Fall and Winter Inventories of Ducks on the Fraser River Delta and Boundary Bay, 1977-1978.

by

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JANUARY 1985

Government of Canada / Gouvernement du Canada

MEMORANDUM **NOTE DE SERVICE**

JPS/sg

TO / À: A/Regional Director
Canadian Wildlife Service
Pacific & Yukon Region

FROM / DE: A/Chief Migratory Birds
Canadian Wildlife Service
Pacific & Yukon Region

SECURITY - CLASSIFICATION - DE SÉCURITÉ
OUR FILE/NOTRE RÉFÉRENCE: 9410-2
YOUR FILE/VOTRE RÉFÉRENCE:
DATE: October 9, 1984

SUBJECT / OBJET: Fall and Winter Inventories of Ducks on the Fraser River Delta and in Boundary Bay, 1977-1978

This report presents the results of aerial surveys conducted on the Fraser Estuary and in Boundary Bay in 1977 and 1978. Its purpose is to make available to other agencies and researchers these results so that they can be used for impact assessments and for the design of more detailed study in the area. The report indicates which waterfowl species winter in the Fraser Estuary and provides insight into their abundance and distribution.

G.W. Kaiser

Abstract

In this report, I present and analyse the results of ground and aerial surveys conducted between October 27, 1977 and March 2, 1978 in Boundary Bay and on the Fraser River Estuary. Dabbling ducks were distributed along the whole foreshore with the greatest numbers in Boundary Bay and were associated with mudflats and tidal marshes. Diving ducks occurred mostly on the outskirts of Boundary Bay and near Iona Island, avoiding extensive mudflats. The most abundant dabblers were mallard (Anas platyrhynchos), American wigeon (A. Americana) and northern pintail (A. acuta), whereas the most common diving ducks were scaup (Aythya sp.), surf scoters (Melanitta perspicillata) and ruddy duck (Oxyura jamaicensis). In the open water of Boundary Bay, scaup and bufflehead (Bucephala albeola) were observed in shallower waters than scoters and oldsquaw (Clangula hyemalis). Ground surveys promised better than aerial surveys for monitoring waterfowl populations on the foreshore, however their accuracy and precision should be investigated further.

Résumé

Je présente et analyse dans ce rapport les résultats d'inventaires terrestres et aériens effectués entre le 27 octobre 1977 et le 2 mars 1978 dans la baie Boundary et dans le delta du fleuve Fraser. Les canards barbotteurs étaient repartis sur tout le delta atteignant les densitées les plus élevées dans la baie Boundary. Ils étaient associés aux battures de même qu'aux marécages intertidaux. Les canards plongeurs étaient surtout concentrés a l'entrée de la baie Boundary et près de l'île Iona, évitant les grandes battures. La population de canards battoteurs était dominée par le canard mallard (Anas platyrhynchos), le canard sifleur (A. Americana) et le canard pilet (A. acuta) alors que celle des canards plongeurs était dominée par les morillons (Aythya sp.), la macreuse a front blanc (Mellinetta perspicillata) et le canard roux (Oxyura jamaicensis). Dans la baie Boundary, les morillons et les petits garrots fréquentent des eaux moins profondes que les macreuses et le canard kakawi (Clangula hyemalis). Les inventaires terrestres semblement plus prometteurs que les inventaires aériens pour dénombrer les populations de sauvagine de l'estuaire. Cependant leur précision et efficacitée devraient etre étudié plus en profondeur.

Introduction

The importance of the Fraser River estuary for wintering waterfowl is well known (Taylor 1970, Campbell et al. 1972, Leach 1972, Vermeer and Levings 1977). In the last decade, several attempts were made by the Canadian Wildlife Service to estimate the size of wintering bird populations along the Fraser foreshore of the Fraser River Delta and in Boundary Bay. Monthly averages of aerial surveys, conducted from September to March between 1966 and 1970, ranged from 22,000 birds in February to 100,000 in November (Taylor 1970). Aerial surveys conducted in 1973 had a maximum monthly average of only 41,720 in October (Entech 1974). The average for November was 24,697.

These surveys provided general information on the seasonal abundance of waterfowl and their distribution along the foreshore of the Fraser River Delta. However, they yielded only crude estimates of abundance of individual species and proved inadequate to detect yearly fluctuations in numbers. This is due in part to the large size of bird concentrations and to the occurrence of mixed flocks.

Up to now, the snow goose (Anser caerulencens) is the only species whose numbers have been successfully monitored (Jeffrey and Kaiser 1979). Aerial photographs were used to remove counting bias. Also the concentration of snow geese into a small portion of the foreshore facilitated the counts.

Surprisingly, few ground surveys have been attempted in spite of good access to most of the foreshore from dykes (Entech 1974, Page 1976). Fewer birds were recorded in ground surveys than in the aerial surveys (Entech 1974). However, more species were identified and for some species better estimates were obtained.

The goal of this report is to present and analyse the results of ground and aerial surveys conducted between October 27, 1977 and March 2, 1978 on the Fraser River Estuary and in Boundary Bay.

Study Area

The study area extended from Iona Beach Park to the tip of Point Roberts and in Boundary Bay from the tip of Point Roberts to Tongue Point U.S. (Fig 1). Some portions of the study area were surveyed more often than others and some were only surveyed from the air.

Methods

1. Ground surveys

All ground surveys were carried out by the author. Vehicular access to the dykes along Boundary Bay and Roberts Bank was obtained from the Delta municipal engineer and from the B.C. Harbour Board. This greatly facilitated the survey work. All observations were recorded on cassette tapes and transcribed at the end of each survey. This considerably shortened the duration of the surveys and enabled us to complete them in spite or rapidly changing tides. The location of observation points is presented in Figs. 2 and 3.

Observations were made from dykes with a 15X - 60X Zoom telescope and 7 X 35mm binoculars. Large flocks of dabbling ducks were not always separated by species because of time constraints and visibility. The size of these large flocks was determined by estimating the number of birds in the field of the telescope and moving the telescope, until the whole flock was covered. Counts were usually done by the 10's, 100's or 1000's depending upon the numbers and concentration of the birds. Whenever possible, birds were counted one by one.

