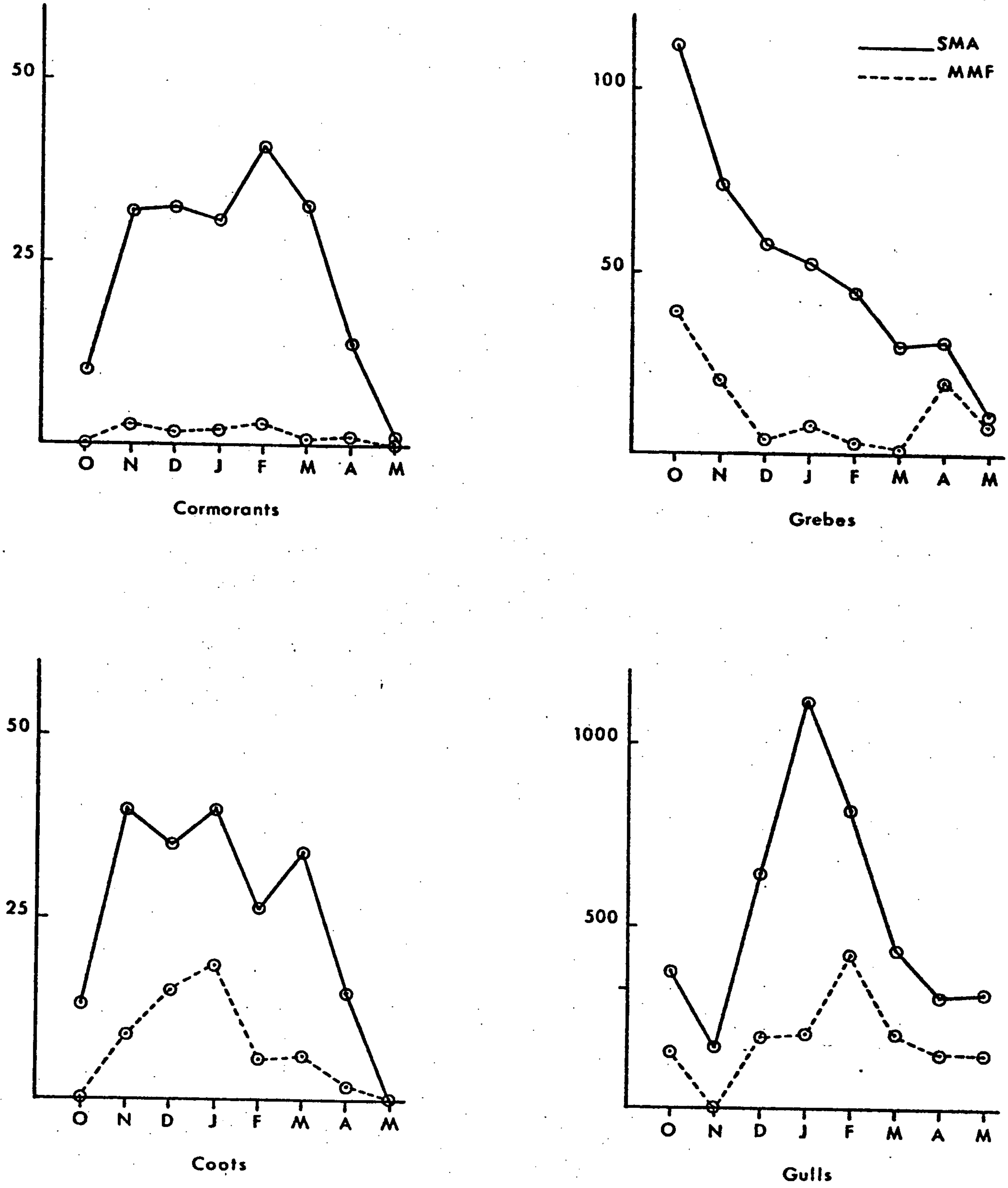



Figure 5. Mean monthly numbers of cormorants, grebes, coots, and gulls seen per visit on the Seymour-Maplewood area (SMA) and Maplewood Mud Flats (MMF), October 1972 to May 1973.

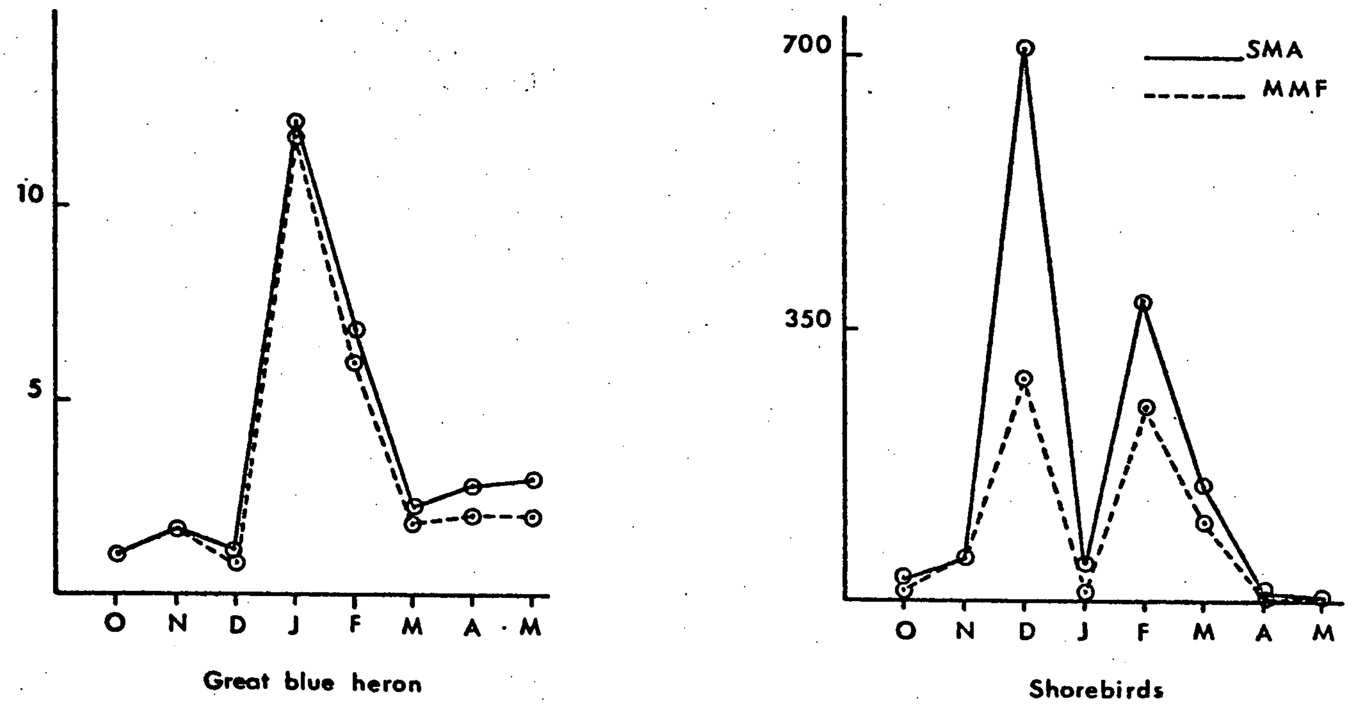



Figure 6. Monthly mean numbers of heron and shorebirds seen per visit on the Seymour-Maplewood area (SMA) and Maplewood Mud Flats (MMF), October 1972 to May 1973.

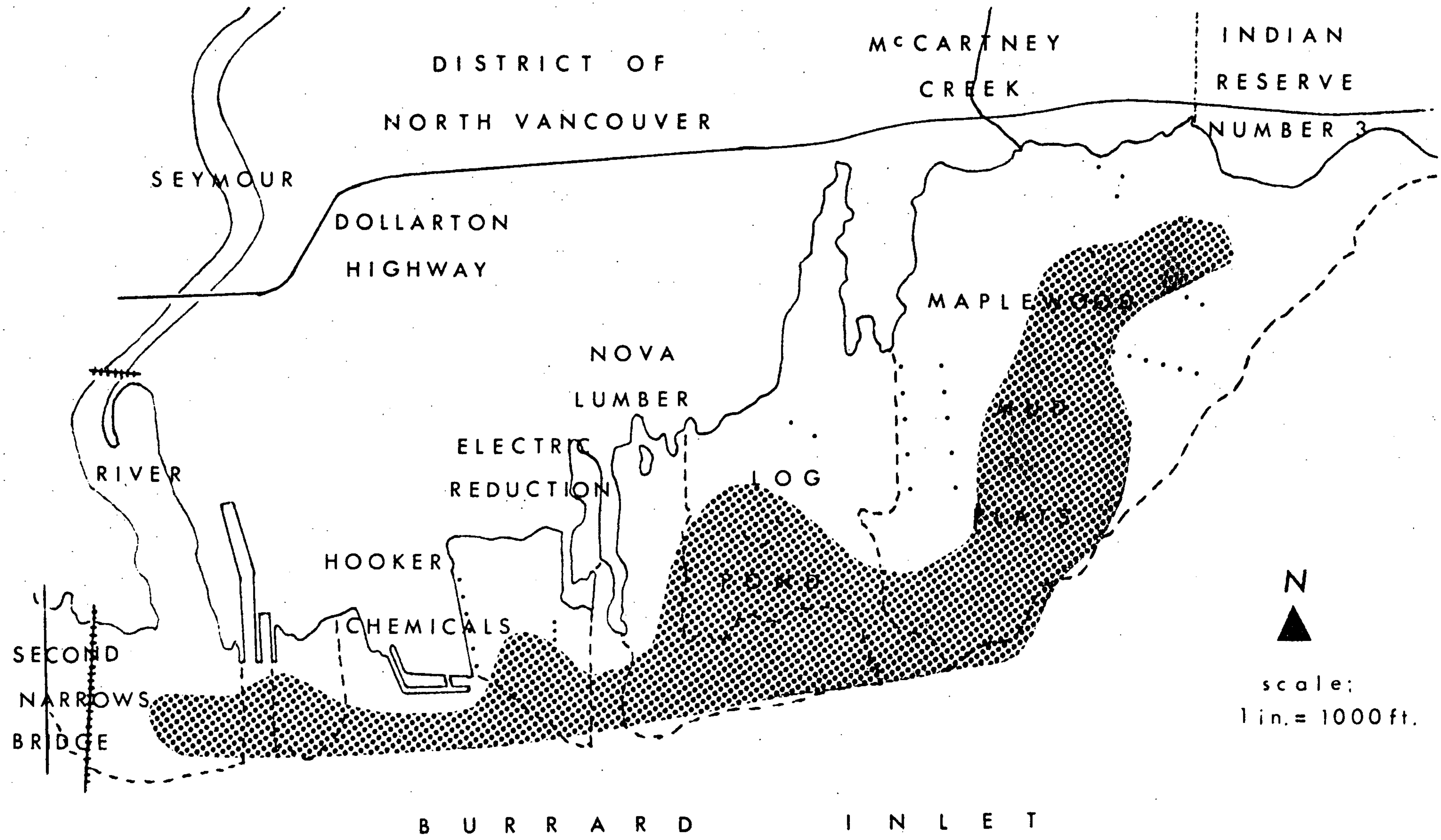



Figure 7. Location of observed concentrations of diving ducks at approximately a 14 foot tide (tidal flats inundated).

