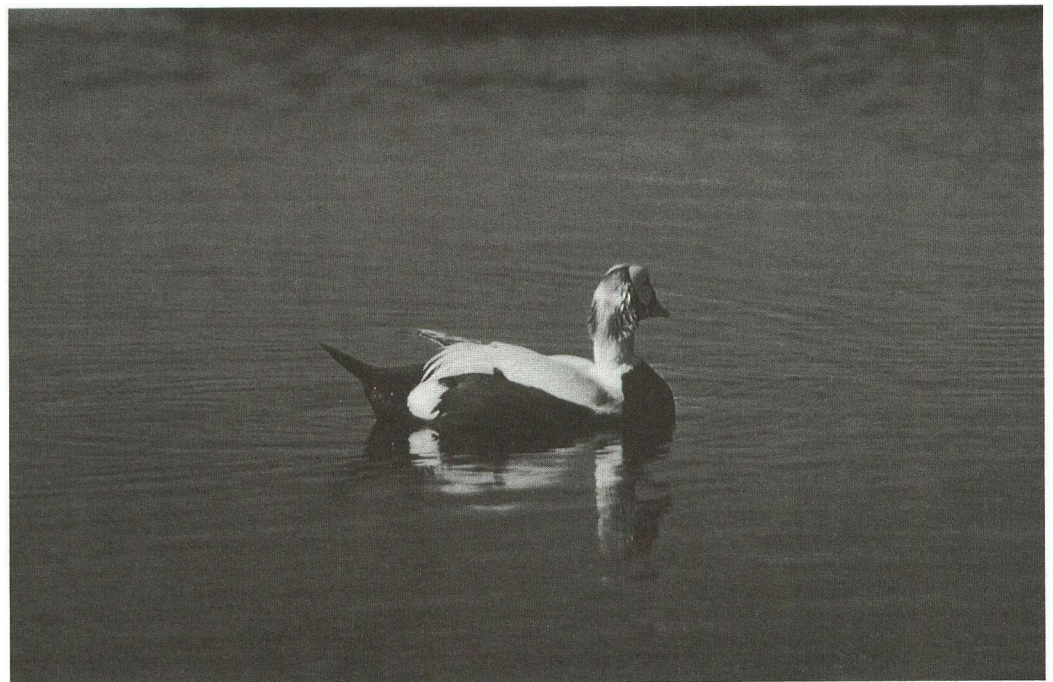


**R. Ian Goudie
Margaret R. Petersen
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(editors)**

Behaviour and ecology of sea ducks

**Occasional Paper
Number 100
Canadian Wildlife Service**



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Behaviour and ecology of sea ducks

Occasional Paper
Number 100
Canadian Wildlife Service

Papers presented at the Pacific Seabird Group Symposium, Victoria, British Columbia, 8–12 November 1995. Published for the Pacific Seabird Group by the Canadian Wildlife Service.



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Preface

Sea ducks are a diverse group of waterfowl exhibiting dramatic ornate plumages and life history strategies that are more akin to seabirds than to other species of ducks. Some sea ducks, such as Common Eiders, have played a long and important historic role in the economy and subsistence of areas of the northern hemisphere. Other species, such as the Nearctic Surf Scoter, are among the most poorly studied waterfowl in the world.

In the general picture, sea ducks have been marginalized in waterfowl conservation and management programs, as most attention has been focused on the "sport ducks," notably Mallards. In fact, much of our understanding of the demography and harvest of ducks is based on the Mallard model. Perceived lack of interest in hunting of the sea ducks had led to liberal management for this group. Large harvests in southern areas and intense subsistence use in the north have proved a dangerous combination. Over the past decade, unprecedented conservation issues have arisen among the sea ducks — notably, *endangered* status for the eastern population of Harlequin Ducks and *threatened* status for Spectacled Eiders and Steller's Eiders. Furthermore, all species in the sea duck tribe except mergansers are exhibiting continental declines. Our understanding of the ecology and causal factors for the declines of these species is poor.

In November 1995, the Colonial Waterbird Society and the Pacific Seabird Group held a joint conference in Victoria, British Columbia. On the first day of the conference, a full-day symposium on the biology of sea ducks was held. The papers in this volume were presented at this symposium. It is hoped that by synthesizing this information, more informed management decisions for sea ducks may emerge. The symposium contents help to emphasize the seriousness of some conservation issues facing sea ducks, notably the possible endangerment of the eastern population of Barrow's Goldeneye and the dwindling numbers of eider ducks in the Nearctic, while also providing new data on the behaviour and habitat use of this beautiful group of ducks.

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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.

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Behaviour of Harlequin Ducks and three species of scoters wintering in the Queen Charlotte Islands, British Columbia

R. Ian Goudie¹

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Abstract

Diving behaviour and activity budgets were determined for Harlequin Ducks *Histrionicus histrionicus* and three species of scoters (*Melanitta* spp.) wintering in the Queen Charlotte Islands, British Columbia. Harlequin Ducks had the most diverse behavioural repertoires. Based on over 100 hours of behavioural sampling, the four species of sea ducks spent in excess of 60% of daylight hours in feeding activities. There was a general pattern of increased feeding from fall to winter, when daylight was shorter and inclement weather more frequent (ranging from an average of 52% of daylight hours in October to 71% in February). Harlequin Ducks did not spend significantly more time feeding than the larger scoters. Relatively mild climatic conditions, availability of energy-rich foods, and extensive shallow-water habitat may account for the lack of body size effect. Linear regression models indicated no significant relationship with environmental variables, whereas tidal regimes accounted for significant variation in proportion of time spent feeding in Black Scoters *M. nigra* and especially Harlequin Ducks. Harlequin Ducks decreased feeding activity with rising tides and increasing amplitudes, whereas Black Scoters increased feeding with increasing tidal amplitude.

Harlequin Ducks and White-winged Scoters *M. fusca* exhibited the highest dive to pause ratios, although the difference from the Surf *M. perspicillata* and Black scoters was not marked. The analyses for sequence effects indicated that Harlequin Ducks and White-winged Scoters might defer full physiological recovery between dives during a diving sequence. Some possible explanations might include optimizing foraging during suitable tidal regimes, limited daylight hours during feeding in winter, optimal foraging of mobile prey items (e.g., crabs), and synchronized flock vigilance to minimize predation.

Résumé

On a établi le comportement de plongée et l'emploi du temps des Arlequins plongeurs (*Histrionicus histrionicus*) et de trois espèces de macreuses (*Melanitta* spp.) hivernant dans les îles de la Reine-Charlotte, en Colombie-Britannique.

Les Arlequins plongeurs présentaient le répertoire comportemental le plus diversifié. Selon un échantillonnage de plus d'une centaine d'heures, les quatre espèces de canards de mer consacraient plus de 60 p. 100 des heures de clarté des activités d'alimentation. On a observé un accroissement général de ces activités de l'automne à l'hiver, au moment où les heures de clarté étaient plus courtes et le temps, moins clément (allant d'une moyenne de 52 p. 100 des heures de clarté en octobre à 71 p. 100 en février). Les Arlequins plongeurs n'ont pas passé beaucoup plus de temps à se nourrir que les macreuses de plus grande taille. Des conditions climatiques relativement douces, la disponibilité d'aliments riches en énergie et un vaste habitat de petits fonds peuvent expliquer l'absence d'effets reliés à la taille du corps. Des modèles de régression linéaire n'ont indiqué aucune relation significative avec les variables environnementales, tandis que les régimes de marée étaient liés à une importante variation de la proportion de temps consacré aux activités alimentaires chez les Macreuses noires (*M. nigra*), en particulier chez les Arlequins plongeurs. Ces derniers diminuaient leurs activités alimentaires avec la montée des marées et l'accroissement des amplitudes, tandis que les Macreuses noires se nourrissaient davantage avec l'accroissement des amplitudes.

Les Arlequins plongeurs et les Macreuses à ailes blanches (*M. fusca*) présentaient la plus forte proportion de plongées par rapport aux pauses, bien que la différence avec les Macreuses noires et à front blanc (*M. perspicillata*) n'ait pas été marquée. Les analyses des effets de séquence ont indiqué que la récupération physiologique complète des Arlequins plongeurs et des Macreuses à ailes blanches ayant lieu habituellement entre les plongées pourrait être reportée durant une séquence de plongée. Les explications possibles à cela peuvent inclure l'optimisation de la récolte durant les périodes de marée favorables, le nombre limité d'heures de clarté propices à l'alimentation en hiver, la récolte optimale de proies mobiles (p. ex. les crabes) et la surveillance synchronisée des volées pour réduire au minimum la prédation.

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1.0 Introduction

In northern marine biomes, feeding activity and diets may be significantly influenced by body size. For example, Goudie and Ankney (1986) demonstrated that smaller species of sea ducks spent proportionately more time feeding and had diets that yielded a higher energy per unit mass of food. Smaller species adjusted activities less in relation to deteriorating environmental conditions. The ratio of pause length to the preceding dive length has been suggested to indicate diving efficiency (e.g., Dewar 1924; Nilsson 1970). Diving behaviour may set upper limits to habitat use by species of sea ducks, as the pause time to recover from dives increases exponentially beyond a certain threshold of water depth. For example, Nilsson (1970) suggested that this may explain the more northerly midwinter distribution of male Common Goldeneye *Bucephala clangula* compared with the smaller females in coastal Sweden.

Specific habitat use by sea ducks has been poorly documented. For the four species in this study, epibenthic foods are pried from the substrate using the chisel-shaped bills with strong down-curved terminal nails in water depths generally less than 10 m (Bellrose 1976). Harlequin Ducks use rocky shorelines, whereas scoters may use sandy through boulder-cobble to bedrock substrates (Stott and Olson 1973; Bellrose 1976; Hirsch 1980; Goudie and Ankney 1988).