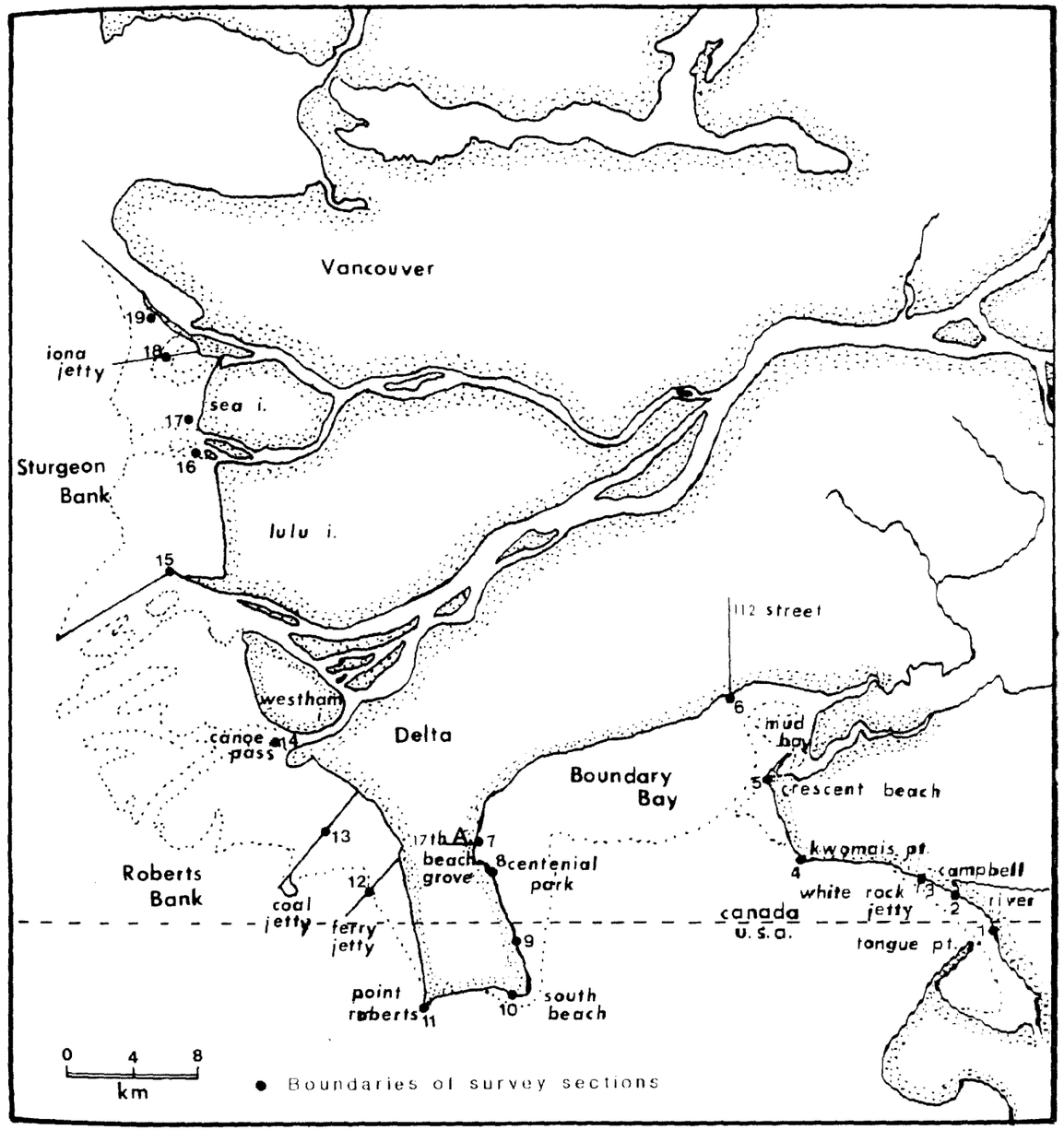

Fig. 1. Study area

Figure 2. Location of observation points and of bird concentrations in Boundary Bay during fall and winter.

▲ Observation points

Distribution of dabbling ducks

Distribution of diving ducks*

Concentration of scaups

Concentration of Western grebes

☆ Concentration of Ruddy ducks

• Boundaries of survey sections

*Diving ducks were also very abundant in the open waters of the Bay.

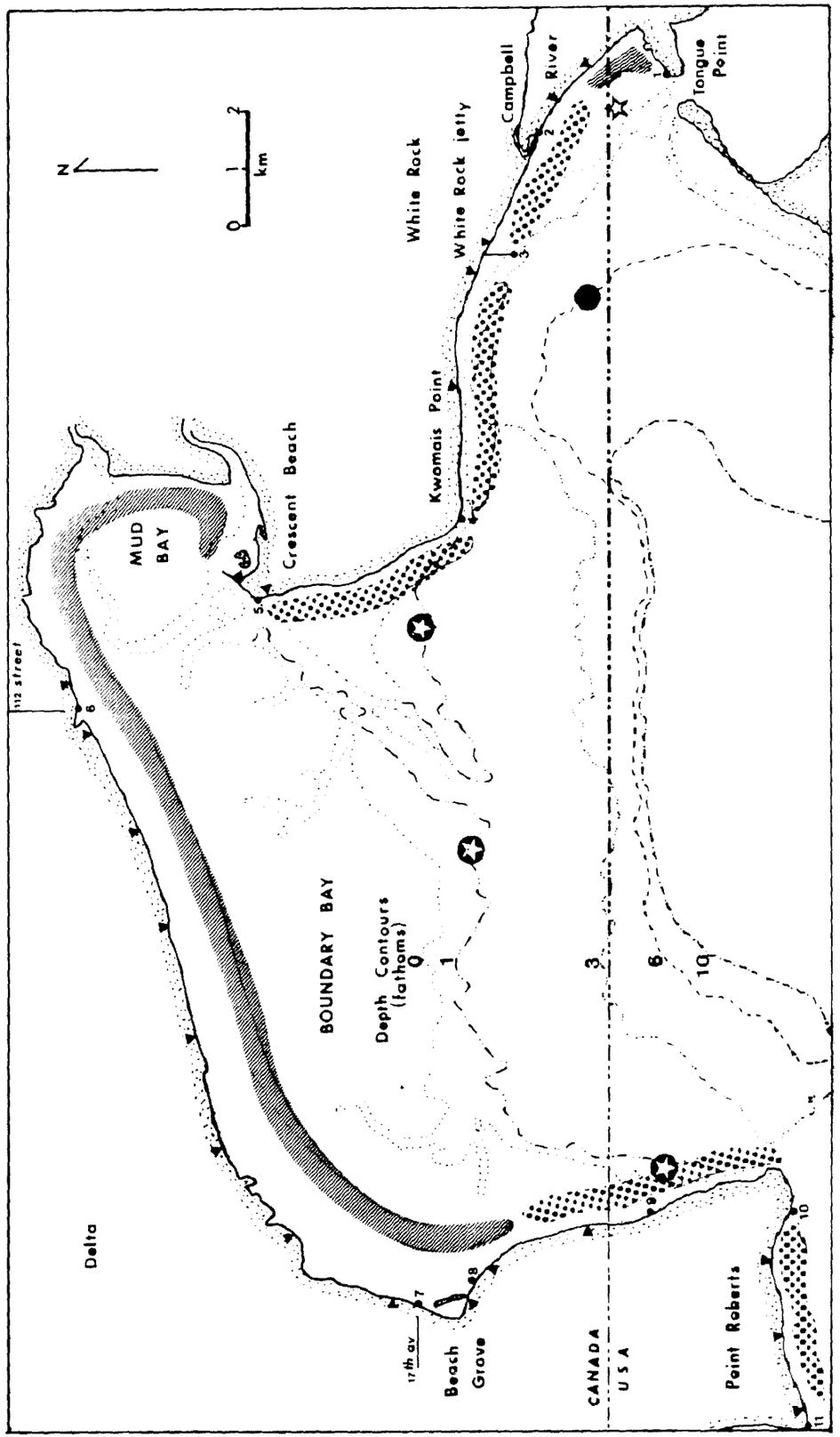

Figure 3. Location of observation points and of bird concentrations in Boundary Bay during fall and winter.

