30215418

SPRING MIGRATION OF WATERBIRDS IN THE BEAUFORT SEA, AMUNDSEN GULF AND LAMBERT CHANNEL POLYNYA, 1993

Stuart A. Alexander
Susan E. Westover
D. Lynne Dickson

Technical Report Series No. 201
Prairie and Northern Region
Canadian Wildlife Service
1994

This report may be cited as:
Alexander, S.A., S.E. Westover, and D.L. Dickson. 1994. Spring migration of waterbirds in the Beaufort Sea, Amundsen Gulf, and Lambert Channel polynya, 1993. Technical Report Series No. 201. Canadian Wildlife Service, Prairie and Northern Region, Alberta.

SK
470
T42
No. 201

Published under the Authority of the
Minister of Environment
Canadian Wildlife Service

© Minister of Supply and Services Canada 1994
Catalogue No. CW69-5/201E
ISBN 0-662-21545-1
ISSN 0831-6481

Copies may be obtained from:

Canadian Wildlife Service
Environmental Conservation Branch
Prairie and Northern Region
Room 210, 4999-98 Avenue
Edmonton, Alberta
T6B 2X3

EXECUTIVE SUMMARY

Each spring during migration, hundreds of thousands of birds stop temporarily in offshore areas of the Beaufort Sea to feed, rest, and court. The staging birds are dependent on open-water leads and polynyas in the ice. Some of the key staging areas are in the vicinity of proposed sites for offshore oil exploration and development. The potential for oil spills in these areas is one of the most serious threats to birds in the western Arctic.

In 1992 and 1993, the Northern Oil and Gas Action Program provided funding to study spring waterbird distributions in relation to oil development. The objectives of this study were to: 1) to examine spring waterbird distributions in offshore areas of the Beaufort Sea, Amundsen Gulf, and Lambert Channel; and 2) to assess the potential threats from oil exploration and development to spring migrants in the southern Beaufort Sea.

We flew aerial surveys for birds in May and June, 1992 and 1993. Lead formation in the eastern Beaufort Sea was retarded in 1992, but well advanced in 1993. This provided an opportunity to examine bird distributions under very different open water conditions. In 1993, open water was abundant throughout the Beaufort Sea, Amundsen Gulf, and at the Lambert Channel polynya from the beginning of surveys in late May. This report presents results from 1993.

In 1993, Pacific Eiders (*Somateria mollissima* v. *nigra*), King Eiders (*S. spectabilis*), and Oldsquaw (*Clangula hyemalis*) were the most abundant species, followed by White-winged Scoters (*Melanitta fusca*), Glaucous Gulls (*Larus hyperboreus*), Yellow-billed Loons (*Gavia adamsii*), Pacific Loons (*G. pacifica*), and Red-throated Loons (*G. stellata*). As in other years, the three most important offshore staging areas were: 1) north of the Tuktoyaktuk Peninsula between Cape Dalhousie and the Baillie Islands (eiders, Oldsquaw); 2) off western Banks Island between Masik River and Storkerson Bay (King Eiders); 3) the Lambert Channel polynya (Pacific Eiders, Yellow-billed Loons). Other areas also considered important are: the southern Beaufort Sea from Tuktoyaktuk to Cape Dalhousie (eiders, Oldsquaw, Red-throated Loons, *G. stellata*); the area between Herschel Island and Tuktoyaktuk (Oldsquaw, Red-throated Loons); and the southern Amundsen Gulf coast (Pacific Eiders, Oldsquaw).

One key pattern that has become clear as a result of several years of study is that seaducks tend to stage in the same key areas each year regardless of ice conditions. Surveys have been conducted in many ice conditions from extensive pack ice with only small patches of open water throughout the Beaufort Sea (1992), to open leads extending only as far east as Cape Parry (1987), to virtually unlimited open water from Herschel Island to Victoria Island, north along Banks Island, and in Lambert Channel (1993). Regardless of the ice conditions, open water off the Tuktoyaktuk Peninsula, particularly between Cape Dalhousie and the Baillie Islands, has been extremely important to Pacific Eiders, King Eiders and Oldsquaw during spring migration. This area appears to be the primary stopping point after what is likely a non-stop migration from western Alaska, especially for the eiders.

The following are general conclusions based on past and present studies. The percentages below represent average proportions of birds present in a given area on a given day during spring migration. *They do not include the turnover of birds during migration, and therefore should be viewed as minimum proportions of total western Arctic populations.*

Pacific Eiders migrate through the Beaufort Sea, Amundsen Gulf, and Lambert Channel in large numbers starting in mid to late May. Peak movement and staging occur in the second week of June most years, but as early as the last week of May in some years. The most important staging areas are off the Tuktoyaktuk Peninsula between Cape Dalhousie and the Baillie Islands, and in the Lambert Channel polynya. The former area is used even in years when pack ice predominates, as long as there is some open water within the ice. Both areas provide water shallow enough for feeding (<20 m). Each of these areas can account for over 50% of Pacific Eiders present on any given day during spring migration. Evidence suggests that most birds using Lambert Channel also stop in the southeastern Beaufort Sea. The southern coast of Amundsen Gulf is also important, where about 19% of Pacific Eiders can be expected on any given day when open water is available. About 15% occur between Tuktoyaktuk and Cape Dalhousie, while 3% occur west of there on any given day.

King Eiders migrate through the Beaufort Sea and Amundsen Gulf starting in the second and third weeks of May. Peak eastward movement and staging occur sometime in the last week of May and the first two weeks of June. Westward moult migration begins in mid to late June. The most important staging areas are off western Banks Island, especially north of Masik River, and in the southern Beaufort Sea between Tuktoyaktuk and the Baillie Islands, both of which provide shallow water for feeding. These areas can each account for 44-87% and 12-43%, respectively, of King Eiders on any given day during spring migration. The range in percentages is the product of both sampling error and variable weather and ice conditions. Very few (about 1%) King Eiders occur west of Tuktoyaktuk on any given day.

Oldsquaw enter the Beaufort Sea in late May. Peak movement and staging occur between the last week in May and the second week in June, and later east of the Beaufort Sea. The later concentrations may include early moult-migrants. Oldsquaw are, in general, dispersed throughout the southern Beaufort Sea: 22% of the Oldsquaw present on any given day during spring migration are between Herschel Island and Tuktoyaktuk; 12% between there and Cape Dalhousie; and 31% between there and the Baillie Islands. About 22% of the Oldsquaw occur between Cape Lyon and Clinton Point in Amundsen Gulf.

Red-throated Loons are particularly abundant between Herschel Island and Tuktoyaktuk (62%) and between Tuktoyaktuk and Cape Dalhousie (37%). Their numbers peak in early June most years. Although they move rapidly onto the breeding grounds along the Beaufort Sea coast, they continue to feed in the offshore leads until the coastline is free of ice. Pre-moulting scoters gather in leads just west and east of the Mackenzie Delta in late June until coastal bays become ice free.

RÉSUMÉ

Chaque année, pendant la migration printanière, des centaines de milliers d'oiseaux font halte au large des côtes de la mer de Beaufort pour se reposer, trouver de la nourriture et s'accoupler. Leur survie dépend de la présence de chenaux d'eau libre et de polynias sur la glace. Certaines des importantes aires de repos se situent à proximité de lieux où l'on se propose de mener des activités et des explorations pétrolières. L'éventualité de déversements d'hydrocarbures dans ces secteurs demeure l'une des menaces les plus sérieuses à l'égard des oiseaux de l'Arctique de l'Ouest.

En 1992 et 1993, le Programme d'initiatives pétrolières et gazières dans le Nord a financé une étude portant sur la distribution des oiseaux aquatiques au printemps par rapport à la zone d'exploitation pétrolière. Les objectifs de cette étude consistaient à: 1) examiner la distribution des oiseaux aquatiques au large des côtes de la mer de Beaufort, du golfe Amundsen et du chenal Lambert; 2) évaluer les menaces éventuelles que constituent les activités et les explorations pétrolières pour les oiseaux migrateurs dans la partie sud de la mer de Beaufort.

Des relevés aériens sur les oiseaux ont été effectués en mai et juin 1992 et 1993. Dans la partie est de la mer de Beaufort, la formation de chenaux était en retard en 1992, mais bien avancée en 1993. Ces conditions ont permis d'examiner la distribution des oiseaux en eau libre dans des circonstances très variées. En 1993, dès le début des relevés à la fin de mai, il y avait des eaux libres en abondance dans la mer de Beaufort et le golfe Amundsen ainsi que dans la polynia du chenal Lambert. Le présent rapport présente les résultats de 1993.

En 1993, les eiders du Pacifique (Somateria mollissima v. nigra), les eider à tête grise (S. spectabilis) et les canards kakawis (Clangula hyemalis) étaient les espèces les plus nombreuses, suivies par les macreuses à ailes blanches (Melanitta fusca), les goélands bourgmestres (Larus hyperboreus), les huarts à bec blanc (Gavia adamsii), les huarts du Pacifique (G. pacifica) et les huarts à gorge rousse (G. stellata). Comme lors des années précédentes, les trois aires de repos les plus importantes ont été: 1) au nord de la péninsule de Tuktoyaktuk, entre le cap Dalhousie et les îles Baillie (eiders et canards kakawis); 2) au large de la partie ouest de l'île Banks, entre la rivière Masik et la baie Storkerson (eiders à tête grise); 3) les polynias du chenal Lambert (eiders du Pacifique, huarts à bec blanc). Les autres aires qui présentent une certaine importance sont la partie sud de la mer de Beaufort, de Tuktoyaktuk au cap Dalhousie (eiders, canards kakawis et huarts à gorge rousse), le secteur situé entre l'île Herschel et Tuktoyaktuk (canards kakawis et huarts à gorge rousse), et la côte de la partie sud du golfe Amundsen (eiders du Pacifique, canards kakawis).

Après plusieurs années d'études, on a constaté que les canards de mer ont tendance à faire halte aux mêmes endroits quel que soit l'état de la glace. Des études ont été effectuées dan de nombreuses conditions, aussi bien lorsque la banquise ne présente que quelques petites ouvertures d'eau libre sur toute la mer de Beaufort (1992) que lorsqu'on trouve des étendues d'eau libre à perte de vue de l'île Herschel à l'île Victoria, au nord le long de l'île Banks et dans le chenal Lambert (1993). Quel que soit l'état de la glace, les eaux libres au large de la péninsule de Tuktoyaktuk, surtout entre le cap Dalhousie et les îles Baillie, sont d'une importance capitale pour les eiders du Pacifique, les

eiders à tête grise et les canards kakawis pendant la migration printanière. Cette région semble être la halte principale après une migration sans halte depuis l'Alaska, surtout pour les eiders.

Les remarques qui suivent sont les conclusions générales qui reposent sur les études effectuées jusqu'à présent. Les pourcentages fournis ci-dessous représentent les proportions moyennes d'oiseaux présents sur une aire donnée un jour donné pendant la migration printanière. *Ils ne comprennent pas la rotation d'oiseaux pendant la migration, et on doit donc les considérer comme des pourcentages minimums des populations totales de l'Arctique de l'Ouest.*

Les eiders du Pacifique traversent la mer de Beaufort, le golfe Amundsen et le chenal Lambert en grand nombre, de la mi-mai à la fin de mai. La plupart du temps, le mouvement migratoire, ainsi que l'occupation des aires de repos, atteint son point culminant pendant la deuxième semaine de juin, mais, certaines années, ce peut être aussi dès la dernière semaine de mai. Les aires de repos les plus importantes se trouvent au large de la péninsule de Tuktoyaktuk, entre le cap Dalhousie et les îles Baillie, ainsi que dans les polynias du chenal Lambert. La première est utilisée même lorsque, certaines années, la banquise est prédominante, pourvu qu'il y ait un peu d'eau libre. Ces deux aires ont des bas-fonds (<20 m) qui permettent aux oiseaux de se nourrir. Elles reçoivent toutes deux plus de 50% des eiders du Pacifique tout au long de la migration de printemps. Tout porte à croire que la plupart des oiseaux qui utilisent le chenal Lambert s'arrêtent aussi dans la partie sud-est de la mer de Beaufort. La côte sud du golfe Amundsen présente aussi une certaine importance, car environ 19% des eiders du Pacifique peuvent y venir certains jours s'il y a de l'eau libre. Entre Tuktoyaktuk et le cap Dalhousie, on compte environ 15% de ces oiseaux, et 3% à l'ouest de cet endroit.

Les eiders à tète grise traversent la mer de Beaufort et le golfe Amundsen au cours de leur migration, dès les deuxième et troisième semaines de mai. Le mouvement migratoire atteint son maximum pendant la dernière semaine de mai et les deux premières semaines de juin, et les aires de repos sont alors remplies. La migration vers l'ouest au moment de la mue commence entre la mi-juin et la fin de juin. Les aires de repos les plus importantes, qui offrent la possibilité de se nourrir grâce à leurs eaux peu profondes, se situent au large de la partie ouest de l'île Banks, en particulier au nord de la rivière Masik, et dans la partie sud de la mer de Beaufort, entre Tuktoyaktuk et les îles Baillie. Elles reçoivent respectivement de 44 à 87%, et de 12 à 43% des eiders à tête grise tout au long de la migration printanière. La variation des pourcentages résulte d'erreurs d'échantillonnage et de changements dans les conditions météorologiques ainsi que dans l'état de la glace. On trouve très peu d'eiders à tête grise (environ 1%) à l'ouest de Tuktoyaktuk.

Les canards kakawis arrivent au-dessus de la mer de Beaufort à la fin de mai. Le mouvement migratoire, ainsi que l'occupation des aires de repos, atteint son maximum entre la dernière semaine de mai et la deuxième semaine de juin, et même plus tard dans la partie est de la mer de Beaufort. Les derniers rassemblements peuvent comprendre des oiseaux dont la mue a commencé. En général, les canards kakawis sont dispersés dans tout le sud de la mer de Beaufort: pendant la migration printanière, 22% d'entre eux se trouvent entre l'île Herschel et Tuktoyaktuk, 12% se trouvent entre Tuktoyaktuk et le cap Dalhousie, et 31% entre le cap et les îles Baillie. Environ 22% des canards kakawis font halte entre le cap Lyon et la pointe Clinton, dans le golfe Amundsen.

Les huarts à gorge rousse sont particulièrement nombreux entre l'île Herschel et Tuktoyaktuk (62%), et entre Tuktoyaktuk et le cap Dalhousie (37%). La plupart du temps, leur nombre atteint un maximum au début de juin. Bien qu'ils se dirigent assex vite vers les aires de reproduction le long de la côte de la mer de Beaufort, ils continuent de se nourrir dans les chenaux d'eau libre jusqu'à ce que la glace ait disparu de la côte. Des macreuses qui n'ont pas encore mué se rassemblent à la fin de juin dans les chenaux à l'ouest et à l'est du delta du Mackenzie, jusqu'à ce que les baies soient libres de glace.

ACKNOWLEDGEMENTS

This project was funded by the Northern Oil and Gas Action Program. Thanks are extended to: Arctic Wings in Inuvik, especially Dave Hindson for his excellent piloting, good company, and interest in the project; Monique LaPalme and Jim McCleod of the Atmospheric Environment Service in Inuvik for allowing us to examine their on-screen digital satellite images, and for helping to interpret them; Ron Goodson, Atmospheric Environment Service, Edmonton, for providing digital satellite data; and Peter Unger, James Hume, Michael Friesen, and others at Trigon Mapping Resources Ltd. in Saskatoon for producing the computer-generated maps using scanned hydrographic charts and digital satellite images of ice conditions. We also thank Humphrey Melling (Institute of Ocean Sciences, Sidney, B.C.) and Robert Suydam (Department of Wildlife Management, Barrow, Alaska) for their comments and unpublished information.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

Each spring during migration, thousands of birds stop temporarily in offshore open-water areas of the Beaufort Sea. Some of the key staging areas are in the vicinity of proposed sites for offshore oil exploration and development. The potential for oil spills in these areas is one of the most serious threats to birds in the western Arctic (FEARO 1984). Information on the distribution of birds during spring migration provides the basis for evaluating threats. Staging birds are dependent on leads in the ice, and there is mounting evidence that birds use the same areas each year despite annual variations in the location and extent of open water.

In 1992, the Northern Oil and Gas Action Program provided funding to study spring waterbird distributions in relation to oil development. The objectives of this study were: 1) to examine spring waterbird distributions in 1992 and 1993 in offshore areas of the Beaufort Sea, Amundsen Gulf, and Lambert Channel; and 2) to assess the potential threats from oil exploration and development to spring migrants in the southern Beaufort Sea. This report presents results from the 1993 surveys. The results of the 1992 surveys are presented in Alexander *et al.* (1993).

Starting in late April, peaking in early June, and continuing throughout most of June, hundreds of thousands of birds, particularly King Eiders (*Somateria spectabilis*), Pacific Eiders (*S. mollissima* v. *nigra*), and Oldsquaw (*Clangula hyemalis*), migrate eastward across the Beaufort Sea (Alexander *et al.* 1988b, Barry 1986, Woodby and Divoky 1982, Richardson and Johnson 1981, Searing *et al.* 1975). Tens of thousands of King Eiders have been found off Banks Island prior to thaw of inland nesting grounds. Similar numbers of Pacific and King eiders and thousands of Oldsquaw have also been observed in leads off the Tuktoyaktuk Peninsula between Cape Dalhousie and the Baillie Islands (Alexander *et al.* 1988b, Searing *et al.* 1975). The leads and polynyas provide a restricted open-water habitat essential for activities such as resting, feeding, courtship, and copulation before the birds move on to the nesting grounds (Barry *et al.* 1981).

Beaufort Sea ice conditions tend to be similar from year to year (Markham 1981, Smith and Rigby 1981, Marko 1975), which has likely influenced spring migration patterns of birds. Open water is common in the Beaufort Sea throughout May, but the location is not predictable until early June (Markham 1981). At that time, spring migration is at its peak, and most birds occur where water is most consistently available: the Cape Bathurst and Cape Kellett regions. Unexpected ice conditions can have dire consequences, such as the massive starvation of eiders in 1964 when even the Cape Bathurst polynya (Smith and Rigby 1981) did not start to open until late July (Barry 1968). Most spring surveys of migrating seabirds to date have been flown during relatively normal years. In 1992, however, open water was very limited throughout the Beaufort Sea and western Amundsen Gulf for the duration of spring migration (Alexander *et al.* 1993). These conditions provided an important opportunity to examine how seabird distributions are affected when habitat is limited in their traditional staging sites, yet available elsewhere. In complete contrast in 1993, lead development was as advanced by mid-May as it usually is by the end of June.

2.0 METHODS

From May 26 to June 16, 1993, we conducted three sets of aerial surveys in offshore areas parallel to the southern and eastern coastlines of the Canadian Beaufort Sea, Amundsen Gulf, and Dolphin and Union Strait (referred to as "extensive surveys"; Figures 1-4; see Appendix A for actual dates). On June 10, we flew eight transects over the open water roughly perpendicular to the landfast ice edge between Atkinson Point and the Baillie Islands (referred to as "intensive transects"; see Appendix B). Transects were spaced approximately 20 km apart and totalled approximately 450 km. We also recorded birds while we flew between airstrips and transects ("deadhead" transects; Appendix D). Ice conditions in Figures 2-4 were based on NOAA satellite imagery obtained from Atmospheric Environment Service, Environment Canada.

We flew all surveys in a high-winged, twin-engine Britten-Norman Islander on wheels. Our usual altitude was 45 m above sea level. Ground speed averaged 150 km/hr but varied somewhat with the wind. We flew 200-230 km/hr in areas that had few birds, which permitted greater coverage. When over leads, we flew 100-300 m to the open-water side of the ice-edge. Some leads were narrow enough for us to see both sides. Extensive survey routes were divided into five-minute segments, whereas intensive transects were divided into two-minute segments. Segment length was estimated by multiplying the time by the average of the ground speed recorded at the beginning and end of each segment (see Appendices B-D for segment and transect lengths). Position of the aircraft (latitude and longitude) and ground speed was determined by a Trimble Navigation Trans-Pac Global Positioning System.

Two observers, one in the right front seat and one in the left seat directly behind the pilot, recorded data on cassette tape recorders. Time of day, estimated wind speed and direction, wave condition, cloud cover, precipitation and visibility were noted at various points throughout the surveys. For each observation, we recorded the species and number. For many flocks of Pacific and King eiders we also recorded the sex ratio. For small flocks (<20) it was possible to count males and females. For larger flocks, which accounted for most eiders seen, we estimated the proportion of males. We recorded lone females as unidentified eiders, and females that were associated with males as conspecifics. In mixed flocks of King and Pacific eiders, we assumed that female eiders were present in the flock in proportions similar to the males. Large flocks where females were clearly dominant to males were never encountered. No attempt was made to identify subadult males. Few subadult birds, however, enter the Beaufort Sea (Johnson 1971, Woodby and Divoky 1982).

For the intensive survey, we recorded birds within 200 m of either side of the aircraft as "on transect" and those outside as "off transect." For extensive surveys, we recorded all birds identifiable from the aircraft (densities are in birds/km rather than birds/km^2). We did this because in many areas, most birds would take flight several kilometres ahead of the aircraft, and fly beyond the 400 m survey strip (Alexander *et al.* 1993, Johnson *et al.* 1993). This problem was particularly acute in southern Amundsen Gulf, off western Banks Island, and in Lambert Channel. In contrast, most birds observed in the southern Beaufort Sea (between Herschel Island and Cape Bathurst) remained sitting on the water when we flew over.