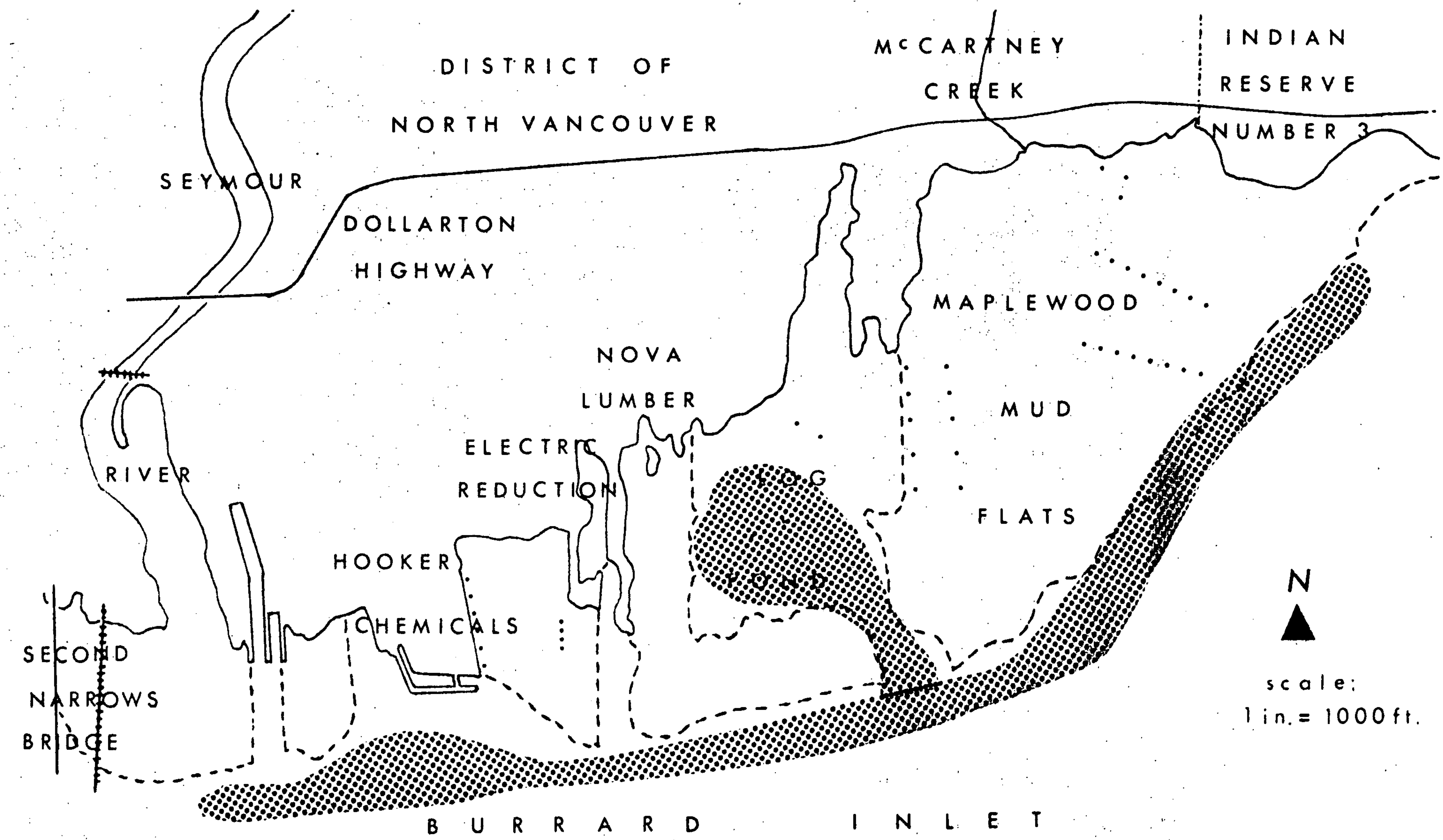



Figure 8. Location of observed concentrations of diving ducks at approximately a 2 foot tide (tidal flats exposed).

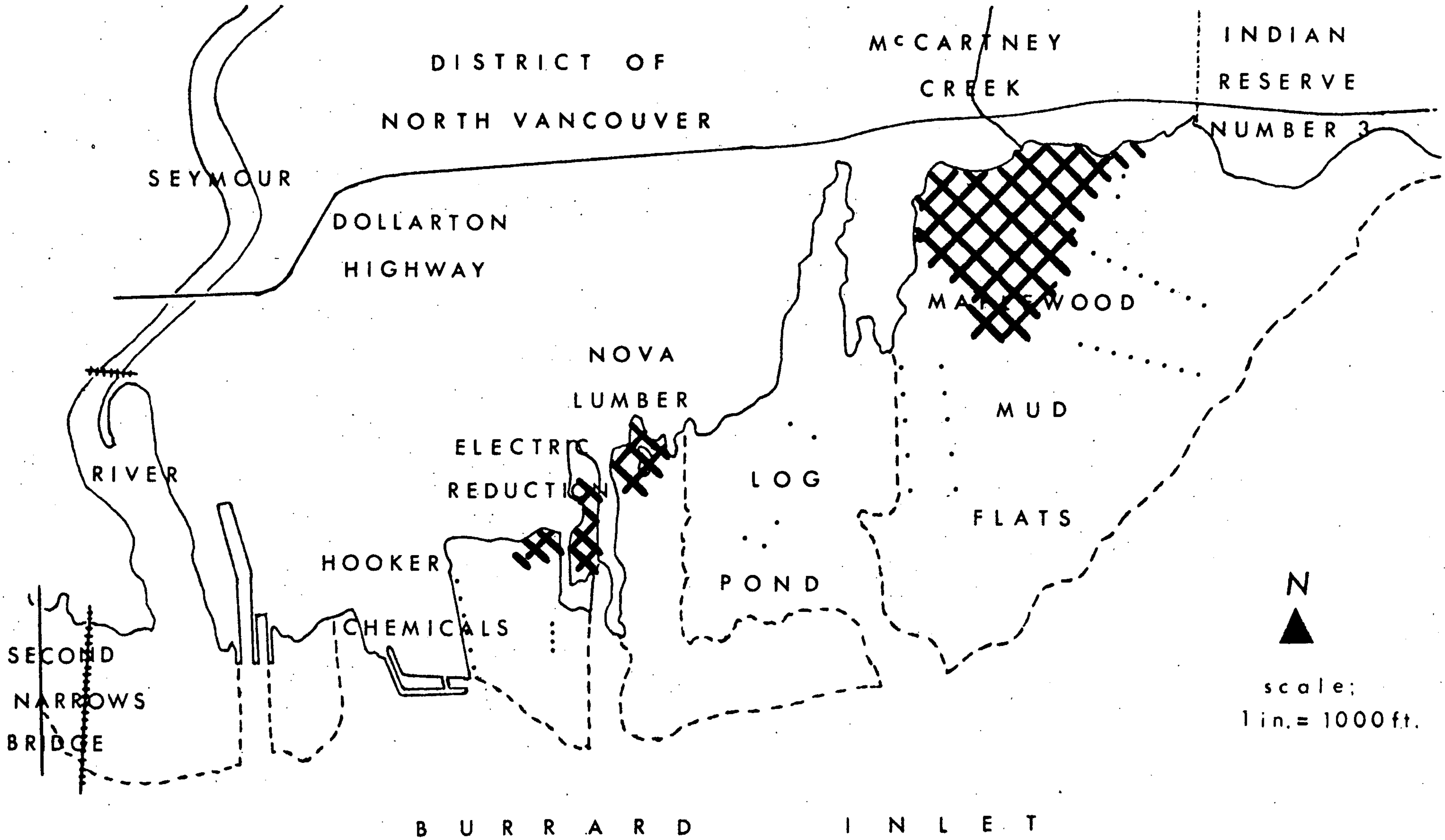



Figure 9. Locations of observed concentrations of dabblers at approximately a 14 foot tide (tidal flats inundated).

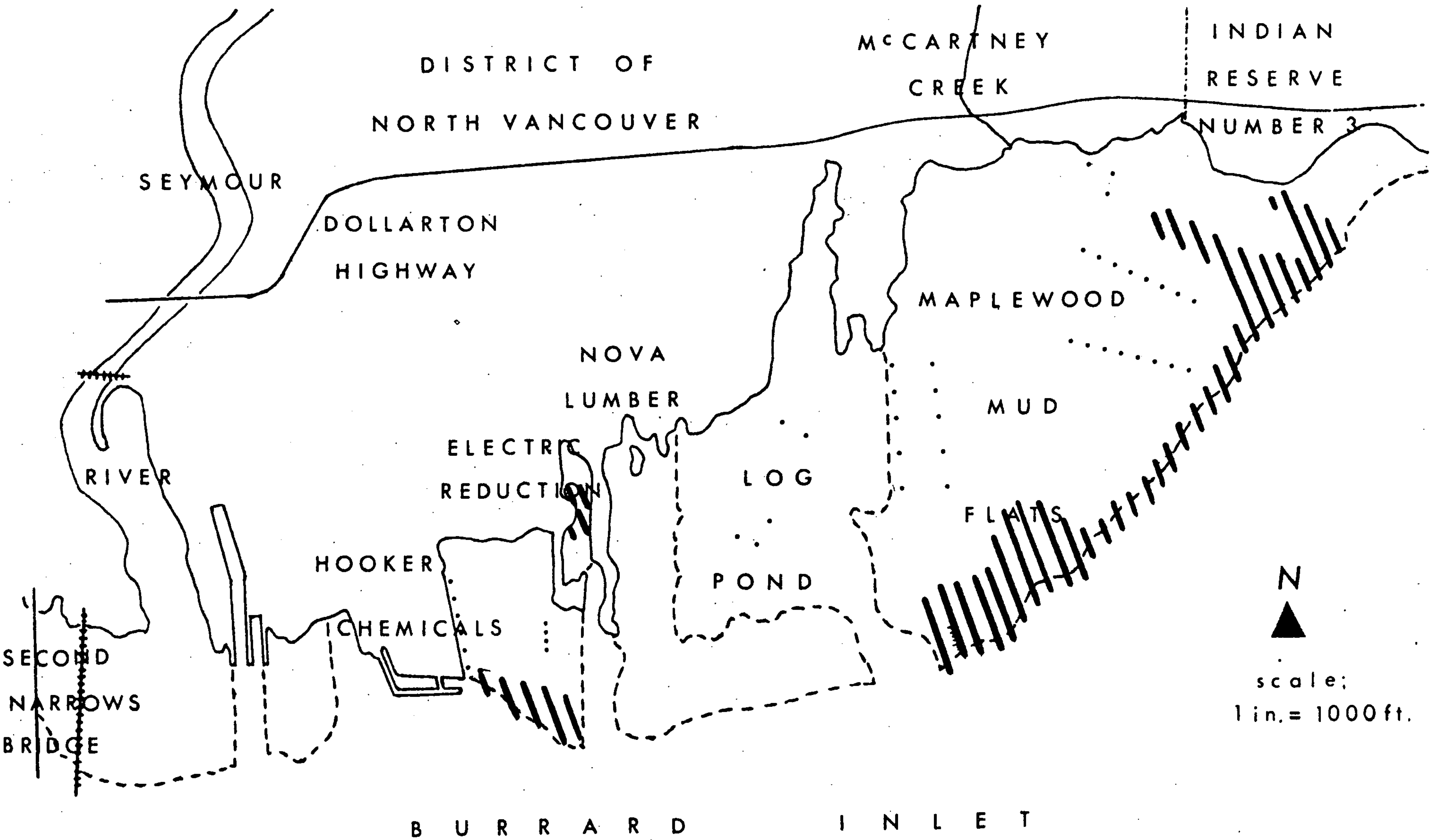



Figure 10. Locations of observed concentrations of dabblers at approximately a 2 foot tide (tidal flats exposed).

