D. Lynne Dickson[1]
(editor)

King and Common eiders of the western Canadian Arctic

Occasional Paper
Number 94
Canadian Wildlife Service

[1] Canadian Wildlife Service, Environment Canada,
Edmonton, AB T6B 2X3.

A member of the Environmental Conservation family

Cover photo: King Eider (G.W. Beyersbergen)

Polar Continental Shelf Project
Publication PCSP/EPCP 00397

Published by Authority of the
Minister of Environment
Canadian Wildlife Service

Catalogue No. CW69-1/94E
ISBN 0-662-25471-6
ISSN 0576-6370

Canadian Cataloguing in Publication Data

Main entry under title:

King and Common eiders of the western Canadian Arctic

(Occasional paper, ISSN 0576-6370; no. 94)
Includes bibliographical references.
ISBN 0-662-25471-6
Cat. no. CW69-1/94E

1. Eider — Arctic regions — Geographical distribution.
2. Eider — Canada, Northern — Geographical distribution.
I. Dickson, D. Lynne.
II. Canadian Wildlife Service.
III. Series: Occasional paper (Canadian Wildlife Service); no. 94.

QL696.A52K56 1997 598.3'3 C97-980059-5

The Canadian Wildlife Service

The Canadian Wildlife Service of Environment Canada handles wildlife matters that are the responsibility of the Canadian government. These include protection and management of migratory birds as well as nationally significant wildlife habitat. Other responsibilities are endangered species, control of international trade in endangered species, and research on wildlife issues of national importance. The service cooperates with the provinces, territories, Parks Canada, and other federal agencies in wildlife research and management.

The Occasional Papers series

Occasional Papers report the results of original research carried out by members of the Canadian Wildlife Service or supported by the Canadian Wildlife Service. Occasional Papers have been subjected to external peer review.

For more information about the Canadian Wildlife Service or its other publications, please contact:

Publications
Canadian Wildlife Service
Environment Canada
Ottawa, Ontario
K1A 0H3
(819) 997-1095
(819) 997-2756 (fax)
mark.hickson@ec.gc.ca

Acknowledgements

This publication was produced by the Scientific and Technical Documents Division of the Canadian Wildlife Service. The following people were responsible: Pat Logan — coordination and supervision; Sylvie Larose — layout; Marla Sheffer (Contract Editor) — scientific editing; and Mark Hickson — printing.

97-03

Contents

Contributors

Stuart A. Alexander
Alexander Ecological Services
14 Oak Street
Whitehorse, YT Y1A 4B1

Rodney Brook
Canadian Wildlife Service
Environment Canada
P.O. Box 637
Yellowknife, NT X1A 2N5
(*Current address:* Wildlife and Economic Development, Government of the Northwest Territories, 600 5102 50 Avenue, Yellowknife, NT X1A 3S8)

Beth J. Cornish
10964–70 Avenue
Edmonton, AB T6H 2G6

Richard C. Cotter
620 Craig's Road
St. Sylvestre, QC G0S 3C0

D. Lynne Dickson
Canadian Wildlife Service
Environment Canada
Room 200, 4999–98 Avenue
Edmonton, AB T6B 2X3

Michael Fabijan
Inuvialuit Joint Secretariat
P.O. Box 2120
Inuvik, NT X0E 0T0

John Craighead George
North Slope Borough Department of Wildlife Management
P.O. Box 69
Barrow, AK 99723

Cindy J. Gratto
620 Craig's Road
St. Sylvestre, QC G0S 3C0

James E. Hines
Canadian Wildlife Service
Environment Canada
P.O. Box 637
Yellowknife, NT X1A 2N5

Anne C. Holcroft-Weerstra
Biota Consultants
P.O. Box 1446
Cochrane, AB T0L 0W0

Michele Johnson
North Slope Borough Department of Wildlife Management
P.O. Box 69
Barrow, AK 99723
(*Current address:* 512 Ninth Street, #3, Davis, CA 95616)

Maureen F. Kay
Canadian Wildlife Service
Environment Canada
P.O. Box 637
Yellowknife, NT X1A 2N5

David Kuptana
Olokhaktomiut Hunters' and Trappers' Committee
Holman, NT X0E 0S0

Lori Quakenbush
Northern Alaska Ecological Services
U.S. Fish and Wildlife Service
101 12th Avenue, Box 19
Fairbanks, AK 99701
(*Current address:* Institute of Marine Science, University of Alaska, Fairbanks, AK 99775)

Robert Suydam
North Slope Borough Department of Wildlife Management
P.O. Box 69
Barrow, AK 99723

Susan E. Westover
Alexander Ecological Services
14 Oak Street
Whitehorse, YT Y1A 4B1

Joanne Young
North Slope Borough Department of Wildlife Management
P.O. Box 69
Barrow, AK 99723
(*Current address:* 456 Strand, Missoula, MT 59801)

Introduction

D. Lynne Dickson

Two eider populations breed in the western Canadian Arctic and winter in the Bering Sea: the Pacific subspecies of the Common Eider *Somateria mollissima v-nigra* and the western Arctic population of the King Eider *S. spectabilis*. Both eiders are harvested primarily in the spring by the Aboriginal people of northern communities and to a small extent in fall by sport hunters. Some eggs of the colonially nesting Common Eider are also taken. Compared with other harvested waterfowl, there are few available data on even the most basic aspects of the biology of these two eider populations, including their status and nesting distribution. This is largely because they inhabit remote areas and thus are logistically difficult and expensive to study. However, several recent events have forced wildlife managers to try to address some of the information gaps.

Exploration for oil and gas in the Canadian Beaufort Sea led to public hearings in the mid-1980s to examine the potential environmental impact of offshore oil and gas production. A major concern identified during those hearings was the effect of an oil spill in the narrow system of open-water leads in the Beaufort Sea on sea ducks during spring migration. The Northern Oil and Gas Action Program (NOGAP) was initiated to address such major environmental concerns. Through this program, four years of data were collected on the movement of eiders through the western Canadian Arctic during spring migration.

A second opportunity to study eiders arose with settlement of the Inuvialuit land claim. The Inuvialuit Final Agreement specified that the Inuvialuit have preferential rights to the allowable harvest of migratory birds in the western Canadian Arctic. It was acknowledged that current data on eiders were inadequate to manage either species in a way that would ensure that its population remained stable. Thus, a series of waterfowl breeding pair surveys was initiated throughout most of the Inuvialuit Settlement Region. The primary objective of the surveys was to establish a baseline for future measurement of population trends. Also as part of the land claim agreement, a harvest study was created to determine the level of subsistence harvest of wildlife, including eiders, and to evaluate the impact of the harvest on wildlife populations.

The dramatic decline of the closely related Spectacled Eider *Somateria fischeri* and Steller's Eider *Polysticta stelleri* in Alaska made us all realize that we urgently needed a means of measuring eider population trends in the western Arctic. As the distributions of all four eider species overlap, the unknown factors causing the decline of Spectacled and Steller's eiders might also be affecting King and Common eiders. In response to this concern, the North Slope Borough of Alaska documented the number of eiders that passed Point Barrow during spring migration in 1987 and again in 1994. These counts provide not only reference points for future monitoring, but also a means of comparing similar counts done more than a decade earlier.

The papers contributed here represent information collected on Common and King eiders in the western Canadian Arctic since Barry's (1986) mid-1980s review of what was known. These data contribute to our knowledge and hence to our ability to manage the two eider populations. However, our level of knowledge must continue to grow if we truly intend to protect and conserve eiders in future.

Literature cited

Barry, T.W. 1986. Eiders of the western Canadian Arctic. Pages 74–80 *in* A. Reed (ed.), Eider ducks in Canada. Can. Wildl. Serv. Rep. Ser. No. 47, Ottawa.

Spring migration of eiders and other waterbirds in offshore areas of the western Arctic

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

Abstract

Hundreds of thousands of birds stop in offshore areas of the western Arctic during spring migration. Some areas within the migration corridor could be affected in the event of oil and gas exploration or development. Our objectives in this study were to identify important staging sites in offshore areas of the Canadian Beaufort Sea, Amundsen Gulf, and Lambert Channel; examine bird distributions under various ice conditions; determine timing of migration; and assess the potential for conflicts between birds and oil and gas activities.

We flew aerial surveys in May and June of 1986, 1987, 1992, and 1993. Peak spring migration occurred from the last week of May to the middle of June. The most abundant species were Common Eiders *Somateria mollissima v-nigra*, King Eiders *S. spectabilis*, and Oldsquaws *Clangula hyemalis*, 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*. The most important offshore staging areas were (1) between Cape Dalhousie and the Baillie Islands (eiders, Oldsquaws); (2) off western Banks Island between the Masik River and Storkerson Bay (King Eiders); and (3) the Lambert Channel polynya (Common Eiders, Yellow-billed Loons). Areas of secondary importance were between Tuktoyaktuk and Cape Dalhousie (eiders, Oldsquaws, Red-throated Loons); between Herschel Island and Tuktoyaktuk (Oldsquaws, Red-throated Loons); and the southern Amundsen Gulf coast (Common Eiders, Oldsquaws). Areas west of Hutchison Bay are the most likely to be affected by oil and gas industry activities, although there are conditions under which the most important staging areas in the Beaufort Sea would also be at risk.

Ice conditions during the four years of surveys varied from extensive pack ice with only small patches of open water in the Beaufort Sea to virtually unlimited open water. Regardless of ice conditions, open water between Cape Dalhousie and the Baillie Islands was always extremely important to eiders and Oldsquaws. Factors that might affect the suitability of staging areas include the annual recurrence of open water (i.e., the presence of recurrent polynyas), availability of shallow water for bottom feeding, and water turbidity.

Résumé

Des centaines de milliers d'oiseaux font escale dans les zones extracôtières de la région ouest de l'Arctique durant la migration printanière. Certaines zones à l'intérieur du corridor de migration pourraient être exposées aux effets d'activités d'exploration ou de mise en valeur du pétrole et du gaz. Nos objectifs dans cette étude étaient de recenser les aires de repos importantes dans les zones extracôtières canadiennes de la mer de Beaufort, du golfe d'Amundsen et du détroit de Lambert; d'examiner les distributions d'oiseaux selon les différentes conditions des glaces, de tracer l'évolution chronologique des migrations et, enfin, d'évaluer les possibilités de conflits entre les oiseaux et les activités d'exploitation du pétrole et du gaz.

Nous avons effectué des relevés aériens en mai et en juin 1986, 1987, 1992 et 1993. La période de pointe des migrations printanières survenait entre la dernière semaine de mai et le milieu de juin. Les espèces les plus abondantes étaient l'Eider à duvet *Somateria mollissima v-nigra*, l'Eider à tête grise *S. spectabilis* et le Canard kakawi *Clangula hyemalis*. Venaient ensuite la Macreuse à tête blanche *Melanitta fusca*, le Goéland bourgmestre *Larus hyperboreus*, le Huart à bec jaune *Gavia adamsii*, le Huart du Pacifique *G. pacifica* et, enfin, le Huart à gorge rousse *G. stellata*. Les aires de repos extracôtières les plus importantes étaient situées (1) entre le cap Dalhousie et les îles Baillie (eiders, Canards kakawi); (2) au large de la partie ouest de l'île Banks entre la rivière Masik et la baie de Storkerson (Eiders à tête grise); et (3) la polynie du détroit de Lambert (Eiders à duvet, Huarts à bec jaune). Il y avait des zones de moindre importance entre Tuktoyaktuk et le cap Dalhousie (eiders, Canards kakawi, Huarts à gorge rousse); entre l'île Herschel et Tuktoyaktuk (Canards kakawi, Huarts à gorge rousse); et la côte sud du golfe d'Amundsen (Eiders à duvet, Canards kakawi). Les zones à l'ouest de la baie d'Hutchison sont les plus exposées aux activités de l'industrie pétrolière et gazière, mais les aires de repos les plus importantes dans la mer de Beaufort peuvent également être exposées à des risques dans certaines conditions.

Les conditions des glaces durant les quatre années d'observation ont passé d'une extrémité à l'autre : vastes étendues de glaces flottantes entassées les unes contre les autres ne laissant que de petites superficies d'eau libre

dans la mer de Beaufort, ou mer libre presque à perte de vue. Il était toujours extrêmement important pour les eiders et les Canards kakawi, quelles que puissent être les conditions des glaces, qu'il y ait de l'eau libre entre le cap Dalhousie et les îles Baillie. Au nombre des facteurs susceptibles d'influencer l'attrait des aires de repos, il y a la présence annuelle d'eau libre (c'est-à-dire l'apparition périodique de polynie), l'accès à des étendues d'eau peu profonde permettant aux oiseaux de se nourrir sur le fond et la turbidité de l'eau.

1.0 Introduction

Each spring during migration, hundreds of thousands of birds stop temporarily in offshore areas of the Canadian Beaufort Sea to feed, rest, and court. The staging birds are dependent on open-water leads and polynyas, which have formed in the ice by the time migration starts each spring. In the event of oil exploration and development in the Beaufort Sea, the potential for oil spills in these areas would be one of the most serious threats to birds in the western Arctic (FEARO 1984). Therefore, our objectives in this study were to identify important staging sites in offshore areas of the Canadian Beaufort Sea, Amundsen Gulf, and Lambert Channel; examine bird distributions under various ice conditions; determine timing of migration; and assess the potential for conflicts between birds and oil and gas activities.

Surveys of offshore areas of the Beaufort Sea, from the Yukon coast to western Banks Island, were first conducted in the early 1970s (Richardson et al. 1975; Searing et al. 1975). Survey routes varied from arbitrary flight paths, searching for open water, to straight transects over the pack ice. In 1980 and 1981, single surveys were conducted along the landfast ice edge of leads off the Tuktoyaktuk Peninsula and western Banks Island (Barry et al. 1981; Barry and Barry 1982). Radar and migration watch studies were conducted in 1975 and 1977 (Richardson and Johnson 1981), which provide some information on timing but not on offshore distributions.

2.0 Methods

From late May to late June in 1986, 1987, 1992, and 1993, we conducted aerial surveys along offshore leads parallel to southern and eastern coastlines of the Canadian Beaufort Sea, Amundsen Gulf, and Dolphin and Union Strait (Fig. 1). In all years, we surveyed the southern Beaufort Sea[1] from just west of Herschel Island to the Baillie Islands. Eastern and northern coverage varied among years: to the Baillie Islands in 1986; to Cape Parry and western Banks Island in 1987; and throughout Amundsen Gulf, western Banks Island, and Lambert Channel in 1992 and 1993. In most locations and years, we flew along the landfast ice edge of leads. The main exception was the Beaufort Sea in 1992, when pack ice predominated because leads did not develop until late June. That year, we flew from patch to patch of open water, roughly along the 20-m depth contour. We also flew blocks of transects to estimate a correction factor for birds in areas not flown (twice the number counted west of the Mackenzie Delta to Herschel Island, and five times the number counted from the Mackenzie Delta to the Baillie Islands, inclusive; Alexander et al. 1993). Results for 1992 presented in this paper have been adjusted as indicated. Blocks were not flown in other years because we assumed that most birds were concentrated along the ice edge. This permitted extensive coverage throughout the western Arctic. Potential problems with this assumption are discussed below.

In some parts of the study area, most birds would swim or dive when we flew over; elsewhere, most birds would take flight several kilometres in advance of our aircraft. Because of the latter behaviour, we counted all birds visible from the aircraft rather than restricting the survey area to a specified width (Johnson et al. 1993).

We flew most surveys in a high-wing, twin-engine Britten-Norman Islander on wheels. A single-engine Cessna 185 on skis was used for surveys between Herschel Island and Cape Bathurst in 1986 and 1987, but its use was discontinued for safety reasons. Our usual altitude was 45 m above sea level, and ground speed averaged 150 km/h. We increased speed to 200–230 km/h in areas that had few birds, which permitted greater coverage. When over leads, we flew approximately 200 m to the open-water side of the ice edge. The survey route was divided into five-minute segments. Segment length was estimated by multiplying the elapsed time by the average ground speed recorded at the beginning and end of each segment. Aircraft position (latitude and longitude) and ground speed were determined by a Global Positioning System. Ice conditions were monitored using National Oceanic and Atmospheric Administration (NOAA) satellite imagery obtained from the Atmospheric Environment Service, Environment Canada.

Two observers, one in the right front seat and one in the left seat directly behind the pilot, recorded the following information on sightings of birds: species, number of individuals, sex, location (water, ice), and behaviour (sitting, diving, flushing, flying). For flocks of fewer than 20 eiders (*Somateria* spp.), we counted males and females. For larger flocks, which accounted for most eiders observed, we estimated the proportion of males. We assumed that females were the same species as the males with them. In mixed flocks of King Eiders *S. spectabilis* and Common Eiders *S. mollissima v-nigra*, we assumed that male and female eiders were present in the flocks in similar proportions. We recorded lone females as unidentified eiders. Large flocks comprising mainly females were never encountered.

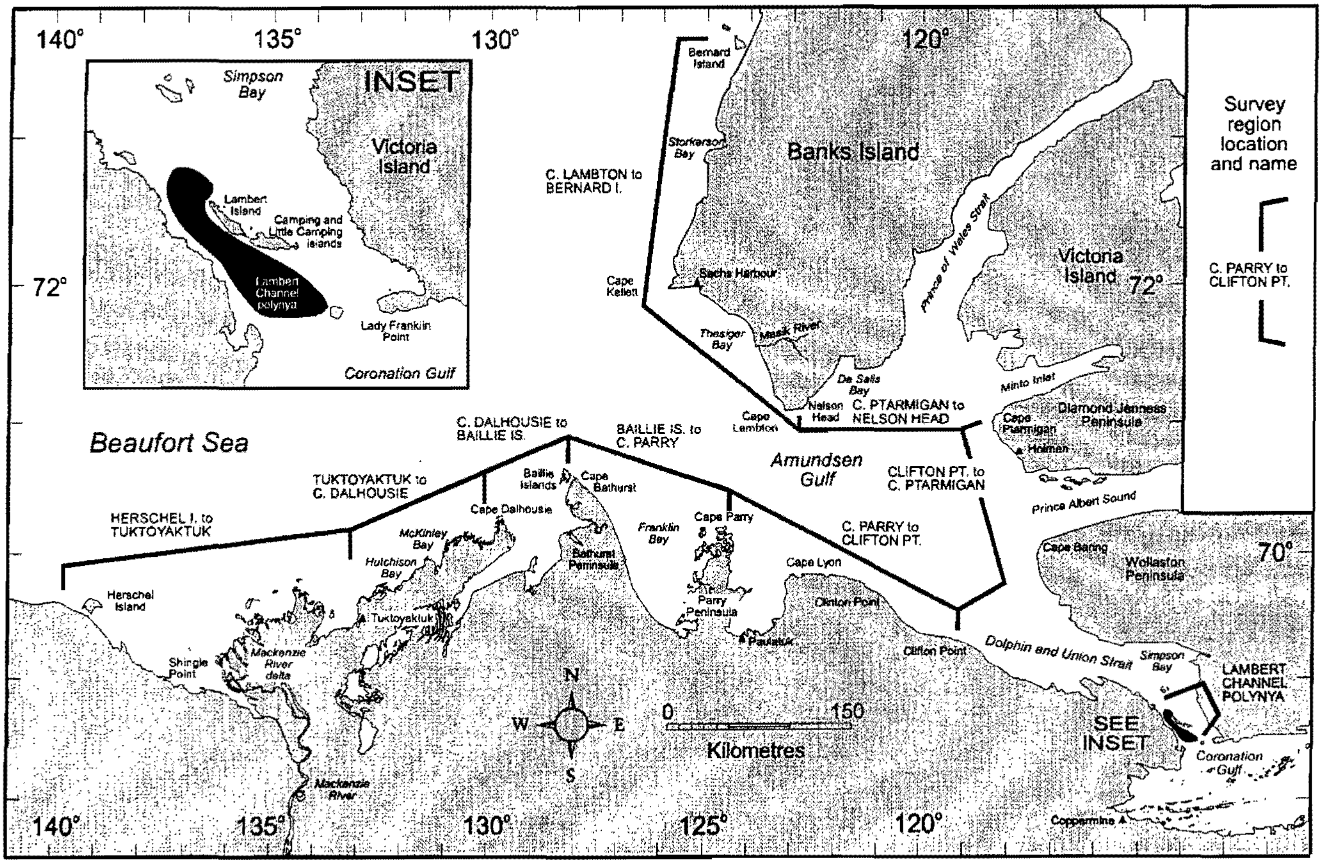
3.0 Results

3.1 Ice conditions

The Cape Bathurst polynya, which extends east and north of Cape Bathurst and the Baillie Islands, is the largest polynya in the western Arctic (Smith and Rigby 1981). It is usually open somewhat during the winter. In most years, long leads open westward and northward from

[1] In this paper, "southern Beaufort Sea" is the area from Herschel Island to the Baillie Islands, and "southeastern Beaufort Sea" is the area from Tuktoyaktuk to the Baillie Islands.

Figure 1
Study area with place names and regions used in describing bird distributions throughout the Beaufort Sea, Amundsen Gulf, and Lambert Channel polynya



the Cape Bathurst polynya in late May and broaden throughout the spring months. The leads eventually transform into open sea when the broad shelf of landfast ice breaks free in July. Leads also occur along the south and east shores of Amundsen Gulf. A second, much smaller polynya recurs in Lambert Channel at the western end of Coronation Gulf.

Ice conditions at the end of the first week of June for each year of this study are depicted in Figure 2. In 1986 and 1987, Beaufort Sea leads were well developed by late May to early June, although only the western half of Amundsen Gulf was open (Alexander et al. 1988a). In 1992, there was little open water in the Beaufort Sea for the duration of our surveys, except for a thin lead along western Banks Island by 23 June (Alexander et al. 1993). In contrast, in 1993, the lead system throughout the Beaufort Sea and Amundsen Gulf was highly developed by mid-May (Alexander et al. 1994).

3.2 Abundance and distribution

We evaluated the distributions of eiders and Oldsquaws *Clangula hyemalis* by examining total counts, densities, and relative abundance by region. Relative abundance is the ratio of number seen in a given region to number seen throughout a survey. We excluded Lambert Channel from evaluations of relative abundance because evidence suggests that most eiders using Lambert Channel first stop in the southeastern Beaufort Sea. In 1993, for example, peak abundance of birds at Lambert Channel coincided with a decline in abundance in the southeastern Beaufort Sea (Table 1). The inclusion of Lambert Channel in evaluations of relative abundance would devalue the importance of regions west of there. In most cases, we could not assess percentages in terms of total western Arctic populations because the sizes of those populations are poorly known.

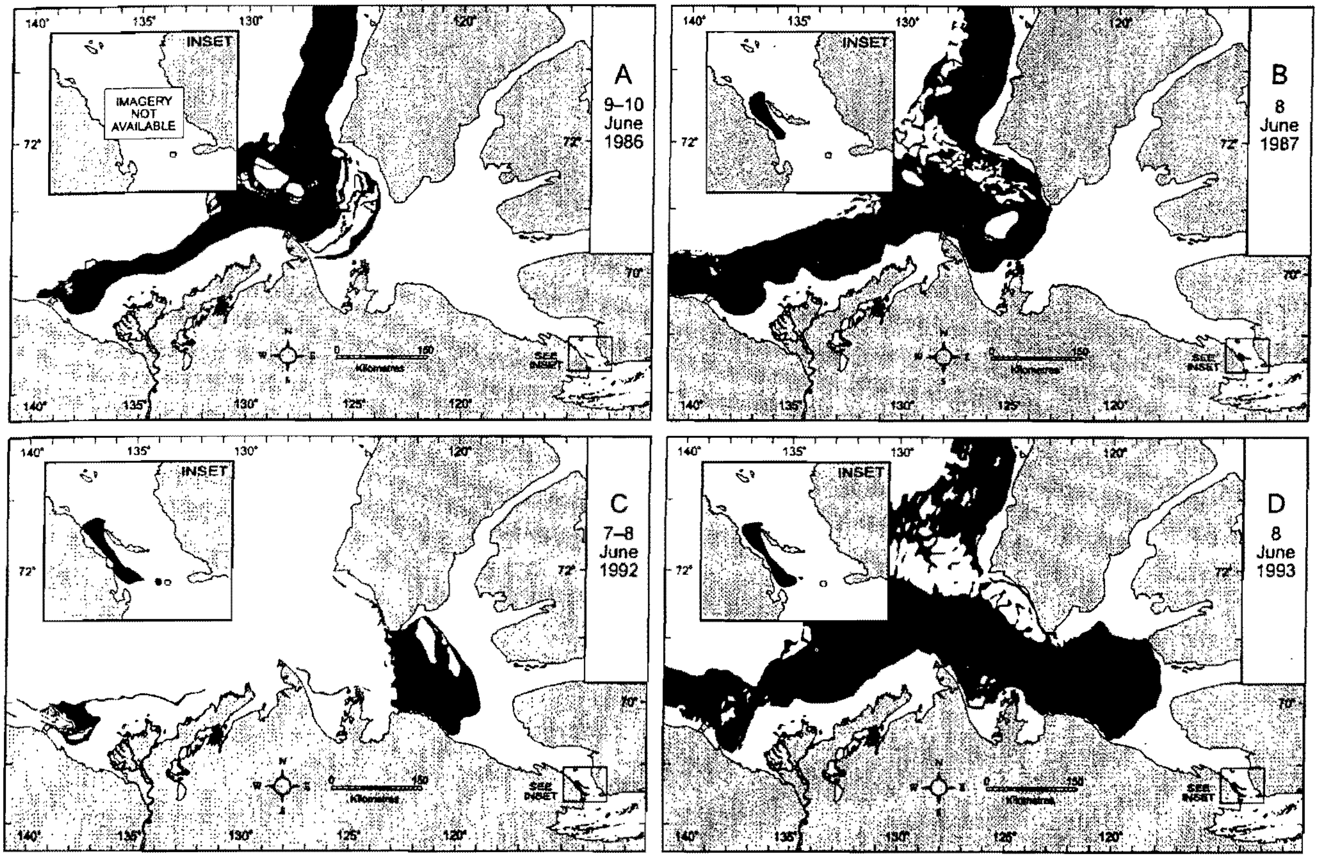
3.2.1 Common Eiders

Lambert Channel had large numbers of Common Eiders in both years that it was surveyed (Table 1). For example, on 9 June 1993, we counted over 64 000 birds, which represent at least 64% of the total population. The highest densities occurred in the shallow southeast end of the polynya.

Excluding Lambert Channel, the lead off Cape Dalhousie and the Baillie Islands consistently had the largest concentrations of Common Eiders in the study area (Tables 1 and 2; Fig. 3). The largest single-day count was over 25 000 birds. Moderate numbers were found off the Tuktoyaktuk Peninsula and in Amundsen Gulf between Cape Lyon and Clinton Point. Few Common Eiders were observed in the leads off western Victoria or Banks Island.

In the southern Beaufort Sea, peak counts were recorded in the second week of June in 1987 and 1992, but in late May in 1993 (Fig. 4). In Amundsen Gulf in 1993, the number of Common Eiders peaked on 9 June (Table 1). A similar peak was not observed in 1992.

Figure 2
Variation in offshore open water (black areas) in the western Arctic in early June. Imagery of Lambert Channel was unavailable for 1986 and early June 1992; the polynya depicted for 1992 was from 15–18 June.



3.2.2 King Eiders

The largest concentrations of King Eiders were observed in the Beaufort Sea between Cape Dalhousie and the Baillie Islands and off western Banks Island north of the Masik River (Table 2; Fig. 3). Peak counts from single-day surveys were 63 000 and 39 000 birds for those two areas, respectively, although observed numbers varied considerably among years (Table 3).

In the southern Beaufort Sea, peak numbers of King Eiders were recorded from late May to the third week of June, depending on year (Fig. 4). The fluctuation in 1992 was likely the result of sampling error due to the clumped nature of eider distributions that year. The data for late June, 1987 and 1992, were excluded from Figure 4 because most King Eiders were males (Table 4), which likely represented the westward moult migration.

3.2.3 Oldsquaws

Oldsquaws occurred in all leads along the mainland coast, although the highest densities were off Cape Dalhousie and the Baillie Islands (Tables 2 and 5; Fig. 3). Peak movement and staging of Oldsquaws in the southern Beaufort Sea occurred in late May and early June (Fig. 4).

3.2.4 Loons

Few (<40) Pacific Loons *Gavia pacifica* were seen in the southern Beaufort Sea except in 1992, when they were common west of the Mackenzie River delta for a short period at the end of the first week in June (Table 6). That year, Pacific Loons were also common in the Lambert Channel polynya. In 1993, they were most common off the Wollaston Peninsula, Victoria Island.

Red-throated Loons *Gavia stellata* were common only in the southern Beaufort Sea (Table 6). Based on the 1992 and 1993 surveys, 62% (on average) of Red-throated Loons seen throughout the study area were between Herschel Island and Tuktoyaktuk, whereas most others (37%) were between Tuktoyaktuk and Cape Dalhousie. A similar pattern was observed in 1987. In 1987 and 1992, Red-throated Loon numbers peaked at the end of the first week in June and dropped quickly thereafter. In contrast, in 1993, their numbers fluctuated over the three surveys, with high points in late May and mid-June.

Notably large numbers of Yellow-billed Loons *Gavia adamsii* were seen in the Beaufort Sea in 1992, but not in other years (Table 6). Most birds were east of Tuktoyaktuk and off western Banks Island north of the Masik River. High densities of Yellow-billed Loons occurred in Lambert Channel during both years surveyed. Most Yellow-billed Loons in Amundsen Gulf were along the southern coast east of Cape Lyon.

3.2.5 Scoters and other waterfowl

In the three years when surveys extended into late June, thousands of White-winged Scoters *Melanitta fusca* were observed in leads in the southern Beaufort Sea in mid-June, particularly around the Mackenzie Delta from

Table 1
Numbers and linear densities of Common Eiders observed during aerial surveys of offshore leads in the western Arctic, spring 1986–1993

Year/region	No. of birds		Linear density (birds/km)	
	3 June	9–10 June	3 June	9–10 June
1986				
Herschel I. to Tuktoyaktuk	908	1 367	4	4
Tuktoyaktuk to C. Dalhousie	2 133	1 338	15	8
C. Dalhousie to Baillie Is.	12 755	19 723	145	188
Total	15 796	22 428	36	38

Year/region	No. of birds					Linear density (birds/km)				
	26–29 May	1–2 June	9–12 June	15–16 June	23 June	26–29 May	1–2 June	9–12 June	15–16 June	23 June
1987										
Herschel I. to Tuktoyaktuk	707	1 492	1 539	328	–	3	6	5	1	–
Tuktoyaktuk to C. Dalhousie	4 066	6 563	7 885	8 105	227	21	32	41	37	1
C. Dalhousie to Baillie Is.	6 054	11 667	15 992	4 274	704	81	145	238	61	10
Baillie Is. to C. Parry	5	680	1 956	3 240	–	<1	4	9	25	–
C. Parry to C. Lambton	0	12	132	0	–	0	<1	2	0	–
C. Lambton to Bernard I.	20	189	–	463	–	<1	1	–	4	–
Total	10 852	20 603	27 504	16 410	931	15	19	32	18	4

Year/region	No. of birds				Linear density (birds/km)			
	24–30 May	7–8 June	15–18 June	23–25 June	24–30 May	7–8 June	15–18 June	23–25 June
1992								
Herschel I. to Tuktoyaktuk[a]	78	920	120	–	<1	3	<1	–
Tuktoyaktuk to C. Dalhousie[a]	4 010	7 340	2 605	1 120	34	39	18	5
C. Dalhousie to Baillie Is.[a]	20 020	25 220	12 780	745	151	174	85	6
Baillie Is. to C. Parry	145	956	1 525	406	1	5	14	2
C. Parry to C. Lambton	128	257	–	–	<1	2	–	–
C. Lambton to Bernard I.	577	–	1 262	616	2	–	4	2
C. Parry to Clifton Pt.	4 653	3 247	3 076	1 803	30	18	11	7
Clifton Pt. to C. Ptarmigan	–	–	1 730	596	–	–	9	2
C. Ptarmigan to Nelson Head	–	0	31 364	7	–	0	–	<1
Lambert Channel polynya	–	–	–	8 577	–	–	295	65
Total	29 611	37 940	54 462	13 870	24	30	32	8

Year/region	No. of birds			Linear density (birds/km)		
	26 May–1 June	7–9 June	14–16 June	26 May–1 June	7–9 June	14–16 June
1993						
Herschel I. to Tuktoyaktuk	1 690	287	372	7	1	1
Tuktoyaktuk to C. Dalhousie	4 589	1 938	1 182	118	10	6
C. Dalhousie to Baillie Is.	15 992	7 017	1 123	138	53	9
Baillie Is. to C. Parry	1 683	2 166	3 038	8	10	12
C. Parry to C. Lambton	–	–	–	–	–	–
C. Lambton to Bernard I.	655	1 407	579	1	3	1
C. Parry to Clifton Pt.	3 224	11 869	3 187	14	48	14
Clifton Pt. to C. Ptarmigan	459	1 251	490	2	6	2
C. Ptarmigan to Nelson Head	0	0	0	0	0	0
Lambert Channel polynya	11 375	64 583	27 330	123	647	206
Total	39 667	90 518	37 301	22	45	17

[a] Corrections applied; see Methods.

Shingle Point to McKinley Bay (Table 6). Only five birds were identified as Surf Scoters *M. perspicillata* in each of 1987 and 1992. In all years, most birds were males and were likely moult-migrants.

We saw few other species of waterfowl over the four years of surveys, and then only a few dozen individuals in total each year. Species noted were Tundra Swans *Cygnus columbianus*, Brant *Branta bernicla*, Lesser Snow Geese *Chen caerulescens caerulescens*, unidentified scaup (probably Greater Scaup *Aythya marila*), Northern Pintails *Anas acuta*, Red-breasted Merganser *Mergus serrator*, and unidentified merganser species.

3.2.6 Gulls, terns, jaegers, shorebirds, and murres

In all years, Glaucous Gulls *Larus hyperboreus* were common throughout the study area and peaked in number in the last week of May (Table 6). In Amundsen Gulf, their distribution varied among years, likely owing to differences in the formation of leads. In 1987, Glaucous Gulls concentrated in large numbers near Cape Parry; in other years, they dispersed eastward along the southern coast of Amundsen Gulf. Leads opened east of Cape Parry earlier in 1992 and 1993 than in 1987 (Fig. 2).

Sabine's Gulls *Xema sabini* were rarely seen; on 8 June 1993, however, we saw over 200 on the ice edge off Prince Albert Sound. The only other gull species noted was the Thayer's Gull *Larus thayeri*, and then only 20 were observed in Amundsen Gulf in 1992. The only notable numbers of Arctic Terns *Sterna paradisaea* (36 and 72) were seen after mid-June. Most observations of

Table 2
Average relative abundance of Common Eiders, King Eiders, and Oldsquaws observed during aerial surveys of offshore leads in the western Arctic, spring 1986–1993

Species/region	Relative abundance (%)				
	3–10 June 1986	26 May–16 June 1987	24 May–18 June 1992	26 May–16 June 1993	Average 1986–1993
Common Eider					
Herschel I. to Tuktoyaktuk	6	5	1	4	3
Tuktoyaktuk to C. Dalhousie	9	32	14	12	15
C. Dalhousie to Baillie Is.	79	44	59	32	48
Baillie Is. to C. Parry	–	6	3	15	7
C. Parry to C. Lambton	–	<1	<1	–	<1
C. Lambton to Bernard I.	–	1	3	4	3
C. Parry to Clifton Pt.	–	–	12	30	19
Clifton Pt. to C. Ptarmigan	–	–	7	4	5
C. Ptarmigan to Nelson Head	–	–	0	0	0
King Eider					
Herschel I. to Tuktoyaktuk	3	2	<1	<1	1
Tuktoyaktuk to C. Dalhousie	36	22	7	8	17
C. Dalhousie to Baillie Is.	14	9	41	43	26
Baillie Is. to C. Parry	–	2	<1	3	2
C. Parry to C. Lambton	–	<1	<1	–	<1
C. Lambton to Bernard I.	–	61	47	30	44
C. Parry to Clifton Pt.	–	–	2	9	5
Clifton Pt. to C. Ptarmigan	–	–	3	7	5
C. Ptarmigan to Nelson Head	–	–	0	<1	<1
Oldsquaw					
Herschel I. to Tuktoyaktuk	21	47	18	14	22
Tuktoyaktuk to C. Dalhousie	12	12	21	10	12
C. Dalhousie to Baillie Is.	58	19	39	23	31
Baillie Is. to C. Parry	–	9	1	14	7
C. Parry to C. Lambton	–	<1	<1	–	<1
C. Lambton to Bernard I.	–	1	1	<1	1
C. Parry to Clifton Pt.	–	–	15	34	22
Clifton Pt. to C. Ptarmigan	–	–	5	4	4
C. Ptarmigan to Nelson Head	–	–	0	0	0

Notes: Values for regions from Herschel Island to Cape Dalhousie in 1992 are corrected for survey efficiency (see Methods). 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. Without these adjustments, percentages in 1986 and 1987 would be misleadingly high.

jaegers (*Stercorarius* spp.) totalled fewer than 30 per survey; on 21 May 1992, however, 98 were seen near Herschel Island, and on 24 May 1992, 224, mostly Pomarine Jaegers *S. pomarinus*, were seen in Franklin Bay. A few Parasitic Jaegers *S. parasiticus* were identified. Lastly, we saw over 260 shorebirds, mostly phalaropes (*Phalaropus* spp.), in southern Amundsen Gulf in mid-June 1992. No shorebirds were seen in 1986 and 1987, and fewer than 30 in total were seen in 1993.

Murres (*Uria* spp.) were seen only near Cape Parry. In 1987, we saw only 19 murres. In 1992, we recorded few murres until 15–18 June, when we saw 387. In 1993, we saw 903 murres on 14–16 June, but none before then.

4.0 Discussion

4.1 Survey limitations

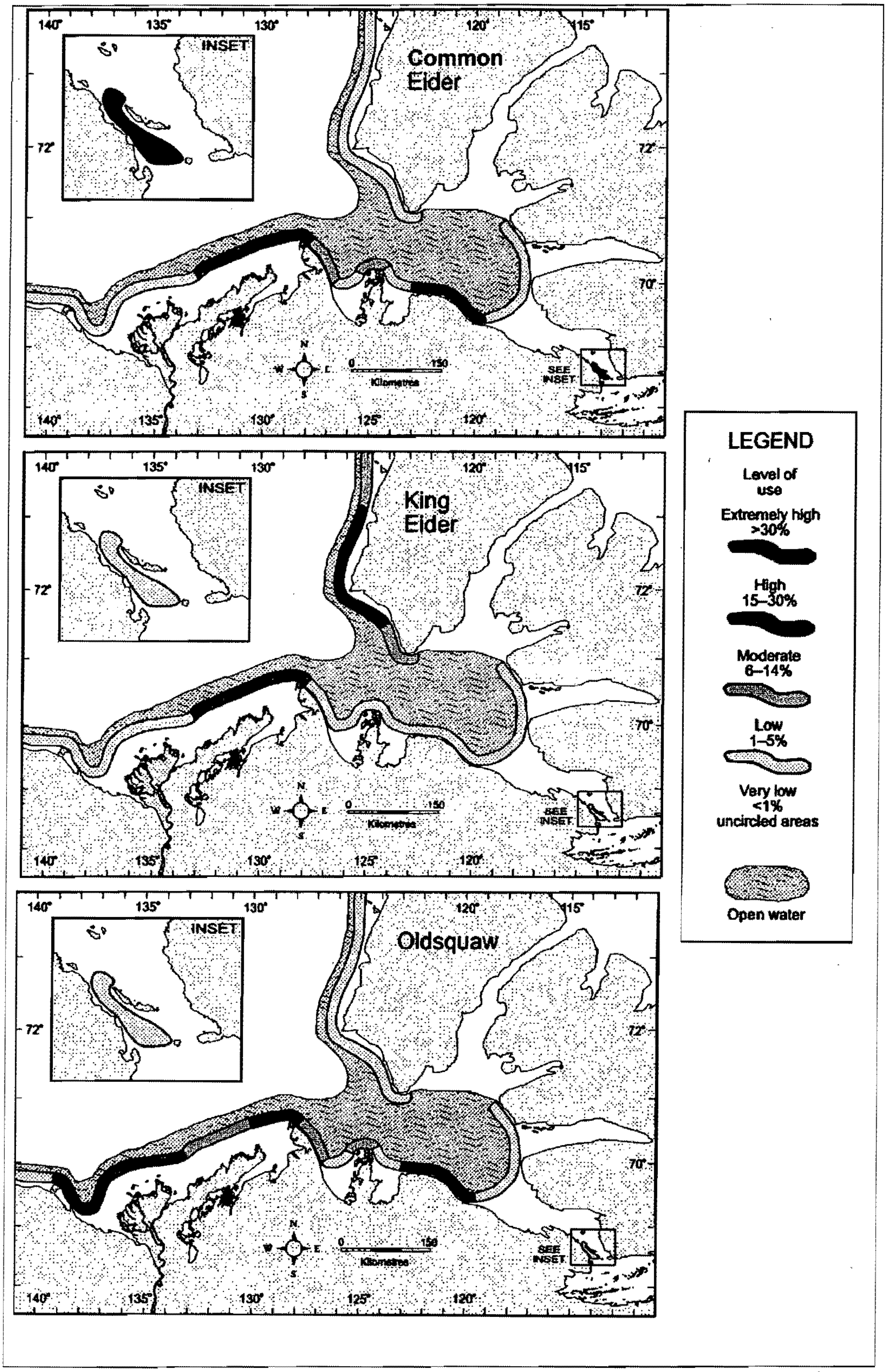
There were three important limitations in the design of our surveys, all resulting in underestimates of bird numbers: (1) we surveyed only the lead edge; (2) we did not estimate turnover rates; and (3) we did not estimate sightability correction factors (corrections for visibility or observer counting biases; Caughley 1977:35, Krebs 1989:98). These limitations seemed to affect our counts of King Eiders in particular. The largest number of King Eiders that we recorded on a set of surveys was only 88 000 birds, compared with recent population estimates of 200 000–600 000 (Dickson et al., this publication; Suydam et al., this publication). Our primary objective, however, was to examine the distribution of birds across a broad area in order to identify important staging sites. As the three sources of error apply throughout the study area, our estimates of the relative abundances among areas within a species are considered reasonable.

4.2 Distribution of waterbirds during spring migration

4.2.1 Common Eiders

The southeastern Beaufort Sea was found to be an important concentration area for Common Eiders during spring migration in six of seven years of surveys (Table 1; Searing et al. 1975; Barry et al. 1981; Barry and Barry 1982). Our surveys indicate that on an average day during spring migration, 63% of Common Eiders present in the Beaufort Sea and Amundsen Gulf occur between Tuktoyaktuk and the Baillie Islands (Table 2). In all studies, few Common Eiders were observed off or west of the Mackenzie Delta. In the Beaufort Sea in 1992, pack

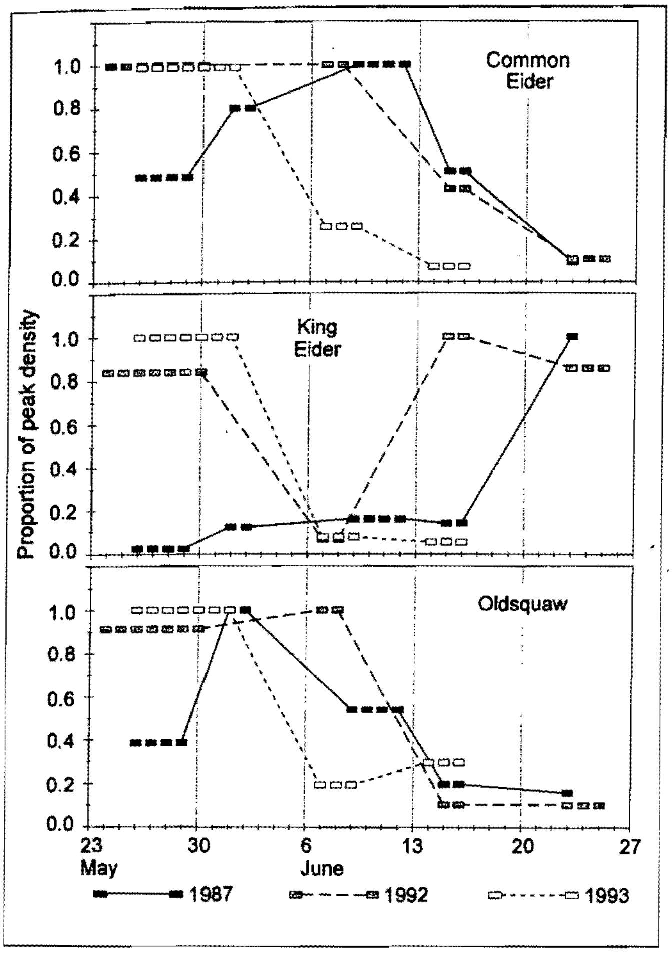
Figure 3
Distribution of Common Eiders, King Eiders, and Oldsquaws in offshore areas throughout the Beaufort Sea, Amundsen Gulf, and Lambert Channel polynya during spring migration



ice cover was extensive, and most of the available water occurred off the Yukon coast. Even under these conditions, few Common Eiders occurred west of the Mackenzie Delta (Alexander et al. 1993).