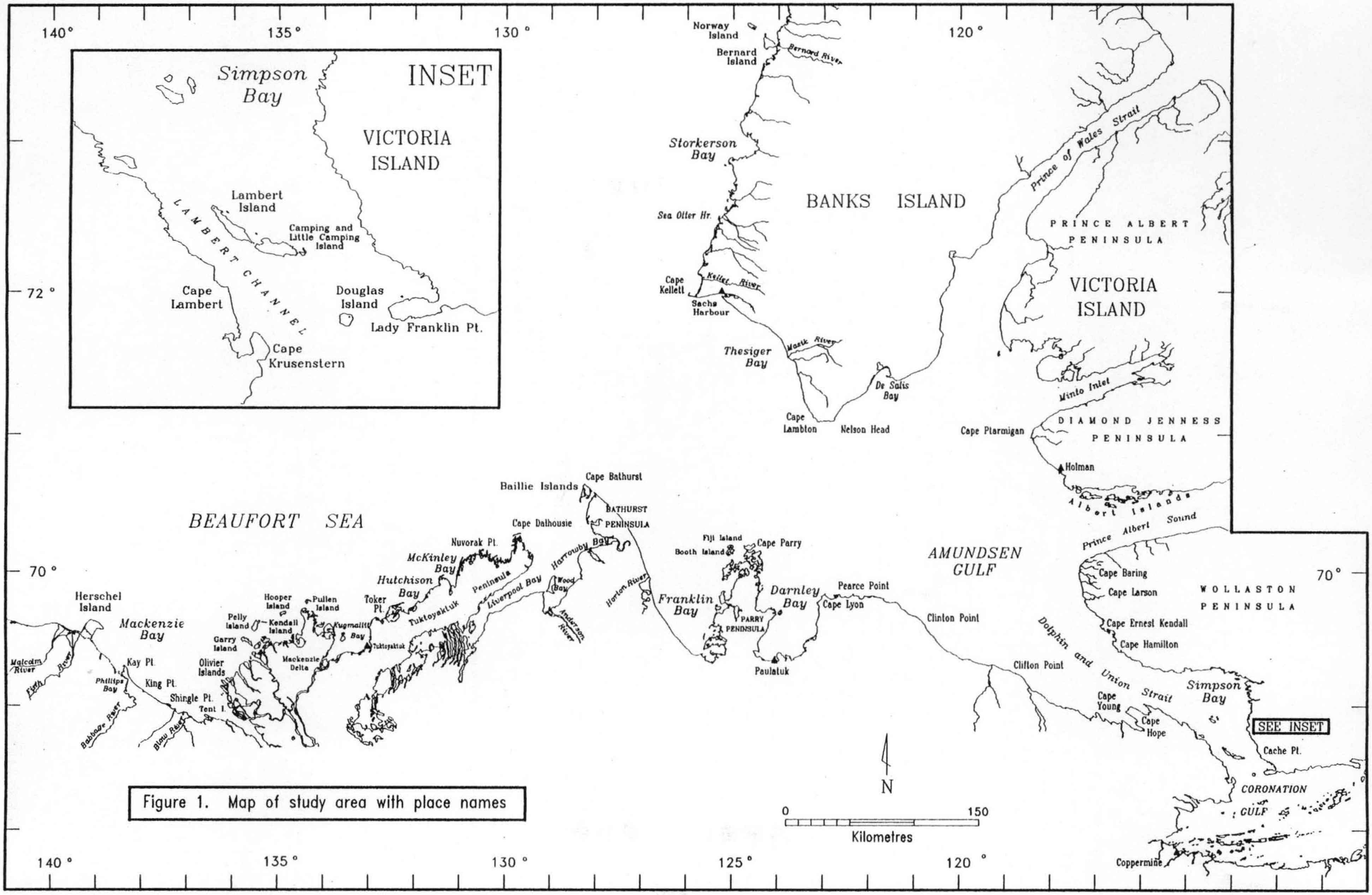


Figure 1. Map of study area with place names

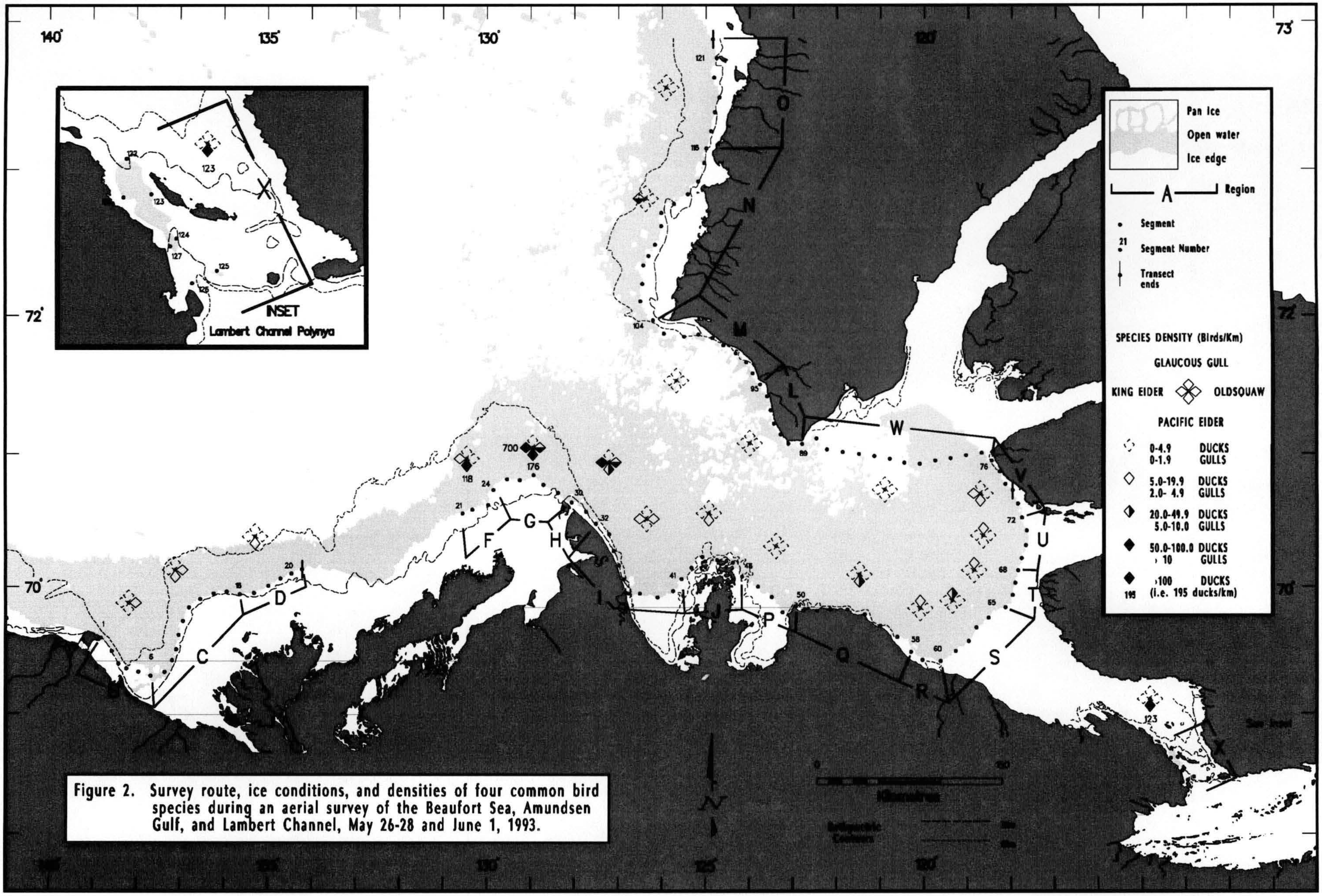


Figure 2. Survey route, ice conditions, and densities of four common bird species during an aerial survey of the Beaufort Sea, Amundsen Gulf, and Lambert Channel, May 26-28 and June 1, 1993.

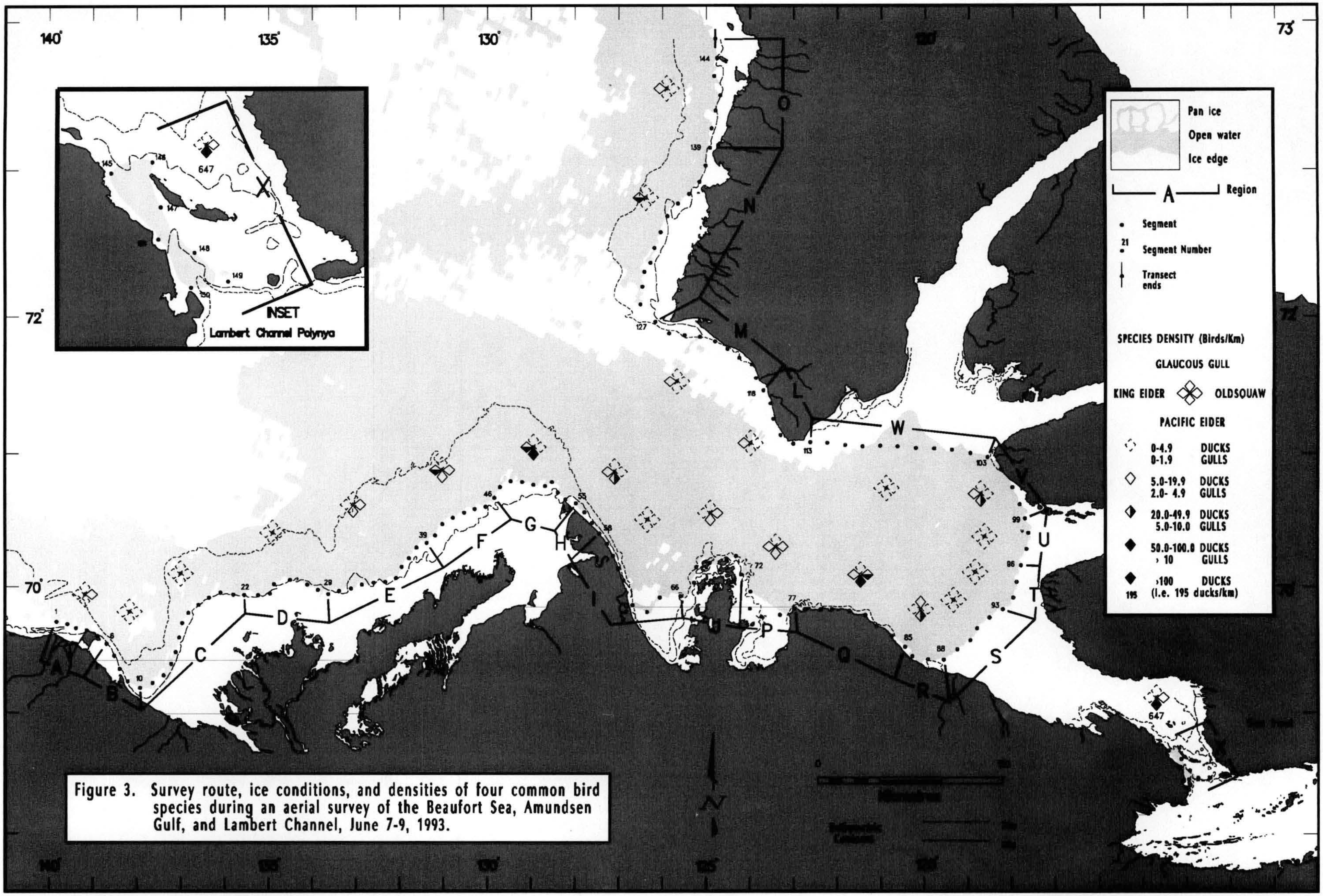


Figure 3. Survey route, ice conditions, and densities of four common bird species during an aerial survey of the Beaufort Sea, Amundsen Gulf, and Lambert Channel, June 7-9, 1993.

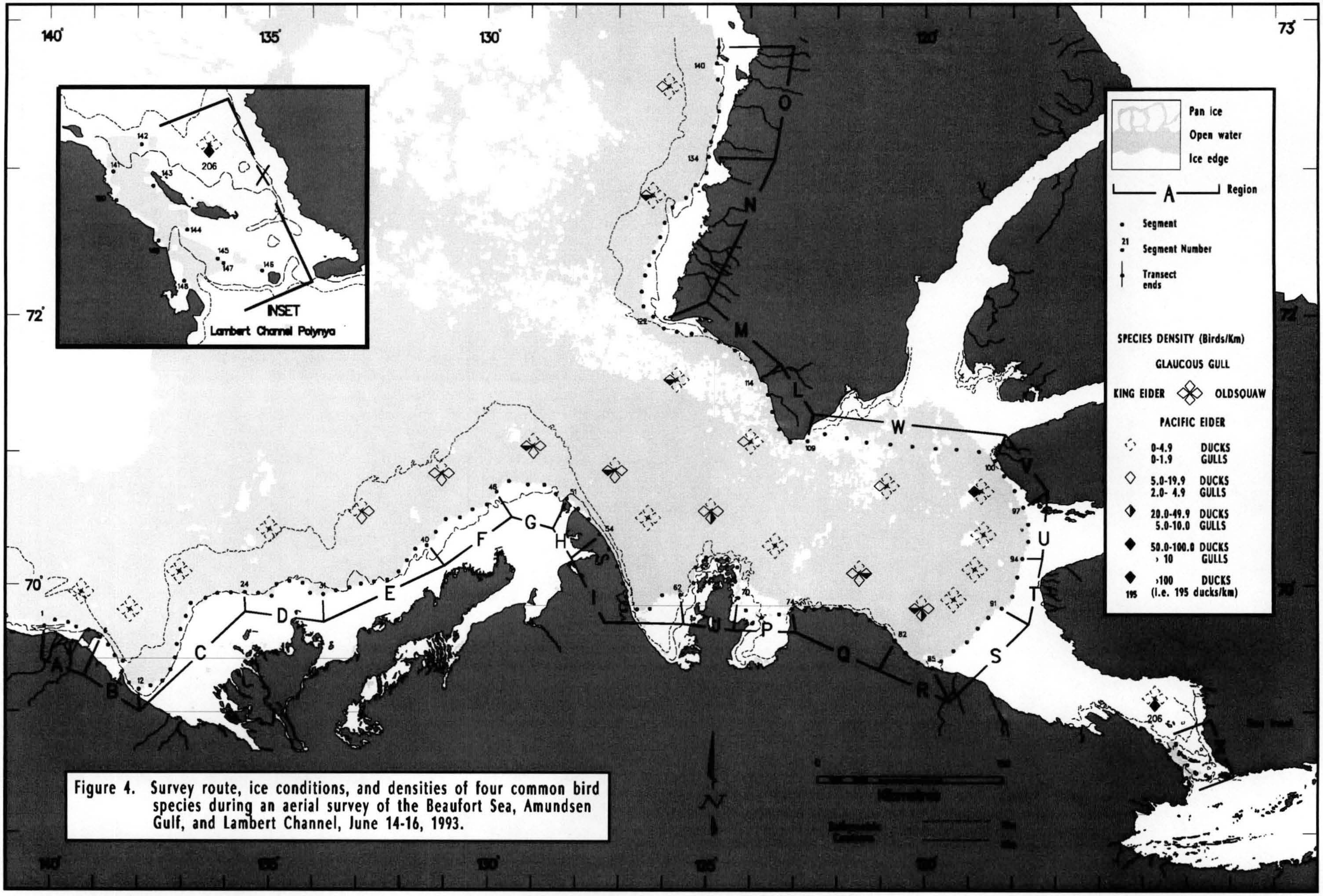


Figure 4. Survey route, ice conditions, and densities of four common bird species during an aerial survey of the Beaufort Sea, Amundsen Gulf, and Lambert Channel, June 14-16, 1993.

3.0 RESULTS

3.1 General ice conditions and survey coverage in 1993

In most years, a long lead opens in the ice covering the southern Beaufort Sea in late May, broadens throughout the spring months, and eventually transforms into open sea when landfast ice breaks free in July. In 1993, the lead system throughout the Beaufort Sea and Amundsen Gulf was highly developed by mid-May (Figures 2-4). The landfast ice shelf was still present at this time. Most of Amundsen Gulf was ice-free by at least May 24. The Lambert Channel polynya was also open by our first survey there on May 27, but did not extend into the shallower, southeast end of the channel. In general, open water was fully available to birds throughout the study area for all surveys.

Given the interest in examining a broad area in 1993, we conducted mostly extensive surveys (Figures 2-4). Generally favourable weather permitted complete coverage on all but the first survey, during which we were unable to fly between Tuktoyaktuk and Nuvorak Point (Figure 2).

3.2 Abundance and distribution of birds

We will evaluate the distributions of birds by examining three types of information, two of which are straightforward (total counts and densities by region) whereas the third (percent occurrence by region) requires some explanation. Percent occurrence is the ratio of the number seen in a given region over the number seen throughout the survey. We have chosen, however, to exclude Lambert Channel from the latter evaluation because evidence suggests that most birds using Lambert Channel first stop in the southeastern Beaufort Sea. In 1993, for example, the peak abundance of birds at Lambert Channel coincided with a decline in abundance in the southeastern Beaufort Sea (Table 1). Also, we have noted in all years of survey since 1986 (Alexander *et al.* 1988b, 1993) that eiders in the Cape Dalhousie to Baillie Islands area tended not to flush when we flew over. In most other areas, especially along the southern coast of Amundsen Gulf and in Lambert Channel, a large proportion of eiders tended to flush several kilometres in advance of the aircraft. Based on these observations, we suggest that eiders arrive in the southeastern Beaufort Sea exhausted from a non-stop flight from the wintering grounds off western Alaska. After a period of rest, they continue migration north and east, progressing in shorter stages, taking advantage of open water as it becomes available.

Lambert Channel, therefore, is eventually used by a substantial proportion of the same Pacific Eider population that stages in the Beaufort Sea and Amundsen Gulf. Its inclusion in evaluations of percent occurrence would thus progressively devalue the apparent importance of regions west of there.

Table 1. Total numbers of key species observed during aerial surveys of offshore leads and polynyas in the Beaufort Sea, Amundsen Gulf, and Lambert Channel, spring 1993.

	Herschel Island to Cape Parry			Western Banks Island			Amundsen Gulf			Lambert Channel		
Species	May 27-28 June 1	June 7, 9	June 14, 16	May 26	June 8	June 15	May 26-27	June 8-9	June 15-16	May 27	June 9	June 16
Pacific Loon	21	7	37	0	0	5	0	78	18	2	21	10
Red-throated Loon	114	67	150	0	0	3	0	1	1	0	0	0
Yellow-billed Loon	2	5	19	0	14	19	0	14	65	0	332	52
Loon sp.	17	3	6	0	5	10	2	23	26	2	9	4
Pacific Eider	23954 (27)	11408 (57)	5715 (45)	655 (13)	1407 (11)	579 (7)	3683 (79)	13120 (82)	3677 (32)	11375 (99)	64583 (99)	27330 (98)
King Eider	66136	8481	7083	4496	11673	7718	980	2958	7827	97	469	457
Eider sp.	440	58	276	105	435	144	16	437	67	8	91	29
Oldsquaw	8812	3737	5368	44	59	43	920	6555	3721	3	635	564
White-winged Scoter	10	72	4169	0	0	0	0	8	36	0	4	0
Surf Scoter	0	0	0	0	0	0	0	0	0	0	0	0
Scoter sp.	0	0	24	0	0	0	0	0	0	0	0	0
Glaucous Gull	217	117	149	119	31	30	961	221	66	164	105	15
Others	3262	108	1092	30	115	91	16	436	67	5	15	10
Total	102985	24063	24088	5449	13739	8642	6578	23851	15571	11656	66264	28471
Regions flown	B-D, F-J	A-J	A-J	L-O	L-O	L-O	P-W	P-W	P-W	X	X	X
Distance (km)	624	888	958	444	433	425	616	613	614	92	100	132

Note: Values in parentheses are the percent Pacific Eiders among identified eiders.

3.2.1 Pacific Eiders

Pacific Eiders were abundant throughout the study area on our first survey (May 26 to June 1; Table 1), particularly between Cape Dalhousie and the Baillie Islands (Table 2, Figure 5). During all surveys, most Pacific Eiders using the southern Beaufort Sea occurred east of the Mackenzie Delta. On average, 32% of the Pacific Eiders were between Cape Dalhousie and the Baillie Islands (Regions G-H), while 12% were off the Tuktoyaktuk Peninsula (Regions E-F). The leads between Herschel Island and Tuktoyaktuk (Regions A-D) had on average 4% of the Pacific Eiders during the three surveys. By mid June, a substantial proportion of Pacific Eiders were around Cape Parry (Regions I-J; Appendix C).

Lambert Channel had the largest numbers and densities of Pacific Eiders (over 64 000 birds or 647 birds/km; Table 1, Figure 5). Numbers peaked there by June 9, coinciding with declines in the Beaufort Sea. Around 50% of the eiders were located in the southeast end of the polynya (e.g. segments 148 & 149 in Figure 3 and Appendix C).

On average, 30% of the Pacific Eiders occurred along the southern coast of Amundsen Gulf (Regions P-R; Table 2). The highest number and density tended to occur between Cape Lyon and Clinton Point (Region Q; Figure 5). Numbers of Pacific Eiders peaked strongly in Amundsen Gulf on June 9 (Table 1).

On average, we recorded 4% of Pacific Eiders off western Banks Island (Table 2). Pacific Eiders were most common in the leads south of Cape Kellett (Regions L-M), and were most abundant during the June 9-10 survey set (Table 1, Figure 5).

3.2.2 King Eiders

In the southern Beaufort Sea, King Eider abundance was at its highest recorded value (over 66 000 birds) during our first survey set (May 26 to June 1; Table 1). Of all King Eiders seen on the entire first survey, 89% were between Cape Dalhousie and the Baillie Islands (Regions G-H; Table 2, Figure 6, Appendix C). Relative abundance in that area dropped to 18-21% for the next two surveys, and averaged 43% for all three surveys. The area between Herschel Island and Tuktoyaktuk (Regions A-D) had <1% of the King Eiders on all surveys (Table 2, Figure 6), while areas off the Tuktoyaktuk Peninsula (Regions E-F) had an average of 8%. By the last survey, males comprised 82% of the King Eiders observed, compared to 55% on the first survey (Appendix E), indicating that the westward moult migration had started.

On average, 30% of King Eiders were off western Banks Island (Regions L-O; Table 2), particularly north of the Masik River (Regions M-N; Figure 6). Peak numbers were recorded on June 8 (Table 1). As in the southern Beaufort Sea, males comprised 82% of the King Eiders observed during the last survey (Appendix E).

On average, 9% of King Eiders were along the southern coast of Amundsen Gulf (Regions P-R; Table 2). Few were observed during our first survey in Amundsen Gulf on

Table 2. Percent occurrence and total number of Pacific Eiders, King Eiders, and Oldsquaw observed during aerial surveys of offshore leads and polynyas in the Beaufort Sea and Amundsen, spring 1993.