Table 1. Monthly and annual mean temperatures, in degrees Fahrenheit, for the 4-year period, 1968-1971, compared with the mean monthly temperatures for selected months of 1972 and 1973, at North Vancouver Cloverly.

| Year | J | F | M | A | M | J | J | A | S | O | N | D | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1968-71 | 34.3 | 40.6 | 42.6 | 47.0 | 55.0 | 61.0 | 64.0 | 63.0 | 57.3 | 49.8 | 44.0 | 37.0 | 49.7 |
| 1972-73 | 36.9 | 42.0 | 43.5 | 48.5 | | | | | | 48.5 | 43.9 | 35.7 | |
| * | + 2.6 | + 1.4 | + 0.9 | + 1.5 | | | | | | - 1.3 | - 0.1 | - 1.3 | |

* deviation, from 4 year average, during study

adapted from British Columbia Department of Agriculture. Reports, 1968-1971.

Table 2. Mean Monthly total precipitation*, mean annual total precipitation* and mean total winter snowfall for the 10-year period from 1962-1971, compared with the monthly mean precipitation* for selected months of 1972 and 1973, at North Vancouver Cloverly (Inches).

| Year | J | F | M | A | M | J | J | A | S | O | N | D | Annual | Winter Snow |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962-71 | 10.68 | 6.69 | 6.11 | 4.71 | 2.51 | 1.92 | 2.31 | 2.33 | 4.72 | 9.37 | 9.30 | 11.99 | 71.99 | 24.97 |
| 1972-73 | 11.92 | 4.34 | 5.04 | 1.03 | | | | | | 2.71 | 9.17 | 17.99 | | |
| ** | +1.24 | -2.35 | -1.07 | -3.68 | | | | | | -6.66 | -0.13 | +6.00 | | |

Altitude of Station - 12 feet above sea level.

*total precipitation is the sum of the rainfall plus the water equivalent of the snowfall, which is snowfall divided by 10.

**deviation, from 10 year average, during study.

adapted from British Columbia Department of Agriculture. Reports, 1962-1971.

Table 3. Mean numbers of birds and mammals observed per day on the entire Maplewood study area and on the Maplewood Mud Flats only, October, 1972 through May, 1973. Numbers in parentheses indicate the maximum number of each species observed on one day during each month.

| Species* | Area | October 4** | November 5** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| Common Loon (*Gavia immer*) | Total† | | | x (1) | | | | x (1) | |
| | Mud Flats †† | | | | | | | x (1) | |
| Red-throated Loon (*Gavia stellata*) | Total | | | | | | | x (1) | |
| | Mud Flats | | | | | | | | |
| Unidentified Loon (Gaviidae) | Total | | 1 (3) | x (4) | 2 (7) | 4 (6) | x (1) | x (2) | |
| | Mud Flats | | | | x (2) | | x (1) | x (2) | |

* Bird nomenclature based on Godfrey (1966) except where recent taxonomic revisions (American Ornithologists' Union, 1973) take precedence. Mammal names from Cowan and Guiguet (1956).

** Number of days of observation each month.

† Entire Maplewood study area (including Maplewood Mud Flats).

†† Maplewood Mud Flats only.

x The mean number of birds observed in a particular month was less than one.

Table 3 cont.

| Species | Area | October 4** | November 3** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| Red-Necked Grebe (*Podiceps grisegena*) | Total | 3 (7) | | 2 (7) | 1 (2) | 1 (2) | 2 (3) | 2 (5) | 1 (2) |
| | Mud Flats | | | x (1) | | | | x (1) | |
| Horned Grebe (*Podiceps auritus*) | Total | 11 (14) | 17 (22) | 19 (31) | 19 (23) | 20 (34) | 20 (23) | 2 (4) | 1 (3) |
| | Mud Flats | x (1) | 1 (2) | 2 (5) | x (4) | 2 (4) | x (1) | | x (2) |
| Western Grebe (*Aechmophorus occidentalis*) | Total | 13 (46) | 57 (89) | 33 (47) | 27 (52) | 22 (33) | 7 (13) | 24 (55) | 9 (12) |
| | Mud Flats | 8 (30) | 18 (40) | 2 (7) | 5 (24) | 2 (4) | x (2) | 20 (50) | 8 (11) |
| Pied-Billed Grebe (*Podilymbus podiceps*) | Total | x (1) | | x (1) | 1 (2) | x (1) | | | |
| | Mud Flats | | | | | x (1) | | | |
| Unidentified Grebe (Podicipedidae) | Total | 12 (29) | | 3 (10) | 5 (14) | 3 (6) | 2 (3) | 4 (9) | |
| | Mud Flats | 7 (15) | | x (1) | 2 (6) | | | x (2) | |

Table 3 cont.

| Species | Area | October 4** | November 3** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| Double-Crested Cormorant (*Phalacrocorax auritus*) | Total | x (1) | | | | | | | |
| | Mud Flats | | | | | | | | |
| Pelagic Cormorant (*Phalacrocorax pelagicus*) | Total | | | | | | x (2) | x (2) | |
| | Mud Flats | | | | | | | | |
| Unidentified Cormorant (Phalacrocoracidae) | Total | 16 (22) | 32 (55) | 33 (52) | 31 (38) | 41 (59) | 32 (36) | 14 (25) | 1 (3) |
| | Mud Flats | | 3 (3) | 2 (5) | 2 (4) | 3 (8) | x (1) | 1 (3) | |
| Great Blue Heron (*Ardea herodias*) | Total | 1 (3) | 2 (4) | 1 (6) | 12 (18) | 7 (13) | 2 (7) | 3 (5) | 3 (4) |
| | Mud Flats | 1 (3) | 2 (4) | x (4) | 12 (18) | 6 (12) | 2 (5) | 2 (4) | 2 (4) |
| Canada Goose (*Branta canadensis*) | Total | | | | | | | 1 (5) | x (2) |
| | Mud Flats | | | | | | | x (1) | |
| Snow Goose (*Chen caerulescens*) | Total | x (1) | | | | | | | |
| | Mud Flats | | | | | | | | |

Table 3 cont.

| Species | Area | October 4** | November 3** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| Mallard (*Anas platyrhynchos*) | Total | 119 (126) | 140 (249) | 315 (519) | 278 (456) | 155 (228) | 62 (73) | 23 (76) | 5 (8) |
| | Mud Flats | 51 (90) | 48 (85) | 97 (150) | 97 (225) | 73 (122) | 43 (55) | 14 (51) | 2 (3) |
| Gadwall (*Anas strepera*) | Total | 2 (7) | 6 (19) | 26 (52) | 20 (27) | 23 (34) | 14 (23) | 2 (8) | |
| | Mud Flats | x (1) | 6 (17) | 17 (50) | 13 (27) | 20 (34) | 11 (21) | 2 (7) | |
| Pintail (*Anas acuta*) | Total | 95 (100) | 41 (43) | 45 (103) | 27 (60) | 6 (18) | 3 (5) | 1 (6) | |
| | Mud Flats | 75 (100) | 30 (40) | 40 (100) | 18 (60) | 3 (5) | 2 (2) | 1 (6) | |
| Green-winged Teal (Anas crecca) | Total | 106 (182) | 46 (60) | 74 (156) | 56 (112) | 34 (42) | 24 (54) | 8 (25) | 7 (21) |
| | Mud Flats | 65 (100) | 39 (40) | 25 (40) | 25 (58) | 21 (32) | 13 (25) | 8 (25) | 7 (21) |
| European Wigeon (Anas penelope) | Total | | | x (1) | 2 (6) | | | | |
| | Mud Flats | | | x (1) | 1 (6) | | | | |

Table 3 cont.

| Species | Area | October 4** | November 3** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| American Wigeon (*Anas americana*) | Total | 894 (950) | 849 (934) | 497 (969) | 195 (385) | 123 (147) | 147 (180) | 76 (118) | 12 (31) |
| | Mud Flats | 756 (850) | 813 (900) | 426 (800) | 163 (358) | 94 (120) | 118 (157) | 57 (95) | 11 (29) |
| Northern Shoveler (*Anas clypeata*) | Total | x (1) | x (1) | x (1) | | | | x (4) | 1 (2) |
| | Mud Flats | x (1) | | x (1) | | | | x (2) | 1 (2) |
| Unidentified Dabblers (Anatinae) | Total | 29 (80) | 10 (23) | 64 (266) | 41 (175) | x (2) | 10 (38) | x (2) | |
| | Mud Flats | 20 (80) | | 10 (26) | 3 (16) | | 5 (15) | x (2) | |
| Greater Scaup (*Aythya marila*) | Total | | | | 104 (404) | | | | |
| | Mud Flats | | | | | | | | |
| Unidentified Scaup (*Aythya spp.*) | Total | 106 (272) | 207 (366) | 251 (379) | 757 (973) | 789 (899) | 477 (621) | 264 (421) | 118 (217) |
| | Mud Flats | 11 (42) | 47 (113) | 123 (254) | 324 (511) | 274 (451) | 174 (212) | 167 (243) | 41 (92) |

Table 3 cont.

| Species | Area | October 4** | November 3** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| Common Goldeneye (<u>Bucephala clangula</u>) | Total | x (1) | | 47 (224) | 201 (479) | 121 (232) | 81 (119) | 8 (18) | x (1) |
| | Mud Flats | | | | 12 (56) | 10 (41) | 12 (24) | 2 (9) | |
| Barrow's Goldeneye (<u>Bucephala islandica</u>) | Total | 11 (42) | 10 (29) | 1 (4) | 25 (50) | 28 (30) | 26 (52) | 25 (81) | |
| | Mud Flats | 11 (42) | 10 (29) | | 6 (12) | 3 (7) | x (2) | 2 (5) | |
| Unidentified Goldeneye (<u>Bucephala spp.</u>) | Total | 5 (17) | 132 (197) | 303 (404) | 218 (430) | 225 (291) | 198 (305) | 27 (39) | 6 (10) |
| | Mud Flats | 4 (15) | 32 (60) | 78 (133) | 41 (206) | 43 (53) | 54 (79) | 14 (25) | 3 (6) |
| Bufflehead (<u>Bucephala albeola</u>) | Total | 14 (47) | 25 (29) | 19 (97) | 23 (38) | 20 (27) | 27 (28) | 25 (45) | 15 (19) |
| | Mud Flats | 14 (47) | 12 (20) | 15 (19) | 20 (34) | 16 (23) | 23 (34) | 24 (44) | 14 (19) |
| Oldsquaw (<u>Clangula hyemalis</u>) | Total | | x (1) | | | | | | |
| | Mud Flats | | | | | | | | |

Table 3 cont.

| Species | Area | October 4** | November 3** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| Harlequin Duck (*Histrionicus histrionicus*) | Total | 1 (2) | 3 (4) | 4 (7) | 2 (6) | 2 (6) | 2 (4) | 3 (7) | 1 (2) |
| | Mud Flats | | 2 (3) | 2 (5) | x (2) | | | | |
| White-Winged Scoter (*Melanitta deglandi*) | Total | 13 (25) | 4 (11) | 2 (10) | 16 (46) | 21 (69) | 20 (47) | 15 (26) | 17 (32) |
| | Mud Flat | | | 2 (10) | 4 (19) | 13 (44) | 5 (10) | 5 (13) | |
| Surf Scoter (*Melanitta perspicillata*) | Total | | x (1) | x (4) | 10 (26) | 130 (223) | 137 (191) | 116 (254) | 10 (31) |
| | Mud Flats | | | | 2 (5) | 17 (28) | 50 (92) | 35 (65) | 3 (9) |
| Black Scoter (*Melanitta nigra*) | Total | | | | x (2) | x (2) | | 1 (3) | |
| | Mud Flats | | | | x (2) | x (2) | | 1 (3) | |
| Unidentified Scoter (Aythyinae) | Total | 103 (215) | 133 (170) | 127 (239) | 202 (235) | 182 (237) | 113 (136) | 82 (202) | 81 (151) |
| | Mud Flats | 3 (5) | 18 (35) | 20 (34) | 61 (94) | 50 (90) | 38 (40) | 19 (51) | 33 (52) |