Sea ducks spend some, or all, portions of the annual life cycle on marine habitats. Little is known of the ecology and demography of sea ducks in the north Pacific, where many populations are declining (Goudie et al. 1994). Relatively large populations of sea ducks occur in winter in the Queen Charlotte Islands (hereafter called Haida Gwaii), and especially large aggregations occur during migration and the annual feather moult (Savard 1988; Campbell et al. 1990). Large concentrations of sea ducks in coastal British Columbia, notably scoters (*Melanitta* spp.), are probably related to the mild environmental conditions, high productivity of nearshore waters, the general lack of hunting interest, and abundance of refuge areas.

This study focused on aspects of the ecology of four species of sea ducks — namely, White-winged Scoter *M. fusca*, Surf Scoter *M. perspicillata*, Black Scoter *M. nigra*, and Harlequin Duck *Histrionicus histrionicus* — in Haida Gwaii in winter. Data collection was focused in the area of Skidegate Inlet but also included the eastern shore of Graham Island north to Tlell and the area of McIntyre Bay around Yakan Point and Tow Hill (Fig. 1). Specific objectives were 1) to determine the time-activity budgets and 2) to compare diving behaviour among the four species.

2.0 Methods

2.1 Activity budgets

Observations of flocks of sea ducks were balanced across species and three time periods: namely, dawn–11:00, 11:00–14:00, and 14:00–dusk. Each sampling unit consisted of a 30-minute watch of a “species” flock with scans every 60 seconds, during which individuals were allocated to the behaviours outlined in Table 1. After each 30-minute watch, a different flock or species was selected. Observations for each watch were summed and the totals converted to proportions.

Figure 1
Map of study area

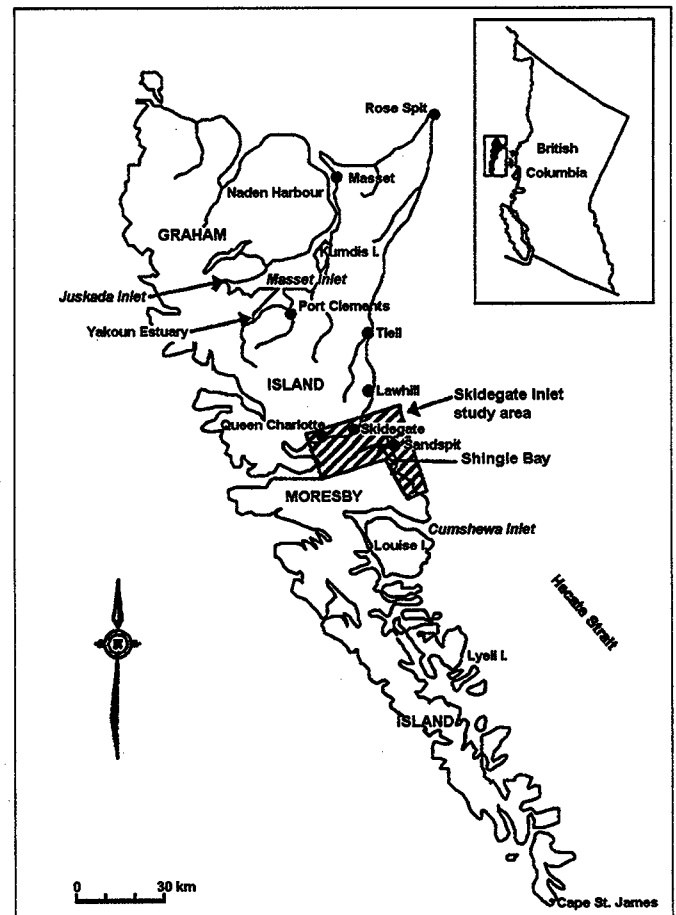


Table 1
Behaviours recorded and categories used in this study

Category	Behaviours recorded
Feeding bout	Peer Dip Dive Pause Submerge
Resting bout	Rest Preen Haul out
Locomotion	Swim Fly
Social	Agonistic Courtship

2.2 Diving behaviour

Data on sequential dives and pauses were collected using a digital stopwatch. Individuals engaged in feeding bouts were observed, and an attempt was made to record a maximum of 10 sequential dives and pauses. Afterwards, a different individual of the same or different species was selected. Sea ducks generally alternate feeding periods (10–20 minutes) with resting periods of similar duration, during which they process captured prey through the muscular gizzard (see Ydenberg and Guillemette 1991).

2.3 Data analyses

Behavioural watches (30 minutes) were summed and converted to proportions that were transformed to arcsine square roots (after Zar 1974) for parametric statistical testing (mainly linear regression). Proportions of time spent feeding or resting were regressed on sea state, tidal amplitude (to nearest 0.1 m), tide cycle, time of day, month, wind speed (km/hour), wind direction, ambient temperature, dewpoint, air pressure (kPa), precipitation, and cloud cover (%). Only independent variables that contributed significantly to the model were retained. The following transformations were applied to independent variables: temperature as degrees Kelvin; wind direction sine (east–west components) and cosine (north–south components).

Dummy variables were created for wind influence (light/no winds, onshore winds, crosswinds, lee winds) and time of day (morning, midday, and afternoon). Precipitation was entered as a rank variable (0 = none, 1 = patchy fog, 2 = solid fog, 3 = mist/light rain, 4 = heavy rain, 5 = light snow, 6 = heavy snow). Sea state was entered as an estimate of wave height to nearest 0.1 m. Tidal cycle was entered as a categorical dummy variable (low slack, rising, high slack, ebbing). Month of observations was entered as an ordinal variable (October = 1 to February = 5).

Differences in proportions of time spent feeding, resting, or in social behaviour were tested using the non-parametric Kruskal-Wallis test. For significant findings, the significant interactions were ascertained using Mann-Whitney U tests.

For diving behaviour, the data collected per feeding bout (usually 5–10 sequential dives) were grouped and the mean values used in order to meet the assumptions of independent data. The length of pause (seconds) was regressed on the length of dive. Interspecific comparisons were made using the dive to pause ratio of the independent mean values calculated above. Differences among species were tested using analysis of variance (ANOVA) and multiple range tests. The relationships between the residuals of the dive–pause regression to dive length and sequence number were analyzed to assess if there was an influence of sequence on the relationship of pause to dive.

3.0 Results

3.1 Activity budgets

3.1.1 Overall time budgets

In total, 209 watches of 30-minute duration were achieved, for an effective sample of 104.5 hours divided among the four species of sea ducks. Behavioural repertoires were most diverse in the Harlequin Duck (Fig. 2), notably because of the additional foraging strategies of peering and dipping. Dipping was used inshore to obtain food at receding tide lines or amongst floating algae (especially *Fucus* spp.) and was similar to the foraging techniques of dabbling ducks (tribe Anatini). Peering may have been of value in locating suitable substrates or prey items and was similar to techniques used by the mergansers (*Mergus* spp.). Only Harlequin Ducks hauled out of water during resting bouts (Fig. 3), a behaviour that permits the resightings of coloured alphanumeric tarsal bands for studies of demography and philopatry (see Robertson et al., this volume).

3.1.2 Time budgeted to foraging

Overall, the four species in this study budgeted a similar proportion of time to feeding ($P > 0.50$), averaging from 61% to 68% of the daylight hours. There was a general pattern for feeding to increase through the winter period, ranging from an average of about 52% of daylight hours in October to 71% of daylight hours in February, when weather was most inclement (Fig. 4). There was no relationship of body size to proportion of time spent feeding ($P > 0.90$).

The general patterns of foraging indicated some apparent interspecific differences. For example, Harlequin Ducks increased the proportion of daylight budgeted to feeding from October to January but subsequently decreased it in February, whereas White-winged Scoters increased proportion of time feeding in each subsequent month and Surf Scoters maintained similar proportions of time feeding in January and February. Black Scoters decreased feeding in January but increased proportion of time budgeted to feeding in February (Fig. 4).

3.1.3 Time budgeted to courtship and agonistic behaviour

Courtship and agonistic behaviours were relatively uncommon (1–2% of budget) and appeared most frequently in Harlequin Ducks and Surf Scoters. Their low levels are consistent with the high flock synchrony and long-term pair bonds observed in sea ducks (Robertson et al. 1998).

3.1.4 Environmental influences on foraging

The stepwise multiple regression models suggested that proportion of time spent feeding was not significantly influenced by ambient temperature, dewpoint, air pressure, wind speed, or wind direction ($P > 0.10$). Tide cycles and amplitude strongly influenced feeding activities for two species. Harlequin Ducks decreased feeding with rising tides ($P = 0.024$) and increased feeding with decreasing tidal amplitude ($P < 0.0001$) ($F_{2,69} = 11.45$, $P < 0.0001$, $R^2 = 0.249$), in the following relationship:

$$\text{\% of time feeding} = 1.403 - 0.097 \text{ amplitude} - 0.177 \text{ rising tides}$$

Black Scoters increased feeding with higher tidal amplitude ($P = 0.25$) and increased feeding with rising tides ($P = 0.014$) ($F_{2,45} = 3.39$, $P < 0.05$, $R^2 = 0.131$) according to the following relationship:

$$\text{\% of time feeding} = 0.701 + 0.034 \text{ amplitude} + 0.222 \text{ rising tides}$$

The pattern of increased feeding with increasing tidal amplitude ($P = 0.136$), rising tides ($P = 0.031$), and ebbing tides ($P = 0.019$) was somewhat evident in White-winged Scoters, although the overall model was not significant ($F_{3,39} = 2.329$, $R^2 = 0.152$, $P = 0.089$). There was no apparent relationship of feeding behaviours of Surf Scoters to tidal cycle and amplitude ($P > 0.50$).