Regions	May 26-28 June 1	June 7-9	June 14-16	Average May 26 - June 16
		PACIFIC EIDER		
A-D	6.0	1.1	3.7	3.6
E-F	16.2	7.5	11.9	11.8
G-H	56.5	27.1	11.3	31.6
I-J	5.9	8.4	30.5	14.9
L-O	2.3	5.4	5.8	4.5
P-R	11.4	45.8	32.0	29.7
S-V	1.6	4.8	4.9	3.8
W	0.0	0.0	0.0	0.0
Number	28292	25935	9971	
		KING EIDER		
A-D	0.3	0.1	0.4	0.3
E-F	0.4	14.2	8.6	7.7
G-H	88.8	21.2	18.4	42.8
I-J	2.8	1.3	4.0	2.7
L-O	6.3	50.5	34.1	30.3
P-R	0.7	9.9	17.3	9.3
S-V	0.6	2.9	17.1	6.9
W	0.1	0.0	0.1	0.1
Number	71612	23112	22628	
		OLDSQUAW		
A-D	27.8	4.9	10.6	14.5
E-F	0.2	14.7	14.0	9.6
G-H	49.6	3.4	17.2	23.4
I-J	12.6	13.1	16.9	14.2
L-O	0.5	0.6	0.5	0.5
P-R	3.9	59.2	39.4	34.2
S-V	5.5	4.2	1.3	3.7
W	0.0	0.0	0.0	0.0
Number	9776	10351	9132	

REGIONS

A-D Herschel Island to Tuktoyaktuk
E-F Tuktoyaktuk to Cape Dalhousie
G-H Cape Dalhousie to the Baillie Islands
I-J Baillie Islands to Cape Parry
L-O Cape Lambton to Bernard Island
P-R Cape Parry to Clifton Point
S-V Clifton Point to Cape Ptarmigan
W Cape Ptarmigan to Nelson Head

Notes: Lambert Channel is excluded from this table because we suspect that most birds using that region had first stopped in the Beaufort Sea and Amundsen Gulf. Consequently, the values in this table take better account of turnover of birds in the western areas. The impact of this is most significant for Pacific Eider (see text for greater detail).

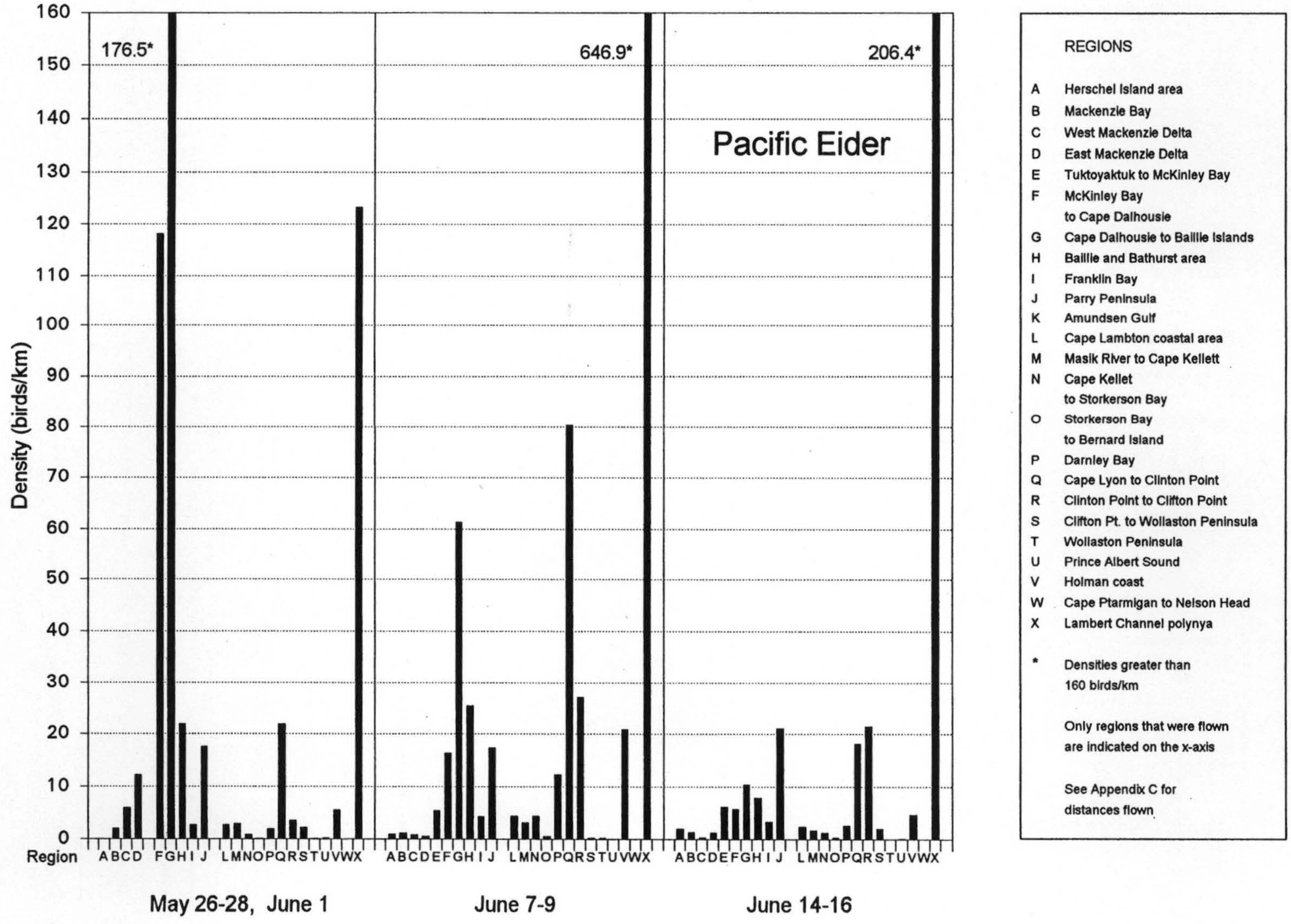


Figure 5. Distribution of Pacific Eiders during aerial surveys of the Beaufort Sea, Amundsen Gulf, and Lambert Channel polynya, May and June 1993.

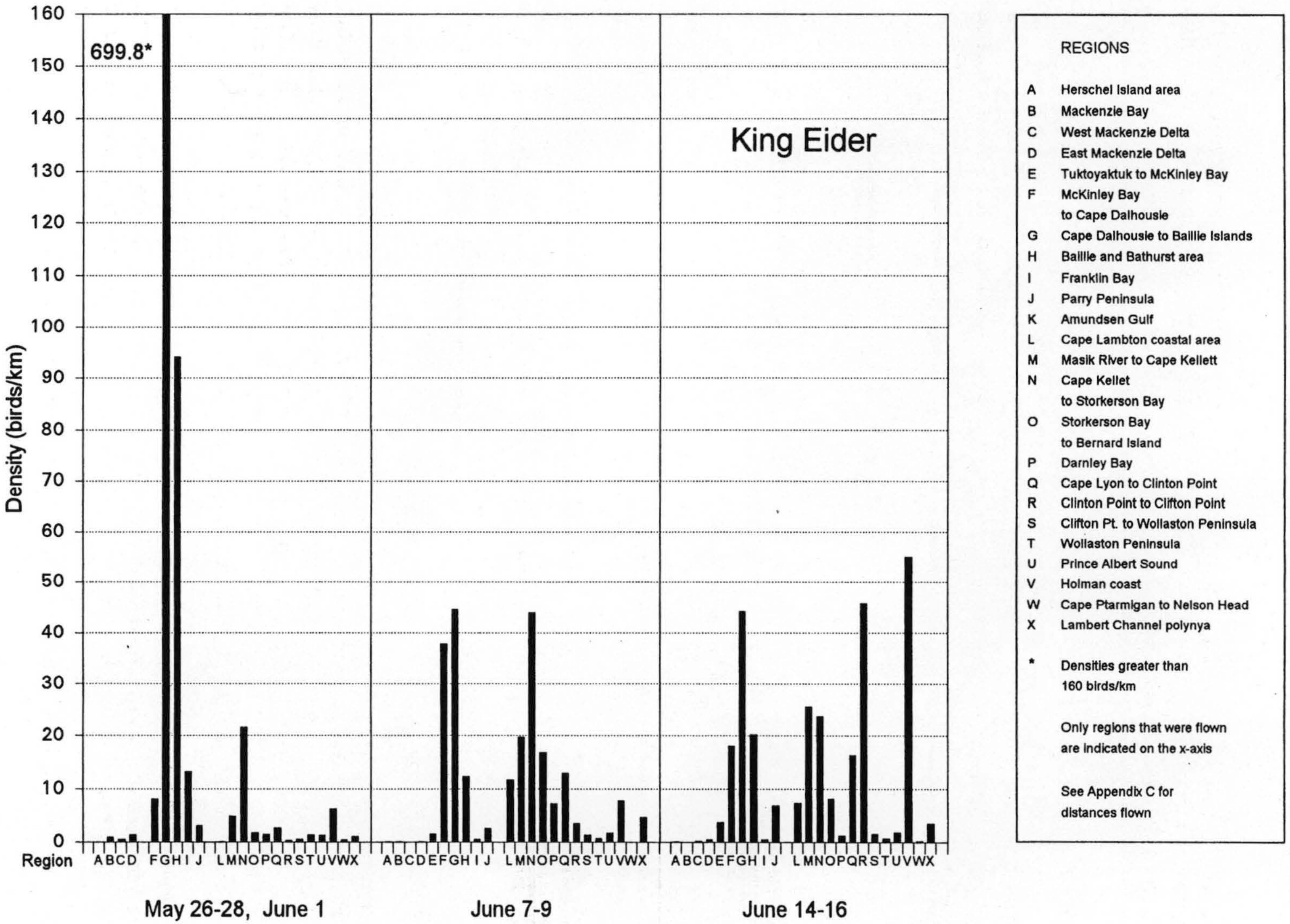


Figure 6. Distribution of King Eiders during aerial surveys of the Beaufort Sea, Amundsen Gulf, and Lambert Channel polynya, May and June 1993.

May 30 (Table 1, Figure 6). King Eider abundance peaked by our June 16 survey. The highest numbers occurred between Cape Lyon and Clinton Point (Region Q) and off Victoria Island north of Holman (Region V). In contrast to more westerly regions, males comprised only 66% of King Eiders in Amundsen Gulf by the last survey.

King Eiders occurred in low numbers in the Lambert Channel polynya (Table 1). Their numbers increased from May 27 to June 9 and 16. The percentage of males changed from around 50% to 60% over the same period (Appendix E).

3.2.3 Oldsquaw

There were more Oldsquaw west of Tuktoyaktuk (Regions A-D) than either eider species (Table 2). Like the eiders, however, they were most abundant between Cape Dalhousie and the Baillie Islands (Regions G-H; Figure 7). On average over all surveys, 23% of the Oldsquaw occurred between Cape Dalhousie and the Baillie Islands, while 24% occurred among regions west of there. Peak numbers were recorded on our first survey (May 26 to June 1; Table 1).

Numbers and densities of Oldsquaw were low (<1% of the birds recorded) off western Banks Island (Regions L-O; Tables 1-2, Figure 7). On average, 34% of Oldsquaw were along the southern shore of Amundsen Gulf, mostly between Cape Lyon and Clinton Point (Region Q). We recorded peak numbers there on June 9. Only three Oldsquaw were recorded in Lambert Channel on our first survey (May 27), whereas several hundred were seen there on subsequent surveys.

3.2.4 Loons

Pacific Loons (*Gavia pacifica*) were recorded in small numbers throughout the study area on all surveys (Table 1). In the southern Beaufort Sea, numbers fluctuated among surveys. In eastern areas, Pacific Loon numbers were highest during the June 8-9 survey.

Red-throated Loons (*G. stellata*) were common only in the Herschel Island to Cape Parry area, and like Pacific Loons, fluctuated in abundance to a high of 150 birds on our last survey (Table 1). On our first survey, all birds were seen west Tuktoyaktuk (0.4 birds/km; Appendix C), and most of those were west of the Mackenzie Delta (Regions B-C, 106 birds, 0.5 birds/km). On our last survey, Red-throated Loons occurred in similar densities from Herschel Island to Cape Dalhousie (0.2 to 0.3 birds/km).

Yellow-billed Loons (*G. adamsii*) occurred in generally low numbers throughout the study area, except in Lambert Channel on the second survey when over 300 were recorded (June 9; Table 1). By June 16, numbers in the channel had dropped considerably. Only one Yellow-billed Loon was seen in offshore areas during our intensive transects in the southeastern Beaufort Sea on June 10.

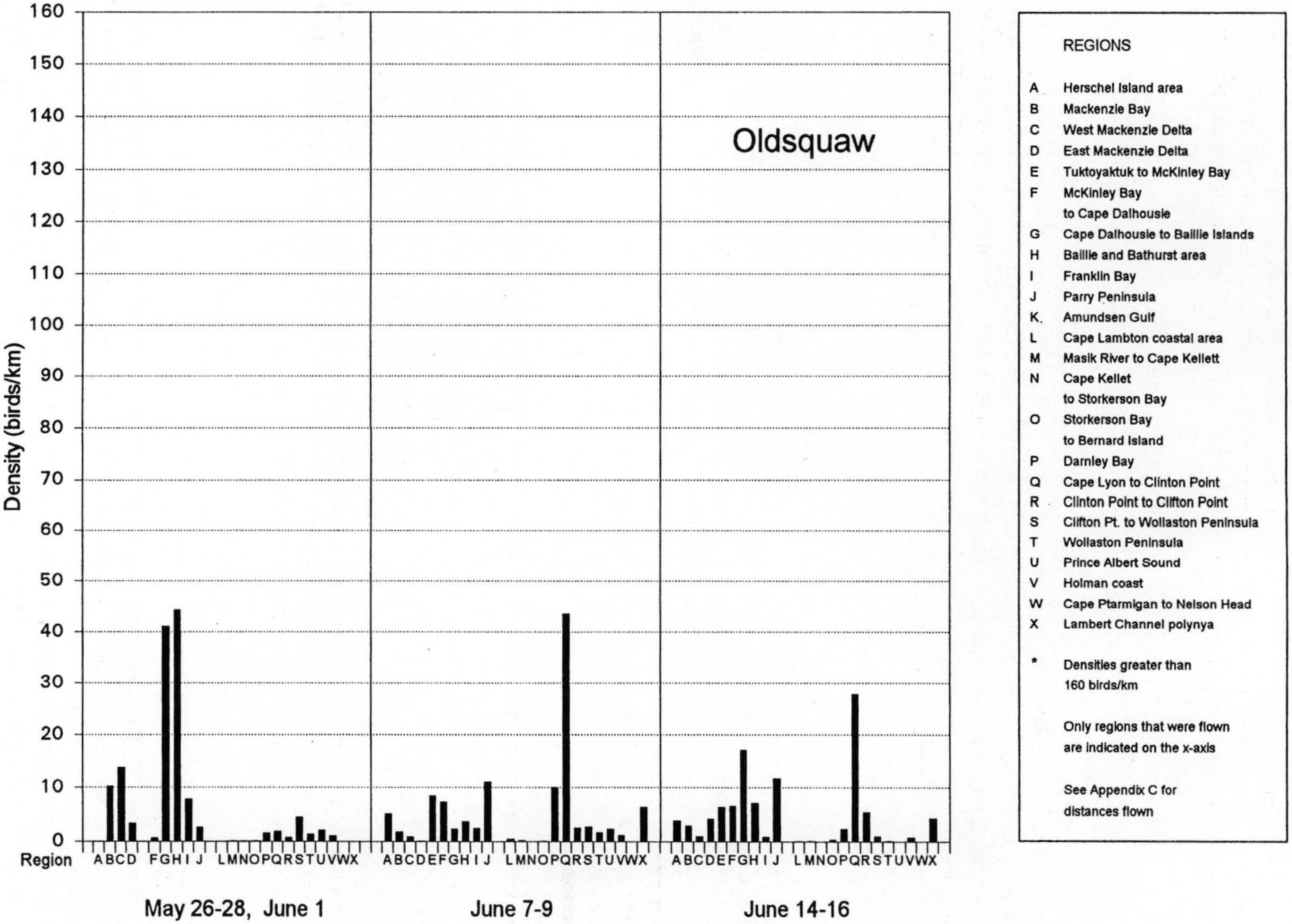


Figure 7. Distribution of Oldsquaws during aerial surveys of the Beaufort Sea, Amundsen Gulf, and Lambert Channel polynya, May and June 1993.

3.2.5 Scoters

Scoters were uncommon in the study area until our last survey (June 14-16; Table 1). At that time, most birds were in the Herschel Island to Cape Parry area, particularly between Herschel Island and Tuktoyaktuk (Regions A-D: 4039 birds). All identified scoters were White-winged Scoters (*Melanitta fusca*), and most of those were males.

3.2.6 Glaucous Gulls

Glaucous Gulls were most abundant in the Amundsen Gulf (Table 1). Highest densities occurred between Clifton Point and the Wollaston Peninsula (Regions S-T, 5.4 birds/km; Appendix C). Two to three hundred gulls were also present at Holman, mostly at the dump. Glaucous Gulls were evenly distributed throughout the southern Beaufort Sea (0.4 birds/km), while off western Banks Island, most occurred south of Cape Kellett (0.6 birds/km; Appendix C). Glaucous Gulls were most numerous in late May in all areas (Table 1). There was a small colony of nesting gulls (<30 pairs) on Ivonayak Island at the east end of the Lambert Channel polynya.

3.2.7 Other species

Swans, geese, and ducks other than eiders and Oldsquaw were uncommon (Table 3). On our first survey we saw a few small flocks of Brant (*Branta bernicla*) flying along leads just west of the Mackenzie Delta, while on our second survey we saw a couple flocks north of Storkerson Bay (Region O). Most unidentified ducks were probably unidentified eiders and Oldsquaw.

Shorebirds (mostly unidentified phalaropes *Phalaropus* sp.), Pomarine Jaegers (*Stercorarius pomarinus*), Parasitic Jaegers (*S. parasiticus*), Sabine's Gulls (*Xema sabini*), and Arctic Terns (*Sterna paradisaea*) were generally uncommon (Table 3). On June 8, we saw a couple hundred Sabine's Gulls along the ice edge in Prince Albert Sound (Region U). Most of the Arctic Terns were seen near Herschel Island.

We saw two flocks of murres, most likely Thick-billed Murres (*Uria lomvia*) (Johnson and Ward 1985), totalling 903 birds near Police Point (Cape Parry) on our last survey (June 16; Table 3). None was seen before then.

3.3 Intensive survey

Of the only 2906 birds seen on and off transect during the intensive survey on June 10, 2661 were King Eiders, 103 were Oldsquaw, 74 were Pacific Eiders, 56 were unidentified eiders, and the remaining 12 were Glaucous Gulls, phalaropes, and loons (Appendix B). The percentages that were associated with the landfast ice edge were: 80% of the Pacific Eiders, 22% of the Oldsquaw, and 7% of the King Eiders. These distributions are, however, somewhat misleading for two reasons: 1) few birds were

Table 3. Other bird species observed during aerial surveys of offshore leads and polynyas in the Beaufort Sea, Amundsen Gulf, and Lambert Channel, spring 1993.

	Herschel Island to Cape Parry			Western Banks Island			Amundsen Gulf			Lambert Channel		
Species	May 26-28, & June 1	June 7-9	June 14-16	May 26-28, & June 1	June 7-9	June 14-16	May 26-28, & June 1	June 7-9	June 14-16	May 27	June 9	June 16
Tundra Swan[a]						1						
Brant	69				95							
Snow Goose[b]	4			11								
Dark Geese	94				9	60	2		8		14	
Duck sp.	3038	96	110	11	5	30	11	199	51	5	1	10
Shorebird sp.			1		5							
Phalarope sp.	3		1	8				7				
Pomarine Jaeger	11								1			
Parasitic Jaeger	3		2				2		3			
Jaeger sp.	13	6	2				1	1	4			
Sabine's Gull	24	5	1					226				
Gull sp.		1			1			3				
Arctic Tern	1		72									
Murre sp.			903									
Short-eared Owl[c]	2											
Totals	3262	108	1092	30	115	91	16	436	67	5	15	10

[a] *Cygnus columbianus*
[b] *Chen caerulescens*
[c] *Asio flammeus*

seen because most had migrated out of the Cape Dalhousie to Baillie Islands area prior to the day we had surveyed; therefore, the observed distributions are not necessarily representative of staging birds; 2) 78% of the eiders and Oldsquaw away from the landfast ice edge were associated with a few patches of pan ice (mostly in transects 5-6) while 13% were migrating (i.e. flying in v-formation) towards Banks Island. Therefore, 8% of all ducks seen (232 birds) were away from the ice edge and were not either migrating or associated with pan ice. We also made observations while flying between transects (84.0 km in offshore waters, 59.2 km along the ice edge). The linear densities of ducks in the two areas were 2.3 (offshore) and 26.3 birds/km (ice edge). Most of the birds seen in the offshore area (172 out of 196) comprised five flocks of migrating King Eiders.

4.0 DISCUSSION

4.1 Limitations of surveys

In general, most birds congregate along the landfast ice edge. The results from our intensive transects indicate, however, that some birds, particularly King Eiders, are not always associated with the landfast ice edge. Most of the birds we saw away from the landfast ice edge were associated with pans of ice. They were likely attracted to such areas because the ice reduces wave action and provides roost sites. Richardson *et al.* (1975:102) flew a lead northwest of Herschel Island and found 70% of the birds were along the landward edge, 29% in the centre, and 1% on the seaward edge (they flew the centre right after flying the landward edge and may have scared some birds from the edge to the centre). Barry *et al.* (1981) noted that, with the exception of loons, most birds occur within one or two kilometres of the landfast ice edge.

Although there is evidence indicating that some birds may be missed by surveying only the ice edge, there is no clear indication of appropriate correction factors. The distribution of pan ice, for example, will vary on an annual and daily basis depending on wind conditions and how the ice breaks up. Therefore, although our extensive surveys following lead edges probably covered most of the heavily-used habitat, abundances are underestimated, especially for the King Eider.