▲ Observation points

Distribution of dabbling ducks

Distribution of diving ducks*

Concentration of scaups

Concentration of Western grebes

☆ Concentration of Ruddy ducks

• Boundaries of survey sections

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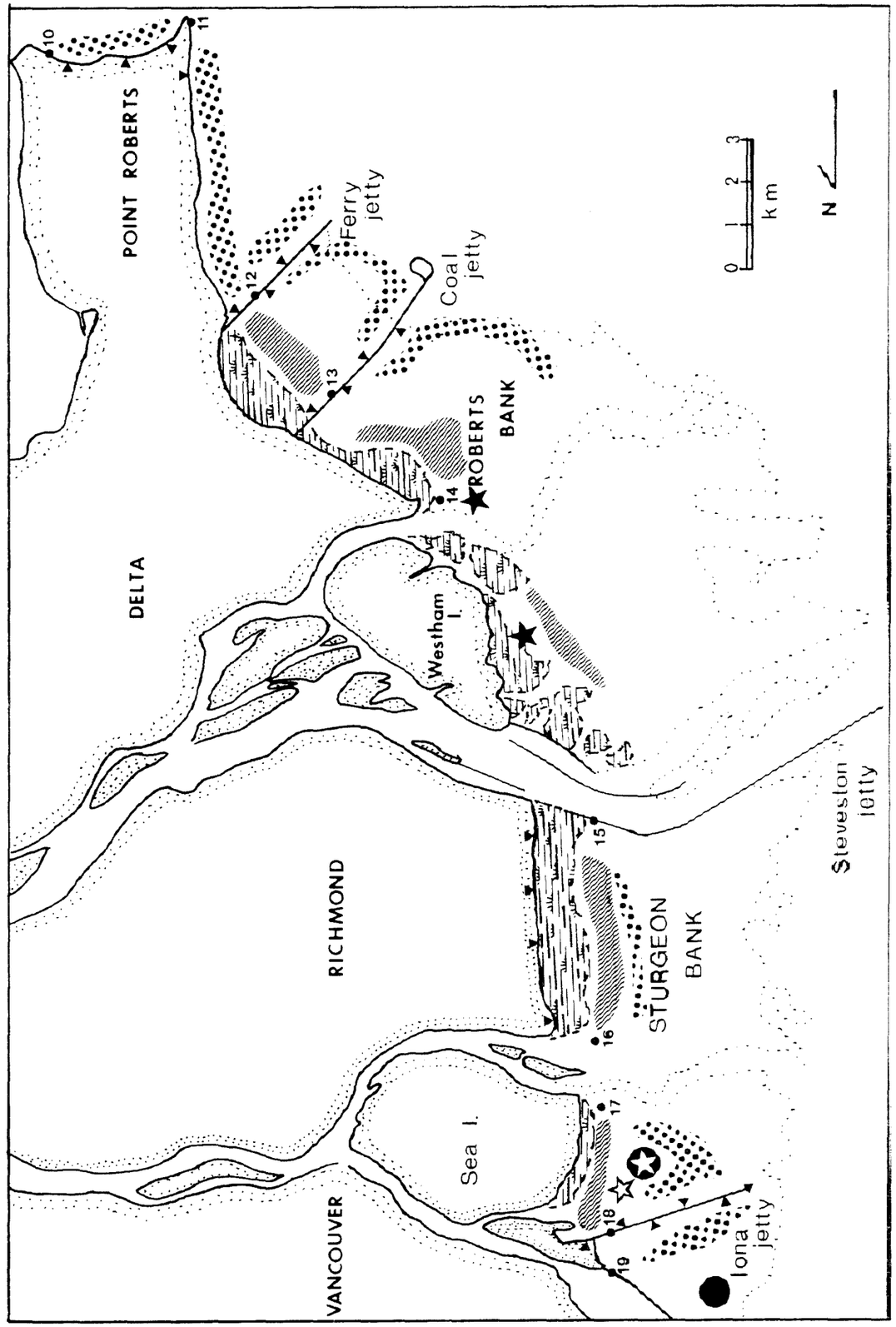

Aerial Surveys

The flight line followed the tide line closely, missing birds inside the marshes. Cruising speed averaged approximately 160 km/hour and flying height 60 meters. No attempts were made to restrict observations to a given width of transect because of the clumped distribution of the birds. All observations were recorded on cassette tapes and transcribed at the end of each trip.

Results

The whole study area was divided into 14 sections (Fig. 1) and the numbers of birds seen in each section during ground surveys are given in appendix 1. The majority of shorebirds were dunlin (Calidris alpina) while most unidentified ducks were probably diving ducks.

Distribution and abundance of dabbling ducks

Dabbling ducks were distributed along the whole foreshore with the greatest numbers occurring in Boundary Bay (Table 1). The highest number of dabbling ducks observed in Boundary Bay was 27,839 individuals compare to 9,914 for Roberts Bank and 5,302 for Sturgeon Bank. In Boundary Bay, dabbling ducks were dispersed along the shoreline from Crescent Beach to Beach Grove but occurred in low numbers on the outskirt of the Bay (Table 1 and 2).

Two ground surveys were conducted over the whole foreshore except Westham Island. During the first survey between December 19 and 21, 39,457 dabbling ducks were counted while on the second survey between February 28 and March 2, 23,314 were observed. The accuracy and precision of those counts are unknown. However, they are believed to be more reliable than aerial counts.

Table 1. Number of dabbling ducks observed during ground surveys.

Survey date	Survey sections (No.)					
	White Rock (1-4)	Boundary and Mud Bay (5-8)	Centennial Park (8-9)	Roberts Bank (12-14)	Sturgeon Bank (15-16)	Iona Island (17-19)
October 31	*	*	2205	*	*	*
November 4-7	*	27839	*	7079	*	*
November 22-23	*	9199	167	*	*	637
November 30	210	23444	0	*	*	*
December 19-20	264	23760	45	9914	5392	481
February 7-9	*	17123	0	6673	1723	1030
February 28 - March 2	761	17175	256	2420	1959	1504

* Section not surveyed on this date.

Table 2. Number of dabbling ducks observed during aerial surveys.

Survey date	Survey section (No.)			
	White Rock (1-5)	Boundary and Mud Bay (5-8)	Centennial Park (8-10)	Point Roberts (10-12)
November 1	0	17272	10	29
November 29	115	2375*	0	0
December 15	0	2503*	0	30
December 15	2	2452*	0	0

* Low numbers because a large number of ducks were unidentified but were probably Dabbling ducks. They were not included here.

These estimates should be regarded as minimum estimates since only the foreshore was surveyed. Many dabbling ducks fed in fields during winter and therefore were not included in the counts. Also, the national wildlife area on Westham Island was not included in these counts. More than 10,000 dabbling ducks have been observed there at times during winter months.

Numbers of dabbling ducks remained fairly constant in Boundary Bay while they fluctuated considerably on Roberts Bank and Sturgeon Bank between December 19 and March 2.

American wigeon (Anas americana), pintail (A. acuta), mallards (A. platyrhynchos), and green-winged teal (A. crecca) accounted for more than 95% of all dabbling ducks. Unfortunately, their relative abundance could not be determined because of large numbers of unidentified ducks. Two other species were observed in lower numbers, the northern shoveler (A. clypeata)and the gadwall (A. strepera).

Species of dabbling ducks were not dispersed uniformely along the foreshore. Gadwall and northern shoveler were observed only on Sturgeon Bank near Iona Island and green-winged teal were more abundant on Sturgeon Bank than in any other section. A few hundred teals were also observed in Boundary Bay but they were concentrated in a small intertidal slough near Beach Grove. Most dabbling ducks observed in Boundary Bay and on Roberts Bank were American wigeon, pintail and mallard.