3.2 Diving behaviour

Average lengths of dives and pauses were highest in the larger species (Table 2). The ratio of the length of the dive to the subsequent pause was highest for the Harlequin Duck and White-winged Scoter and lower for the other two

Figure 2
Time spent in various feeding behaviours by four species of sea ducks wintering in Haida Gwaii, British Columbia

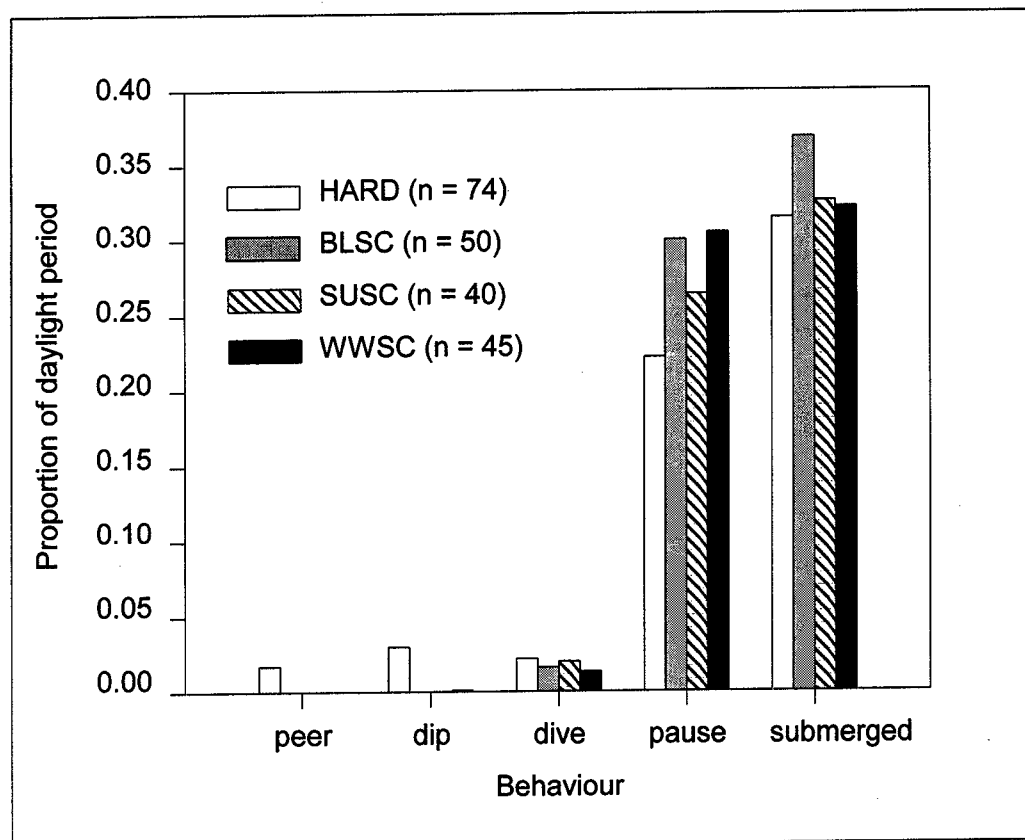


Figure 3
Time spent in nonfeeding behaviours by four species of sea ducks wintering in Haida Gwaii, British Columbia

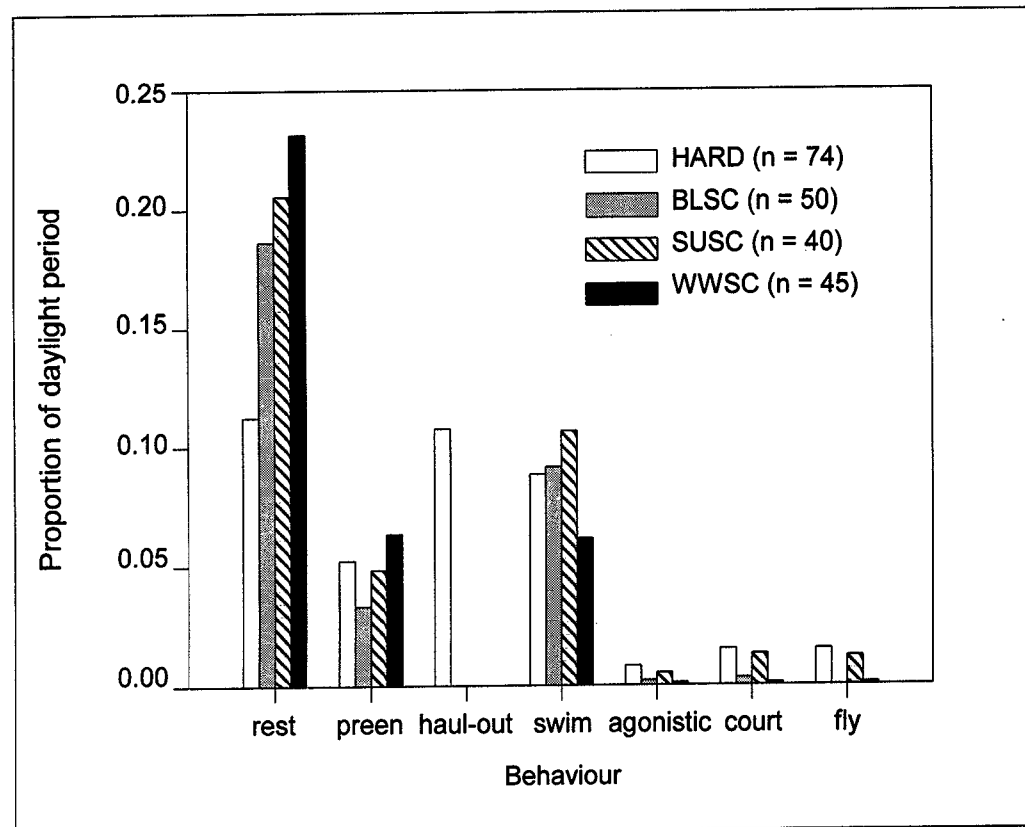
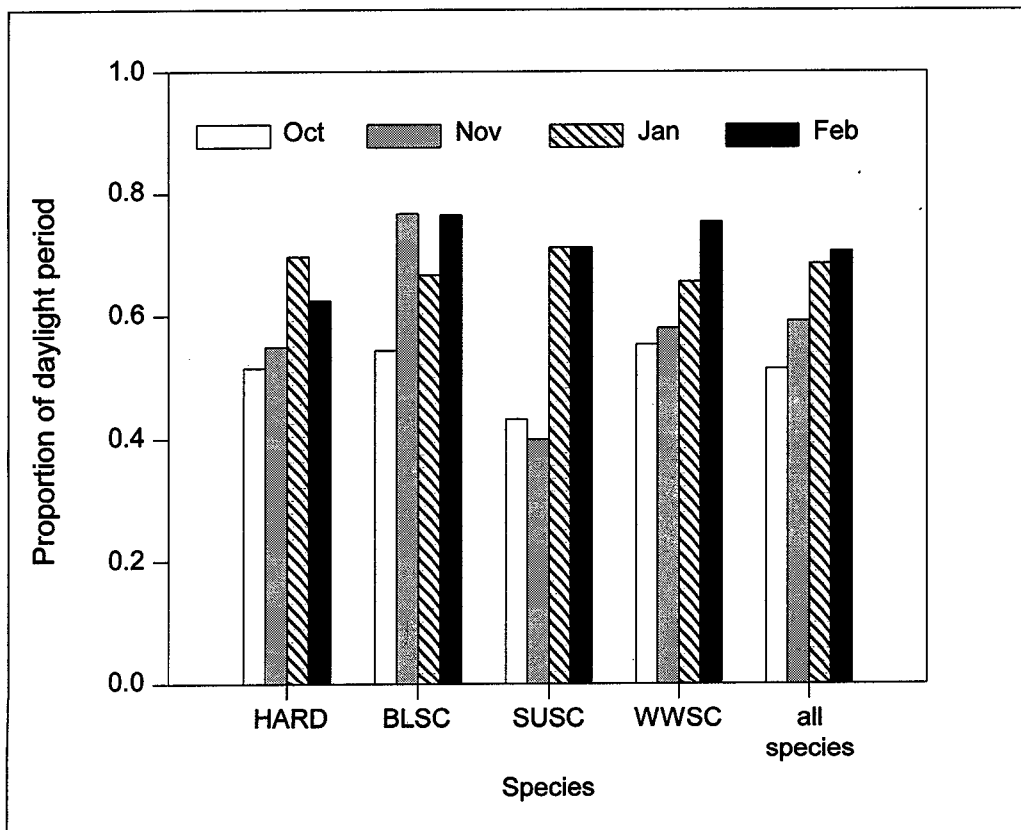


Figure 4

Proportion of daylight hours spent foraging over the winter season by four species of sea ducks wintering in Haida Gwaii, British Columbia

**Table 2**

Mean lengths of dive and pause for sea ducks wintering in Haida Gwaii, British Columbia

Species	n	Mean dive length \pm SD (s)	Mean pause length \pm SD (s)	Dive:pause ratio ^a
Harlequin Duck	368	21.7 \pm 7.4	12.0 \pm 6.3	1.81
Black Scoter	162	23.3 \pm 8.0	17.7 \pm 9.5	1.32
Surf Scoter	96	34.9 \pm 16.7	23.3 \pm 19.7	1.49
White-winged Scoter	196	31.7 \pm 8.0	17.8 \pm 8.6	1.78

^a Ratios are based on all data (i.e., not segregated by cycles).

species of scoters. In general, Black Scoters and Surf Scoters displayed much higher variance than Harlequin Ducks and White-winged Scoters (Table 2).