There are two other sources of error that result in underestimates of abundance. First, none of our results are corrected for visibility or observer counting biases (Caughley 1977:35, Krebs 1989:98). Second, birds migrate through the study area over several weeks, but we had no means of measuring turnover rates. Reported numbers of birds thus underestimate actual numbers migrating through the Beaufort Sea, Amundsen Gulf, and Lambert Channel. Since the three sources of error apply throughout the study area, relative abundances among areas are considered reasonable.

4.2 Key results from 1993

The most prominent contrast between spring breakup in 1993 and other years studied to date was the extent of open water in and east of the Beaufort Sea in mid to late May, and continuing throughout the migration period (compare Figures 2-4 with similar figures in Alexander *et al.* 1988b, 1993). Furthermore, tens of thousands of eiders and Oldsquaw stopped in the Cape Dalhousie to Baillie Islands area despite the clear availability of water east and north of there. Similarly, in 1992 we found that eiders and Oldsquaws persisted in using the Cape Dalhousie to Baillie islands for staging even though this area was virtually ice-bound and open water was available elsewhere (Alexander *et al.* 1993).

In 1993, spring thaw of nesting areas on Banks Island, the Tuktoyaktuk Peninsula, and to a lesser extent, Victoria Island was early compared to other years (at least 10 days earlier than in 1992). This appears to have accelerated the pace of migration through the Beaufort Sea, but it was not clear whether migration also started earlier. Peak numbers of both King and Pacific eiders were recorded in late May (Table 1), which is earlier than other years (Alexander *et al.* 1988b, 1993). Such differences in timing could arise from differences in either the timing of peak movement into the southeastern Beaufort Sea or the duration of staging once there.

In 1993 we recorded larger numbers of King Eiders (over 65 000 on May 28) near the Baillie Islands than ever reported previously. It is not clear to us whether King Eiders stop annually in such large numbers in the southeastern Beaufort Sea. Nearly 40 000 were recorded there in 1992, but this was attributed, perhaps erroneously, to lack of open water off Banks Island (Alexander *et al.* 1993). Considerably smaller numbers have been recorded in all other surveys from 1974 to 1987 (Searing *et al.* 1975, Barry *et al.* 1981, Barry and Barry 1982, Alexander *et al.* 1988b). The survey conditions on May 28, 1993, were unusually excellent (i.e. calm and overcast), which likely resulted in greater visibility. Most surveys have been done under less ideal conditions (Appendix A; Alexander *et al.* 1988b, 1993).

The second striking observation in 1993 was that there were relatively few King Eiders off western Banks Island (a peak of about 12 000 on our June 7 survey). Since western Banks Island was already clear of snow and ice by our second survey, we suspect that many King Eiders had not required a lengthy staging period off western Banks Island and had proceeded directly to their nesting grounds (while flying over Banks Island from Bernard Island to Sachs Harbour, we noted several flocks and pairs of King Eiders inland). Furthermore, by our last survey in mid-June, males were already more common than females indicating that breeding was well underway nearly ten days earlier than in 1987 or 1992 (Alexander *et al.* 1988b, 1993).

4.3 Evaluations of distribution and abundance

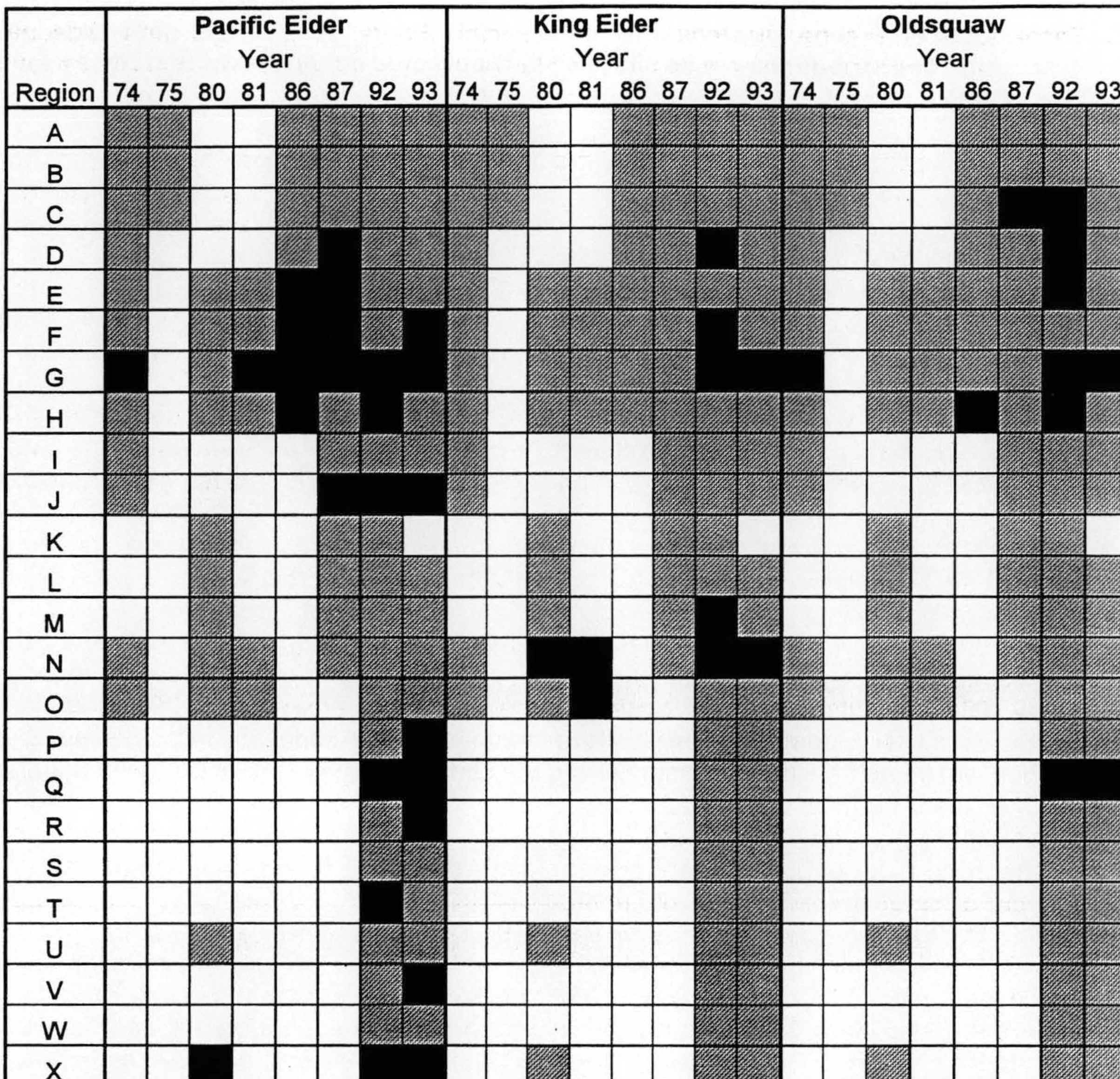
The main objective of this study is to outline the distributions of western Arctic populations of seabirds during spring migration through offshore areas of the Beaufort Sea, Amundsen Gulf, and Dolphin and Union Strait. Since seabird distributions can be understood only through several years of study under various ice conditions, our description of distributions will be based on data collected during previous studies as well as in 1993.

We will determine key staging areas using two approaches: 1) we will identify where at least 1% of the western Arctic population of each key species (Pacific Eiders, King Eiders, and Oldsquaw) occurs; and 2) we will consider the average relative distribution of each key species in the study area.

In our first approach, we will use the following estimates for western Arctic populations to provide a general indication of key areas from a broad range of data (Figure 8): 100 000 Pacific Eider, 400 000 King Eider, and 240 000 Oldsquaw. The Pacific Eider and Oldsquaw population estimates are crude and were obtained 17-23 years ago from migration-watch studies at Point Barrow, Alaska (reviewed in Alexander *et al.* 1988b). The King Eider population represents a compromise between breeding-ground and migration-watch estimates. Breeding-ground surveys were done in 1992 and 1993 by D.L. Dickson and others for the Canadian Wildlife Service. Preliminary analyses suggest that the breeding population in the Canadian western Arctic (Banks Island, Victoria Island, continental coast including Queen Maud Gulf area) is in the order of 200 000 birds. In contrast, the Alaskan studies from 1970 (Johnson 1971) and 1976 (Woodby and Divoky 1982) suggest a population in the order of 800 000. A more recent study (1987) at Point Barrow suggests a population in the order of 600 000 King Eiders (R. Suydam, pers. comm.). Our spring migration surveys suggest King Eider numbers are similar to Pacific Eider numbers. Given the conflicting information on the abundance of King Eiders in the western Arctic, a population estimate of 400 000 birds seemed the best compromise for the purpose of this paper. Versions of Figure 8 for larger and smaller King Eider populations are presented in Appendix F for reference in the future if a larger or smaller estimate is confirmed.

Figure 8 identifies the areas where at least 1% of the western Arctic population has been seen. The surveys from 1980 to 1993 were similar in method but not in coverage (see Figure 8 for sources). Only one survey was conducted in each of 1980 and 1981, two in 1986, five in each of 1974, 1975, 1987, and 1992, and three in 1993. Each region was not necessarily visited on all surveys. In 1974, long transects extended over the pack ice, without necessarily following ice edges. In 1975, surveys were restricted to Mackenzie Bay, and were somewhat arbitrary in location and extent. The 1% criterion has a greater chance of being met in years with several surveys. None of the studies take turnover rates into account. *The blackened regions in Figure 8 are, therefore, the regions in which there is a high probability of encountering greater than 1% of the western Arctic population of a certain species on at least one day sometime during spring migration*. Other regions may also be visited by greater than 1% of a population but in smaller numbers at any given time.

In our second approach, we have included only the most consistently collected data (1986-1993). Table 4 excludes 1974-75 because survey coverage was poor in many areas used by birds, and 1980-81 because only one survey was flown each year and overall abundance those years was low (exceptions will be noted in the text). Both limitations would result in misleading indications of relative distribution. The 1986-87



Symbols: ■ 1% or more of the population ▒ <1% of the population □ Not surveyed

Sources: 1974 (Searing et al. 1975); 1975 (Richardson et al. 1975); 1980 (Barry et al. 1981, Allen 1982); 1981 (Barry and Barry 1982); 1986, 1987 (Alexander et al. 1988b); 1992 (Alexander et al. 1993); 1993 (this study).

Regions:

A	Herschel Island area	I	Franklin Bay	Q	Cape Lyon to Clinton Point
B	Mackenzie Bay	J	Parry Peninsula	R	Clinton Point to Clifton Point
C	West Mackenzie Delta	K	Amundsen Gulf	S	Clifton to Wollaston Peninsula
D	East Mackenzie Delta	L	Cape Lambton coastal area	T	Wollaston Peninsula
E	Tuktoyaktuk to McKinley Bay	M	Masik River to Cape Kellett	U	Prince Albert Sound
F	McKinley to Cape Dalhousie	N	Kellett to Storkerson Bay	V	Holman coast
G	Dalhousie to Baillie Islands	O	Storkerson to Bernard Island	W	Cape Ptarmigan to Nelson Head
H	Baillie and Bathurst area	P	Darnley Bay	X	Lambert Channel

Figure 8. Regions in which at least 1% of the western Arctic populations of Pacific Eiders, King Eiders, and Oldsquaw have been observed, 1974-1993.

Table 4. Average percent occurrence of Pacific Eiders, King Eiders, and Oldsquaw observed during aerial surveys of offshore leads and polynyas in the Beaufort Sea and Amundsen Gulf, spring 1986-1993.

Regions	June 3-10 1986	May 26 - June 16 1987	May 24 - June 18 1992	May 26 - June16 1993	Average 1986 - 1993
			PACIFIC EIDER		
A-D	5.6	4.9	1.0	3.6	3.4
E-F	9.2	31.9	13.8	11.8	15.0
G-H	79.3	44.2	59.3	31.6	48.1
I-J	--	5.9	3.0	14.9	7.1
K	--	0.1	0.5	--	0.3
L-O	--	1.1	3.5	4.5	2.7
P-R	--	--	11.8	29.7	18.6
S-V	--	--	7.0	3.8	4.9
W	--	--	0.0	0.0	0.0
			KING EIDER		
A-D	2.7	2.5	0.3	0.3	1.4
E-F	36.2	21.7	6.9	7.7	17.3
G-H	14.1	9.4	40.9	42.8	25.6
I-J	--	2.4	0.1	2.7	1.6
K	--	0.2	0.1	--	0.1
L-O	--	60.9	47.2	30.3	44.0
P-R	--	--	1.6	9.3	5.2
S-V	--	--	3.0	6.9	4.7
W	--	--	0.0	0.1	<0.1
			OLDSQUAW		
A-D	20.9	46.8	17.8	14.5	22.4
E-F	12.1	12.1	20.6	9.6	12.2
G-H	58.0	19.4	39.0	23.4	31.3
I-J	--	8.7	1.2	14.2	7.2
K	--	0.1	0.5	--	0.3
L-O	--	0.9	0.8	0.5	0.7
P-R	--	--	14.9	34.2	22.0
S-V	--	--	5.2	3.7	4.0
W	--	--	0.0	0.0	0.0

REGIONS

A-D	Herschel Island to Tuktoyaktuk
E-F	Tuktoyaktuk to Cape Dalhousie
G-H	Cape Dalhousie to the Baillie Islands
I-J	Baillie Islands to Cape Parry
K	Cape Parry to Cape Lambton
L-O	Cape Lambton to Bernard Island
P-R	Cape Parry to Clifton Point
S-V	Clifton Point to Cape Ptarmigan
W	Cape Ptarmigan to Nelson Head

Notes: Values for Regions A-H in 1992 are corrected for survey efficiency (see Alexander *et al.* 1993). Values in 1986 and 1987 have been adjusted for missing data in regions not flown those years. The adjustment corresponds to the proportion of birds seen in the missed regions in other years. For example, in 1987, Regions P-W were ice covered during surveys 1-2 and not flown during surveys 3-4. These regions had 29% of the Oldsquaw in 1992 and 1993. Therefore, we assumed only 71% of Oldsquaw occurred in the regions flown in surveys 3-4 of 1987 and adjusted percentages to that total. Similar arguments can be made for the eider species. Without these adjustments, percentages in 1986 and 1987 would be misleadingly high.

percentages have been adjusted for missing data in regions not flown those years (see Table 4). Lastly, we have not included Lambert Channel in Table 4 for the reasons outlined above for Table 2 (Section 3.3).

4.3.1 Pacific Eiders

In the Beaufort Sea in 1993, Pacific Eiders were most abundant between Cape Dalhousie and the Baillie Islands. This region was an important concentration area for Pacific Eiders during spring migration in six of the eight years of surveys (Alexander *et al.* 1988b, 1993; Figure 8). On any given day, an average of 48% of Pacific Eiders can occur between Cape Dalhousie and the Baillie Islands, while 15% can occur off the Tuktoyaktuk Peninsula (Table 4). In all years, few Pacific Eiders occurred either off the Mackenzie Delta or west of it (average of 3%). In the Beaufort Sea in 1992, most of the available water occurred off the Yukon coast, while the rest was covered with pack ice. Even under these conditions, few Pacific Eiders occurred west of the Mackenzie Delta (Alexander *et al.* 1993).

In the southern Beaufort Sea in 1974 (Searing *et al.* 1975) and 1993, peak numbers of Pacific Eiders were recorded in the last week of May. In 1986, 1987, and 1992, however, peak numbers of Pacific Eiders occurred in the second week of June (Alexander *et al.* 1988b, 1993). In 1976 at Point Barrow, Alaska (approximately 1100 km west of Cape Bathurst), Pacific Eider migration did not start in earnest until June 4 (Woodby and Divoky 1982). Therefore, peak movement and/or buildup of birds in the southeastern Beaufort Sea likely occurs in mid-June most years, but will occur as early as late May in some years.

The Lambert Channel polynya is as important as the southeastern Beaufort Sea for Pacific Eiders during spring migration. Barry (1986) speculated that in the order of 70 000 Pacific Eiders migrate through Dolphin and Union Strait, which represents 70% of the western Arctic population. We counted peak numbers of over 31 000 and 64 000 Pacific Eiders on June 17, 1992, and June 9, 1993, respectively (Table 1; Alexander *et al.* 1993). In 1980, peak Pacific Eider abundance occurred June 7-13 (Allen 1982). In a single 2-hour watch from shore on June 10, Allen tallied 18 408 birds. If, as we have argued above, the birds staging in Lambert Channel first stop in the southeastern Beaufort Sea and Amundsen Gulf, then the number using the Cape Dalhousie to Baillie Islands area is at least as high. This should be confirmed more directly, perhaps using radio-marked birds.

With surveys in 1992 and 1993, it is apparent that the southern coast of Amundsen Gulf is important for migrating Pacific Eiders (Figure 8). On average, 19% of Pacific Eiders can occur between Cape Lyon and Clifton Point when open water is available. Leads off the Wollaston Peninsula and Prince Albert Sound, Victoria Island, have on average 5% of Pacific Eiders during migration (Table 4). Pacific Eiders have not been very abundant in offshore areas of Amundsen Gulf (Regions K and W) or off western Banks Island in any year (Table 4, Figure 8; Alexander *et al.* 1988b, 1993). The timing of movement into Amundsen Gulf is likely related to the timing of availability of open water.

In summary, Pacific Eiders migrate through the Beaufort Sea, Amundsen Gulf, and Lambert Channel in large numbers starting in mid-May. Peak movement and staging occur in the second week of June most years, but as early as the last week of May in some years. The most important staging areas are off the Tuktoyaktuk Peninsula between Cape Dalhousie and the Baillie Islands, and in the Lambert Channel polynya. The former area is used even in years when pack ice predominates, as long as there is some open water within the ice. Both areas provide water shallow enough for feeding (<20 m). Each of these areas can account for over 50% of Pacific Eiders present on any given day during spring migration. Our evidence suggests that most birds using Lambert Channel also stop in the southeastern Beaufort Sea. The southern coast of Amundsen Gulf is also important, where about 19% of Pacific Eiders can be expected on any given day when open water is available. About 15% occur between Tuktoyaktuk and Cape Dalhousie, while 3% occur west of there on any given day. The cumulative percentages of birds using these areas throughout the migration period is undoubtedly higher than indicated, but cannot be estimated because turnover rates are not known.

4.3.2 King Eiders

In some years, the largest concentrations of King Eiders occur off western Banks Island, particularly between Masik River and Bernard Island (Barry *et al.* 1981, Barry and Barry 1982, Alexander *et al.* 1993). Barry (1986) described the southern two-thirds of the west coast of Banks Island as "the largest known spring staging area for King Eiders: as many as 95 000 have been observed at one time." An average of 87% of King Eiders were seen there on single surveys in 1980 and 1981 (Barry *et al.* 1981, Barry and Barry 1982). In comparison, an average of 44% of King Eiders occurred off western Banks Island on any given day during spring migration from 1986 to 1993 (Table 4).

In 1993, the largest single concentration of King Eiders was off the Baillie Islands (over 65 000 birds). On average from 1986 to 1993, 17% of King Eiders occurred between Tuktoyaktuk and Cape Dalhousie, while 26% occurred between Cape Dalhousie and the Baillie Islands (Table 4). In 1980 and 1981, there was an average of only 12% between Tuktoyaktuk and the Baillie Islands. King Eiders are much less common west of these areas, between Herschel Island and Tuktoyaktuk (an average of 1% of King Eiders on any given day during migration).

King Eiders occurred in low densities throughout Amundsen Gulf in 1992 and 1993 (Figure 6, Table 4; Alexander *et al.* 1993). In both years, the two most significant concentration areas were between Cape Lyon and Clifton Point, and off the tip of Wollaston Peninsula, Victoria Island. In mid-June 1993, in the order of 4000 King Eiders were observed in the open water off the Victoria Island coast north of Holman. These are the only areas surveyed in Amundsen Gulf where water is shallow enough for feeding. Peak numbers in southern Amundsen Gulf occurred by mid-June in both years. In 1971, eiders had started to move into the Holman region in mid to late May, and the main eider hunt took place in the first two weeks of June (Smith 1973).

Considering that 70% of the western Arctic King Eiders are thought to nest on Victoria Island (Barry 1968), and that relatively few have been seen in the leads just west of the island, it would appear that these leads are relatively unimportant for migrating King Eiders. Most Victoria Island birds might stage off Banks Island or the Baillie Islands, and then migrate directly to the nesting grounds without further stopovers.

King Eiders were uncommon in the Lambert Channel polynya in early to mid-June in 1980 (Allen 1982), 1992 (Alexander et al. 1993), and 1993 (Table 1). In late June 1992, however, over 3000 King Eiders were observed, 78% of which were males. There is no other documentation of the late spring and summer use of Lambert Channel by eiders.

The timing of King Eider migration is not entirely clear. Off the Tuktoyaktuk Peninsula in 1993, we recorded the largest numbers of King Eiders in late May. Off western Banks Island that year, we recorded the largest numbers at the beginning of the second week in June. Off western Banks Island in 1987, peak numbers were recorded June 9-12 but since only a couple thousand birds were present, this record is of questionable relevance (Alexander *et al.* 1988b). Other years do not provide useful data on timing. In general, however, the timing of migration for King Eiders was similar to the timing for Pacific Eiders. Peak passage of King Eiders at Point Barrow in 1976 occurred on May 25 compared to after June 4 for Pacific Eiders (Woodby and Divoky 1982), indicating that King Eiders should peak earlier than Pacific Eiders. The timing of peak eastward movement and/or buildup of birds in the southeastern Beaufort Sea thus appears to be similar to or possibly earlier than Pacific Eiders, which means it can occur any time from late May to mid-June.

There is considerable discrepancy between the numbers of King Eiders observed during spring migration surveys and the estimated population size (see Section 4.3). This could be due to either a high turnover of birds at staging areas, or a large percentage of the King Eider population occurring further offshore than usually surveyed. In contrast, Pacific Eiders have been seen during spring surveys in numbers comparable to their estimated population size (e.g. June 7-9, 1993; Table 1).