The Lambert Channel polynya is as important as the southeastern Beaufort Sea for Common Eiders during spring migration. Our peak, uncorrected number (Table 1) supports Barry's (1986) speculation that in the order of

Figure 4
Timing of migration of Common Eiders, King Eiders, and Oldsquaws in the southern Beaufort Sea (Herschel Island to the Baillie Islands), 1987, 1992, and 1993. Data are standardized by dividing counts by the peak count for the year. Sets of rectangles indicate dates over which survey set was flown.



70 000 Common Eiders migrate through Dolphin and Union Strait. Allen (1982) tallied 18 408 birds in a single two-hour watch from shore in Lambert Channel during spring migration in 1980 (10 June). If the birds staging in Lambert Channel first stop in the southeastern Beaufort Sea, then the number using the Cape Dalhousie to Baillie Islands area also totals at least 70 000 birds.

From our surveys in 1992 and 1993 (the only surveys to date), it is apparent that the southern coast of Amundsen Gulf can be important for migrating Common Eiders. All studies indicate that western Banks and Victoria islands are used by few Common Eiders.

In the southern Beaufort Sea in 1974 (Searing et al. 1975) and 1993, peak numbers of Common Eiders were recorded in the last week of May. In 1987 and 1992, however, peak numbers of Common Eiders occurred in the second week of June. In 1976 at Point Barrow, Alaska (approximately 1100 km west of Cape Bathurst), Common Eider migration did not start in earnest until 4 June (Woodby and Divoky 1982). Therefore, peak movement or buildup of birds in the southeastern Beaufort Sea likely occurs in the second week of June most years, but can occur as early as late May in some years. At Lambert Channel in 1993, the peak buildup of Common Eiders occurred one to two weeks after the peak in the Beaufort Sea.

4.2.2 *King Eiders*

The most important staging areas for King Eiders are between Cape Dalhousie and the Baillie Islands and off western Banks Island. However, the relative importance of these two areas varies among years. Barry (1986) noted that as many as 95 000 King Eiders can occur off the southern two-thirds of western Banks Island. On single surveys in 1980 and 1981, 87% of King Eiders counted, on average, were seen off western Banks Island (Barry et al. 1981; Barry and Barry 1982). In comparison, we estimated that an average of only 44% of King Eiders occurred there, and our highest count was 39 000 birds. Instead, there were many more King Eiders off the Baillie Islands (e.g., over 65 000 in 1993).

Our low total counts of King Eiders suggest that many either occur away from the landward ice edge or stop in the leads for only a short period. The latter is quite likely, as King Eiders are less dependent than Common Eiders on marine prey as a source of energy and nutrients for egg production. Female King Eiders feed heavily in freshwater habitats near the nest site (reviewed in Cramp et al. 1977; Holcroft-Weerstra and Dickson, this publication), whereas Common Eiders *Somateria mollissima* do not, because they usually nest on small islands in marine areas.

There is also some evidence, however, that King Eiders migrate across the Beaufort Sea over a broader front than do Common Eiders and, at times, stop in small leads far offshore or among pans of ice away from the landward edge of the main shoreleads. Biologists surveying for whales have seen King Eiders sitting in and flying over leads in the Beaufort Sea pack ice 400–500 km west of Banks Island (Barry 1986). During a block of transects over open water off the Tuktoyaktuk Peninsula in 1993, we observed King Eiders sitting among pans of ice 22–48 km from the landward edge of the lead (Alexander et al. 1994). On all our flights between Banks Island and the mainland or across Amundsen Gulf, however, we never saw many birds far offshore. Therefore, although King Eiders do occur away from the landfast ice edge, the extent of use of offshore areas is unknown.

King Eiders were uncommon in coastal areas of Amundsen Gulf and in the Lambert Channel polynya (Table 3; Allen 1982). Therefore, most of the birds that nest on Victoria Island (up to 70% of the western Arctic population; Barry 1968) likely stage off Banks Island or the Baillie Islands and then migrate directly to the nesting grounds, with perhaps only a very brief stop in the leads off Holman.

King Eiders arrived in the Beaufort Sea in late May and early June, but the timing of peak migration is unclear from our data. Woodby and Divoky (1982) noted that in 1976, the peak passage of King Eiders at Point Barrow, Alaska, was on 25 May, roughly 10 days earlier than the first wave of Common Eiders. In 1992, the mid-June buildup of King Eiders likely occurred because of the late melt on the breeding grounds that year. Barry (1986) suggested that the length of time that King Eiders remain

Table 3
Numbers and linear densities of King Eiders observed during aerial surveys of offshore leads in the western Arctic, spring 1986–1993

	No. of birds		Linear density (birds/km)	
Year/region	3 June	9–10 June	3 June	9–10 June
1986				
Herschel I. to Tuktoyaktuk	95	558	<1	2
Tuktoyaktuk to C. Dalhousie	2 759	4 180	20	24
C. Dalhousie to Baillie Is.	625	2 560	7	24
Total	3 479	7 298	8	12

	No. of birds					Linear density (birds/km)				
Year/region	26–29 May	1–2 June	9–12 June	15–16 June	23 June	26–29 May	1–2 June	9–12 June	15–16 June	23 June
1987										
Herschel I. to Tuktoyaktuk	32	69	100	104	–	<1	<1	<1	<1	–
Tuktoyaktuk to C. Dalhousie	82	832	1 038	868	1 108	<1	4	5	4	7
C. Dalhousie to Baillie Is.	110	272	443	397	2 800	1	3	7	6	39
Baillie Is. to C. Parry	10	38	758	178	–	<1	<1	4	1	–
C. Parry to C. Lambton	0	11	29	0	–	0	<1	<1	0	–
C. Lambton to Bernard I.	1 971	1 080	–	1 613	–	29	5	–	15	–
Total	2 205	2 302	2 368	3 160	3 908	3	2	3	3	17

	No. of birds				Linear density (birds/km)			
Year/region	24–30 May	7–8 June	15–18 June	23–25 June	24–30 May	7–8 June	15–18 June	23–25 June
1992								
Herschel I. to Tuktoyaktuk[a]	0	69	537	–	0	<1	1	–
Tuktoyaktuk to C. Dalhousie[a]	4 615	1 475	3 865	9 615	39	8	27	45
C. Dalhousie to Baillie Is.[a]	18 995	1 145	38 020	8 120	143	8	251	61
Baillie Is. to C. Parry	53	73	19	3 547	<1	<1	<1	20
C. Parry to C. Lambton	27	750	–	–	<1	5	–	–
C. Lambton to Bernard I.	24 479	–	39 097	9 916	95	–	124	27
C. Parry to Clifton Pt.	0	1 004	2 889	1 614	0	6	11	6
Clifton Pt. to C. Ptarmigan	–	–	2 607	3 343	–	–	14	14
C. Ptarmigan to Nelson Head	–	0	–	150	–	0	–	1
Lambert Channel polynya	–	–	622	3 275	–	–	6	25
Total	48 169	4 516	87 656	39 580	38	4	52	23

	No. of birds			Linear density (birds/km)		
Year/region	26 May–1 June	7–9 June	14–16 June	26 May – 1 June	7–9 June	14–16 June
1993						
Herschel I. to Tuktoyaktuk	211	21	83	1	<1	<1
Tuktoyaktuk to C. Dalhousie	315	3 271	1 940	8	17	10
C. Dalhousie to Baillie Is.	63 611	4 894	4 157	549	37	35
Baillie Is. to C. Parry	1 999	295	903	10	1	4
C. Parry to C. Lambton	–	–	–	–	–	–
C. Lambton to Bernard I.	4 496	11 673	7 718	10	27	18
C. Parry to Clifton Pt.	467	2 294	3 920	2	9	18
Clifton Pt. to C. Ptarmigan	456	664	3 879	2	3	16
C. Ptarmigan to Nelson Head	57	0	28	<1	0	<1
Lambert Channel polynya	97	469	457	1	5	3
Total	71 709	23 581	23 085	40	12	11

[a] Corrections applied; see Methods.

on marine staging areas depends on the timing of spring thaw.

Male King and Common eiders became increasingly more abundant than females in later surveys (Table 4), which likely represents the westward, postbreeding, male moult migration (reviewed by Johnson and Herter 1989:80–86). The change in sex ratio started earlier for King Eiders (mid-June) than for Common Eiders (late June), which suggests that either King Eiders nest earlier than Common Eiders or Common Eider males remain near the nest site longer.

4.2.3 Oldsquaws

In all our surveys from 1986 to 1993, Oldsquaws were abundant throughout the southern Beaufort Sea from Herschel Island to Cape Parry, although they were usually most abundant between Cape Dalhousie and the Baillie Islands. In 1974, about 10 000 Oldsquaws were counted in the latter area in late May (Searing et al. 1975). Unlike eiders, Oldsquaws are common nesting birds all along the continental coast (Johnson and Herter 1989). Therefore, Oldsquaws west of Tuktoyaktuk were probably local breeders as well as migrants.

Oldsquaws were also somewhat abundant in southern Amundsen Gulf east of Cape Lyon, especially after the first week of June. Some of these birds might have been male moult-migrants. Our conclusion that Oldsquaws are uncommon off western Banks Island is supported by observations from Barry et al. (1981) and Barry and Barry (1982). At Lambert Channel, Allen (1982) found more than five times the number of Oldsquaws (up to 2000) that we did (Table 5).

Table 4
Percentage of males among eiders observed during aerial surveys of offshore leads in the western Arctic, spring 1987–1993

	Common Eiders						King Eiders					
	1987		1992		1993		1987		1992		1993	
Area/date	%	(n)[a]	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)
Herschel Island to Cape Parry												
26 May – 1 June	54	(6 635)	50	(705)	52	(4 871)	67	(161)	51	(267)	50	(16 756)
1–2 June	50	(15 711)	–	–	–	–	64	(903)	–	–	–	–
7–12 June	50	(18 194)	59	(414)	56	(3 462)	53	(1 758)	64	(76)	58	(2 317)
14–16 June	53	(15 313)	58	(1 105)	69	(2 149)	65	(1 517)	76	(1 217)	82	(2 806)
23–25 June	93	(527)	69	(61)	–	–	90	(1 724)	92	(1 240)	–	–
Western Banks Island												
26 May – 1 June	56	(55)	50	(52)	55	(520)	50	(817)	52	(387)	55	(1 660)
1–2 June	54	(205)	–	–	–	–	58	(714)	–	–	–	–
7–12 June	–	–	–	–	53	(1 193)	–	–	–	–	54	(5 476)
14–16 June	52	(475)	50	(846)	66	(524)	53	(1 218)	50	(3 953)	82	(2 377)
23–25 June	–	–	61	(239)	–	–	–	–	80	(1 161)	–	–
Amundsen Gulf												
26 May – 1 June	–	–	–	–	58	(1 063)	–	–	–	–	56	(238)
7–12 June	–	–	56	(458)	52	(2 887)	–	–	62	(195)	53	(704)
14–16 June	–	–	53	(1 889)	66	(854)	–	–	62	(328)	66	(634)
23–25 June	–	–	78	(409)	–	–	–	–	77	(251)	–	–
Lambert Channel polynya												
26 May – 1 June	–	–	–	–	51	(2 283)	–	–	–	–	53	(36)
7–12 June	–	–	–	–	50	(11 406)	–	–	–	–	51	(226)
14–16 June	–	–	50	(3 905)	50	(14 817)	–	–	52	(335)	60	(121)
23–25 June	–	–	62	(1 737)	–	–	–	–	78	(187)	–	–

[a] n = number of eiders sexed.

In the southern Beaufort Sea, peak numbers of Oldsquaws occurred in the last week of May in 1993 and in the first few days of June in 1987. In 1992, Oldsquaw numbers had reached near-peak values by 24 May, but they continued to increase through the first week of June, likely owing to the late spring thaw. In 1975, large eastward movements of Oldsquaws were noted along Yukon's coast starting on 29 May, but peak movements occurred in the second week of June (Richardson and Johnson 1981). At Point Barrow in 1976, Oldsquaws were uncommon before 4 June (Woodby and Divoky 1982). Therefore, peak Oldsquaw migration occurs sometime between the last week in May and the second week in June.

4.2.4 Other species

In general, loons are dispersed throughout leads in the Beaufort Sea from late May to mid-June (Table 6). They move onto breeding grounds as soon as open water is available (Sage 1971; North and Ryan 1988; Dickson 1993). Unlike sea ducks, loons do not normally form flocks during spring migration, although Barry et al. (1981) noted that in years of bad ice and weather, Yellow-billed Loons congregated in flocks of up to 100 birds in river mouths. In 1992, we observed Yellow-billed Loons in the southeastern Beaufort Sea and off western Banks Island in numbers larger than ever reported previously. There are two possible explanations. First, Yellow-billed Loons might have postponed moving onto the breeding grounds because of the late thaw. This would have reduced turnover rates and consequently increased the number present in leads at any time. Second, the loons might have been more concentrated than usual because there was comparatively little open water available in 1992. This might have increased our chance of flying over them, particularly off Banks Island, where open water was especially limited.

Hundreds of Yellow-billed Loons were seen in the Lambert Channel polynya in both 1992 and 1993. Therefore, this polynya is likely an important staging area for Yellow-billed Loons in most years.

Red-throated Loons were abundant in early June between Herschel Island and Tuktoyaktuk. The loons in leads in mid-June 1993 (Table 6) were probably local breeders. Although Red-throated Loons usually move onto nesting ponds in the first half of June, they feed in marine areas throughout the nesting season (Dickson 1993).

White-winged Scoters do not use offshore leads for spring migration; however, in mid- to late June, post- or nonbreeding birds (mostly males) gather in large flocks (several thousands) in leads just west and east of the Mackenzie Delta. From there, many White-winged Scoters migrate west into unknown moulting grounds (Johnson and Herter 1989:112), while others remain to moult in areas such as Hutchison Bay and McKinley Bay once the ice has broken up (Alexander et al. 1988b; Cornish et al. 1992).

Glaucous Gulls are the most common gulls in the western Arctic. They are found in offshore leads throughout the Beaufort Sea, but concentrations are more likely to occur in Amundsen Gulf. Our results show that they are most common in late May. Other authors have noted that Glaucous Gulls migrate into the Beaufort Sea in late May (see Johnson and Herter 1989).

In the western Arctic, Thick-billed Murres *Uria lomvia* 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

Table 5
Numbers and linear densities of Oldsquaws observed during aerial surveys of offshore leads in the western Arctic, spring 1986–1993

	No. of birds		Linear density (birds/km)	
Year/region	3 June	9–10 June	3 June	9–10 June
1986				
Herschel I. to Tuktoyaktuk	137	758	1	2
Tuktoyaktuk to C. Dalhousie	290	391	2	2
C. Dalhousie to Baillie Is.	6 977	572	79	5
Total	7 404	1 721	17	3

	No. of birds					Linear density (birds/km)				
Year/region	26–29 May	1–2 June	9–12 June	15–16 June	23 June	26–29 May	1–2 June	9–12 June	15–16 June	23 June
1987										
Herschel I. to Tuktoyaktuk	1 484	3 605	1 824	231	–	6	14	6	1	–
Tuktoyaktuk to C. Dalhousie	328	1 053	133	279	275	2	5	1	1	2
C. Dalhousie to Baillie Is.	168	1 000	1 181	629	98	2	12	18	9	1
Baillie Is. to C. Parry	44	68	274	642	–	1	<1	1	5	–
C. Parry to C. Lambton	0	11	7	0	–	0	<1	<1	0	–
C. Lambton to Bernard I.	4	29	–	52	–	<1	<1	–	<1	–
Total	2 028	5 766	3 419	1 833	373	3	5	4	2	2

	No. of birds				Linear density (birds/km)			
Year/region	24–30 May	7–8 June	15–18 June	23–25 June	24–30 May	7–8 June	15–18 June	23–25 June
1992								
Herschel I. to Tuktoyaktuk[a]	2 894	15 462	1 142	–	13	49	3	–
Tuktoyaktuk to C. Dalhousie[a]	1 985	17 035	1 985	1 645	17	90	14	8
C. Dalhousie to Baillie Is.[a]	23 520	10 745	1 765	745	177	74	12	6
Baillie Is. to C. Parry	574	387	105	73	4	2	1	<1
C. Parry to C. Lambton	173	234	–	–	1	1	–	–
C. Lambton to Bernard I.	73	–	150	190	<1	–	<1	<1
C. Parry to Clifton Pt.	11	966	4 541	346	<1	5	17	1
Clifton Pt. to C. Ptarmigan	–	–	552	388	–	–	3	2
C. Ptarmigan to Nelson Head	–	0	–	2	–	0	–	<1
Lambert Channel polynya	–	–	294	279	–	–	3	2
Total	29 230	44 829	10 534	3 668	23	36	6	2

	No. of birds			Linear density (birds/km)		
Year/region	26 May – 1 June	7–9 June	14–16 June	26 May– 1 June	7–9 June	14–16 June
1993						
Herschel I. to Tuktoyaktuk	2 716	510	972	10	1	3
Tuktoyaktuk to C. Dalhousie	21	1 522	1 278	<1	8	6
C. Dalhousie to Baillie Is.	4 845	351	1 571	42	3	13
Baillie Is. to C. Parry	1 230	1 354	1 547	6	6	6
C. Parry to C. Lambton	–	–	–	–	–	–
C. Lambton to Bernard I.	44	59	43	<1	<1	<1
C. Parry to Clifton Pt.	384	6 123	3 600	2	25	16
Clifton Pt. to C. Ptarmigan	536	431	121	3	2	<1
C. Ptarmigan to Nelson Head	0	1	0	0	<1	0
Lambert Channel polynya	3	635	564	<1	6	4
Total	9 779	10 986	9 696	5	5	5

[a] Corrections applied; see Methods.

birds in 1979 (Johnson and Ward 1985). Our sightings in 1992 and 1993 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 16 June, indicating a sudden arrival in the second week of June.

4.3 Factors affecting distributions of waterbirds during spring migration

Most studies have focused on identifying where birds occur during spring migration. Few investigations have addressed why they occur where they do. The following discussion examines the limited information on factors that might influence waterbird distributions: recurrence of open water, water depth, and water turbidity. These factors combine to affect prey availability. The discussion is speculative and is presented to outline possible avenues for future research.

4.3.1 Recurrence of open water

Our studies have shown that the Cape Bathurst polynya is used heavily by birds even in years when it is covered with broken pack ice. In 1992, open water was abundant off the Yukon coast and in Amundsen Gulf, yet birds congregated in the small patches of open water available off capes Bathurst and Kellett, the two key staging areas within the polynya. During the spring migration period, this polynya is the most predictably available open water in the Beaufort Sea (Marko 1975; Markham 1981; Smith and Rigby 1981). It is probable,

Table 6
Abundance of less common bird species observed during aerial surveys of offshore leads in the western Arctic, spring 1986–1993

	1986		1987					1992				1993		
Species/area	3 June	9–10 June	26–29 May	1–2 June	9–12 June	15–16 June	23 June	24–30 May	7–8 June	15–18 June	23–25 June	26 May–1 June	7–9 June	14–16 June
Pacific Loon														
Herschel I. to C. Parry	4	3	1	0	4	8	0	3	159	35	12	21	7	37
West Banks I.	–	–	0	0	–	0	–	2	–	18	0	0	0	5
Amundsen Gulf	–	–	0	0	–	0	–	0	1	39	12	0	78	18
Lambert Channel polynya	–	–	–	–	–	–	–	–	–	72	93	2	21	10
Red-throated Loon														
Herschel I. to C. Parry	24	48	2	1	108	59	1	0	130	23	10	114	67	150
West Banks I.	–	–	0	0	–	0	–	0	–	8	2	0	0	3
Amundsen Gulf	–	–	0	0	–	0	–	0	0	0	0	0	1	1
Lambert Channel polynya	–	–	–	–	–	–	–	–	–	0	0	0	0	0
Yellow-billed Loon														
Herschel I. to C. Parry	0	5	0	0	0	2	0	0	217	59	21	2	5	19
West Banks I.	–	–	0	0	–	3	–	49	–	254	51	0	14	19
Amundsen Gulf	–	–	0	0	–	0	–	0	57	87	119	0	14	65
Lambert Channel polynya	–	–	–	–	–	–	–	–	–	259	133	0	332	52
Scoter species														
Herschel I. to C. Parry	0	13	2	4	11	596	1626	0	0	5690	6966	10	72	4193
West Banks I.	–	–	0	0	–	0	–	0	–	0	0	0	0	0
Amundsen Gulf	–	–	0	0	–	0	–	5	0	1	15	0	8	36
Lambert Channel polynya	–	–	–	–	–	–	–	–	–	0	1	0	4	0
Glaucous Gull														
Herschel I. to C. Parry	78	249	1840	1114	221	229	4	98	55	28	14	217	117	149
West Banks I.	–	–	8	17	–	3	–	184	–	43	17	119	31	30
Amundsen Gulf	–	–	255	321	–	0	–	528	162	226	89	961	221	66
Lambert Channel polynya	–	–	–	–	–	–	–	–	–	37	11	164	105	15
No. of kilometres flown														
Herschel I. to C. Parry	440	591	549	713	776	687	228	600	823	814	520	624	888	958
West Banks I.	0	0	68	235	0	107	0	258	0	314	362	444	433	425
Amundsen Gulf	0	0	111	111	0	109	0	396	431	452	674	616	613	614
Lambert Channel polynya	0	0	0	0	0	0	0	0	0	106	131	92	100	132

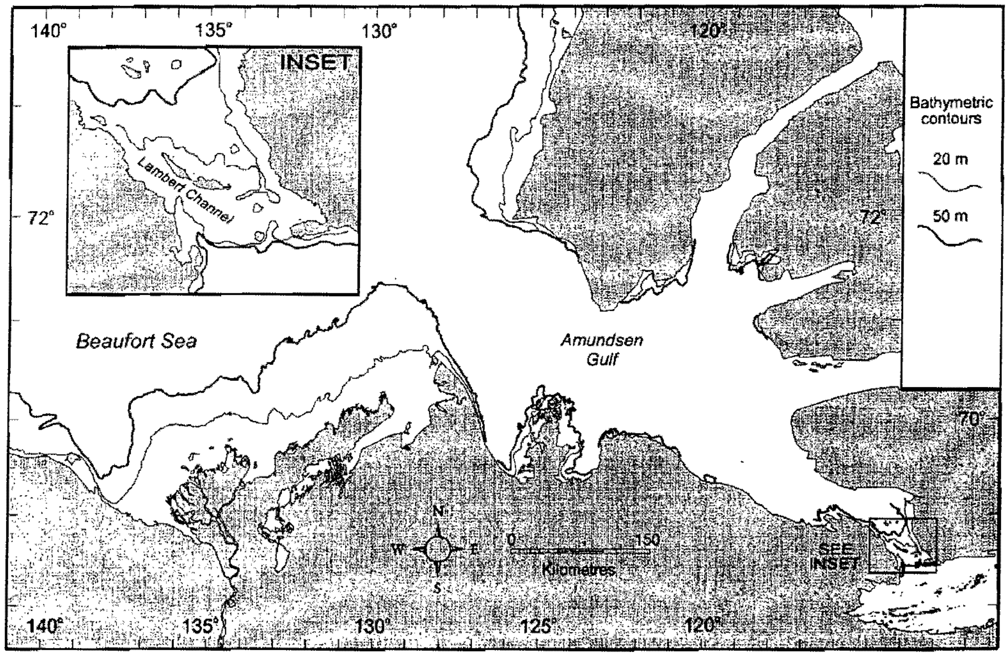
therefore, that timing of migration and flight capacities of waterbirds, especially eiders, crossing the ice-bound Beaufort Sea are adapted or conditioned to the recurrence of open water in the Cape Bathurst polynya. Common Eiders likely have a similar connection to the recurrence of the Lambert Channel polynya.

4.3.2 Water depth

Water depth likely determines the suitability of open-water areas for staging by species that eat mostly bottom-dwelling invertebrates. For example, in the deeper water west of Tuktoyaktuk (Fig. 5), Oldsquaws and Red-throated Loons are relatively more common than eiders, possibly because of differences in diving ability and feeding habits. Oldsquaws can dive to greater depths than eiders (maximum recorded depths: Common Eider, 20 m; King Eider, 55 m; Oldsquaw, 73 m; reviewed in Cramp et al. 1977; Bellrose 1978). In addition, Oldsquaws use a greater variety of prey captured from various habitats, including the water column and the ice undersurface, as well as the sea bottom (Peterson and Ellarson 1977; Bellrose 1978; Johnson 1984; Sanger and Jones 1984). For example, Johnson and Richardson (1981) found large numbers of an ice-associated invertebrate (*Apherusa glacialis*) in the digestive tracts of Oldsquaws feeding among Beaufort Sea ice floes. Eiders, on the other hand, feed mainly on benthic and epibenthic marine invertebrates (Cottam 1939, cited in Bellrose 1978; Cantin et al. 1974; Cramp et al. 1977; Bellrose 1978; Goudie and Ankney 1986; Bustnes and Erikstad 1988). Therefore, in both their diving ability and their feeding habits, Oldsquaws are less restricted by water depth than eiders, particularly Common Eiders. Loons, which feed on fish rather than bottom-dwelling invertebrates, would also be better able than eiders to forage in the deeper waters off Yukon's coast.

King Eiders dive deeper than Common Eiders; for bottom feeding, however, they would still be restricted to the <50-m-deep water along coastlines (Fig. 5). Based on diving depth, Common Eiders would be expected to stay close to the landfast ice edge where water is shallowest (all of the Lambert Channel polynya is <20 m deep), whereas King Eiders could venture into deeper water away from the ice edge. Within the study area, the greatest expanses of water <50 m in depth underlay the primary King Eider staging areas. It is also possible that King Eiders forage on pelagic or ice-associated invertebrates to some degree, which would enable them to use deeper water. For example, Røen (1965) observed King Eiders eating crustaceans that had been frozen in ice covering lakes and released during thaw. Furthermore, if King Eiders move quickly onto the breeding grounds and depend more on prey from freshwater habitats, then they will have diminished dependence on the shallow-water areas associated with the landfast ice edge. Our under-

Figure 5
Distribution of shallow water (<50 m) throughout the Beaufort Sea, Amundsen Gulf, and Lambert Channel



standing of the importance of water depth to birds staging in the western Arctic, especially King Eiders, will remain speculative without more research on their feeding habits and prebreeding nutrient dynamics (e.g., Milne 1976; Parker and Holm 1990).

4.3.3 Water turbidity

Water off the Mackenzie Delta is turbid, which could reduce visibility and hamper foraging by all diving birds. Furthermore, invertebrate productivity is possibly higher outside the Mackenzie River plume (Parsons et al. 1988). These factors perhaps contribute to the low numbers of birds off the Mackenzie Delta. In contrast, water in all key spring staging areas is clear. Similarly, in summer, clear-water bays on the northeast side of the Mackenzie Delta, which are sheltered from the plume, are the main areas in the outer delta used by moulting diving ducks (Alexander et al. 1988b).

5.0 Oil and gas development and spring migration in the southern Beaufort Sea

Oil pollution in the southern Beaufort Sea during spring migration could be devastating to several populations of birds, including Red-throated, Pacific, and Yellow-billed loons, Common and King eiders, Oldsquaws, White-winged Scoters, and Glaucous Gulls. Sea ducks and loons are particularly vulnerable to oil on the water's surface because they dive to forage (Brown et al. 1973; Vermeer and Anweiler 1975; Follestad 1986; Hooper et al. 1987).

The most critical area for most species during spring migration is between Cape Dalhousie and the Baillie Islands (Fig. 3). On one day alone in 1993, we recorded over 100 000 birds in the southern Beaufort Sea, mostly near the Baillie Islands. This area is used heavily regardless of the relative abundance of open water elsewhere. Oil between Cape Dalhousie and the Baillie Islands could affect, on average, 48% of Common Eiders, 26% of King Eiders, and 31% of Oldsquaws (Table 2) present throughout the Beaufort Sea and Amundsen Gulf on any given day during spring migration. Thousands of other waterbirds, including the uncommon Yellow-billed Loon, could also be affected. It is important to recognize that these percentages represent potential deaths on a given day and do not include turnover. Throughout spring migration, much larger percentages of the total populations of these species might visit this area, if only for a brief stop. Therefore, the percentages listed above are expected minimums.

The area between Tuktoyaktuk and Cape Dalhousie is also important during spring migration. In this area, oil contamination in late May to mid-June could affect, on average, 15% of Common Eiders, 17% of King Eiders, 12% of Oldsquaws, and 37% of Red-throated Loons present throughout the Beaufort Sea and Amundsen Gulf on any given day during spring migration. Oil spilled between Herschel Island and Tuktoyaktuk would have a small impact on Common Eiders (3%) and King Eiders (1%) but a considerable impact on Oldsquaws (22%) and Red-throated Loons (62%) on any given day. In late June, thousands of early moult-migrant White-winged Scoters would be vulnerable to oil spilled just west and east of the Mackenzie Delta.

To date, most offshore oil exploration has occurred west of Hutchison Bay. Oil from a blowout occurring at or after freeze-up would become trapped in and under ice. Winter ice movement would likely carry oil westward, possibly into Alaskan waters (Colony and Thorndike 1984; Gulf Canada 1990). Oil from a blowout coinciding with strong northwesterly winds in autumn could become trapped in landfast ice east of Hutchison Bay or in stable ice forming the eastern edge of the Cape Bathurst polynya (H. Melling, Institute of Ocean Sciences, pers. commun.) and be released in these areas the following spring. The specific ice and meteorological conditions required could occur in any year, if only for a short period (H. Melling, pers. commun.). Therefore, there is evidence to suggest that threats to spring migrants could exist anywhere in the southern Beaufort Sea, including key areas east of Hutchison Bay, although with a higher but undetermined probability west of there. 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.

Use of ice-breaking oil tankers in the Northwest Passage (Beaufort Sea, Amundsen Gulf, Prince of Wales Strait, Viscount Melville Sound, Barrow Strait, Lancaster Sound, Davis Strait; FEARO 1984:27–29), if ever implemented, would increase the probability of serious oil-related impacts in the southeastern Beaufort Sea and expand the area of potential impact into Amundsen Gulf and Prince of Wales Strait and off southwestern Banks Island. Impacts could be severe off western Banks Island (a key staging area for King Eiders, where 44–87% occur on any given day during spring migration) and moderate in southern Amundsen Gulf (19% of Common Eiders and 22% of Oldsquaws). The impact of an oil spill in deep-water areas away from coastlines would likely be low, although the degree of use of these areas by King Eiders remains unknown.

Acknowledgements

This study was funded by the Northern Oil and Gas Action Program and the Canadian Wildlife Service. Spring weather over the Beaufort Sea spawns many aeronautical challenges, and we are very grateful for the skilled piloting provided by Greg Bulger, Fred Carmichael, Michael Digaspari, Dave Hindson, and Cece Rilling. We are also grateful for the detailed weather forecasts and access to satellite imagery provided by Jim McCleod, Monique Lapalme, and other staff with the Atmospheric Environment Service in Inuvik, Northwest Territories. Base maps for figures were created on computer by Trigon Mapping Resources Ltd. in Saskatoon, Saskatchewan. Thanks also go to Jim Hines (Canadian Wildlife Service, Yellowknife, Northwest Territories) for reviewing the manuscript and Humphrey Melling (Institute of Ocean Sciences, Sidney, British Columbia) for information and comments on ice and water movements in the southeastern Beaufort Sea.

Literature cited

Alexander, S.A.; Ealey, D.M.; Barry, S.J. 1988a. Spring migration of eiders, Oldsquaws, and Glaucous Gulls along offshore leads of the Canadian Beaufort Sea. Can. Wildl. Serv. Tech. Rep. Ser. No. 56, Western & Northern Region, Edmonton. 55 pp.

Alexander, S.A.; Barry, T.W.; Dickson, D.L.; Prus, H.D.; Smyth, K.E. 1988b. Key areas for birds in coastal regions of the Canadian Beaufort Sea. Can. Wildl. Serv., Western & Northern Region, Edmonton. 146 pp.

Alexander, S.A.; Ferguson, R.S.; McCormick, K.J. 1991. Key migratory bird terrestrial habitat sites in the Northwest Territories. Can. Wildl. Serv. Occas. Pap. No. 71, Ottawa. 184 pp.

Alexander, S.A.; Westover, S.E.; Dickson, D.L. 1993. Spring migration of waterbirds in the Beaufort Sea, Amundsen Gulf and Lambert Channel polynya, 1992. Can. Wildl. Serv. Tech. Rep. Ser. No. 171, Western & Northern Region, Edmonton. 73 pp.

Alexander, S.A.; Westover, S.E.; Dickson, D.L. 1994. Spring migration of waterbirds in the Beaufort Sea, Amundsen Gulf and Lambert Channel polynya, 1993. Can. Wildl. Serv. Tech. Rep. Ser. No. 201, Western & Northern Region, Edmonton. 61 pp.

Allen, L. 1982. Bird migration and nesting observations, western Victoria Island, N.W.T., June, 1980. Unpubl. rep., Can. Wildl. Serv., Yellowknife. 61 pp.

Barry, S.J.; Barry, T.W. 1982. Sea-bird surveys in the Beaufort Sea, Amundsen Gulf, and Prince of Wales Strait — 1981 season. Unpubl. rep., Can. Wildl. Serv., Edmonton. 52 pp.

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

Barry, T.W. 1986. Eiders of the western Canadian Arctic. Pages 74-80 *in* A. Reed (ed.), Eider ducks in Canada. Can. Wildl. Serv. Rep. Ser. No. 47, Ottawa.

Barry, T.W.; Barry, S.J.; Jacobson, B. 1981. Sea-bird surveys in the Beaufort Sea, Amundsen Gulf, Prince of Wales Strait and Viscount Melville Sound — 1980 season. Unpubl. rep., Can. Wildl. Serv., Edmonton. 69 pp.

Bellrose, F.C. 1978. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Pennsylvania. 540 pp.

Brown, R.G.B.; Gillespie, D.I.; Lock, A.R.; Pearce, P.A.; Watson, G.H. 1973. Bird mortality from oil slicks off eastern Canada, February–April 1970. Can. Field-Nat. 87:225–234.

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

Cantin, M.; Bédard, J.; Milne, H. 1974. The food and feeding of common eiders in the St. Lawrence estuary in summer. Can. J. Zool. 52:319–334.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley & Sons, New York. 234 pp.

Colony, R.; Thorndike, A.S. 1984. An estimate of the mean field of Arctic sea ice motion. J. Geophys. Res. 89:10 623–10 629.

Cornish, B.J.; Dickson, D.L.; Dickson, H.L. 1992. Bird surveys of McKinley Bay and Hutchison Bay, Northwest Territories, in 1991. Can. Wildl. Serv. Tech. Rep. Ser. No. 147, Western & Northern Region, Edmonton. 53 pp.

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

Cramp, S.; Simmons, K.E.L.; Ferguson-Lees, I.J.; Gillmor, R.; Hollom, P.A.D.; Hudson, R.; Nicholson, E.M.; Ogilvie, M.A.; Olney, P.J.S.; Voous, K.H.; Wattel, J. (eds.). 1977. Handbook of the birds of Europe, the Middle East, and North Africa: the birds of the western Palearctic. Vol. 1. 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.

FEARO (Federal Environmental Assessment Review Office). 1984. Beaufort Sea hydrocarbon production and transportation. Final report of the Environmental Assessment Panel. Hull, Quebec. 146 pp.

Follestad, A. 1986. Seabird mapping in Norway and the work on consequences evaluation, seabird/oil. Seevögel 7(4):51–56.

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

Gulf Canada. 1990. Spills. Section 6. Kulluk drilling program, 1990–1992. Submission to the Environmental Impact Review Board.

Hooper, T.D.; Vermeer, K.; Szabo, I. 1987. Oil pollution of birds: an annotated bibliography. Can. Wildl. Serv. Tech. Rep. Ser. No. 34, Pacific & Yukon Region, Delta, B.C. 180 pp.

Johnson, S.R. 1984. Prey selection by Oldsquaws in a Beaufort Sea lagoon, Alaska. Pages 12–19 *in* D.N. Nettleship, G.A. Sanger, and P.F. Springer (eds.), Marine birds: their feeding ecology and commercial fisheries relationships. Can. Wildl. Serv. Spec. Publ., Ottawa.

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

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

Johnson, S.R.; Ward, J.G. 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.; Wiggins, D.A.; Wainwright, P.F. 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 Tech. Rep. No. 34, Department of the Environment, Victoria, B.C. 137 pp.

Milne, H. 1976. Body weights and carcass composition of the common eider. Wildfowl 27:115–122.

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

Parker, H.; Holm, H. 1990. Patterns of nutrient and energy expenditure in female Common Eiders nesting in the High Arctic. Auk 107:660–668.

Parsons, T.R.; Webb, D.G.; Dovey, H.; Haigh, R.; Lawrence, M.; Hopky, G.E. 1988. Production studies in the Mackenzie River – Beaufort Sea estuary. Polar Biol. 8:235–239.

Peterson, S.R.; Ellarson, R.S. 1977. Food habits of Oldsquaw wintering on Lake Michigan. Wilson Bull. 89:81–91.

Richardson, W.J.; Johnson, S.R. 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.; Morrell, M.R.; Johnson, S.R. 1975. Bird migration along the Beaufort Sea coast: radar and visual observations in 1975. Beaufort Sea Tech. Rep. No. 3c, Department of the Environment, Victoria, B.C. 131 pp.

Røen, U. 1965. Ornithological observations on the 3rd Pearyland Expedition in the summer of 1964. Dan. Ornithol. Foren. Tidsskr. 59:85–91.

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

Sanger, G.A.; Jones, R.D., Jr. 1984. Winter feeding ecology and trophic relationships of Oldsquaws and White-winged Scoters on Kachemak Bay, Alaska. Pages 20–28 *in* D.N. Nettleship, G.A. Sanger, and P.F. Springer (eds.), Marine birds: their feeding ecology and commercial fisheries relationships. Can. Wildl. Serv. Spec. Publ., Ottawa.

Searing, G.F.; Kuyt, E.; Richardson, W.J.; Barry, T.W. 1975. Seabirds of the southeastern Beaufort Sea: aircraft and ground observations in 1972 and 1974. Beaufort Sea Tech. Rep. 3b, Department of the Environment, Victoria, B.C. 257 pp.

Smith, M.; Rigby, B. 1981. Distribution of polynyas in the Canadian Arctic. Pages 7–28 *in* I. Stirling and H. Cleator (eds.), Polynyas in the Canadian Arctic. Can. Wildl. Serv. Occas. Pap. No. 45.

Vermeer, K.; Anweiler, G.G. 1975. Oil threat to aquatic birds along the Yukon coast. Wilson Bull. 87(4):467–480.

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

Migration of King and Common eiders past Point Barrow, Alaska, in spring 1987, spring 1994, and fall 1994

Robert Suydam, Lori Quakenbush, Michele Johnson, John Craighead George, and Joanne Young

Abstract

King *Somateria spectabilis* and Common *S. mollissima v-nigra* eiders pass Point Barrow, Alaska, during both the spring and fall migrations. We conducted counts to document the species and sex composition, the timing of migration, and the number of eiders passing Point Barrow during spring 1987, spring 1994, and fall 1994. The migrations were characterized by the arrival of King Eiders, followed by Common Eiders 4–10 days later. Eiders appeared to be paired when they passed by Point Barrow in the spring. During the fall migration, males appeared first in mid-July, followed by females in early August. For spring 1987, we projected a King Eider passage of 555 870 (95% C.I. ±101 335) and a Common Eider passage of 95 069 (95% C.I. ±27 821). For 1994, we estimated a King Eider passage of 373 069 (95% C.I. ±105 506) in the spring and 301 174 (95% C.I. ±42 190) in the fall and a Common Eider passage of 71 164 (95% C.I. ±16 038) in the spring and 67 145 (95% C.I. ±8785) in the fall. Estimates of the numbers of King and Common eiders were considerably lower in 1987 and 1994 than estimates from counts conducted at Barrow during the last 40 years. A previous estimate from 1976 placed King and Common eider numbers at ~800 000 and ~150 000, respectively.

Résumé

Les Eiders à tête grise *Somateria spectabilis* et à duvet *S. mollissima v-nigra* passent par Point Barrow, en Alaska, pendant les migrations du printemps et de l'automne. Nous avons effectué des dénombrements selon l'espèce et le sexe, établi l'évolution chronologique de la migration et recensé le nombre d'eiders passant par Point Barrow durant le printemps de 1987, le printemps de 1994 et l'automne de 1994. Les Eiders à tête grise arrivaient les premiers et ensuite les Eiders à duvet suivaient de quatre à dix jours plus tard. Les eiders semblaient être en couple lorsqu'ils passaient à Point Barrow au printemps. Durant la migration d'automne, les mâles étaient les premiers à arriver vers le milieu de juillet, suivi des femelles au début d'août. Dans le cas du printemps 1987, nous avons projeté le passage de 555 870 Eiders à tête grise (C.I. de 95 % à ±101 335) et de 95 069 Eiders à duvet (C.I. de 95 % à ±27 821). Dans le cas du passage des Eiders à tête grise en 1994, nous en avons estimé un nombre de 373 069 (C.I. de 95 % à ±105 506) au printemps et de 301 174 (C.I. de 95 % à ±42 190) à l'automne et, dans le cas des Eiders à duvet, un nombre de 71 164 (C.I. de 95 % à ±16 038) au printemps et de 67 145 (C.I. de 95 % à ±8 785) à l'automne. Les nombres estimatifs d'Eiders à tête grise et à duvet étaient beaucoup moins élevés en 1987 et 1994 que les nombres estimatifs calculés à partir de dénombrements effectués à Barrow au cours des quarante dernières années. Selon une estimation antérieure effectuée en mai 1976, la population des Eiders à tête grise se situait à ~800 000 et celle des Eiders à duvet, à ~150 000.

1.0 Introduction

The migrations of eiders and other waterbirds past Point Barrow, Alaska, in both spring and fall are among the most spectacular waterbird migrations in North America. Large flocks of eiders can pass for hours on end; Woodby and Divoky (1982) estimated that 360 000 King Eiders *Somateria spectabilis* passed in a 10-hour period, with a peak passage of 113 000 birds in a half-hour period! The migrations consist of thousands of King and Common *S. mollissima v-nigra* eiders, other waterfowl, loons, gulls, and shorebirds (Murdoch 1885; Bailey et al. 1948; Thompson and Person 1963; Johnson 1971; Timson 1976; Brueggeman 1980; Woodby and Divoky 1982). The proximity of the migration to Point Barrow provides an accessible location to examine migration behaviour and to potentially monitor population trends of King and Common eiders using the Beaufort Sea.

During spring migration, birds travel north and east following a series of open leads and polynyas — areas of open water — that occur nearshore in the sea ice in the eastern Chukchi Sea and the Beaufort Sea (Woodby and Divoky 1982). The postbreeding migration (westward and southward) occurs along the Beaufort Sea coast of Alaska (Johnson and Richardson 1982) and appears to constrict at Point Barrow as birds round the point and pass into the Chukchi Sea (Flock 1973). An unknown number of eiders and other birds are also known to pass over the tundra to the south of Point Barrow during both the spring and fall migrations (Myres 1958; Flock 1973; Richardson and Johnson 1981).

Developing an index to monitor population trends of Beaufort Sea King and Common eiders is important because of the dramatic declines in two closely related species: Spectacled Eiders *Somateria fischeri* and Steller's Eiders *Polysticta stelleri*. Spectacled Eider numbers have declined by more than 90% on the Yukon–Kuskokwim Delta, Alaska (Stehn et al. 1993), and possibly in the Prudhoe Bay area on the North Slope of Alaska (Warnock and Troy 1992). The number of Steller's Eiders wintering in Alaska has declined, and the species disappeared as a nesting bird on the Yukon–Kuskokwim Delta (Kertell 1991). The cause or causes of Spectacled and Steller's eider declines are unknown. King and Common eiders have some distributional overlap with Spectacled and Steller's eiders during migration and in some nesting areas, and there may be some overlap in the wintering areas (Bellrose 1980; Johnson and Herter 1989). Thus, King and Common eiders may be confronted with the same unknown factor or factors causing population declines in Spectacled and Steller's eiders.

The purposes of this study were to estimate the magnitude of the passage of King and Common eiders and to document the timing and species and sex composition of the migration past Point Barrow during spring 1987, spring 1994, and fall 1994. This is the first study to document both the spring and fall migrations in the same year — 1994.

2.0 Methods

2.1 Spring migration, 1987

We counted migrating eiders during the spring of 1987 secondarily to a behavioural study of migrating bowhead whales *Balaena mysticetus* (Zeh et al. 1993). An observation site was established on 24 April about 5 km north of Point Barrow (71°26'N, 156°27'W) on an ice pressure ridge on the seaward edge of the shorefast ice (for explanation, see George et al. 1995). The site was situated on a block of ice about 7 m above sea level. Two to three observers counted from 5 to 30 May during the first 15 minutes of each hour, as often as possible. We counted during a total of 76 hours. The average number of counts per day was 11.7, with a maximum of 17 counts in a day and a minimum of one (Fig. 1). All hours of the day were sampled with similar intensity except for the hours between 02:00 and 06:00 Alaska Daylight Time (ADT), when no counts were conducted.

On two days, 7 and 8 May, we were able to count only during one 15-minute period. Thus, for estimates of daily passage for 7 and 8 May, we extrapolated from 6 and 9 May, respectively.

2.2 Spring migration, 1994

We established an observation site on 1 May 1994 on an ice pressure ridge on the seaward edge of shorefast ice. The site was located about 5 km southwest of Point Barrow (71°22'N, 156°46'W) and was situated on a block of ice about 3 m above sea level. Two to three observers counted migrating eiders from 1 May to 10 June. By 8 June, the sea ice was no longer safe for travel; thereafter, we conducted the counts from a platform 5 m high situated on the beach 6 km south of Point Barrow.