There were also considerable differences in the relationship of pause to the preceding dive for the three species of scoters. White-winged Scoters demonstrated proportionately longer pause times (steeper slope) than Surf Scoters, which generally paused longer than Black Scoters (Fig. 5).

In analyzing the relationship of pause to preceding dives, it was apparent that use of all sequential data may have violated the assumptions of parametric statistics (independence of samples), as data and residuals were strongly truncated. Use of average values for each collected series in a bout (cycle) resulted in somewhat higher values for the dive-pause relationship (Table 3). However, using these mean values considerably increased the power of the regression coefficient; for example, for Harlequin Ducks and White-winged Scoters, R^2 was increased from 0.35 and 0.38 to 0.55 and 0.74, respectively. However, there was still

evidence of truncation in the data when using mean values per cycle, as indicated by the increasing variance in pause length with increasing dive length seen in Harlequin Ducks (Fig. 6). This suggested that some individuals may have incurred a physiological debt, as proportionately longer pauses may be necessary for longer dives, and that the length of the pause may be influenced by the sequence number within the feeding bout.

The relationship of the length of pause to the length of the preceding dive was affected by dive sequence. In Harlequin Ducks and White-winged Scoters, there was a positive relationship between the residuals of the dive-pause regression with dive length and sequence number — i.e., the length of pauses accelerated as sequence increased (Table 4). This suggested that Harlequin Ducks and White-winged Scoters may defer complete physiological recovery when into a feeding cycle.

Figure 5
Relationship between dive and subsequent pause (in seconds) in four species of sea ducks wintering in Haida Gwaii, British Columbia

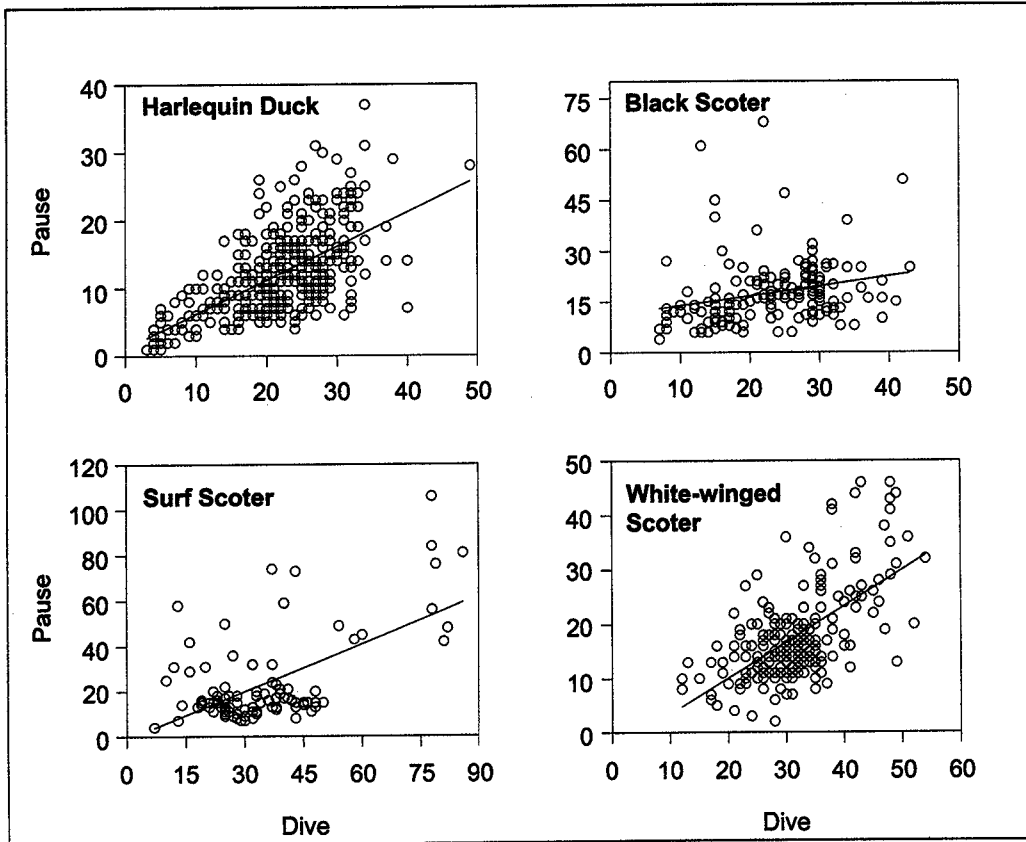


Table 3
Mean lengths of dive and pause for each bout of sea ducks wintering in Haida Gwaii, British Columbia

Species	n (bouts)	Mean dive length \pm SD (s)	Mean pause length \pm SD (s)	Dive:pause ratio ^a	CV
Harlequin Duck	45	22.7 \pm 6.8	12.9 \pm 5.3	1.90 \pm 0.59	0.31
Black Scoter	25	26.2 \pm 7.2	18.6 \pm 1.4	1.72 \pm 0.94	0.54
Surf Scoter	14	33.4 \pm 18.3	25.3 \pm 18.4	1.69 \pm 0.89	0.53
White-winged Scoter	24	33.2 \pm 7.6	19.8 \pm 7.8	1.78 \pm 0.36	0.20

^a Ratios are based on mean value per dive cycle.

4.0 Discussion

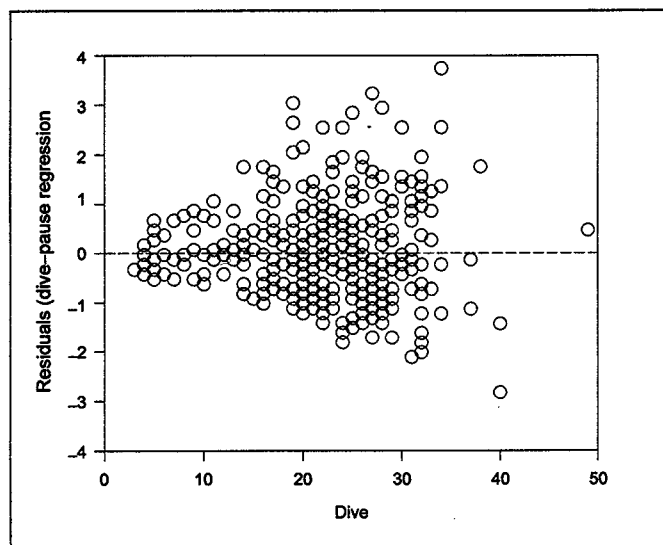
4.1 Activity budgets

In Haida Gwaii, the four species of sea ducks in this study foraged for similar durations during the winter, averaging about 65% of daylight hours. This contrasts sharply with studies in the northwest Atlantic, where smaller species such as Harlequin Duck spent longer periods of daylight seeking food. Goudie and Ankney (1986) proposed that thermodynamic implications of small body size might require smaller species to forage more and select higher-quality foods because of the allometric relationship of body size to metabolic rates and heat loss. For this study, the differences in body size were less pronounced for the scoter species — i.e., White-winged Scoter: females (f) = 1200 g, males (m) = 1500 g; Surf Scoter: f = 900 g, m = 1000 g; Black Scoter: f = 800 g, m = 1100 g; Harlequin Duck: f = 558 g, m = 687 g (from Dunning 1993).

There are two proposed explanations for the lack of a demonstrated body size effect in this study in Haida Gwaii: climate and water depth. The winters in Haida Gwaii are mild, and ambient temperatures only rarely drop below freezing. Therefore, much feeding activity occurs in the range of thermoneutrality, where allometric implications of metabolic rate and body size would not be expected to manifest (Calder 1974). In this study, Harlequin Ducks foraged mostly in very shallow waters and even spent considerable periods dipping for food amongst algae along the shoreline or along receding tide lines. Scoters foraged entirely by diving in deeper waters, and this was especially the case for the Surf Scoter, which foraged at the greatest distance from shore. Hence, Harlequin Ducks were likely feeding more intensely but in shallower water, and this reduced the proportion of the day required for foraging activities — i.e., less transit time to substrates. Goudie and Ankney (1986) suggested this explanation to account for the high proportion of daylight spent in feeding by the

Figure 6

Relationship between dive length (in seconds) and standardized residuals from a regression of dive length on pause length in Harlequin Ducks wintering at Haida Gwaii, British Columbia

**Table 4**

Relationship of the standardized residuals of the regression of dive to pause on dive length and sequence number within dive cycles for Harlequin Ducks and White-winged Scoters wintering in Haida Gwaii

Species	Linear regression	R ²	Probability
Harlequin Duck	Residuals = 0.12 + 0.011 Dive + 0.037 Sequence	0.05	F _{2,364} = 9.61 P < 0.0001
White-winged Scoter	Residuals = -0.353 + 0.002 Dive + 0.05 Sequence	0.042	F _{2,193} = 4.22 P < 0.02

deep-diving Oldsquaw *Clangula hyemalis* at Cape St. Mary's, Newfoundland.

The strong relationship of Harlequin Ducks to tidal regimes in Haida Gwaii demonstrated the close tracking of the shallow-water zone by this species. At Cape St. Mary's, Harlequin Ducks fed closer to shore in more shallow waters than other sea ducks (Goudie and Ankney 1986). A weak pattern of increased feeding with rising tides in Black Scoters and White-winged Scoters might be explained by inundation, enabling individuals to access intertidal molluscs, which are important prey for these species (Vermeer and Bourne 1984).

Foraging might be expected to increase in these diurnal feeders in winter, when daylight is short and weather conditions worsen. This appears to be the general case for the study area, as feeding time ranged from roughly 50% of daylight hours in fall up to 70% or more in January–February. During winter, water temperatures are cooler, environmental conditions deteriorate, and prey items often yield minimum energy per unit consumed. These findings are consistent with a hypothesis that winter conditions might impose greater demographic constraints on sea duck populations than conditions at other times of the year.