Table 3 cont.

| Species | Area | October 4** | November 3** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| Ruddy Duck (*Oxyura jamaicensis*) | Total | | | x (2) | x (4) | 2 (2) | | | |
| | Mud Flats | | | | x (1) | | | x (1) | |
| Unidentified Diving Ducks (Aythyinae) | Total | | 30 (90) | 87 (402) | 6 (25) | 68 (273) | 54 (191) | 3 (15) | |
| | Mud Flats | | | 3 (12) | 5 (25) | | 9 (16) | | |
| Hooded Merganser (*Lophodytes cucullatus*) | Total | | 2 (6) | 3 (8) | 4 (12) | | | | |
| | Mud Flats | | 2 (6) | 1 (2) | 2 (4) | | | | |
| Common Merganser (*Mergus merganser*) | Total | 1 (2) | 8 (14) | | | 2 (6) | | x (2) | x (2) |
| | Mud Flats | | 2 (4) | | | | | | |
| Red-Breasted Merganser (*Mergus serrator*) | Total | | 2 (5) | x (3) | 11 (15) | 15 (25) | 8 (13) | 6 (10) | x (2) |
| | Mud Flats | | | | x (4) | x (2) | x (1) | x (2) | |

Table 3 cont.

| Species | Area | October 4** | November 3** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| Unidentified Merganser (Merginae) | Total | 6 (12) | 4 (9) | 13 (36) | 3 (6) | 1 (2) | 3 (5) | x (2) | x (2) |
| | Mud Flats | 2 (6) | | 1 (3) | x (1) | | | x (1) | x (1) |
| Unidentified Divers | Total | 131 (234) | | | | | | | |
| | Mud Flats | 24 (86) | | | | | | | |
| Bald Eagle (<u>Haliaeetus</u> <u>leucocephalus</u>) | Total | | | | | | | x (1) | |
| | Mud Flats | | | | | | | x (1) | |
| American Coot (<u>Fulica</u> <u>americana</u>) | Total | 22 (42) | 40 (54) | 35 (39) | 40 (48) | 27 (38) | 36 (44) | 15 (34) | |
| | Mud Flats | | 9 (16) | 15 (22) | 19 (24) | 6 (12) | 0 (12) | 2 (5) | |
| Killdeer (<u>Charadrius</u> <u>vociferus</u>) | Total | 22 (38) | 3 (5) | 7 (16) | x (2) | 4 (6) | 6 (10) | 3 (5) | 3 (7) |
| | **Mud Flats** | 7 (20) | x (2) | 2 (5) | | x (2) | | x (2) | x (1) |

Table 3 cont.

| Species | Area | October 4** | November 3** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| Unidentified Yellowlegs (Tringa spp.) | Total | x (1) | x (1) | | | | | | |
| | Mud Flats | x (1) | x (1) | | | | | | |
| Dunlin (Calidris alpina) | Total | | | | | | | 6 (30) | |
| | Mud Flats | | | | | | | | |
| Westerm Sandpiper (Calidris mauri) | Total | | | 269 (1345) | | | | | |
| | Mud Flats | | | 60 (300) | | | | | |
| Long-Billed Dowitcher (Limnodromus acolopaceus) | Total | 4 (17) | 2 (6) | | | | | | |
| | Mud Flats | 4 (17) | 2 (6) | | | | | | |
| Unidentified Sandpiper (Scolopacidae) | Total | | | 360 (1800) | 14 (70) | | | | |
| | Mud Flats | | | 200 (1000) | | | | | |

Table 3 cont.

| Species | Area | October 4** | November 3** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| Unidentified Shorebirds (Charadriiformes) | Total | 12 (26) | 53 (150) | 75 (200) | 34 (85) | 383 (540) | 135 (338) | | 3 (6) |
| | Mud Flats | 4 (13) | 50 (150) | 25 (125) | 11 (57) | 250 (450) | 99 (235) | | 1 (3) |
| Gulls (Glaucous, *Larus hyperboreus*; Glaucous-Winged, *Larus glaucescens*; Herring, *Larus argentatus*; California, *Larus californicus*; Mew, *Larus canus*; Bonaparte's, *Larus philadelphia*) | Total | 567 (572) | 168 (180) | 651 (1085) | 1103 (2460) | 818 (1335) | 442 (695) | 312 (375) | 323 (540) |
| | Mud Flats | 147 (472) | | 197 (350) | 208 (650) | 425 (600) | 210 (290) | 149 (200) | 154 (300) |
| **Unidentified Terns (*Sterninae*)** | Total | 4 (15) | | | | | | | |
| | Mud Flats | 4 (15) | | | | | | | |
| Pigeon Guillemot (*Cepphus columba*) | Total | | | | | | | 1 (3) | 2 (2) |
| | Mud Flats | | | | | | | | |
| Marbled Murrelet (*Brachyramphus marmoratus*) | Total | | | | | | | | x (2) |
| | Mud Flats | | | | | | | | x (2) |

Table 3 cont.

| Species | Area | October 4** | November 3** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| Cassin's Auklet (*Ptychoramphus aleuticus*) | Total | | | | | | | | x (2) |
| | Mud Flats | | | | | | | | x (2) |
| Rock Dove (*Columba livia*) | Total | | | 3 (7) | 5 (13) | 11 (30) | 7 (21) | 4 (8) | 6 (8) |
| | Mud Flats | | | | | | | | |
| Belted Kingfisher (*Megaceryle alcyon*) | Total | x (1) | | | | | x (1) | | |
| | Mud Flats | x (1) | | | | | | | |
| Unidentified Swallow (Hirundinidae) | Total | | | | | | | | 5 (15) |
| | Mud Flats | | | | | | | | 5 (15) |
| Northwestern Crow (*Corvus caurinus*) | Total | 74 (180) | 160 (460) | 200 (329) | 368 (886) | 270 (500) | 91 (216) | 52 (109) | 104 (222) |
| | Mud Flats | 48 (170) | 67 (200) | 122 (180) | 270 (506) | 231 (500) | 49 (135) | 37 (85) | 67 (160) |

Table 3 cont.

| Species | Area | October 4** | November 3** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| American Robin (*Turdus migratorius*) | Total | x (1) | | | | | | | |
| | Mud Flats | x (1) | | | | | | | |
| Common Starling (*Sturnus vulgaris*) | Total | 65 (100) | 83 (250) | | 3 (15) | | x (2) | 59 (260) | |
| | Mud Flats | 40 (100) | 67 (200) | | | | | 24 (100) | |
| Unidentified Finches (Fringillidae) | Total | | 8 (25) | | | | | | |
| | Mud Flats | | | | | | | | |
| **American Goldfinch (*Spinus tristis*)** | Total | | | 2 (8) | | | | | |
| | Mud Flats | | | | | | | | |
| Savannah Sparrow (*Passerculus sandwichensis*) | Total | | | | | | x (1) | | |
| | Mud Flats | | | | | | | | |
| Unidentified Sparrows (Fringillidae) | Total | x (2) | | | | | | | |
| | Mud Flats | x (2) | | | | | | | |

Table 3 cont.

| Species | Area | October 4** | November 3** | December 5** | January 5** | February 4** | March 4** | April 5** | May 3** |
|---|---|---|---|---|---|---|---|---|---|
| Unidentified Passerines (Passeriformes) | Total | | | x (1) | | | | | |
| | Mud Flats | | | x (1) | | | | | |
| Harbour Seal (*Phoca vitulina richardi*) | Total | | x (1) | 1 (2) | 1 (2) | 2 (4) | 1 (2) | x (1) | 1 (4) |
| | Mud Flats | | | x (1) | | x (1) | x (2) | | x (1) |

## References cited in Table 3


American Ornithologists' Union. 1973. Thirity-second supplement to the American Ornithologists' Union Checklist of North American Birds. Auk 90: 411-419.

Cowan, I. McT. and C.J. Guiguet. 1960. The mammals of British Columbia. B.C. Prov. Museum Handbook No. 11. Victoria. 413 p.

Godfrey, W.E. 1966. The birds of Canada. Nat. Museum of Canada Bulletin 203. Ottawa. 428 p.

Table 4. Bird groups and species seen on the Maplewood study area expressed as a percentage of all birds seen during the study[1], bird groups and species seen at Maplewood Mud Flats expressed as a percentage of all birds seen on the entire study area[2], and species composition (in percent) of selected groups of birds seen on the entire Maplewood study area[3].

| Bird Group | Bird Species | Bird groups and species seen: On the Maplewood study area expressed as a percentage of all birds seen during the study | Bird groups and species seen: On the Maplewood Mud Flats expressed as a percentage of all birds seen during the study | Species composition (%) of selected groups of birds seen on the entire Maplewood study area |
|---|---|---|---|---|
| Dabblers | | 22.9[1] | 16.2[2] | 100.0 |
| | American wigeon | 13.1 | 11.5 | 56.9[3] |
| | mallard | 5.7 | 2.2 | 25.0 |
| | green-winged teal | 1.7 | 1.0 | 7.5 |
| | pintail | 1.1 | 0.9 | 4.6 |
| | gadwall | 0.5 | 0.4 | 2.1 |
| | European wigeon | P | P | 0.1 |
| | northern shoveler | P | P | 0.1 |

Table 4 cont.

| Bird Group | Bird Species | Bird groups and species seen: | | Species Composition[3] |
|---|---|---|---|---|
| | | Maplewood study area[1] | Maplewood Mud Flats[2] | |
| | unidentified dabblers | 0.8 | 0.2 | 3.7 |
| Gulls | | 22.2 | 7.6 | 100.0 |
| Scaup | | 15.9 | 6.2 | 100.0 |
| Goldeneye | | 9.0 | 1.7 | 100.0 |
| | common | 2.5 | 0.2 | 27.9 |
| | Barrow's | 0.7 | 0.1 | 7.2 |
| | unidentified goldeneyes | 5.8 | 1.4 | 64.9 |
| Passerines | | 7.7 | 5.3 | 100.0 |
| | northwestern crow | 6.8 | 4.7 | 87.2 |
| | starling | 0.9 | 0.6 | 12.0 |
| | others | P | P | 0.8 |
| Shorebirds | | 7.5 | 3.7 | 100.0 |
| | western sandpiper | 1.6 | 0.4 | 21.5 |
| | killdeer | 0.2 | P | 2.8 |
| | dunlin | P | P | 0.5 |

Table 4 cont.

| Bird Group | Bird Species | Bird groups and species seen: | | |
|---|---|---|---|---|
| | | Maplewood study area[1] | Maplewood Mud Flats[2] | Species Composition[3] |
| | long-billed dowitcher | P | P | 0.4 |
| | unidentified shorebirds | 3.4 | 2.1 | 45.0 |
| | sandpipers | 2.3 | 1.2 | 29.8 |
| | yellowlegs | P | P | P |
| Scoters | | 7.5 | 1.9 | 100.0 |
| | black | 2.1 | 0.6 | 27.6 |
| | white-winged | 0.5 | 0.1 | 6.7 |
| | common | P | P | 0.2 |
| | unidentified scoters | 4.9 | 1.2 | 65.5 |
| Grebes | | 1.7 | 0.4 | 100.0 |
| American Coots | | 1.0 | 0.3 | 100.0 |
| Cormorants | | 1.0 | P | 100.0 |
| Others | | 3.6 | 1.5 | 100.0 |
| Total | | 100.0 | | |

P - Species was present, but not in large numbers.