Continuous daylight allowed us to count throughout the day. On 1 and 2 May, we counted for four and six hours, respectively. From 3 May to 4 June, we attempted to count for 12 hours each day, counting for two hours and not counting for the next two hours beginning at 02:00 ADT. Occasionally, we were unable to maintain this schedule. Strong winds, freezing rain, and unsafe ice reduced our counting efforts on 4, 5, 12, 13, and 23–26 May (Fig. 2). From 5 to 10 June, near the end of spring migration, we counted for three to seven hours each day (Fig. 2). We counted migrating birds during a total of 375 hours over 40 days.

2.3 Fall migration, 1994

We conducted migration counts during the fall migration from the base of Point Barrow spit (71°21'N, 156°35'W). The counts were made from a truck or four-wheeler by one to four observers. We began counts on 13 July and finished on 27 October. Typically, a count lasted two hours, although occasionally counts lasted up to three hours or were as short as 0.5 hours. We counted birds over a total of 624.2 hours. Twenty-four hours of daylight allowed us to count throughout the entire day in July and early August (Fig. 3). During September and October, the amount of daylight decreases rapidly (10–20 minutes per day), so that by late October, we counted only about two hours a day (Fig. 3).

2.4 Data collection and analysis

We recorded the following data for each count: date, start and end time, observers, and weather variables, including categorization of the weather (i.e., cloud cover, fog, and precipitation), temperature, visibility, wind speed, and wind direction. For each flock that was sighted, we recorded time, direction of travel, species composition, total number sighted, number of males and females of each species whenever possible (except in 1987), the distance the flock was from the lead edge (spring 1994 only), and additional comments (e.g., notable changes in the weather or ice conditions, interesting behavioural observations of the migrating birds). We were often unable to identify birds to species in eider flocks that were at a distance, although we were able to estimate the size of the flock. In these cases, the flock was categorized as unidentified eiders.

Observers were trained on species identification and flock estimation with the use of slide photographs. Slides of eider flocks of known size were shown for a brief period of time, and observers estimated the flock size and species and sex composition. During the counts, observers independently estimated the size of each flock, then arrived at a consensus for an estimate for each flock. Estimates between and among observers were generally within 10% of each other.

We calculated a daily passage for King and Common eiders during spring 1987 by multiplying the average number of eiders passing in 15 minutes for each day by 96 — the number of 15-minute periods in 24 hours. We calculated a daily passage for King and

Figure 1
Number of 15-minute counts per day and projected daily passage of King Eiders during spring 1987 at Point Barrow, Alaska

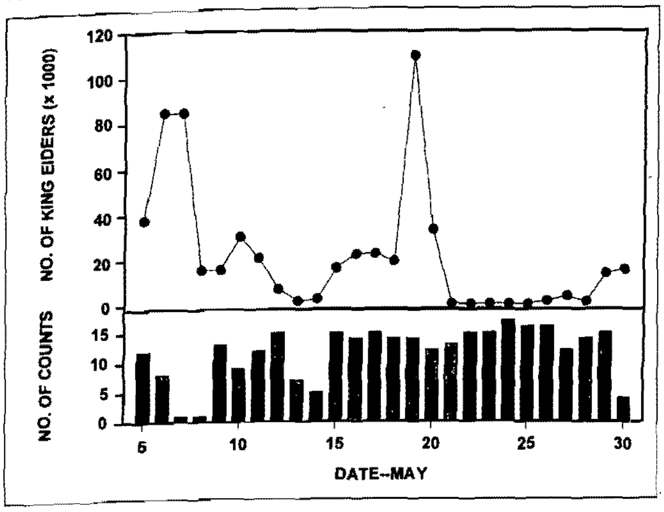
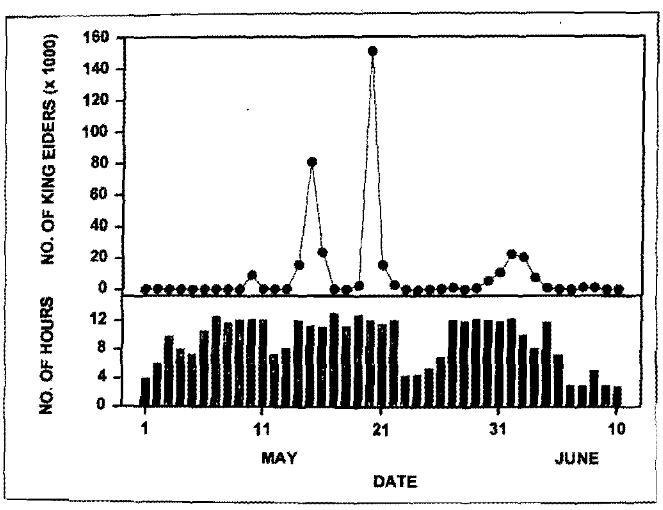
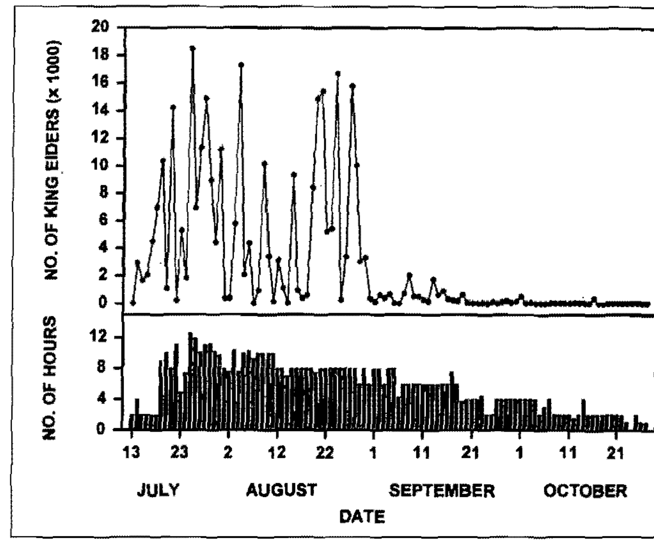


Figure 2
Hours of observation per day and projected daily passage of King Eiders during spring 1994 at Point Barrow, Alaska. Projected passages include a proportion of unidentified eiders that were divided between King and Common eiders based on the daily proportion of King and Common eiders that were identified.



Common eiders in 1994 by multiplying the average net number of eiders passing to the northeast (the number of eiders moving to the southwest was subtracted from the number of birds moving northeast) in two hours by 12 hours. We divided the number of unidentified eiders in 1994 between King and Common eiders based on the daily proportion of King and Common eiders that we identified. No unidentified eiders were recorded in 1987. We assumed a constant movement throughout the 24 hours of a day. We estimated a total passage for each species by summing the daily passages (including the unidentified eiders), and we also calculated a 95% confidence interval (C.I.) based on 15-minute systematic sampling intervals for 1987 and two-hour systematic sampling intervals for 1994 (Scheaffer et al. 1986).

Figure 3
Hours of observation per day and projected daily passage of King Eiders during fall 1994 at Point Barrow, Alaska. Projected passages include a proportion of unidentified eiders that were divided between King and Common eiders based on the daily proportion of King and Common eiders that were identified.



3.0 Results

3.1 Sex composition

During early spring migration, we saw flocks containing mostly male King and Common eiders in both 1987 and 1994; over the course of spring migration in 1994, however, we observed approximately equal sex ratios (Fig. 4). Our high percentage of males on 1 and 25 May 1994 was due to our observation of only one and three flocks, respectively, consisting mostly of males. During fall migration, we observed flocks consisting mostly of males through early August (Fig. 5). We saw fewer and fewer males as August progressed, until flocks consisted mostly of females during late August and early September (Fig. 5). We observed adult males again in flocks in late September and October (Fig. 5). The sex ratios we observed are somewhat biased during both the spring and fall migrations in 1994 owing to our data-recording technique. In mixed-species flocks that were at a moderate distance from the counting station, we were able to distinguish between male King and Common eiders. Females were difficult to identify in these same flocks; thus, in many instances, we recorded the females as unidentified. The sex ratios we present are therefore biased towards males. The spring migration sex ratios are more susceptible to this bias than the fall migration sex ratios, because spring flocks were more often composed of both males and females.

3.2 Timing of migration and species composition

3.2.1 Spring 1987

In 1987, we observed the first King Eiders before the migration count began — a flock of 32 birds on 24 April. We also opportunistically recorded six other flocks, ranging in size from seven to 100 birds, migrating north prior to the beginning of our migration counts. Large

Figure 4
Percentage of males observed in eider flocks during the spring migration at Point Barrow, Alaska, 1994

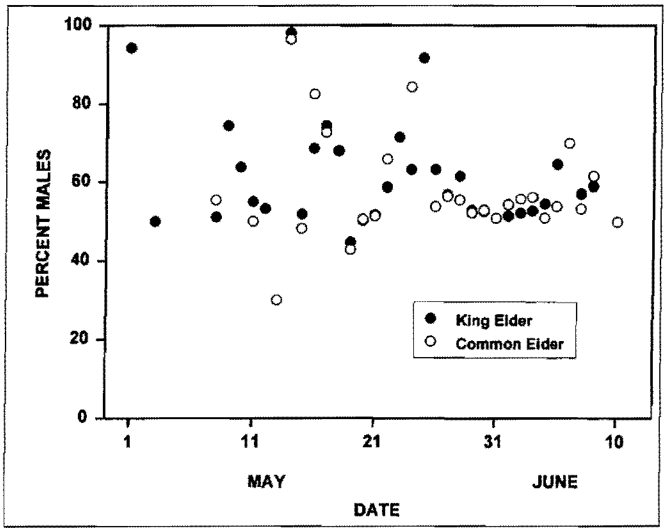
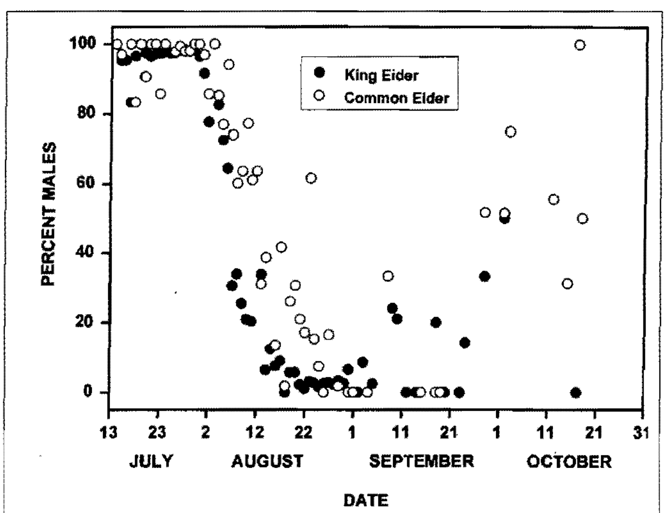


Figure 5
Percentage of males observed in eider flocks during the fall migration at Point Barrow, Alaska, 1994



movements of King Eiders occurred during the first three days of counting (~207 000), and a steady movement of birds continued until 18 May. Another large pulse of birds occurred on 19 and 20 May (~141 000), and we saw relatively few King Eiders after 20 May (Fig. 1). King Eider migration was 94% complete by 20 May. We saw the first Common Eiders on 4 May. Even though we observed Common Eiders in early May, they were present only in small numbers until 16 May; only 29% of the Common Eiders we observed passed before 16 May (Fig. 6). From 16 to 19 May, a large pulse of Common Eiders passed Point Barrow (~71 000). A smaller pulse of Common Eiders occurred during the last few days of May (~10 000; Fig. 6).

3.2.2 Spring migration, 1994

King Eiders were first seen on 1 May, but the first noticeable movement of King Eiders (~120 000) occurred from 14 to 16 May (Fig. 2). Two other large movements of

Figure 6
Number of 15-minute counts per day and projected daily passage of Common Eiders during spring 1987 at Point Barrow, Alaska

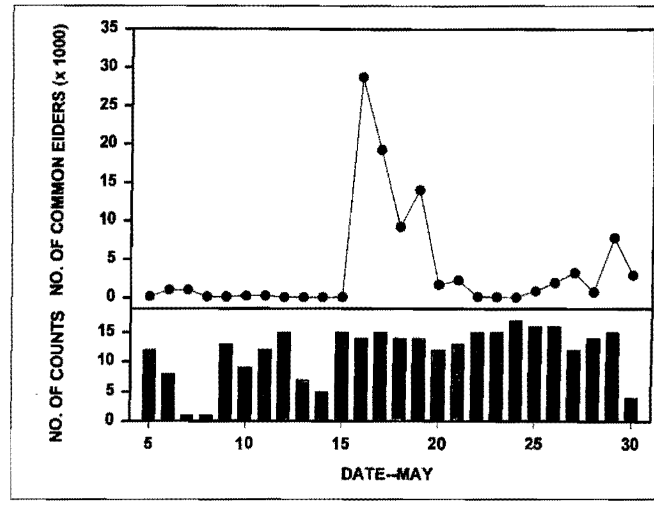
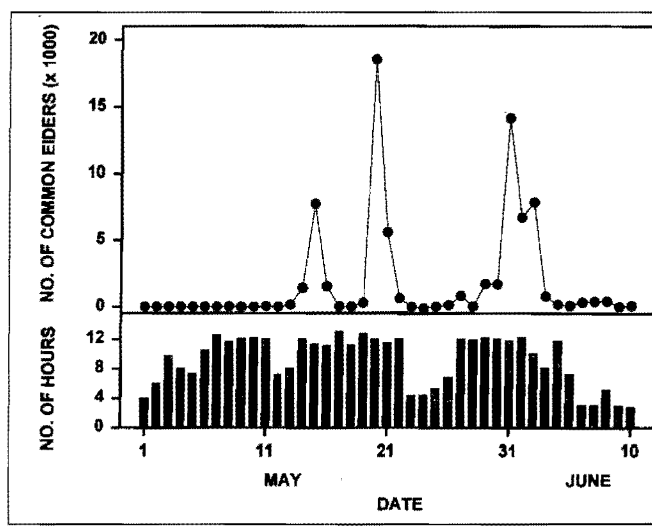


Figure 7
Hours of observation per day and projected daily passage of Common Eiders during the spring migration at Point Barrow, Alaska, 1994. Projected passages include a proportion of unidentified eiders that were divided between King and Common eiders based on the daily proportion of King and Common eiders that were identified.



King Eiders occurred on 20 May (~150 000) and from 31 May to 2 June (~50 000) (Fig. 2). Common Eiders were first observed on 11 May. Relatively large pulses of Common Eiders passed from 14 to 16 May (~10 000), from 20 to 21 May (~25 000), and from 31 May to 2 June (~30 000) (Fig. 7). King Eiders appeared in large numbers approximately four days before Common Eiders. The most noticeable difference between King and Common eider migrations is that approximately 50% of the Common Eider migration occurred late in May and early in June, whereas King Eider migration was 80% complete by 21 May.

3.2.3 Fall migration, 1994

King Eiders were observed on the first day of the fall migration survey, 13 July. Relatively large numbers of

King Eiders continued passing Point Barrow through the first of September (Fig. 3). After 1 September, only several small passages of King Eiders occurred — on 9 and 14 September. Common Eiders were first observed on 13 July, but sizeable numbers of birds were not observed until after 26 July (Fig. 8). A relatively large movement of Common Eiders passed in mid-August, although we observed approximately 50% of the Common Eider migration between 10 and 19 October (Fig. 8). This late passage of Common Eiders included a large number of adult birds. We observed King Eiders in large numbers approximately eight days before Common Eiders. As with the spring migration, the most noticeable difference between the migrations of King and Common eiders is that the Common Eider migration occurred later than the King Eider migration; approximately 50% of the Common Eider migration occurred during October, whereas King Eider migration was more than 90% complete by 1 September.

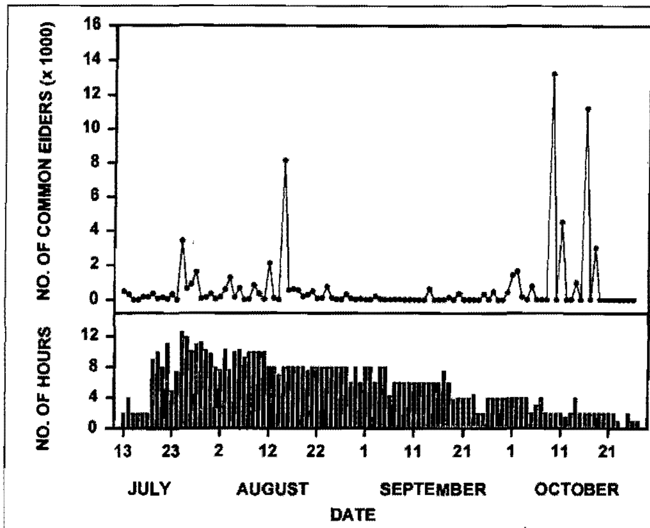
3.3 Numbers of eiders

In 1987, we observed a total of 70 672 King and Common eiders between 5 and 30 May. Of these, 57 126 (80.8%) were King Eiders and 13 546 (19.2%) were Common Eiders (Table 1). We projected a total of 555 870 (95% C.I. ±101 335) King Eiders and 95 069 (95% C.I. ±27 821) Common Eiders that passed Point Barrow during the 26 days we counted migrating birds (Table 2). The greatest number of King Eiders observed in a 15-minute count was 3327, which occurred on 19 May. The greatest number of Common Eiders observed in a 15-minute count was 1213 on 16 May.

During spring 1994, we observed a total of 213 477 King and Common eiders between 1 May and 10 June; 98.9% were moving to the northeast, for a net movement of 208 837 (Table 1). We were able to identify 121 164 eiders; 82.7% were King Eiders, 17.3% were Common Eiders, and we observed 52 Spectacled Eiders. Of the 100 125 King Eiders we identified, 98.9% were moving northeast (1.1% were moving southwest), for a net movement of 97 873 King Eiders to the northeast (Table 1). Of the 20 987 Common Eiders we identified, 98.5% were moving northeast (1.5% were moving southwest), for a net movement of 20 377 Common Eiders to the northeast (Table 1). The 52 Spectacled Eiders were all moving northeast during June. We may have missed Spectacled Eiders in the large flocks of King and Common eiders. We projected a net northeast movement of 373 069 (95% C.I. ±105 506) King Eiders and 71 164 (95% C.I. ±16 038) Common Eiders past Point Barrow during spring 1994 (Table 1).

We observed a total of 121 476 eiders between 13 July and 27 October 1994; 99.4% were observed moving to the southwest, for a net movement of 120 775 King, Common, and unidentified eiders (Table 1). We were able to identify 61 833 eiders; 88.6% were King Eiders, 11.2% were Common Eiders, and we observed 99 Spectacled Eiders and 29 Steller's Eiders. Of the 54 947 King Eiders we identified, 99.5% were moving southwest (0.5% were moving northeast), for a net movement of 54 369 King Eiders to the southwest (Table 1). Of the 6888 Common Eiders we identified, 99.9% were moving southwest

Figure 8
Hours of observation per day and projected daily passage of Common Eiders during the fall migration at Point Barrow, Alaska, 1994. Projected passages include a proportion of unidentified eiders that were divided between King and Common eiders based on the daily proportion of King and Common eiders that were identified.



(0.1% were moving northeast), for a net movement of 6874 Common Eiders to the southwest (Table 1). Of the 99 Spectacled Eiders we observed, 92 were moving southwest (seven were moving northeast). Of the 29 Steller's Eiders, 28 were moving southwest (one was moving northeast). We projected a net northeast movement of 301 174 (95% C.I. ±42 190) King Eiders and 67 145 (95% C.I. ±8785) Common Eiders past Point Barrow during fall 1994 (Table 1).

4.0 Discussion

Based on observations of mostly male eiders early in spring migration, Woodby and Divoky (1982) and Barry (1986) suggested that pair formation in King Eiders likely occurs in polynyas offshore of nesting areas. We counted similar numbers of male and female King and Common eiders during spring migration in 1994 (Fig. 4). We also observed pair bond behaviours (cooing, rearing, etc.; Johnsgard 1964) among eiders sitting on the water in leads off Point Barrow. Our observations suggest that in 1994, many King and Common eiders were paired or in the process of pair formation when they passed Point Barrow.

Male eiders abandon females soon after incubation begins (Lamothe 1973; Palmer 1976). Thus, the fall migration at Point Barrow begins with predominantly males. As with other studies (Thompson and Person 1963; Johnson 1971), we recorded mostly males in July, with the migration consisting mostly of females by mid- to late August. Our count in fall 1994 continued later than any previous count, and we observed adult plumaged males in the flocks of King and Common eiders in September and October. This indicates that some adult male eiders moult in the Beaufort Sea, confirming reports of other authors (Barry and Barry 1982; Johnson and Herter 1989).

Table 1
Number of King, Common, and unidentified eiders seen during the spring and fall migrations in 1987 and 1994, projected total passage, and 95% confidence interval

	Spring 1987			Spring 1994			Fall 1994		
	No. seen[a]	Projected passage[b]	95% C.I.	No. seen[a]	Projected passage[b]	95% C.I.	No. seen[a]	Projected passage[b]	95% C.I.
King Eider	57 126	555 870	101 335	97 873	373 069	105 506	54 369	301 174	42 190
Common Eider	13 546	95 069	27 821	20 377	71 164	16 038	6 874	67 145	8 785
Unidentified eiders				90 587			59 532		
Total[a]	70 672	650 939		208 837	444 233		120 775	368 319	

[a] Net number of birds migrating northeast (spring) or southwest (fall).
[b] Sum of the daily projected passage — number seen expanded for the time not observed. Unidentified eiders were divided between King and Common eiders for each day based on the proportion of King and Common eiders observed for that day.

Table 2
Year, dates, number of days the count spanned, and number of hours of counting during spring and fall migration at Point Barrow, Alaska

Year	Date	No. of days	No. of hours
Spring			
1976[a]	6 May – 4 June	30	129
1987[b]	5 May – 30 May	26	76
1994[b]	1 May – 10 June	41	375
Fall			
1953[c]	13 July – 1 Sept.	50	62
1970[d]	13 July – 7 Sept.	57	110
1994[b]	13 July – 27 Oct.	107	624.2

[a] From Woodby and Divoky (1982).
[b] From this study.
[c] From Thompson and Person (1963).
[d] From Johnson (1971).

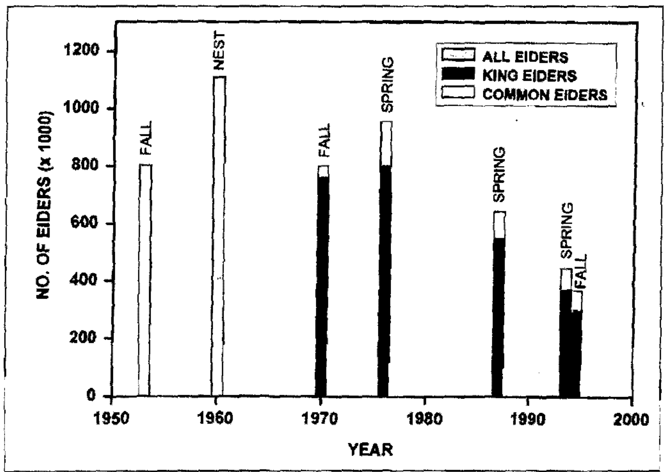
Johnson (1971) estimated that 95% of the eiders passing Point Barrow between mid-July and early September were King Eiders and 5% were Common Eiders. In 1994, between mid-July and early September, 91% of the eiders we observed were King Eiders and 9% were Common Eiders. We documented that 50% of the Common Eider migration passed Point Barrow in late October, almost two months after the King Eider migration was complete. It is likely that Johnson's (1971) estimate of the percentage of Common Eiders was low and did not represent the actual percentage of Common Eiders using the Beaufort Sea.

Woodby and Divoky (1982) estimated that 90% of the eiders passing Point Barrow during spring 1976 were King Eiders and 10% Common Eiders. Our estimates of the percentage of King and Common eiders passing Point Barrow during spring 1994 were similar. In the spring, we found that King Eiders appeared in large numbers at Point Barrow four days before Common Eiders. Woodby and Divoky (1982) observed King Eiders in large numbers 9–10 days before Common Eiders. Most of the King Eiders that migrate through the Beaufort Sea nest on Banks and Victoria islands, Northwest Territories (Barry 1986). Common Eiders nest along the Beaufort Sea coast from Point Barrow to Dolphin and Union Strait and on Banks and Victoria islands (Johnson and Herter 1989), but it is not readily apparent where the majority of Common Eiders nest.

Murdoch (1885) first described the impressive migration of eiders and other waterbirds past Point Barrow. He believed that more than one million birds passed during migration. Leffingwell (1919) also believed that between 700 000 and one million birds passed Point Barrow. Since Murdoch's (1885) and Leffingwell's (1919) estimates, there have been surprisingly few surveys of the eider passage during either the spring or fall. Thompson and Person (1963) projected a total flight of 800 000 eiders from 14 July to 1 September in 1953 and believed that more than one million birds passed Point Barrow during the entire migration. Barry (1968) estimated that 1 108 000 used the Beaufort Sea migration corridor based on numbers of nesting birds in northwest Canada and Alaska. Johnson (1971) counted fall migrating birds from 13 July to 7 September 1970 at Point Barrow and estimated a passage of 800 210 (760 199 King Eiders and 40 011 Common Eiders). Woodby and Divoky (1982) quantified the spring migration of waterbirds past Point Barrow in 1976. They estimated that 802 556 King Eiders and 153 081 Common Eiders passed Point Barrow to the northeast in a 30-day period. Our estimates — 650 939 (555 870 King Eiders and 95 069 Common Eiders) during spring 1987, 444 233 (373 069 King Eiders and 71 164 Common Eiders) during spring 1994, and 368 319 (301 174 King Eiders and 67 145 Common Eiders) during fall 1994 — are considerably less than previous estimates (Fig. 9).

Comparison of 1987 and 1994 migration estimates with past estimates (Fig. 9) is complicated by (1) differences in total watch effort, (2) differences between spring and summer migrations with respect to the timing of King and Common eider movements, (3) likely interannual differences in the timing of the migrations owing to environmental variables, such as wind and ice conditions, (4) lack of confidence intervals for most of the previous estimates, and (5) the fact that the fall migration counts may contain young-of-the-year birds, whereas spring counts do not. Even with the difficulties in comparing migration estimates, our estimates are considerably lower, despite the fact that our spring and fall 1994 migration counts covered a greater number of days and more hours than any previous count (Table 2). Additionally, our fall count includes young-of-the-year, whereas other counts do not. Our results indicate declines in numbers of eiders passing by Point Barrow. The declines may represent actual population declines in King and Common eiders using the Beaufort Sea or dramatic shifts in the migration route. Traditional knowledge of Alaska Natives in Barrow does not indicate a change of eider migration routes, and there are no historic scientific data with which to evaluate changes in migration routes.

Figure 9
Projected passages of King and Common eiders at Point Barrow in 1953 (Thompson and Person 1963), in 1970 (Johnson 1971), in 1976 (Woodby and Divoky 1982), in 1987, and in 1994 (this study) and an estimate of the number of eiders using the Beaufort Sea migration corridor in 1960 based on numbers of nesting birds (Barry 1968)



We believe that our data represent a decline in the number of eiders using the Beaufort Sea.

To better evaluate possible declines in King and Common eider populations, we recommend the following: (1) continuing migration counts at Point Barrow to evaluate population trends, (2) determining current nesting distribution and abundance, (3) determining population abundance through more extensive migration counts, especially documenting birds moving across the tundra, (4) evaluating the effectiveness of documenting recruitment through subsistence hunter bag checks or late fall migration counts, (5) determining winter distribution of Beaufort Sea King and Common eiders, and (6) documenting possible sources and magnitude of mortality, including subsistence harvest, exposure to disease, parasite loads, and levels of environmental contaminants and their possible effects.

Acknowledgements

We are grateful to Billy Adams, Bill Barber, Dave Barron, Forest Blau, Geoff Carroll, Merrill Gosho, Cyd Hanns, Polly Hessing, Phil Kauffman, John Locke, Elaine Patkotak, and Dave Ramey for assistance with data collection, and Kirstin Bagne helped with 1987 data entry and checking. The North Slope Borough Department of Wildlife Management funded the migration count in 1987. In 1994, funding was provided by the North Slope Borough Department of Wildlife Management and the U.S. Fish and Wildlife Service (Northern Alaska Ecological Services). Assistance with data collection in 1994 was provided by Cathy Donaldson, Janey Fadely, Shawn Johnson, Mark Korte, Charles Leavitt, Steve A. MacLean, Mike Maples, Raynita Opie, Michael Romero, Mia Wesselmann, and John Wingfield. April Brower, Shawn Johnson, Steve MacLean, Josie Nungasak, Chris Savok, and Charlene Skin assisted with data entry and checking in 1994. We are grateful to Lynne Dickson for her encouragement and assistance. An anonymous reviewer provided useful comments on an earlier draft of this manuscript.

Literature cited

Bailey, A.M.; Brower, C.D.; Bishop, L.B. 1948. Birds of the region of Point Barrow, Alaska. Chicago Acad. Sci. 4:15–40.

Barry, S.J.; Barry, T.W. 1982. Sea-bird surveys in the Beaufort Sea, Amundsen Gulf and Prince of Wales Strait — 1981 season. Unpubl. rep., Can. Wildl. Serv., Edmonton.

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

Barry, T.W. 1986. Eiders of the western Canadian Arctic. Pages 74–80 *in* A. Reed (ed.), Eider ducks in Canada. Can. Wildl. Serv. Rep. Ser. No. 47, Ottawa.

Bellrose, F.C. 1980. Ducks, geese and swans of North America. 3rd edition. Stackpole Books, Harrisburg, Pennsylvania.

Brueggeman, J.J. 1980. Coastal occurrence of birds at Point Barrow, Alaska, in spring. Murrelet 61:31–34.

Flock, W.L. 1973. Radar observations of bird movements along the arctic coast of Alaska. Wilson Bull. 85:259–275.

George, J.C.; Suydam, R.S.; Philo, L.M.; Albert, T.F.; Zeh, J.E.; Carroll, G.M. 1995. Report of the spring 1993 census of bowhead whales, *Balaena mysticetus*, off Point Barrow, Alaska, with observations on the 1993 subsistence hunt of bowhead whales by Alaska Eskimos. Rep. Int. Whal. Comm. 45:371–384.

Johnsgard, P.A. 1964. Comparative behavior and relationships of the eiders. Condor 65:113–129.

Johnson, L.L. 1971. The migration, harvest, and importance of waterfowl at Barrow, Alaska. MS thesis, University of Alaska, Fairbanks. 87 pp.

Johnson, S.R.; Herter, D.R. 1989. The birds of the Beaufort Sea. BP Exploration (Alaska) Inc., Anchorage, Alaska.

Johnson, S.R.; Richardson, W.J. 1982. Waterbird migration near the Yukon and Alaskan coast of the Beaufort Sea: II. Moult migration of seaducks in summer. Arctic 35:291–301.

Kertell, K. 1991. Disappearance of the Steller's Eider from the Yukon–Kuskokwim Delta, Alaska. Arctic 44:177–187.

Lamothe, P. 1973. Biology of King Eider (*Somateria spectabilis*) in a fresh water breeding area on Bathurst Island, Northwest Territories. MSc thesis, University of Alberta, Edmonton. 125 pp.

Leffingwell, E. de K. 1919. The Canning River region, northern Alaska. U.S. Geol. Surv. Prof. Pap. 109, Washington, D.C.

Murdoch, J. 1885. Birds. Pages 104–128 *in* P.H. Ray (ed.), Report of the International Polar Expedition to Point Barrow, Alaska. Part 4. U.S. Government Printing Office, Washington, D.C.

Myres, M.T. 1958. Preliminary studies of the behavior, migration and distributional ecology of eider ducks in northern Alaska, 1958. Interim Prog. Rep. to the Arctic Institute of North America, McGill University, Montreal. 14 pp.

Palmer, R.S. 1976. Handbook of North American birds. Waterfowl (Part 1), Vol. 2. Yale University Press, New Haven, Connecticut.

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

Scheaffer, R.L.; Mendenhall, W.; Ott, L. 1986. Elementary survey sampling. Duxbury Press, Boston. 324 pp.

Stehn, R.A.; Dau, C.P.; Conant, B.; Butler, W.I.J. 1993. Decline of Spectacled Eiders nesting in western Alaska. Arctic 46:264–277.

Thompson, D.Q.; Person, R.A. 1963. The eider pass at Point Barrow, Alaska. J. Wildl. Manage. 27:348–356.

Timson, R.S. 1976. Late summer migration at Barrow, Alaska. Pages 354–400 *in* Environmental assessment of the Alaskan Continental Shelf. Principal investigator's report, April–June 1976. Vol. 1. National Oceanic and Atmospheric Administration, Boulder, Colorado.

Warnock, N.D.; Troy, D.M. 1992. Distribution and abundance of Spectacled Eiders at Prudhoe Bay, Alaska: 1991. Unpubl. rep. to BP Exploration (Alaska) Inc., Anchorage, Alaska. 21 pp.

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

Zeh, J.E.; Clark, C.W.; George, J.C.; Withrow, D.; Carroll, G.M.; Koski, W.R. 1993. Current population size and dynamics. Pages 409–489 *in* J.J. Burns, J.J. Montague, and C.J. Cowles (eds.), The bowhead whale. Spec. Publ. No. 2, The Society of Marine Mammalogy, Lawrence, Kansas.

Distribution and abundance of King Eiders in the western Canadian Arctic

D. Lynne Dickson, Richard C. Cotter, James E. Hines, and Maureen F. Kay

Abstract

Aerial surveys were conducted on Banks Island, western Victoria Island, and the mainland of the western Canadian Arctic from 1991 to 1994 to determine the abundance and distribution of King Eiders *Somateria spectabilis* on their nesting grounds. The highest densities of King Eiders (about 1.5/km^2) occurred on Victoria Island in the Kagloryuak River valley and in a wetland adjacent to Tahiryuak Lake. On Banks Island, there were moderate numbers on the western lowlands, but few on the east side of the island. Most of the mainland had very few King Eiders, although the birds were locally abundant on Cape Parry and the east end of Tuktoyaktuk Peninsula.

Using a correction factor of 1.31 ± 0.26 to compensate for eiders not detected during the aerial surveys, we calculated an adjusted population estimate of 92 000 King Eiders within the study area. Based primarily on the results of this study and similar surveys in the Queen Maud Gulf Migratory Bird Sanctuary, we estimate that roughly 200 000–260 000 King Eiders occur in the western Canadian Arctic. This estimate should be regarded as preliminary, as much of the information crucial to calculating the breeding population size is sparse, including data on eider densities throughout much of the breeding range and knowledge of the limits of the breeding range.

Résumé

Entre 1991 et 1994, des relevés aériens ont été effectués au-dessus de l'île Banks, de la partie ouest de l'île Victoria et de la partie continentale de la région ouest de l'Arctique canadien, afin d'établir l'abondance et la distribution des Eiders à tête grise *Somateria spectabilis* dans leurs aires de nidification. Les densités les plus fortes d'Eiders à tête grise (environ 1,5/km^2) ont été observées dans l'île Victoria, dans la vallée de la rivière Kagloryuak et dans une zone palustre avoisinant le lac Tahiryuak. Dans le cas de l'île Banks, des quantités moyennes ont été observées dans les basses terres à l'ouest mais les nombres étaient très peu élevés dans la partie est de l'île. Il y avait très peu d'Eiders à tête grise dans la plupart des régions continentales, mais ces oiseaux étaient assez nombreux à des points isolés du cap Parry et à l'extrémité est de la péninsule de Tuktoyaktuk.

En utilisant un facteur de correction de 1,31 ± 0,26 pour tenir compte des eiders que les relevés aériens n'ont pas permis de repérer, nous avons obtenu après correction un chiffre approximatif de 92 000 pour la population d'Eiders à tête grise dans la zone d'étude. À partir surtout des résultats de cette étude et de relevés semblables effectués dans le Refuge d'oiseaux migrateurs du golfe de la Reine-Maud, nous estimons qu'il y a en gros entre 200 000 et 260 000 Eiders à tête grise qui fréquentent la région ouest de l'Arctique canadien. Il s'agit d'une estimation qu'il faut considérer comme étant préliminaire, car une bonne partie de l'information indispensable au calcul de la taille de la population nicheuse n'est guère riche; il faut notamment des données sur les densités d'eiders un peu partout dans leur aire de reproduction et sur les limites de cette aire.

1.0 Introduction

Information on the abundance and distribution of the western Arctic population of King Eiders *Somateria spectabilis* on their breeding grounds in Canada is limited. There are a number of earlier accounts of where nesting King Eiders occur (Gavin 1947; Ellis 1956; Hanson et al. 1956; Manning et al. 1956; McEwen 1957; Parmelee et al. 1967; Smith 1973), but these studies provide no means of comparing abundance among areas or years. Aside from surveys along a proposed pipeline route on Victoria Island in 1980 (McLaren and Alliston 1981; Allen 1982), there have been no systematic surveys on the nesting grounds to determine densities or to estimate total numbers of King Eiders. Barry (1960) conducted an aerial reconnaissance for waterfowl in 1958 and 1960 in the central and western Arctic to locate the major breeding areas of waterfowl. Based on this reconnaissance, he estimated that there were over 900 000 King Eiders in the region, 800 000 of which were on Victoria Island, 100 000 on Banks Island, and 8000 in Queen Maud Gulf. The only other estimates of population size were obtained during migrations past Point Barrow, Alaska, in the 1970s: 760 200 (Johnson 1971) and 802 556 (Woodby and Divoky 1982).

With settlement of the Inuvialuit land claim came a need to improve our knowledge of the population status of the King Eider in the western Arctic. The Inuvialuit Final Agreement specified that the Inuvialuit have preferential hunting rights for wildlife in their settlement region.

Waterfowl surveys were needed in order to set harvest limits that would ensure that waterfowl populations remained stable. Thus, the Canadian Wildlife Service, in cooperation with the Inuvialuit, conducted several years of aerial surveys for nesting waterfowl throughout much of the western Canadian Arctic. The objectives of the surveys were to determine the abundance and distribution of harvested species of waterfowl and to establish a baseline for periodic monitoring of their numbers. This paper presents the data on King Eiders collected during those surveys.

2.0 Methods

From 1991 to 1994, we conducted waterfowl breeding population surveys in the western Arctic on Banks Island, western Victoria Island, and the mainland from the Mackenzie Delta to Keats Point (Figs. 1, 2, and 3). All surveys occurred between 11 June and 1 July each year.

We divided the study area into 17 strata, based on physiographic and habitat similarities (Figs. 1, 2, and 3). Topographical maps and descriptions of the geology, physical features, and vegetation were used to determine the boundaries of the strata. On Victoria Island, we also used Landsat Thematic Mapper satellite imagery that had been enhanced to display the amount of vegetation (colour bands 3, 5, 4 with histogram enhancement). Using a Bell 206 Jet Ranger helicopter, we flew straight-line transects across each stratum at 10-km intervals, except in areas of prime waterfowl habitat, where the transect lines were 5 km apart. These areas were the Mackenzie, Anderson, Smoke, Moose, and Mason river deltas on the mainland, western lowlands of Banks Island, and Kagloryuak River valley and Tahiryuak Lake wetland on Victoria Island. Because of the immense size of western Victoria Island, we surveyed only a portion (38% on average) of each stratum (Fig. 3).

Transects averaged 25 km in length on the mainland and 50 km on Victoria and Banks islands. Each transect was divided into 2-km segments. On the mainland and Banks Island, where the target species were geese, the helicopter maintained an elevation of 45 m and a ground speed of 80–100 km/h. On Victoria Island, where King Eiders were of primary interest, the surveys were conducted at 30 m and approximately 145 km/h.

During all surveys, there were two observers: one in the left front seat and the other in the right rear seat, which had a bubble window for easier viewing. Both recorded on audio tape all birds within 200 m of their respective side of the aircraft. For each sighting, the transect and segment number were recorded, as well as the species, group size, and sex (eider species only).

To calculate the indicated breeding population and number of indicated breeding pairs of King Eiders, we followed the standard operating procedure for waterfowl breeding population surveys, developed by the U.S. Fish and Wildlife Service and the Canadian Wildlife Service (Anonymous 1987). King Eider observations were divided into the following categories: lone males, flocks of two to four males, pairs, and groups of five or more birds. An observation of one female and two males was treated as a pair and lone male. Likewise, a female and three males were treated as a pair and two males. To calculate indicated breeding pairs, the numbers of lone males, males in flocks of two to four, and pairs were added together. To calculate the total indicated birds, we multiplied the indicated breeding pairs by two and added the number of grouped birds. Observations of one to four females without a male were not included in the calculations.

The population estimate, density, and standard error for each stratum were calculated using the ratio method (Jolly 1969:48; Cochran 1977:155):

$$\hat{R} = \Sigma y_i / \Sigma x_i$$

where:

$\hat{R}$ = population density (number of birds/km^2);

x_i = area of transect i; and

y_i = total indicated birds on transect i

and

$$s^2 = 1 - n/N\,[\sum_{i=1}^{n} (y_i - \hat{R}x_i)^2\,]/(n-1)\,n\bar{x}^2$$

where:

s^2 = variance of $\hat{R}$;

n = number of transects in stratum that were sampled;

N = number of possible transects; and

1 − n/N = finite population correction factor.

On Victoria Island, where only a portion of each stratum was surveyed, we assumed that the density and variance found within the survey plot were representative of the entire stratum. If there was more than one survey plot within the stratum, we used the average density and maximum variance, thus conservatively assuming that the largest variance applied to the entire stratum. The estimated total population of eiders in each stratum was calculated by multiplying the density by the stratum area. We calculated the population variance by multiplying the variance of the density by the square of the area (Beyer 1968:15).

The total population for a number of strata was calculated by taking the sum of the population estimates for each stratum. Likewise, the variance for the entire region was calculated by summing the variances for each stratum (Caughley 1977:614), and the standard error was obtained by taking the square root of the sum of the variances.

Among-year comparisons in the number of indicated breeding pairs and total indicated birds on Victoria Island were made using the Randomized Complete Blocks method, in which the years were the treatments and the strata were the blocks (Sokal and Rohlf 1981:348). The density of King Eiders in each stratum was used in the comparison. When a significant difference among years was detected, the Tukey multiple comparison test was used to detect which years were different (Zar 1984:186).

The lone drake index (ratio of males without females to total males, excluding groups >4) was determined for each day of survey on Banks and Victoria

Figure 1
Location of strata surveyed on the mainland in the western Canadian Arctic from 1991 to 1993

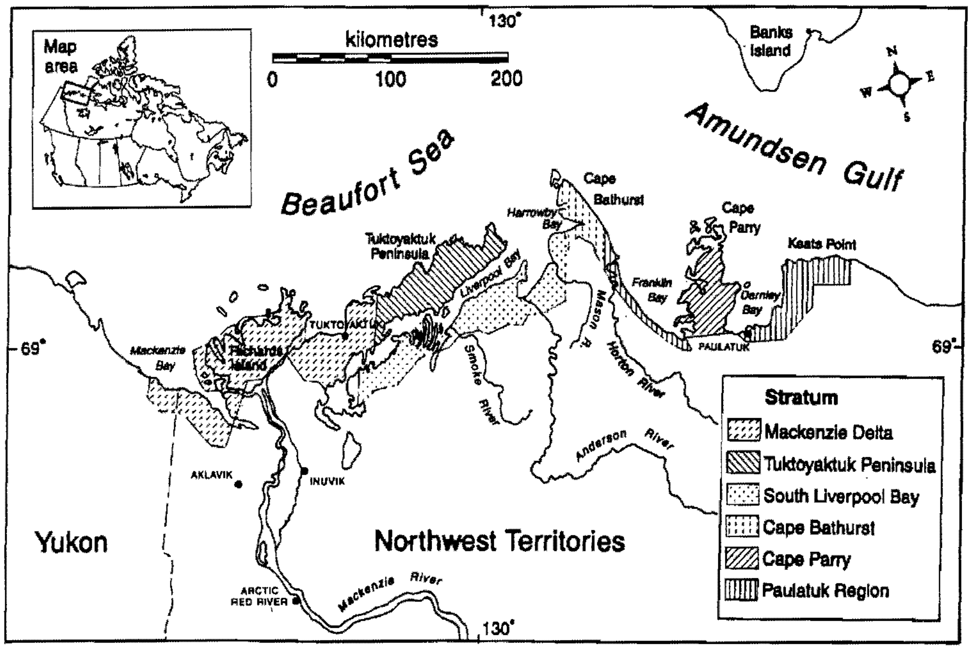


Figure 2
Location of strata surveyed on Banks Island in 1992 and 1993

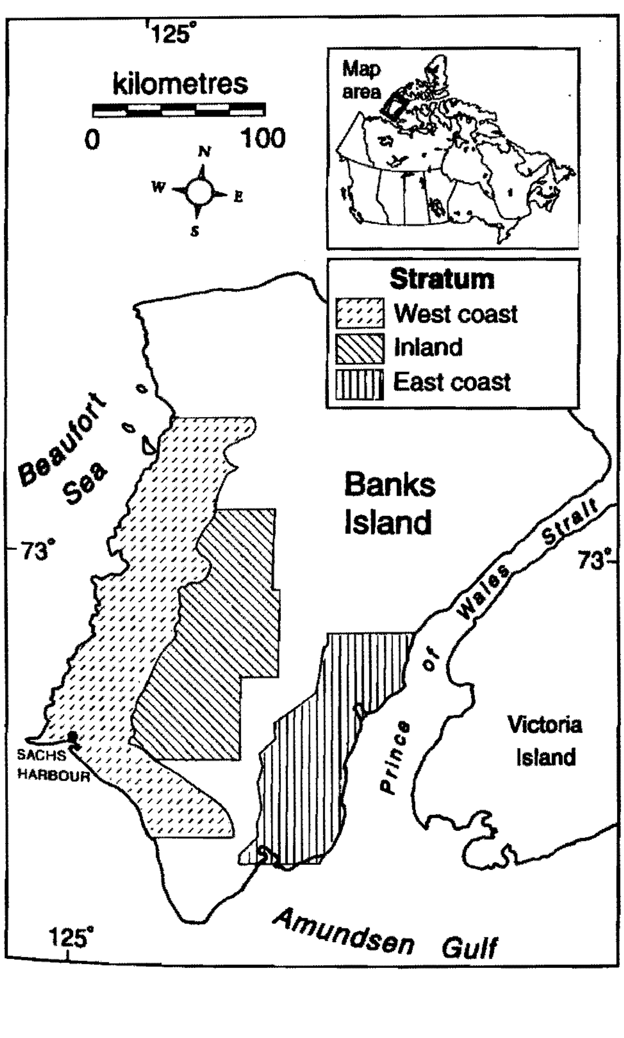
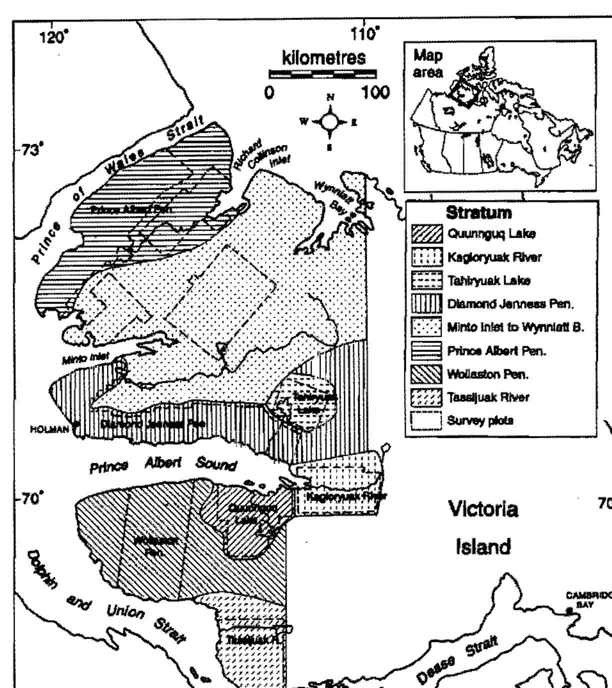


Figure 3
Location of strata boundaries and plots surveyed on Victoria Island from 1992 to 1994



islands. A daily mean and standard error were calculated based on the ratio seen on each transect that day using Tukey's Jackknife technique (Sokal and Rohlf 1981:795).