4.2 Diving behaviour

The relationship of the length of the dive to the length of the pause has been interpreted to infer diving ability (Dewar 1924; Nilsson 1970). In Haida Gwaii, major

interspecific differences were not evident in the species studied, although the highest ratio was evident for the Harlequin Duck, closely followed by the White-winged Scoter. The dramatic values reported for Harlequin Ducks by some authors were not evidenced here (e.g., 4:1 in Pool 1962).

For sea ducks, a complete dive cycle comprises underwater time, during which prey are captured, and surface time between successive dives. Surface time is used for recovery from the physiological effects of diving — i.e., oxygen depletion and lactic acid buildup in muscle tissue (anaerobic metabolism) — and food handling (Ydenberg 1988). Mean dive length is a general indication of mean water depth in which individuals are feeding. Hence, the lowest average dive length recorded (21.7 seconds) suggests that Harlequin Ducks are feeding in shallower waters than the inshore Black Scoters (23.3 seconds), White-winged Scoters (31.7 seconds), and the more subtidal Surf Scoters (34.9 seconds). These dive lengths may also provide some indication of foraging strategy. For example, the White-winged Scoters frequently fed inshore in the same range as Black Scoters but displayed higher bottom times and often emerged some distance from the site of submergence, in contrast to the other three species.

The role of sequence in dive cycle has been little investigated in sea ducks. Some waterbird species, such as Western Grebes *Aechmophorus occidentalis*, may defer aerobic metabolism between dives in an effort to maximize catch success on schooling fish prey (Ydenberg and Forbes 1988). Ydenberg and Guillemette (1991) demonstrated that, at least at a low level, Common Eiders *Somateria mollissima* may accumulate physiological debt — i.e., use anaerobic metabolism during dive cycles. Examination of the relationship of pause to preceding dives in Harlequin Ducks and White-winged Scoters in Haida Gwaii suggested that individuals may defer complete physiological recovery during dives early in each cycle or bout, as relatively longer pauses were taken for the same dive length later in the cycle. Explanations for this phenomenon may include the maximization of foraging during optimal tidal cycles, optimal foraging once mobile prey are located (e.g., small crabs by Harlequin Ducks), or synchronized flock vigilance, to minimize predation rates or to maximize food intake during limited daylight. Sea ducks are thought to forage during feeding bouts until the gullet is full, after which individuals enter a resting bout, during which food is processed through the muscular gizzard (see Goudie and Ankney 1986; Ydenberg and Guillemette 1991). The surface time during the resting bout (usually 20–30 minutes) would provide plenty of time for physiological recovery due to oxygen depletion during diving and thereby optimize catch per unit effort during diving cycles.

Acknowledgments

The development of this study was encouraged by Rick McKelvey of the Pacific Wildlife Research Centre. My stay while in the Skidegate Inlet area was made especially comfortable by Bonny Wasleski (Seaport Bed and Breakfast). Further thanks go to Stuart H. Jackson for field assistance. Margo Hearne provided the location of some potential sea duck sites near Masset.

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Productivity of Harlequin Ducks breeding in Prince William Sound, Alaska

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Abstract

Harlequin Ducks *Histrionicus histrionicus* breeding along coastal streams in Prince William Sound (PWS), Alaska, forage opportunistically on abundant resources of intertidal deltas and salmon spawning beds during summer. In contrast, inland-breeding Harlequin Ducks rely entirely on lotic invertebrates, a shortage of which may reduce breeding propensity (proportion of adult females breeding) during some seasons. Harlequin Ducks breeding in eastern PWS exhibited higher breeding propensity than inland-breeding populations. Twelve of 15 and 20 of 27 adult female Harlequin Ducks captured at stream mouths in PWS were breeding birds in 1991 and 1992, respectively. Of 16 nonbreeding females captured, paired nonbreeders weighed significantly more than unpaired nonbreeders, which I suggest were sexually immature yearlings. Average clutch size for seven nests was 6.1 eggs. Observed duckling mortality from hatching to near fledging age was at least 57%, which was high compared with inland breeding populations. Unusually high mortality of ducklings occurred from three to five weeks of age relative to other populations. Average brood size at fledging age was 2.4 ± 0.8 young. Despite the higher breeding propensity observed in eastern PWS, preliminary estimates of recruitment suggest that coastal-breeding Harlequin Ducks have lower productivity than inland-breeding populations.

Résumé

Les Arlequins plongeurs (*Histrionicus histrionicus*) se reproduisant le long des cours d'eau côtiers dans le golfe du Prince-William, en Alaska, bénéficient des abondantes ressources alimentaires offertes par les deltas intertidaux et les frayères de saumons durant l'été. Par contraste, l'alimentation des Arlequins plongeurs se reproduisant à l'intérieur des terres repose entièrement sur les invertébrés lotiques, dont une pénurie peut réduire la capacité de reproduction de cette espèce (proportion des femelles adultes se reproduisant) en certaines saisons. Les Arlequins plongeurs se reproduisant dans la partie est du golfe du Prince-William présentaient une tendance naturelle de reproduction plus forte que les populations se reproduisant à l'intérieur des terres. Douze des 15, et 20 des 27, Arlequins plongeurs femelles adultes capturés à l'embouchure de cours d'eau dans le golfe du Prince-William étaient des oiseaux

reproducteurs en 1991 et 1992, respectivement. Des 16 femelles non reproductrices capturées, les femelles accouplées pesaient beaucoup plus que les femelles non accouplées, qui étaient probablement des jeunes immatures. La ponte moyenne pour sept nids était de 6,1 œufs. La mortalité, de l'éclosion à un âge approchant la maturité, était d'au moins 57 p. 100, un taux élevé comparativement à celui des populations des terres intérieures. On a observé un taux de mortalité des canetons anormalement élevé entre l'âge de trois à cinq semaines relativement aux autres populations. La taille moyenne des couvées à l'âge de l'envol était de $2,4 \pm 0,8$ petits. Malgré la plus forte propension à se reproduire des oiseaux de l'est du golfe du Prince-William, les premières estimations indiquent que les Arlequins plongeurs se reproduisant sur la côte présentent une productivité moins grande que les populations se reproduisant à l'intérieur des terres.

1.0 Introduction

Harlequin Ducks *Histrionicus histrionicus* exhibit delayed sexual maturity, low annual production, variable breeding propensity, and long lives, typical traits of all sea duck species (Goudie et al. 1994). Population levels are sensitive to adult mortality, particularly when proportionately high losses occur (Goudie et al. 1994). The Exxon Valdez oil spill (March 1989) in Prince William Sound (PWS), Alaska, raised concern over the potential effects of oil on the abundance and productivity of Harlequin Ducks in the spill area. Research on Harlequin Ducks breeding in unperturbed coastal ecosystems was limited to three streams in eastern PWS (Dzinbal 1982; Dzinbal and Jarvis 1984) and nine on the coast of Iceland (Bengtson 1972). To gain more insight into pre-spill productivity, we studied coastal-breeding Harlequin Ducks in eastern PWS, a region that was bypassed by the southwestwardly flowing oil spill (Crowley 1994).

Harlequin Ducks breeding in PWS nest along short streams flowing seaward from coastal mountains (Dzinbal 1982; Crowley 1994). The number of Harlequin Ducks breeding in PWS is unknown. The total population in PWS during July 1991 was an estimated 8300 ± 3100 Harlequin Ducks (K. Laing, pers. commun.). This estimate, however, was an instantaneous sample of a seasonally fluctuating population (Isleib and Kessel 1973; D.W. Crowley, unpubl. data). Typically, the summer population of Harlequin Ducks begins increasing in late June and July, as postbreeding

males return to moult in PWS from their inland breeding areas (D. Rosenberg, pers. commun.). This increase in abundance continues during August and September as failed-breeding and postbreeding females and broods arrive in PWS (D. Rosenberg, pers. commun.). In addition to locally breeding Harlequin Ducks, most yearlings reared either locally or on inland streams also spend the entire summer along the coast (Salomonsen 1950; Bengtson 1972; Palmer 1976).

Bengtson and Ulfstrand (1971) and Gardarsson and Einarsson (1994) reported that low food resources limited production on interior streams of Iceland, where Harlequin Ducks relied on stream invertebrates (particularly simuliids) for all of their diet. Coastal-breeding Harlequin Ducks, however, are probably not limited by food resources on streams in PWS (Dzinbal and Jarvis 1984). Dzinbal and Jarvis (1984) reported that prior to the arrival of anadromous salmon (pink salmon *Oncorhynchus gorbuscha* and chum salmon *O. keta*), Harlequin Ducks avoided foraging in streams in PWS, feeding almost exclusively on marine invertebrates in the intertidal delta. When salmon returned to spawn in July, Harlequin Ducks moved slightly upstream to forage on salmon roe, usually within 0.5 km of intertidal deltas (Dzinbal and Jarvis 1984). In PWS and coastal Iceland, incubating females flew from upstream nest sites down to spawning beds and deltas to feed (Bengtson 1972; Dzinbal 1982; Crowley 1994). The abundance of forage, combined with relatively high pair density observed by Dzinbal (1982) in PWS, suggested that the productivity of coastal-breeding Harlequin Ducks could be higher than that of populations breeding farther inland.

The primary objectives of the study were to develop indices of abundance and productivity in PWS and to determine habitat use by breeding Harlequin Ducks. In this paper, I calculate indices of productivity of Harlequin Ducks in eastern PWS and compare them with the performance of Harlequin Duck populations breeding in inland regions.