Distribution and abundance of diving ducks

The distribution of diving ducks contrasted with that of dabbling ducks. Diving ducks were observed mostly on the ends of Boundary Bay (i.e. near White

Rock and Centennial Park) while dabbling ducks were in the bay itself (Tables 1 and 2, and Fig. 3). More diving ducks were seen near Iona Island than on either Roberts Bank or Sturgeon Bank while the reverse applied to dabbling ducks (Table 1 and 3).

Two complete surveys of the foreshore, Westham Island excluded, were conducted. During the first survey between December 19 and 21, 6,030 diving ducks were seen, while 8,571 were recorded on the second survey (February 28 to March 2). Ground surveys tend to underestimate diving duck numbers because only birds close to the shore can be counted.

Scaup (Aythya sp.) were the most abundant diving ducks in Boundary Bay and on the forshore of the Fraser River Delta (Tables 5 and 6). Flocks of this species were observed regularly near Iona Island (section 17-18), near the Canada U.S.A. boundary line in Boundary Bay (section 9-10) and off Kwomais Point (section 3-4) (Figs. 2 and 3). Surf scoter (Melanitta perspicillata) were the second most abundant diving ducks in Boundary Bay followed by Ruddy duck (Oxyura jamaicensis) (Table 5). The order of abundance of those two species was reversed on the Fraser foreshore (Table 6). White-winged scoter (Melanitta deglandi) outnumbered black scoter (M. nigra) in Boundary Bay but not on the Fraser foreshore. Bufflehead (Bucephala albeola) were abundant in both areas but never occurred in large concentrations. Goldeneye (Bucephala sp.) and oldsquaw (Clangula hyemalis) were sparsely distributed and never formed large concentrations. The latter was more abundant offshore. Canvasback (Aythya valisineria) were mostly observed in front of the marshes along Sturgeon Bank, usually in flocks of 10 to 30 birds. Males were more numerous than females. An increase in the number of canvasback occurred in early March when the counts in the study area tripled.

Table 3. Number of diving ducks observed during ground surveys.

Survey date	Survey sections (No.)					
	White Rock (1-4)	Boundary and Mud Bay (5-8)	Centennial Park (8-9)	Roberts Bank (12-14)	Sturgeon Bank (15-16)	Iona Island (17-19)
October 31	*	*	4411	*	*	*
November 4-7	*	410	*	936	*	*
November 22	*	195	5935	*	*	2116
November 30	4346	471	1672	*	*	*
December 19-20	2282	278	381	231	401	2457
February 7-9	*	290	832	445	247	1761
February 28 - March 2	738	342	1794	915	582	4200

* Not surveyed.

Table 4. Number of diving ducks observed during aerial surveys.

Survey date	Survey sections (No.)			
	White Rock (1-5)	Boundary and Mud Bay (5-8)	Centennial Park (8-10)	Point Roberts (10-12)
November 1	910	543	12291	1015
November 29	1936	5	420	524
December 15	1135	76	283	98
December 15	1481	84	302	285

Table 5. Relative abundance (Number of birds seen) of diving ducks in Boundary Bay.

Species	Survey date		
	November 30 1977	December 19 1977	February 28-March 2 1978
Canvasback		6	101
Scaup sp.	3175	1427	1501
Common goldeneye	65	13	11
Goldeneye sp.	39	14	15
Bufflehead	174	64	363
Oldsquaw	10	2	74
Harlequin duck	10	2	
White-winged scoter	125	88	13
Surf scoter	618	294	387
Black scoter	53	43	23
Scoter sp.	265	58	101
Ruddy duck	375	572	6
Red-breasted merganser		2	7
Merganser	65	4	
Duck sp.	1326*	322	1065**

* Approximately 1000 were believed to be scaups.
** Were seen in Beach Grove and were probably scaups.

Table 6. Relative abundance (number of birds seen) of diving ducks on the Fraser Foreshore.

	Survey Date		
	December 20-21 1977	February 8-9 1978	February 28 March 1 1978
Canvasback	115	57	416
Scaup sp.	1182	781	2745
Common goldeneye	14	33	29
Barrow's goldeneye	9	8	31
Goldeneye sp.	12	18	16
Bufflehead	109	42	224
Oldsquaw	66	76	42
White-winged scoter	46	48	117
Surfscoter	249	337	445
Black scoter	112	261	203
Scoter sp.	23	39	94
Ruddy duck	795	783	1300
Red-breasted merganser	16	4	37
Merganser sp.	4		2
Duck sp.	307	29	43

Large numbers of diving ducks were observed in the open waters of Boundary Bay. Species appeared to be distributed according to water depth (Table 7). Scaup and bufflehead were more abundant in transects over water 0 to 2 fathoms deep. Scoters and oldsquaw preferred deeper waters ranging from 2 to 4 fathoms. Loons (Gaviidae) and grebes (Podicipedidae)were mostly observed in water over 4 fathoms deep.

Discussion

1. Dabbling ducks

Ground surveys seemed to provide a good estimate of the numbers of dabbling ducks in Boundary Bay and along the foreshore of the Fraser River Delta. Counts in Boundary Bay have to be done at high tide, because the large sand and mud flats exposed at low tides make identification impossible. A complete ground survey of Boundary Bay and the foreshore must be spread over three days by one observer. More time is required if all counts are to be done at exactly the same tide height but other factors such as wind direction and weather also affect bird distribution and such precision is not necessarily productive of more information.

Data is lacking on the relative abundance of each species of dabbling duck. Proportions given in the literature (Taylor 1970, Vermeer and Levings 1977) are all derived from aerial surveys and therefore questionable. The occurrence of mixed flocks and the specific habitat preferences of some species considerably influence aerial survey data. Unfortunately, dabbling ducks were not all identified to species in the present ground surveys because of tide and time constraints in the attempt to survey all species of birds at the same time. A fairly complete speciation is possible for surveys limited to dabbling ducks.

Table 7. Distribution of some species in the open water of Boundary Bay (% seen in each zone. Results of 3 surveys combined).

Species	Depth in fathoms		
	0-2	2-4	4-10
Loons n=90*	27	28	45
Grebes n-962	7	5	88
Scaups n=7602	97	2	1
Bufflehead n-252	87	13	0
Oldsquaw n=806	17	61	22
Scoters n=2441	13	75	12

* n = Total number of individuals seen during the three surveys.

Data are lacking on the activity of dabbling ducks on the foreshore. Although feeding has been observed, most birds seemed to rest on the water. Daily and tidal monitoring of bird activity should help to evaluate the importance of the tidal zone for dabbling ducks.

Diving ducks

Ground surveys provided a biased picture of the diving duck populations in the study area since offshore waters were not sampled adequately. Counts for Roberts Bank and Iona Island were the most accurate because the jettys allow coverage of deeper water. Along Sturgeon Bank, only those birds close to shore could be adequately counted and identified. However, aerial surveys did not necessarily present a more precise inventory of diving ducks. All flights followed the shoreline and there were overwhelming numbers of dabbling ducks present. Ground counts, although incomplete, provided more information about diving ducks in these areas than did aerial surveys.