Not all animals on transects are seen from the air; thus, aerial surveys typically underestimate the number of animals present in a given area (Pollock and Kendall 1987). We developed a visibility correction factor (VCF) for King Eiders by resurveying at half speed (40–50 km/h) a 10-km section of 40 transects randomly selected from the 80 flown at regular speed (88% of resurveys were done 1–2 days later; range 0.5–5 days). The visibility correction factor was calculated by comparing the counts obtained on the second survey with those from the regular survey (Snedecor and Cochran 1967:155; Jolly 1969:48). Thus,

$$VCF = \Sigma y / \Sigma x$$

and

$$S(VCF) = (1/\bar{x}) \sqrt{\Sigma (y - VCFx)^2 / n(n-1)}$$

where:

$S(VCF)$ = the standard error of the visibility correction factor;

$\bar{x}$ = the mean number of birds seen per transect during survey x (regular survey);

x = the number of King Eiders seen during survey x (regular survey);

y = the number of King Eiders seen during survey y (intensive survey); and

n = the number of transects surveyed.

To correct for visibility bias, we multiplied the population estimate by the visibility correction factor. The variance of the adjusted population estimate was calculated using the method described by Gasaway et al. (1986:39), which combines the variance of the population estimate with that of the visibility correction factor:

$$V(\hat{T}_a) = VCF^2 [V(\hat{T}_o)] + \hat{T}_o{}^2 [V(VCF)] - V(VCF) [V(\hat{T}_o)]$$

where:

$\hat{T}_o$ = population estimate unadjusted for visibility;

$V(\hat{T}_o)$ = variance of population estimate unadjusted for visibility;

VCF = visibility correction factor;

$V(VCF)$ = variance of visibility correction factor;

$\hat{T}_a$ = population estimate adjusted with visibility correction factor; and

$V(\hat{T}_a)$ = variance of adjusted population estimate.

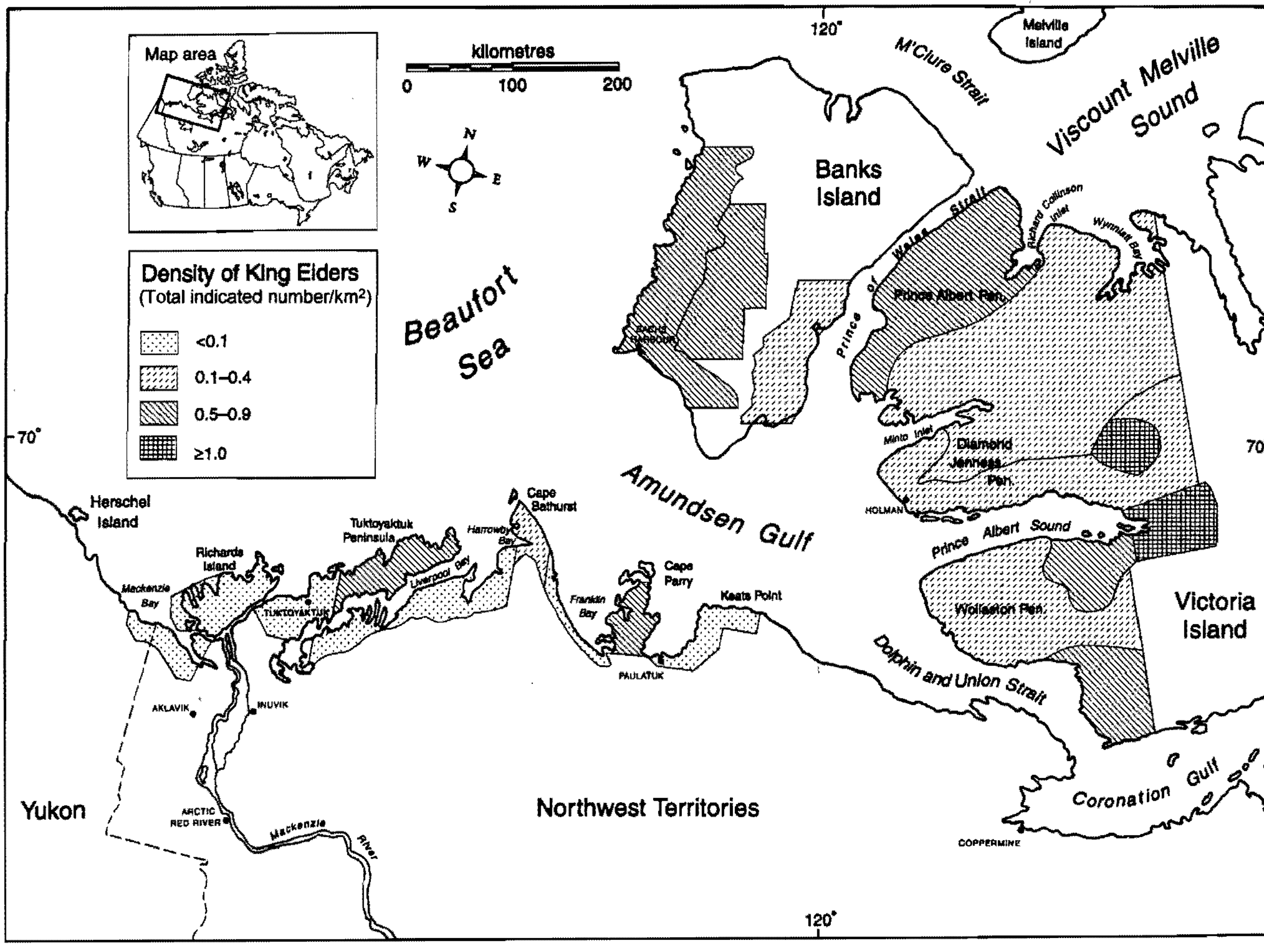
3.0 Results

The highest densities of King Eiders occurred on Victoria Island in the Kagloryuak River valley and around Tahiryuak Lake (Table 1; Fig. 4). Both of these areas contained pockets of wetland that had ponds and complete vegetation cover. Densities encountered there were considerably higher than elsewhere in the western Arctic: about 1.5 eiders/km^2, compared with the next highest

Table 1
Number and density of King Eiders observed during aerial surveys for waterfowl in the western Arctic from 1991 to 1994

Stratum/year	No. of transects	Distance surveyed (km)	Indicated no. of eiders	Population density (no./km^2 ± SE)
Mainland				
Mackenzie Delta				
1991	30	1256	0	0.00 ± 0.00
1992	30	1256	0	0.00 ± 0.00
1993	30	1256	10	0.02 ± 0.01
Tuktoyaktuk Peninsula				
1991	11	372	94	0.63 ± 0.22
1992	11	372	124	0.83 ± 0.30
1993	11	372	121	0.81 ± 0.15
South Liverpool Bay				
1991	21	588	0	0.00 ± 0.00
1992	21	588	0	0.00 ± 0.00
1993	21	588	0	0.00 ± 0.00
Cape Bathurst				
1991	4	146	22	0.38 ± 0.07
1992	4	146	10	0.17 ± 0.06
1993	4	146	14	0.24 ± 0.16
Cape Parry				
1991	5	236	65	0.69 ± 0.17
Paulatuk Region				
1991	14	284	0	0.00 ± 0.00
Banks Island				
West coast				
1992	50	2500	963	0.96 ± 0.09
1993	50	2500	650	0.65 ± 0.08
Inland				
1992	16	800	238	0.74 ± 0.11
1993	16	800	86	0.27 ± 0.05
East coast				
1993	14	700	34	0.12 ± 0.04
Victoria Island–Northwest				
Quunnguq Lake				
1992	7	172	56	0.81 ± 0.18
1993	7	324	109	0.84 ± 0.19
1994	7	324	103	0.79 ± 0.15
Kagloryuak River				
1992	8	608	330	1.36 ± 0.20
1993	9	688	358	1.30 ± 0.12
1994	9	688	512	1.86 ± 0.23
Tahiryuak Lake				
1992	8	282	158	1.40 ± 0.26
1993	9	322	171	1.33 ± 0.21
1994	9	322	214	1.66 ± 0.23
Diamond Jenness Peninsula				
1992	24	817	134	0.41 ± 0.07
1993	16	527	82	0.39 ± 0.09
1994	21	709	140	0.49 ± 0.10
Minto Inlet to Wynniatt Bay				
1992	16	690	32	0.10 ± 0.07
1993	6	338	24	0.18 ± 0.05
1994	9	476	72	0.38 ± 0.09
Prince Albert Peninsula				
1992	29	964	239	0.60 ± 0.11
1993	26	914	159	0.47 ± 0.18
1994	29	984	312	0.75 ± 0.20
Victoria Island–Southwest				
Wollaston Peninsula				
1993	6	662	102	0.39 ± 0.10
Tassijuak River				
1993	12	799	276	0.86 ± 0.10

Figure 4
Distribution of King Eiders on their breeding grounds in the western Canadian Arctic



density of 1.0 eider/km^2. Elsewhere on Victoria Island, moderately high densities were found in the broad band of lowlands along the south side of the island, in the wetlands around Quunnguq Lake, and in the broad river valleys of the uplands on Prince Albert Peninsula. The gently rolling, well-vegetated lowlands of western Banks Island also had relatively high densities of King Eiders. On much of the drier, poorly vegetated uplands of Victoria Island, including Wollaston Peninsula and Diamond Jenness Peninsula, King Eiders were low in numbers and highly dispersed (0.4–0.5/km^2). Densities were even lower in the dry interior of Victoria Island (stratum extending from Minto Inlet to Wynniatt Bay) and in the rugged uplands on the east side of Banks Island. Most of the mainland had either no King Eiders or very low densities. The exceptions were the east end of Tuktoyaktuk Peninsula and Cape Parry, where densities were moderately high. Relative to the rest of the mainland, these two areas had shorter vegetation (<0.3 m), fewer shrubs, and a later spring thaw.

On average, our population estimate for the study area, unadjusted for survey bias, was about 70 000 King Eiders (Table 2). Approximately 70% of the King Eiders occurred within the Victoria Island strata, 23% on Banks Island, and 7% on the mainland. The visibility correction factor that we obtained for King Eiders on Banks Island in 1993 was 1.31 (±0.26 standard error). Using this correction factor, our adjusted breeding population estimate for the study area was approximately 92 000 eiders (Table 3).

The number of King Eiders observed on the western and inland strata of Banks Island in 1992 declined to almost half the number in 1993, although not significantly (Randomized Complete Block, $F = 15.0$, $p > 0.05$) (Table 2). For this same period, on Victoria Island, population numbers remained the same; however, the following year, the number of King Eiders increased significantly (Randomized Complete Block, $F = 10.1$, $p < 0.01$: Tukey Multiple Comparison Test, $p < 0.05$). The increase in eiders was due to the presence of two to three times more small flocks of mixed sex (groups of five or more) than in the previous two years. The number of indicated breeding pairs actually did not change significantly among years: the estimate, unadjusted for visibility bias, was 19 691 ± 2282 in 1994 compared with 17 287 ± 1810 in 1992 and 15 444 ± 2294 in 1993 (Randomized Complete Block, $F = 2.3$, $p > 0.10$).

More than half of the King Eiders seen during the aerial surveys were pairs, except in 1993 on Banks Island, where we saw almost equal numbers of lone males and pairs (Table 4). Only 1–2% of observations were lone females, again with the exception of Banks Island in 1993.

Table 2
Estimated total indicated number of King Eiders in each stratum surveyed in the western Arctic from 1991 to 1994

Stratum location	Stratum size (km²)	Estimated number in stratum ± standard error[a] 1991	1992	1993	1994
Mainland					
Mackenzie Delta	9 061	0 ± 0	0 ± 0	180 ± 124	
Tuktoyaktuk Peninsula	3 682	2 326 ± 826	3 068 ± 1 104	2 994 ± 536	
South Liverpool Bay	5 080	0 ± 0	0 ± 0	0 ± 0	
Cape Bathurst	1 432	539 ± 101	245 ± 86	343 ± 225	
Cape Parry	2 277	1 568 ± 376			
Paulatuk Region	2 407	0 ± 0			
Banks Island					
West coast	12 436		11 976 ± 1 148	8 083 ± 933	
Inland	8 978		6 677 ± 1 008	2 413 ± 446	
East coast	7 000			850 ± 251	
Victoria Island–Northwest					
Quunnguq Lake	3 971		3 232 ± 721	3 340 ± 737	3 156 ± 611
Kagloryuak River	4 573		6 204 ± 897	5 948 ± 568	8 507 ± 1 055
Tahiryuak Lake	2 298		3 219 ± 590	3 051 ± 485	3 818 ± 519
Diamond Jenness Peninsula	15 866		6 505 ± 1 071	6 172 ± 1 471	7 832 ± 1 624
Minto Inlet to Wynniatt Bay	39 676		3 832 ± 2 802	7 043 ± 1 963	15 003 ± 3 640
Prince Albert Peninsula	16 366		9 880 ± 1 815	7 766 ± 2 967	12 243 ± 3 344
Victoria Island–Southwest					
Wollaston Peninsula	16 596			6 393 ± 1 634	
Tassijuak River	5 508			4 757 ± 560	

[a] Refer to Table 1 for number of transects surveyed in each stratum each year.

Table 3
Adjusted estimated breeding population of King Eiders in areas of the western Arctic surveyed from 1991 to 1994

Region	Size (km²)	Adjusted estimated number ± standard error[a] 1991 (n)	1992 (n)	1993 (n)	1994 (n)
Mainland					
- Mackenzie Delta to Cape Bathurst	19 255	3 753 ± 1 304 (66)	4 340 ± 1 663 (66)	4 607 ± 1 184 (66)	
- Cape Parry to Keats Point	4 684	2 054 ± 632 (19)			
Banks Island					
- West coast and inland	21 414		24 435 ± 6 850 (66)	13 750 ± 3 035 (66)	
- East coast	7 000			1 114 ± 391 (14)	
Victoria Island					
- Northwest	82 750		43 064 ± 9 802 (92)	43 649 ± 10 064 (73)	66 232 ± 14 843 (84)
- Southwest	22 104			14 607 ± 3 651 (18)	

[a] Estimates adjusted with visibility correction factor of 1.31 ± 0.26 (SE).

That year in the east coast stratum, 31% of all observations were of lone females. Eiders in groups of more than four varied from none on the mainland in 1992 to 25% of the observations on Victoria Island in 1994. With the exception of Banks Island in 1992, there was little or no buildup of lone males as nest initiation progressed (Fig. 5). Throughout the surveys, we never saw flocks of more than four males without females.

4.0 Discussion

Based primarily on our surveys and recent similar work by Alisauskas (1992) in the Queen Maud Gulf Migratory Bird Sanctuary, we estimate that there are roughly 200 000–260 000 King Eiders breeding in the western Canadian Arctic (Table 5). This estimate should be regarded as preliminary, as much of the information crucial to calculating the breeding population size is sparse, including data on eider densities throughout much

Table 4
Composition of King Eider population during waterfowl surveys in the western Arctic conducted between 11 June and 1 July, from 1991 to 1994

	% pairs	% lone males	% lone females	% groups >4	Total observed no.[a]
Mainland					
1991	77.1	15.0	1.3	6.5	153
1992	80.0	20.0	0	0	110
1993	77.8	18.2	0	4.0	126
1994	–	–	–	–	–
Banks Island					
1991	–	–	–	–	–
1992	85.8	11.2	0.6	2.4	1086
1993	46.2	44.9	6.0	2.9	554
1994	–	–	–	–	–
Victoria Island					
1991	–	–	–	–	–
1992	64.6	26.4	1.3	7.8	759
1993	56.5	27.0	2.2	14.3	1027
1994	60.3	13.2	1.2	25.4	1208

[a] Excludes eight eiders of unknown sex on Mainland strata.

of the breeding range and knowledge of the limits of the breeding range.

Waterfowl breeding population surveys have been conducted on only about half of the presumed breeding grounds of the western Arctic King Eider population. Thus, our population estimates for much of the breeding grounds were derived from densities in adjacent areas. Specifically, we obtained an estimate of 150 200 King Eiders on Victoria Island by applying the densities we found on western Victoria Island to the remaining 62% of the island that had not been surveyed. Similarly, we obtained a population estimate for the unsurveyed portion of Banks Island (53% of the island) by using the densities found in our study area.

Our estimate of 10 000 eiders along the mainland between Keats Point and Kent Peninsula is speculative, as there have been no systematic surveys for breeding waterfowl in this entire region. Barry (1986) noted that the King Eider breeds only occasionally in Amundsen Gulf and western Coronation Gulf. The low density of King Eiders found along the coast near Paulatuk during this study supports Barry's (1986) observation. In Coronation Gulf, Ellis (1956) noted that the King Eider was rare around Coppermine, and McEwen (1957) saw few eiders in Bathurst Inlet. However, during aerial surveys for waterfowl in midsummer from 1989 to 1991, Bromley and Stenhouse (1994) noted two areas of exceptional waterfowl habitat within this region: an area 60 km north of Coppermine and the western half of Kent Peninsula. The estimate is based on all of the above observations.

Our population estimate likely approximates the size of the western Arctic population of King Eiders that breeds in Canada. However, this cannot be confirmed until the eastern and northern limits of their breeding range have been more thoroughly investigated. We included in our calculations all of Victoria and Banks islands and the Queen Maud Gulf Migratory Bird Sanctuary, but we excluded all areas east and north of there (Fig. 6).

Observations on the direction of movement of eiders past a field camp in mid-June 1993 confirmed that the eiders in the Kagloryuak River valley on Victoria Island are part of the western Arctic population (Cotter et al., this publication). However, it is unknown how far east of the valley the eiders travel. At least some of the King Eiders that nest on southeastern Victoria Island are from the eastern Arctic population, as a bird banded off Greenland was recovered near Cambridge Bay (Salomonsen 1968). Another King Eider from Greenland was recovered on King William Island (Salomonsen 1979); as well, there have been several recoveries from Boothia Peninsula and one from Prince of Wales Island (Salomonsen 1968). Eiders nesting on Bathurst Island in the High Arctic islands are part of the eastern Arctic population, based on two recoveries off Greenland of birds banded on Bathurst Island (Canadian Wildlife Service Bird Banding Office, Ottawa). However, it is unknown which population nests on the High Arctic islands west of Bathurst Island.

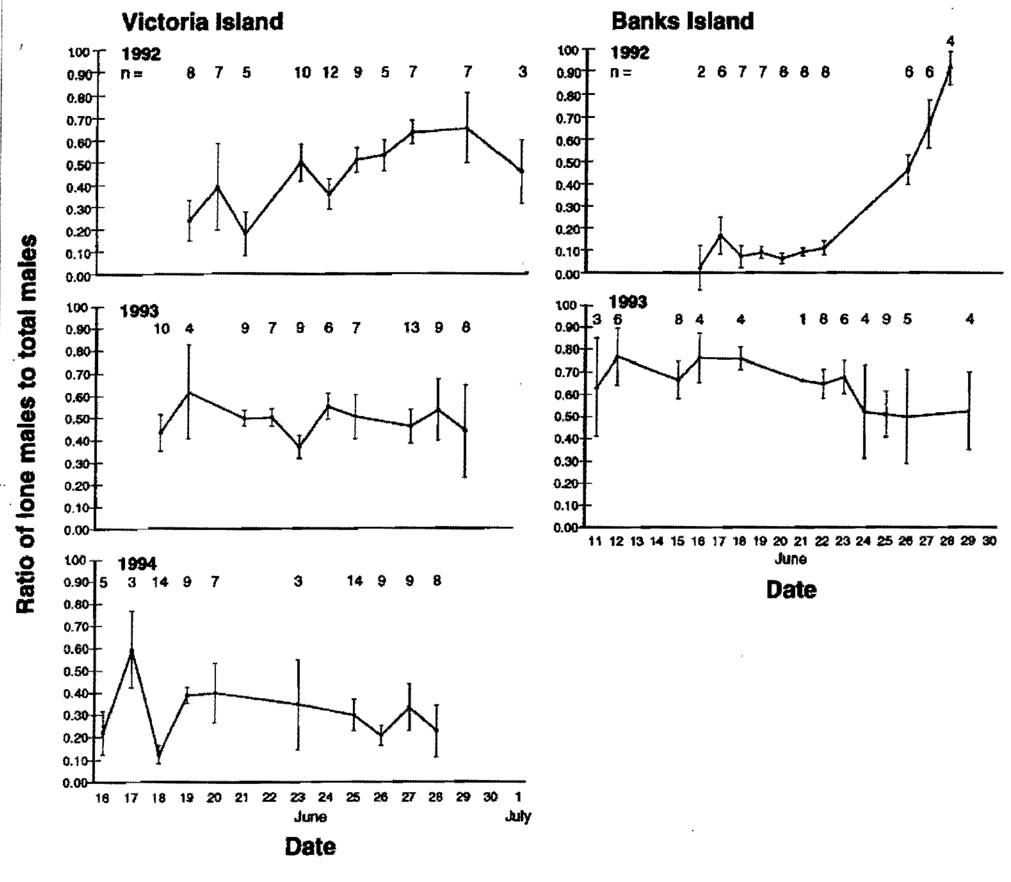
Our population estimate of 200 000–260 000 King Eiders is considerably lower than previous estimates of 760 000–900 000 (Barry 1960; Johnson 1971; Woodby and Divoky 1982), which suggests that the western Arctic population of King Eiders has declined in number. A more recent count of eiders at Point Barrow also indicated a decline: an estimated 30% fewer eiders flew past Point Barrow during spring migration in 1987 than in 1976 (Suydam et al., this publication).

Several other populations of sea ducks that inhabit the Pacific Northwest are declining. The number of Common Eiders *Somateria mollissima v-nigra* in Russia has dropped three- to fourfold since the early 1970s and is also thought to be declining in Alaska (Goudie et al. 1994). Spectacled Eider *S. fischeri* populations in Alaska have declined at a rate of 14% per year since the early 1970s (Stehn et al. 1993), and the Steller's Eider *Polysticta stelleri* is apparently extinct in one of the two areas in Alaska where it was once a regular breeder (Kertell 1991). All of the eider species share similar wintering and moulting areas in the Bering Sea (Kistchinski 1973). If their decline is linked to changes in the quality or availability of habitat in the Bering Sea, it could be affecting the King Eider as well.

King Eiders periodically experience mass mortality during spring migration. In years when leads of open water fail to form in the Beaufort Sea, large numbers of starving and dead King Eiders are found (Barry 1968; Palmer 1976; Fournier and Hines 1994). For example, in 1964, an estimated 100 000 King Eiders starved to death (Barry 1968). Our low population estimate might be due in part to the most recent die-off, which occurred in 1990 (Fournier and Hines 1994). Recovery from such an event would take several years, as King Eiders are not sexually mature until they are two to three years old (Palmer 1976).

There are, however, several other possible reasons why our estimate is lower than earlier estimates. Barry's (1960) estimate was based on a reconnaissance of the western Arctic. Given the limited coverage of the breeding grounds and unsystematic survey method, his estimate could be quite inaccurate. Counts of eiders migrating past Point Barrow were based on systematic observations. However, should a large pulse of birds pass in a short period of time, an accurate count would likely be difficult to obtain. This happened in 1976, when an estimated

Figure 5
Change in proportion of lone drakes (males not associated with females) as the nesting season progressed during aerial surveys on Victoria Island and Banks Island from 1992 to 1994. Vertical lines indicate standard errors. Samples sizes (number of transects) are given above each graph.



360 000 King Eiders passed within a 10-hour period, with a peak of 113 000 in one half hour (Woodby and Divoky 1982). Furthermore, it is unknown what proportion of the King Eiders that pass Point Barrow reach the breeding grounds in Canada. Some nest in northern Alaska. A few immature birds pass Point Barrow in spring (R. Suydam, pers. commun.), but even fewer may reach the breeding grounds in Canada, where they occur in very low numbers (Hanson et al. 1956; Lamothe 1973). Similarly, adults not in breeding condition might remain in salt water, where we did not survey.

Several factors lend uncertainty to our population estimate. As discussed, our estimates for much of the breeding grounds were derived from densities in adjacent areas. Also, the boundaries and degree of overlap of breeding ranges of the eastern and western Arctic populations of King Eider have only been partially delineated. Another uncertainty is the visibility correction factor of 1.31 that we used to calculate our population estimate. It has a large 95% confidence interval (0.80–1.83), indicating that more intensive sampling is needed to obtain a more reliable correction factor. Also, this correction factor should be considered a minimum, as, even at half the survey speed, not all birds would be detected from an aircraft. Further work by JEH in 1994 indicated that 1.31 is probably low and that the actual correction factor might be as much as twice that value.

We suspect that our population estimate was biased downward owing to the tendency of male King Eiders to leave the nesting area within a few days of the start of incubation (Lamothe 1973). In the last days of our surveys, males from the earliest nesting pairs may have already left the nesting grounds. Because females are not included in the breeding population calculation, departure of the males has a direct effect on the population estimate. We assessed the degree to which this might have affected our counts using Lamothe's (1973: Fig. 5) data on the changing social composition of a group of King Eiders in a wetland on Bathurst Island. We plotted the change in the number of lone males (males not accompanied by females) in the study area on Bathurst Island as the nesting season advanced (Fig. 7). Using the mean date of clutch initiation (Lamothe 1973; Cotter et al., this publication) as a reference point for differences in timing of nesting between years and regions, we overlaid on the graph the timing of our surveys on Banks and Victoria islands. We were unable to examine the timing of surveys relative to nesting phenology on the mainland, because we had no data on the timing of nest initiation for that area.

The count most affected by timing of the surveys was the east coast stratum on Banks Island in 1993. This survey was conducted 14–16 days after the mean date of clutch initiation, at a time when males on Bathurst Island would have already departed from the nesting grounds (Fig. 7). The high proportion of lone females observed in

Table 5
Approximate estimate of breeding population of King Eiders in the western Canadian Arctic

Location	Adjusted population size	Source
Yukon Coastal Plain	0	Dickson et al. (1988) Hawkings (1987) Salter et al. (1980)
Mackenzie Delta	100	This study
Tuktoyaktuk Peninsula	3 700	This study
Cape Bathurst to Keats Point	2 500	This study
Keats Point to Kent Peninsula	10 000	Barry (1986) Bromley and Stenhouse (1994) Ellis (1956) McEwen (1957)
Queen Maud Gulf Migratory Bird Sanctuary[a]	19 400	Alisauskas (1992)
Banks Island[b]	42 600	This study
Victoria Island[c]	150 200	This study
Total	228 500	

[a] Applied a visibility correction factor of 1.31 to Alisauskas's (1992) unadjusted estimate of 11 949 (95% CL of 3116) in 1990 and 17 674 (95% CL of 5582) in 1991 for Queen Maud Gulf Migratory Bird Sanctuary.

[b] Multiplied the weighted average density of King Eiders for all Banks Island strata (0.54 eiders/km^2) by the area of Banks Island outside the study area (31 751 km^2), added 15 400 eiders, then applied a visibility correction factor of 1.31.

[c] Multiplied the weighted average density of King Eiders for all Victoria Island strata (0.48 eiders/km^2) by the area of Victoria Island outside the study area (134 541 km^2), added 50 100 eiders, then applied a visibility correction factor of 1.31.

the east coast stratum (31% of observations, compared with 1–2% elsewhere in the study area) is another indication that the surveys in that area were conducted too late in the nesting season to get an accurate breeding pair count. Thus, our estimate of 1100 King Eiders nesting on the east side of Banks Island is likely considerably lower than the actual number.

Our population estimate was based on only one year of surveys in parts of the study area, with a maximum of three years of surveys in other areas. Several years of data are needed for an accurate population estimate owing to the natural annual variability in the size of Arctic breeding populations. Factors such as spring weather, abundance of predators (particularly the Arctic fox *Alopex lagopus*), and abundance of alternative prey (e.g., lemmings) all affect the distribution, breeding effort, and reproductive success of Arctic nesting birds (Barry 1962; Lamothe 1973; Pehrsson 1986; Dickson 1992), which in turn affect the annual breeding population estimate (Coulson 1984; Bromley et al. 1995).

It is unknown why there were more small flocks of eiders on Victoria Island in 1994 than in the previous two years. They were unlikely to be immature birds, as the males are easily identified and as most immature King Eiders do not usually migrate as far as the nesting grounds (Palmer 1976; this study). They were probably not birds waiting to move to breeding areas farther north or east, because spring thaw was early in 1994. Feeding areas on the migration route and nesting grounds were available earlier, so that birds should have had adequate energy reserves for egg production. The presence of just as many breeding pairs in 1994 as in the previous two years also suggests that breeding conditions were favourable. These extra flocks might have been an influx of an unusually large number of first-time breeders. Common Eider *Somateria mollissima* first-year breeders tend to nest late, and a greater proportion do not nest at all (Baillie and Milne 1982). The flocks might also have been breeders that lost their eggs early. Regardless of why the flocks were there, their presence elevated our population estimate, as flocks are easier to detect than nesting pairs (Bromley et al. 1995). Until we know much more about the factors influencing the size, detectability, and distribution of the eider breeding population each year, multiyear surveys are our only means of obtaining an accurate impression of the breeding population size.

On Victoria Island, the lone drake index never rose above 0.64, or about three males without females for every two males in pairs. This could be interpreted in two ways. Each year, a substantial proportion of the adults might not have nested. Coulson (1984) noted that as many as 65% of Common Eiders did not breed in a given year. He linked nonbreeding to poor body condition and suggested that it was a strategy for survival in ducks that are long-lived. The low lone drake index might have also been due to early departure of males from the nesting grounds. If males departed at a rate similar to the rate of disappearance of females onto nests, the ratio of lone males to pairs would not rise as noticeably as if the males remained on the nesting grounds throughout the nest initiation period. Lamothe (1973) noted that males on Bathurst Island left the nesting area within a few days of the start of incubation. We saw few flocks of males and none with more than four birds, which suggests that they were gathering for moult migration on marine waters outside the study area.

5.0 Conclusions and recommendations

The systematic aerial surveys conducted during this study provide information on the distribution of King Eiders on their nesting grounds in the western Canadian Arctic. They also provide a benchmark for monitoring King Eider population trends in future years. However, much work is needed to obtain a more reliable breeding population estimate for the western Arctic King Eider. Systematic aerial surveys have been conducted only in about half of their breeding range. Unsurveyed areas include the mainland between Keats Point and Queen Maud Gulf, northern Banks Island, eastern Victoria Island, and the western High Arctic islands. A more accurate visibility correction factor with tighter confidence limits (CL) than those obtained on Banks Island should be developed. A study of the changing composition of the King Eider population as the nesting season progresses is needed on Banks and Victoria islands to determine the degree to which early departure of males is affecting the population estimate. A study is also needed to clarify the eastern and northern limits of the breeding range of the King Eiders that winter west of the continent. Fortunately, the King Eider is a relatively easy species to detect from an aircraft, because of the bright black and white plumage of the male. It is also relatively easy to count with

Figure 6
Eastern and northern limits of the breeding range assumed in estimating the size of the western Arctic population of King Eiders breeding in Canada

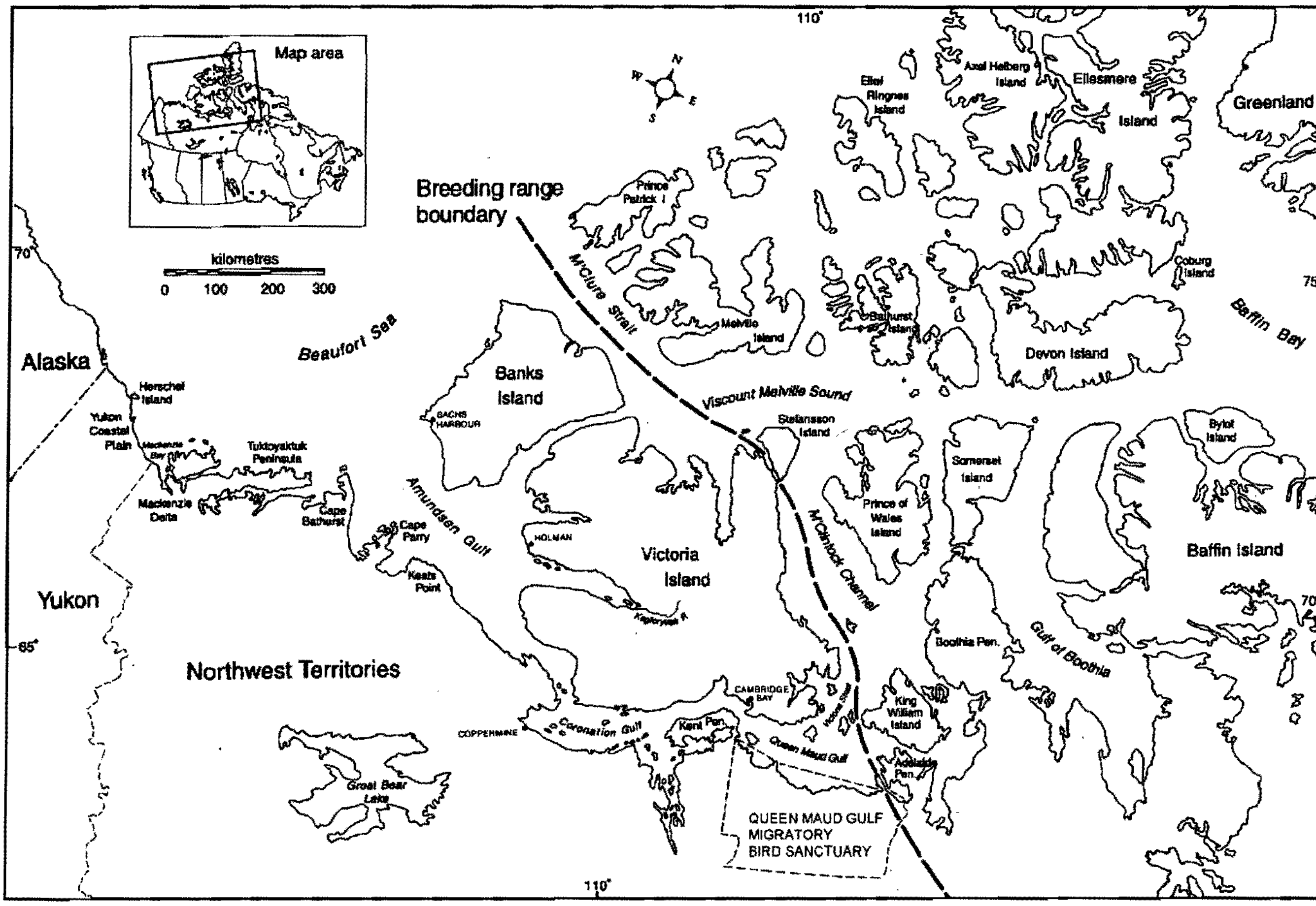
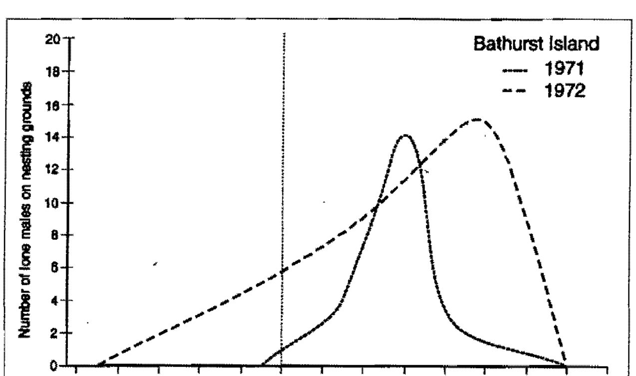


Figure 7
Timing of our surveys relative to timing of departure of males from nesting grounds. Timing of departure of males is based on data from Bathurst Island (Lamothe 1973). The mean date of clutch initiation was used as a reference point for timing differences between years and areas.



accuracy, because it tends to nest in a dispersed manner, rather than in clumps. However, without the above-mentioned studies, our population estimate will remain largely speculative.

Acknowledgements

We would like to thank Beth Cornish, David Kay, Mark Kornder, and Susan Westover for their assistance with the aerial surveys; Dale Caswell and Bruce Turner for helpful suggestions on interpretation of the results; and Sam Barry for statistical advice. An anonymous reviewer provided many useful comments.

The study was funded jointly through the Inuvialuit Final Agreement, Canadian Wildlife Service, and Polar Continental Shelf Project. Special thanks to the staff of the Polar Continental Shelf Project for their assistance with logistics.

Literature cited

Alisauskas, R.T. 1992. Distribution and abundance of geese in the Queen Maud Gulf Migratory Bird Sanctuary. Unpubl. Prog. Rep. for the Arctic Goose Joint Venture, Canadian Wildlife Service, Saskatoon. 8 pp. (Available from Canadian Wildlife Service, Prairie Migratory Research Centre, 115 Perimeter Road, Saskatoon, SK S7N 0X4.)

Allen, D.L. 1982. Bird migration and nesting observations, western Victoria Island, NWT, June, 1980. Unpubl. rep., Can. Wildl. Serv., Yellowknife. 61 pp. (Available from Environment Canada Library, Rm. 200, 4999–98 Avenue, Edmonton, AB T6B 2X3.)

Anonymous. 1987. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys in North America. U.S. Fish and Wildlife Service, Washington, D.C., and Canadian Wildlife Service, Ottawa.

Baillie, S.R.; Milne, H. 1982. The influence of female age on breeding in the eider *Somateria mollissima*. Bird Study 29:55–66.

Barry, T.W. 1960. Waterfowl reconnaissance in the western Arctic. Arct. Circle 13(4):51–58.

Barry, T.W. 1962. Effects of late seasons on Atlantic Brant reproduction. J. Wildl. Manage. 26(1):19–26.

Barry, T.W. 1968. Observations on natural mortality and native use of eider ducks along the Beaufort Sea coast. Can. Field-Nat. 82:140–146.

Barry, T.W. 1986. Eiders of the western Canadian Arctic. Pages 74–80 *in* A. Reed (ed.), Eider ducks in Canada. Can. Wildl. Serv. Rep. Ser. No. 47, Ottawa.

Beyer, W.H. 1968. Handbook of tables for probability and statistics. 2nd edition. The Chemical Rubber Co., Cleveland, Ohio.

Bromley, R.G.; Stenhouse, G.B. 1994. Cooperative central Arctic waterfowl surveys, 1989–1991. File Rep. No. 112, Government of the Northwest Territories, Yellowknife. 47 pp. (Available from Library, Government of the Northwest Territories, Yellowknife, NT X1A 2L9.)

Bromley, R.G.; Heard, D.C.; Croft, B. 1995. Visibility bias in aerial surveys relating to nest success of arctic geese. J. Wildl. Manage. 59(2):364–371.

Caughley, G. 1977. Sampling in aerial survey. J. Wildl. Manage. 41(4):605–615.

Cochran, W.G. 1977. Sampling techniques. 3rd edition. John Wiley & Sons, Toronto.

Coulson, J.C. 1984. The population dynamics of the Eider Duck *Somateria mollissima* and evidence of extensive non-breeding by adult ducks. Ibis 126:525–543.

Dickson, D.L. 1992. The Red-throated Loon as an indicator of environmental quality. Can. Wildl. Serv. Occas. Pap. No. 73, Ottawa. 17 pp.

Dickson, D.L.; Dickson, H.L.; Aiudi, G.M. 1988. Bird surveys at Stokes Point and Phillips Bay, Yukon in 1983. Can. Wildl. Serv. Tech. Rep. Ser. No. 40, Prairie & Northern Region, Edmonton. 117 pp.

Ellis, D.V. 1956. Observations on the migration, distribution and breeding of birds in the Canadian Arctic during 1954 and 1955. Dan. Ornithol. Foren. Tidsskr. 50:207–230.

Fournier, M.A.; Hines, J.E. 1994. Effects of starvation on muscle and organ mass of King Eiders (*Somateria spectabilis*) and the ecological and management implications. Wildfowl 45:188–197.

Gasaway, W.C.; DuBois, S.D.; Reed, D.J.; Harbo, S.J. 1986. Estimating moose population parameters from aerial surveys. Biol. Pap. Univ. Alaska No. 22, University of Alaska Press, Fairbanks. 108 pp.

Gavin, A. 1947. Birds of Perry River District, Northwest Territories. Wilson Bull. 59(4):195–203.

Goudie, R.I.; Brault, S.; Conant, B.; Kondratyev, A.V.; Petersen, M.; Vermeer, K. 1994. The status of sea ducks in the north Pacific Rim: toward their conservation and management. Trans. North Am. Wildl. Nat. Resour. Conf. 59:27–49.

Hanson, H.C.; Queneau, P.; Scott, P. 1956. The geography, birds, and mammals of the Perry River Region, NWT. Arct. Inst. North Am. Spec. Publ. No. 3. 96 pp.

Hawkings, J. 1987. Population status of migratory waterfowl on the Yukon Coastal Plain and adjacent Mackenzie Delta. Can. Wildl. Serv. Tech. Rep. Ser. No. 28, Pacific & Yukon Region, Whitehorse. 65 pp.

Johnson, L.L. 1971. The migration, harvest and importance of waterfowl at Barrow, Alaska. MSc thesis, University of Alaska, Fairbanks. 87 pp.

Jolly, G.M. 1969. Sampling methods for aerial censuses of wildlife populations. East Afr. Agric. For. J. 34(Spec. Issue):46–49.

Kertell, K. 1991. Disappearance of the Steller's Eider from the Yukon–Kuskokwim Delta, Alaska. Arctic 44:177–187.

Kistchinski, A.A. 1973. Waterfowl in north-east Asia. Wildfowl 24:88–102.

Lamothe, P. 1973. Biology of King Eider (*Somateria spectabilis*) in a fresh water breeding area on Bathurst Island, Northwest Territories. MSc thesis, University of Alberta, Edmonton. 125 pp.

Manning, T.H.; Hohn, E.O.; Macpherson, A.H. 1956. The birds of Banks Island. Natl. Mus. Can. Bull. No. 143, Biol. Ser. No. 48, Ottawa. 144 pp.

McEwen, E.H. 1957. Birds observed at Bathurst Inlet, Northwest Territories. Can. Field-Nat. 71:109–115.

McLaren, M.A.; Alliston, W.G. 1981. Summer bird populations on western Victoria Island, Northwest Territories, July 1980. Unpubl. rep. by LGL Ltd. for Polar Gas Project. 147 pp. (Available from LGL Ltd., 22 Fisher Street, P.O. Box 280, King City, ON L7B 1A6.)

Palmer, R.S. (ed.). 1976. Handbook of North American birds. Waterfowl (Part 2), Vol. 3. Yale University Press, New Haven, Connecticut.

Parmelee, D.F.; Stephens, H.A.; Schmidt, R.H. 1967. The birds of southeastern Victoria Island and adjacent small islands. Natl. Mus. Can. Bull. No. 222, Biol. Ser. No. 78, Ottawa. 229 pp.