If several hundred thousand King Eiders use offshore areas, then they must be spread out well into the pack ice, or along its southern and east edge, north of about 71°N and west of about 130°W. These degrees roughly delimit the extent of surveys into the Beaufort Sea to date. For example, the most extensive offshore surveys were done by Searing *et al.* (1975) in 1974. The highest number of King Eiders seen on any survey set was a mere 634 birds (although they also observed 1000-5000 unidentified eiders at roughly 71°N 130°W). Similarly, in all our flights between Banks Island and the continent, we have never seen many birds far offshore, nor did we see many during our intensive transects in the southeastern Beaufort Sea. Barry (1986) notes, however, that biologists conducting surveys for whales have seen unspecified numbers of eiders sitting in and flying over rectilinear leads in the Beaufort Sea pack ice 400-500 km west of Banks Island. These birds were in a line between Point Barrow and Banks Island and may have been in the process of migration.

Since the water in offshore areas would be so deep, the eiders would have to either feed on something other than benthic invertebrates, or fast and rely on nutrient reserves and food from the breeding grounds. There is little evidence for or against any of these possibilities other than that while on the breeding grounds, King Eiders, especially females, eat substantial numbers of aquatic insect larvae and crustaceans (reviewed in Cramp and Simmons 1977).

In summary, King Eiders migrate through the Beaufort Sea and Amundsen Gulf starting in the second and third weeks of May. Peak eastward movement and staging occur sometime in the last week of May and the first two weeks of June. Westward moult migration begins in mid to late June. The most important staging areas are off western Banks Island, especially north of Masik River, and in the southern Beaufort Sea between Tuktoyaktuk and the Baillie Islands, both of which provide shallow water for feeding. These areas can each account for 44-87% and 12-43%, respectively, of King Eiders on any given day during spring migration. The range in percentages is likely the product of both sampling error and variable weather and ice conditions. Very few (about 1%) King Eiders occur west of Tuktoyaktuk on any given day.

4.3.3 Oldsquaw

In all studies from 1986 to 1993, Oldsquaw have been abundant throughout the southern Beaufort Sea (Table 4). They have usually been most abundant between Cape Dalhousie and the Baillie Islands, where an average of 31% of the Oldsquaw can occur on any given day during spring migration. Similarly, in 1974, about 10 000 Oldsquaw were counted between Cape Dalhousie and the Baillie Islands in late May (Searing *et al.* 1975). While 10 to 21% (average of 12%) of the Oldsquaw occur between Tuktoyaktuk and Cape Dalhousie, 19 to 58% (average of 22%) occur between Herschel Island and Tuktoyaktuk. In the latter area, they are more abundant than either species of eider.

The greater presence of Oldsquaw than eiders west of Tuktoyaktuk may be related to their nesting distribution, diving ability, and feeding habits. The Oldsquaw is a common nesting bird all along the continental coast while eiders are not. The flocks west of Tuktoyaktuk may, therefore, comprise local breeders as well as migrants. Oldsquaw are able to dive to greater depths than the eiders (maximum recorded depths: Common Eider, 20m; King Eider, 55m; Oldsquaw, 73m; reviewed in Cramp and Simmons 1977, Bellrose 1978). Oldsquaw also use a greater variety of habitats and prey, such as various invertebrates (e.g. mussels, isopods, amphipods), fish, and fish eggs (Peterson and Ellarson 1977, Bellrose 1978, Johnson 1984, Sanger and Jones 1984) that may occur in the water column and under the ice, as well as on the sea bottom. Johnson and Richardson (1981), for example, found large numbers of the ice-associated invertebrate, *Apherusa glacialis*, in the digestive tracts of Oldsquaw feeding among ice floes. Eiders, on the other hand, feed mainly on benthic and epibenthic marine invertebrates (especially mussels and echinoderms, but also annelids and fish eggs; Cantin *et al.* 1974, Cramp and Simmons 1977, Bellrose 1978, Goudie and Ankney 1986, Bustnes and Erikstad 1988). Pacific Eiders also eat substantial numbers of crustaceans (Cottam 1939 in Bellrose 1978). King Eiders, however, may have a more varied diet under particular conditions. For example, King Eiders from coastal lakes in Greenland during spring ate recently thawed crustaceans (*Branchinecta paludosa*) that had been frozen-in since the previous autumn (Røen 1965). On the breeding grounds, both Oldsquaw and King Eider eat substantial numbers of aquatic insect larvae and crustaceans (reviewed in Cramp and Simmons 1977). Therefore, it appears that in both their diving ability and feeding habits, Oldsquaw are less restricted by water depth than the eiders, particularly the Pacific Eider, and are thus better able to make use of the deeper water areas between Herschel Island and the Mackenzie Delta. The water off the Mackenzie Delta itself is very turbid due to river effluent. Reduced visibility while diving in the murky water may hamper foraging by all species of birds, which may explain the low numbers of birds seen in this area.

Oldsquaw were uncommon off western Banks Island in all years (Table 4, Table 8; Barry *et al.* 1981, Barry and Barry 1982). They were considerably more common throughout Amundsen Gulf in 1992 and 1993 (average of 22%), especially after the first week of June, and particularly along the mainland coast between Cape Lyon and Clifton Point (Tables 2 and 4; Figure 8). Some of these birds may have been male moult-migrants. We saw few Oldsquaw in the Lambert Channel polynya in either 1992 or 1993 (Table 1). On an aerial survey June 25, 1980, Allen (1982) recorded 1851 birds, and on a single migration watch on June 10 Allen recorded 2002 birds. The latter number represents just under 1% of the western Arctic population.

In 1993, peak numbers of Oldsquaw in the southern Beaufort Sea occurred in the last week of May. In 1986 and 1987, peak numbers occurred in the first week of June (Alexander *et al.* 1988b). In 1975, large eastward movements of Oldsquaw were noted along the western Yukon coast starting May 29, but peak movements occurred in the second week of June (Richardson and Johnson 1981). At Point Barrow in 1976, Oldsquaw were uncommon before June 4 (Woodby and Divoky 1982). Therefore, peak Oldsquaw migration occurs sometime between the last week in May and the second week in June.

In summary, Oldsquaw enter the Beaufort Sea in late May. Peak movement and staging occur between the last week in May and the second week in June, and later east of the Beaufort Sea. Oldsquaw are, in general, dispersed throughout the southern Beaufort Sea: 22% of the Oldsquaw present on any given day during spring migration are between Herschel Island and Tuktoyaktuk; 12% between there and Cape Dalhousie; and 31% between there and the Baillie Islands. About 22% of the Oldsquaw occur between Cape Lyon and Clinton Point in Amundsen Gulf.

4.3.4 Loons

In 1992, Pacific Loons were common in the southern Beaufort Sea west of the Mackenzie River delta for a short period at the end of the first week in June (Alexander *et al.* 1993). Few (<40) were seen on any of the surveys in 1975, 1986, 1987, and 1993 (Searing *et al.* 1975, Alexander *et al.* 1988b; Table 1). In mid to late June, 1992, Pacific Loons were most common in the Lambert Channel polynya, whereas in 1993, they were most common off the Wollaston Peninsula, Victoria Island. In 1980, Allen (1982) found that these birds were second in abundance to Yellow-billed Loons, and that they did not appear in the Lambert Channel polynya until mid-June. Parmelee *et al.* (1967) noted a similar arrival time at Cambridge Bay.

Red-throated Loons are common only in the southern Beaufort Sea. Based on the 1992 (Alexander *et al.* 1993) and 1993 surveys, an average of 62% of Red-throated Loons occurred between Herschel Island and Tuktoyaktuk while most of the remainder occurred between Tuktoyaktuk and Cape Dalhousie. In 1987, they were also most abundant in the former area (Alexander *et al.* 1988b). Red-throated Loons feed on fish rather than bottom-dwelling invertebrates and are thus, like Oldsquaw, better able than the eiders to forage in the deeper waters off the Yukon coast.

In 1987 and 1992, Red-throated Loon numbers peaked abruptly at the end of the first week in June and dropped quickly thereafter. In contrast, in 1993 their numbers fluctuated over the three surveys to a high point on June 14. Since spring thaw occurred earlier in 1993 than 1992, the difference in patterns of abundance cannot be attributed to weather-related delays in breeding. Although Red-throated Loons move onto their nesting ponds along the Beaufort Sea coast as soon as the ponds have thawed (usually in the first and second week of June), they remain dependent on fish from the Beaufort Sea throughout the nesting season (Dickson 1993). Therefore, the loons in the leads in mid-June, 1993, may have been local breeders that had flown to the leads to forage.

Large numbers of Yellow-billed Loons were seen in the Beaufort Sea in 1992 (over 200 on each of two surveys; Alexander *et al.* 1993), but not in other years (Table 1; Barry *et al.* 1981, Barry and Barry 1982, Alexander *et al.* 1988b, Johnson and Herter 1989). Banks Island was free of snow and ice about 10 days later in 1992 than in 1993. The delayed melt on the breeding grounds in 1992 might have forced Yellow-billed Loons to accumulate offshore more than they normally would. According to Sage (1971) and North and Ryan (1988), Yellow-billed Loons move from offshore leads to rivers and later to lakes on their nesting territories as soon as these areas have adequate open water. It is also possible, however, that the reduced availability of water in 1992 may have caused Yellow-billed Loons to be more clumped than usual, which may have simply increased our chance of seeing them during the surveys. Barry *et al.* (1981) noted, for example, that in years of bad ice and weather, Yellow-billed Loons congregated in flocks up to 100 birds in river mouths.

High densities of Yellow-billed Loons occurred in Lambert Channel during both years that this area was surveyed (Table 1; Alexander *et al.* 1993). Therefore, Lambert Channel is likely an important staging area for this species.

4.3.5 Scoters

In all three years when the ice-edge surveys extended into late June, White-winged Scoters started to flock in leads in the southern Beaufort Sea in mid-June, particularly around the Mackenzie Delta from off Shingle Point to McKinley Bay (Alexander *et al.* 1988b, 1993). In all years, most birds were males and were likely moult-migrants. Searing *et al.* (1975) recorded only small numbers of scoters during surveys in May and June, 1974 (200 on May 21 off Cape Dalhousie, and fewer thereafter). Barry and Barry (1982) saw 50 scoters off Hutchison Bay on June 9, 1981.

Although it appears that many White-winged Scoters migrate west into unknown moulting grounds (Johnson and Herter 1989:112), birds seen off the Tuktoyaktuk Peninsula may remain to moult in areas such as Hutchison Bay and McKinley Bay once the ice in these areas has broken up. Most years, several thousand White-winged Scoters and Surf Scoters moult in these bays (Alexander *et al.* 1988a, Cornish *et al.* 1992). It appears that post-breeding Surf Scoters gather for moult in the southern Beaufort Sea later than White-winged Scoters. In summary, thousands of scoters stop during moult migration in offshore leads off the Mackenzie Delta and Tuktoyaktuk Peninsula prior to the break-up of landfast ice.

4.3.6 Gulls

Glaucous Gulls were seen in greater numbers in the southern Beaufort Sea in 1987 than in 1992 or 1993. In 1987, a peak of about 2100 gulls was observed in the last week of May (Alexander *et al.* 1988b). By June 9 numbers had dropped to 10% of peak. Similarly, in 1992 (Alexander *et al.* 1993) and 1993, we noted peak numbers in all areas in late May. Other authors have noted that Glaucous Gulls migrate into the Beaufort Sea in late May (see Johnson and Herter 1989). In 1987, 1992, and 1993, Glaucous Gulls were relatively evenly dispersed throughout the southern Beaufort Sea. In 1987, the largest concentrations occurred around Cape Parry. This was not the case in either 1992 or 1993 and we suspect that the presence of open water east of Cape Parry in those two years, but not in 1987, prompted gulls to disperse eastward. Glaucous Gulls were abundant along the eastern edge of the polynya in Amundsen Gulf in both 1987 and 1992.

4.3.7 Murres

In the western Arctic, Thick-billed Murres nest only on cliffs near Cape Parry (Alexander *et al.* 1991). The main colony at Police Point (the second point west of Cape Parry) numbered approximately 800 birds in 1979 (Johnson and Ward 1985). Our sightings in 1992 (Alexander *et al.* 1993) and 1993 (Table 3) indicate that hundreds of murres still use the colony, although we did not try to confirm any nesting. Johnson and Herter (1989:216) speculated that murres arrive at Cape Parry in June or possibly early July. In both 1992 and 1993, we saw few murres until June 16, indicating a sudden arrival in the second week of June.

4.4 Hydorcarbon development and spring migration

The potential impacts on spring migrants of hydrocarbon activities in the Beaufort Sea are discussed in detail in Alexander *et al.* (in prep.). We present here the main conclusion from that analysis. Migrating eiders, Oldsquaw, and loons are particularly susceptible to environmental disasters such as oil spills because of their foraging habits (i.e. diving) and their tendency to congregate in specific, limited areas. Within the Canadian Beaufort Sea, contamination from offshore oil exploration and development is most likely to occur between Herschel Island and Hutchison Bay. The key staging area off Cape Dalhousie and the Baillie Islands is less likely to be affected. Oldsquaw and Red-throated Loon populations are thus more likely than eider populations to be affected by pollution from offshore oil activities in the Beaufort Sea. There are, however, conditions under which the Hutchison Bay to Baillie Islands area would be susceptible to oil contamination. Such an event could produce severe consequences for Pacific Eider, King Eider, and Oldsquaw populations.

5.0 RECOMMENDATIONS FOR FUTURE RESEARCH

There are several data gaps that hinder our evaluation of both the importance of offshore staging areas and the potential impacts of hydrocarbon activity in the western Arctic:

1. *Turnover rates are unknown.* Without knowing how long birds stop in a particular area, we are unable to properly determine the number of birds, and thus the percentage of a species' population, that uses an area over the course of migration. As a result, the percentages we have presented above underestimate the actual use and therefore underestimate the potential impact of hydrocarbon pollution. A special case of this is the question of whether Pacific Eiders that use the Lambert Channel polynya first stop in the southeastern Beaufort Sea. A second special case is the low numbers of King Eiders that have been seen during spring surveys relative to the population estimates (see Section 4.3). A high turnover of King Eiders at Beaufort Sea staging areas would limit the number observed during any one survey set, thereby giving the impression that many fewer occur than actually do. Turnover rates could be investigated using radio or satellite-telemetry techniques. Such studies would, however, be costly and difficult to conduct.

2. *There is little information on the sizes of the western Arctic bird populations.* The value of a specific staging area, and thus the potential magnitude of impacts from hydrocarbon pollution, is best assigned on the basis of the percentages of bird populations that occur there. We have been unable to use this approach because the information on population sizes is either limited and dated (eiders and Oldsquaw), or non-existent (all other species). This problem is compounded by not knowing turnover rates, as discussed above. Studies to determine population sizes should be considered, particularly for Pacific and King eiders, Oldsquaw, and Red-throated Loons, which are at greatest risk from hydrocarbon activity in the Beaufort Sea.

3. *Survey coverage is incomplete in some areas.* It is clear that the southeastern Beaufort Sea is extremely important to spring migrants. The importance of other areas is less well documented. Western Banks Island has been surveyed in six years but with limited coverage and success. Multiple surveys, unhampered by poor weather, were conducted in only one year, 1993. Similarly, southern Amundsen Gulf has been surveyed only twice. Further surveys in these areas would be beneficial.

Areas away from the landfast-ice edge of leads, particularly the pack-ice edge of the Beaufort Sea lead system, and the pack ice itself, have not been surveyed to any useful degree; therefore, important offshore staging areas may have been missed in this assessment. This is likely important only for King Eiders. For example, the discrepancy in King Eider abundance between spring surveys and population estimates could be due to a large percentage of King Eiders occurring further offshore than surveyed. Aerial surveys with long-range aircraft would provide information on distributions far offshore. Satellite transmitters on birds caught in Alaska could provide information on migration routes, offshore distributions, and also direct the long-range aerial surveys.

4. It is not known to what extent migrants rely on nutrients from the open water leads for migration and reproduction. Birds passing through the Beaufort Sea likely feed to some extent on nutrients from the marine staging areas. Oil spills and associated cleanup activities occurring prior to spring migration could potentially contaminate critical food sources. Studies on food habits and nutrient dynamics (e.g. changes in body fat and protein content; Alisauskas and Ankney 1992) in relation to reproduction and migration would help determine whether birds are reliant on stored nutrients acquired prior to migration, or on nutrients acquired either in the Beaufort Sea or on the breeding grounds. Stable-isotope techniques may be useful in differentiating between marine-based and freshwater-based sources of nutrients for egg production (e.g. Hobson 1987, 1990, Schell and Ziemann 1989, Schaffner and Swart 1991, Alisauskas and Hobson 1993). An examination of body composition in migrating birds from specific locations along the migration route could also provide an indication of flight capabilities (e.g. Pennycuick 1989), and thus provide indirect evidence of the degree of turnover at staging sites. For example, Pacific Eiders from Point Barrow would be expected to have substantial fat, whereas birds from the southeastern Beaufort Sea, if incapable of migrating further without refuelling, should have, on average, much smaller or no fat reserves.

5. Studies to date have not fully addressed the question of why birds occur where they do during spring migration. An understanding of the factors influencing the suitability of open water areas as staging sites would enhance our ability to both predict where birds will occur in a given year and suggest ways of protecting them in the event of oil spills. The main factors likely are: 1) predictability of open water; 2) water depth; 3) water turbidity; and 4) invertebrate abundance. The first factor has been addressed to some extent by this study and others (e.g. Marko 1975, Markham 1981). The other three factors, which affect prey availability, have not been addressed. Invertebrate abundance and availability studies are generally very labour-intensive and costly to conduct even under favourable conditions, and would likely not be practical in the Beaufort Sea during spring break-up. The diet studies discussed above would be simpler, and would provide direct evidence of what the birds can successfully find and capture.

6.0 CONCLUSIONS

In May and June, hundreds of thousands of Pacific Eiders, King Eiders, Oldsquaw, loons, and other waterbirds migrate east through the Canadian Beaufort Sea, Amundsen Gulf, and Dolphin and Union Strait, stopping to rest, feed, and court in traditional staging areas. The three most important staging areas are: 1) north of the Tuktoyaktuk and

Bathurst peninsulas between Cape Dalhousie and the Baillie Islands (eiders, Oldsquaw); 2) off western Banks Island between Masik River and Storkerson Bay (King Eiders); and 3) the Lambert Channel polynya (Pacific Eiders, Yellow-billed Loons). Other areas also considered important are: the southern Beaufort Sea from Tuktoyaktuk to Cape Dalhousie (eiders, Oldsquaw, Red-throated Loons); the area between Herschel Island and Tuktoyaktuk (Oldsquaw, Red-throated Loons); and the southern Amundsen Gulf coast (Pacific Eiders, Oldsquaw).

One key pattern that has become clear as a result of several years of study is that seaducks tend to stage in the same areas each year regardless of ice conditions. Surveys have been conducted in many ice conditions from extensive pack ice with only small patches of open water throughout the Beaufort Sea (1992), to open leads extending only as far east as Cape Parry (1987), to virtually unlimited open water from Herschel Island to Victoria Island, north along Banks Island, and in Lambert Channel (1993). Regardless of the ice conditions, open water off the Tuktoyaktuk Peninsula, particularly the key staging area between Cape Dalhousie and the Baillie Islands, has been extremely important to Pacific Eiders, King Eiders, and Oldsquaw during spring migration. This area appears to be the primary stopping point after what is likely a non-stop migration from western Alaska, especially for the eiders. Most eiders thus bypass the lead between Herschel Island and Tuktoyaktuk.

Migrating eiders, Oldsquaw, and loons are particularly susceptible to environmental disasters such as oil spills because of their staging and foraging habits. Within the Canadian Beaufort Sea, contamination from offshore oil exploration and development is most likely to occur between Herschel Island and Hutchison Bay. The Cape Dalhousie to Baillie Islands key area is less likely to be affected. Oldsquaw and Red-throated Loon populations are thus more likely than eider populations to be affected by pollution from offshore oil activities in the Beaufort Sea. There are, however, conditions under which the Hutchison Bay to Baillie Islands area would be susceptible to oil contamination. Such an event could produce severe consequences for Pacific Eider, King Eider, and Oldsquaw populations.

7.0 LITERATURE CITED

Alexander, S.A., T.W. Barry, D.L. Dickson, H.D. Prus, and K.E. Smyth. 1988a. Key Areas for Birds in Coastal Regions of the Canadian Beaufort Sea. Canadian Wildlife Service, Western and Northern Region, Alberta. 146 pp.

Alexander, S.A., D.M. Ealey, and S.J. Barry. 1988b. Spring migration of Eiders , Oldsquaws, and Glaucous Gulls along offshore leads of the Canadian Beaufort Sea. Technical Report Series No. 56. Canadian Wildlife Service, Western and Northern Region, Alberta. 55 pp.

Alexander, S.A., R.S. Ferguson, and K.J. McCormick. 1991. Key migratory bird terrestrial habitat sites in the Northwest Territories. Occasional Paper No. 71, Canadian Wildlife Service, Ottawa. 184 pp.

Alexander, S.A., S.E. Westover, & D.L. Dickson. 1993. Spring migration of waterbirds in the Beaufort Sea, Amundsen Gulf and Lambert Channel Polynya, 1992. Technical Report Series No. 171, Canadian Wildlife Service, Western and Northern Region, Alberta. 73 pp.

Alexander, S.A., S.E. Westover, & D.L. Dickson. In prep. Spring migration of waterbirds of offshore areas of the western Arctic: a summary in relation to potential hydrocarbon development. For submission to Arctic.

Allen, L. 1982. Bird migration and nesting observations, western Victoria Island, N.W.T., June, 1980. Canadian Wildlife Service, unpublished report, Yellowknife, Northwest Territories. 61 pp.

Alisauskas, R.T., & C.D. Ankney. 1992. The cost of egg laying and its relationship to nutrient reserves in waterfowl. Pp. 30-61 in: B.D.J. Batt, A.D. Afton, M.G. Anderson, C.D. Ankney, D.H. Johnson, J.A. Kadlec, and G.L. Krapu (eds.). Ecology and Management of Breeding Waterfowl. University of Minnesota Press, Minneapolis. 635 pp.