Only in Boundary Bay did aerial surveys provided a better estimate of diving duck numbers because transects were flown over the open waters of the Bay which are relatively shallow and harbored large numbers of diving ducks.

Ground surveys gave a better idea of the species composition of diving ducks than aerial surveys. Speciation in aerial surveys is often precarious and usually birds are lumped into broad groups so that less abundant species are missed or underestimated (Savard 1979). The abundance of ruddy ducks in ground counts is surprising in the light that this species was barely mentioned in previous aerial surveys (Taylor 1970, Vermeer and Levings 1977). This is probably a consequence of their restricted distribution along the foreshore and their tendency to mix with

dabbling ducks. Most surveys probably did not adequately cover Iona Island because of its proximity to Vancouver International Airport and neglected the American side of the Bay near White Rock where most ruddy duck were observed.

No data are available on habitat utilization by diving duck species in the study area. Information on the daily and tidal activities of the major species would be most useful to design efficient surveys.

Conclusion

So far, attempts to monitor the aquatic bird populations wintering on the Fraser River Delta and in Boundary Bay have failed. Aerial surveys conducted in the last two decades, provided only relative estimates of the global wintering population and have proved inadequate as a tool to measure yearly fluctuations of most species. Ground surveys seem to offer better potential but their accuracy and precision should be investigated further. Research is needed on habitat selection and feeding habits on most wintering species. Results of such research would help in improving the accuracy and precision of surveys.

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Appendix 1.A Ground surveys near White Rock

Location	Kwomais Pt. to White Rock Jetty			White Rock to Campbell River			Campbell River to Tongue Pt.		
Section	3-4			2-3			1-2		
Survey date	Nov. 30,1977	Dec. 19,1977	Mar. 2,1978	Nov. 30,1977	Dec. 19,1977	Mar. 2,1978	Nov. 30,1977	Dec. 19,1977	Mar. 2,1978
Common loon		2		1	2		1		
Red-throated loon	2	15			2		1	2	
Loon sp.		7		3	2	1	6	1	2
Red-necked grebe		2							
Horned grebe	9	6		6	1		4		
Western grebe	1			11		51	18		432
Pied-billed grebe	1								
Grebe sp.	4						1		1
Cormorant sp.	2			1			1		
Great blue heron							2		
Mallard							1	7	2
Pintail								5	279
American wigeon				1			2	14	1
Dabbler sp.						10	206	238	479
Scaup	802	230	15	84	344	8	1530	501	144
Common goldeneye	3		1	3		2		1	
Goldeneye sp.	1	3	3	2	4		2	1	1
Bufflehead	22	11	6	12	10	7	8	5	35
Oldsquaw	1		10	1				1	4
Harlequin duck	7	2							
White-winged scoter	4	1	4	7	2		29	13	7
Surf scoter	195	95	148	126	48	142	98	63	67
Black scoter	16	2	12	5	4	4	3		5
Scoter sp.	13	26	1	9	12	1	154	17	37
Ruddy duck	11	5	1	64	96	1	291	430	41
Red-breasted merganser			1						4
Merganser sp.								4	
Duck sp.	778	316			30		65	5	26
American coot							15	3	
Dunlin							85		
Shorebird sp.								75	
Gull sp.	2	12	35	135	109	12	89	330	159
Alcid	4								

Appendix 1.B Ground surveys in Mud Bay (Section 5-6)

Survey date	Nov. 4, 1977	Nov. 22, 1977	Nov. 30, 1977	Dec. 19, 1977	Feb. 7, 1978	Mar. 2, 1978
Common loon	7	4				
Red-throated loon			2	1		
Loon sp.		3	26	5		1
Red-necked grebe	1					
Horned grebe				2		
Western grebe			176			
Grebe sp.	3		2			
Cormorant sp.		5	12	3	7	7
Great blue heron		2	6	4	2	
Brant			7	4	26	
Mallard	30	4				
Pintail	30			1		
Green-winged teal	2	9				
American wigeon	375	46				
Northern shoveler			1			
Dabbler sp.	5070	1731	5860	6392	482	720
Canvasback		10		6	3	101
Scaup sp.	20	123	86	11	3	
Common goldeneye			43	12	1	
Goldeneye sp.		38	32	5		
Bufflehead	1	15	17	28	2	
White-winged scoter	21	6	2	2	13	
Surf scoter	25	5	9	20	10	2
Scoter sp.	11	7	6	3		3
Ruddy duck			9	23	9	6
Red-breasted merganser				2	7	
Merganser sp.	1	2	10			
Duck sp.	3	387	17		38	1
Black-bellied plover		77				
Dunlin		645	209		550	
Shorebird sp.	3010	375		965		3950
Gull sp.	9	298	46	133	11	
Pigeon guillemot	1					

Appendix 1.C Ground surveys in Boundary Bay from 17 Avenue to 117 Street (Section 6-7)

Survey date	Nov. 4, 1977	Nov. 22, 1977	Nov. 30, 1977	Dec. 19, 1977	Feb. 7, 1978	Mar. 2, 1978
Common loon	5					
Loon sp.	3			2		
Western grebe	51			1		
Cormorant sp.		5		3		
Great blue heron	4	4	16	1		4
Mallard		176	16	12	1249	170
Pintail	450	163	5	20	1635	973
Green-winged teal	3		16		110	
American wigeon	2744	658	1096	600	2268	427
Dabbler sp.	16726	4544	15244	15223	10288	14037
Scaup sp.				6	26	
Goldeneye sp.		1				
Buflehead		1				
White-winged scoter	2		29	29	4	
Surf scoter	3	2	13	19	32	
Black scoter				21		
Scoter sp.	24					
Ruddy duck				12		
Duck sp.	200	2744*			25	175
Red-tailed hawk				3		
Rough-legged hawk				1		
Bald eagle					2	1
Marsh hawk		4		4		1
Peregrine falcon						1
Pigeon hawk				1		
Black-bellied plover	189	7	1		52	
Dunlin		6800	21530		7024	
Shorebird	28513			5150	1150	3865
Gull sp.	6	757	36	55	291	260
Snowy owl				9		1
Short-eared owl			1			

* Probably dabbling ducks.

Appendix 1.D Ground surveys in Beach grove from 17th Avenue to Centenial Park (Section 7-8)

Survey date	October 31, 1977	November 4, 1977	November 22, 1977	November 30, 1977	December 19, 1977	February 7, 1978	March 2, 1978
Red-throated loon				1	2		
Horned grebe	3			2			
Western grebe	10	1		3	5	3	
Grebe sp.	1						
Great blue heron	4	1	1		1		11
Mallard	65	130	433	197	209	123	1
Pintail	2382	582	266	910	1048	38	125
Green-winged teal	232	138	338	21	17	244	222
American wigeon	875	1509	231	78	143	686	121
Dabbler sp.	750	50	600		95		379
Scaup sp.	14	12		65	62	43	
Common goldeneye				11		3	1
Goldeneye sp.				2			
Bufflehead	8			19		1	5
Oldsquaw						1	
White-winged scoter	5	59		33	8	16	10
Surf scoter		13		27	6	28	8
Black scoter		10		8	1	5	
Scoter sp.	11	2				4	28
Ruddy duck					2		
Red-breasted merganser						17	2
Merganser sp.				1			
Duck sp.	1292	3		32		2	1065
Dunlin	40		1	25			
Dowitcher	200						
Sanderling						10	
Gull sp.	26	168	127	40	1	46	34