Pehrsson, O. 1986. Duckling production of the Oldsquaw in relation to spring weather and small-rodent fluctuations. Can. J. Zool. 64:1835–1841.

Pollock, K.H.; Kendall, W.L. 1987. Visibility bias in aerial surveys: a review of estimation procedures. J. Wildl. Manage. 51:502–510.

Salomonsen, F. 1968. The moult migration. Wildfowl 19:5–24.

Salomonsen, F. 1979. Thirteenth preliminary list of recoveries abroad of birds ringed in Greenland. Dan. Ornithol. Foren. Tidsskr. 73:191–206.

Salter, R.E.; Gollop, M.A.; Johnson, S.R.; Koski, W.R.; Tull, C.E. 1980. Distribution and abundance of birds on the Arctic Coastal Plain of northern Yukon and adjacent Northwest Territories, 1971–1976. Can. Field-Nat. 94(3):219–237.

Smith, T.G. 1973. The birds of the Holman Region, western Victoria Island. Can. Field-Nat. 87:35–42.

Snedecor, G.W.; Cochran, W.G. 1967. Statistical methods. 6th edition. Iowa State University Press, Ames, Iowa.

Sokal, R.R.; Rohlf, F.J. 1981. Biometry. The principles and practice of statistics in biological research. 2nd edition. W.H. Freeman & Company, New York.

Stehn, R.A.; Dau, C.P.; Conant, B.; Butler, W.I., Jr. 1993. Decline of Spectacled Eiders nesting in western Alaska. Arctic 46(3):264–277.

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

Zar, J.H. 1984. Biostatistical analysis. 2nd edition. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Common Eiders nesting in the western Canadian Arctic

Beth J. Cornish and D. Lynne Dickson

Abstract

The breeding range of the Pacific subspecies of the Common Eider *Somateria mollissima v-nigra* in Canada extends from the Yukon coast to Queen Maud Gulf and north to include Victoria and Banks islands. However, the distribution of these eiders within their breeding range is not well known. This report presents data collected during recent Canadian Wildlife Service bird surveys. In addition, we summarize historical records of nesting *S. m. v-nigra* in Canada.

Surveys were conducted between 1991 and 1993 on western Victoria Island, Banks Island, and a section of the mainland Arctic coast. On western Victoria Island, 762 Common Eider nests were recorded in 1992, with a mean clutch size of 3.93 ± 1.55 eggs; in 1993, 678 nests were found, with a mean clutch size of 3.59 ± 1.48 eggs. From nest counts and aerial surveys, a local population of 1300 breeding pairs was estimated in 1992, and 900 pairs were estimated in 1993. On Banks Island, an estimated 54 ± 193 Common Eiders were in the west coast stratum in 1992, and 373 ± 101 birds were found there in 1993. No Common Eiders were observed in the two other Banks Island strata. On the mainland coast between the Mackenzie Delta and Keats Point in 1991, there were an estimated 1251 ± 419 Common Eiders. About 85% of these birds were near Cape Parry.

Based on available records, the most important nesting areas for *S. m. v-nigra* are in Prince Albert Sound off western Victoria Island and along the south coast of Victoria Island. However, the data are scattered and incomplete, especially for eastern parts of the range. The entire breeding population of *S. m. v-nigra* in Canada has been estimated at 81 500 birds. In contrast, documented nest records represent only about 10% of this estimate. Furthermore, about 65 000 *S. m. v-nigra* have been observed migrating eastward in spring through Dolphin and Union Strait, yet fewer than 1000 nests have been recorded east of the strait.

Common Eiders nest primarily on small marine islands. Occasionally, they nest in mainland areas not far from the coast.

Most Common Eider nests that we recorded off western Victoria Island in 1992–1993 were in large colonies of more than 100 birds. However, in eastern sections of the breeding range, most observations of nesting Common Eiders were of individual pairs or small scattered groups. This suggests a more dispersed nesting behaviour for much of the population.

In 1992–1993, we observed several nests with more than seven Common Eider eggs, assumed to have been laid by more than one female. We also recorded eggs of other bird species laid in the same nest as Common Eider eggs. Possible factors involved in these laying phenomena are discussed.

Résumé

L'aire de reproduction au Canada des sous-espèces du Pacifique de l'Eider à duvet *Somateria mollissima v-nigra* s'étend de la côte du Yukon au golfe de la Reine-Maud et vers le nord jusqu'aux îles Victoria et Banks. Toutefois, la distribution de ces eiders dans leur aire de reproduction n'est pas bien connue. Ce rapport présente les données recueillies au cours de récents relevés d'oiseaux du Service canadien de la faune. Nous présentons également un résumé des données historiques concernant l'Eider à duvet au Canada.

Les relevés ont été effectués entre 1991 et 1993 dans la partie ouest de l'île Victoria, dans l'île Banks et dans une partie du littoral continental de l'Arctique. Dans le cas de la partie ouest de l'île Victoria, 762 nids d'Eiders à duvet ont été notés en 1992 et la ponte moyenne était de 3,93 ± 1,55 oeufs. En 1993, 678 nids ont été observés et la ponte moyenne était de 3,59 ± 1,48 oeufs. À partir des dénombrements de nids et des relevés aériens, on a estimé qu'il y avait en 1992 une population locale de 1 300 couples; l'estimation pour 1993 était 900 couples. On a estimé qu'il y avait en 1992 sur l'île Banks 54 ± 193 Eiders à duvet dans la strate de la côte ouest, et 373 ± 101 oiseaux ont été observés au même endroit en 1993. Aucun Eider à duvet n'a été observé dans les deux autres strates de l'île Banks. Dans la zone côtière continentale entre le delta du Mackenzie et Keats Point, la population estimée en 1991 était de 1 251 ± 419 Eiders à duvet. Environ 85 % de ces oiseaux se trouvaient près du cap Parry.

D'après les données enregistrées dont nous disposons, les zones de nidification les plus importantes de l'Eider à duvet sont dans la baie Prince-Albert au large de la partie ouest de l'île Victoria et le long de la côte sud de l'île Victoria. Toutefois, les données sont fragmentaires et incomplètes, surtout en ce qui concerne les parties est

de l'aire. L'ensemble de la population nicheuse d'Eiders à duvet au Canada a été évaluée à 81 500. Par contre, les données enregistrées concernant les nids représentent seulement 10 % de cette estimation. De plus, environ 65 000 Eiders à duvet ont été observés dans une migration printanière vers l'est, via Dolphin et le détroit Union, mais pourtant moins de 1 000 nids ont été observés à l'est du détroit.

Les Eiders à duvet font surtout leurs nids sur de petites îles océaniques. Parfois, ils font leurs nids dans des zones continentales près de la côte.

La plupart des nids d'Eiders à duvet qui ont été observés au large de la partie ouest de l'île Victoria en 1992–1993 se trouvaient dans d'importantes colonies de plus de 100 oiseaux. Toutefois, dans les parties est de l'aire de reproduction, la plupart des Eiders à duvet observés étaient en couples isolés ou en petits groupes dispersés. Il faut croire que pour la plus grande partie de la population, le regroupement ne fait pas partie des habitudes de reproduction.

En 1992–1993, nous avons observé plusieurs nids d'Eiders à duvet qui comptaient plus de sept oeufs et on a supposé que ces oeufs ne provenaient pas tous de la même femelle. Nous avons noté également des cas d'oeufs d'autres espèces pondus dans le même nid que les oeufs d'Eiders à duvet. On aborde dans la discussion les facteurs qui pourraient être à l'origine de ce phénomène.

1.0 Introduction

The Pacific subspecies of the Common Eider *Somateria mollissima v-nigra* nests along the Arctic coastline from Alaska east to Queen Maud Gulf and on Banks and Victoria islands (Palmer 1976; Barry 1986; Johnson and Herter 1989) (Fig. 1). Because these birds are often found in large aggregations, they are particularly vulnerable to human or industry-related disturbances. However, detailed information on the distribution and abundance of Common Eiders in the western Canadian Arctic during the nesting season is fragmented and incomplete. A better understanding of nesting distribution and habits would allow protection of critical nesting areas.

The objective of this report is to present data on *S. m. v-nigra* nesting distribution, habitat use, chronology, and clutch size collected during recent Canadian Wildlife Service bird studies on western Victoria Island, Banks Island, and a section of the mainland coast. We also summarize available information from both published and unpublished sources on the breeding distribution of *S. m. v-nigra* throughout its range in Canada.

2.0 Methods

2.1 Western Victoria Island surveys, 1992–1993

Aerial surveys for Common Eiders in Prince Albert Sound, Minto Inlet, and Prince of Wales Strait were conducted using a Bell 206 helicopter at 35 m above ground level (agl) on 3–6 July 1992 and on 2–5 July 1993 (Fig. 1). To calculate indicated number of breeding pairs, we assumed that each adult male signified one breeding pair (Lock 1986).

If we saw large numbers of eiders near an island during the aerial surveys, an intensive ground search for nests was subsequently carried out. Clutch size and amount of down in each nest were recorded. The latter was used as an indication of stage of nesting. In Common Eiders of the eastern Canadian Arctic *Somateria mollissima borealis*, a full complement of down is usually not observed until after the laying of the third egg, which is also when incubation is commenced by most females (Cooch 1965). Nests with recent down but no eggs were listed as predated and included in the total nest count.

2.2 Banks Island surveys, 1992–1993

Information on Common Eider distribution on Banks Island was collected during systematic surveys for Black Brant *Branta bernicla nigricans* in 1992 and 1993 (Cotter et al. 1993, 1994). Aerial surveys were flown on 16–28 June 1992 and on 11 June – 1 July 1993, using a Bell 206B helicopter at an altitude of 45 m agl. The study area was divided into three strata based on topography (west coast — 12 436 km^2; inland — 8978 km^2; and east coast — 7000 km^2, 1993 only) (Fig. 1). A series of transects each 50 km in length was flown in each stratum. Transects were 5 km apart in the west coast stratum and 10 km apart in the east coast and inland strata. All birds within 200 m of each side of the aircraft were recorded. Preliminary population estimates for Common Eiders in each stratum were extrapolated from observed densities (Snedecor and Cochran 1967; Jolly 1969).

Ground checks of Black Brant colonies on Banks Island were conducted on 13 June and 1, 5, and 9 July 1993. Clutch size and hatching data were recorded for Common Eider nests encountered within the Black Brant colonies. Only colonies that contained Black Brant nests were investigated. Therefore, these observations do not represent thorough coverage of all areas potentially supporting Common Eider nests on Banks Island.

2.3 Mainland coast surveys, 1991–1993

Aerial surveys of waterfowl were conducted along the mainland Arctic coast from 1991 to 1993 (Hines et al. 1992). In 1991, the study area extended from the Yukon north coast to Keats Point (Fig. 1); in 1992 and 1993, only areas west of Cape Bathurst were surveyed. North–south transects 10 km apart were flown using a Bell 206L helicopter at 45 m agl, between 11 and 21 June each year. One observer on each side of the helicopter recorded all birds observed within 200 m of the aircraft. Population estimates were calculated by extrapolation from observed densities (Jolly 1969).

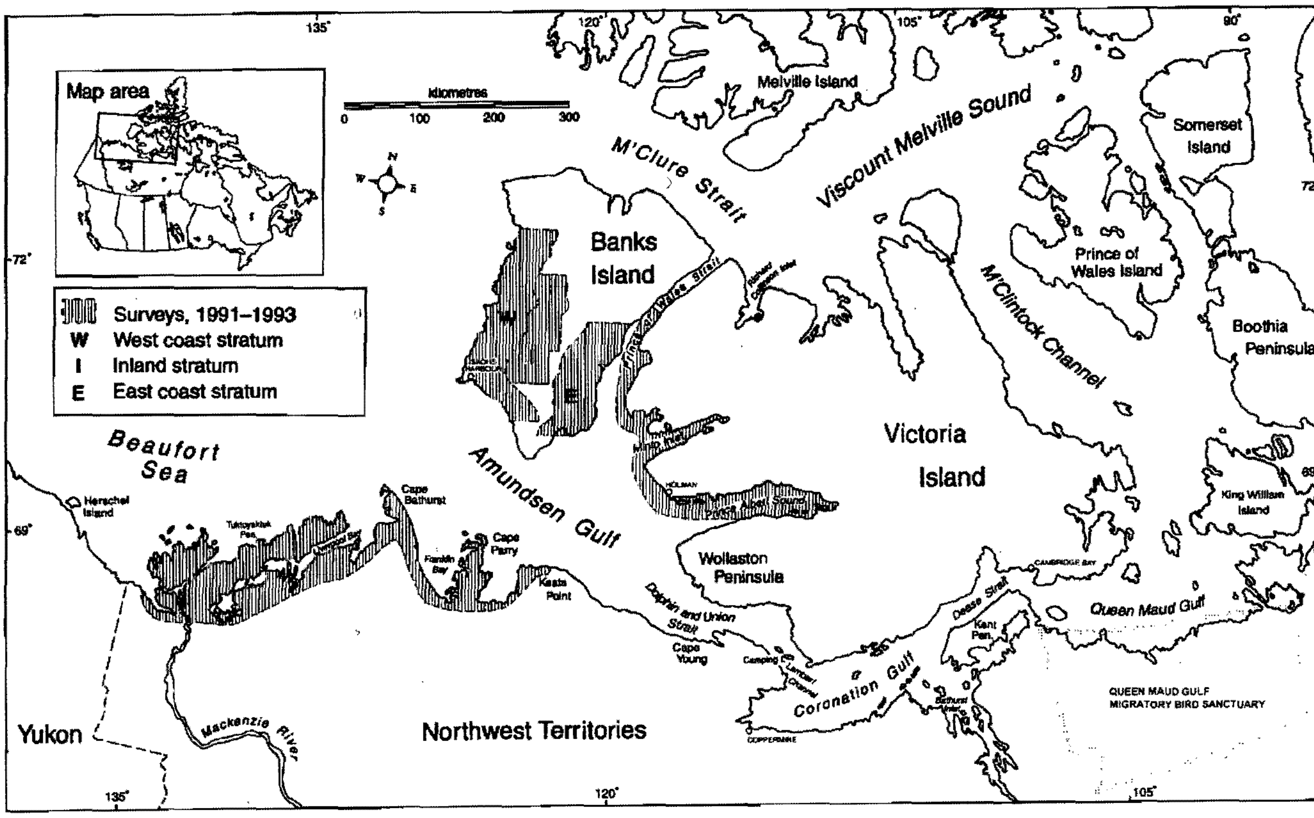
3.0 Results

3.1 Surveys

3.1.1 Western Victoria Island, 1992–1993

3.1.1.1 Nesting distribution. Common Eiders were nesting on 13 of the 43 islands surveyed off the coast of western Victoria Island in 1992 and 1993 (Table 1; Fig. 2). Seven of the islands supported nesting Common Eiders in 1992 but not in 1993, and two new sites were discovered in

Figure 1
Location of the study areas of three Canadian Wildlife Service waterfowl surveys conducted in 1991–1993



1993. Only four islands had colonies in both years. In both years, three colonies in Prince Albert Sound accounted for over 90% of all nests discovered. In 1992, we found 762 nests, of which 67 had been destroyed by predators (Table 1). In total, 678 nests were counted in 1993, including 137 predated nests.

The three colonies with the greatest number of nests were on small islands less than 5 ha in size. These islands were covered with gravel or boulders, with little vegetation or relief. Many nests were located on exposed gravel substrates, but the limited areas of vegetation generally supported the greatest densities of nests. For example, in one small vegetated area 4 m in diameter, 16 nests were found. Occasionally, nests were so close that they were touching.

Common Eiders frequently nested in association with other bird species, especially Glaucous Gulls *Larus hyperboreus* and Black Brant. There were 10–17 Glaucous Gull nests at each of the three major Common Eider colonies. In 1992, a total of 18 Black Brant nests were found at three Common Eider colonies; in 1993, there were nine Black Brant nests at two sites.

Sixteen nests contained both Common Eider and Black Brant eggs (Table 2). Although the female was not always observed leaving the nest, the type of nest down indicated that 14 of these nests were probably tended by Common Eider females, and two by Black Brant.

3.1.1.2 Nesting chronology. Incubation was under way at most nests in Prince Albert Sound at the time of our ground surveys. In both years, over 80% of nests had a full complement of down, and many females on nests were reluctant to flush.

Egg laying was likely initiated later at locations north of Prince Albert Sound. In early July of both years, Minto Inlet was almost completely ice-bound, and there was very little open water at Ramsay Island. When the most northern site, Princess Royal Islands, was checked on 5 July 1993, only two nests with eggs were found, and these contained very little down. On 26 July 1992 at this site, 13 nests with eggs were recorded, most with a full complement of down. Also, the ratio of nests counted to breeding pairs observed was greater in Prince Albert Sound than in Minto Inlet or Prince of Wales Strait (Table 3). In Prince Albert Sound, especially the eastern part, some males had apparently already begun to depart on their moult migration. At the same time, north of Prince Albert Sound, there were a large number of indicated pairs but few nests.

3.1.1.3 Clutch size. The mean clutch size for the 695 intact Common Eider nests found off western Victoria Island in 1992 was 3.93 ± 1.55 eggs, and the mode was three eggs (Table 1). In 1993, mean clutch size for 541 nests was 3.59 ± 1.48 eggs, with a mode of four eggs.

Clutches of eight or more eider eggs, up to 14 eggs in two cases, were assumed to have been laid by more than one female (Bellrose 1976). These clutches occurred only in the larger colonies with more than 100 nests, primarily in areas with a high density of nests, and often

Table 1
Number of Common Eider nests and clutch size distribution at sites off western Victoria Island and Banks Island, 1992 and 1993

Site[a]	No. of nests with eggs	Clutch size 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Mean ± SD[b]	Predated nests	Total nests
Victoria Island, 1992																		
28	13	3	5	3	2											2.31 ± 1.03	17	30
29	4			2		2										4.00 ± 1.15	3	7
30	2															n.d.[c]	0	2
31	0															–	2	2
32	2			1	1											3.50 ± 0.71	0	2
33	5	1		2		1	1									3.60 ± 1.95	0	5
34	1					1										5	1	2
35	180	8	34	47	48	24	13	2	2	1			1			3.75 ± 1.57	11	191
36	304	4	73	81	41	25	16	11	6	3	2	1		1	1	3.54 ± 2.06	15	319
38	181	1	14	23	31	36	20	11	10	13	3	4	3	2	1	5.27 ± 2.71	5	186
39	3	2				1										2.33 ± 2.31	13	16
All	695	6	126	159	123	90	50	24	18	17	5	5	4	3	2	3.93 ± 1.55	67	762
Victoria Island, 1993																		
28	2		1	1												2.50 ± 0.71	5	7
35	262	1	47	69	78	28	13	8	1	2	1		1			3.68 ± 1.58	1	263
36	87	2	26	19	12	7										2.47 ± 1.24	128	215
37	20	2	1	2	6	7	1	1								4.10 ± 1.52	0	20
38	136	7	27	23	32	16	9	11	4	3		2	1	1		4.23 ± 2.30	0	136
40	34	1	9	6	13	3	1	1								3.44 ± 1.31	3	37
All	541	4	111	120	141	61	24	21	5	5	1	2	2	1		3.59 ± 1.48	137	678
Banks Island, 1993																		
25	4		1		1	1						1				5.50 ± 3.87	n.d.	4
26	8			1	1	1	3	2								5.50 ± 1.41	n.d.	10[d]
27	1		1													2	n.d.	1
All	13		2	1	2	2	3	2				1				5.23± 2.42		15

[a] Site locations shown on Figures 2 and 3.
[b] SD = standard deviation.
[c] n.d. = no data.
[d] Includes two nests that had already hatched.

within 0.5 m of another nest. In total, 54 parasitized nests with eggs assumed to have been laid by more than one eider were recorded in 1992, and 16 in 1993 (Table 1).

3.1.1.4 Numbers of breeding pairs. In our preliminary aerial surveys off western Victoria Island, most Common Eiders occurred in the western part of Prince Albert Sound. Based on observed numbers of adult males, approximately 900 indicated breeding pairs utilized west Prince Albert Sound in 1992, and about 600 in 1993 (Table 3). We counted about 500 nests in this area each year.

Using the largest values obtained from nest counts or aerial survey results, we estimate that a minimum of 1300 breeding pairs of Common Eiders utilized Prince Albert Sound and the western coastal areas north of Holman in 1992, compared with an estimated 900 breeding pairs in 1993 (Table 3).

3.1.2 Banks Island, 1992–1993

Three sites with nesting Common Eiders were recorded on Banks Island in 1993 (Table 1), with a total of 15 Common Eider nests (R. Cotter, unpubl. data). The sites were all located inland, but within 4 km of the nearest coast. All were on islands, in ponds or lakes.

Hatching was observed from 5 to 9 July, which suggests that nesting chronology at Banks Island was two to three weeks ahead of that on western Victoria Island. Clutch size at the Banks Island sites was 5.23 ± 2.42 (n = 13; range: 2–11) (Table 1).

Totals of 44 and 30 Common Eiders were recorded in the west coast stratum in 1992 and 1993, respectively. Most were within 12 km of the coast (73% in 1992, and 90% in 1993). However, the birds occurred up to 46 km inland. Extrapolating from observed densities, population estimates of Common Eiders in the west coast stratum were 547 ± 193 birds in 1992 and 373 ± 101 birds in 1993. No Common Eiders were observed on transects during surveys of the other two strata on Banks Island in either 1992 or 1993.

3.1.3 Mainland, 1991–1993

There were an estimated 1251 ± 419 Common Eiders on the mainland study area in mid-June 1991, 85% of which were in the Cape Parry area (J. Hines, Canadian Wildlife Service, unpubl. data). The 1992 and 1993 study areas did not include Cape Parry. No Common Eiders were recorded in 1992. However, in 1993, the area from Cape Bathurst westward had 231 ± 147 Common Eiders, primarily (70%) near Cape Bathurst.

3.2 Summary of nesting records

3.2.1 Nesting distribution

Records from known *S. m. v-nigra* nesting sites in the Canadian Arctic are summarized in Table 4 and Figure 3.

Figure 2
Common Eider nesting sites off western Victoria Island, 1992–1993

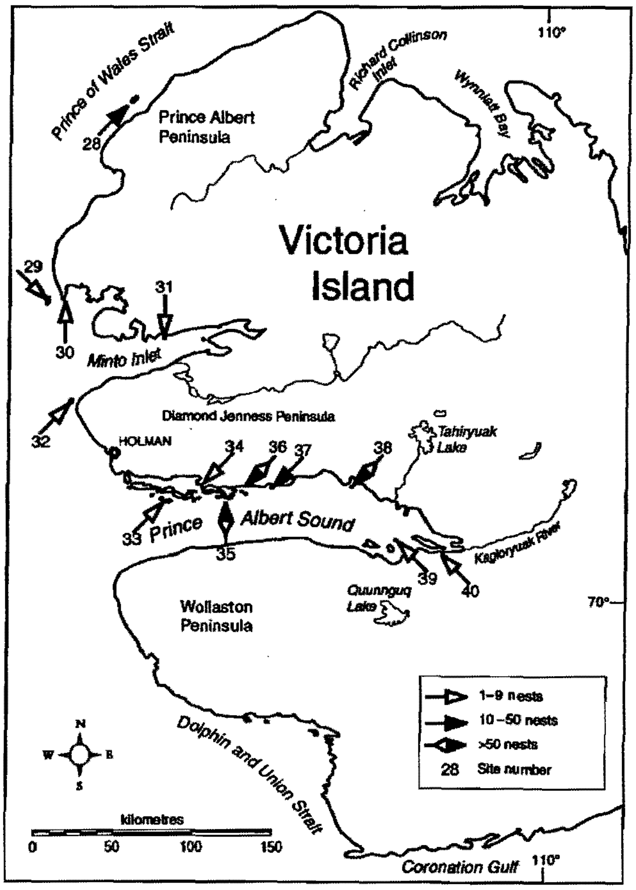


Table 2
Occurrence of Common Eider and Black Brant eggs in the same nests at sites off western Victoria Island, July 1992 and 1993

	No. of eggs		
No. of nests	Common Eider	Black Brant	Type of down
5	1	3, 3, 4, 4, 6	3 eider, 2 brant
2	2	3	eider
1	3	1	eider
2	4	2, 3	eider
2	5	3, 5	eider
1	7	4	eider
2	8	2	eider
1	9	2	eider
Total 16	62	45	14 eider, 2 brant

3.2.1.1 Yukon coast to Keats Point (including nearshore islands). Common Eiders nest in small numbers along the Yukon coast, on coastal spits and barrier islands (Table 4; Fig. 3) (Hawkings 1987). A maximum of 34 nests has been documented on or near Nunaluk Spit (Site 1), but recent observations suggest that more than three times that number may nest there each year (A. Tardiff, Herschel Island Territorial Park Ranger, pers. commun.).

The only Common Eider nests that have been recorded on the Mackenzie River delta were on an island in Kidluit Bay (Site 6) on the east side of the delta (Alexander et al. 1988). East of the Mackenzie Delta, researchers have located several colonies of fewer than 30 nests on islands off Tuktoyaktuk Peninsula (Sites 7–16) (DLD, unpubl. data; Alexander and Hawkings 1988), near Harrowby Bay (Site 19), and on the Baillie Islands (Site 20) (Alexander et al. 1988) (Table 4; Fig. 3). Historically, Liverpool Bay (Site 18) was a major breeding area, and over 1000 eggs were collected by MacFarlane (1891). Also, based on observations made in 1912, Anderson (1937) described large colonies on sandspit islands near Cape Dalhousie (Site 17) and south of Cape Bathurst near the old Horton River mouth, in Franklin Bay (Site 21). These colonies are now much reduced (Barry 1986). Substantial numbers of nesting Common Eiders utilize the Cape Parry area (Site 22) in most years (Barry 1986). Ward (1979) estimated that a minimum of 50 pairs nested there in 1978 based on brood counts.

3.2.1.2 Banks Island. Historical and recent nest records for Banks Island were restricted to the south and west coasts. The largest colony recorded (about 250 Common Eider nests in 1953) was at Moose Island (Site 23), about halfway up the west coast of Banks Island (Manning et al. 1956) (Table 4; Fig. 3). There are no records of breeding north of the Moose Island colony.

3.2.1.3 Victoria Island (except south shore). Based on both historical and recent research, the largest colonies of nesting Common Eiders off Victoria Island, excluding the southern coast, were on islands in Prince Albert Sound (Sites 33–40) (Table 4; Fig. 3). Barry and Barry (1982) counted 600–700 nests in total at two colonies in western Prince Albert Sound in 1981, and we recorded similar numbers in 1992 and 1993 (Table 1). At the southeast end of Prince Albert Sound, a colony of 73 nests was observed in 1980 by McLaren and Alliston (1981); in 1992–1993, we found two eider colonies (with a total of fewer than 40 nests) in the same area and a third larger colony near the northeast shore. North of Prince Albert Sound, we recorded few Common Eider nests in 1992–1993. However, Barry et al. (1981) noted numerous crèches of young in Minto Inlet in mid-August 1980.

We found no documented records of Common Eiders nesting off the north or northeast coasts of Victoria Island (Fig. 3). No Common Eiders were observed during our surveys in Richard Collinson Inlet in 1992 or 1993 (Dickson and Cornish 1993, 1994). However, Allen (1982) recorded 24 Common Eiders during aerial surveys there in June 1980.

3.2.1.4 Keats Point to King William Island, and southern Victoria Island. There are relatively few recent records of nesting Common Eiders east of Keats Point, except in Dolphin and Union Strait and on the south side of Kent Peninsula. On an island in Dolphin and Union Strait, McLaren and Alliston (1981) counted a minimum of 319 nests in 1980 (Site 43) (Table 4; Fig. 3). During goose studies near the south shore of Kent Peninsula in the late 1980s and early 1990s, R. Bromley (N.W.T. Wildlife Service, pers. commun.) recorded a Common Eider colony that supported up to 75 pairs in some years (Site 47). Bromley also noted several smaller colonies, with a total of up to 100 Common Eider nests, on low islands in

Table 3
Number of breeding pairs of Common Eiders off western Victoria Island, based on aerial surveys in 1992 and 1993

Location[a]	Year	Survey dates	No. of pairs observed	No. of adult males observed	Indicated breeding pairs[b] (A)	No. of nests counted (B)	Estimated no. of breeding pairs[c]
West Prince Albert Sound	1992	1, 3, 4 July	432	419	851	517	900
(Sites 33–37)	1993	2, 3 July	489	93	582	498	600
East Prince Albert Sound	1992	5 July	26	33	59	202	200
(Sites 38–40)	1993	3, 4 July	117	12	129	173	200
Southwest of Minto Inlet to							
Prince of Wales Strait	1992	6, 26 July[d]	86	90	176	43	200
(Sites 28–32)	1993	5 July	25	26	51	7	100
Totals — entire area	1992		544	542	1086	762	1300
	1993		631	131	762	678	900

[a] Site numbers refer to Figure 2.
[b] Calculated from number of observed pairs plus males.
[c] Using the greatest value of (A) or (B) each year; total rounded to nearest hundred.
[d] Site 28 (Princess Royal Islands) surveyed on 26 July 1992.

southern Melville Sound (Site 48) and a few scattered individual nests farther east, in Elu Inlet (Site 49) (Fig. 3).

Nest records from Bathurst Inlet are limited to dispersed observations of individual nests or small clusters of nests (McEwen 1957). According to G. Warner (Bathurst Inlet Lodge, pers. commun.), hundreds of pairs of Common Eiders nest individually or in small groups scattered on islands throughout southern Bathurst Inlet.

Systematic aerial surveys were conducted along the northern inland and coastal areas of the Queen Maud Gulf Migratory Bird Sanctuary in June 1991 and 1992 (R. Alisauskas, Canadian Wildlife Service, pers. commun.). Many separate observations of Common Eider pairs were recorded, suggesting scattered use of this area for nesting. The total numbers of Common Eiders observed varied substantially between the two years, ranging from 100 in 1992 to almost 2000. Most observations were in the northwest part of the Queen Maud Gulf Migratory Bird Sanctuary, in Labyrinth Bay and Foggy Bay (Fig. 1).

Some nest records from decades ago have not been recently verified. For example, Camping, Little Camping, and Lambert islands in Lambert Channel at the east end of Dolphin and Union Strait (Fig. 1) were reported to be of major significance as nesting sites (Nettleship and Smith 1975), but neither Allen (1982) nor Barry and Barry (1982) found nests there in mid-June 1980 or early July 1981, respectively. Also, on the Finlayson Islands (Site 50) in Dease Strait, there was evidence of nesting in 1960. At that time, local Inuit reported that some of the islands were important egging areas (Table 4; Fig. 3) (Parmelee et al. 1967). It is unknown to what extent Common Eiders currently use these islands for nesting.

Jenny Lind Island (Site 51) in Queen Maud Gulf is the easternmost documented nesting site (Parmelee et al. 1967) (Table 4; Fig. 3). However, pairs have been seen as far east as the small islands southwest of King William Island (Gavin 1947; Fraser 1957).

The limited extent of current knowledge of *S. m. v-nigra* nesting distribution is apparent from Table 4. Based on records since 1950, and using the maximum number of nests counted each year, only about 2100 nests have been documented throughout the breeding range of these eiders.

3.2.2 *Clutch size*

Mean clutch size generally ranged from 2.5 to 5.5 eggs (Table 4), with 15 the largest reported clutch size (McLaren and Alliston 1981). These data were recorded at different stages of egg laying; therefore, the results from the many surveys may not be directly comparable.

4.0 Discussion

There is a paucity of information on the breeding distribution of the Pacific subspecies of the Common Eider in Canada. Spring migration counts suggest an Arctic breeding population of 70 000–95 000 birds (Woodby and Divoky 1982; Alexander et al. 1994; Suydam et al., this publication). Barry (1986) estimated a total of 81 500 breeding *S. m. v-nigra* in the western Canadian Arctic. In contrast, recent nest counts and breeding pair surveys account for fewer than 10 000 *S. m. v-nigra*. Surveys of the breeding grounds are particularly scarce east of Dolphin and Union Strait. An estimated 70 000 *S. m. v-nigra* migrate eastward through Dolphin and Union Strait in mid-June (Barry 1986). Alexander et al. (1994) counted over 64 000 Common Eiders staging in Lambert Channel in mid-June 1993. Presumably, many of these birds nest in Coronation and Queen Maud gulfs, yet few nesting records exist. A thorough investigation of the Coronation Gulf and Queen Maud Gulf areas is needed.

Common Eiders nest most frequently on coastal islands (Barry 1986) to avoid predation by Arctic foxes *Alopex lagopus*, which can quickly destroy hundreds of nests (Larsen 1960; Ahlen and Andersson 1970; Quinlan and Lehnhausen 1982). Nesting is usually delayed until ice contact with the nesting island is broken, providing further protection from marauding foxes (Ahlen and Andersson 1970; Schamel 1978; Gerell 1985; Barry 1986).

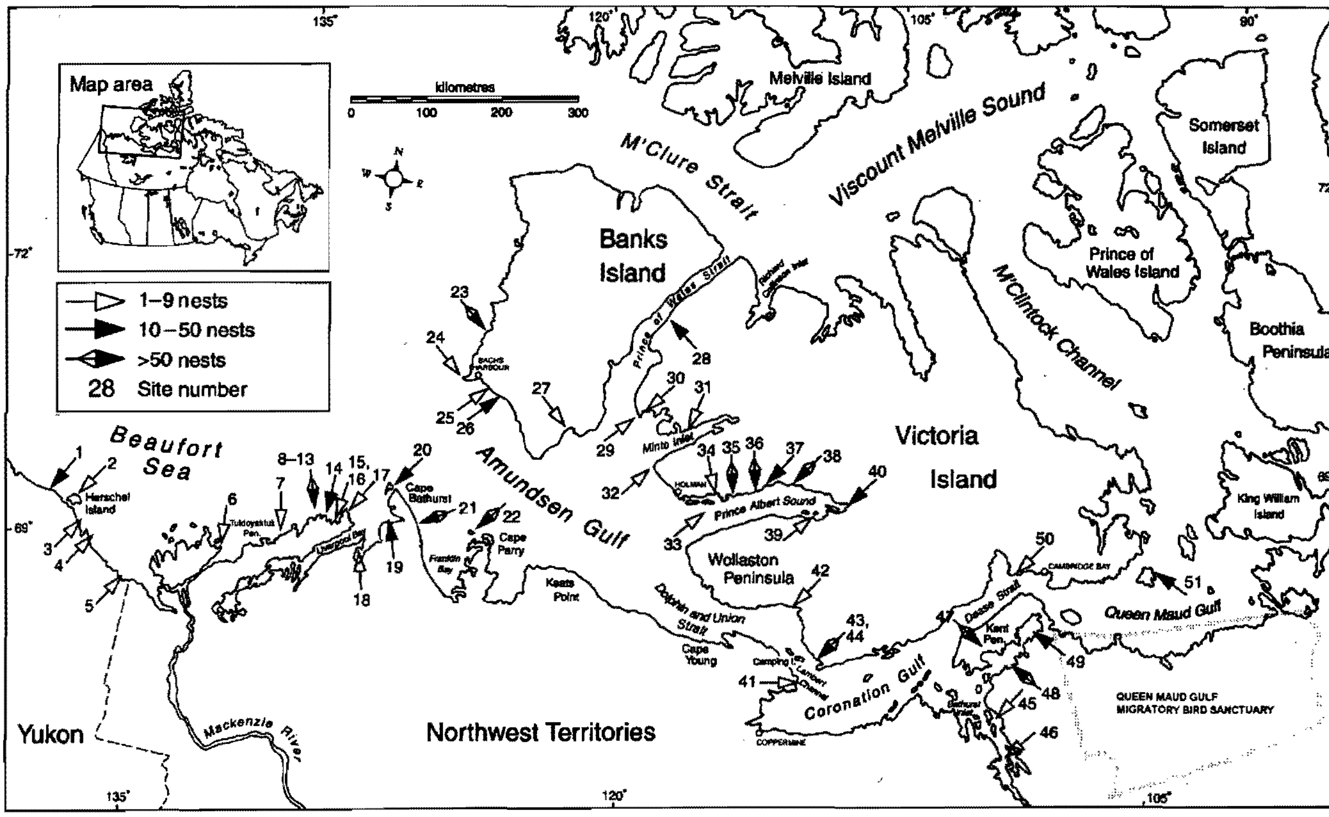
Smaller islands, which are less likely to support a resident fox, are more frequently utilized by nesting Common Eiders (Schmutz et al. 1983; Barry 1986;

Table 4
Common Eider nest records in the western Canadian Arctic

Site[a]	Location	No. of nests	No. of broods	Mean clutch size[b]	Survey years	Sources
Yukon coast to Keats Point						
1	Nunaluk Spit	9		3.55	1971	Schweinsburg (1974)
		5–34		–	1970s	Gollop and Richardson (1974) Vermeer and Anweiler (1975)
2	Herschel Island	7		4.86	1986	Talarico and Mossop (1986)
		6		–	1985	Ward and Mossop (1985)
3	Stokes Point	1		6	1983	Dickson et al. (1988)
4	Phillips Bay	10+		–	1986	Hawkings (1987)
5	Escape Reef	5		–	1962	Alexander et al. (1988)
		2		4.50	1987	Alexander and Hawkings (1988)
6	Kidluit Bay	5–25		–	1960–1980s	Alexander et al. (1988)
7	E. Hutchison Bay	7		3.33	1987	Alexander and Hawkings (1988)
8	W. Nuvorak Point	18		3.12 ± 1.67	1981	DLD (unpubl. data)
		12		–	1987	Alexander and Hawkings (1988)
9	W. Nuvorak Point	6		2.55 ± 1.00	1981	DLD (unpubl. data)
		3		–	1987	Alexander and Hawkings (1988)
10	W. Nuvorak Point	26		–	1987	Alexander and Hawkings (1988)
11	W. Nuvorak Point	16		–	1987	Alexander and Hawkings (1988)
12	Near Phillips Island	27		4.11 ± 0.83	1981	DLD (unpubl. data)
13	Near Phillips Island	9		5 (n = 1)	1981	DLD (unpubl. data)
14	S. Nuvorak Point	5–25		–	1960–1980s	Alexander et al. (1988)
15	Russell Inlet	3		–	1987	Alexander and Hawkings (1988)
		7		–	1981	DLD (unpubl. data)
16	Russell Inlet	2		–	1981	DLD (unpubl. data)
17	Cape Dalhousie	9		–	1987	Alexander and Hawkings (1988)
		Large colony		–	1912	Anderson (1937)
18	Near old Fort Anderson	Many[c]		–	1862–1866	MacFarlane (1891)
19	Harrowby Bay	5–25		–	1960–1980s	Alexander et al. (1988)
20	Baillie Islands	25		–	1971	Alexander et al. (1988)
21	Horton River mouth, Franklin Bay	Large colonies		–	1912	Anderson (1937)
22	Cape Parry		50	–	1979	Ward (1979)
Banks Island						
23	Moose Island	250		1–11	1953	Manning et al. (1956)
24	Cape Kellett	Many		–	1992	Traditional knowledge (R. Cotter, pers. commun.)
25	Near Sachs Harbour	4		5.50 ± 3.87	1993	R. Cotter (unpubl. data)
		5		3–5	1953	Manning et al. (1956)
26	Thesinger Bay	8	2	5.50 ± 1.41	1993	R. Cotter (unpubl. data)
27	Windrum Lagoon	1		2	1993	R. Cotter (unpubl. data)
		5		4–7	1952	Manning et al. (1956)
Victoria Island (except south shore)						
28	Princess Royal Islands	30		2.31 ± 1.03	1992	This study
		7		2.50 ± 0.71	1993	This study
29	Ramsay Island	7		4.00 ± 1.15	1992	This study
30	Berkeley Point	2		n.d.	1992	This study
31	Minto Inlet	2		Predated	1992	This study
			Many	–	1980	Barry et al. (1981)
32	SW of Minto Inlet	2		3.50 ± 0.71	1992	This study
33–37	Western Prince Albert Sound	517		3.25	1992	This study
		498		3.29	1993	This study
		600–700		3.71	1981	Barry and Barry (1982)
38–40	Eastern Prince Albert Sound	202		4.15	1992	This study
		173		3.64	1993	This study
		73		4.77	1980	McLaren and Alliston (1981)
Keats Point to King William Island, and southern Victoria Island						
41	Ivonayak Island	(indications)		–	1981	Barry and Barry (1982)
42	Simpson Bay	1		–	1911	Anderson (1913)
43	Austin Bay	>319		4.42 ± 2.25	1980	McLaren and Alliston (1981)
44	Lady Franklin Point	2		5.00	1980	McLaren and Alliston (1981)
45	Bathurst Inlet	3		5.33	1950	McEwen (1957)
46	Small islands near S. Quadyuk Island	1–10		2–7	1969–1984	G. Warner (Bathurst Inlet Lodge, pers. commun.)
47	Freshwater lake near Parry Bay	Up to 120		–	1980s, 1990s	R. Bromley (N.W.T. Wildlife Service, pers. commun.)
48	Hope Bay, Melville Sound	50–100		–	1980s, 1990s	R. Bromley (pers. commun.)
49	Elu Inlet	Up to 30		–	1980s, 1990s	R. Bromley (pers. commun.)
50	Finlayson Islands	1[d]		–	1960	Parmelee et al. (1967)
		Many		–	–	Traditional knowledge (Parmelee et al. 1967)
51	Jenny Lind Island	1		5	1962	Parmelee et al. (1967)

[a] Site numbers refer to Figure 3.
[b] Mean ± standard deviation.
[c] MacFarlane (1891) collected over 1000 eggs.
[d] Pair flushed from beside fresh scrape. Also, enlarged reproductive organs in another pair (collected) indicated egg laying was about to commence.

Figure 3
Reported Common Eider nesting sites in the western Canadian Arctic, based on observations from the 1890s to 1993



Nakashima and Murray 1988). This concurs with our findings in 1992–1993 on western Victoria Island, where all colonies with more than 100 nests were located on small islands less than 5 ha in size. A relative scarcity of suitable small coastal islands, as well as perpetual ice cover, may limit the breeding population in some areas of higher latitude, such as along the northern coasts of Banks and Victoria islands (Manning et al. 1956; Barry et al. 1981).

Although most nesting occurs on islands in marine areas, Common Eiders nest occasionally on islands in freshwater lakes. On Banks Island, nests were found up to about 4 km inland, and Common Eiders were observed up to 46 km inland during aerial surveys (R. Cotter, unpubl. data). R. Bromley (pers. commun.) observed Common Eider nests 6 km inland on Kent Peninsula. Colonies of the Northern subspecies of the Common Eider *Somateria mollissima borealis* have been noted up to 7 km inland (Chapdelaine et al. 1986).

Although most Common Eiders nesting on western Victoria Island occurred in colonies, in other parts of the breeding range, such as Bathurst Inlet and southwest Queen Maud Gulf, Common Eiders nested singly or in small groups. Thus, a substantial proportion of the *S. m. v-nigra* breeding population may be widely dispersed, especially in the eastern part of the range.

On Victoria Island, nesting began first on the south coast. At Lady Franklin Point in 1980, laying commenced in mid-June, and hatching began on 15 July (McLaren and Alliston 1981). Farther north, in eastern Prince Albert Sound, McLaren and Alliston (1981) determined that laying began up to three weeks later. In 1992–1993, we found incubation under way by early July in Prince Albert Sound and at least a week later in areas to the north. This assessment of nesting chronology is based on observations of the number of pairs in relation to the number of nests found and on the amount of down present in the nests.

In 1992, we estimated almost 200 indicated breeding pairs north of Prince Albert Sound, but we found only 43 nests in late July. Large numbers of old nest cups at the Princess Royal Islands in Prince of Wales Strait indicated heavy use by nesting eiders in years previous to 1992. Thus, many of the Common Eiders may not have nested in 1992. Spring thaw that year occurred about 10 days later than normal, which might have affected nesting effort and timing in the northernmost colonies.

At lower latitudes (~55°N), Coulson (1984) noted that up to 65% of adult Common Eiders with breeding experience failed to nest in a given year. As Common Eiders are long-lived (Palmer 1976), they can miss breeding in a year when adverse conditions make nesting a poor risk. For example, when female eiders are in poor condition, nesting may endanger their survival. Non-breeding in unfavourable years thus increases the chances that a bird will be alive to breed in a favourable year. This strategy serves to increase the bird's lifelong reproductive output (Coulson 1984). Climatic delays to onset of nesting are important factors that may result in nonnesting (Milne 1974; Barry et al. 1981).

Mean clutch sizes for Common Eiders on western Victoria Island (3.93 eggs in 1992 and 3.59 in 1993) were lower than recorded elsewhere. Palmer (1976) indicated that five eggs constituted the normal clutch for Common Eiders along northwestern Canadian coastal areas, whereas Bellrose (1976) reported an average clutch size of 4.25 eggs. Schamel (1977) calculated a mean clutch size of 5.3 ± 1.3 eggs (n = 39) for Common Eiders along the Alaskan Beaufort Sea coast.

Clutch size can vary dramatically between localities and between years in the same locality, depending on such factors as a late season (Milne 1974; Gerell 1985), condition of the breeding females (Coulson 1984), and the number of females nesting for the first time (Baillie and Milne 1982). However, in our western Victoria Island study area, partial predation was likely the most significant factor lowering mean clutch size. In 1993, at Site 36 in Prince Albert Sound, more than half of the total nests (n = 215) had been destroyed by predators, whereas at Site 35, only one of 263 nests had been predated (Table 1). Mean clutch size was 2.47 ± 1.24 eggs at Site 36 compared with 3.68 ± 1.58 eggs at Site 35. According to Ahlen and Andersson (1970), differences in clutch size are likely so dependent on local predation rates that analysis of numbers of eggs for determination of geographical variation in clutch size may be meaningless.