Alisauskas, R.T., & K.A. Hobson. 1993. Determination of Lesser Snow Goose diets and winter distribution using stable isotope analysis. Journal of Wildlife Management 57(1):49-54.

Barry, S.J. and T.W. Barry. 1982. Sea-bird surveys in the Beaufort Sea, Amundsen Gulf, and Prince of Wales Strait - 1981 Season. Canadian Wildlife Service, unpublished report, Edmonton, Alberta. 52 pp.

Barry, T.W. 1968. Observations on natural mortality and native use of eider ducks along the Beaufort Sea coast. Canadian Field-Naturalist 82: 140-144.

Barry, T.W. 1986. Eiders of the western Canadian Arctic. Pages 74-80 in: A. Reed (ed.). Eider Ducks in Canada. Canadian Wildlife Service Report Series No. 47, Ottawa. 177 pp.

Barry, T.W., S.J. Barry, and B. Jacobson. 1981. Sea-bird surveys in the Beaufort Sea, Amundsen Gulf, Prince of Wales Strait and Viscount Melville Sound - 1980 Season. Canadian Wildlife Service, unpublished report, Edmonton, Alberta. 69 pp.

Bellrose, F.C. 1978. Ducks, Geese and Swans of North America. Stackpole Books, Harrisburg, PA. 540 pp

Bustnes, J.O., & K.E. Erikstad. 1988. The diets of sympatric wintering populations of Common Eider *Somateria mollissima* and King Eider *Somateria spectabilis*. Ornis Fennica 65:163-167.

Cantin, M., J. Bédard, & H. Milne. 1974. The food and feeding of common eiders in the St. Lawrence estuary in summer. Canadian Journal of Zoology 52:319-334.

Caughley, G. 1977. Analysis of Vertebrate Populations. John Wiley & Sons, New York. 234 pp.

Cornish, B.J., D.L. Dickson, and H.L. Dickson. 1992. Bird surveys of McKinley Bay and Hutchison Bay, Northwest Territories, in 1991. Technical Report Series No. 147. Canadian Wildlife Service, Western & Northern Region, Edmonton. 53 pp.

Cottam, C. 1939. Food habits of North American diving ducks. U.S. Department of Agriculture Technical Bulletin 643. 140 pp.

Cramp, S., & K.E.L. Simmons. 1977. Handbook of the Birds of Europe, the Middle East, and North Africa. Volume I. Ostrich to Ducks. Oxford University Press, Oxford. 722 pp.

Dickson, D.L. 1993. Breeding biology of Red-throated Loons in the Canadian Beaufort Sea region. Arctic 46(1):1-7.

Federal Environmental Assessment Review Office (FEARO). 1984. Beaufort Sea Hydrocarbon Production and Transportation. Final Report of the Environmental Assessment Panel. FEARO, Hull, Quebec. 146pp.

Goudie, R.I., & C.D. Ankney. 1986. Body size, activity budgets, and diets of sea ducks wintering in Newfoundland. Ecology 67(6):1475-1482.

Hobson, K.A. 1987. Use of stable-carbon isotope analysis to estimate marine and terrestrial protein content in gull diets. Canadian Journal of Zoology 65:1210-1213.

Hobson, K.A. 1990. Stable isotope analysis of Marbled Murrelets: evidence for freshwater feeding and determination of trophic level. Condor 92:897-903.

Johnson, L.L. 1971. The migration, harvest, and importance of waterfowl at Barrow, Alaska. M.Sc. Thesis. University of Alaska, Fairbanks. 87 pp.

Johnson, S.R. 1984. Prey selection by Oldsquaws in a Beaufort Sea lagoon, Alaska. Pp. 12-19 in: D.N. Nettleship, G.A. Sanger, & P.F. Springer (eds.). Marine Birds: Their Feeding Ecology and Commercial Fisheries Relationship. Canadian Wildlife Service, Ottawa. 220 pp.

Johnson, S.R. and D.R. Herter. 1989. The Birds of the Beaufort Sea. BP Exploration (Alaska) Inc., Anchorage. 372 pp.

Johnson, S.R., and W.J. Richardson. 1981. Beaufort Sea barrier island-lagoon ecological process studies: Simpson Lagoon. Part 3, Birds. Pp. 109-363 in: Environmental Assessment of the Alaskan Continental Shelf. Final Report. Biological Studies. Volume 7. National Oceanic and Atmospheric Administration, Boulder, Colorado.

Johnson, S.R. and J.G. Ward. 1985. Observations of Thick-billed murres (*Uria lomvia*) and other seabirds at Cape Parry, Amundsen Gulf, NWT. Arctic 38(2):112-115.

Johnson, S.R., D.A. Wiggins, & P.F. Wainwright. 1993. Late-summer abundance and distribution of marine birds in Kasegaluk Lagoon, Chukchi Sea, Alaska. Arctic 46(3):212-227.

Krebs, C.J. 1989. Ecological Methodology. Harper & Row, Publishers, New York. 654 pp.

Markham, W.E. 1981. Ice Atlas: Canadian Arctic Waterways. Atmospheric Environment Service, Environment Canada, Ottawa. 198 pp.

Marko, J. 1975. Satellite observations of the Beaufort Sea ice cover. Beaufort Sea Technical Report No. 34. Victoria, British Columbia. 137 pp.

North, M.R. and M.R. Ryan. 1988. Yellow-billed Loon, *Gavia adamsii*, breeding chronology and reproductive success in arctic Alaska. Canadian Field-Naturalist 102(3):485-490.

Parmelee, D.F., H.A. Stephens, and R.H. Schmidt. 1967. The birds of southeastern Victoria Island and adjacent small islands. National Museum of Canada, Bulletin 222. 229 pp.

Pennycuick, C.J. 1989. Bird Flight Performance: A Practical Calculation Manual. Oxford University Press, Oxford, U.K. 153 pp.

Peterson, S.R., & R.S. Ellarson. 1977. Food habits of Oldsquaw wintering on Lake Michigan. Wilson Bulletin 89:81-91.

Richardson, W.J. and S.R. Johnson. 1981. Waterbird migration near the Yukon and Alaskan coast of the Beaufort Sea: I. Timing, routes and numbers in spring. Arctic 34(2):108-121.

Richardson, W.J., M.R. Morrell, and S.R. Johnson. 1975. Bird migration along the Beaufort Sea coast: Radar and visual observations in 1975. Beaufort Sea Technical Report No. 3c. Victoria, British Columbia. 131 pp.

Røen, U. 1965. Ornithological observations on the 3rd Pearyland Expedition in the summer of 1964. Dansk ornithologisk Forenings Tidsskrift 59:85-91.

Sage, B.L. 1971. A study of White-billed Divers in arctic Alaska. British Birds 64:519-528.

Sanger, G.A., & R.D. Jones, Jr. 1984. Winter feeding ecology and trophic relationships of Oldsquaws and White-winged Scoters on Kachemak Bay, Alaska. Pp. 20-28 in: D.N. Nettleship, G.A. Sanger, & P.F. Springer (eds.). Marine Birds: Their Feeding Ecology and Commercial Fisheries Relationship. Canadian Wildlife Service, Ottawa. 220 pp.

Schaffner, F.C., & P.K. Swart. 1991. Influence of diet and environmental water on the carbon and oxygen isotopic signatures of seabird eggshell carbonate. Bulletin of Marine Science 48(1):23-38.

Schell, D.M., & P.J. Ziemann. 1989. Natural carbon isotope tracers in arctic aquatic food webs. Pp. 230-251 in: P.W. Rundel, J.R. Ehleringer, & K.A. Nagy (eds.). Stable Isotopes in Ecological Research. Springer-Verlag, Berlin.

Searing, G.F., E. Kuyt, W.J. Richardson, and T.W. Barry. 1975. Seabirds of the southeastern Beaufort Sea: Aircraft and ground observations in 1972 and 1974. Beaufort Sea Technical Report 3-b. Victoria, British Columbia. 257 pp.

Smith, M. and B. Rigby. 1981. Distribution of polynyas in the Canadian Arctic. Pp. 7-28 *in*: I. Stirling and H. Cleator (eds.). Polynyas in the Canadian Arctic. Canadian Wildlife Service Occasional Paper No. 45.

Smith, T.G. 1973. The birds of the Holman region, western Victoria Island. Canadian Field-Naturalist 87: 35-42.

Woodby, D.A. and G.J. Divoky. 1982. Spring migration of eiders and other waterbirds at Point Barrow, Alaska. Arctic 35(3): 403-410.

APPENDICES

APPENDIX A

Weather and ice conditions during aerial surveys of offshore leads, pack ice, and polynyas in the Beaufort Sea, Amundsen Gulf, and Lambert Channel, spring 1993.

May 26: (Figure 2; Regions L-O, V-W, Z1) Clear skies throughout survey. Winds were E to SE 15-20 knots. The lead system was already highly developed. Most of Thesiger Bay (Region M) and some of Amundsen Gulf was cluttered with ice. Survey conditions were generally good except in Thesiger Bay (strong turbulence).

May 27: (Figure 2; Regions I-J, P-U, X) Clear skies throughout survey. Winds were SE, 25-30 knots. All areas were flown along clean ice-edges. Survey conditions were generally good.

May 28: (Figure 2; Regions G-I) Low overcast, calm winds. Encountered fog north of Nuvorak Point and had to abort survey. Ice edge was non-distinct along the east side of the Bathurst Peninsula (abundant broken land-fast ice), but distinct from Baillie Islands to end of survey. Small pans of ice (e.g. 15x15m) were scattered within a couple kilometres of ice edge off east side of Baillie Islands. Visibility was generally excellent.

June 1: (Figure 2; Regions B-D) Fog and freezing rain prevented surveying from May 29 to 31. On June 1, fog persisted west of Herschel Island and east of the Mackenzie Delta. The regions in between were flown under clear skies. Winds were generally calm.

June 7: (Figure 3; Regions A-I) Clear skies throughout most of survey area. Winds were NE, 25-35 knots. Wave action and sun glare made visibility poor at times.

June 8: (Figure 3; Regions L-O, V-W, Z1) Clear skies throughout most of survey area. Winds were SE, 20-30 knots. Wave action was minimal along western Banks Island, and visibility was generally good. Strong down-draughts along cliffs in Thesiger Bay (Region L) precluded surveying there at low altitude. Most of Region M was cluttered with pack ice.

June 9: (Figure 3; Regions I-J, P-U, X) Clear skies and strong SE winds (25-35 knots) throughout Amundsen Gulf. Low overcast and light winds (<5 knots) at Lambert Channel. Survey conditions were excellent at Lambert Channel, but poor along the mainland coast because of the strong winds.

June 10: (Figure 5) Clear skies and moderate easterly winds (5-15 knots). Sun glare often made visibility poor.

June 14: (Figure 4; Regions A-F) Clear skies and moderate easterly winds (10-15 knots). Fog near the Baillie Islands prevented surveying east of Region F. Survey conditions were generally good, except for the last couple segments of Region F flown in light fog.

June 15: (Figure 4; Regions L-O, V-W) Clear skies and light NE winds (5 knots). Fog off the Baillie Islands prevented surveying Z1 between the mainland and Banks Island. Thesiger Bay was completely clear of ice. Survey conditions were excellent throughout survey area.

June 16: (Figure 4; Regions G-J, P-U, X) Clear skies and winds moderate easterly winds (5-10 knots) throughout survey area. Most of the areas surveyed around the north end and east side of the Parry Peninsula and along the east side of the Bathurst Peninsula were full of shattered landfast ice extending several hundred metres from shore. Survey conditions and visibility were generally good.

APPENDIX B

Distributions of key species of birds observed during intensive aerial surveys between Atkinson Point and the Baillie Islands on June 10, 1993.

Transects run perpendicular to the ice edge and are spaced about 20 km apart, starting off Atkinson Point and ending off the Baillie Islands. Within each transect, Segment 1 is offshore away from the ice edge (i.e. the largest segment numbers are closest to the the landfast ice edge). Open water conditions were as in Figure 3.

Table B1. Distribution of Pacific Eiders (numbers of birds on and off transect) during intensive aerial surveys of an open-water lead between Atkinson Point and the Baillie Islands, June 10, 1993.

		Transect number (west to east)							
Segment		1	2	3	4	5	6	7	8
1	On	0	0	0	0	0	0	0	0
(North)	Off	0	0	0	0	0	0	0	0
2	On	**2**	0	0	0	0	0	0	0
	Off	0	0	0	0	0	0	0	0
3	On	0	0	0	0	0	0	0	0
	Off	0	0	0	0	0	0	0	0
4	On	0	0	**4**	0	0	0	0	0
	Off	0	0	0	0	0	0	0	0
5	On	0	0	0	0	0	0	0	0
	Off	0	0	0	0	0	0	**2**	0
6	On	**6**	N/A	0	0	0	0	0	0
	Off	0		0	**1**	0	0	0	0
7	On	0	N/A	0	0	0	0	0	0
	Off	0		0	**1**	0	0	0	0
8	On	0	N/A	0	N/A	0	**1**	0	0
	Off	0		0		0	0	0	0
9	On	N/A	N/A	0	N/A	0	0	0	0
	Off			0		0	0	0	0
10	On	N/A	N/A	N/A	N/A	0	**1**	**56**	0
	Off					0	0	0	0
11	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
	Off					0			
12	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
	Off					0			
13	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
	Off					0			
14	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
(South)	Off					0			
Total	On	**8**	0	**4**	0	0	**2**	**56**	0
	Off	0	0	0	**2**	0	0	**2**	0
Transect length (km)		46.5	30.8	50.6	42.6	97.2	56.0	69.3	56.4

N/A: Not applicable - transect had less than fourteen segments.

Table B2. Distribution of King Eiders (numbers of birds on and off transect) during intensive aerial surveys of an open-water lead between Atkinson Point and the Baillie Islands, June 10, 1993.

		Transect number (west to east)							
Segment		1	2	3	4	5	6	7	8
1	On	5	0	0	0	0	8	0	0
(North)	Off	0	0	0	0	0	0	0	0
2	On	0	0	0	0	0	0	60	128
	Off	0	0	0	0	0	0	0	0
3	On	2	0	0	14	0	0	17	0
	Off	0	0	0	0	1	0	0	0
4	On	1	0	0	21	0	4	40	0
	Off	0	0	0	0	0	5	0	0
5	On	6	0	0	12	0	27	0	6
	Off	0	0	0	3	0	20	0	0
6	On	0	N/A	0	2	0	450	0	0
	Off	8		0	23	0	101	20	0
7	On	0	N/A	0	0	4	240	0	0
	Off	2		0	0	40	142	7	0
8	On	0	N/A	4	N/A	570	17	2	3
	Off	0		0		444	10	0	0
9	On	N/A	N/A	0	N/A	14	6	20	0
	Off			0		21	0	0	0
10	On	N/A	N/A	N/A	N/A	4	2	76	40
	Off					0	0	0	0
11	On	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A
	Off					2			
12	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
	Off					0			
13	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
	Off					0			
14	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
(South)	Off					2			
Total	On	14	0	4	49	597	754	215	177
	Off	10	0	0	26	510	278	27	0
Transect length (km)		46.5	30.8	50.6	42.6	97.2	56.0	69.3	56.4

N/A: Not applicable - transect had less than fourteen segments.

Table B3. Distribution of unidentified eiders (numbers of birds on and off transect) during intensive aerial surveys of an open-water lead between Atkinson Point and the Baillie Islands, June 10, 1993.

		Transect number (west to east)							
Segment		1	2	3	4	5	6	7	8
1	On	0	0	0	0	0	0	0	0
(North)	Off	0	0	0	0	0	0	0	0
2	On	0	0	0	0	0	0	0	0
	Off	0	0	0	0	0	0	0	0
3	On	0	0	0	0	0	0	0	0
	Off	0	0	0	0	0	0	0	0
4	On	0	0	0	0	0	0	0	0
	Off	0	0	0	0	0	0	0	0
5	On	0	0	0	0	0	0	0	0
	Off	0	0	0	0	0	0	0	0
6	On	0	N/A	0	0	0	0	0	0
	Off	0		0	**2**	0	0	**50**	0
7	On	0	N/A	0	0	0	0	0	0
	Off	0		**2**	0	0	0	0	0
8	On	0	N/A	0	N/A	0	0	0	0
	Off	0		0		0	0	0	0
9	On	N/A	N/A	0	N/A	0	0	0	0
	Off			0		0	0	0	0
10	On	N/A	N/A	N/A	N/A	0	0	0	0
	Off					0	0	0	0
11	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
	Off					0			
12	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
	Off					0			
13	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
	Off					0			
14	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
(South)	Off					0			
Total	On	0	0	0	0	0	0	0	0
	Off	0	0	**2**	**2**	0	0	**50**	0
Transect length (km)		46.5	30.8	50.6	42.6	97.2	56.0	69.3	56.4

N/A: Not applicable - transect had less than fourteen segments.

Table B4. Distribution of Oldsquaw (numbers of birds on and off transect) during intensive aerial surveys of an open-water lead between Atkinson Point and the Baillie Islands, June 10, 1993.

		Transect number (west to east)							
Segment		1	2	3	4	5	6	7	8
1	On	**1**	0	0	0	0	0	0	0
(North)	Off	**2**	0	0	0	0	0	0	0
2	On	0	0	0	0	**3**	0	0	0
	Off	0	0	0	0	0	0	0	0
3	On	0	0	0	**2**	0	**2**	**6**	0
	Off	0	0	0	0	0	0	0	0
4	On	**2**	**6**	0	0	0	0	**20**	0
	Off	0	**1**	0	0	0	0	0	0
5	On	0	0	0	0	0	0	0	0
	Off	0	0	0	0	0	0	0	0
6	On	0	N/A	0	**1**	0	**12**	**1**	0
	Off	0		0	0	0	**20**	0	0
7	On	0	N/A	0	0	0	**1**	0	0
	Off	0		0	0	0	0	0	0
8	On	0	N/A	0	N/A	0	**8**	0	0
	Off	0		0		0	0	0	0
9	On	N/A	N/A	0	N/A	0	0	**8**	0
	Off			0		0	0	0	0
10	On	N/A	N/A	N/A	N/A	0	**1**	**1**	**2**
	Off					0	0	0	0
11	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
	Off					0			
12	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
	Off					0			
13	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
	Off					0			
14	On	N/A	N/A	N/A	N/A	**3**	N/A	N/A	N/A
(South)	Off					0			
Total	On	**3**	**6**	0	**3**	**6**	**24**	**36**	**2**
	Off	**2**	**1**	0	0	0	**20**	0	0
Transect length (km)		46.5	30.8	50.6	42.6	97.2	56.0	69.3	56.4

N/A: Not applicable - transect had less than fourteen segments.

Table B5. Distribution of all ducks (numbers of birds on and off transect) during intensive aerial surveys of an open-water lead between Atkinson Point and the Baillie Islands, June 10, 1993.

		Transect number (west to east)							
Segment		1	2	3	4	5	6	7	8
1	On	**6**	0	0	0	0	**8**	0	0
(North)	Off	**2**	0	0	0	0	0	0	0
2	On	**2**	0	0	0	**3**	0	**60**	**128**
	Off	0	0	0	0	0	0	0	0
3	On	**2**	0	0	**16**	0	**2**	**23**	0
	Off	0	0	0	0	**1**	0	0	0
4	On	**3**	**6**	**4**	**21**	0	**4**	**60**	0
	Off	0	**1**	0	0	0	**5**	0	0
5	On	**6**	0	0	**12**	0	**27**	0	**8**
	Off	0	0	0	**3**	0	**20**	**2**	0
6	On	**6**	N/A	0	**3**	0	**462**	**1**	0
	Off	**8**		0	**26**	0	**121**	**70**	0
7	On	0	N/A	0	0	**4**	**241**	0	0
	Off	**2**		**2**	**1**	**40**	**142**	**7**	0
8	On	0	N/A	**4**	N/A	**570**	**26**	**2**	**3**
	Off	0		0		**444**	**10**	0	0
9	On	N/A	N/A	0	N/A	**14**	**6**	**28**	0
	Off			0		**21**	0	0	0
10	On	N/A	N/A	N/A	N/A	**4**	**4**	**133**	**42**
	Off					0	0	0	0
11	On	N/A	N/A	N/A	N/A	**5**	N/A	N/A	N/A
	Off					**2**			
12	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
	Off					0			
13	On	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A
	Off					0			
14	On	N/A	N/A	N/A	N/A	**3**	N/A	N/A	N/A
(South)	Off					**2**			
Total	On	**25**	**6**	**8**	**52**	**603**	**780**	**307**	**181**
	Off	**12**	**1**	**2**	**30**	**510**	**298**	**79**	0
Transect length (km)		46.5	30.8	50.6	42.6	97.2	56.0	69.3	56.4

N/A: Not applicable - transect had less than fourteen segments.

APPENDIX C.

Total numbers of most common bird species observed per segment and per region during aerial surveys of offshore leads and polynyas in the Beaufort Sea, Amundsen Gulf, and Lambert Channel, spring 1993.