Appendix 1.E Ground survey near Centenial Park (Section 8-9)

Survey date	October 31, 1977	November 22, 1977	November 30, 1977	December 19, 1977	February 7, 1978	February 28, 1978
Common loon	2		1			
Loon sp.	6	2	5	1		5
Red-necked grebe			1			
Horned grebe	54		28	3		
Western grebe	2		9	2	2	
Grebe sp.	14	1	5			
Double-crested cormorant	12	12				
Cormorant sp.	3	15	2	13	10	
Canada goose	1					
Brant					35	
Mallard	72	10				6
Pintail	1228					3
Green-winged teal				45		
American wigeon	903	157				247
Northern shoveler	2					
Scaup sp.	126	5319	608	273	710	1349
Common goldeneye			5		3	7
Barrow's goldeneye	2					
Goldeneye sp.		4	16	1		11
Bufflehead	109	118	96	10	28	310
Oldsquaw	3	6	8	1	3	60
Harlequin duck	2		3			
White-winged scoter	31	7	21	33	5	3
Surf scoter	45	42	150	43	62	20
Black scoter	37	19	21	15	19	2
Scoter sp.	56	18	83		1	31
Ruddy duck				4		
Red-breasted merganser			173			1
Merganser sp.	8		54			
Duck sp.	3992	402	434	1	1	
Marsh Hawk			1			
Dunlin		50				
Sanderling			45		50	
Gull sp.	229	242	74	8	12	302

Appendix 1.F Ground surveys near Point Roberts

Location	Ferry Jetty to Point Roberts		Point Roberts to South Beach	
Section	11-23		10-11	
Survey Date	November 22, 1977	February 28, 1978	November 22, 1977	February 28, 1978
Common loon	4	1		1
Loon sp.	2	5	24	5
Horned grebe	13		4	
Western grebe	81	2	19	
Grebe sp.	3		1	
Double-crested cormorant	28	30		2
Pelagic cormorant	1		30	
Cormorant sp.	1	10	1	22
Great blue heron	2			
Brant			1	
Scaup sp.	28	89	21	17
Common goldeneye	86	12	9	2
Goldeneye sp.	17	5	35	6
Bufflehead	24	65	20	1
Oldsquaw	9	2	16	4
Harlequin duck	3	2	18	32
White-winged scoter	1	18	4	7
Surf scoter	11	29	234	117
Black scoter	4	17	30	8
Scoter sp.	18	14	37	50
Ruddy duck		8		
Red-breasted merganser	5	1	1	
Merganser sp.	11		4	1
Duck sp.	221	20	60	3
Black-bellied plover			45	
Black turnstone			7	
Dunlin			6	
Sanderling			5	
Shorebird sp.			21	
Gull sp.	115	26	68	49
Common murre	26		8	
Pigeon guillemot			2	
Alcid sp.	18		1	

Appendix 1.G Ground surveys over Roberts Bank from ferry jetty to coal jetty (Section 12-13)

Survey Date	November 7, 1977	December 20, 1977	February 8, 1978	February 28, 1978
Common loon	6	3	1	6
Red-throated loon	1	4		1
Loon sp.	2	2	1	15
Red-necked grebe	9			9
Horned grebe	13	7		
Western grebe	64	100		1
Grebe sp.	13			4
Pelagic cormorant	1		2	
Cormorant sp.	7	9	1	6
Great blue heron	19		3	2
Mallard	74	28		89
Pintail	60			241
Green-winged teal				11
American wigeon	4994	1094	44	46
Dabbler sp.		5814	5440	260
Canvasback	2	2		
Scaup sp.	207	53	77	191
Common goldeneye		5	16	14
Goldeneye sp.	1	2		1
Bufflehead	214	90	4	113
Oldsquaw	1		1	
Harlequin duck	1			
White-winged scoter	13	8	21	87
Surf scoter	6	9	20	36
Black scoter	7	8	16	42
Scoter sp.		8	6	33
Ruddy duck		10	1	
Red-breasted merganser	83	2		6
Merganser sp.	2			
Duck sp.	90	31	7	
Marsh hawk		1		1
Bald eagle	1			1
Black turnstone		8		
Dunlin		2855	900	2
Shorebird sp.	1915			
Gull sp.	276	38	7	23

Appendix 1.I Ground surveys over Sturgeon Bank (Section 15-16)

Survey Date	December 20, 1977	February 9, 1978	March 1, 1978
Red-throated loon	1		
Horned grebe	2		15
Western grebe	5	2	1
Cormorant sp.	5	1	1
Great blue heron	7	3	4
Swan sp.	5	7	9
Snow goose			75
Mallard	326	53	148
Gadwall		8	2
Pintail	196	65	376
Green-winged teal	1297	147	581
American wigeon	590	195	810
Dabbler sp.	2893	1255	42
Canvasback	86	18	232
Scaup sp.	3	207	199
Common goldeneye	3		
Goldeneye sp.	1	1	1
Bufflehead	8	12	53
Oldsquaw	3	1	
White-winged scoter	8		13
Surf scoter	10		34
Scoter sp.	1		27
Red-breasted merganser	8		16
Merganser sp.	2		2
Duck sp.	268	8	5
Marsh hawk	1		1
American coot	1		9
Dunlin	75		
Shorebird sp.	460	207	260
Mew gull			8
Gull sp.	92	520	48
Snowy Owl	1	2	2

Appendix 1.J Ground surveys on Iona Island, south of Iona jetty (Section 17-18)

Survey date	November 23, 1977	December 21, 1977	February 9, 1978	March 1, 1978
Common loon	4			
Red-throated loon		1		
Loon sp.	5	11		5
Red-necked grebe	4	7	4	9
Horned grebe	9	28	3	46
Western grebe	335	254	10	3
Grebe sp.	4			10
Double-crested comorant	1			
Cormorant sp.	7	3	1	1
Gadwall	103	152	6	2
Pintail	28		1	482
Green-winged teal			644	90
American wigeon	53	2		
Northern shoveler	72	19	32	
Dabbler sp.			327	930
Canvasback	1	27	36	114
Scaup sp.	173	750	125	1956
Common goldeneye	8	5	3	5
Barrow's goldeneye		3		16
Goldeneye sp.	8	7	4	11
Bufflehead	1	9	1	14
Oldsquaw	30	51	8	75
White-winged scoter	11	14	1	8
Surf scoter	78	108	52	212
Black scoter	2	17	13	3
Scoter sp.	5	8	4	20
Ruddy duck	335	785	752	1300
Red-breasted merganser	6	6	1	3
Merganser sp.	3			
Duck sp.	8	8	12	12
Sanderling	1			35
Shorebird sp.			1160	1150
Gull sp.	107	295	84	394
Murre sp.		28		
Pigeon guillemot	1			
Alcid sp.		32		
Short-eared owl		2		

Appendix 1.K Ground surveys on Iona Island, north of Iona jetty (Section 18-19)