In our western Victoria Island study area, egg parasitism, where eggs are laid in the same nest by more than one eider female, occurred only in the three island colonies with more than 100 nests. During a study of the Common Eider in Hudson Bay *Somateria mollissima sedentaria*, Robertson et al. (1992) also found significantly higher rates of egg parasitism in areas where nest density was greater. Potential factors resulting in egg parasitism are nest displacement by more aggressive females, simultaneous laying by more than one female (Palmer 1976; Eadie et al. 1988), and opportunistic laying by females attracted to unattended nests with uncovered eggs (Robertson et al. 1992).

In the Hudson Bay study, a maximum of three parasitic eggs was found in any one nest (Robertson et al. 1992). In contrast, we found nests with up to 14 Common Eider eggs.

On islands off western Victoria Island, we occasionally found Common Eider eggs in the same nest with Black Brant eggs. Common Eiders have also parasitized the nests of Blue Geese *Chen caerulescens caerulescens* (Lieff 1969), Canada Geese *Branta canadensis* (Prevett et al. 1972), and Glaucous Gulls (Schweinsburg 1974). These species have nesting habitat requirements similar to those of Common Eiders, occasionally nesting in close proximity, and they may even compete for nest sites. In habitats that provide the necessary resources for nesting of several species, Common Eider females may be attracted to and lay in any nest with eggs, regardless of the species of the host (Prevett et al. 1972).

5.0 Conclusions

This paper presents the relative abundance and distribution of the Pacific subspecies of the Common Eider in various parts of the Canadian Arctic during the nesting season. The most important *S. m. v-nigra* nesting areas discovered to date are in Prince Albert Sound off western Victoria Island and along the south coast of Victoria Island. Few eiders nest in the Mackenzie Delta area or coastal Yukon Territory to the west (Hawkings 1987). Nesting Common Eiders utilize the northeastern tip of the Tuktoyaktuk Peninsula, Cape Parry, and Banks Island in moderate numbers. Numbers and distribution of nesting birds east of Dolphin and Union Strait are not well known.

Available ground and aerial data account for less than 10% of the estimated *S. m. v-nigra* breeding population in Arctic Canada, which is surprising, as Common Eiders supposedly nest in colonies. This suggests that, unlike other subspecies of Common Eiders (Reed 1986; Nakashima and Murray 1988), a large proportion of the *S. m. v-nigra* breeding population may nest individually or in small dispersed groups. Systematic surveys of *S. m. v-nigra* over all potential breeding habitat are necessary to reveal their nesting distribution and abundance.

Recent observations suggest that changes in nesting abundance have occurred in some areas. There are now only a few breeding pairs at Liverpool Bay and Cape Bathurst on the mainland Arctic coast, where large Common Eider colonies were found previously (MacFarlane 1891). The current status of other large colonies is unknown, including Moose Island off the west coast of Banks Island and the many islands around Camping Island in Dolphin and Union Strait. Intensive surveys of these areas are required.

The distribution and size of the *S. m. v-nigra* breeding population will vary between years, requiring replicate surveys under different regimes of climatic phenology. Both ground counts and appropriately timed aerial surveys for breeding pairs are required. In particular, there is a pressing need to expand our knowledge of the abundance and distribution of breeding Common Eiders in Dolphin and Union Strait, Coronation Gulf, Bathurst Inlet, and Queen Maud Gulf. Also, we need to determine the eastern limit of the range of *S. m. v-nigra*. More detailed information on the location and relative importance of specific nesting sites is required, in order to adequately monitor the status of the population and ensure that critical nesting areas are protected. Until we have a viable population estimate, we cannot determine how the subspecies is faring in light of both harvest and industrial development.

Acknowledgements

We are grateful to the following people who assisted with data collection off western Victoria Island: M. Ekootak, V. Johnston, D. Notaina, R. Notaina, G. Okheena, H. Trefry, and A. Weerstra. We thank R. Cotter and J. Hines for contributing their unpublished data on Common Eiders obtained during recent waterfowl surveys on Banks Island and the mainland western Arctic. We also thank R. Alisauskas, R. Bromley, and G. Warner for providing unpublished data on the distribution of nesting Common Eiders off Queen Maud Gulf, off Kent Peninsula, and in Bathurst Inlet, respectively. Bob Bromley, Jim Hines, and an anonymous reviewer provided helpful comments on the manuscript.

The project was funded jointly by the Inuvialuit Final Agreement Implementation Funds and Canadian

Wildlife Service. Logistical support was provided by the Polar Continental Shelf Project of Natural Resources Canada.

Literature cited

Ahlen, I.; Andersson, A. 1970. Breeding ecology of an eider population on Spitzbergen. Ornis Scand. 1:83–106.

Alexander, S.A.; Hawkings, J.S. 1988. Breeding bird survey of coastal islands of the outer Mackenzie Delta and northern Tuktoyaktuk Peninsula, 1987. Can. Wildl. Serv. Tech. Rep. Ser. No. 39, Yellowknife.

Alexander, S.A.; Barry, T.W.; Dickson, D.L.; Prus, H.D.; Smyth, K.E. 1988. Key areas for birds in coastal regions of the Canadian Beaufort Sea. Can. Wildl. Serv., Western & Northern Region, Edmonton. 146 pp.

Alexander, S.A.; Westover, S.E.; Dickson, D.L. 1994. Spring migration of waterbirds in the Beaufort Sea, Amundsen Gulf and Lambert Channel polynya, 1993. Can. Wildl. Serv. Tech. Rep. Ser. No. 201, Western & Northern Region, Edmonton.

Allen, L. 1982. Bird migration and nesting observations, western Victoria Island, N.W.T., June, 1980. Unpubl. rep., Can. Wildl. Serv., Yellowknife. 61 pp.

Anderson, R.M. 1913. Report on the natural history collections of the expedition (1908–1912). Pages 436–527 *in* V. Stefansson, My life with the Eskimo. Macmillan Co., New York.

Anderson, R.M. 1937. Mammals and birds of the western Arctic district, Northwest Territories, Canada. Pages 97–122 *in* Canada's western northlands. Land, Parks and Forests Branch, Government of Canada, Ottawa.

Baillie, S.R.; Milne, H. 1982. The influence of female age on breeding in the eider *Somateria mollissima*. Bird Study 29:55–66.

Barry, S.J.; Barry, T.W. 1982. Sea-bird surveys in the Beaufort Sea, Amundsen Gulf and Prince of Wales Strait — 1981 season. Unpubl. rep., Can. Wildl. Serv., Edmonton. 52 pp.

Barry, T.W. 1986. Eiders of the western Canadian Arctic. Pages 74–80 *in* A. Reed (ed.), Eider ducks in Canada. Can. Wildl. Serv. Rep. Ser. No. 47, Ottawa.

Barry, T.W.; Barry, S.J.; Jacobson, B. 1981. Sea-bird surveys in the Beaufort Sea, Amundsen Gulf, Prince of Wales Strait and Viscount Melville Sound — 1980 season. Unpubl. rep., Can. Wildl. Serv., Edmonton. 69 pp.

Bellrose, F.C. 1976. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Pennsylvania.

Chapdelaine, G.; Bourget, A.; Kemp, W.B.; Nakashima, D.J.; Murray, D.J. 1986. Population d'Eider à duvet près des côtes du Québec septentrional. Pages 39–50 *in* A. Reed (ed.), Eider ducks in Canada. Can. Wildl. Serv. Rep. Ser. 47, Ottawa.

Cooch, F.G. 1965. The breeding biology and management of the northern eider (*Somateria mollissima borealis*) in the Cape Dorset area, Northwest Territories. Wildl. Manage. Bull. Ser. 2, No. 10, Can. Wildl. Serv. 68 pp.

Cotter, R.C.; Kay, D.G.; Hines, J. 1993. Population survey of Pacific Brant in Banks Island, Northwest Territories, in 1992: a progress report. Unpubl. rep., Can. Wildl. Serv., Yellowknife.

Cotter, R.C.; Kornder, M.; Hines, J. 1994. Population surveys of Pacific Brant and other waterfowl on Banks Island, Northwest Territories, in 1993 — progress report. Unpubl. rep., Can. Wildl. Serv., Yellowknife.

Coulson, J.C. 1984. The population dynamics of the eider duck *Somateria mollissima* and evidence of extensive non-breeding by adult ducks. Ibis 126:525–543.

Dickson, D.L.; Cornish, B.J. 1993. Progress report: survey for eiders on western Victoria Island, 1992. Unpubl. rep., Can. Wildl. Serv., Edmonton.

Dickson, D.L.; Cornish, B.J. 1994. Survey for eiders on western Victoria Island, 1993, progress report. Unpubl. rep., Can. Wildl. Serv., Edmonton.

Dickson, D.L.; Dickson, H.L.; Aiudi, G.M. 1988. Bird surveys at Stokes Point and Phillips Bay, Yukon, in 1983. Can. Wildl. Serv. Tech. Rep. Ser. No. 40, Edmonton.

Eadie, J.M.; Kehoe, F.P.; Nudds, T.D. 1988. Pre-hatch and post-hatch brood amalgamation in North American Anatidae: a review of hypotheses. Can. J. Zool. 66:1709–1721.

Fraser, J.K. 1957. Birds observed in the central Canadian Arctic, 1953, 1955, 1956. Can. Field-Nat. 71:192–199.

Gavin, A. 1947. Birds of Perry River District, Northwest Territories. Wilson Bull. 59:195–203.

Gerell, R. 1985. Habitat selection and nest predation in a Common Eider population in southern Sweden. Ornis Scand. 16:129–139.

Gollop, M.A.; Richardson, W.J. 1974. Inventory and habitat evaluation of bird breeding and moulting areas along the Beaufort Sea coast from Prudhoe Bay to Shingle Point, Yukon Terr., July 1973. Arct. Gas Biol. Rep. Ser. 26(1):1–61.

Hawkings, J.S. 1987. Population status of migratory waterbirds on the Yukon Coastal Plain and adjacent Mackenzie Delta. Can. Wildl. Serv. Tech. Rep. Ser. No. 28, Pacific & Yukon Region.

Hines, J.E.; Westover, S.E.; Callan, M.F. 1992. Progress report: surveys of geese and swans in the Inuvialuit Settlement Region, 1991. Unpubl. rep., Can. Wildl. Serv., Yellowknife.

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

Jolly, G.M. 1969. The treatment of errors in aerial survey counts of wildlife populations. East Afr. Agric. For. J. 34(Spec. Issue):50–56.

Larsen, S. 1960. On the influence of the Arctic Fox *Alopex lagopus* on the distribution of Arctic birds. Oikos 11:276–305.

Lieff, B. 1969. Eider hatching goose egg. Wilson Bull. 81:465–466.

Lock, A.R. 1986. A census of Common Eiders breeding in Labrador and the Maritime provinces. Pages 30–38 *in* A. Reed (ed.), Eider ducks in Canada. Can. Wildl. Serv. Rep. Ser. 47, Ottawa.

MacFarlane, R. 1891. Notes on and list of birds and eggs collected in Arctic America, 1861–1866. Proc. U.S. Natl. Mus. 14:413–446.

Manning, T.H.; Hohn, E.O.; Macpherson, A.H. 1956. The birds of Banks Island. Natl. Mus. Can. Bull. No. 143, Ottawa.

McEwen, E. 1957. Birds at Bathurst Inlet. Can. Field-Nat. 71:109–115.

McLaren, M.A.; Alliston, W.G. 1981. Summer bird populations on western Victoria Island, Northwest Territories, July 1980. Unpubl. rep. by LGL Ltd. for Polar Gas Project. 147 pp. (Available at LGL Ltd., 22 Fisher Street, P.O. Box 280, King City, ON L7B 1A6.)

Milne, H. 1974. Breeding numbers and reproductive rate of eiders at the Sands of Forvie National Nature Reserve, Scotland. Ibis 116:135–152.

Nakashima, D.J.; Murray, D.J. 1988. The Common Eider (*Somateria mollissima sedentaria*) of eastern Hudson Bay: a survey of nest colonies and Inuit ecological knowledge. Environmental Studies Revolving Funds Rep. No. 102, Ottawa. 188 pp.

Nettleship, D.N.; Smith, P.A. (eds.). 1975. Ecological sites in northern Canada. Can. Comm. Int. Biol. Program, Conserv. Terr. Panel 9, Can. Wildl. Serv., Ottawa. 330 pp.

Palmer, R.S. (ed.). 1976. Handbook of North American birds. Vol. 3. Yale University Press, London. 560 pp.

Parmelee, D.F.; Stephens, H.A.; Schmidt, R.H. 1967. The birds of southeast Victoria Island and adjacent small islands. Natl. Mus. Can. Bull. No. 222, Biol. Ser. No. 78, Ottawa. 229 pp.

Prevett, J.P.; Lieff, B.C.; MacInnes, C.D. 1972. Nest parasitism at McConnell River, N.W.T. Can. Field-Nat. 86:369–372.

Quinlan, S.E.; Lehnhausen, W.A. 1982. Arctic Fox, *Alopex lagopus*, predation on nesting Common Eiders, *Somateria mollissima* at Icy Cape, Alaska. Can. Field-Nat. 96(4):462–466.

Reed, A. (ed.). 1986. Eider ducks in Canada. Can. Wildl. Serv. Rep. Ser. No. 47, Ottawa. 177 pp.

Robertson, G.J.; Watson, M.D.; Cooke, F.D. 1992. Frequency, timing and costs of intraspecific nest parasitism in the Common Eider. Condor 94:871–879.

Schamel, D. 1977. Breeding of the Common Eider (*Somateria mollissima*) on the Beaufort Sea coast of Alaska. Condor 79:478–485.

Schamel, D. 1978. Bird use of a Beaufort Sea barrier island in summer. Can. Field-Nat. 92:55–60.

Schmutz, J.K.; Robertson, R.J.; Cooke, F. 1983. Colonial nesting of the Hudson Bay eider duck. Can. J. Zool. 61:2424–2433.

Schweinsburg, R.E. 1974. An ornithological study of proposed gas pipeline routes in Alaska, Yukon and the Northwest Territories, 1971. Arct. Gas Biol. Rep. Ser. 10. 215 pp.

Snedecor, G.W.; Cochran, W.G. 1967. Statistical methods. 6th edition. Iowa State University Press, Ames, Iowa.

Talarico, D.; Mossop, D. 1986. A three-year summary of avifauna research on Herschel Island — an interim report for use in park management and interpretive programs. Yukon Department of Renewable Resources.

Vermeer, K.; Anweiler, G.G. 1975. Oil threat to aquatic birds along the Yukon coast. Wilson Bull. 87(4):467–480.

Ward, J.G. 1979. Bird and mammal surveys in the Cape Parry area, Northwest Territories, June–Aug. 1979. Unpubl. rep. by LGL Ltd. for Dome Petroleum Ltd., Calgary. 40 pp.

Ward, R.; Mossop, D. 1985. The birds of Herschel Island relative to its use as a territorial park. Yukon Department of Renewable Resources. 41 pp.

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

Breeding biology of the King Eider in the western Canadian Arctic

Richard C. Cotter, D. Lynne Dickson, and Cindy J. Gratto

Abstract

In 1992–1993, data were collected on the breeding biology of the King Eider *Somateria spectabilis* on Victoria Island and Banks Island, Northwest Territories. We searched for nests in the Kagloryuak River valley on Victoria Island in 1992 and at seven widely scattered areas on the west side of Banks Island in 1992 and 1993. When the data for the two years were pooled, the start of egg laying ranged from 7 to 28 June (n = 10) on Victoria and Banks islands, with an average of 4.2 and 5.0 eggs laid per clutch on Victoria Island (n = 4) and Banks Island (n = 13), respectively. Length of incubation for two nests from Banks Island in 1993 was 22 and 23 days. In 1993, movement of pairs onto the breeding grounds in the Kagloryuak River valley started before 9 June, peaked around 15 June, and ended around 20 June. In that year, incubation started around 22 June; in the same area in the previous year, start of incubation ranged from 24 to 29 June. Of nests with known fates on both Victoria and Banks islands in the two years (n = 11), 45% suffered either complete or partial hatching failure, with predation being responsible for 73% of the eggs that failed to hatch (n = 11). In 1993, male King Eiders in the Kagloryuak River valley left the breeding grounds soon after the start of incubation. Very few groups of males were observed in the wetland at that time, suggesting that flock formation for the moult migration occurred at the coast rather than inland.

Résumé

En 1992–1993, des données ont été recueillies relativement à la biologie de reproduction de l'Eider à tête grise *Somateria spectabilis*, sur l'île Victoria et l'île Banks dans les Territoires du Nord-Ouest. Nous avons travaillé à repérer des nids dans la vallée de la rivière Kagloryuak sur l'île Victoria en 1992 et dans sept zones considérablement dispersées dans la partie ouest de l'île Banks en 1992 et 1993. D'après les données réunies pour ces deux années, le début de la ponte se situait entre le 7 et le 28 juin (n = 10) sur les îles Victoria et Banks, la ponte moyenne étant de 4,2 oeufs sur l'île Victoria (n = 4) et 5,0 oeufs sur l'île Banks (n = 13). La durée d'incubation dans le cas de deux nids de l'île Banks en 1993 était de 22 et de 23 jours. En 1993, le mouvement des couples vers les aires de ponte dans la vallée de la rivière Kagloryuak a commencé avant le 9 juin, a culminé vers le 15 juin et s'est terminé vers le 20 juin. Cette année-là, l'incubation a commencé vers le 22 juin. L'année précédente, dans la même zone, le début de l'incubation se situait entre le 24 et le 29 juin. Parmi les nids où on a pu observer les résultats de la ponte sur l'île Victoria et l'île Banks au cours des deux années (n = 11), il y a eu perte complète ou partielle de la ponte dans le cas de 45 % des nids, et la prédation a été la cause de la perte de 73 % de ces oeufs (n = 11). En 1993, les Eiders à tête grise mâles dans la vallée de la rivière Kagloryuak ont quitté les aires de reproduction peu après le début de l'incubation. Un nombre très restreint de groupes de mâles ont été observés dans la zone humide à cette époque, ce qui laisse supposer que la formation des volées pour la migration de la mue a eu lieu sur la côte et non à l'intérieur des terres.

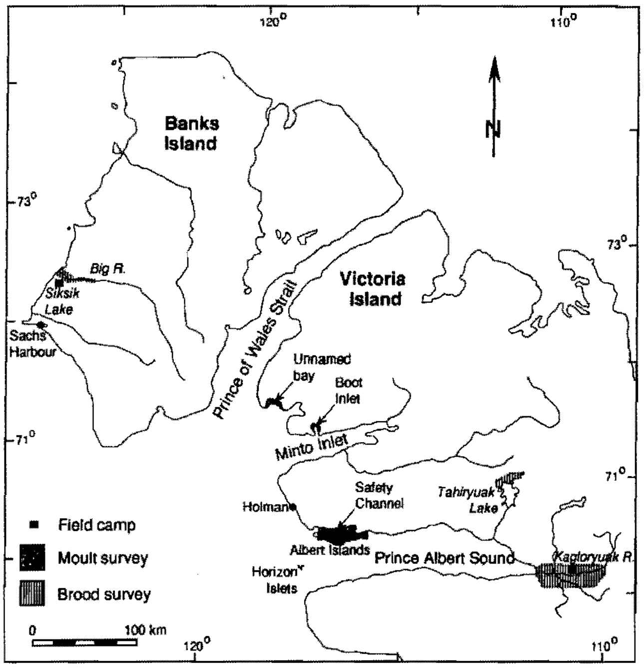
1.0 Introduction

Little is known of the breeding biology of the King Eider *Somateria spectabilis*. Some data are available on clutch size (Hanson et al. 1956; Manning and Macpherson 1961; Parmelee et al. 1967; Lamothe 1973), incubation times (Parmelee et al. 1967; Norderhaug 1978), nest site selection (Manning et al. 1956; Parmelee et al. 1967; Lamothe 1973; McLaren and Alliston 1981), and migration phenology (Bray 1943; Parmelee and MacDonald 1960; Thompson and Person 1963; Parmelee et al. 1967; Lamothe 1973; Barry 1986; Alexander et al. 1993, 1994), but this information is incomplete across the eider's breeding range. In this paper, we present data collected on the breeding biology of the King Eider nesting on Banks Island and western Victoria Island in 1992–1993, as well as the results of a 1992 postbreeding survey along western Victoria Island for moulting eiders *Somateria* spp.

2.0 Methods

On Victoria Island, searches for King Eider nests were conducted in an area of approximately 45 km^2 in the Kagloryuak River valley from 9 to 23 July 1992 (Fig. 1). Clutch size was recorded for each nest located. Each egg

Figure 1
Location of moult and brood surveys on Banks Island and western Victoria Island, Northwest Territories, 1992–1993



was measured to the nearest one-hundredth of a millimetre (length and width) and weighed to the nearest one-tenth of a gram with a Pesola 100-g scale, and its age was approximated using flotation (Gorman 1974; van Paassen et al. 1984). Age was later cross-checked with the date of hatching to ensure accuracy. On Banks Island, data on King Eider nests were collected incidentally during a study of Black Brant *Branta bernicla nigricans* in 1992 and 1993. Consequently, most King Eider nests were either within or near brant nesting colonies. The exception was three nests found near the field camp at Siksik Lake in 1993 (Fig. 1).

Some of the nests were visited periodically during incubation to determine time of hatch and hatching success. If shells with detached membranes were present, the egg was assumed to have hatched successfully (Girard 1939). If there were eggshells with no membranes or if the entire egg was absent, we assumed the eggs had been depredated. Nesting success was defined as the percentage of all nests initiated in which at least one egg hatched successfully.

The first day of incubation was approximated by subtracting an average of a 23-day incubation (Parmelee et al. 1967; Lamothe 1973; Norderhaug 1978; this study) from the date of hatch. Because one King Eider egg is laid approximately every 24 hours and incubation commences with laying of the last egg (Lamothe 1973; Cramp and Simmons 1977:609), the date of initiation of egg laying was estimated as the date of onset of incubation minus total number of eggs laid minus one. These calculations were confirmed with data from two of the nests from Banks Island in 1993.

For each nest found on both Victoria and Banks islands, nest location (island vs. mainland), presence of other nesting species, and approximate distances to water were recorded.

Data were collected on the changing population structure during migration, laying, and incubation at the study site in the Kagloryuak River valley from 14 June to 2 July 1993. A count was taken from a blind overlooking a wetland at 30-minute intervals for two hours every four hours for a total of 30 counts per 24 hours (e.g., counts were taken at 01:00, 01:30, 02:00, 02:30, 03:00, 05:00, 05:30, etc. throughout). As counts started with the 05:00–07:00 time period and ended with the 01:00–03:00 time period, results for each day were summarized for that 24-hour period. Observations of King Eiders were categorized as single male, single female, pairs, 2–4 males, 2–4 females, and groups (>4 birds). Number of *indicated breeding pairs* was calculated by summing observations of single males, of pairs, and of 2–4 males (Anonymous 1987).

In 1992, surveys for moulting King Eiders and Common Eiders *Somateria mollissima v-nigra* were conducted on western Victoria Island. On 29 July, 14 parallel transects spaced 5 km apart and 6–18 km in length were surveyed over Safety Channel and the Albert Islands (Fig. 1); on 26 July, the coastal area of two bays on the north side of Minto Inlet was surveyed by flying 200 m offshore (Fig. 1). All surveys were flown in a Bell 206B Jet Ranger helicopter at a height of 30 m above sea level and a ground speed of 145 km/h. Two observers recorded observations of eiders within 200 m of each side of the transect line. For each sighting, the transect number, species, sex, and group size were recorded.

Densities were calculated for Safety Channel and the coastal area of the two bays in Minto Inlet by dividing total number of birds observed by total transect area. Population estimates and standard errors were derived for moulting King and Common eiders within Safety Channel using the ratio method (Snedecor and Cochran 1967:515; Jolly 1969; Cochran 1977:155).

Two types of brood surveys were conducted on Victoria Island in 1992: a wetland survey and a transect survey. Wetland surveys, rather than transect surveys, were designed to count all King Eiders. Twelve wetlands were surveyed, four of which were located south of the Kagloryuak River (surveyed 27 July) and eight near Tahiryuak Lake (surveyed 28 July) (Fig. 1). Both types of surveys were flown in a Bell 206B Jet Ranger helicopter. For the wetland surveys, two observers flew along the shoreline of every water body in the wetland at a height of approximately 12 m above ground level (agl) and at a velocity of approximately 30 km/h and recorded all sightings of King Eiders. The transect surveys were flown at 30 m agl and at 145 km/h. One transect followed the river, whereas the other two were straight lines running west through the valley. Two observers counted all King Eiders within 200 m of the transect line.

On Banks Island, 10 14-km transects located along the Big River were surveyed for broods from 3 to 5 August 1992 and on 28 July 1993 (Fig. 1). All King Eiders were counted within 200 m of the transect. A Bell 206B Jet Ranger helicopter flying at 45 m agl and approximately 80 km/h was used.

3.0 Results

3.1 Chronology

In 1992, RCC arrived at Sachs Harbour on Banks Island on 11 June. The first King Eiders were seen on 13 June, when a flock of 36 flew past the hamlet. In 1993, King Eiders were on the nesting grounds by at least 7 June, as determined by back-dating a nest on western Banks Island.

No data are available on timing of arrival of King Eiders on Victoria Island in 1992; however, in 1993, a few were present in the Kagloryuak River valley when DLD arrived on 9 June. A pair as well as a pair with an additional male were observed on that date. Until 16 June, several flocks of as many as 12 pairs daily moved through the wetland. All birds travelled in an easterly direction, sometimes stopping for several hours to rest. After 16 June, only a small number of eiders were observed flying through the wetland.

In 1992, King Eiders commenced egg laying between 21 and 25 June (n = 5) (Table 1) on both western Victoria Island and Banks Island. On Banks Island in 1993, start of egg laying was as early as 7 June, extending until at least 28 June (n = 5) (Table 1). Both egg laying and hatching were observed for two nests on Banks Island in 1993, with hatching occurring on the 23rd and 24th days of incubation.

Nesting chronology on western Victoria Island in 1993 was obtained by repeated counts of eiders in a wetland in the Kagloryuak River valley rather than by checking nests. Nearly all of the migrant flocks of King Eiders (groups of >4) moved through the wetland during the first two days of observations on 14 and 15 June (Table 2). After that, we saw only two groups of >4 birds, one on 23 June (two males and three females) and one on 2 July (one male and four females) (Table 2); from the agonistic behaviour observed between the males in the first group, it is likely that they were local breeders, and the presence of four females in the second group suggests that they were failed breeders or nonbreeders. Incidental observations indicated that most flocks of King Eiders moved through the wetland from 11 to 14 June, although the occasional flock was seen until 20 June. Direction of travel of the migrant flocks was from west to east (n = 23 flocks). The number of King Eider pairs in the wetland peaked on 15 June and declined slowly, although steadily, thereafter (Fig. 2). The number of males, either single or in groups of 2–4, remained about the same throughout the study period (Fig. 2). Groups of 2–4 females were first observed on the wetland on 27 June and were seen each day afterwards for the duration of the counts (Table 2).

Approximately a week after the start of incubation on Victoria Island in 1992, postbreeding males began their westward migration to moulting areas. On 3 July, several flocks totalling 700 male King Eiders were observed flying westward along the north shore of Prince Albert Sound near the Albert Islands. Another 500 males were seen staging in open water along the ice edge between Holman Island and the Horizon Islets. The following day, two more groups of males were seen flying westward near the Albert Islands, one of 17 and one of 350. These sightings were recorded incidentally to other fieldwork and thus should be considered only a sample of the migration past the Albert Islands during those two days. When surveys for moulting birds were conducted about three weeks later, only two male King Eiders were observed (Table 3). This resulted in a moulting population estimate of only 25 King Eiders within Safety Channel. None was seen in the two bays surveyed on the north side of Minto Inlet.

Common Eiders were observed in all three areas surveyed for moulting birds (Table 3; Fig. 1). Densities ranged from 5.8 to 10.3 birds/km^2. Most of the eiders in Boot Inlet and the unnamed bay along the north shore of Minto Inlet were females, whereas in Safety Channel, approximately 58% were males. There were an estimated 5175 ± 1463 (SE) Common Eiders in Safety Channel. The majority of eiders took flight as the survey aircraft approached, indicating that they had not yet entered the moult.

Table 1
Range of dates of reproductive events for King Eiders on Victoria Island and Banks Island in 1992 and 1993

Location/year	Dates of clutch initiation (n)	Dates of start of incubation (n)	Dates of hatch (n)
Victoria Island			
1992[a]	21–25 June (3)	24–29 June (6)	17–22 July (6)
Banks Island			
1992[b]	21–23 June (2)	25–27 June (2)	18–20 July (2)
1993[c]	7–28 June (5)	12–30 June (5)	5–23 July (4)

Note: Unless otherwise indicated, dates of clutch initiation and start of incubation were calculated by back-dating from date of hatch.

[a] Hatching observed for only one nest (22 July); dates of hatching of other nests were estimated by flotation (after Gorman 1974) and correlated with dates when young broods were observed on nearby ponds.

[b] Hatching observed for only one nest (20 July); the other nest had already hatched when visited on 19 July; therefore, it is assumed to have hatched no later than 18 July.

[c] Egg laying and hatching were observed for two nests, and hatching was also observed for two other nests. A female was flushed off a fifth nest containing a clutch of six eggs on 13 June and is assumed to have initiated incubation no later than that date.

3.2 Reproduction

Of nests with known fates, success was 100% in both 1992 (n = 2) and 1993 (n = 4) on Banks Island and 60% in 1992 (n = 5) on Victoria Island. On Banks Island, hatching success was 100% in 1992 (n = 10) and 84% in 1993 (n = 19); on Victoria Island, success was 76% in 1992 (n = 17). Clutch size averaged 5.00 for both years on Banks Island and 4.25 for Victoria Island (1992) (Table 4). An average of 4.3 eggs hatched per successful nest on both Banks Island (n = 6; 1992, 1993) and Victoria Island (n = 3; 1992). Egg measurements from four nests on Victoria Island are presented in Table 5.

Of clutches with known fates on both Banks and Victoria islands, 45% (5 of 11 nests) suffered either complete or partial hatching failure. Causes of hatching failure included complete clutch predation (n = 2 nests; 17% of all nests), partial clutch predation (n = 1 nest; 8% of all nests), infertility (n = 1 nest; 2% of total eggs), and damaged egg(s) (n = 1 nest; 2% of total eggs). An Arctic fox *Alopex lagopus* destroyed one nest during incubation, whereas the predator was not determined for the second

Table 2
Average number of King Eiders observed each day from a blind overlooking a wetland in the Kagloryuak River valley in 1993

			Average no. of King Eiders observed per count					
Date	Blind	No. of counts	Single male	Single female	Pairs	2–4 males	2–4 females	Group of >4 birds
14 June	West	30	0.00	0.03	3.67	0.00	0.00	0.20
15 June	West	30	0.47	0.03	4.87	0.00	0.00	6.03
16 June	West	30	0.87	0.07	4.10	0.53	0.00	0.00
17 June	West	30	0.43	0.13	3.40	0.13	0.00	0.00
18 June	West	30	0.43	0.00	3.10	0.00	0.00	0.00
19 June	West	25	0.96	0.12	3.80	0.00	0.00	0.00
20 June	West	25	1.20	0.60	2.88	0.00	0.00	0.00
21 June	West	30	1.53	0.50	2.60	0.00	0.00	0.00
22 June	West	26	0.92	0.15	1.54	0.00	0.00	0.00
23 June	West	30	0.50	0.13	1.80	0.00	0.00	0.17
24 June	East	30	0.40	0.13	0.87	0.00	0.00	0.00
25 June	West	27	0.19	0.19	2.30	0.00	0.00	0.00
26 June	East	30	1.03	1.20	2.53	0.00	0.00	0.00
27 June	East	30	0.63	0.17	2.07	0.00	0.13	0.00
28 June	West	30	0.20	0.13	1.70	0.00	0.27	0.00
29 June	East	30	0.43	0.30	2.60	0.00	0.20	0.00
30 June	East	30	0.53	0.50	2.10	0.00	1.30	0.00
1 July	West	30	0.57	0.17	0.83	0.97	0.67	0.00
2 July	East	30	0.07	0.60	1.10	0.00	0.80	0.17

Figure 2
Change in composition of King Eiders observed from the west blind overlooking a wetland in the Kagloryuak River valley in 1993

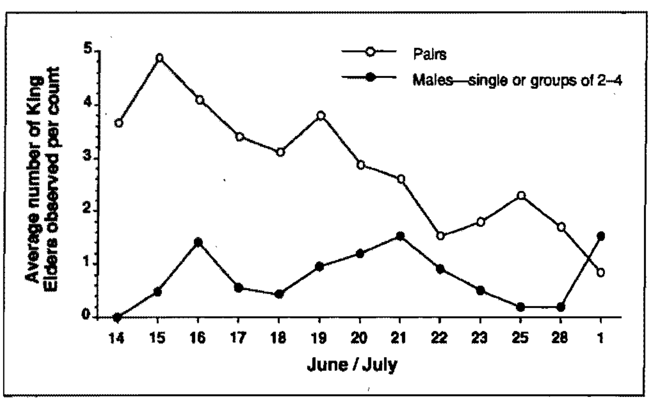


Table 3
Number, density, and percentage of male King and Common eiders[a] observed during a moulting survey off western Victoria Island, 26–29 July 1992

		King Eider			Common Eider		
Location	No. of km surveyed	No.	No./km^2	% males	No.	No./km^2	% males
Boot Inlet	25.5	0	0	–	58	5.8	16
Unnamed bay	35.5	0	0	–	144	10.3	<1
Safety Channel	175.5	2	0.03 (0.02)[b]	100	414	5.9 (1.7)[b]	58

[a] Assumed females were same species as males associated with them.
[b] Standard error for eiders in Safety Channel.

nest lost during egg laying. A short-tailed weasel *Mustela erminea*, seen repeatedly, is the suspected predator of a nest suffering partial clutch loss on Banks Island in 1993, as only one egg was taken and as no eggshells were found at the nest site (Fleskes 1988).

The results of brood surveys are summarized in Table 6. The mean number of ducklings per group was 3.8 (n = 13), 15.5 (n = 2), and 6.0 (n = 1) for Victoria Island in 1992 and Banks Island in 1992 and 1993, respectively.

On Banks Island, the two nests found in 1992 were located on the mainland within 200 m of each other and an active Snowy Owl *Nyctea scandiaca* nest. In 1993, 11 nests were found in six widely separated island (n = 1) and mainland (n = 5) areas on the west side of the island. At three of the mainland sites, nests (n = 5) were within 200 m of an active Snowy Owl nest and more than 300 m from the nearest body of water. All other nests were within 30 m of a lake or pond, regardless of whether they were located on the mainland (n = 4 nests) or on an island (n = 2 nests); three of the mainland nests were within 15 m of each other.

On Victoria Island in 1992, all were mainland nest sites within 400 m of water. The shortest distance to water was 6 m, and the median was 60 m. Although there were two Snowy Owl nests in the study area, there were no King Eider nests within 200 m of them.

4.0 Discussion

4.1 Chronology

The timing of nesting on Banks Island (1992, 1993) and Victoria Island (1992) was consistent with dates previously reported for the western Canadian Arctic. Manning et al. (1956) reported incubation lasting from 19 June to 18 July on Banks Island in 1953, and Parmelee et al. (1967) noted that nest initiation on southeastern Victoria Island in 1960 extended from 12 June to early July, reaching a peak around 20 June.

In 1993, pairs arrived at the Kagloryuak River valley before 9 June, peaked from 11 to 15 June, and ended around 20 June. The equal sex ratio observed

Table 4
Mean clutch sizes of King Eiders from Svalbard, Russia, and the Canadian Arctic

Location	Study	Year	Mean	SE	Range	n
Svalbard	Norderhaug (1978)	1969–1971	5.30	0.21	4–6	10
Chaun tundra, Russia	Kondrat'ev and Zadorina (1992)	1988–1989	4.9	0.3		7
Taimyr Peninsula, Russia	Summers et al. (1994)	1991	5.3			3
Adelaide Peninsula	Macpherson and Manning (1959)	1957	4.4		2–6	6
Perry River	Hanson et al. (1956)	1949	4.9			14[a]
Prince of Wales Island	Manning and Macpherson (1961)	1958	4.1		1–8	26
Bathurst Island	P.S. Taylor (pers. commun.), cited in Lamothe (1973)	1968	5.25		4–6	4
Bathurst Island	Lamothe (1973)	1969	4.6		3–6	7
Bathurst Island	P.S. Taylor (pers. commun.), cited in Lamothe (1973)	1970	4.3		3–5	3
Bathurst Island	Lamothe (1973)	1971	4.4		3–6	14
Bathurst Island	Lamothe (1973)	1972	4.0		3–5	8
Victoria and Jenny Lind islands	Parmelee et al. (1967)	1960, 1962	5.04	0.17	3–6	27
Jenny Lind Island	Parmelee et al. (1967)	1966	4.2		3–6	9
Victoria Island	This study	1992	4.25	0.48	3–5	4
Banks Island	This study	1992	5.00	0	5–5	2
Banks Island	This study	1993	5.00	0.47	2–7	11

[a] Excludes two clutches of eight and one of nine eggs thought to possibly represent the efforts of two females.

Table 5
King Eider egg dimensions and age of egg at time of measurement for four nests on Victoria Island, 1992

Nest no.	Length (mm)		Width (mm)		Weight (g)		No. of eggs	Age estimate (days)[a]
	Mean	SE	Mean	SE	Mean	SE		
1	62.08	2.11	43.35	0.65	63.17	3.70	3	6–8
2	66.37	0.85	43.82	0.67	64.40	0.98	5	15–17
3	64.71	0.89	42.13	0.10	53.83	0.66	4	16–18
4	63.19	0.95	43.55	0.38	54.70	1.44	5	16–19
Average	64.29	0.64	43.26	0.23	58.84	1.42	4.2	

[a] Number of days incubated based on flotation (after Gorman 1974).

suggests that only breeding birds come to the nesting grounds. Based on the changing numbers of pairs and males in the wetland, incubation began about 17 June for one nest and 22 June for two others. Incubation at a fourth nest probably began about 2 July, and there was still no sign of nest initiation for a fifth pair when observations stopped on 2 July. In comparison, incubation began from 24 to 29 June in the same area in the previous year. Spring thaw in the Kagloryuak River valley occurred about 10 days earlier in 1993 than in 1992, which likely accounts for the earlier nest starts.

The number of single or grouped males in the Kagloryuak River valley did not increase as the number of breeding pairs declined, which suggests that the males leave the breeding grounds as soon as the females start to incubate. On Bathurst Island, Lamothe (1973:33, 66, 110) reported that the males remained in the vicinity of the nest until laying of the third egg. Flocks of males (4) started forming in the freshwater ponds during egg laying and were absent shortly after incubation started. On Victoria Island, only one group of three males was observed after the start of nesting. Therefore, flock formation for the moult migration likely occurred at the coast rather than inland.

Westward movement of the males towards the moulting grounds must be very rapid. Large flocks of males were seen moving westward along the north shore of Prince Albert Sound only 8–10 days after females first initiated incubation in the Kagloryuak River valley. This rapid exodus of males concurs with reports from local hunters that peak movement of male King Eiders past Holman occurs in the first week of July and then declines rapidly to very few birds the following week (Kay et al. 1996).

The small flocks of females that were seen in the wetland from 27 June onward in 1993 were likely failed breeders, as they were not present prior to nesting. Lamothe (1973) likewise noted few unpaired females before nesting, just small flocks that appeared during incubation. They remained in his study area on Bathurst Island for about three weeks longer than the postbreeding males.

King Eider females and their broods move from their nest ponds within 24 hours of hatch (Parmelee et al. 1967). There is a continual movement of broods among ponds (Savile and Oliver 1964), with a directional tendency towards the sea (Parmelee et al. 1967). Crèches of up to 100 or more young with 2–9 females in attendance are formed during this period (Parmelee et al. 1967). The wetland brood surveys on Victoria Island did not indicate formation of large crèches: the largest number

Table 6
Number and density of King Eider females and young observed during brood surveys on Victoria Island and Banks Island

Location (year)	Survey coverage km	Survey coverage km²	Number: Females only	Number: Broods Females	Number: Broods Young (%)[a]	Density (no./km²) Females	Density (no./km²) Young
Victoria Island							
12 wetlands (1992)	–	92.8	41	50	40 (31)	0.98	0.43
2 transects (1992)	112.0	44.8	53	3	5 (8)	1.25	0.11
Kagloryuak River (1992)	80.0	32.0	28	1	4 (12)	0.91	0.13
Banks Island							
10 transects (1992)	140.0	56.0	103	8	31 (22)	1.98	0.55
10 transects (1993)	140.0	56.0	19	2	6 (22)	0.38	0.11

[a] Percent young of all females and young observed during surveys.

Table 7
King Eider egg dimensions from various populations

Location	Reference	Length (mm) Mean	Length (mm) SE	Width (mm) Mean	Width (mm) SE	No. of eggs
Novaya Zemlya	Dement'ev and Gladkov (1967)	67.0		44.0		n.a.[a]
Chaun tundra, Russia	Kondrat'ev and Zadorina (1992)	66.3	0.3	44.3	0.2	34
Taimyr Peninsula, Russia	Summers et al. (1994)	64.7	2.4[b]	43.8	0.4[b]	16
Svalbard	Norderhaug (1978)	65.3		44.7		41
Various collections	Bent (1925)	67.6		44.7		152
Cape Churchill	Moser and Rusch (1988)	62.5		43.0		6
Bathurst Island	Lamothe (1973)	66.8		45.1		14
Victoria and Jenny Lind islands	Parmelee et al. (1967)	64.4		43.2		6
Victoria Island	This study	64.3	0.6	43.3	0.2	17

[a] n.a. = not available.
[b] Standard deviation.

of ducklings per group was seven, and the mean number was 3.6. However, at the time of the surveys, most of the ducklings were probably only 1–2 weeks old, and the formation of crèches may not occur until the ducklings are older.

On Victoria Island in 1992, the number of females associated with groups of young ranged from 1 to 26, resulting in a very low proportion of young to adult females (0.80; 40 young/50 attending females). Such low numbers of young could indicate a high duckling mortality or a large number of nonbreeding or unsuccessfully breeding females. King Eiders at Banks Island showed a slightly higher tendency towards crèche formation in 1992 than was observed on Victoria Island. Although few young in total were seen, two groups of 17 young with four females and 14 young with four females were seen. The Banks Island surveys were conducted when the ducklings were 2–3 weeks old.

4.2 Reproduction

Mean clutch sizes from Banks Island (1992, 1993) and Victoria Island (1992) were similar to those from other sites (Table 4). Likewise, the egg dimensions recorded on Victoria Island (1992) were within the range recorded in other regions (Table 7).

None of the seven nests with known fates on Banks Island were destroyed by predators. In comparison, two of five nests on Victoria Island were depredated, and Lamothe's (1973) study showed a high degree of nest predation by foxes (18 of 25 nests). On Banks Island, the location of the nests probably deterred predators such as foxes: three were located within 15 m of our field camp, one was located on an island, and the remaining three were within 200 m of an active Snowy Owl nest. Snowy Owls typically do not tolerate foxes within 200–300 m of their nests (Litvin et al. 1985; Dorogoi 1990), thus providing indirect protection to nests of other species located within that radius (Summers et al. 1994). Similarly, in Greenland, King Eiders have been observed nesting in association with solitary breeding Long-tailed Jaegers *Stercorarius longicaudus*, probably benefiting from the jaeger's own defence of its nest against predators (Blomqvist and Elander 1988).

Acknowledgements

This study was funded jointly through the Inuvialuit Final Agreement and the Canadian Wildlife Service. Field assistance on Banks Island was provided by Greg Green, James Harry, David Kay, Mark Kornder, Trevor Lucas, and Geddes Wolki. Field assistance on Victoria Island was provided by Andy Bezener, Beth Cornish, Anne Holcroft-Weerstra, Vicky Johnston, Jacques Sirois, and Helen Trefry. Jim Hines reviewed and provided comments on the manuscript. Special thanks are extended to the Polar Continental Shelf Project and the Inuvik Research Centre for their assistance with logistics.

Literature cited

Alexander, S.A.; Westover, S.E.; Dickson, D.L. 1993. Spring migration of waterbirds in the Beaufort Sea, Amundsen Gulf, and Lambert Channel polynya, 1992. Can. Wildl. Serv. Tech. Rep. Ser. No. 171, Western & Northern Region, Edmonton.

Alexander, S.A.; Westover, S.E.; Dickson, D.L. 1994. Spring migration of waterbirds in the Beaufort Sea, Amundsen Gulf, and Lambert Channel polynya, 1993. Can. Wildl. Serv. Tech. Rep. Ser. No. 201, Western & Northern Region, Edmonton.

Anonymous. 1987. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys in North America. U.S. Fish and Wildlife Service, Washington, D.C., and Canadian Wildlife Service, Ottawa.

Barry, T.W. 1986. Eiders of the western Canadian Arctic. Pages 74-80 *in* A. Reed (ed.), Eider ducks in Canada. Can. Wildl. Serv. Rep. Ser. No. 47, Ottawa.

Bent, A.C. 1925. Life histories of North American wild fowl. Part 2. U.S. Natl. Mus. Bull. 130.