Region	Segment No.	Distance (km)	Pacific Loon	Red-throated Loon	Yellow-billed Loon	Pacific Eider	King Eider	Scoter sp.	Oldsquaw	Glaucous Gull
Survey Period: May 26-28, June 1										
B Yukon Coast										
B	1	16.4	0	0	0	47	36	0	127	5
B	2	13.0	0	4	0	10	7	0	121	1
B	3	12.2	2	3	0	68	22	1	96	1
B	4	11.8	1	9	0	6	0	0	149	4
B	5	12.5	0	6	0	0	0	0	185	1
Total: Region B		65.9	3	22	0	131	65	1	678	12
C West Mackenzie Delta										
C	6	13.6	1	18	0	14	5	0	930	0
C	7	13.4	2	17	0	0	0	0	197	20
C	8	13.2	1	20	0	0	0	2	96	4
C	9	13.3	0	7	0	6	12	0	104	1
C	10	13.2	2	7	0	5	0	0	78	0
C	11	13.1	2	6	1	0	0	0	61	6
C	12	13.1	0	4	0	8	7	1	19	2
C	13	13.1	0	4	0	138	10	2	65	5
C	14	13.0	1	1	0	132	8	0	103	6
C	15	12.7	0	0	0	476	19	0	172	1
Total: Region C		131.8	9	84	1	779	61	5	1825	45
D East Mackenzie Delta										
D	16	12.8	0	2	0	301	30	0	50	6
D	17	13.0	0	2	0	209	26	0	72	5
D	18	12.9	0	0	0	78	5	0	55	0
D	19	12.7	0	0	0	21	4	1	35	0
D	20	12.6	0	4	0	171	20	0	1	1
Total: Region D		64.0	0	8	0	780	85	1	213	12
F McKinley Bay to Cape Dalhousie										
F	21	9.4	0	0	0	96	3	0	0	10
F	22	14.7	0	0	0	2425	5	0	21	15
F	23	14.7	0	0	0	2068	307	0	0	13
Total: Region F		38.8	0	0	0	4589	315	0	21	38
G Cape Dalhousie to Baillie Islands										
G	24	14.5	0	0	0	574	5579	0	0	0
G	25	14.9	0	0	0	0	1753	0	0	3
G	26	14.2	0	0	0	74	30327	0	850	1
G	27	13.9	6	0	0	4215	21455	0	437	0
G	28	14.7	0	0	0	9102	1749	0	1760	6
G	29	14.7	0	0	0	1392	30	0	519	4
Total: Region G		87.0	6	0	0	15357	60893	0	3566	14
H Baillie and Bathurst area										
H	30	14.4	0	0	0	356	77	0	1179	6
H	31	14.5	0	0	0	279	2641	0	100	1
Total: Region H		28.9	0	0	0	635	2718	0	1279	7
I Franklin Bay										
I	32	14.8	0	0	0	0	1	0	10	0
I	33	14.7	0	0	0	38	148	0	9	1
I	34	14.4	0	0	0	131	1185	0	13	2
I	35	14.1	0	0	0	14	223	0	12	0
I	36	14.3	0	0	0	123	104	3	396	5
I	37	15.4	1	0	0	12	72	0	137	6
I	38	15.5	0	0	0	27	0	0	52	23
I	39	15.0	0	0	0	2	25	0	363	11
I	40	14.6	0	0	0	9	6	0	47	2
Total: Region I		132.7	1	0	0	356	1764	3	1039	50

Appendix C. Continued.

Region	Segment No.	Distance (km)	Pacific Loon	Red-throated Loon	Yellow-billed Loon	Pacific Eider	King Eider	Scoter sp.	Oldsquaw	Glaucous Gull
May 26-28, June 1 Continued										
J Parry Peninsula										
J	41	14.7	2	0	0	4	40	0	89	0
J	42	15.4	0	0	0	99	6	0	41	0
J	43	15.4	0	0	0	583	166	0	1	1
J	44	14.1	0	0	0	421	21	0	31	18
J	45	15.7	0	0	1	220	2	0	29	20
Total: Region J		75.3	2	0	1	1327	235	0	191	39
L Cape Lambton coastal area										
L	89	12.1	0	0	0	0	0	0	0	3
L	90	10.7	0	0	0	69	4	0	0	3
L	91	10.5	0	0	0	55	0	0	0	5
L	92	10.8	0	0	0	52	0	0	0	33
L	93	11.9	0	0	0	11	0	0	3	7
L	94	12.0	0	0	0	0	0	0	0	0
Total: Region L		67.9	0	0	0	187	4	0	3	51
M Masik River to Cape Kellett										
M	95	11.7	0	0	0	246	114	0	0	12
M	96	11.4	0	0	0	26	191	0	0	1
M	97	11.3	0	0	0	2	31	0	0	0
M	98	11.7	0	0	0	15	15	0	10	18
M	99	11.6	0	0	0	3	51	0	1	2
M	100	11.4	0	0	0	4	63	0	2	7
M	101	12.0	0	0	0	0	0	0	0	0
M	102	13.7	0	0	0	0	0	0	0	0
M	103	16.4	0	0	0	30	76	0	2	8
Total: Region M		111.4	0	0	0	326	541	0	15	48
N Cape Kellett to Storkerson Bay										
N	104	16.7	0	0	0	10	266	0	0	0
N	105	15.9	0	0	0	50	97	0	5	3
N	106	15.1	0	0	0	16	255	0	0	0
N	107	14.7	0	0	0	8	198	0	0	2
N	108	15.5	0	0	0	6	181	0	4	1
N	109	15.7	0	0	0	2	68	0	3	0
N	110	15.6	0	0	0	15	210	0	0	0
N	111	14.0	0	0	0	0	1374	0	0	3
N	112	13.0	0	0	0	4	1083	0	2	0
N	113	12.5	0	0	0	16	12	0	1	1
N	114	12.7	0	0	0	0	0	0	0	2
N	115	13.6	0	0	0	3	48	0	0	0
Total: Region N		175.0	0	0	0	130	3792	0	15	12
O Storkerson Bay to Bernard Island										
O	116	13.9	0	0	0	0	0	0	9	3
O	117	15.0	0	0	0	0	19	0	0	0
O	118	15.1	0	0	0	12	28	0	2	0
O	119	15.5	0	0	0	0	104	0	0	2
O	120	15.5	0	0	0	0	1	0	0	1
O	121	15.0	0	0	0	0	7	0	0	2
Total: Region O		90.0	0	0	0	12	159	0	11	8
P Darnley Bay										
P	46	16.9	0	0	0	0	3	0	0	14
P	47	17.2	0	0	0	2	0	0	7	3
P	48	16.2	0	0	0	0	0	0	0	8
P	49	14.7	0	0	0	123	88	0	93	29
Total: Region P		65.1	0	0	0	125	91	0	100	54
Q Cape Lyon to Clinton Pt.										
Q	50	13.0	0	0	0	395	187	0	5	0
Q	51	13.0	0	0	0	324	0	0	41	13
Q	52	15.7	0	0	0	55	2	0	142	25
Q	53	17.1	0	0	0	394	35	0	2	27
Q	54	19.1	0	0	0	746	111	0	58	8
Q	55	20.5	0	0	0	840	24	0	7	11
Q	56	19.2	0	0	0	213	4	0	3	6
Q	57	17.8	0	0	0	12	3	0	3	0
Total: Region Q		135.4	0	0	0	2979	366	0	261	90

Appendix C. Continued.

Region	Segment No.	Distance (km)	Pacific Loon	Red-throated Loon	Yellow-billed Loon	Pacific Eider	King Eider	Scoter sp.	Oldsquaw	Glaucous Gull
May 26-28, June 1 Continued										
R Clinton Pt. to Clifton Pt.										
R	58	17.4	0	0	0	28	0	0	23	19
R	59	17.1	0	0	0	92	10	0	0	68
Total: Region R		34.5	0	0	0	120	10	0	23	87
S Clifton Pt. to Wollaston Peninsula										
S	60	16.1	0	0	0	116	5	0	102	133
S	61	15.2	0	0	0	28	4	0	67	115
S	62	14.9	0	0	0	1	21	0	27	49
S	63	14.5	0	0	0	1	7	0	21	58
S	64	14.1	0	0	0	18	0	0	115	87
Total: Region S		74.8	0	0	0	164	37	0	332	442
T Wollaston Peninsula										
T	65	13.0	0	0	0	1	40	0	15	72
T	66	11.7	0	0	0	0	0	0	10	37
T	67	11.2	0	0	0	3	8	0	23	46
Total: Region T		35.9	0	0	0	4	48	0	48	155
U Prince Albert Sound										
U	68	11.3	0	0	0	0	0	0	2	18
U	69	12.1	0	0	0	4	0	0	20	26
U	70	12.8	0	0	0	3	12	0	46	54
U	71	12.6	0	0	0	0	46	0	35	1
Total: Region U		48.8	0	0	0	7	58	0	103	99
V Holman Coast										
V	72	12.3	0	0	0	2	2	0	11	14
V	73	14.6	0	0	0	2	0	0	0	0
V	74	12.2	0	0	0	22	4	0	7	6
V	75	11.7	0	0	0	258	307	0	35	9
Total: Region V		50.8	0	0	0	284	313	0	53	29
W Cape Ptarmigan to Nelson Head										
W	76	12.3	0	0	0	0	30	0	0	0
W	77	13.3	0	0	0	0	0	0	0	0
W	78	12.9	0	0	0	0	0	0	0	1
W	79	12.9	0	0	0	0	0	0	0	0
W	80	13.3	0	0	0	0	0	0	0	0
W	81	12.9	0	0	0	0	0	0	0	0
W	82	12.7	0	0	0	0	0	0	0	0
W	83	13.0	0	0	0	0	0	0	0	0
W	84	13.0	0	0	0	0	0	0	0	0
W	85	13.0	0	0	0	0	20	0	0	0
W	86	14.0	0	0	0	0	0	0	0	1
W	87	14.1	0	0	0	0	0	0	0	3
W	88	13.7	0	0	0	0	7	0	0	0
Total: Region W		171.0	0	0	0	0	57	0	0	5
X Lambert Channel										
X	122	12.0	0	0	0	1992	8	0	0	13
X	123	12.6	0	0	0	1330	44	0	1	2
X	124	12.7	0	0	0	254	28	0	0	0
X	125	14.4	0	0	0	2048	0	0	0	125
X	126	16.4	0	0	0	2647	4	0	0	16
X	127	16.4	2	0	0	2593	9	0	2	7
X	128	7.7	0	0	0	511	4	0	0	1
Total: Region X		92.3	2	0	0	11375	97	0	3	164
Survey Period: June 7-9										
A Herschel Island area										
A	1	12.6	0	0	0	0	0	0	11	1
A	2	11.7	0	0	0	18	0	5	13	4
A	3	11.2	0	0	0	0	0	0	8	0
A	4	11.5	0	0	0	7	1	5	230	1
A	5	12.7	0	5	0	33	3	4	42	5
Total: Region A		59.7	0	5	0	58	4	14	304	11

Appendix C. Continued.

Region	Segment No.	Distance (km)	Pacific Loon	Red-throated Loon	Yellow-billed Loon	Pacific Eider	King Eider	Scoter sp.	Oldsquaw	Glaucous Gull
June 7-9 Continued										
B Yukon Coast										
B	6	12.7	0	2	0	42	5	4	75	2
B	7	12.9	0	7	0	18	0	15	14	2
B	8	13.5	2	1	0	0	0	0	1	0
B	9	14.0	0	0	0	0	0	4	0	2
Total: Region B		53.0	2	10	0	60	5	23	90	6
C West Mackenzie Delta										
C	10	13.3	0	0	0	0	0	5	6	0
C	11	12.4	0	10	0	0	0	15	7	1
C	12	12.4	1	2	0	2	0	2	20	1
C	13	12.4	0	3	0	2	0	7	0	2
C	14	12.8	0	6	0	0	0	0	11	0
C	15	13.6	0	0	0	0	0	0	5	0
C	16	13.6	0	2	0	2	0	0	3	0
C	17	12.8	0	0	0	21	1	0	10	0
C	18	11.7	0	0	0	76	0	0	27	2
C	19	11.3	0	0	0	19	0	0	1	0
C	20	11.2	0	0	0	0	0	0	0	0
C	21	11.3	0	2	0	7	0	0	15	0
Total: Region C		148.6	1	25	0	129	1	29	105	6
D East Mackenzie Delta										
D	22	11.3	1	2	0	21	3	6	2	4
D	23	11.4	0	0	0	0	1	0	0	0
D	24	12.6	0	9	0	19	7	0	3	1
D	25	12.7	0	1	0	0	0	0	6	0
D	26	13.7	0	0	0	0	0	0	0	0
D	27	13.7	0	0	0	0	0	0	0	0
D	28	11.3	0	0	0	0	0	0	0	0
Total: Region D		86.7	1	12	0	40	11	6	11	5
E Tuktoyaktuk to McKinley Bay										
E	29	10.4	1	0	0	0	0	0	0	0
E	30	10.5	0	0	0	0	0	0	0	0
E	31	10.9	0	1	0	1	0	0	108	0
E	32	10.7	1	0	0	41	15	0	207	0
E	33	10.3	0	2	0	99	44	0	13	11
E	34	11.1	0	2	0	27	13	0	45	4
E	35	11.7	0	2	0	144	9	0	194	3
E	36	11.7	0	1	0	126	37	0	306	0
E	37	11.5	0	0	0	128	33	0	29	5
E	38	10.7	0	0	0	25	12	0	25	0
Total: Region E		109.5	2	8	0	591	163	0	927	23
F McKinley Bay to Cape Dalhousie										
F	39	11.5	0	2	0	33	72	0	91	2
F	40	13.4	0	1	0	9	27	0	160	1
F	41	13.0	0	1	0	115	57	0	295	5
F	42	11.7	0	0	0	57	34	0	24	0
F	43	10.7	0	0	0	36	74	0	6	0
F	44	10.4	0	0	0	127	583	0	14	0
F	45	11.5	0	0	0	970	2261	0	5	3
Total: Region F		82.2	0	4	0	1347	3108	0	595	11
G Cape Dalhousie to Baillie Islands										
G	46	11.9	0	1	0	1037	2222	0	0	14
G	47	11.0	0	2	0	245	612	0	2	2
G	48	11.0	0	0	0	55	212	0	1	0
G	49	11.2	0	0	0	448	642	0	4	5
G	50	11.2	0	0	0	1585	325	0	8	5
G	51	12.3	0	0	0	0	2	0	0	0
G	52	11.8	0	0	0	15	15	0	7	0
G	53	10.3	0	0	0	2698	406	0	201	2
G	54	10.2	0	0	0	103	58	0	7	0
Total: Region G		100.8	0	3	0	6186	4494	0	230	28

Appendix C. Continued.

Region	Segment No.	Distance (km)	Pacific Loon	Red-throated Loon	Yellow-billed Loon	Pacific Eider	King Eider	Scoter sp.	Oldsquaw	Glaucous Gull
June 7-9 Continued										
H Baillie and Bathurst area										
H	55	10.3	0	0	0	103	82	0	2	1
H	56	11.0	0	0	0	293	303	0	112	2
H	57	11.3	0	0	0	435	15	0	7	0
Total: Region H		32.6	0	0	0	831	400	0	121	3
I Franklin Bay										
I	58	11.2	0	0	0	150	2	0	3	2
I	59	11.4	0	0	0	68	15	0	9	0
I	60	11.8	0	0	0	0	0	0	1	0
I	61	12.2	0	0	0	1	12	0	0	2
I	62	17.5	0	0	0	254	17	0	0	17
I	63	17.9	0	0	0	6	2	0	41	0
I	64	18.2	1	0	0	2	4	0	152	1
I	65	18.2	0	0	0	18	0	0	77	0
Total: Region I		118.5	1	0	0	499	52	0	283	22
J Parry Peninsula										
J	66	15.8	0	0	0	27	0	0	213	0
J	67	13.6	0	0	0	449	12	0	381	0
J	68	12.9	0	0	0	626	127	0	68	2
J	69	15.9	0	0	0	434	74	0	348	0
J	70	19.1	0	0	4	121	30	0	59	0
J	71	19.0	0	0	1	10	0	0	2	0
Total: Region J		96.3	0	0	5	1667	243	0	1071	2
L Cape Lambton coastal area										
L	113	15.1	0	0	0	0	29	0	0	0
L	114	14.1	0	0	0	44	334	0	0	0
L	115	14.2	0	0	0	35	14	0	0	0
L	116	14.7	0	0	0	157	47	0	0	2
L	117	12.9	0	0	0	71	402	0	28	19
Total: Region L		70.9	0	0	0	307	826	0	28	21
M Masik River to Cape Kellett										
M	118	12.7	0	0	0	36	112	0	2	0
M	119	12.5	0	0	0	131	102	0	9	1
M	120	11.7	0	0	6	77	1393	0	0	0
M	121	11.9	0	0	0	0	0	0	2	1
M	122	12.3	0	0	0	11	97	0	6	0
M	123	12.6	0	0	5	96	320	0	0	0
M	124	12.8	0	0	0	0	215	0	0	0
M	125	12.4	0	0	0	0	0	0	0	0
M	126	15.2	0	0	0	0	15	0	0	0
Total: Region M		114.1	0	0	11	351	2254	0	19	2
N Cape Kellett to Storkerson Bay										
N	127	17.2	0	0	1	28	318	0	0	1
N	128	15.1	0	0	0	186	213	0	0	0
N	129	13.7	0	0	0	49	340	0	0	0
N	130	13.2	0	0	1	41	573	0	1	0
N	131	13.3	0	0	0	66	782	0	2	0
N	132	13.4	0	0	0	48	1051	0	0	0
N	133	13.4	0	0	0	56	301	0	0	0
N	134	12.5	0	0	0	103	1586	0	0	0
N	135	12.3	0	0	0	13	814	0	0	0
N	136	12.2	0	0	0	28	385	0	3	0
N	137	13.0	0	0	0	44	444	0	1	0
N	138	13.6	0	0	0	43	342	0	0	0
Total: Region N		162.8	0	0	2	705	7149	0	7	1
O Storkerson Bay to Bernard Island										
O	139	13.6	0	0	0	10	445	0	0	2
O	140	14.3	0	0	0	8	480	0	0	1
O	141	13.8	0	0	0	6	159	0	4	0
O	142	14.4	0	0	0	16	190	0	0	2
O	143	14.9	0	0	1	0	97	0	1	0
O	144	14.6	0	0	0	4	73	0	0	2
Total: Region O		85.6	0	0	1	44	1444	0	5	7

Appendix C. Continued.

Region	Segment No.	Distance (km)	Pacific Loon	Red-throated Loon	Yellow-billed Loon	Pacific Eider	King Eider	Scoter sp.	Oldsquaw	Glaucous Gull
June 7-9 Continued										
P Darnley Bay										
P	72	17.8	0	0	0	0	0	0	0	0
P	73	13.4	0	0	0	0	0	0	2	0
P	74	13.3	0	0	2	23	0	0	2	1
P	75	16.5	0	0	0	0	0	0	2	0
P	76	17.7	0	0	1	945	580	0	783	2
Total: Region P		78.7	0	0	3	968	580	0	789	3
Q Cape Lyon to Clinton Pt.										
Q	77	14.1	0	0	0	1663	144	8	1435	5
Q	78	13.5	0	0	0	1773	256	0	1858	0
Q	79	17.1	0	0	0	243	315	0	762	1
Q	80	17.1	0	0	0	379	210	0	59	15
Q	81	13.2	0	0	1	1805	491	0	714	1
Q	82	13.0	0	0	0	3471	123	0	0	2
Q	83	16.1	0	0	0	290	7	0	389	0
Q	84	15.7	0	0	0	0	5	0	2	0
Total: Region Q		119.7	0	0	1	9624	1551	8	5219	24
R Clinton Pt. to Clifton Pt.										
R	85	15.4	0	0	1	908	88	0	5	110
R	86	15.5	1	0	0	367	63	0	98	50
R	87	16.0	0	0	0	2	12	0	12	0
Total: Region R		46.9	1	0	1	1277	163	0	115	160
S Clifton Pt. to Wollaston Peninsula										
S	88	15.1	28	0	0	5	13	0	30	5
S	89	14.6	9	0	2	0	0	0	68	1
S	90	14.8	4	0	0	0	26	0	69	0
S	91	14.6	0	0	0	2	45	0	26	12
S	92	14.7	2	0	0	4	10	0	9	12
Total: Region S		73.8	43	0	2	11	94	0	202	30
T Wollaston Peninsula										
T	93	14.5	3	0	0	0	7	0	34	1
T	94	14.2	11	0	1	4	21	0	17	0
T	95	14.6	19	0	0	4	2	0	18	0
Total: Region T		43.3	33	0	1	8	30	0	69	1
U Prince Albert Sound										
U	96	14.4	0	1	0	0	10	0	46	0
U	97	14.1	0	0	0	0	53	0	12	3
U	98	13.6	1	0	0	0	14	0	38	0
Total: Region U		42.1	1	1	0	0	77	0	96	3
V Holman Coast										
V	99	13.7	0	0	0	2	60	0	24	0
V	100	15.5	0	0	0	0	44	0	2	0
V	101	14.7	0	0	0	232	106	0	12	0
V	102	15.2	0	0	0	998	253	0	26	0
Total: Region V		59.1	0	0	0	1232	463	0	64	0
W Cape Ptarmigan to Nelson Head										
W	103	14.9	0	0	6	0	0	0	0	0
W	104	15.2	0	0	0	0	0	0	0	0
W	105	15.2	0	0	0	0	0	0	0	0
W	106	15.0	0	0	0	0	0	0	0	0
W	107	14.9	0	0	0	0	0	0	0	0
W	108	14.5	0	0	0	0	0	0	0	0
W	109	14.5	0	0	0	0	0	0	0	0
W	110	14.9	0	0	0	0	0	0	0	0
W	111	15.1	0	0	0	0	0	0	1	0
W	112	15.1	0	0	0	0	0	0	0	0
Total: Region W		149.3	0	0	6	0	0	0	1	0
X Lambert Channel										
X	145	14.9	10	0	79	571	21	0	0	0
X	146	13.0	3	0	25	11400	11	4	194	0
X	147	13.0	0	0	73	4390	15	0	58	0
X	148	14.7	3	0	12	20618	88	0	16	0
X	149	14.9	3	0	36	11981	308	0	52	104
X	150	14.6	0	0	99	2631	24	0	40	1

Appendix C. Continued.