2.0 Study area

PWS is located on the south-central coast of Alaska (see Isleib and Kessel 1973). The study area consisted of shoreline, estuaries, and stream mouths from Cordova to Valdez and the protected leeward shores of Hinchinbrook and Hawkins islands, covering approximately 630 km of coastline and 85 streams. Streams used by Harlequin Ducks breeding in PWS are relatively low in average length (13.2 km), average volume discharge (3.2 m³/s) (Crowley 1994), and invertebrate abundance (Dzinbal and Jarvis 1984). Daily tidal exchange of up to 6 m creates large intertidal deltas at the outflow of streams.

3.0 Methods

Harlequin Ducks were captured in mist nets suspended across streams within 100 m of intertidal deltas. We monitored streams from 21:00 to 01:00 and from 03:00 to 08:00 during June, when ducks were flying to and from upstream reaches while searching for nest sites (Bengtson 1966) and laying eggs (Crowley 1994). Mist nets used (Avinet Inc., #12N-210/2) had a 10-cm mesh and measured 1.8 m in height by 12 m or 18 m in length. Mist nets were most effective when placed in pairs (10–20 m apart) on

bends in the stream channel. This trap configuration 1) took advantage of the characteristic low flight (<1 m off the surface) of Harlequin Ducks closely following the stream channel (Bengtson 1966), 2) was less visible on bends and consequently not often avoided by ducks, 3) caught Harlequin Ducks flying more slowly around sharp bends, resulting in fewer ducks bursting through nets, and 4) usually captured ducks in the second net if the first net was avoided or breached. I assumed that all females using streams had equal probability of capture using this configuration. Streams were kept under surveillance while nets were deployed, allowing immediate removal of captured birds and observation of whether females were paired (accompanied proximally by a male) before striking the net.

Captured female Harlequin Ducks exhibiting a distended and flaccid cloacal aperture (indicating egg laying) or brood patch (indicating incubation) were considered breeding, and those with neither were nonbreeding. I further classified nonbreeding females as paired or unpaired. To limit a potential low bias in estimating breeding propensity (caused by a change of status from nonbreeding to breeding), we continued trapping streams for three weeks beyond the peak period of nest initiation, which occurred during the first two weeks of June (DWC, unpubl. data). We also trapped again in late June on streams that had been monitored early in the season (May – 7 June). I estimated breeding propensity (percentage of adult females breeding) by dividing the number of breeders captured by the total number of adult females captured.

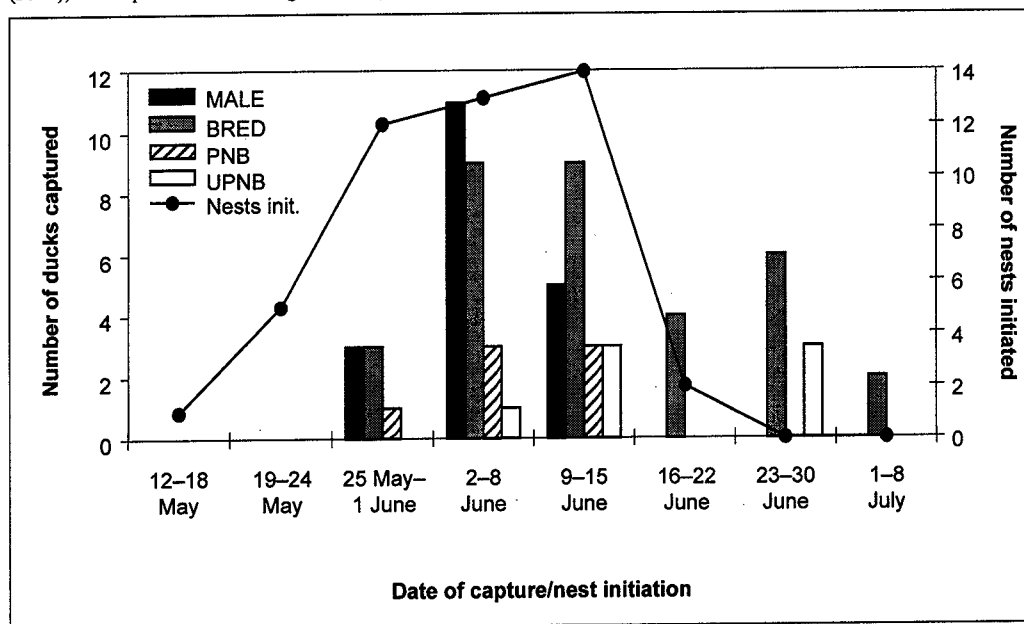
We measured mass, tarsus, culmen, and wing chord of captured ducks. I compared morphology between sexes and among breeding, paired nonbreeding (PNB), and unpaired nonbreeding (UPNB) females using two-sample testing (Student's *t* and Mann-Whitney-Wilcoxon *Z*) and analysis of variance (ANOVA). We determined age class of captured males (adult or subadult) by plumage characteristics (Dement'ev and Gladkov 1967; Palmer 1976), but there was no similar technique to determine age of nonbreeding females (Bengtson 1972), which therefore remained unknown.

Captured female Harlequin Ducks were tagged with a 4.5-g radio transmitter (Advanced Telemetry Systems, model #357) glued to the centre tail feathers. I located the general vicinity of nesting females by radiotelemetry from fixed-wing aircraft, then hiked up streams to search for nests. I determined clutch size and hatching success (eggs hatched/eggs laid) by observing eggs pipping or ducklings drying in the nest and by counting shell membranes and added eggs in nests that I revisited.

I assessed duckling mortality using data from coastal surveys from July and August, 1991–1993 and 1995–1996. Surveys were conducted from a skiff piloted within 5–30 m of shore. Deltas and approximately 100 m of streams were surveyed on foot if not navigable by boat. Harlequin Duck broods were counted and classified by age based on plumage development (Gollop and Marshall 1954). Assuming that juveniles fledged at 42 days (Bengtson 1972; Wallen 1987), approximate ages (days) of ducklings classified by plumage development were as follows: 1a = 1–5, 1b = 6–9, 1c = 10–14, 2a = 15–21, 2b = 22–27, 2c = 28–35, and 3 = 36–42 (Wallen 1987). I did not attempt to follow individual broods through time. Consequently, mortality was indicated by the

Figure 1

Chronology and numbers of Harlequin Ducks captured and nests initiated on breeding streams in Prince William Sound, Alaska, 1991–1992. Sex and breeding status include adult males, breeding females (BRED), paired nonbreeding females (PNB), and unpaired nonbreeding females (UPNB). Age of most PNB and all UPNB females was unknown.



change in average brood size from one age class to the next, analyzed using ANOVA and Mann-Whitney-Wilcoxon tests.

4.0 Results

4.1 Breeding status of captured ducks

We captured 23 Harlequin Ducks (16 females) in 1991 during 330 net-hours of trapping effort and 42 ducks (32 females) in 1992 during 224 net-hours (Fig. 1). We captured Harlequin Ducks on 10 of 23 streams trapped. I assumed that PNB females were adults that did not breed, a status that characteristically applies to 15–60% of adult female Harlequin Ducks on breeding streams (Bengtson and Ulfstrand 1971; Bengtson 1972; Dzinbal 1982; Wallen 1987). Because there was typically a surplus of unpaired adult males using streams (Bengtson 1972; Kuchel 1977; Dzinbal 1982; DWC, pers. obs.), I assumed that UPNB females were subadults as yet incapable of breeding or forming pair bonds. We captured six of seven UPNB females during mid- to late June (Fig. 1), by which time most breeding females had begun incubating. Four of seven UPNB females were captured while males were still present on streams (Fig. 1). Pair status of two nonbreeding females was unknown; they were assumed to be adults. Of six females captured in both 1991 and 1992, two PNB females in 1991 became breeders in 1992, three females bred in both years, and one breeder in 1991 was a nonbreeding female in 1992. Although we discontinued trapping after 7 July, we regularly observed flocks of 5–15 non- and failed-breeding females (with few or no males present) at stream mouths during surveys.

All 17 male Harlequin Ducks captured were in adult breeding plumage. Males were more likely than females to break through or avoid mist nets. No males were captured or observed flying up streams after 15 June, indicating that pair bonds had dissolved for both breeding and nonbreeding

females. Male Harlequin Ducks shifted use from stream mouths to exposed coastline to moult after females began incubating.

Male Harlequin Ducks had significantly greater average body weight ($F = 9.25$, $P = 0.0001$) (Fig. 2) and lengths of tarsus ($t = 3.97$, $df = 2,59$, $P < 0.001$), culmen ($t = 4.23$, $df = 2,59$, $P < 0.001$), and wing chord (1992 data only, $t = 3.08$, $df = 2,35$, $P = 0.004$) than those of captured females. Weights of PNB females were significantly greater than those of UPNB females ($F = 9.25$, $P = 0.0001$) (Fig. 2), although other body measurements did not differ significantly. Breeding females did not differ in weight from PNB females but were significantly heavier than UPNB females ($F = 9.25$, $P = 0.0001$) (Fig. 2). Two breeding females recaptured as the nesting season progressed indicated a tendency to lose weight (by 17% and 12% over one month). However, breeding females captured after 13 June ($n = 12$) still weighed significantly more ($Z = 2.74$, $P = 0.006$) than UPNB females ($n = 5$) captured after 13 June.

4.2 Productivity

Breeding propensity of adult females was higher in 1991 than in 1992, averaging 80% (Table 1). Nest initiations, calculated by back-dating from seven nests and 40 broods of known age class (1991–1992, combined), occurred from 15 May through 18 June, with 45 of 47 occurring by 15 June. Average number of eggs in seven clutches of known size was 6.13 ± 0.92 (SD). Low density and difficulty in locating Harlequin Duck nests resulted in a sample size too small to estimate nest success (proportion of nests producing broods). At least five of seven nests produced hatchlings, and known hatching success for 32 eggs in five nests was 97.2%.