1. For example, 22.9% of all the birds seen on the Maplewood study area were dabblers and 13.1% of all the birds seen on the Maplewood study area were American wigeon.
2. For example, the dabblers seen only on the Maplewood Mud Flats represented 16.2% of all the birds seen on the entire Maplewood study area. Similarly, the American wigeon seen only on the Maplewood Mud Flats represented 11.5% of all the birds seen on the entire Maplewood study area.
3. For example, of all the dabblers seen on the entire Maplewood study area 56.9% were wigeon, 25.0% mallards, etc.

Table 5. Bird groups and species seen at Maplewood Mud Flats expressed as a percentage of all birds in these individual groups and species seen on the entire study area[1], bird groups and species seen at Maplewood Mud Flats expressed as a percentage of all birds seen at Maplewood Mud Flats[2], and species composition (in percent) of selected groups of birds seen at Maplewood Mud Flats[3].

| Bird Group | Bird Species | Bird groups and species seen at Maplewood Mud Flats | | Species composition (%) of selected groups of birds seen at Maplewood Mud Flats |
|---|---|---|---|---|
| | | As a percentage of all birds of same group or species seen on entire study area | As a percentage of all birds seen on Maplewood Mud Flats | |
| Dabblers | | 70.6 [1] | 35.9[2] | 100.0 |
| | American wigeon | 88.3 | 25.6 | 71.2 [3] |
| | mallard | 38.9 | 5.0 | 13.8 |
| | green-winged teal | 57.8 | 2.2 | 6.1 |
| | pintail | 80.5 | 1.9 | 5.3 |
| | gadwall | 73.0 | 0.8 | 2.2 |
| | European wigeon | 71.4 | P | 0.1 |
| | northern shoveler | 72.7 | P | 0.1 |
| | unidentified dabblers | 23.6 | 0.4 | 1.2 |

Table 5 cont.

| Bird Group | Bird Species | Bird groups and species seen: Maplewood study area[1] | Bird groups and species seen: Maplewood Mud Flats[2] | Species Composition[3] |
|---|---|---|---|---|
| Gulls | | 34.5 | 17.0 | 100.0 |
| Scaup | | 39.1 | 13.8 | 100.0 |
| Passerines | | 68.4 | 11.8 | 100.0 |
| | northwestern crow | 69.6 | 10.4 | 88.7 |
| | starling | 62.2 | 1.3 | 10.9 |
| | other | 35.8 | 0.1 | 0.4 |
| Shorebirds | | 49.8 | 8.3 | 100.0 |
| | western sandpiper | 22.3 | 0.8 | 9.6 |
| | killdeer | 29.9 | 0.1 | 1.7 |
| | long-billed dowitcher | 100.0 | P | 0.7 |
| | unidentified shorebirds | 61.9 | 4.7 | 55.9 |
| | sandpipers | 53.5 | 2.7 | 32.0 |
| | yellowlegs | 100.0 | P | 0.1 |
| Scoters | | 25.9 | 4.3 | 100.0 |
| | black | 26.8 | 1.3 | 28.7 |

Table 5 cont.

| Bird Group | Bird Species | Bird groups and species seen: Maplewood study area[1] | Maplewood Mud Flats[2] | Species Composition[3] |
|---|---|---|---|---|
| | white-winged | 29.7 | 0.3 | 7.6 |
| | common | 81.8 | P | 0.6 |
| | unidentified scoters | 24.9 | 2.7 | 63.1 |
| Goldeneye | | 19.4 | 3.9 | 100.0 |
| | common | 7.5 | 0.4 | 10.8 |
| | Barrow's | 23.5 | 0.4 | 8.7 |
| | unidentified goldeneyes | 24.1 | 3.1 | 80.5 |
| Bufflehead | | 83.4 | 1.6 | 100.0 |
| Other | | 44.0 | 3.4 | 100.0 |
| Total | | | 100.0 | |

P - Species was present, but not in large numbers.

1. For example, 70.6% of all the dabblers seen on the entire Maplewood study area were seen on the Maplewood Mud Flats, and 88.3% of all the American wigeon seen on the entire Maplewood study area were seen on the Maplewood Mud Flats.

2. For example, of all the birds seen on the Maplewood Mud Flats, 35.9% were dabblers, and 25.6% were American wigeon.

3. For example, of all the dabbling ducks seen on the Maplewood Mud Flats 71.2% were wigeon, 13.8% were mallards, etc.

Figure 11. Calculations of the estimated carrying capacity for dabbling ducks of the Seymour-Maplewood area prior to 1930.

1. Highest estimate

The estimated maximum number of dabblers dependent on the 16 acres of marsh remaining on the study area in 1972-73 was 2,100 (Table 2). Therefore, the potential carrying capacity of the 108 acres of marsh available in the study area in 1930 was:

$$\frac{(108) \quad (2100)}{16} = \underline{\underline{14,175}}$$

2. Lowest estimate

Because wigeon were observed to spend more time feeding on the mudflats than in the marshes, the maximum number of wigeon (1970) estimated to be dependent on the study area in 1972-73 was subtracted from the estimated total maximum number of dabblers (2,100) and the calculations based on 1,130 dabblers dependent on 16 acres of marsh as follows:

$$\frac{(108) \quad (1130)}{16} = \underline{\underline{7,627}}$$

Using the same basis for calculations, it is estimated the 350 acres of marsh available on the North Shore in 1930 could have supported 25,000 to 46,000 dabbling ducks.

Table 6: Main plant species identified at the marsh at Maplewood Mud Flats, their relative abundance and an evaluation of their importance to waterfowl.

| Name[1] | Relative Abundance | Direct Value to Waterfowl | |
|---|---|---|---|
| | | In General[3] | At Maplewood |
| | Rating[2] | | |
| *Family* TYPHACEAE (Cat-tail family) | | | |
| Cat-tail (*Typha latifolia*) | 1 | Geese eat roots and vegetation; Provides some cover for ducks. | Some potential value to geese. However, neither cat-tails nor geese are abundant at the present time. |
| *Family* JUNCAGINACEAE (Arrow-grass family) | | | |
| Seaside arrow-grass (*Triglochin maritimum*) | 2-3 | Ducks eat seeds; Potential nesting cover. | Potentially important food source for wintering dabblers due to relative abundance of these species |
| *Family* ALISMATACEAE (Water-plantain family) | | | |
| American waterplantain (*Alisma plantago-aquatica*) | 1-2 | Geese sometimes eat fleshy bases of plants; Ducks occasionally eat seeds. | Seeds probably form a small part of diet of wintering dabblers. |

1 Nomenclature for vascular plants based on Hitchcock and Cronquist (1974).

2 The relative abundance of plants was arbitrarily rated on a scale of five as follows: 1- Low occurrence; 2- Fairly common in some areas; 3- Common; 4- Abundant; 5- Very abundant to dominant.

3 General value of plants to waterfowl based on the following references: Burgess (1970); Caldwell (1960); Cottam (1939); Cottle (1949); Martin, Zim and Nelson (1951); Munro (1934); Munro (1936); McAtee (1939); Yocom (1951).

| Name | Relative Abundance | Direct Value to Waterfowl | |
|---|---|---|---|
| | | In General | At Maplewood |
| | Rating | | |
| *Family* GRAMINEAE (Grass family) | | | |
| Seashore saltgrass (*Distichlis spicata*) | 4 | Waterfowl eat seeds, young plants and root-stocks; Potential nesting cover. | Potentially important year-round food source for ducks and geese due to its abundance and acceptance by waterfowl. |
| Red fescue (*Festuca rubra*) | 1 | Waterfowl may eat seeds, green vegetation and roots of these grasses; Potential nesting cover. | Individually, these grass species probably contribute a small amount of waterfowl food, but their combined abundance makes them a potentially valuable year-round food source. |
| Bluegrass (*Poa sp.*) | 1 | | |
| Foxtail barley (*Hordeum jubatum*) | 1 | | |
| *Family* CYPERACEAE (Sedge family) | | | |
| Lyngby's sedge (*Carex lyngbyei*) | 3-4 | Seeds of *Carex sp.* are a valuable source of food for waterfowl; Vegetative parts of plants occasionally are eaten. | Carex seeds probably are an important food source for wintering dabblers. |

| Name | Relative Abundance | Direct Value to Waterfowl | |
|---|---|---|---|
| | | In General | At Maplewood |
| *Family* JUNCACEAE (Rush family) | Rating | Waterfowl may occasionally eat the seeds and vegetative parts of rushes; Potential nesting cover. | Normally, the seeds of rush individual species probably form only a small part of the diet of wintering dabblers. However, due to the general overall abundance and variety of rushes, they may be an important emergency source of winter food during adverse weather conditions. |
| Tapered rush (*Juncus acuminatus*) | 1 | | |
| Jointed rush (*J. articulatus*) | 1 | | |
| Baltic rush (*J. balticus*) | 1 | | |
| Toad rush (*J. bufonius*) | 1 | | |
| Common rush (*J. effusus*) | 1 | | |
| Dagger-leaf rush (*J. ensifolius*) | 1 | | |
| Mud rush (*J. gerardii*) | 1 | | |

| Name | Relative Abundance | Direct Value to Waterfowl | |
|---|---|---|---|
| | | In General | At Maplewood |
| | Rating | | |
| *Family* CHENOPODIACEAE (Goosefoot family) | | | |
| Pigweed or lambsquarter (*Chenopodium album*) | 1 | No reference found for waterfowl use of this genus, but seeds extensively used by upland game birds and songbirds; Potential nesting cover. | Seeds possibly play a minor role in diet of wintering dabblers. |
| Glasswort (*Salicornia sp.*) | 4 | Waterfowl may eat the seeds and vegetative parts of these plants. | Normally, *salicornia* probably plays a small role in the diet of wintering waterfowl. However, due to its relative abundance, it is a potentially important source of food for wintering birds especially during adverse weather conditions. |
| Orache (*Atriplex patula*) | 1-2 | Waterfowl occasionally eat seeds and vegetative parts; Potential nesting cover. | Potential year-round food source for Canada geese; Seeds may form a small part of diet of wintering dabblers. |
| *Family* ROSACEAE (Rose family) | | | |
| Cinquefoil (*Potentilla sp.*) | 1 | Ducks occasionally eat the seeds of this group of plants; Potential nesting cover. | Seeds probably form a small part of diet of wintering dabblers. |

| Name | Relative Abundance | Direct Value to Waterfowl | |
|---|---|---|---|
| | | In General | At Maplewood |
| | Rating | | |
| *Family* PLANTAGINACEAE (Plantain family) | | | |
| Seaside plantain (*Plantago maritima*) | 2 | No reference found specifically for waterfowl use of these species, but ducks occasionally eat the seeds of other plantain species. | Seeds possibly form a small part of diet of wintering dabblers. |
| *Family* COMPOSITAE (Aster family) | | | Seeds possibly form a small part of diet of wintering dabblers. |
| Eaton's aster (*Aster eatonii*) | 2 | No reference found specifically for waterfowl use, but seeds eaten by upland game birds and song-birds; Potential nesting cover. | |
| Nodding beggars-tick (*Bidens cernua*) | 1-2 | Seeds of *Bidens sp.* eaten by ducks, sometimes extensively; Potential nesting cover. | |
| Gumweed (*Grindelia integrifolia*) | 2 | No reference found for bird food use; Potential nesting cover. | |
| Hairy cats-ear (*Hypochaeris radicata*) | 1 | No reference found for bird food use; Potential nesting cover. | |

| Name | Relative Abundance | Direct Value to Waterfowl | |
|---|---|---|---|
| | | In General | At Maplewood |
| | Rating | | |
| Unidentified members of Family *UMBELLIFERAE* (Parsley family) | 1-2 | Some limited waterfowl use of seeds; Potential nesting cover. | Seeds possibly form a small part of diet of wintering dabblers. |
| Unidentified filamentous green algae | 3-4 | Filamentous green algae often eaten in large quantities by ducks. | A potentially important food source. |
| The following drift species also were found among the plants growing in the marsh: | | | |
| Eel-grass (*Zostera marina*) | Variable | All parts of this plant are readily eaten by many species of waterfowl. | Potentially valuable food source for all waterfowl. |
| Sea lettuce (*Ulva lactuca*) | Variable | A favoured food of wigeon and black brant. | Potentially valuable food for wintering wigeon. |
| Rock weed (*Fucus gardneri*) | Variable | May occasionally be eaten by waterfowl. | Use probably of little direct value. |

# REFERENCES FOR NOMENCLATURE AND FOOD VALUE OF PLANTS IN MARSH AT MAPLEWOOD MUD FLATS


Burgess, T.E. 1970. Foods and habitat for four anatinids wintering on the Fraser delta tidal marshes. M. Sc. Thesis, Dept. of Zool., U.B.C. 124 pp.