Region	Segment No.	Distance (km)	Pacific Loon	Red-throated Loon	Yellow-billed Loon	Pacific Eider	King Eider	Scoter sp.	Oldsquaw	Glaucous Gull
June 7-9 Continued										
X	151	14.7	2	0	8	12992	2	0	276	0
Total: Region X		99.8	21	0	332	64583	469	4	636	105
Survey Period: June 14-16										
A Herschel Island area										
A	1	13.0	0	0	3	89	0	0	7	0
A	2	12.4	0	0	0	5	5	0	3	0
A	3	12.3	2	8	0	2	0	5	6	4
A	4	11.7	0	5	0	4	0	0	3	1
A	5	13.0	0	7	0	24	3	404	220	1
Total: Region A		62.3	2	20	3	124	8	409	239	6
B Yukon Coast										
B	6	13.4	0	12	0	95	0	1435	195	0
B	7	12.4	3	4	0	0	0	20	0	6
B	8	12.4	1	12	0	0	0	13	16	2
B	9	12.2	0	0	0	0	0	0	0	1
B	10	11.7	0	0	0	0	0	2	1	1
B	11	11.8	0	0	1	0	0	5	0	0
Total: Region B		73.9	4	28	1	95	0	1475	212	10
C West Mackenzie Delta										
C	12	12.0	0	4	0	0	0	8	0	0
C	13	12.6	0	9	1	0	0	5	0	3
C	14	13.0	0	4	0	7	0	66	7	7
C	15	12.6	0	5	0	0	0	42	0	0
C	16	13.9	0	1	0	0	0	127	0	0
C	17	14.4	0	4	0	0	0	13	60	0
C	18	13.7	1	2	0	0	0	3	9	0
C	19	13.7	0	0	0	0	0	71	23	0
C	20	15.5	4	0	0	5	4	0	17	0
C	21	15.9	0	1	0	26	23	0	7	0
C	22	13.5	0	1	0	9	0	0	0	0
C	23	13.1	1	2	0	1	5	0	26	0
Total: Region C		163.8	6	33	1	48	32	335	149	10
D East Mackenzie Delta										
D	24	13.0	1	0	0	9	8	0	3	0
D	25	12.7	0	11	0	30	0	140	337	10
D	26	12.5	0	0	0	8	0	339	3	1
D	27	12.4	5	4	0	11	0	0	13	0
D	28	12.4	0	3	0	6	9	0	5	1
D	29	13.0	0	0	0	39	12	40	11	0
D	30	13.0	4	17	0	2	14	1301	0	16
Total: Region D		89.0	10	35	0	105	43	1820	372	28
E Tuktoyaktuk to McKinley Bay										
E	31	12.4	5	2	0	44	2	54	499	1
E	32	12.6	0	0	0	15	15	16	51	1
E	33	12.4	1	0	0	241	136	8	18	1
E	34	12.4	0	1	0	26	1	0	41	0
E	35	12.3	0	3	0	37	3	0	0	0
E	36	13.1	0	18	0	69	9	3	23	0
E	37	13.7	0	2	0	58	55	25	38	1
E	38	13.4	1	3	0	185	102	0	53	3
E	39	13.4	0	0	0	31	107	0	5	0
Total: Region E		115.6	7	29	0	706	430	106	728	7
F McKinley Bay to Cape Dalhousie										
F	40	13.7	0	1	0	36	151	0	211	0
F	41	14.1	1	1	0	31	35	0	107	1
F	42	14.1	1	0	0	118	110	0	146	0
F	43	13.9	0	0	0	93	95	0	25	0
F	44	13.8	0	0	0	24	68	0	6	1
F	45	13.9	0	0	0	174	1051	0	55	6
Total: Region F		83.6	2	2	0	476	1510	0	550	8

Appendix C. Continued.

Region	Segment No.	Distance (km)	Pacific Loon	Red-throated Loon	Yellow-billed Loon	Pacific Eider	King Eider	Scoter sp.	Oldsquaw	Glaucous Gull
June 14-16 Continued										
G Cape Dalhousie to Baillie Islands										
G	46	14.4	0	0	0	32	662	0	6	0
G	47	16.7	0	0	0	11	673	0	0	0
G	48	15.3	0	0	0	57	665	0	28	0
G	49	13.3	0	0	0	298	216	0	10	0
G	50	13.8	0	0	0	369	1030	0	1211	4
Total: Region G		73.4	0	0	0	767	3246	0	1255	4
H Baillie and Bathurst area										
H	51	15.0	0	0	0	145	214	0	111	1
H	52	14.9	0	0	1	115	697	0	84	2
H	53	15.1	0	0	0	96	0	0	121	2
Total: Region H		44.9	0	0	1	356	911	0	316	5
I Franklin Bay										
I	54	15.4	0	0	0	179	42	0	9	8
I	55	15.2	0	0	0	77	5	0	30	1
I	56	15.1	0	2	0	33	0	8	28	1
I	57	15.6	2	0	0	120	1	40	1	50
I	58	15.8	0	0	0	1	0	0	0	0
I	59	16.0	0	0	0	3	0	0	3	0
I	60	16.8	2	0	0	3	2	0	23	0
I	61	17.1	0	0	0	0	4	0	7	1
Total: Region I		127.1	4	2	0	416	54	48	101	61
J Parry Peninsula										
J	62	16.3	0	0	1	67	276	0	1147	0
J	63	15.4	0	1	0	350	112	0	199	0
J	64	16.1	0	0	0	169	54	0	18	5
J	65	11.8	1	0	0	214	88	0	27	0
J	66	16.8	1	0	0	197	202	0	12	1
J	67	16.5	0	0	4	1359	81	0	15	2
J	68	15.5	0	0	4	91	27	0	26	2
J	69	15.7	0	0	4	175	9	0	2	0
Total: Region J		124.1	2	1	13	2622	849	0	1446	10
L Cape Lambton coastal area										
L	109	15.1	0	0	0	0	0	0	0	0
L	110	15.3	0	0	1	66	344	0	0	0
L	111	15.7	0	0	2	38	105	0	0	20
L	112	15.4	0	1	0	24	61	0	10	3
L	113	15.4	1	0	9	55	61	0	0	0
Total: Region L		76.8	1	1	12	183	571	0	10	23
M Masik River to Cape Kellett										
M	114	15.7	0	2	0	26	125	0	3	0
M	115	16.0	0	0	1	24	360	0	0	0
M	116	15.8	1	0	1	72	540	0	0	2
M	117	15.5	0	0	1	2	685	0	0	0
M	118	14.3	0	0	1	38	542	0	0	0
M	119	11.4	0	0	0	2	212	0	2	0
M	120	11.4	0	0	2	2	34	0	6	0
M	121	11.9	0	0	1	16	354	0	0	0
Total :Region M		112.0	1	2	7	182	2852	0	11	2
N Cape Kellett to Storkerson Bay										
N	122	12.6	0	0	0	38	481	0	0	0
N	123	13.0	0	0	0	5	109	0	0	0
N	124	12.7	1	0	0	18	223	0	0	0
N	125	13.2	1	0	0	1	75	0	0	0
N	126	13.1	0	0	0	47	566	0	0	0
N	127	12.6	1	0	0	16	503	0	2	0
N	128	12.9	0	0	0	11	542	0	0	0
N	129	13.0	0	0	0	7	368	0	0	0
N	130	12.6	0	0	0	8	179	0	0	0
N	131	12.0	0	0	0	17	184	0	0	0
N	132	12.0	0	0	0	5	179	0	0	0
N	133	12.3	0	0	0	15	197	0	0	2
Total: Region N		151.9	3	0	0	188	3606	0	2	2

Appendix C. Continued.

Region	Segment No.	Distance (km)	Pacific Loon	Red-throated Loon	Yellow-billed Loon	Pacific Eider	King Eider	Scoter sp.	Oldsquaw	Glaucous Gull
June 14-16 Continued										
O Storkerson Bay to Bernard Island										
O	134	11.8	0	0	0	12	164	0	0	0
O	135	11.5	0	0	0	0	222	0	16	0
O	136	12.0	0	0	0	5	41	0	0	3
O	137	12.1	0	0	0	7	86	0	0	0
O	138	12.0	0	0	0	0	98	0	4	0
O	139	12.4	0	0	0	2	61	0	0	0
O	140	12.3	0	0	0	0	17	0	0	0
Total: Region O		84.1	0	0	0	26	689	0	20	3
P Darnley Bay										
P	70	17.1	0	0	1	0	0	0	1	0
P	71	16.3	0	0	1	74	0	0	0	0
P	72	14.8	0	0	0	5	0	0	0	0
P	73	15.1	0	0	6	84	77	0	142	0
Total: Region P		63.3	0	0	8	163	77	0	143	0
Q Cape Lyon to Clinton Pt.										
Q	74	13.5	0	0	0	130	61	27	71	1
Q	75	11.7	1	0	0	161	53	0	338	5
Q	76	13.7	0	0	1	89	57	0	2566	4
Q	77	15.7	0	0	4	218	186	9	66	1
Q	78	15.8	0	0	2	55	246	0	107	2
Q	79	15.3	0	0	7	875	899	0	14	0
Q	80	15.2	6	0	1	499	311	0	62	0
Q	81	14.8	0	0	1	76	69	0	2	0
Total: Region Q		115.7	7	0	16	2103	1882	36	3226	13
R Clinton Pt. to Clifton Pt.										
R	82	14.4	2	0	2	553	831	0	39	2
R	83	14.3	0	0	5	322	960	0	29	5
R	84	14.1	1	1	7	46	170	0	163	0
Total: Region R		42.8	3	1	14	921	1961	0	231	7
S Clifton Pt. to Wollaston Peninsula										
S	85	14.7	1	0	4	169	116	0	84	4
S	86	15.5	1	0	0	5	0	0	0	1
S	87	15.3	0	0	1	0	6	0	0	0
S	88	14.6	2	0	0	0	0	0	0	28
S	89	14.5	1	0	0	0	1	0	0	1
S	90	14.9	0	0	0	0	10	0	2	0
Total: Region S		89.6	5	0	5	174	133	0	86	34
T Wollaston Peninsula										
T	91	15.5	1	0	0	0	11	0	2	1
T	92	16.3	0	0	1	0	20	0	1	4
T	93	16.1	0	0	0	0	1	0	0	1
Total: Region T		47.9	1	0	1	0	32	0	3	6
U Prince Albert Sound										
U	94	15.4	0	0	0	2	0	0	0	3
U	95	14.7	0	0	0	3	24	0	2	1
U	96	15.1	0	0	0	0	60	0	0	0
Total: Region U		45.1	0	0	0	5	84	0	2	4
V Holman Coast										
V	97	16.3	0	0	0	0	192	0	30	0
V	98	16.1	0	0	0	0	64	0	0	0
V	99	15.7	0	0	0	191	2169	0	0	2
Total: Region V		48.1	0	0	0	191	2425	0	30	2
W Cape Ptarmigan to Nelson Head										
W	100	17.9	0	0	21	120*	1205*	0	0	0
W	101	18.8	0	0	0	0	0	0	0	0
W	102	17.8	0	0	0	0	0	0	0	0
W	103	18.4	0	0	0	0	0	0	0	0
W	104	18.5	0	0	0	0	0	0	0	0
W	105	18.1	0	0	0	0	0	0	0	0
W	106	18.1	0	0	0	0	0	0	0	0
W	107	17.4	0	0	0	0	0	0	0	0
W	108	16.1	2	0	0	0	28	0	0	0
Total: Region W		161.2	2	0	21	120	1233	0	0	0

Appendix C. Continued.

Region	Segment No.	Distance (km)	Pacific Loon	Red-throated Loon	Yellow-billed Loon	Pacific Eider	King Eider	Scoter sp.	Oldsquaw	Glaucous Gull
June 14-16 Continued										
X Lambert Channel										
X	141	14.9	1	0	9	663	10	0	74	0
X	142	15.5	2	0	8	986	25	0	31	1
X	143	13.7	2	0	5	2530	52	0	134	1
X	144	14.1	5	0	9	1664	27	0	44	0
X	145	13.7	0	0	7	4019	243	0	3	1
X	146	11.4	0	0	4	6671	21	0	0	3
X	147	12.0	0	0	2	4096	39	0	44	8
X	148	12.2	0	0	5	1541	31	0	54	0
X	149	12.6	0	0	1	2158	3	0	127	0
X	150	12.4	0	0	2	3002	6	0	53	1
Total: Region X		132.4	10	0	52	27330	457	0	564	15

* In Region W, June 14-16 survey, all eiders were close to Cape Ptarmigan and have been included as part of Region V in analyses.

APPENDIX D

Total numbers of most common bird species observed during "deadhead" portions of aerial surveys of offshore leads and polynyas in the Beaufort Sea, Amundsen Gulf, and Lambert Channel, spring 1993.

"Deadhead" flight (Z1)	Distance (km)	Pacific Loon	Red-throated Loon	Yellow-billed Loon	Pacific Eider	King Eider	Scoter sp.	Oldsquaw	Glaucous Gull
Survey Period: May 26-28, June 1									
Z1 Sachs Harbour to Cape Bathurst									
Total: Z1	172.0	0	0	0	34	32	0	6	9
Survey Period: June 7-9									
Z1 Sachs Harbour to Cape Bathurst									
Total: Z1	181.6	0	0	0	12	82	0	43	0

APPENDIX E

Percentage of males among Pacific and King eiders observed during aerial surveys of offshore leads and polynyas in the Beaufort Sea, Amundsen Gulf, and Lambert Channel, spring 1993.

	Pacific Eiders		King Eiders	
Date	% Males	Number sexed	% Males	Number sexed
	Herschel Island to Cape Parry			
May 26-28, June 1	52	4871	50	16756
June 7-9	56	3462	58	2317
June 14-16	69	2149	82	2806
	Western Banks Island			
May 26-28, June 1	55	520	55	1660
June 7-9	53	1193	54	5476
June 14-16	66	524	82	2377
	Amundsen Gulf			
May 26-28, June 1	58	1063	56	238
June 7-9	52	2887	53	704
June 14-16	66	854	66	634
	Lambert Channel			
May 27	51	2283	53	36
June 9	50	11406	51	226
June 16	50	14817	60	121

APPENDIX F

Versions of Figure 8 based on King Eider populations of 200 000 and 800 000 birds.

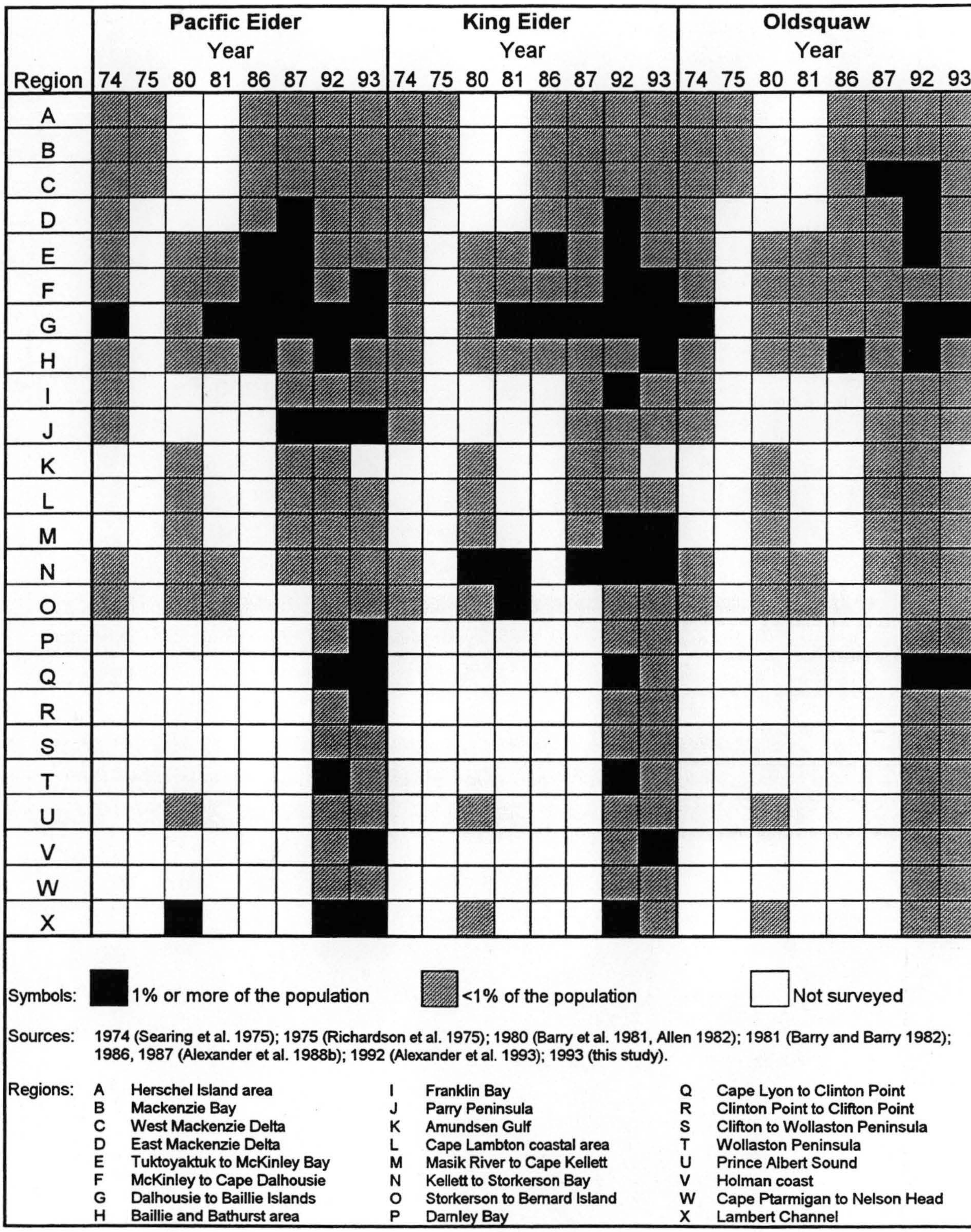
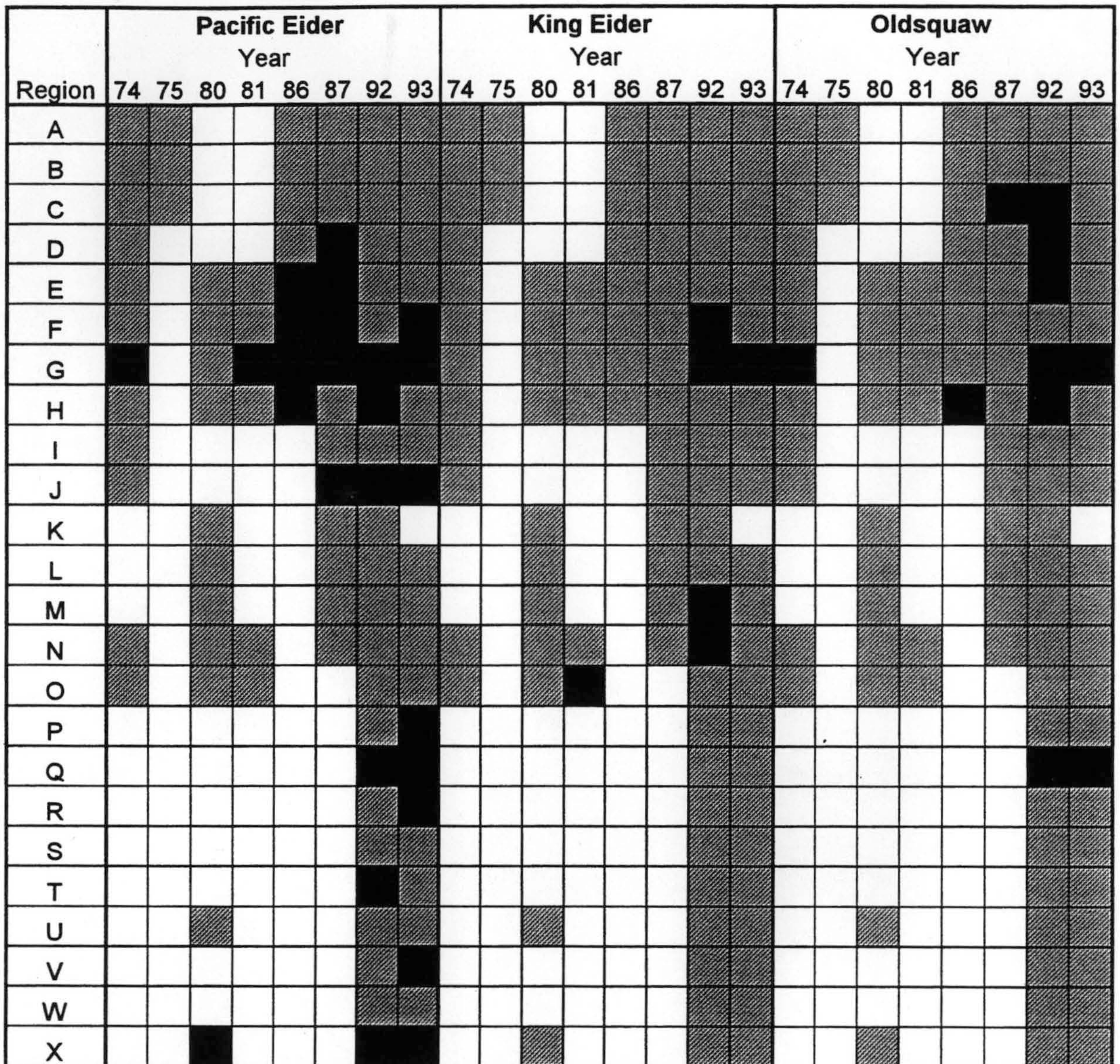


Figure F.1. Regions in which at least 1% of the western Arctic populations of Pacific Eiders, King Eiders (population=200000), and Oldsquaw have been observed, 1974-1993.



Symbols: ■ 1% or more of the population ▒ <1% of the population □ Not surveyed

Sources: 1974 (Searing et al. 1975); 1975 (Richardson et al. 1975); 1980 (Barry et al. 1981, Allen 1982); 1981 (Barry and Barry 1982); 1986, 1987 (Alexander et al. 1988b); 1992 (Alexander et al. 1993); 1993 (this study).

Regions:

A	Herschel Island area	I	Franklin Bay	Q	Cape Lyon to Clinton Point
B	Mackenzie Bay	J	Parry Peninsula	R	Clinton Point to Clifton Point
C	West Mackenzie Delta	K	Amundsen Gulf	S	Clifton to Wollaston Peninsula
D	East Mackenzie Delta	L	Cape Lambton coastal area	T	Wollaston Peninsula
E	Tuktoyaktuk to McKinley Bay	M	Masik River to Cape Kellett	U	Prince Albert Sound
F	McKinley to Cape Dalhousie	N	Kellett to Storkerson Bay	V	Holman coast
G	Dalhousie to Baillie Islands	O	Storkerson to Bernard Island	W	Cape Ptarmigan to Nelson Head
H	Baillie and Bathurst area	P	Darnley Bay	X	Lambert Channel

Figure F.2. Regions in which at least 1% of the western Arctic populations of Pacific Eiders, King Eiders (population=800000), and Oldsquaw have been observed, 1974-1993.