We observed 60 broods during five years of surveys in PWS. Six of seven broods of class 1a were in or near nests at time of observation; all other broods were seen near stream mouths and along the coast. The average number of

Figure 2

Body weight of Harlequin Ducks captured on streams in Prince William Sound, Alaska, 1991–1992. Sex and breeding status include adult males, breeding females, paired nonbreeding females (PNB), and unpaired nonbreeding females (UPNB). Age of most PNB and all UPNB females was unknown. UPNB females weighed significantly less than other females ($P < 0.001$). Error bars represent 95% confidence interval; numbers above bars are sample sizes.

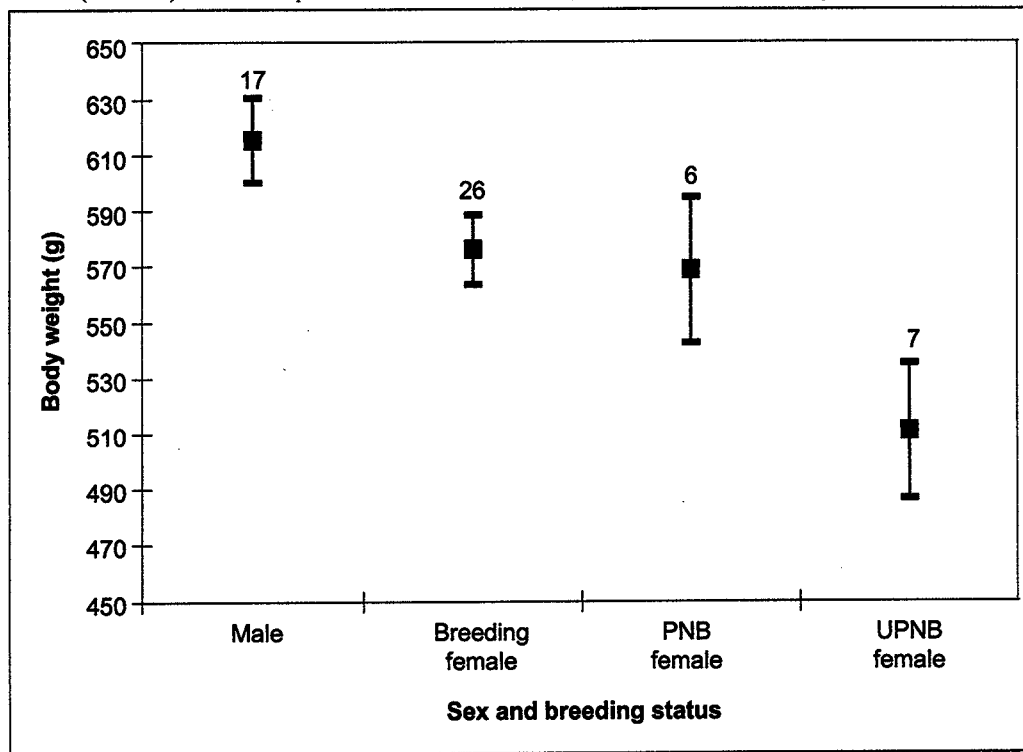


Table 1
Estimated breeding^a propensity of female Harlequin Ducks captured near stream mouths in Prince William Sound, Alaska, 1991–1992

	1991	1992
Total females captured (TOT)	16	32
Total breeders (B)	12	20
Paired breeders (PB)	4	2
Unpaired breeders (UPB)	0	10
Other breeders ^b	8	8
Total nonbreeders	4	12
Paired nonbreeders (PNB)	1	6
Unpaired nonbreeders (UPNB)	2	5
Other nonbreeders (NB) ^b	1	1
% females breeding (B/TOT)	75	63
Adult females (B+PNB+NB)	14	27
Subadult females (UPNB)	2	5
% adults [(B+PNB+NB)/TOT]	88	84
% adults breeding [B/(B+PNB+NB)]	86	74

^a Breeding was indicated by the presence of distended cloacal aperture and brood patch.

^b Pair status unknown.

ducklings in broods decreased with an increase in age class ($F = 3.91$, $P = 0.0042$) (Fig. 3). Under this model, broods of age class 1a were significantly larger than those of age classes 2b, 2c, and 3, but not age class 1c. Harlequin Duck broods decreased in size by 27% from age class 2b to 2c ($Z = 1.94$, $P = 0.052$), when most broods first appeared near stream mouths, then dropped by 9% from 2c to 3 (Fig. 3).

The observed cumulative mortality of ducklings from age class 1a to fledging was approximately 57%. This was likely an underestimation of mortality, because loss of entire broods was not detectable using this method. The average brood size at fledging age was 2.4 ± 0.82 (SD), assuming that pre-fledged class 3 ducklings survived to fledging.

5.0 Discussion

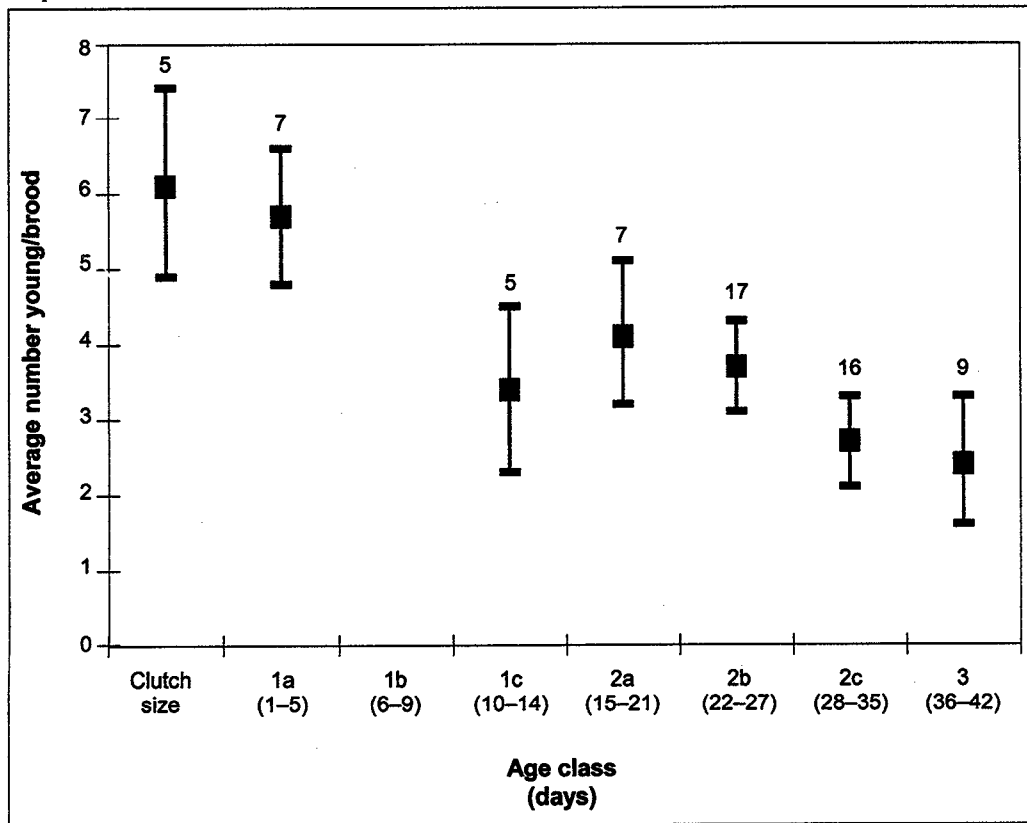
5.1 Breeding status of captured ducks

The coastal-breeding population of PWS Harlequin Ducks exhibited characteristics similar to those of inland-breeding populations in Iceland and western North America, including the presence of nonbreeding adult females and the absence or scarcity of yearling males (Bengtson and Ulfstrand 1971; Bengtson 1972; Kuchel 1977; Dzinbal 1982; Wallen 1987). Bengtson and Ulfstrand (1971) also determined by cloacal examination and necropsy that yearling females were absent from their inland study streams of Iceland. In contrast, the presence of yearlings could be expected on streams in PWS, because most yearlings apparently spend their first summer on the coast (Salomonsen 1950; Bengtson 1972; Palmer 1976), and stream mouths are preferred feeding areas for Harlequin Ducks during summer (Dzinbal 1982). Dzinbal (1982) captured two yearling males on several streams in PWS but did not determine age of captured females.

Harlequin Ducks do not begin breeding until they are at least two years of age (Bent 1925; Dement'ev and Gladkov 1967), and age at first breeding often varies for sea

Figure 3

Mortality of juvenile Harlequin Ducks hatched on streams in Prince William Sound, Alaska, 1991–1992, indicated by decreasing number of ducklings per brood with increasing age. Most broods first appeared at stream mouths at age 2a–2c, during which high mortality occurred. Error bars represent 95% confidence interval; numbers above bars are sample sizes.



ducks (Bellrose 1980). First breeding for Common Goldeneyes *Bucephala clangula*, for example, occurs from two to six years of age and averages 3.2 years (Dow and Fredga 1984). The presence of yearlings and the fact that sexual maturity can be delayed for a variable number of years suggest that the following classes of females were captured at our study site: 1) experienced adults, either breeding or nonbreeding (three or more years of age), 2) those breeding for the first time (two years and older), and 3) sexually immature subadults not yet attempting to breed (yearlings and older).