Caldwell, J.R. 1960. Guide to Saskatchewan marsh plants. Ducks Unlimited (Canada), Winnipeg. 77 pp.

Cottam, C. 1939. Food habits of North American diving ducks. U.S. Dept. of Agr. Tech. Bull. 643. 140 pp.

Cottle, W.H. 1949. A study of the feeding behaviour of some members of the Anatinae wintering in the lower Fraser Valley of British Columbia. B.A. Thesis, U.B.C. 65 pp.

Hitchcock, C.L. and A. Cronquist. 1974. FLora of the Pacific Northwest. U. of Wash. Press, Seattle and London. 730 pp.

Martin, A.C., H.S. Zim, and A.L. Nelson. 1951. American wildlife and plants, a guide to wildlife food habits. Dover Publications, New York. 500 pp.

Munro, J.A. 1934. Stomach analyses, January-March, 1934. Can. Wildl. Serv. Unpubl. rept. 87 pp.

Munro, J.A. 1936. Food of the common mallard in the lower Fraser Valley, British Columbia. Condor. 38: 109-111.

McAtee, W.L. 1939. Wildfowl food plants, their value, propagation and management. Collegiate Press, Inc., Ames. Iowa. 141 pp.

Yocom, C.F. 1951. Waterfowl and their food plants in Washington. Univ. of Wash. Press, Seattle. 272 pp.

Table 7. Species list of waterbird food organisms found on the intertidal foreshore immediately east of the Seymour River, North Vancouver, B.C., August 16, 1974.

| Name of Organism | Relative Abundance |
|---|---|
| Barnacles (*Balanus* sp.) | Abundant, widespread |
| Hermit crab (*Pagurus hirsutiusculus*) | Abundant, widespread |
| Shore crabs (*Hemigrapsus* sp.) | Abundant, widespread |
| Cancer crabs (*Cancer* sp.) | Common where substrate suitable for burrowing |
| Isopods (*Gnorimosphaeroma oregenensis*) | Abundant, widespread |
| Amphipods (*Anisogammerus confervicolus*) | Abundant in drift material at high tide line |
| Pacific oyster (*Crassostrea gigas*) | Few, scattered |
| Blue mussel (*Mytilus edulis*) | Abundant in inner 1/3-1/2 of area except next to shoreline |
| Clams (at least six species observed) | Abundant, widespread |
| Native little-neck (*Protothaca staminea*)<br>Thin-shelled little-neck (*Venerupis tenerrima*)<br>Macoma (*Macoma* sp.)<br>Rock-dwelling entodesma (*Entodesma saxicola*)<br>Heart cockle (*Clinocardium nuttalli*)<br>Butter clam (*Saxidomas giganteus*) | |
| Limpets (*Acmaea* sp.) | |
| Snails (*Thais* sp.) | |
| Polychaete worms | Abundant, widespread |
| Members of Family Terebellidae and superfamily Aphroditoidae | |
| Unidentified Nemertean worms | Abundant, widespread |
| Fishes | |
| Unidentified flatfishes | Common in tidepools |
| Unidentified sculpins | Abundant in tidepools |
| Unidentified blennies | Abundant in tidepools and under objects |
| Purple starfish (*Pisaster ochraceus*) | Few scattered |

Table 8. Matrix of bird groups and potential food items identified at the proposed Columbia Bitulithic intertidal fill area, North Vancouver, B.C.

| Bird Groups[1] | Potential Food Items[2]: Small crustaceans[3] | Mollusks[4] | Marine worms[5] | Echinoderms[6] | Small fishes[7] | Marine vegetation[8] | Remarks |
|---|---|---|---|---|---|---|---|
| Loons | x[9] | x | | | x | | |
| Grebes | x | x | | | x | | |
| Cormorants | x | | x | | x | | |
| Geese | | | | | | | Probably casual visitors |
| Dabbling ducks | x | x | x | | | x | |
| Diving ducks | x | x | x | x | x | x | |
| Gulls | x | x | x | x | x | x | |
| Coots | x | x | | | | x | |
| Alcids | x | x | x | | x | | |
| Herons | x | | | | x | | |
| Shorebirds | x | x | x | | | | |
| Crows | x | x | x | | | | Mainly scavengers |
| Rock Doves | | | | | | | Probably casual visitors |

1. Based on data collected by C.W.S. October 1972 - May 1973.
2. Based on investigations by C.W.S. and F.M.S. summer and fall, 1974.
3. Includes barnacles, crabs, amphipods, isopods, copepods, cumaceans and insect larvae.
4. Includes clams, mussels, oysters, snails and limpets.
5. Includes Annelids (Oligochaetes and Polychaetes) and Nemerteans.
6. Includes starfish, sea urchins, etc.
7. Includes sculpins, blennies and flatfish observed in tidepools and under rocks and vegetation at the study area as well as other unidentified small fish which move onto the area to feed when it is flooded and retreat to deeper water when the tide ebbs.
8. Provides food and cover for many of the marine animals listed as potential food items for birds.
9. An X indicates that a particular food item identified in the column headings is known to be eaten by a particular bird group listed at the left-hand edge of the row (e.g. - loons eat small crustaceans, mollusks and small fishes).

# APPENDIX 3

## FISH OF THE SEYMOUR-MAPLEWOOD AREA

Fisheries and Marine Service
unpublished data:

- Maplewood fish sampling
- Spawning escapements

Contents: (in order)

# METHODS

Purse seining was conducted during flood tides with the 27-foot research vessel "E.Q. 101" equipped for table seining. The purse seine net measured 91.4 meters in length by 5.5 meters in depth. Stretch mesh size ranged from 2.5 centimeters on the lead to 1.3 centimeters on bunt. The net was set in the normal circular pattern and retrieved with the aid of a hydraulic power block. The unpursed volume fished by the purse seine is approximately 3,590 cubic meters.

Tow netting was also conducted during high tide using a small scale otter trawl, modified to sample surface waters. The net opening, rectangular in shape, measured 348 centimeters by 74 centimeters. Length of the tow net is 688 centimeters composed of 3 sections each with different mesh sizes ranging from 2.54 centimeters stretch mesh in the lead to 0.63 centimeters at the bunt. The net was towed with nylon line 46 meters behind and between two inboard water-jet powered skiffs running parallel and 15 meters apart. At a speed of approximately 2.4 m/sec., approximately 3,500 cubic meters of water is strained during a 10-minute tow. Catch samples or subsamples were preserved in 10% formalin for laboratory analysis.

Laboratory analysis of samples included identification, weights and lengths of fish, and the identification and enumeration of stomach contents. In addition, the weight of the food bolus and estimates of the stomach fullness and percent digestion of the food bolus were made.

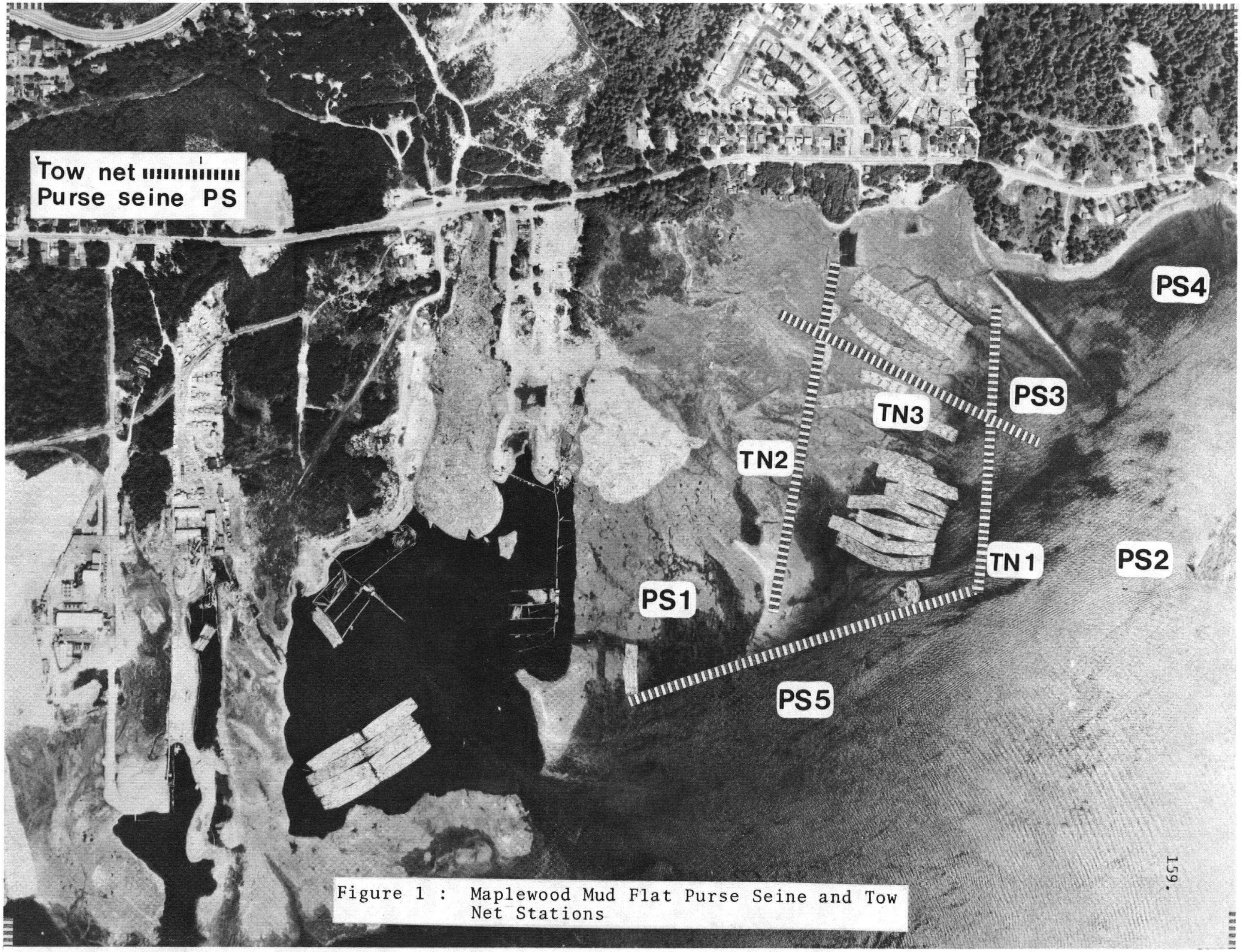



Figure 1 : Maplewood Mud Flat Purse Seine and Tow Net Stations

TABLE 1. Number and Species of Fish Caught during May, June and August Sampling Periods

| Date | Time | Station | Chinook | Chum | Coho | Herring | Smelts | Staghorn Sculpin | Starry Flounder | Threespine Stickleback | Lemon Sole | Anchovy | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 28/73 | 1625 | PS 1 | | | | | | | 11 | | 2 | | 13 |
| May 28/73 | 1800 | PS 2 | | 50 chum fry* | | | | | 10 | | 1 | | 11 |
| May 29/73 | 1630 | PS 3 | | | | | | 1 | 1 | | 1 | | 3 |
| May 29/73 | 1730 | PS 4 | | | | | | | | | | | 0 |
| May 29/73 | 1830 | PS 5 | | | | 75 | | | | | | 2 | 77 |
| June 21/73 | 2000 | TNI 10 min. | 8 | 2 | 2 | 210 | 3 | | | 2 | | | 227 |
| June 22/73 | 2145 | TN2 5 min. | 2 | | | 160 | 200 | | | | | | 372 |
| June 22/73 | 1048 | TN3 2 min. | | | | | | | | 3 | | | 3 |
| Aug. 22/73 | 1431 | TN1 15 min. | | | | | | | | 7 | | | 7 |
| Aug. 22/73 | 1500 | TN2 5 min. | | | | | | | | | | | 0 |
| Aug. 22/73 | 1545 | TN3 10 min. | | | | | | | | 2 | | | 2 |
| TOTAL | | | 10 | 2 | 2 | 445 | 203 | 1 | 22 | 14 | 4 | 2 | 705 |