Blomqvist, S.; Elander, M. 1988. King Eider (*Somateria spectabilis*) nesting in association with Long-tailed Skua (*Stercorarius longicaudus*). Arctic 41:138–142.

Bray, R. 1943. Notes on the birds of Southampton Island, Baffin Island and Melville. Auk 60:504–536.

Cochran, W.G. 1977. Sampling techniques. 3rd edition. John Wiley & Sons, New York.

Cramp, S.; Simmons, K.E.L. (eds.). 1977. Handbook of the birds of Europe, the Middle East, and North Africa: the birds of the Western Palearctic. Vol. 1. Ostrich to ducks. Oxford University Press, Oxford.

Dement'ev, G.P.; Gladkov, N.A. (eds.). 1967. Birds of the Soviet Union. Vol. 2. Translated from Russian by Israel Prog. Sci. Trans., U.S. Department of the Interior and National Science Foundation, Washington, D.C.

Dorogoi, I.V. 1990. Factors influencing communal nesting of Snowy Owls and Anseriforms on Wrangel Island. Ornitologia 24:26–33 (in Russian, with English summary).

Fleskes, J.P. 1988. Predation by Ermine and Long-tailed Weasels on duck eggs. J. Iowa Acad. Sci. 95:14–17.

Girard, G.L. 1939. Notes on the life history of the shoveler. Trans. North Am. Wildl. Conf. 4:364–371.

Gorman, M.L. 1974. Criteria for ageing embryos of the eider. Wildfowl 25:29–32.

Hanson, H.C.; Queneau, P.; Scott, P. 1956. The geography, birds, and mammals of the Perry River region. Arct. Inst. North Am. Spec. Publ. 3.

Jolly, G.M. 1969. The treatment of errors in aerial counts of wildlife populations. East Afr. Agric. For. J. 34(Spec. Issue):50–56.

Kay, D.; Kornder, M.; Hines, J. 1996. Inuvialuit traditional knowledge of King Eider (*Somateria spectabilis*), Pacific Eider (*Somateria mollissima v-nigra*), and Black Brant (*Branta bernicla*) at Holman and Sachs Harbour, NWT. Unpubl. rep., Can. Wildl. Serv., Yellowknife.

Kondrat'ev, A.V.; Zadorina, L.V. 1992. Comparative ecology of King Eider *Somateria spectabilis* and Spectacled Eider *S. fischeri* in chaun tundra. Zool. Zh. 71:99–108 (in Russian, with English summary).

Lamothe, P. 1973. Biology of King Eider (*Somateria spectabilis*) in a fresh water breeding area on Bathurst Island, N.W.T. MSc thesis, University of Alberta, Edmonton.

Litvin, K.E.; Pulyaev, A.I.; Syroechkovskiy, E.V. 1985. Colonies of the Snow Goose *Anser caerulescens*, Brent Goose *Branta bernicla* and Eider *Somateria mollissima* near the Snowy Owl *Nyctea scandiaca* nests on Wrangel Island. Zool. Zh. 64:1012–1023 (in Russian, with English summary).

Macpherson, A.H.; Manning, T.H. 1959. The birds and mammals of Adelaide Peninsula, N.W.T. Natl. Mus. Can. Bull. 161.

Manning, T.H.; Macpherson, A.H. 1961. A biological investigation of Prince of Wales Island, N.W.T. Trans. R. Can. Inst. 33:116–239.

Manning, T.H.; Höhn, E.O.; Macpherson, A.H. 1956. The birds of Banks Island. Natl. Mus. Can. Bull. 143.

McLaren, P.L.; Alliston, W.G. 1981. Summer bird populations on western Victoria Island, N.W.T., July 1980. Unpubl. rep. by LGL Ltd. for Polar Gas Project, Toronto.

Moser, T.J.; Rusch, D.H. 1988. Nesting of King Eiders, *Somateria spectabilis*, and Snowy Owls, *Nyctea scandiaca*, near Cape Churchill, Manitoba. Can. Field-Nat. 102:60–61.

Norderhaug, M. 1978. Studies of the King Eider (*Somateria spectabilis*) in Svalbard. Nor. Polarinst. Årbok (Oslo) 1976:271–283 (in Norwegian, with English summary).

Parmelee, D.F.; MacDonald, S.D. 1960. The birds of west-central Ellesmere Island and adjacent areas. Natl. Mus. Can. Bull. 169.

Parmelee, D.F.; Stephens, H.A.; Schmidt, R.H. 1967. The birds of southeastern Victoria Island and adjacent small islands. Natl. Mus. Can. Bull. 222.

Savile, D.B.O.; Oliver, D.R. 1964. Bird and mammal observations at Hazen Camp, northern Ellesmere Island in 1962. Can. Field-Nat. 65:145–157.

Snedecor, G.W.; Cochran, W.G. 1967. Statistical methods. 6th edition. Iowa State University Press, Ames, Iowa.

Summers, R.W.; Underhill, L.G.; Syroechkovski, E.E., Jr.; Lappo, H.G.; Prŷs-Jones, R.P.; Karpov, V. 1994. The breeding biology of Dark-bellied Brent *Branta b. bernicla* and King Eiders *Somateria spectabilis* on the northeastern Taimyr Peninsula, especially in relation to Snowy Owl *Nyctea scandiaca* nests. Wildfowl 45:110–118.

Thompson, D.G.; Person, R.A. 1963. The eider pass at Point Barrow, Alaska. J. Wildl. Manage. 27:348–355.

van Paassen, A.G.; Veldman, D.H.; Beintema, A.J. 1984. A simple device for determination of incubation stages in eggs. Wildfowl 35:173–178.

Activity budgets of King Eiders on the nesting grounds in spring

Anne C. Holcroft-Weerstra and D. Lynne Dickson

Abstract

A behaviour study of the King Eider *Somateria spectabilis* was undertaken as part of a program to estimate the nesting population of King Eiders on western Victoria Island, Northwest Territories. King Eiders were observed in a wetland in the Kagloryuak River valley from shortly after their arrival on the breeding grounds until the early phases of incubation (14 June – 3 July). The percent frequencies of behaviours between the sexes at different times of day and on different dates were compared. Female King Eiders foraged over 3.5 times more frequently than males, whereas males performed resting, travelling, courtship, and agonistic behaviours more frequently. Of the courtship displays, females performed more bill dipping than did males, but they did not perform head turning, reaching, pushing, or bathing, whereas males did not perform chin lifting. Of the agonistic behaviours, females engaged in more chin lifting, threatening, and attacking than did males, whereas males engaged in more pushes and chases. Time of day and date also influenced behaviour. Foraging activity was greatest from early afternoon to very early morning, when ice melt and warming of the pond water were most rapid — hence invertebrate availability was likely highest. Nesting activity, including searching for a site, nest building, and egg laying, peaked in mid-morning. Foraging by both sexes increased towards the end of the nest initiation period, probably due to failed nesting attempts. Behaviour patterns of the King Eider that contribute to its reproductive success are discussed.

Résumé

Une étude de comportement de l'Eider à tête grise *Somateria spectabilis* a été entreprise dans le cadre d'un programme de surveillance de la population nicheuse d'Eiders à tête grise dans la partie ouest de l'île Victoria dans les Territoires du Nord-Ouest. L'observation des Eiders à tête grise s'est faite dans une zone palustre de la vallée de la rivière Kagloryuak peu après leur arrivée dans les aires de reproduction et jusqu'aux premières phases de l'incubation (14 juin - 3 juillet). On a comparé les fréquences en pourcentage des comportements des sexes à différentes époques de la journée et à différentes dates. Les Eiders à tête grise femelles partaient à la quête de nourriture 3,5 fois plus souvent que les mâles, qui s'adonnaient plus souvent aux comportements associés au repos, à l'exploration, à la parade et aux manifestations agonistiques. Dans le cas des activités de parade, les femelles agitaient la tête vers le bas plus souvent que les mâles, mais elles s'abstenaient des mouvements consistant à se tourner la tête, à s'avancer, à pousser ou à faire sa toilette, tandis que les mâles s'abstenaient de s'agiter la tête vers le haut. Dans le cas des comportements agonistiques, les femelles étaient plus souvent portées que les mâles à s'agiter la tête vers le haut, à menacer et à attaquer, tandis que les mâles étaient plus souvent portés à pousser et à prendre en chasse. Les comportements dépendaient également du moment de la journée et de l'époque. La quête de nourriture était la plus fréquente entre le début de l'après-midi et les toutes petites heures du matin, lorsque la glace fond et que l'eau des mares se réchauffe plus rapidement, permettant ainsi aux oiseaux de se nourrir plus facilement d'invertébrés. Les activités de nidification, notamment la recherche d'un site, la construction du nid et la ponte, avaient surtout lieu vers le milieu de l'avant-midi. La quête de nourriture par les deux sexes devenait plus fréquente vers la fin de la période de nidification, sans doute à cause des échecs sur ce plan. Le document décrit les habitudes de l'Eider à tête grise qui renforcent sa capacité de reproduction.

1.0 Introduction

The behaviour of King Eiders *Somateria spectabilis* on the breeding grounds has been studied by a limited number of researchers, among which are Höhn (1957), Drury (1961), Johnsgard (1964), Myres (1964), and Lamothe (1973). The focus of research has been on courtship displays, with the exception of Lamothe (1973), who has contributed to knowledge of foraging, agonistic, courtship, and nesting behaviours.

Pair formation is performed on the wintering grounds and during northward movement (Lamothe 1973; Palmer 1976:124). By the time King Eiders reach the breeding grounds, the majority are paired (Parmelee et al. 1967; Lamothe 1973). Courtship displays on the breeding grounds are most likely related to pair bond maintenance and temporary pairing by prebreeders (Palmer 1976:124).

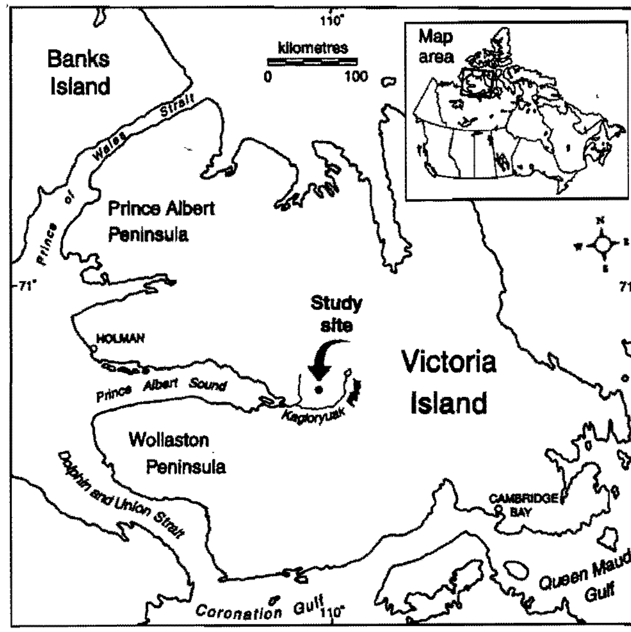
On arrival, it is common for the female to forage much more than the male (Rutilevskii 1957, cited in

Palmer 1976:129). The male remains at her side to protect her, thereby allowing her to spend the maximum time feeding (Cramp and Simmons 1977:594). He remains on the nesting grounds until shortly after egg laying is complete and incubation has begun, at which time he begins the moult migration (Hanson et al. 1956; Parmelee et al. 1967; Lamothe 1973).

The present study was part of a project to estimate the breeding population of King Eiders on western Victoria Island, Northwest Territories (Dickson et al., this publication). To ensure that aerial surveys for breeding pairs were conducted at the optimum time, it was necessary to determine the timing of nest initiation and departure of males from the nesting grounds (Cotter et al., this publication). Observations made for this purpose provided the opportunity to collect activity budget information on King Eiders from shortly after their arrival on the breeding grounds until the early phases of incubation.

The study site was a wetland in the broad Kagloryuak River valley (70°21′N, 110°32′W) (Fig. 1). The valley is characterized by a mosaic of moist to wet, well-vegetated lowlands and dry, poorly vegetated, rocky uplands composed of low ridges and hills. The area under observation was a cluster of small freshwater ponds drained during spring floods by a stream. The majority of the area was a wet sedge meadow with 100% vegetation cover, dominated by sedges (*Carex aquatilis* and *C. membranacea*) and cotton-grasses (*Eriophorum angustifolium* and *E. triste*). Much of the soil substrate was organic, and the moisture regime was hygric to hydric, often with standing water.

Figure 1
Location of study site on Victoria Island



2.0 Methods

2.1 Field data collection

We obtained time budget data for nesting pairs of King Eiders from 14 June to 3 July 1993 by observing their behaviour from a blind over a two-hour period every four hours throughout each day (01:00–03:00, 05:00–07:00, 09:00–11:00, 13:00–15:00, 17:00–19:00, and 21:00–23:00 Mountain Daylight Time [MDT]). On 3 July, observations were made only on a female from 01:00 to 03:00. Behavioural data on a focal pair of King Eiders were collected during four 15-minute periods within each two-hour period.

At the beginning of each two-hour watch, we made notes on the weather, including wind speed, precipitation, and temperature. The visibility (e.g., sun angle, fog, rain, snow, wind) was also described.

We used the instantaneous or interval sampling method (Lehner 1979:122–123; Tacha et al. 1985), in which the behaviour of both members of the focal pair was recorded simultaneously every 30 seconds. We obtained a maximum of 31 data points during each 15-minute session for each sex. Fewer data points were obtained if the birds moved out of sight for short periods or flew from the wetland. In the case of the latter or if it appeared that the focal pair would be out of view for the duration of the 15-minute period, a new focal pair was chosen.

Thirty-four behavioural patterns were differentiated based on descriptions by Myres (1964), Johnsgard (1964, 1965:261), Lamothe (1973), and Palmer (1976:124). These behaviours were then grouped under eight categories (Table 1). Courtship behaviours are often ritualized comfort and/or agonistic behaviours. For behaviours that occurred in more than one category, such as these, notes were made in the comments column of the field data form regarding the circumstances of the behaviour so that the proper category could be interpreted. When copulations were observed, notes again were made, if possible, listing the specific displays performed prior to and following the copulation. These observations were not included in the data set but were used in the discussion.

2.2 Data summary and comparison

For each sex, we summed all of the data points for each type of behaviour. The data were further summarized by calculating the totals for the eight behaviour categories. This allowed comparisons using the categories as well as the individual behaviours. Data points for each type of behaviour and behaviour categories were also summed by time of day (in the two-hour periods) and by date.

The percent frequency of each behaviour was calculated for comparison in tables and figures. Nesting behaviour was omitted in discussions comparing the behaviour of males and females, because males do not actively engage in nesting (Hanson et al. 1956; Lamothe 1973). Similarly, prone posture and inciting were omitted in discussions comparing the courtship behaviours of males and females, because they are exclusively performed by the female (Johnsgard 1964; Lamothe 1973).

We were unable to apply statistical tests to our data, because the duck pairs were not marked or otherwise distinguishable. We suspect that as many as five different pairs resided in the wetland; however, we did not know at

Table 1
Types of behaviour and behaviour categories used to describe King Eider behaviour on Victoria Island in 1993

Category	Behaviour	Category	Behaviour
Resting	Sleep	Courtship	Preen — dorsal
	Loaf		Preen — back wing
	Float		Head turn
Alert	Alert		Bill dip
			Upward stretch
Foraging	Upend		Wing flap
	Head dip		Chin lift
	Sieve		Neck stretch
	Dive		Reach
			Push
Travelling	Walk		Head roll
	Swim		Bathe
	Fly		Prone posture
			Incite
Nesting	Walk — Nest search		Copulate
	Sit — Nest search	Agonistic	Upward stretch
	Nest build		Wing flap
	Incubate		Chin lift
			Neck stretch
Comfort	Preen		Reach
	Upward stretch		Push
	Wing flap		Threat
	Head roll		Chase
	Bathe		Attack

what times we were observing the same pair. Therefore, our samples were not independent, which violates the assumptions of statistical tests. However, the magnitude of differences in behaviour in most instances was large enough to enable us to draw conclusions on the data without the use of statistical tests.

3.0 Results

When we arrived on 9 June, the wetland was largely frozen and snow-covered, although a drainage crossing the wetland was swollen with open water. King Eider pairs were already present on the open water. Over the next week, they continued to move through the wetland, primarily in small flocks of pairs. From 14 June to 3 July, we collected a total of 10 793 data points on the behaviour of females and 10 413 data points on males during 113 two-hour periods of observation.

The frequencies of behaviours performed by male and female King Eiders differed a great deal. Females foraged more frequently than males, whereas the frequencies of resting, travelling, courtship, and agonistic behaviours were higher in males (Table 2). Nesting behaviours were exclusive to females.

The behaviour of both male and female King Eiders varied with the time of day. The eiders were least active from 05:00 to 07:00 (Fig. 2). Foraging was most frequent from 13:00 to 19:00. Nesting activities of females peaked between 09:00 and 11:00 and did not occur between 01:00 and 03:00. Comfort behaviours were highest between 01:00 and 03:00. Male courtship and travelling behaviours peaked between 21:00 and 23:00. Alert, comfort, and agonistic behaviours of males showed a sharp increase between 17:00 and 19:00 (Fig. 2).

The behaviour of both males and females changed as the nesting season progressed. Foraging by females almost doubled towards the end of the study period (Fig. 3). Similarly, male foraging activity increased over the period from 24 June to 1 July (Fig. 3). Agonistic behaviours of both sexes peaked from 16 to 21 June. Courtship behaviours peaked from 18 to 21 June and from 25 to approximately 27 June.

Foraging methods differed between sexes and changed over the course of the study. Females fed by upending or head dipping more than did males, whereas males fed most often by diving (Table 3). Upending by both sexes was more prevalent early in the season (Fig. 4). Head dipping showed the opposite trend. Except for the first day of observation, very little sieving was observed. Diving for food was not observed until 19 June in females and 22 June in males, and it became prevalent by 29 June. The high proportion of diving in males is explained by the fact that their foraging activity increased towards the end of the study period.

Elements of courtship displays differed between the sexes. Of those performed by both sexes, sizeable differences were noted only in pushing, chin lifting, and bill dipping. More bill dipping was observed in females than in males (Table 3). Females did not perform head turning, reaching, pushing, or bathing courtship behaviours, whereas males did not perform chin lifting (nor prone posture and inciting, which are exclusive to females).

The first copulation was observed on 15 June, and further copulations were observed approximately every other day until 27 June. A single copulation was later observed on 2 July. The female occasionally initiated copulation by assuming the prone posture several seconds before the male mounted her. At other times, she assumed the prone posture only a moment before being mounted. Males typically performed one or two series of pushes, bill dips, and a wing flap prior to copulation, although there was no consistent sequence of behaviours. The female generally performed a wing flap following copulation, and both sexes occasionally preened for several seconds.

Males tended to perform agonistic displays that were different from those of females. Females engaged in more chin lifting, threatening, and attacking than males, whereas males engaged in more pushes and chases. Females did not perform upward stretching, reaching, or pushing agonistic behaviours (Table 3).

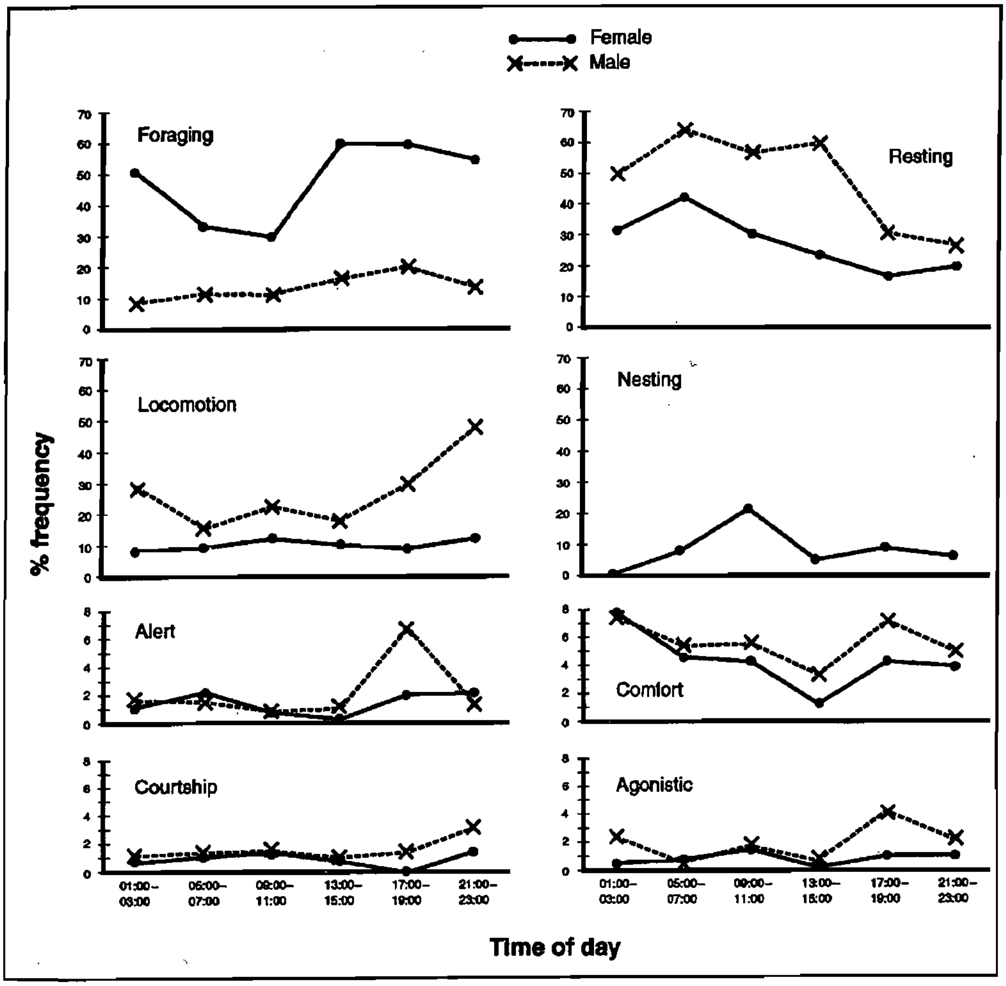
The pushing and chasing agonistic displays of the male and the chin lifting of the female generally were directed towards other King Eider pairs or individual males if they approached too close. However, slightly over 50% of the threatening and attacking agonistic displays of both sexes were directed towards Pomarine Jaegers *Stercorarius pomarinus*. King Eider pairs were occasionally attacked by Pomarine Jaegers during nest searching and when on or at the edge of the ponds. The increase in agonistic behaviour from 16 to 21 June reflects encounters with Pomarine Jaegers as well as encounters with other King Eiders. Agonistic behaviour generally declined as the season advanced (Fig. 3).

Agonistic displays were occasionally recorded between a pair and other eiders if the pair was approached while feeding. This agonistic behaviour was sometimes followed by the eiders all diving together. As the season progressed, the eiders were less aggressive towards one

Table 2
Comparison of behaviour of male and female King Eiders from shortly after their arrival on the breeding grounds to early in the incubation phase (14 June – 3 July 1993)

		% frequency of data points							
	n	Resting	Foraging	Locomotion	Nesting	Comfort	Courtship	Agonistic	Alert
Female	10 793	27.6	47.0	10.1	7.6	4.5	0.9	0.9	1.4
Male	10 413	48.6	13.2	27.1	0.0	5.6	1.6	1.9	2.0

Figure 2
Change in behaviour of King Eiders with the time of day. Sample sizes for each two-hour period starting at 01:00 hours: 2015, 1864, 1768, 1561, 1699, 1886 for females; 1901, 1815, 1741, 1672, 1602, 1682 for males.



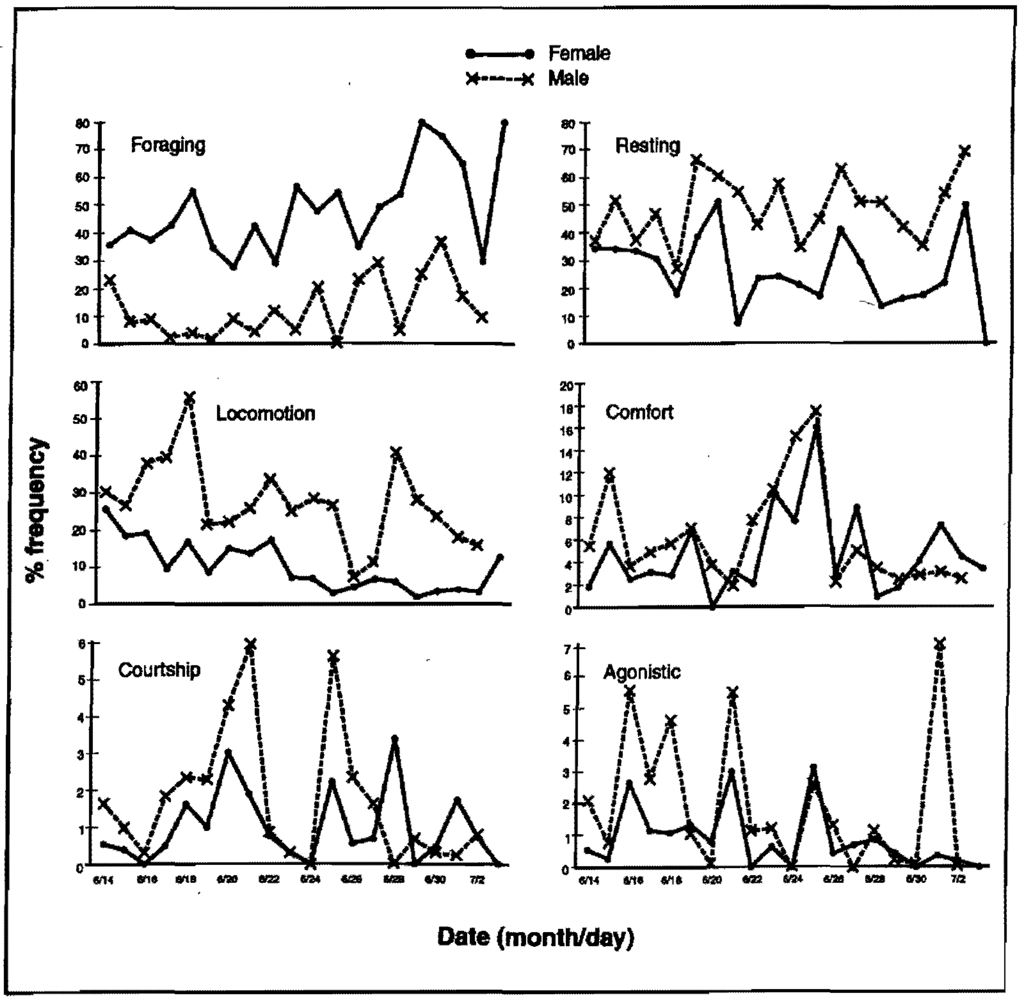
another. They rested, fed, and moved through the wetland in mixed groups of usually one or two males and several females.

A female was first seen searching for a nest on 16 June. Nest searching dropped off after 22 June. Nest building was first observed on 21 June. Nest building and incubation were noted on and off up to 2 July. As the female became more engaged in nesting behaviours, the pair spent more time apart. The male was usually seen on the water or resting on the shore of a nearby pond. Occasionally, we observed his mate join him and commence feeding. On two occasions, while the female was nest searching or nest building, the male flew from the wetland.

Nest failures became apparent in late June when groups of two to five females began to congregate on the ponds. Only one nest was found following the study. It appeared to have been preyed upon by a fox. Arctic foxes *Alopex lagopus* were seen almost every day in the wetland throughout the study period.

The alert posture was observed in a variety of situations. It often immediately preceded flight. It occasionally occurred in association with agonistic behaviours, either prior to or, in the case of females, during agonistic behaviour by the male. At other times, it was assumed briefly in anticipation of certain threats, such as when a goose flew over or a loon called. Females

Figure 3
Change in behaviour of King Eiders over the study period. Sample sizes for each day from 14 June to 3 July: 548, 742, 680, 609, 563, 609, 499, 635, 393, 632, 577, 225, 720, 589, 472, 713, 639, 289, 540, 119 for females; 611, 713, 678, 600, 555, 620, 532, 507, 343, 633, 464, 231, 602, 558, 427, 741, 678, 412, 508 for males.



were alert periodically when engaged in nesting behaviours.

4.0 Discussion

4.1 Study limitations

Caution must be used when interpreting interval data such as those collected in this study. No information is provided on the duration of behaviours; therefore, the percentage of time spent in certain activities cannot be determined precisely. If the interval is longer than the duration of a brief behaviour, such as courtship, agonistic, comfort, and alert behaviours, then behaviours may be missed. Tacha et al. (1985) determined that 9% of rare and brief behaviours were never recorded when using 30-second intervals within 327 20-minute observation periods. In addition, interval observations tend to underestimate the percentage of time for rare behaviour and for behaviour of short and moderate duration, and they tend to overestimate behaviours of moderate frequency and long duration (Tacha et al. 1985).

Our results are based on one year of data. However, behavioural activity can change from year to year owing to various factors (Lamothe 1973; Zicus and Hennes 1993). Lamothe (1973), for example, found that the amount of open water at the time of arrival at the nesting ground affected the amount of feeding and the number of courtship displays. These activities were performed less in a year when there was less open water. Rather, loafing was the preferred activity.

Nesting pairs of King Eiders likely began to arrive in the study area one to two weeks prior to the start of our observations. Parmelee et al. (1967) first noted King Eiders near Cambridge Bay on 4 June in 1960 and on 6 June in 1962. The eiders became more numerous each day until mid-June. Thus, our collection of behavioural data likely began with the arrival of the last pairs. Likewise, our study terminated when we suspected that most, but not all, pairs had finished egg laying.

Table 3
Comparison of behaviours of male and female King Eiders on their nesting grounds on Victoria Island from shortly after arrival to early in the incubation period (14 June – 3 July 1993)

Category	Behaviour	% frequency Females	Males
		(n = 5076)	(n = 1379)
Foraging	Upend	46.0	27.9
	Head dip	40.3	28.1
	Sieve	3.2	7.5
	Dive	10.5	36.6
		(n = 94)	(n = 199)
Agonistic	Upward stretch	0.0	2.0
	Wing flap	4.3	2.0
	Chin lift	26.6	4.5
	Neck stretch	4.3	1.5
	Reach	0.0	3.5
	Push	0.0	60.8
	Threat	48.9	10.6
	Chase	2.1	9.1
	Attack	13.8	6.0
		(n = 97)	(n = 163)
Courtship	Preen — dorsal	13.4	16.0
	Preen — back wing	17.5	14.7
	Head turn	0.0	1.2
	Bill dip	19.6	4.3
	Upward stretch	6.2	6.8
	Wing flap	11.3	8.6
	Chin lift	5.2	0.0
	Neck stretch	1.0	3.1
	Reach	0.0	4.3
	Push	0.0	31.9
	Head roll	5.2	3.1
	Bathe	0.0	1.2
	Prone posture	15.5	0.0
	Incite	1.0	0.0
	Copulate	4.1	4.9

4.2 Comparisons of activity budgets

4.2.1 Foraging behaviour

Females foraged over 3.5 times more frequently than males. As the female fed, the male spent the majority of his time either resting or travelling beside her.

Slightly higher rates of feeding have been reported for other ducks. When not engaged in nesting behaviours, the female King Eiders spent approximately 51% of their time foraging over the period of study, whereas Northern Shovelers *Anas clypeata* (Afton 1979) and Ruddy Ducks *Oxyura jamaicensis* (Tome 1991) spent 54–61% of the prelaying and laying periods foraging, and Common Goldeneyes *Bucephala clangula* spent 61–86% of each day foraging during the laying and incubation periods (Zicus and Hennes 1993).

Certain bird species, including the Common Eider *Somateria mollissima*, arrive on the breeding grounds with sufficient protein and lipid reserves to produce and incubate a clutch of eggs, eliminating the need for foraging during egg laying and incubation (Milne 1974; Parker and Holm 1990; Mann and Sedinger 1993). The female King Eider forages heavily from the time of arrival to the start of incubation, which suggests that she may be less dependent on endogenous nutrients and more dependent on the availability of food on the breeding grounds. By the end of that period, she must have obtained enough energy for both egg production and incubation, as the King Eider does not appear to feed during the 22–24 days of incubation (Parmelee et al. 1967; Lamothe 1973).

The period of the greatest foraging activity began in early afternoon when the sun was highest in the sky and ended very early in the morning. The timing might be linked to food availability because, as the water warms, invertebrates become more active. Earlier in the season, invertebrates are released from the ice as it melts. Roen (1965) noted that King Eiders in northern Greenland ate crustaceans that had been frozen in the ice of shallow lakes. Lamothe (1973) cited a correlation between the amount of upending and chironomid larvae leaving their muddy substrate once the pond started to melt.

Foraging by both sexes increased towards the end of the nest initiation period. Normally, females spend a longer period on the nest with each egg laid and, once incubation begins, seldom leave the nest (Lamothe 1973). The nesting attempt of one focal pair failed sometime between 27 and 30 June, likely owing to Arctic fox predation. We suspect that the other nests in the wetland were also depredated, as none was located during an intensive search of the wetland at the end of the study period. The increase in foraging activity by the failed breeding females, as well as males still in the area, might be linked to weakening of the pair bond.

The utilization of different methods of foraging is dependent on water depth and type of food, which in turn is related to the degree of melting of the ponds (Lamothe 1973). The wetland went through a gradual process of melting, initially being flooded by meltwater, which gradually receded to reveal the distinct ponds. Therefore, the availability of both vegetable and animal matter likely changed over the study period. This is reflected in the patterns of individual foraging behaviours.

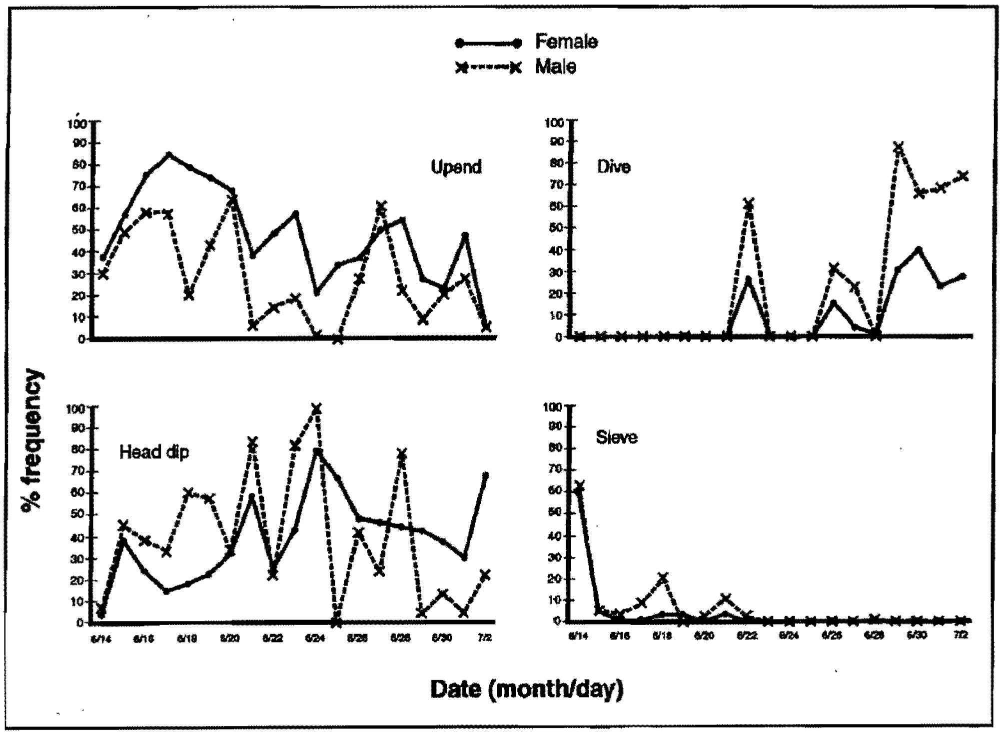
According to Lamothe (1973), both upending and head dipping retrieved vegetable matter and freshwater invertebrates, but head dipping was performed at shallower depths. In our study, upending declined over the season and head dipping increased, suggesting that food became more abundant in shallower water as the season progressed. Sieving took place mostly at the beginning of the season when the birds were feeding primarily in meltwater. Lamothe (1973) noted that sieving generally occurred at the periphery of ponds and lakes. The preponderance of diving late in the season may be in response to the release of invertebrates from the muddy bottoms.

The diving we observed was clearly a feeding activity. It often occurred for prolonged periods and in association with other feeding behaviours. Diving is seldom reported as a feeding method of adult King Eiders in fresh water (Lamothe 1973; Howard 1974; Palmer 1977), although the eiders regularly use this method at sea (Johnsgard 1965:261; Palmer 1977). However, Kondratiev and Zadorina (1992) noted that diving as a feeding method was usual in nonbreeding females as well as ducklings on deep lakes.

4.2.2 Displays

Courtship and agonistic displays were performed more frequently by males than by females. In contrast, Myres (1964) found that when in small groups on the

Figure 4
Change in foraging behaviour of King Eiders from shortly after their arrival on the breeding ground to early in the incubation period. Sample sizes for each day from 14 June to 3 July: 195, 303, 254, 259, 309, 209, 137, 268, 114, 356, 273, 122, 250, 288, 253, 568, 476, 187, 160 for females; 140, 53, 57, 12, 20, 7, 45, 18, 41, 27, 96, 0, 137, 161, 18, 185, 247, 69, 46 for males.



tundra, female King Eiders seemed to display as much as, if not more than, males. Similarly, Drury (1961) stated that ducks did much more inciting than the drakes did courtship.

The most common courtship and agonistic display of the male was pushing, as was also the case in studies by Myres (1964) and Lamothe (1973). Palmer (1976:125) indicated that pushing occurred as long as the pair bond was maintained. Pushing and reaching by females were not observed. Others have noted that pushing is rare in females (Myres 1964; Lamothe 1973), whereas reaching is not part of the female's courtship display repertoire (Lamothe 1973).

Other than aggressive threatening movements, chin lifting was the most frequent agonistic display of the female. It was used much less in courtship displays. Similarly, Lamothe (1973) found it to be primarily an agonistic display and the one used most frequently by females. As a courtship display, it always preceded the prone posture (Lamothe 1973). Johnsgard (1964) indicated that, as an agonistic display, it is generally directed towards other males. In our study, it was directed primarily towards other pairs, as well as individual males, mixed-sex groups, and Pomarine Jaegers.

4.2.3 Nesting behaviour

Nest searching was first observed on 16 June, one day after the observation of the first copulation. However, nesting behaviour might have begun prior to the start of our observations on 14 June. Egg laying started as early as 12 June near Cambridge Bay and continued into late June, falling off sharply by early July (Parmelee et al. 1967). This pattern corresponds with our observations.

Nesting behaviour in females peaked from 09:00 to 11:00, which coincides with the period of the least foraging by females. In contrast, the average time of day that eggs were laid by Common Eiders was 13:49 (Watson et al. 1993).

The involvement of the male in nesting was minimal. He only occasionally accompanied the female, from a distance, during nest searching. More often he loafed or swam and fed in a nearby pond while his mate was nest searching, nest building, or sitting on the nest. On two occasions, he quickly joined the female to help her defend against a Pomarine Jaeger. In contrast, Parmelee et al. (1967) flushed several pairs from nests and concluded that the drakes follow the ducks right to the nest site. On Bathurst Island, most of the males accompanied the females during nest site selection but kept from 10 to 50 m from the nest once it was established, remaining until after the laying of the first egg (Lamothe 1973). Whether or not the male attends the nest might be influenced by the local abundance of fox and avian predators, as the bright coloration of the male King Eider could attract attention to the location of the nest. Thus, in our study area and Lamothe's (1973), where predators were abundant, the male avoided the nest site; in Parmelee et al.'s (1967) study area near Cambridge Bay, where the foxes had been heavily trapped, the male remained by the female at the nest site.

There is a weakening of the pair bond with the initiation of incubation (Lamothe 1973; Cramp and Simmons 1977:594). The weakened bond was apparent by late June, as mixed-sex groups of presumably failed nesters commonly displayed no agonistic behaviour. The weakened pair bond between one focal pair was apparent when the female left her mate to join one of these groups, while the male remained apart and performed the pushing display with regularity.

4.3 Adaptive behaviour patterns

The King Eider has developed behaviour patterns that contribute to its reproductive success. By establishing the pair bond prior to arrival at the nesting site (Lamothe 1973; Palmer 1976:124), both time and energy are saved, as activities related to preparation for nesting can be initiated on arrival. This is particularly important in Arctic breeding grounds where the summer season is so short.

Prior to incubation, females spent nearly half of their time feeding. This period of heavy feeding may contribute to the ability of female King Eiders to go without food during incubation. By remaining on the nest, the risk of egg predation is reduced and chance of hatching success increased. The feeding efficiency of the female, therefore, is of utmost importance. The male contributes to this efficiency by remaining by her side as she feeds, thereby maintaining a territory, protecting her from predators, and reducing the female's interactions with other birds (Milne 1974; Ashcroft 1976). Less foraging by the males also would ensure as much food as possible for the female when the supply is limited.

Once the female becomes engaged in nesting behaviours, how closely the male attends the female appears to be variable, based on our observations and those reported by Parmelee et al. (1967) and Lamothe (1973). His presence nearby serves to protect her and defend the territory, but his conspicuous plumage could call attention to the nest site. If he remains at a distance, he might divert the attention of predators from the nest owing to the disruptive nature of his plumage (Lamothe 1973). Therefore, a balance must be reached, perhaps depending on the local abundance of foxes and avian predators.

4.4 Coexistence with avian predators

King Eiders and Pomarine Jaegers shared the same nesting habitat in our study area. As a result, energy was expended by the King Eider, as is evidenced by the fact that over half of the threatening and attacking agonistic behaviours were directed towards jaegers. In addition, the eiders risked losing eggs or chicks to the jaegers, particularly if lemming numbers were low (Maher 1974). However, the eider might benefit from nesting in close proximity to the jaeger because of the jaeger's general defence of its own clutch against other jaegers and predators such as the Arctic fox. Blomqvist and Elander (1988) found that most King Eiders in northeast Greenland clustered their nests around Long-tailed Jaeger *Stercorarius longicaudus* nests. Based on the clustering, they suggested that reproductive output is higher for King Eiders associated with the Long-tailed Jaeger. Although we did not determine nest patterns with respect to jaeger nests, the same phenomenon might have been occurring in our study area.

Acknowledgements

We are grateful to the following people who assisted with the collection of the field data: A. Bezener, B. Cornish, J. Sirois, and H. Trefry. We also thank Dr. L. Linton of the Biology Department, University of Calgary, and S. Barry for their statistical advice.

This project was funded by the Canadian Wildlife Service and the Inuvialuit Implementation Funds, with logistical support from the Polar Continental Shelf Project.

Literature cited

Afton, A.D. 1979. Time budget of breeding Northern Shovelers. Wilson Bull. 91:42–49.

Ashcroft, R.E. 1976. A function of the pair bond in the Common Eider. Wildfowl 27:101–105.

Blomqvist, S.; Elander, M. 1988. King Eider (*Somateria spectabilis*) nesting in association with Long-tailed Skua (*Stercorarius longicaudus*). Arctic 41:138–142.

Cramp, S.; Simmons, K.E.L. 1977. Handbook of the birds of Europe, the Middle East and North Africa: the birds of the western Palearctic. Vol. 1. Ostrich to ducks. Oxford University Press, Oxford.

Drury, W.H. 1961. Observations on some breeding water birds on Bylot Island. Can. Field-Nat. 75:84–101.

Hanson, H.C.; Queneau, P.; Scott, P. 1956. The geography, birds, and mammals of the Perry River region. Arct. Inst. North Am. Spec. Publ. No. 3.

Höhn, E.O. 1957. Observations on display and other forms of behavior of certain Arctic birds. Auk 74:203–214.

Howard, R.L. 1974. Aquatic invertebrate–waterbird relationships on Alaska's Arctic coastal plain. MSc thesis, Iowa State University, Ames. 49 pp.

Johnsgard, P.A. 1964. Comparative behavior and relationships of the eiders. Condor 66:113–129.

Johnsgard, P.A. 1965. Handbook of waterfowl behavior. Comstock Publishing Associates (a division of Cornell University Press), Ithaca, New York.

Kondratiev, A.V.; Zadorina, L.V. 1992. Comparative ecology of King Eider *Somateria spectabilis* and Spectacled Eider *S. fischeri* in chaun tundra. Zool. Zh. 71:99–108 (in Russian, with English summary).

Lamothe, P. 1973. Biology of King Eider (*Somateria spectabilis*) in a fresh water breeding area on Bathurst Island, N.W.T. MSc thesis, University of Alberta, Edmonton. 125 pp.

Lehner, P.N. 1979. Handbook of ethological methods. Garland STPM Press, New York. 403 pp.

Maher, W.J. 1974. Ecology of pomarine, parasitic, and long-tailed jaegers in northern Alaska. Pacific Coast Avifauna No. 37, Cooper Ornithological Society, Los Angeles, California.

Mann, F.E.; Sedinger, J.S. 1993. Nutrient-reserve dynamics and control of clutch size in Northern Pintails breeding in Alaska. Auk 110:264–278.

Milne, H. 1974. Breeding numbers and reproductive rate of Eiders at the sands of Forvie National Nature Reserve, Scotland. Ibis 116:135–152.

Myres, M.T. 1964. The display behavior of the King Eider; with a discussion of interspecific selection for reproductive isolation between the King and Common Eiders. Arctic Institute of North America. 20 pp.