Survey date	November 23, 1977	December 21, 1977	February 9, 1978	March 1, 1978
Common loon	5			
Red-throated loon	3			
Loon sp.	3	5	7	14
Red-necked grebe		1		2
Horned grebe	10	1	5	7
Western grebe	2748	148	2	460
Grebe sp.				2
Double-crested comorant			1	
Pelagic cormorant				1
Cormorant sp.		2	1	2
Great blue heron	1		24	
Mallard	10	7		
Gadwall	92	297	17	
Green-winged teal			2	
American wigeon	12	4	1	
Northern shoveler				
Dabbler sp.	267			
Canvasback			2	
Scaup sp.	37	376	254	213
Common goldeneye		1	4	2
Barrow's goldeneye		6	8	15
Goldeneye sp.	4	2	13	3
Bufflehead		2		2
Oldsquaw	13	33	12	30
White-winged scoter	1	14	16	8
Surf scoter	123	122	242	153
Black scoter	11	96	172	129
Scoter sp.	21	5	12	10
Ruddy duck			3	
Red-breasted merganser	1		3	
Merganser sp.	3	2		
Duck sp.	104		8	
Sanderling		17	11	50
Shorebird sp.		13		11
Gull sp.	32	191	302	15
Murre sp.				1

Appendix 2.A. Aerial survey on November 1, 1977 between 14, 10 and 1530 h. (observers: Gary Kaiser and Jean-Pierre Savard; airplane: Cessna)

Species	Survey Sections (No.) Tongue Pt. to Mud Bay (1-5)	Mud Bay (5-6)	Boundary Bay (6-8)	Centennial Park (8-10)
Common loon	1			1
Loon sp.		9	7	29
Red-necked grebe				1
Western grebe	13			
Grebe sp.			13	3
Cormorant sp.	2	1		
Great Blue Heron		3	3	8
Brant				
Snow goose				
Mallard		42	107	5
Pintail		7	201	
Green-winged teal		10		
American wigeon		12	1441	
Dabbling duck sp.		3406	12046	5
Canvasback		25		2
Scaup sp.	201			12086
Goldeneye sp.				
Bufflehead	4	4		29
Oldsquaw				45
Harlequin duck				4
White-winged scoter			3	16
Surf scoter	1	2	59	3
Black scoter				
Scoter sp.	704	9	441	108
Merganser sp.		5		83
Duck sp.	1080	94	127	710
Bonaparte's gull	26			
Gull sp.	32	306	334	85
Alcid sp.				
Shorebird sp.		1040	5950	50

Appendix 2.A continued

Species	Tip off Pt. Roberts (10-11)	Pt. Roberts Ferry jetty (11-12)	Ferry jetty Coal Jetty (12-13)	Coal jetty Canoe Pass (13-14)	Wetham Island (14-15)	Sturgeon Bank (15-16)
	Survey Sections (No.)					
Common loon						
Loon sp.	14					
Western grebe		2				1
Grebe sp.	1					
Cormorant sp.		26		4		3
Great Blue Heron					1	
Brant					6	
Snow goose				8000		
Pintail						
Green-winged teal				50		1258
American wigeon			7750	120	50	
Dabbling duck sp.		25	3000	200		2100
Canvasback						
Scaup sp.		63				
Goldeneye sp.						
Bufflehead	20					
Oldsquaw	3					
Harlequin duck	18					
White-winged scoter	2					
Surf scoter	68	161				
Black scoter						
Scoter sp.	673	3				
Merganser sp.	4					
Duck sp.	84			212	64	50
Bonaparte's gull						
Gull sp.	56	224		5	29	13
Alcid sp.	1					
Shorebird sp.				19400		
Mallard		4	15300	2		15

Appendix 2.B. Aerial survey done on November 29, 1977 between 1235 and 1435 h. (observers: Leo Collins and Jean-Pierre Savard; airplane: Twin Otter)

Species	Tongue Pt. to White Rock Jetty (1-3)	White Rock Jetty to Kwomais Pt. (3-4)	Kwomais Pt. to Crescent Beach (4-5)	Mud Bay (5-6)	Boundary Bay (7-8)	Centenial Park (9-10)	Tip of Pt. Roberts (10-11)	Pt. Roberts to Ferry Jetty (11-12)
	Survey Sections (No.)							
Loon sp.								2
Western grebe							32	
Grebe sp.							1	20
Double-crested cormorant							1	3
Cormorant sp.	1			2			3	59
Great blue heron	4			3	14			
Mallard		90		235	1084			
American wigeon	15				21			
Dabbling duck sp.	10			775	260			
Scaup sp.	3	1200	142			201	15	56
Common goldeneye							1	
Goldeneye sp.	4		7	1		5	13	
Bufflehead	3	27	62			51	48	62
Oldsquaw		28	4	2			4	1
Harlequin duck		1				2	23	
White-winged scoter			3					4
Surf scoter		158		1		147	159	27
Black scoter							16	22
Scoter sp.	7	131	156	1		14	55	15
Merganser sp.							3	
Duck sp.	24	65	505	4	6439	76	36	163
Shorebird sp.				777	5045	65		
Gull sp.	218	7	25	207	296	92	25	28
Murre sp.								2
Alcid sp.						3		

Appendix 2.C. First Aerial survey done on December 15, 1977 between 1030 and 1210 h. (observers: Leo Collins and Jean-Pierre Savard; airplane: Cessna)

Species	Tongue Pt. to White Rock Jetty (1-3)	White Rock to Jetty to Kwomais Pt. (3-4)	Kwomais Pt. to Crescent Beach (4-5)	Mud Bay (5-6)	Boundary Bay (7-8)	Centenial Park (9-10)
	Survey Sections (No.)					
Loon	1		1	1		2
Western grebe						
Grebe sp.		1				
Cormorant sp.	2	1	1	3		1
Swan sp.						
Snow goose						
American wigeon						
Dabbling duck sp.				2503		
Scaup sp.	123	334	50	11		81
Bufflehead	8	2	19	1		3
Oldsquaw	2	3	43	2	1	6
White-winged scoter	3					
Surf scoter	49	105	1			19
Black scoter						2
Scoter sp.	74	184	135		61	171
Merganser sp.						1
Duck sp.	75	130	14	2271	3320	2436
Gull sp.	10	17	15	8	32	12
Alcid sp.			1			3

Appendix 2.C continued

Species	Tip of Pt. Roberts (10-11)	Pt. Roberts to Ferry (11-12)	Ferry Jetty to Coal (12-13)	Coal Jetty to Canoe (13-14)	Westham Island (14-15)
	Survey Sections (No.)				
Loons sp.	4				
Western grebe		15			
Grebe sp.		2			
Cormorant sp.		3			9
Swan sp.				77	
Snow goose				3875	3500
American wigeon	5		2		2
Dabbling duck sp.		25			
Scaup sp.					
Goldeneye		1			
Bufflehead	1	20			
Oldsquaw	1				
White-winged scoter					
Surf scoter	36	1			
Black scoter		1			
Scoter sp.	34	3			
Merganser sp.					
Duck sp.	1	14	16911	3	
Gull sp.	8	9	22	1	13
Alcid sp.	6	22			

Appendix 2.D Second aerial survey done on December 15, 1977 between 1030 and 1210 (observers: Leo Collins and Jean-Pierre Savard; airplane: Cessna)