PS - Purse Seine

TN - Tow Net

* - Escaped

TABLE 2. Range and Average Lengths and Weights of Fish Caught During May and June Sampling Periods

| Date | Station | Species | Length (mm) | | Weight (gm) | | Sample Size (N) |
|---|---|---|---|---|---|---|---|
| | | | Range | Ave. | Range | Ave. | |
| May 28/73 | PS 1 | Lemon Sole | -- | 406.0 | -- | 535.0 | 1 |
| May 28/73 | PS 1 | Starry Flounder | -- | 332.0 | -- | 521.0 | 1 |
| May 29/73 | PS 5 | Herring | 104.0-127.0 | 111.7 | 12.58-24.55 | 16.28 | 10 |
| June 21/73 | TN 1 | Herring | 44.0-50.0 | 45.9 | 0.71-1.22 | 0.94 | 10 |
| June 21/73 | TN 1 | Coho | 130.0-137.0 | 133.5 | 27.60-33.78 | 30.69 | 2 |
| June 21/73 | TN 1 | Chinook | 107.0-130.0 | 122.8 | 17.85-31.49 | 26.70 | 8 |
| June 21/73 | TN 1 | Chum | 61.0-66.0 | 63.5 | 2.75-3.28 | 3.01 | 2 |
| June 21/73 | TN 1 | Longfin Smelt | 82.0-83.0 | 82.5 | 5.21-5.69 | 5.45 | 2 |
| June 21/73 | TN 1 | Threespine Stickleback | 53.0-63.0 | 58.0 | 1.98-3.20 | 2.59 | 2 |
| June 22/73 | TN2 | Surf Smelt | 84.0-100.0 | 90.2 | 2.44-10.91 | 6.55 | 10 |
| June 22/73 | TN2 | Chinook | 135.0-140.0 | 137.5 | 33.10-36.47 | 34.79 | 2 |
| June 22/73 | TN2 | Herring | 43.0-80.0 | 53.7 | 0.69-5.80 | 1.66 | 10 |
| June 22/73 | TN3 | Three-spine Stickleback | 52.0-55.0 | 53.7 | 1.70-2.14 | 1.95 | 3 |

PS -- Purse Seine

TN -- Tow Net

TABLE 3. Frequency of Occurrence and Percent Representation of Food Items found in the stomachs of fish caught during May and June Sampling Periods

| DATE | STATION | FISH SPECIES | Ave. Food Bolus Wt.(gm) | Ave. % Digested | Food Species | Freq. Occur. | % Rep. |
|---|---|---|---|---|---|---|---|
| May 28/73 | PS1 | Parophrys vetulus Lemon Sole | 5.40 | 50 | Anisogammarus sp. | 100.0 | 55.1 |
| | | | | | Pelecypods | 100.0 | 14.3 |
| | | | | | Corophium | 100.0 | 8.2 |
| | | | | | Prickleback | 100.0 | 2.0 |
| | | | | | Unid. polychaetes | 100.0 | 6.0 |
| | | | | | Unid. oligochaetes | 100.0 | 12.2 |
| | | | | | Cumacean | 100.0 | 2.0 |
| | | | | | | (N=1)[1] | (N=49)[2] |
| May 28/73 | PS1 | Platichthys Stellatus Starry Flounder | 1.650 | 99.0 | Pelecypod | 100.0 | 100.0 |
| | | | | | | (N=1) | (N=1) |
| May 29/73 | PS5 | Clupea pallasii Herring | 0.826 | 40.0 | Calanus glacialis | 80.0 | 92.6 |
| | | | | | Euphausiacea pacifica | 60.0 | 0.6 |
| | | | | | Unid. decapod | 40.0 | 0.4 |
| | | | | | Barnacle nauplii | 40.0 | 4.3 |
| | | | | | Pseudocalanus minutus | 20.0 | 0.9 |
| | | | | | Parathemisto pacifica | 20.0 | 0.2 |
| | | | | | Crab Zoea | 20.0 | 0.2 |
| | | | | | Crab Megalops | 20.0 | 0.2 |
| | | | | | Cumacean | 20.0 | 0.4 |
| | | | | | Pelecypods | 20.0 | 0.2 |
| | | | | | | (N=5) | (N=460) |

1. Number of stomachs examined
2. Total number of food items

TABLE 3. (continued)

| DATE | STATION | FISH SPECIES | Ave. Food Bolus Wt.(gm) | Ave. % Digested | Food Species | Freq. Occur. | % Rep. |
|---|---|---|---|---|---|---|---|
| June 21/73 | TN1 | O. kisutch Coho | 0.876 | 9.25 | Clupea pallasii(Herring) | 50.0 | 66.7 |
| | | | | | Crab Zoea | 50.0 | 33.3 |
| | | | | | Unid. larval fish | 50.0 | ---[3] |
| | | | | | | (N=2) | (N=3) |
| | | O. tshawytscha Chinook | 0.842 | 6.9 | Crab Megalops | 37.5 | 14.4 |
| | | | | | Clupea pallasii(Herring) | 37.5 | 9.1 |
| | | | | | Unid. larval fish | 37.5 | -- |
| | | | | | Barnacle Cirri | 12.5 | 45.4 |
| | | | | | Crab Zoea | 12.5 | 27.3 |
| | | | | | Homoptera | 12.5 | 1.8 |
| | | | | | | (N=8) | (N=55) |
| | | Clupea pallasii Herring | 0.0070 | 94.0 | Barnacle Cypris | 80.0 | 53.8 |
| | | | | | Harpacticoid | 20.0 | 7.7 |
| | | | | | Shrimp | 20.0 | 7.7 |
| | | | | | Crab Zoea | 20.0 | 30.8 |
| | | | | | | (N=5) | (N=13) |
| | | Gasterosteus aculeatus Threespine Stickleback | 0.0515 | 92.5 | Parathemisto pacifica | 50.0 | 55.6 |
| | | | | | Cumacean | 50.0 | 44.4 |
| | | | | | | (N=2) | (N=9) |
| | | Spirinchus dilatus Longfin Smelt | 0.1290 | 40.0 | Scaphocalanus echinatus | 100.0 | 44.2 |
| | | | | | Unid. Chaetognath | 100.0 | 21.1 |
| | | | | | Parathemisto pacifica | 50.0 | 2.1 |
| | | | | | Shrimp | 100.0 | 10.5 |
| | | | | | Unid. larval fish | 100.0 | 14.7 |
| | | | | | Cumacean | 50.0 | 1.1 |
| | | | | | Eggs | 50.0 | 6.3 |
| | | | | | | (N=2) | (N=95) |
| | | O. keta Chum | 0.082 | 82.5 | Parathemisto pacifica | 100.0 | 33.3 |
| | | | | | Homoptera | 100.0 | 22.2 |
| | | | | | Calanus Pacificus | 50.0 | 11.1 |
| | | | | | Unid. copepod | 50.0 | 11.1 |
| | | | | | Euphausiacea pacifica | 50.0 | 11.1 |
| | | | | | Diptera | 50.0 | 11.1 |
| | | | | | Unid. larval fish | 50.0 | --- |
| | | | | | | (N=2) | (N=9) |

3. Present but uncountable

TABLE 3. (continued)

| DATE | STATION | FISH SPECIES | Ave. Food Bolus Wt.(gm) | Ave. % Digested | Food Species | Freq. Occur. | % Rep. |
|---|---|---|---|---|---|---|---|
| June 22/73 | TN2 | O. tshawytscha Chinook | 1.043 | 70.0 | Clupea pallasii (Herring) | 100.0 | 100.0 |
| | | | | | | (N=2) | (N=4) |
| | | Clupea pallasii Herring | 0.0278 | 68.0 | Pseudocalanus minutus | 80.0 | 38.7 |
| | | | | | Crab Zoea | 80.0 | 46.7 |
| | | | | | Calanus plumchrus | 40.0 | 5.3 |
| | | | | | Parathemisto pacifica | 40.0 | 2.7 |
| | | | | | Shrimp | 20.0 | 1.3 |
| | | | | | Barnacle cypris | 20.0 | 2.7 |
| | | | | | Euphausiacea pacifica | 20.0 | 1.3 |
| | | | | | Cumacean | 20.0 | 1.3 |
| | | | | | Unid. Chaetognath | 20.0 | --- |
| | | | | | | (N=5) | (N=75) |
| | | Hypomesus pretiosus Surf Smelt | 0.0434 | 42.0 | Pseudocalanus minutus | 40.0 | 2.9 |
| | | | | | Calanus pacificus | 20.0 | 0.3 |
| | | | | | Eucalanus bungii bungii | 20.0 | 0.5 |
| | | | | | Copepod Nauplii | 20.0 | 88.8 |
| | | | | | Parathemisto pacifica | 20.0 | 0.2 |
| | | | | | Shrimp | 20.0 | 0.7 |
| | | | | | Crab Zoea | 20.0 | 0.2 |
| | | | | | Euphausiacea pacifica | 20.0 | 0.2 |
| | | | | | Cumacean | 20.0 | 0.9 |
| | | | | | Eggs | 20.0 | 0.7 |
| | | | | | Unid. Chaetognath | 20.0 | 4.7 |
| | | | | | | (N=5) | (N=580) |
| June 22/73 | TN3 | Gasterosteus Aculeatus Threespine Stickleback | 92.5 | 77.5 | Harpacticoid | 100.0 | 97.4 |
| | | | | | Ostracod | 50.0 | 2.6 |
| | | | | | | (N=2) | (N=39) |

TABLE 4. Percent Representation of Food Items by Category for Fish Species Caught During May and June Sample Periods

| Fish species | No. Fish Stomachs | Total No. Food Items | Categories of Food Items: Benthic Invertebrates | Pelagic | Terrestrial | Fish | Eggs |
|---|---|---|---|---|---|---|---|
| O. kisutch<br>Coho | 2 | 3 | | 100 | | x | |
| O. tshawytscha<br>Chinook | 10 | 59 | | 83.1 | 1.7 | 15.3 | |
| O. keta<br>Chum | 2 | 9 | | 66.6 | 33.3 | x | |
| Clupea pallasii<br>Herring | 10 | 548 | 1.6 | 98.4 | | x | |
| Parophrys vetulus<br>Lemon Sole | 1 | 49 | 97.8 | | 2.0 | | |
| Platichthys stellatus<br>Starry Flounder | 1 | 1 | 100 | | | | |
| Hypomesus pretiosus<br>Surf Smelt | 5 | 580 | 6.3 | 93.1 | | | 0.7 |
| Spirinchus dilatus<br>Longfin Smelt | 2 | 95 | 32.7 | 46.3 | | 14.7 | 6.3 |
| Gasterosteus aculeatus<br>Threespine stickleback | 4 | 54 | 90.7 | 9.3 | | | |

x present but uncountable

Table 5. Salmon and steelhead spawner escapement records for the years 1963 to 1972 for Seymour River, Lynn Creek, Capilano River, and Indian River, B.C.