Palmer, R.S. (ed.). 1976. Handbook of North American birds. Waterfowl (Part 2). Vol. 3. Yale University Press, New Haven, Connecticut.

Palmer, R.S. 1977. King Eider studies. Br. Birds 70:107–113.

Parker, H.G.; Holm, H. 1990. Patterns of nutrient and energy expenditure in female Common Eiders nesting in the high Arctic. Auk 107:660–668.

Parmelee, D.F.; Stephens, H.A.; Schmidt, R.H. 1967. The birds of southeastern Victoria Island and adjacent small islands. Natl. Mus. Can. Bull. No. 222, Biol. Ser. No. 78.

Roen, U. 1965. Ornithological observations on the 3rd Pearyland Expedition in the summer of 1964. Dan. Ornithol. Foren. Tidsskr. 59:85–91.

Tacha, T.C.; Vohs, P.A.; Iverson, G.C. 1985. A comparison of interval and continuous sampling methods for behavioral observations. J. Field Ornithol. 56:258–264.

Tome, M.W. 1991. Diurnal activity budget of female Ruddy Ducks breeding in Manitoba. Wilson Bull. 103:183–189.

Watson, M.D.; Robertson, G.J.; Cooke, F. 1993. Egg-laying time and laying interval in the Common Eider. Condor 95:869–878.

Zicus, M.C.; Hennes, S.K. 1993. Diurnal time budgets of breeding Common Goldeneyes. Wilson Bull. 105:680–685.

The subsistence harvest of King and Common eiders in the Inuvialuit Settlement Region, 1988–1994

Michael Fabijan, Rodney Brook, David Kuptana, and James E. Hines

Abstract

This chapter summarizes information on the subsistence harvest of King Eiders *Somateria spectabilis* and the Pacific subspecies of the Common Eider *S. mollissima v-nigra* from the western Canadian Arctic, gathered from 1988 to 1994 under the Inuvialuit Harvest Study (IHS). It also evaluates the impact that hunting in the Inuvialuit Settlement Region (ISR) and elsewhere might have on western populations of the two species. The reported harvest of eiders in the ISR, based on monthly interviews of potential hunters, was adjusted to produce harvest estimates by accounting for hunters that could not be interviewed in a given month. Minimum estimates of eider harvest ranged from 1804 to 5013 birds per year and averaged 3446. Most (99%) of the harvest occurred at the community of Holman on western Victoria Island, where the eiders pass close to shore while migrating eastward towards breeding areas in June. The kill at Holman was composed predominantly of King Eiders (95.6% of the eiders taken from 1991 to 1994) and a smaller proportion of Common Eiders (4.4%). If these percentages are applied to the annual harvest at other communities in the ISR (where the data were recorded only as eider species), the average harvest becomes 3294 King Eiders and 152 Common Eiders per year. There was a slightly larger proportion of males (52%) than females (48%) in the harvest of both species at Holman. The IHS data do not include unretrieved kill and are possibly influenced by other forms of sampling bias. Therefore, we suspect that the IHS provides minimum estimates of harvest, which should be increased by as much as 25%. A review of published data suggests that during the period 1976–1995, 2.4–5.1% of the western populations of King and Common eiders were killed by hunters in Alaska and Arctic Canada each year. The overall rates of harvest for western eiders are below the sustainable harvest rates for other related populations or species. The harvest of King Eiders at Holman is taken as the birds approach the breeding grounds, however, and may be drawn from a relatively small subpopulation. Investigations of the size of the subpopulation of eiders that moves through the Holman area and additional harvest information on the sex, age, reproductive status, and unretrieved kill for this particular population segment would be useful for management purposes.

Résumé

Le présent chapitre résume les données relatives à la récolte d'Eiders à tête grise *Somateria spectabilis* et des sous-espèces du Pacifique de l'Eider à duvet *S. mollissima v-nigra* à des fins de subsistance, dans la région ouest de l'Arctique canadien. Ces données ont été réunies entre 1988 et 1994 dans le cadre de l'Étude des prises par les Inuvialuit (EPI). On y évalue également l'impact de la chasse dans la Région visée par le règlement de la revendication des Inuvialuit (RRRI) et dans d'autres régions sur les populations de l'ouest des deux espèces. Les prises d'eiders déclarées dans la RRRI, selon des entrevues effectuées tous les mois auprès des chasseurs éventuels, ont fait l'objet de corrections pour permettre d'arriver à des estimations de prises qui tiennent compte des chasseurs qui ne pouvaient pas être interviewés au cours d'un mois donné. Les estimations minimales de prises annuelles d'eiders se situaient entre 1 804 et 5 013 oiseaux et atteignaient en moyenne 3 446 oiseaux. La plupart des prises (99 %) ont eu lieu à la collectivité de Holman dans la partie ouest de l'île Victoria, où les eiders passent près de la côte en juin au moment de leur migration vers l'est à destination des zones de reproduction. Les prises à Holman étaient surtout composées d'Eiders à tête grise (95,6 % des eiders tués entre 1991 et 1994), les Eiders à duvet ne comprenant que 4,4 % de ces prises. Lorsque ces pourcentages sont ajoutés au pourcentage des prises annuelles dans les autres collectivités de la RRRI (où des données ont été réunies pour la seule espèce des eiders), les prises annuelles totalisent en moyenne 3 294 Eiders à tête grise et 152 Eiders à duvet. Dans les prises des deux espèces à Holman, la proportion des mâles était légèrement plus élevée (52 %) que celle des femelles (48 %). Les données EPI ne tiennent pas compte des oiseaux tués et laissés sur place, et sont peut-être influencées par d'autres types de biais d'échantillonnage. C'est pourquoi nous pensons que l'EPI indique des estimations minimales pour les prises et ces chiffres devraient être relevés d'au moins 25 %. D'après un examen des données publiées, les chasseurs de l'Alaska et de l'Arctique canadien ont tué chaque année entre 1976 et 1995 de 2,4 à 5,1 % des populations de l'ouest d'Eiders à tête grise et à duvet. Les taux globaux de prise dans le cas des eiders de l'ouest sont inférieurs aux taux de prises viables applicables à d'autres

populations ou espèces dans des circonstances semblables. Toutefois, à Holman, les Eiders à tête grise sont tués au moment où les oiseaux approchent des zones de reproduction et pourraient provenir d'une sous-population relativement restreinte. Il serait utile du point de vue de la gestion de procéder à des études sur la taille de la sous-population d'eiders qui passent par la région de Holman et d'obtenir d'autres renseignements sur les prises selon le sexe, l'âge, l'étape de reproduction et les oiseaux tués et abandonnés dans le cas de ce groupe particulier de la population.

1. Introduction

The cultural and economic importance of waterfowl and other wildlife to the Aboriginal people of the western Canadian Arctic is clearly identified in the Inuvialuit Final Agreement, which devotes much of its content to conservation and other environmental issues (Anonymous 1984). As part of the final land claim agreement, a harvest study was created to document the numbers of birds, mammals, and fish taken by the Inuvialuit. The information gathered during the study is intended for use in (1) wildlife management, (2) calculating a compensation regime for loss of wildlife and habitat caused by industrial development in the Inuvialuit Settlement Region (ISR), and (3) determining the subsistence wildlife use and requirements of the Inuvialuit.

Much concern has been expressed about declining numbers of eiders and other sea ducks in northwestern Canada and Alaska (Kertell 1991; Stehn et al. 1993; this publication), in part because of the low potential of sea ducks for population growth and the limited harvest that their populations can presumably withstand (Goudie et al. 1994). Harvest is a variable that wildlife management agencies and cooperative management boards can reasonably expect to influence. Thus, it is important to understand if current levels of hunting are having a detrimental effect on populations.

In this chapter, we present information on King Eiders *Somateria spectabilis* and the Pacific subspecies of the Common Eider *S. mollissima v-nigra* gathered through the Inuvialuit Harvest Study (IHS) from 1988 to 1994. We relate the results of the IHS to harvest information from other sources in order to evaluate the impact that hunting, both in and outside the ISR, might be having on the western Arctic populations of eiders.

2. Methods

The IHS is a "recall survey," and, like similar studies carried out elsewhere in northern Canada (Usher and Wentzel 1987), it has attempted to survey all hunters in the region. The basic goal was to interview every hunter in the ISR on a monthly basis and record the number of animals taken as well as locations of harvest.

One or two field workers in each of the six communities in the region carried out the interviews. Calendars with pictures as well as Inuvialuktun and English names of commonly hunted species, illustrations of King and Common eiders, bird identification books, and maps (scale 1:250 000) were used as identification and recall aids. Hunters were encouraged to record harvest information on the calendars to make the resulting data as complete and accurate as possible.

Although a complete survey of all hunters was attempted, not all individuals could be interviewed each month. Therefore, total harvest for each community was calculated according to the following formula:

$$EH = RH/IS$$

where:

EH = the estimated monthly harvest by a given community;
RH = the reported monthly harvest in a given community; and
IS = interview success (the proportion of active hunters in a given community that were interviewed during a particular month).

The estimated community harvest for a given year was the sum of the monthly harvests for that year.

King and Common eiders were identified only as "eiders" during the first four years of the study (1988–1991). From 1992 to 1994, the species and sex of eiders were recorded at the community of Holman.

The populations of King and Common eiders that occur in the western Arctic are also hunted outside the ISR. Therefore, to assess the total harvest that is being taken from the population, we also considered harvest data from Alaska and the central Canadian Arctic.

3. Results

The number of active hunters per year in the ISR ranged from 676 to 852 and averaged 743. The average number of hunters differed greatly from community to community, ranging from 52 in the hamlet of Sachs Harbour to 225 in the largest community (Inuvik) (Table 1).

Interview success was high in all communities and averaged >90% overall (Table 1). Thus, failure to interview a significant number of the hunters from any of the communities should not bias the results greatly.

Only a few hunters from most of the communities reported taking eiders, and the annual harvest was small for all parts of the ISR except near Holman on western Victoria Island (Tables 1 and 2; Fig. 1). The magnitude of the eider harvest near the different communities undoubtedly reflected in part the local availability of eiders and other species of waterfowl in different parts of the ISR. Near Holman, eiders were the most abundant waterfowl, whereas near the other communities, geese were far more numerous and apparently more preferred.

The hunters from Holman accounted for nearly 99% of the eider kill in the ISR. Migrating King Eiders follow a nearshore lead while moving eastward along the north shore of Prince Albert Sound towards breeding areas. They pass close to shore between Holman and Victoria Island at a place that the local people call Masoyak. There, the birds are highly accessible to hunters and are shot in large numbers. It seems probable that annual ice conditions and the amount of open water influence the flight path of the birds and the subsequent harvest at the Masoyak eider pass. For example, during

Table 1
Population size, number of hunters, number of hunters harvesting eiders, and average monthly interview success for the six communities in the Inuvialuit Settlement Region, 1988–1994

Community	1988	1989	1990	1991	1992	1993	1994	Mean
Aklavik (801)[a]								
No. of hunters	162	157	150	144	144	138	229	161
Interview success (%)[b]	99	99	99	97	99	99	82	96
No. of hunters harvesting eiders	2	1	0	0	1	0	0	1
Inuvik (3206)								
No. of hunters	220	218	212	229	225	232	236	225
Interview success (%)	38	88	92	89	99	94	97	85
No. of hunters harvesting eiders	0	0	0	0	0	0	0	0
Tuktoyaktuk (918)								
No. of hunters	116	117	122	134	133	132	138	127
Interview success (%)	80	99	86	94	96	92	89	91
No. of hunters harvesting eiders	2	1	0	0	1	0	0	1
Paulatuk (255)								
No. of hunters	63	62	65	79	79	77	76	72
Interview success (%)	100	100	100	98	100	100	100	100
No. of hunters harvesting eiders	6	4	3	1	3	2	0	3
Holman (361)								
No. of hunters	76	80	79	131	135	126	120	107
Interview success (%)	96	98	98	95	97	95	100	97
No. of hunters harvesting eiders	65	65	56	65	59	66	66	63
Sachs Harbour (125)								
No. of hunters	51	50	48	56	58	50	53	52
Interview success (%)	95	96	98	91	92	95	91	94
No. of hunters harvesting eiders	5	4	1	5	3	3	1	3
All communities (5666)								
No. of hunters	688	684	676	773	774	755	852	743
Interview success (%)	76	95	94	93	98	95	92	92
No. of hunters harvesting eiders	80	75	60	71	67	71	67	70

[a] 1991 population of the community in parentheses (N.W.T. Bureau of Statistics).
[b] Percentage of hunters that were interviewed each month (average for the 12-month period).

Table 2
Estimated eider harvest in the Inuvialuit Settlement Region, 1988–1994

	No. of eiders harvested							
Community	1988	1989	1990	1991	1992	1993	1994	Mean
Aklavik	5	9	0	0	5	0	0	3
Inuvik	0	0	0	0	0	0	0	0
Tuktoyaktuk	6	11	0	24	0	0	0	6
Paulatuk	35	21	14	6	19	2	0	14
Holman	4942	3667	2375	3859	4467	1794	2720	3403
Sachs Harbour	25	53	5	20	25	8	7	20
Total	5013	3761	2394	3909	4516	1804	2727	3446

the early spring and relatively open-water year of 1993, harvest was the lowest recorded in the seven years of study (Table 2).

The estimated eider harvest in the region ranged from 1804 in 1993 to 5013 in 1988 and averaged 3446 birds per year (Table 2). If the percentages of King (95.6%) and Common (4.4%) eiders in the bag at Holman (Table 3) are applied to the kill for the other communities as well, the average harvest becomes 3296 King and 150 Common eiders each year. There was a slightly higher proportion of males (52%) than females (48%) in the harvest of both species at Holman (Table 3).

The harvest of eiders occurred mainly in June, when the birds were arriving on the breeding grounds. Only about 5% of the eiders were taken in the late summer and fall (Table 4).

4. Discussion

4.1 Characteristics of the eider harvest in the Inuvialuit Settlement Region

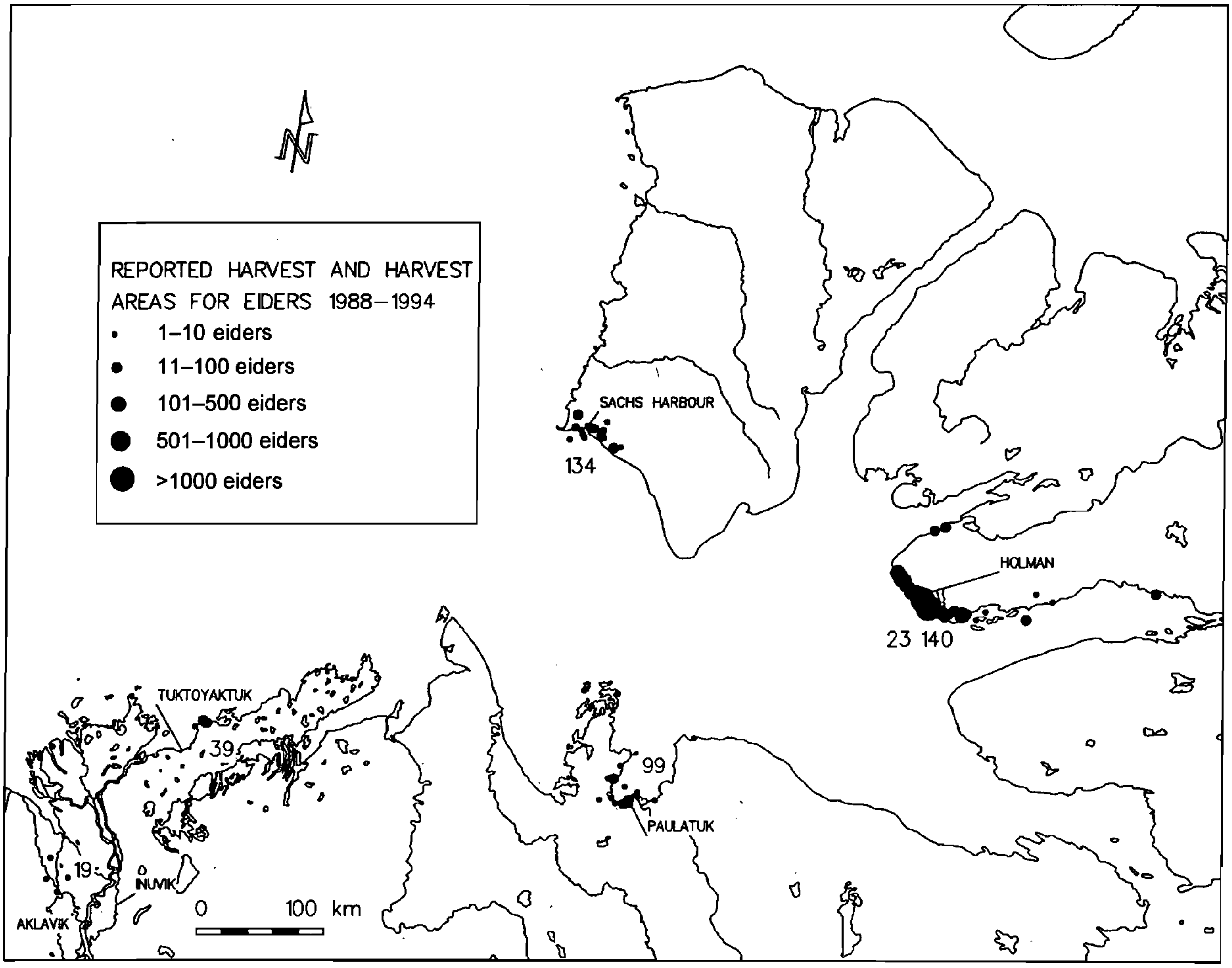
Opportunities for hunting eiders in the ISR are apparently limited, and the eider harvest in the region is concentrated near Holman in June. Most (>95%) of the kill consists of King Eiders and is taken by relatively few hunters (70 on average). Given the localized nature of the hunt, the relatively short period over which it occurs, and the small number of hunters involved, management of the harvest should be readily attainable.

4.2 Potential sources of error

To determine what impact the harvest in the ISR is having on eider numbers, we need to understand the possible limitations of the IHS data. Errors or biases in harvest estimates would result (1) if hunters inaccurately recall how many birds were taken, (2) if the estimated number of hunters taking waterfowl in spring were incorrect, or (3) if significant numbers of shot birds were not retrieved. All three types of biases might influence the results of the IHS to some degree.

The first potential bias, inaccurate estimates of the number of animals taken per hunter, has been identified as

Figure 1
Locations where eiders were killed by hunters in the Inuvialuit Settlement Region, 1988–1994



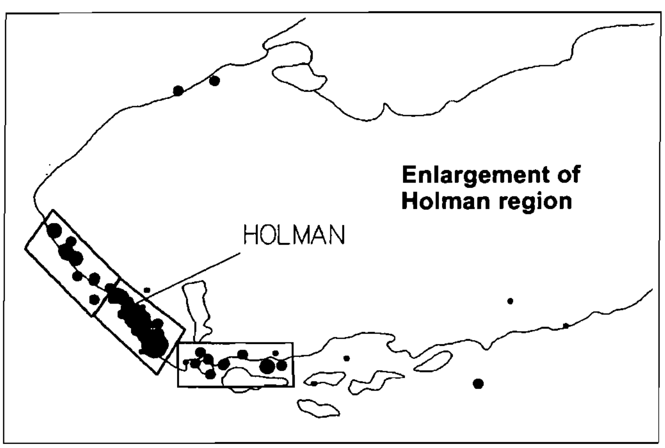


Table 3
Reported number of male and female King and Common eiders harvested near Holman, 1988–1994

	No. of eiders harvested				
	1992	1993	1994	Total	Mean
King Eider					
Female	1347	708	1223	3278	1093
Male	1396	809	1403	3608	1203
Unknown	1229	196	53	1478	493
Total	3972	1713	2679	8364	2788
Common Eider					
Female	115	5	17	137	46
Male	124	5	21	150	50
Unknown	94	0	0	94	31
Total	333	10	38	381	127
Both species	4305	1723	2717	8745	2915

a possible problem with IHS data for one community. Bromley (1993) conducted an independent investigation of spring waterfowl hunting by the Inuvialuit that overlapped temporally with the IHS. The average number of waterfowl taken per hunter was similar for two of the three communities considered by both investigations. Bromley (1993) suggested that the average harvest of Lesser Snow Geese *Chen caerulescens caerulescens* for

Table 4
Average reported eider harvest per month in the Inuvialuit Settlement Region, 1988–1994

Community	No. of eiders harvested				
	May	June	July	August	September
Aklavik	0	1	0	0	1
Inuvik	0	0	0	0	0
Tuktoyaktuk	4	1	0	0	0
Paulatuk	1	12	0	0	1
Holman	1	3128	3	8	166
Sachs Harbour	1	16	0	1	0
All communities	7	3158	3	9	168

the third community, Sachs Harbour, where individual hunters take large numbers of geese, was underestimated by the IHS, leading to a low estimate of total harvest. Insofar as large numbers of eiders were taken by relatively few hunters at Holman, the situation with the eider harvest there might be similar. Preliminary comparisons of the Bromley and IHS data sets on a hunter by hunter basis suggest that the typical harvest per hunter was not significantly different for the two studies (MF, unpubl. data), but additional evaluation of this possible form of bias is warranted.

The second potential bias, an incorrect estimate of the number of hunters taking waterfowl, could also be important. Bromley (1993) suggested that the IHS might underestimate the number of waterfowl hunters, especially in larger communities such as Tuktoyaktuk or Inuvik, where the number of people hunting waterfowl was less well known. His results suggested that any bias in estimating the number of waterfowl hunters appeared to be minor in a small community (Paulatuk). Most of the eider harvest in the ISR occurred at the small settlement of Holman, where interview success was high and the hunting population was small and well known. Therefore, we suspect that the number of hunters was estimated accurately at Holman and that the second potential bias was relatively unimportant in estimating total eider harvest. Some hunters from other communities in the ISR hunt eiders at Holman, however, so it would be useful to confirm that their harvest is being recorded along with that of local residents.

No estimate of the third type of bias, variously termed "crippling loss," "unretrieved kill," or animals that are "struck but lost," is available for the eider harvest in the ISR. However, at least one authority believed that it was significant (Smith 1973). In southern Canada and the United States, the unretrieved kill of waterfowl has been shown to be important, exceeding 25% on average (see Nieman et al. 1987 for a summary of several studies). Perhaps of even more direct relevance is information gathered at Point Barrow, Alaska, where there is a large subsistence harvest of migrating eiders. Studies at Point Barrow place the unretrieved kill of eiders at 30–40% (Thompson and Person 1963; Johnson 1971). More recent information indicates a loss rate of ≥31% of the Spectacled Eiders *Somateria fischeri* shot in the subsistence hunt near St. Lawrence Island, Alaska (C.P. Dau, U.S. Fish and Wildlife Service, Cold Bay, Alaska, pers. commun.).

Most studies of unretrieved kill have been made during late summer or fall (i.e., the open-water season). This contrasts with the situation at Holman, where the hunt occurs mainly in the spring and many of the shot birds fall on the ice, where they can be more readily retrieved. Nevertheless, we believe that estimates of waterfowl harvest from the IHS might best be considered as minimum estimates of retrieved kill and probably should be increased by 25% or more to account for the various forms of bias discussed above. This would place the annual harvest in the ISR at about 4600 eiders or about 4400 King and 200 Common eiders.

4.3 Is the current harvest of the western populations of King and Common eiders sustainable?

The western populations of King and Common eiders are hunted by the Inupiat and Yupik in Alaska and the Inuit of the central Canadian Arctic, as well as by the Inuvialuit. Sport hunters in the United States and Canada also take a small number of birds. In an attempt to understand the impact that hunting, both within and outside the ISR, might have on eiders, we have summarized the available information on harvest for other areas and time periods (Table 5). The summary suggests an overall annual harvest (including unretrieved kill) of about 20 000 King Eiders and 2 500 Common Eiders in recent years.

The western Arctic populations of eiders have apparently declined at an average rate of 4.5% per year, from about 803 000 King and 153 000 Common eiders in 1976 to 556 000 King and 95 000 Common eiders in 1987 and to 373 000 King and 71 000 Common eiders in 1995 (Woodby and Divocky 1982; Suydam et al., this publication). The data summarized in Table 5 suggest that the overall annual harvest of eiders was similar in the 1960s and 1970s to that of recent years. Using our estimate of an annual kill of 22 500 eiders, we have calculated that 2.4% of the overall population was harvested in 1976, 3.5% was harvested in 1987, and 5.1% was harvested in 1994.

Although the degree of exploitation that eider populations can safely withstand is not well understood, it appears that the harvest of eiders from the western Arctic has been within sustainable limits during the period of population decline. In support of this view, we cite two examples: the population models for Common Eiders from the eastern Arctic presented by Reed and Erskine (1986), and the population simulation for Harlequin Ducks *Histrionicus histrionicus* described by Goudie et al. (1994). Sustainable harvest rates for eiders from the eastern Arctic exceeded 10% of the fall population each year. The sustainable level of harvest for Harlequin Ducks, possibly among the most sensitive of sea ducks to overhunting, was computed as 3–5% of the adult population. Thus, throughout most or all of the period that their populations were declining, the kill of King and Common eiders from the western Arctic has been well below the sustainable harvest values reported for similar species or populations. In fact, the estimated rate of population decrease (about 4.5% per annum) was greater than the estimated harvest rate during most of the period of

Table 5
The estimated harvest of the western populations of King and Common eiders

Location	Year	No. of eiders	% King Eiders	% Common Eiders	Authority
Yukon–Kuskokwim Delta[a]	1964	4 691			Klein (1966)
Yukon–Kuskokwim Delta[b]	1985–1994	5 258	86	14	Wentworth and Seim (1995)
Point Barrow, Alaska[c]	1970	8 480	96	4	Johnson (1971)
Point Barrow, Alaska[d]	1987–1989	9 077			Braund (1993a)
Wainright, Alaska[e]	1987–1990	970	91	9	Braund (1993b)
Holman, N.W.T.[f]	1969	8 624	95	5	Smith (1973)
Inuvialuit Settlement Region, N.W.T.[g]	1988–1994	4 595	96	4	This paper
Central Canadian Arctic[h]	1983–1989	2 679	56	44	A. D'Hondt (N.W.T. Department of Renewable Resources, Yellowknife, pers. commun.)
Sport harvest (Alaska, N.W.T.)	1985–1994	<500			Lévesque et al. (1993), Martin and Padding (1994)
Inuvialuit Settlement Region and Alaska[i]	1986	10 000–20 000			Barry (1986)
Western Arctic populations	Recent	22 500	89	11	Synthesis of above studies

[a] Estimated retrieved harvest of 3300 eiders. We assumed after Wentworth and Seim (1995) that species composition was 79% King Eiders, 13% Common Eiders, and 8% Spectacled Eiders. Adjusted for unretrieved kill (35%).
[b] Estimated retrieved harvest of 3418 King and Common eiders. Adjusted for unretrieved kill (35%).
[c] Estimate includes unretrieved kill (40%).
[d] Estimated retrieved harvest of 5900 King and Common eiders, adjusted for unretrieved kill (35%).
[e] Estimated retrieved harvest of 630 King and Common eiders, adjusted for unretrieved kill (35%).
[f] Estimated retrieved harvest of 6468 King and Common eiders, adjusted for unretrieved kill (25%).
[g] Estimated retrieved harvest of 3446 King and Common eiders, adjusted for unretrieved kill (25%).
[h] Estimated retrieved harvest of 1972 King and Common eiders, adjusted for unretrieved kill (25%).
[i] Based on Thompson and Person (1963), Johnson (1971), and Smith (1973).

decline. We conclude that it is unlikely that overharvest has been the cause of the population decline.

Finally, we recognize that there is a high degree of uncertainty associated with some of the estimates of numbers and harvests used in our analyses. Given the current concerns about declining populations of eiders in western North America and the low level of harvest that sea duck populations theoretically can withstand, improved estimates of all demographic and population parameters would be valuable. In the ISR, the harvest of King Eiders is restricted mainly to Holman, at a time when the birds are nearing the breeding grounds. If drawn from a subpopulation of eiders breeding on Victoria Island, this substantial harvest has the potential to impact the long-term availability of eiders for the Inuvialuit. Thus, an estimate of the size of the eider migration through Holman and confirmation of the accuracy of the harvest study results for this area are warranted. In addition, detailed information documenting the sex, age, and reproductive status of harvested eiders, as well as the amount of unretrieved kill, should be gathered. This would be especially valuable if the group of eiders hunted at Holman proves to be from a small breeding population.

Acknowledgements

The success of the IHS is largely dependent on the willing participation of the Inuvialuit hunters and the efforts of the community field workers who conducted the interviews. Field workers included Foster Allen, Billy Archie, Dean Arey, Nellie Elanik, Bessie Erigaktuk, and Dodie Malegana (Aklavik); Victor Allen, Linly Day, Noel Dick, Alex Kaglik, Ann Kasook, Lawrence Rogers, Troy Smith, and Tommy Thrasher (Inuvik); Janet Elias, Laura Ettagiak, Charles Gruben, Bessie Hagan, Marjorie Ovayuak, and Fred Wolki (Tuktoyaktuk); Noel Green (Paulatuk); and Earl Esau and Samantha Lucas (Sachs Harbour). The IHS Working Group, the Inuvialuit Game Council, and the Hunters' and Trappers' Committees of Aklavik, Holman, Inuvik, Paulatuk, Sachs Harbour, and Tuktoyaktuk provided valuable advice on study design and operations. The study was supported by funding made available through the Inuvialuit Final Agreement. In addition to the individuals and groups mentioned above, we would like to thank Adrian D'Hondt for providing information on the harvest of eiders in the central Arctic, Bob Bromley, Chris Dau, and Grant Gilchrist for reviewing the manuscript, and Maureen Kay for producing the map of harvest locations.

Literature cited

Anonymous. 1984. The Western Arctic Claim: The Inuvialuit Final Agreement. Department of Indian Affairs and Northern Development, Ottawa.

Barry, T.W. 1986. Eiders of the western Canadian Arctic. Pages 74–80 *in* A. Reed (ed.), Eider ducks in Canada. Can. Wildl. Serv. Rep. Ser. No. 47, Ottawa.

Braund, S.R. 1993a. North Slope subsistence study Barrow, 1987, 1988 and 1989. Tech. Rep. No. 149, Minerals Management Service, U.S. Department of the Interior, Anchorage, Alaska.

Braund, S.R. 1993b. North Slope subsistence study Wainwright, 1988 and 1989. Tech. Rep. No. 147, Minerals Management Service, U.S. Department of the Interior, Anchorage, Alaska.

Bromley, R. 1993. Comparison of results from two waterfowl harvest studies in three Inuvialuit communities, Northwest Territories, 1988–1990. File Rep. No. 111, Northwest Territories Department of Renewable Resources, Yellowknife.

Goudie, R.I.; Brault, S.; Conant, B.; Kondratyev, A.V.; Petersen, M.R.; Vermeer, K. 1994. The status of sea ducks in the North Pacific Rim: toward their conservation and management. Trans. North Am. Wildl. Nat. Resour. Conf. 59:27–49.

Johnson, L.L. 1971. The migration, harvest, and importance of waterfowl at Barrow, Alaska. MSc thesis, University of Alaska, Fairbanks. 87 pp.

Kertell, K. 1991. Disappearance of the Steller's Eider from the Yukon–Kuskokwim Delta, Alaska. Arctic 44:177–187.

Klein, D.R. 1966. Waterfowl in the economy of the Eskimos of the Yukon–Kuskokwim Delta, Alaska. Arctic 19:319–336.

Lévesque, H.; Collins, B.; Legris, A.M. 1993. Migratory game birds harvested in Canada during the 1991 hunting season. Can. Wildl. Serv. Prog. Note No. 204, Ottawa. 42 pp.

Martin, E.M.; Padding, P.I. 1994. Preliminary estimates of waterfowl harvest and hunter activity in the United States during the 1993 hunting season. Admin. Rep., Off. Migr. Bird Manage., U.S. Fish Wildl. Serv., Laurel, Maryland. 33 pp.

Nieman, D.J.; Hochbaum, G.S.; Caswell, F.D.; Turner, B. 1987. Monitoring hunter performance in prairie Canada. Trans. North Am. Wildl. Nat. Resour. Conf. 52:233–245.

Reed, A.; Erskine, A.J. 1986. Populations of the Common Eider in eastern North America: their size and status. Pages 156–170 *in* A. Reed (ed.), Eider ducks in Canada. Can. Wildl. Serv. Rep. Ser. No. 47, Ottawa.

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

Stehn, R.A.; Dau, C.P.; Conant, B.; Butler, W.I. 1993. Decline of Spectacled Eiders nesting in Western Alaska. Arctic 46(3):264–277.

Thompson, D.Q.; Person, R.A. 1963. The eider pass at Point Barrow, Alaska. J. Wildl. Manage. 27:348–356.

Usher, P.J.; Wentzel, G. 1987. Native harvest surveys and statistics: a critique of their construction and use. Arctic 40:145–160.

Wentworth, C.; Seim, S. 1995. Subsistence waterfowl harvest survey, Yukon–Kuskokwim Delta. Unpubl. rep., U.S. Fish Wildl. Serv., Anchorage, Alaska. 213 pp.

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

Recent publications in the Occasional Papers series

No. 37
The wildlife valuation problem: A critical review of economic approaches, by William A. Langford and Donald J. Cocheba.
Cat. No. CW69-1/37. Publ. 1978.
No. 38
Spatial changes in waterfowl habitat, 1964–74, on two land types in the Manitoba Newdale Plain, by G.D. Adams and G.G. Gentle.
Cat. No. CW69-1/38. Publ. 1978.
No. 39
Patterns of pelagic distribution of seabirds in western Lancaster Sound and Barrow Strait, Northwest Territories, in August and September 1976, by D.N. Nettleship and A.J. Gaston.
Cat. No. CW69-1/39. Publ. 1978.
No. 40
Responses of Peary caribou and muskoxen to turbo-helicopter harassment, Prince of Wales Island, Northwest Territories, by Frank L. Miller and Anne Gunn.
Cat. No. CW69-1/40. Publ. 1979.
No. 41
Avian community structure of six forest stands in La Mauricie National Park, Quebec, by J.-L. DesGranges. Disponible également en français.
Cat. No. CW69-1/41E. Publ. 1979.
No. 42
Population ecology studies of the polar bear in northern Labrador, by Ian Stirling and H.P.L. Kiliaan. Disponible également en français.
Cat. No. CW69-1/42E. Publ. 1980.
No. 43
Census methods for murres, *Uria* species; a unified approach, by T.R. Birkhead and D.N. Nettleship. Disponible également en français.
Cat. No. CW69-1/43E. Publ. 1980.
No. 44
Population ecology studies of the polar bear in the area of southeastern Baffin Island, by Ian Stirling, Wendy Calvert, and Dennis Andriashek. Disponible également en français.
Cat. No. CW69-1/44E. Publ. 1980.
No. 45
Polynyas in the Canadian Arctic, by Ian Stirling and Holly Cleator, eds. Disponible également en français.
Cat. No. CW69-1/45E. Publ. 1981.
No. 46
The Lesser Snow Geese of the eastern Canadian Arctic, by H. Boyd, G.E.J. Smith, and F.G. Cooch. Disponible également en français.
Cat. No. CW69-1/46E. Publ. 1982.
No. 47
The distribution and abundance of seals in the eastern Beaufort Sea, 1974–79, by Ian Stirling, Michael Kingsley, and Wendy Calvert. Disponible également en français.
Cat. No. CW69-1/47E. Publ. 1982.
No. 48
Foraging behaviour of Peary caribou in response to springtime snow and ice conditions, by F.L. Miller, E.J. Edmonds, and A. Gunn. Disponible également en français.
Cat. No. CW69-1/48E. Publ. 1982.
No. 49
A review of some important techniques in sampling wildlife, by A.R. Sen. Disponible également en français.
Cat. No. CW69-1/49E. Publ. 1982.
No. 50
Intensive regulation of duck hunting in North America: its purpose and achievements, by Hugh Boyd. Disponible également en français.
Cat. No. CW69-1/50E. Publ. 1983.
No. 51
Human dimensions of migratory game-bird hunting in Canada, by Shane A.D. Parker and Fern L. Filion. Disponible également en français.
Cat. No. CW69-1/51E. Publ. 1984.
No. 52
Components of hunting mortality in ducks, by G.S. Hochbaum and C.J. Walters. Disponible également en français.
Cat. No. CW69-1/52E. Publ. 1984.
No. 53
The interpretation of aerial surveys for seabirds: some effects of behaviour, by A.J. Gaston and G.E.J. Smith. Disponible également en français.
Cat. No. CW69-1/53E. Publ. 1984.
No. 54
Waterfowl studies in Ontario, 1973–81, by S.G. Curtis, D.G. Dennis, and H. Boyd, eds. Disponible également en français.
Cat. No. CW69-1/54E. Publ. 1985.
No. 55
The reported kill of ducks and geese in Canada and the USA, 1974–82, by Hugh Boyd. Disponible également en français.
Cat. No. CW69-1/55E. Publ. 1985.
No. 56
Population dynamics of the Common Loon (*Gavia immer*) associated with mercury-contaminated waters in northwestern Ontario, by J.F. Barr. Disponible également en français.
Cat. No. CW69-1/56E. Publ. 1986.
No. 57
The Ring-billed Gull in Ontario: a review of a new problem species, by H. Blokpoel and G.D. Tessier. Disponible également en français.
Cat. No. CW69-1/57E. Publ. 1986.
No. 58
The birds of the Creston Valley and southeastern British Columbia, by R.W. Butler, B.G. Stushnoff, and E. McMackin. Disponsible également en français.
Cat. No. CW69-1/58E. Publ. 1986.
No. 59
Estimating densities of birds at sea and the proportion in flight from counts made on transects of indefinite width, by A.J. Gaston, B.T. Collins, and A.W. Diamond. Disponible également en français.
Cat. No. CW69-1/59E. Publ. 1987.
No. 60
Waterfowl breeding population surveys, Atlantic Provinces, by A.J. Erskine, ed. Disponible également en français.
Cat. No. CW69-1/60E. Publ. 1987.

No. 61
A survey of Lesser Snow Geese on Southampton and Baffin islands, NWT, 1979, by A. Reed, P. Dupuis, and G.E.J. Smith. Disponible également en français.
Cat. No. CW69-1/61E. Publ. 1987.

No. 62
Studies of the effects of acidification on aquatic wildlife in Canada: waterfowl and trophic relationships in small lakes in northern Ontario, by D.K. McNicol, B.E. Bendell, and R.K. Ross. Disponible également en français.
Cat. No. CW69-1/62E. Publ. 1987.

No. 63
Bison ecology in relation to agricultural development in the Slave River lowlands, NWT, by H.W. Reynolds and A.W.L. Hawley, eds.
Cat. No. CW69-1/63E. Publ. 1987.

No. 64
A simulation model for the Greater Snow Goose population, by J. Gauvin and A. Reed. Disponible également en français.
Cat. No. CW69-1/64E. Publ. 1987.

No. 65
The birds of the Fraser River delta: populations, ecology and international significance, by Robert W. Butler and R.Wayne Campbell.
Cat. No. CW69-1/65E. Publ. 1987.

No. 66
Mortality of migratory barren-ground caribou on the calving grounds of the Beverly herd, Northwest Territories, 1981–83, by Frank L. Miller, Eric Broughton, and Anne Gunn.
Cat. No. CW69-1/66E. Publ. 1988.

No. 67
Studies of the effects of acidification on aquatic wildlife in Canada: Lacustrine birds and their habitats in Quebec, by Jean-Luc DesGranges, ed. Disponible également en français.
Cat. No. CW69-1/67E. Publ. 1989.

No. 68
Studies of high-latitude seabirds. 1. Behavioural, energetic, and oceanographic aspects of seabird feeding ecology, by W.A. Montevecchi and A.J. Gaston, eds.
Cat. No. CW69-1/68E. Publ. 1991.

No. 69
Studies of high-latitude seabirds. 2. Conservation biology of Thick-billed Murres in the Northwest Atlantic, by A.J. Gaston and R.D. Elliot, eds.
Cat. No. CW69-1/69E. Publ. 1991.

No. 70
Habitats of the northeast coast of James Bay, by N. Dignard, R. Lalumière, A. Reed, and M. Julien. Disponible également en français.
Cat. No. CW69-1/70E. Publ. 1991.

No. 71
Key migratory bird terrestrial habitat sites in the Northwest Territories (2nd edition), by Stuart A. Alexander, Robert S. Ferguson, and Kevin J. McCormick.
Cat. No. CW69-1/71E. Publ. 1991.

No. 72
Atlas of pelagic birds of western Canada, by K.H. Morgan, K. Vermeer, and R.W. McKelvey.
Cat. No. CW69-1/72E. Publ. 1991.

No. 73
The Red-throated Loon as an indicator of environmental quality, by D. Lynne Dickson. Disponible également en français.
Cat. No. CW69-1/73E. Publ. 1992.

No. 74
Aerial radio-tracking of Whooping Cranes migrating between Wood Buffalo National Park and Aransas National Wildlife Refuge, 1981–84, by E. Kuyt.
Cat. No. CW69-1/74E. Publ. 1992.

No. 75
The ecology, status, and conservation of marine and shoreline birds on the west coast of Vancouver Island, by K. Vermeer, R.W. Butler, and K.H. Morgan, eds.
Cat. No. CW69-1/75E. Publ. 1992.

No. 76
Declines in Canadian amphibian populations: designing a national monitoring strategy, by C.A. Bishop, K.E. Pettit, eds.
Cat. No. CW69-1/76E. Publ. 1992.

No. 77
Studies of high-latitude seabirds. 3. A model of the energy demands of the seabirds of eastern and Arctic Canada, by A.W. Diamond, A.J. Gaston, and R.G.B. Brown (edited by W.A. Montevecchi).
Cat. No. CW69-1/77E. Publ. 1993.

No. 78
Historical review of water bird populations and annotated list of water birds associated with Burlington Bay, Lake Ontario, 1857–1990, by M.B. Gebauer, R.Z. Dobos, and D. Vaughn Weseloh.
Cat. No. CW69-1/78E. Publ. 1993.

No. 79
Hydrological classification of Canadian prairie wetlands and prediction of wetland inundation in response to climatic variability, by Ming-ko Woo, Robert D. Rowsell, and Robert G. Clark.
Cat. No. CW69-1/79E. Publ. 1993.

No. 80
Monitoring Thick-billed Murre populations at colonies in northern Hudson Bay, 1972–92, by A.J. Gaston, L.N. de Forest, G. Gilchrist, and D.N. Nettleship.
Cat. No. CW69-1/80E. Publ. 1994.

No. 81
Colonies and numbers of Ross' Geese and Lesser Snow Geese in the Queen Maud Gulf Migratory Bird Sanctuary, by R.H. Kerbes.
Cat. No. CW69-1/81E. Publ. 1994.

No. 82
The 1991 International Piping Plover Census in Canada, by S.P. Flemming, ed.
Cat. No. CW69-1/82E. Publ. 1994.

No. 83
The abundance and distribution of estuarine birds in the Strait of Georgia, British Columbia, by R.W. Butler and K. Vermeer, eds.
Cat. No. CW69-1/83E. Publ. 1994.

No. 84
Wintering populations of Lesser Snow Geese and Ross' Geese in the Northern Highlands of México, 1988–1990, by Bruce Turner, Roy Tomlinson, Raquel Leyva, and Pablo Dominguez.
Cat. No. CW69-1/84E. Publ. 1994.

No. 85
Caspian Terns on the Great Lakes: organochlorine contamination, reproduction, diet, and population changes, 1972–91, by Peter J. Ewins, D.V. (Chip) Weseloh, Ross J. Norstrom, Karin Legierse, Heidi J. Auman, and James P. Ludwig.
Cat. No. CW69-1/85E. Publ. 1994.

No. 86
The patient predator: foraging and population ecology of the Great Blue Heron *Ardea herodias* in British Columbia, by Robert W. Butler.
Cat. No. CW69-1/86E. Publ. 1995.

No. 87
Use of various habitat types by nesting ducks on islands in the St. Lawrence River between Montréal and Trois-Rivières, by Luc Bélanger and Denis Lehoux. Disponible également en français.
Cat. No. CW69-1/87E. Publ. 1995.

No. 88
A review of the environmental impacts of lead shotshell ammunition and lead fishing weights in Canada, by A.M. Scheuhammer and S.L. Norris. Disponible également en français.
Cat. No. CW69-1/88E. Publ. 1995.

No. 89
The colonial waterbirds of Great Slave Lake, Northwest Territories: an annotated atlas, by J. Sirois, M.A. Fournier, and M.F. Kay.
Cat. No. CW69-1/89E. Publ. 1995.

No. 90
Duck use of the coastal habitats of northeastern James Bay, by Austin Reed, Réjean Benoit, Richard Lalumière, and Michel Julien. Disponible également en français.
Cat. No. CW69-1/90E. Publ. 1996.

No. 91
Studies of high-latitude seabirds. 4. Trophic relationships and energetics of endotherms in cold ocean systems, by W.A. Montevecchi, ed.
Cat. No. CW69-1/91E. Publ. 1996.

No. 92
Goose use of the coastal habitats of northeastern James Bay, by Austin Reed, Réjean Benoit, Michel Lalumière. Disponible également en français.
Cat. No. CW69-1/92E. Publ. 1996.

No. 93
The ecology, status, and conservation of marine and shoreline birds of the Queen Charlotte Islands, by K. Vermeer and K.H. Morgan, eds.
Cat. No. CW69-1/93E. Publ. 1997.