Species	Tongue Pt. to White Rock Jetty (1-3)	White Rock to Jetty Kwomais Pt. (3-4)	Kwomais Pt. Pt. to Crescent Beach (4-5)	Mud Bay (5-6)	Boundary Bay (7-8)	Centenial Park (9-10)
Survey Sections (No.)						
Loon sp.	2	1	5	2		3
Western grebe				1		
Cormorant sp.				3	4	
Great blue heron						
Swan sp.						
Snow goose						
Mallard	2			2	100	
Pintail				2		
Dabbling duck				2352		
Scaup sp.	87	749	157	3	6	136
Common goldeneye						
Goldeneye sp.	2	2		3		
Bufflehead		2	4	2		10
Oldsquaw	9		8	7		24
White-winged scoter				1		
Surf scoter	55	53	13	7	15	26
Scoter sp.	83	110	147	12	28	100
Merganser sp.						6
Duck sp.	88	39	21	4	1743	2105
Shorebird sp.					4	
Gull sp.	8	2	14	20	35	12
Murre sp.					3	
Alcid sp.			12			

Appendix 2.D continued

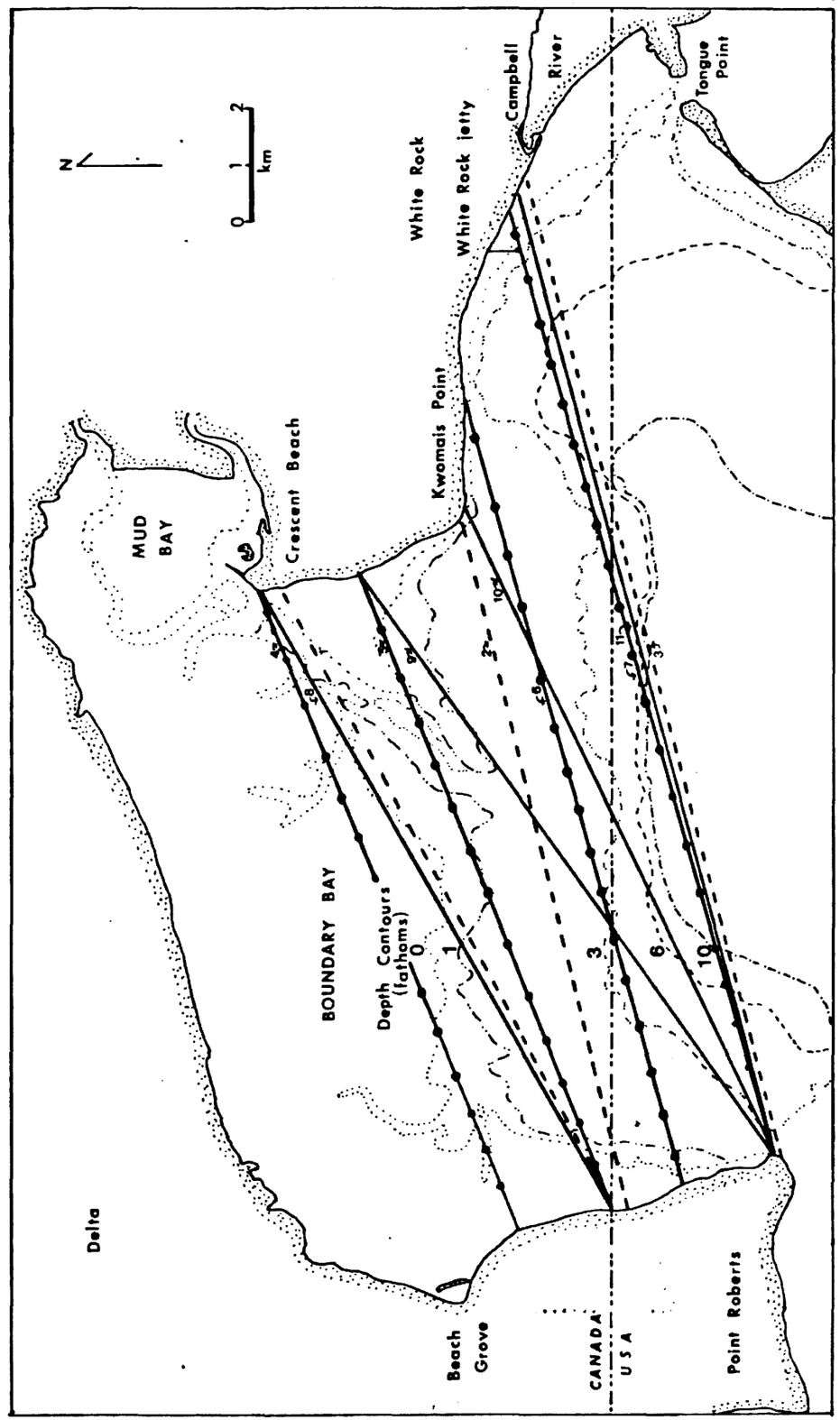
Species	Tip of Pt. Roberts (10-11)	Pt. Roberts to Ferry Jetty (11-12)	Ferry Jetty to Coal Jetty (12-13)	Coal Jetty to Canoe Pass (13-14)	Westham Island (14-15)
Survey Sections (No.)					
Loon sp.	2	1			
Western grebe		18			19
Cormorant sp.	2	40		1	1
Great blue heron				20	
Swan sp.				2700	1000
Snow goose					2
Mallard		1			
Pintail			25		365
Dabbling duck sp.					
Scaup sp.	27	31			
Common goldeneye			1		1
Goldeneye sp.		17			
Bufflehead		10	2		
Oldsquaw	1	7			
White-winged scoter					
Surf scoter	15		13		
Scoter sp.	132	44	3		
Merganser sp.		1			
Duck sp.	23	82	25327		36
Shorebird sp.					
Gull sp.	7	29	2	2	5
Murre sp.		1			
Alcid sp.					

Appendix 3.A. Location of transect lines in the open water of Boundary Bay.

Lines 1,2,3 surveyed on November 1, 1977

Lines 4,5,6,7 surveyed on November 29, 1977

Lines 8,9,10,11 surveyed on December 15, 1977



Appendix 3.B Results of transects in the open water of Boundary Bay

Survey Date	November 1, 1977			November 29, 1977				December 15, 1977			
Depth (Fathoms)	0-2	2-4	4-10	0-2	0-2	2-4	4-10	0-2	2-4	2-4	4-10
Observer	1	2	3	4	5	6	7	8	9	10	11
Common loon						2					
Red-throated loon				2	1	1					
Loon sp.	5	3	27	11	10	8	2	6	5	13	12
Western grebe	5	3	581				31		6	21	24
Grebe sp.	35		134	1	21	6	60	2	5	20	13
Cormorant sp.	1		4	1	4			2			2
Mallard								2			
Pintail									12		
American wigeon	1							75			
Dabbler sp.	2		1		2	1		4			
Scaup sp.	4267	102		908	2174	76	6	967	7	12	1
Goldeneye sp.	19				20						
Bufflehead	111	30		49	92	3		16			
Oldsquaw	60	250	10	7	61	193	156	17	48	44	11
White-winged scoter				11	5	8	10			1	4
Surf scoter	14	528		75	33	323	74	24	82	55	32
Black scoter			74			5				10	
Scoter sp.	41	459	22	61	33	181	51	83	247	202	32
Merganser sp.	7		20	1						1	
Duck sp.	1153	583	265	181	347	108	20	324	59	35	43
Gull sp.	162	9	49	43	56	4	6	22	85	214	54
Murre sp.		1				2					2
Pigeon guillemot							1				
Alcid			2			4	33				2