CAPILANO RIVER ESCAPEMENTS

| Year | Chinook | Coho | Chum | Pink | Steelhead |
|---|---|---|---|---|---|
| 1963 | - | 2,071 | 100 | 100 | 92 |
| 1964 | - | 2,622 | 25 | - | 161 |
| 1965 | - | 750 | 25 | 25 | 25 |
| 1966 | - | 2,092 | 25 | - | 84 |
| 1967 | - | 1,203 | 25 | - | 127 |
| 1968 | - | 1,500 | 150 | - | 25 |
| 1969 | - | 1,500 | 150 | 25 | 75 |
| 1970 | - | 3,500 | 75 | - | 75 |
| 1971 | 44 | 4,000 | 75 | 25 | 200 |
| 1972 | 38 | 1,200 | 700 | 7 | 34 |
| Ten Year Average | - | 2,043.8 | 135 | - | 90.3 |

## SEYMOUR CREEK ESCAPEMENTS

| Year | Chinook | Coho | Chum | Pink | Steelhead |
|---|---|---|---|---|---|
| 1963 | - | 1,500 | 75 | 400 | 400 |
| 1964 | - | 750 | 25 | - | 750 |
| 1965 | - | 400 | 25 | 150 | 150 |
| 1966 | - | 1,500 | 25 | - | 400 |
| 1967 | - | 400 | 25 | 400 | 150 |
| 1968 | - | 1,500 | 25 | - | 400 |
| 1969 | - | 1,500 | - | 25 | 400 |
| 1970 | - | 1,500 | - | - | 150 |
| 1971 | - | 3,500 | 25 | 150 | 150 |
| 1972 | - | 1,500 | 750 | - | 150 |
| 10 Year Average | - | 1,405 | 97.5 | (5 Yr.) 225* | 310 |

## LYNN CREEK

| Year | Chinook | Coho | Chum | Pink | Steelhead |
|---|---|---|---|---|---|
| 1963 | - | 25 | 25 | 25 | 25 |
| 1964 | - | 25 | 25 | - | 25 |
| 1965 | - | 25 | 25 | 25 | 25 |
| 1966 | - | 25 | 25 | - | 750 |
| 1967 | - | 25 | 25 | - | 25 |
| 1968 | - | 25 | 25 | - | 25 |
| 1969 | - | 150 | - | - | 150 |
| 1970 | - | 75 | - | - | 25 |
| 1971 | - | 75 | - | - | 25 |
| 1972 | - | 400 | 400 | - | 150 |
| 10 Year Average | - | 85 | 55 | - | 122.5 |

INDIAN RIVER ESCAPEMENTS

| Year | Chinook | Coho | Chum | Pink | Steelhead | Sockeye |
|---|---|---|---|---|---|---|
| 1963 | - | 1,500 | 3,000 | 200,000 | 400 | - |
| 1964 | - | 3,500 | 5,000 | - | 150 | - |
| 1965 | - | 400 | 5,000 | 35,000 | 150 | - |
| 1966 | - | 1,500 | 3,500 | 75 | 150 | - |
| 1967 | - | 1,500 | 3,500 | 7,500 | 150 | - |
| 1968 | - | 750 | 15,000 | - | 400 | - |
| 1969 | - | 400 | 15,000 | 7,500 | 150 | 25 |
| 1970 | - | 750 | 15,000 | - | 150 | 25 |
| 1971 | - | 750 | 7,500 | 35,000 | 150 | 25 |
| 1972 | - | 400 | 35,000 | - | 150 | - |
| Ten Year Average | - | 1,145 | 10,750 | (5 Yr.) 57,000 | 200 | - |

Table 6. Salmon and steelhead spawner escapement records for the years 1934 to 1971 (10 year averages mainly) for Seymour River, Lynn Creek, Capilano River, and Indian River, B.C.

## SEYMOUR RIVER

| | Pinks | | | | | |
|---|---|---|---|---|---|---|
| Years | Even | Odd | Chum | Coho | Chinook | Steelhead |
| 1934-41 (8) | 238 (2) | 38,125 (4) | 15,292 (6) | 7,333 (6) | | 792 (6) |
| 1942-51 (10) | 15 (5) | 788 (4) | 2,467 (9) | 2,972 (9) | | 822 (9) |
| 1952-61 | 13 (4) | 469 (4) | 800 (8) | 2,113 (8) | | 706 (8) |
| 1962-71 | No Run | 245 (5) | 23 (10) | 1,405 (10) | | 315 (10) |

Note: (10) denotes number of years averaged.

- Vancouver had a water intake on this system as early as 1924.
- 1928 - water intake dam, eight miles upriver was reported to cut off some ten miles of mainstem and tributaries to coho and steelhead.
- 1947 - dam at eight mile point reported to be an obstruction to coho and steelhead at both high and low discharges.
- 1948 - dam and 90" pipeline at Seymour falls (12 miles) enables massive water withdrawal for domestic use.
- 1950 - eight mile dam removed.
- 1961 - new dam completed at Seymour falls (12 miles).
- pink and chum utilize lower river to Seymour canyon; coho and steelhead upper area and tributaries.
- late thirties and forties - gravel pit operating in and adjacent to river below Dollarton road (pink and chum area).
- 1950 - extensive emergency flood control work (winter dragline and bulldozing Keith road to Dollarton road). Disastrous to pink and chum depositions.
- 1955 - regular flood control work (gravel removal and channelizing) and massive low water withdrawals for domestic purposes have seriously affected pink and chum spawning areas.

# LYNN CREEK

| Years | Pinks Even | Pinks Odd | Chum | Coho | Chinook | Steelhead |
|---|---|---|---|---|---|---|
| 1940-41 (2) | 400 (2) | 25 (2) | 75 (2) | 300 (2) | | 25 (2) |
| 1942-51 (10) | 100 (4) | 50 (5) | 203 (9) | 147 (9) | | 31 (9) |
| 1952-61 (10) | No Run | 25 (4) | 66 (9) | 106 (9) | | 47 (9) |
| 1962-71 (10) | No Run | 5 (5) | 15 (10) | 53 (10) | | 108 (10) |

Note: (10) denotes number of years averaged.

- natural barrier to fish in canyon at 3 miles.
- North Vancouver water supply intake at 4 miles.
- Lynn Valley and lower reaches considered a populated area in 1929 reports. B.C.E. tramline to upper valley.
- silting and heavy gravel removal recorded for the lower area over a number of years. Lower sections considered unstable.
- 1970's very heavy leaching from the north shore sanitary fill area located just above upper levels highway.

# CAPILANO RIVER

| Years | Pinks Even | Pinks Odd | Chum | Coho | Chinook | Steelhead |
|---|---|---|---|---|---|---|
| 1934-41 (8) | 681 (4) | 41,250 (4) | 7,125 (8) | 11,313 (8) | | 1,679 (8) |
| 1942-51 (10) | 15 (5) | 2,470 (5) | 2,970 (10) | 4,300 (10) | | 1,125 (10) |
| 1952-61 (10) | 25 (4) | 400 (5) | 758 (9) | 3,990 (9) | | 491 (9) |
| 1962-71 (10) | No Runs | 35 (10) | 73 (10) | 2,353 (10) | *44 1971 | 93 (10) |

Note: (10) denotes number of years averaged.

- prior to construction of Cleveland dam - coho and steelhead migrated at least to Capilano forks (900' elevation).

- Vancouver city intake operative as early as 1924 (1st report on file).

- 1930 - Vancouver intake 8.5 miles up Capilano River. Water storage at Roger and Pallisade Lakes to compensate for summer low flows.

- West Vancouver water intake in headwaters of Brothers Creek, a tributary running through the present British properties area (chums, coho and steelhead utilize the system).

- Railway logging in Capilano Valley. P.G.E. rail along North Vancouver waterfront.

- 1939 - First Narrows bridge opened - north shore development starts but impetus slowed through war years.

- 1950 - extensive flood control from Keith road down (bulldozing and dragline) affected over 50 percent of the pink and chum spawning grounds.

- 1951 - temporary fishway seven miles upstream to ease low water passage of coho.

- Cleveland dam diversion tunnel under construction.

CAPILANO RIVER (Continued)

- 1952-53 - Cleveland dam under construction and temporary fishway operating.

- 1954 - Cleveland dam filled, fish trapping facilities installed. Dam 300' high is located 3.5 miles from mouth. Reservoir floods out miles of coho and steelhead rearing water. Tests conducted over next few years indicate smolt experience mortality descending dam spillway. Coho appear to rear reasonably well in reservoir but steelhead population declines badly.

- 1955 and succeeding years: flood control in lower system (bulldozing and channelization affects 75 percent of chum and pink salmon spawning ground.

- 1968 - course of Brothers Creek altered by heavy machinery.

- 1971 - fish being molested in lower river - Capilano hatchery begins operation.

- 1972 - Upper levels highway widening (long culverts) dooms the already decimated upper area of Brothers Creek for fish production.

  * First returns from chinook transplants (Big Qualicum River donor stock).

# INDIAN RIVER

| Years | Pinks Even | Pinks Odd | Chum | Coho | Chinook | Steelhead |
|---|---|---|---|---|---|---|
| 1934-41 (8) | 256 (4) | 87,500 (4) | 19,313 (8) | 1,678 (8) | | 559 (8) |
| 1942-51 (10) | 20 (5) | 66,500 (5) | 11,900 (10) | 1,603 (10) | | 175 (10) |
| 1952-61 (10) | 95 (5) | 93,560 (5) | 11,278 (9) | 2,083 (9) | | 356 (9) |
| 1962-71 | 15 (5) | 57,000 (5) | 7,889 (9) | 1,455 (10) | | 267 (9) |

Note: (10) denotes number of years averaged.

- lower 6 miles and tributaries accessible to salmon and steelhead.
- frequent fall and winter freshets produce some changes in flood plain channels resulting in scouring and/or drying up of spawning areas.
- relatively good summer flows.
- 1930's - shingle bolt operation (flume transport).
- 1955 - good forest cover remains on stream - relatively stable flows reported.
- 1963 - Canadian Collieries (Weldwood) - logging road up right bank to falls and beyond. Logging up tributary streams.
- chum salmon reported to use sloughs, tributaries and the main channel to some extent.
- pink salmon more frequent in main channels.

# APPENDIX 4

## NAUTICAL CHARTS DOCUMENTING CHANGES IN INTERTIDAL HABITAT BETWEEN 1929 AND 1975 ON THE NORTH SHORE OF BURRARD INLET.

Figures 1 - 4 prepared from:

Historical nautical charts in the files of the Canadian Hydrographic Service, Marine Services Branch, Department of the Environment, Victoria, B.C.; and 1975 editions of Canadian Nautical Charts 3482 and 3483.


FIGURE 1. A portion of Canadian Hydrographic Service Field Sheet 2206-L showing the relationship between developed and undeveloped intertidal lands in the Seymour-Maplewood area in 1929.


Figure 2. A portion of British Admiralty Chart 922 showing the relationship between developed and undeveloped intertidal lands on the north shore of Burrard Inlet in 1930.

Figure 3. A portion of British Admiralty Chart 922 showing the relationship between developed and undeveloped intertidal lands on the north shore of Burrard Inlet in 1957.


Figure 4. Portions of Canadian Nautical Charts 3482 and 3483 showing the relationship between developed and undeveloped intertidal lands on the north shore of Burrard Inlet in 1975. Note: Canadian Nautical Chart 3483 has not been updated to show the filled areas at the Log Pond and adjacent to Electric Reduction.