Breeding females captured in PWS probably included some proportion of two-year-olds that had initiated nests. Kuchel (1977) observed two female Harlequin Ducks returning to natal streams at two years of age. They were paired and established home ranges but arrived 2–3 weeks later than nesting females and apparently did not produce broods (Kuchel 1977). Two-year-old females resident in PWS may be more likely to attempt nesting than inland-breeding Harlequin Ducks, because no energetically costly migration is necessary, and the maritime climate remains relatively mild into September, allowing later nest initiation. Eadie and Gauthier (1985) reported that two-year-old female goldeneyes might be more likely to attempt nesting if they had spent the previous season on the breeding grounds as yearlings.

PNB females in PWS were similar to nonbreeding females on inland streams recorded in Iceland that arrived paired, did not nest, parted from mates by mid-June, and

were observed in small flocks on breeding streams during the rest of the summer (Bengtson and Ulfstrand 1971). There was no obvious reason why PNB Harlequin Ducks in PWS did not nest. Availability of nest sites limited by spring snow (Wallen 1987; Crowley 1994) or lack of suitable nesting habitat (Bengtson 1972) could be environmental or density-dependent effects (respectively) that preclude some adult females from nesting but not from pairing. Alternatively, some PNB females may have been young adults that lacked nesting experience.

I believe that at least some proportion of UPNB females were yearlings. Although samples of UPNB females were small, they had lower weights, did not have mates, and continued to make visits upstream during the incubation period (Fig. 1). These characteristics were similar to those reported by Eadie and Gauthier (1985) for yearling female Barrow's Goldeneye *Bucephala islandica* and Buffleheads *B. albeola* that, when captured while prospecting nest cavities during incubation and hatching, weighed significantly less than nesting adults. Visiting a future breeding stream (perhaps a natal stream) in PWS prior to the moult would provide yearling females familiarity with potential nest sites, foraging areas, and predators (Lack 1966). Dow and Fredga (1983) suggested that Common Goldeneyes may increase their chance of success during first breeding attempt by spending a season or two on the breeding grounds as subadults.

Table 2
Indices of productivity of Harlequin Ducks breeding on coastal streams of eastern Prince William Sound (PWS), Alaska, compared with populations breeding on inland streams

Region	% adult breeding propensity	Breeding density (no./km)	Fledged brood size	Duckling mortality (%)	Fledged young/female	Breeding success (%)
PWS, 1991–1993	74–86		2.4	57		
PWS, 1979–1980 ^a	50–53 ^b	1.3–1.8	2.5–2.7	33–50	0.8	57–67
Idaho ^c	33–36 ^b	0.06–1.3	3.3	27–55	0.8–1.2	33–36
Wyoming ^d	38 ^b	0.89	4.5		1.9	
Montana	41 ^{b,e}	0.05–1.2 ^{e,f}	3.5–3.9 ^f	25–82 ^f	0.3–1.44 ^f	41
Iceland ^g	70–85	0.2–7.1	2.9	44	1.5–2.2	87

^a Dzinbal (1982).

^b Assumes all females were adults, which is probably valid for paired females only. This assumption was not valid for PWS, where unpaired yearling females are probably present. Whether yearlings visit inland breeding areas in North America is unknown.

^c Summary of productivity in Idaho from 1990 to 1996 (F. Cassirer, pers. commun.).

^d Wallen (1987).

^e D. Genter (pers. commun.).

^f Seasons of low productivity in Montana were caused by flooding (Kuchel 1977; P. Finnegan, pers. commun.).

^g Bengtson (1972).

5.2 Productivity

Estimated breeding propensity in PWS was similar to that of two interior rivers in Iceland (Table 2) (Bengtson and Ulfstrand 1971). Dzinbal (1982) estimated breeding propensity in PWS using mature and subadult females combined (Table 2). Although my estimate of the same parameter for PWS was higher (B/TOT in Table 1), both indicated higher breeding propensity in PWS than on inland rivers of Idaho (F. Cassirer, pers. commun.), Montana (D. Genter, pers. commun.), and Wyoming (Wallen 1987) (Table 2). Unlike most inland regions, nesting areas in PWS were not subject to human disturbance, which may contribute to lower breeding propensity (Kuchel 1977; Wallen 1987). Breeding and wintering in the same area might also contribute to higher breeding propensity along the coast, by allowing young females to gain familiarity with breeding streams and eliminating the need to migrate.

The first 2–3 weeks of brood rearing usually occurred far upstream of areas observable during boat surveys (Crowley 1994). Consequently, broods younger than age class 2a had low probability of being observed, which was implicit in small samples of age classes 1a–1c. I suspect that those 1c broods observed near stream mouths were more exposed to predation than 1c broods that remained upstream, resulting in the low average of that age class (Fig. 3), although stochastic variation is also a likely explanation.

The high level of mortality observed from age 2b to 2c (4–5 weeks) was unusual for Harlequin Ducks (Bengtson 1972) and other duck species, which typically have progressively decreasing mortality after the first two weeks of life (Baldassarre and Bolen 1994). Potential predators (e.g., mink *Mustela vison*, river otters *Lutra canadensis*, Glaucous-winged Gulls *Larus glaucescens*, and Bald Eagles *Haliaeetus leucocephalus*) attracted to lower stream reaches during the salmon spawn may have contributed to the observed increase in duckling mortality (Dzinbal 1982). Indices of brood size at fledging and recruitment in PWS (Dzinbal 1982) compared with indices for inland regions (Table 2) suggest that the relatively high breeding propensity and pair density may be offset by higher duckling mortality.

Unusually high mortality of Harlequin Duck broods on inland streams has been ascribed to flooding (Kuchel 1977; Wallen 1987; P. Finnegan, pers. commun.). Flooding appeared less important than predation for coastal streams in

PWS. Broods were hatched after high spring water and reared during receding water levels (Dzinbal 1982). Furthermore, potential effects of flooding are probably minimized once broods begin using intertidal areas for foraging.

Acknowledgments

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Time budgets of Surf Scoter broods

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Abstract

We quantified time budgets of Surf Scoter *Melanitta perspicillata* broods at Lake Malbaie, located in the Laurentide Wildlife Reserve, approximately 95 km north of Quebec City. In 1994, the lake harboured 40 breeding pairs of Surf Scoters, the largest and most southerly breeding concentration known. Over 200 hours of observation were distributed among at least 11 different broods. In general, resting and feeding bouts of females and young were synchronized. Feeding bouts for class I young averaged longer (30.2 ± 3.7 minutes) than resting bouts (23.1 ± 1.9 minutes). Overall, young spent more time feeding than females (58% vs. 32%), more time resting (27% vs. 18%), but less time in alert posture (2% vs. 36%). Females spent more time in alert posture with young ducklings than with older ones (41% vs. 22%). Duckling activity was highly synchronized, and transitions between feeding and resting bouts lasted less than five minutes. Preening occurred during these transitions and was more prevalent following feeding bouts than after resting bouts. Overall, time budgets of females and broods at Lake Malbaie were similar to those measured in northern Quebec and similar to time budgets of other waterfowl.

Résumé

Nous avons quantifié l'emploi du temps de la progéniture des Macreuses à front blanc (*Melanitta perspicillata*) au lac Malbaie, situé dans la réserve faunique des Laurentides, à environ 95 km au nord de Québec. En 1994, 40 couples de Macreuses à front blanc habitaient près du lac, la concentration la plus importante et la plus au sud connue. Plus de 200 heures d'observation ont été réparties entre au moins 11 couvées différentes. En général, les périodes de repos et d'alimentation des femelles et des jeunes étaient synchronisées. En moyenne, les périodes d'alimentation ($30,2 \pm 3,7$ minutes) des petits de classe I étaient plus longues que les périodes de repos ($23,1 \pm 1,9$ minutes). Dans l'ensemble, les jeunes passaient plus de temps à se nourrir que les femelles (58 p. 100 par rapport à 32 p. 100), plus de temps à se reposer (27 p. 100 par rapport à 18 p. 100), mais moins de temps en posture de vigilance

(2 p. 100 par rapport à 36 p. 100). Les femelles passaient plus de temps en posture de vigilance avec les jeunes canetons qu'avec les plus vieux (41 p. 100 par rapport à 22 p. 100). L'activité des canetons était fortement synchronisée, et les périodes de transition entre les périodes de repos et d'alimentation duraient moins de cinq minutes. Le lissage avait lieu durant ces périodes de transition, et la fréquence en était plus grande après les périodes d'alimentation que celles de repos. Dans l'ensemble, l'emploi du temps des femelles et de leur progéniture, au lac Malbaie, était semblable à celui observé dans le nord du Québec et à celui d'autres espèces de sauvagine.

1.0 Introduction

Surf Scoters *Melanitta perspicillata* are among the least studied waterfowl species in North America (Bellrose 1976; Palmer 1976). Little is known of their breeding ecology, undoubtedly because they breed in remote areas at low densities (Savard and Lamothe 1991). The recent discovery of a lake with about 50 breeding pairs near Quebec City opened up opportunities to document several aspects of the breeding ecology of Surf Scoters (Reed et al. 1994; Lesage et al. 1997; Morrier et al. 1997). In this paper, we present data on time budgets of Surf Scoter broods.

2.0 Study area and methods

The study was conducted at Lake Malbaie (47°34'N, 71°00'W) in the Laurentide Wildlife Reserve, 95 km NNE of Quebec City. Two wooded islands are found on this 664-ha shallow lake (mean depth ~2 m; maximum depth 7 m). The lake is within a mountainous enclave mostly >800 m above sea level and is characterized by the presence of high boreal plant communities that typically occur farther north (Richard 1975). Lake Malbaie and a few other nearby lakes are probably ecologically similar to those used by Surf Scoters in more northerly areas.

Time budget data were collected during 36 observation periods of 2–4.5 hours, for a total of ~200 hours, between 9 July and 5 September 1994. The behaviour of

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Figure 1
Time budgets of adult female Surf Scoters and broods

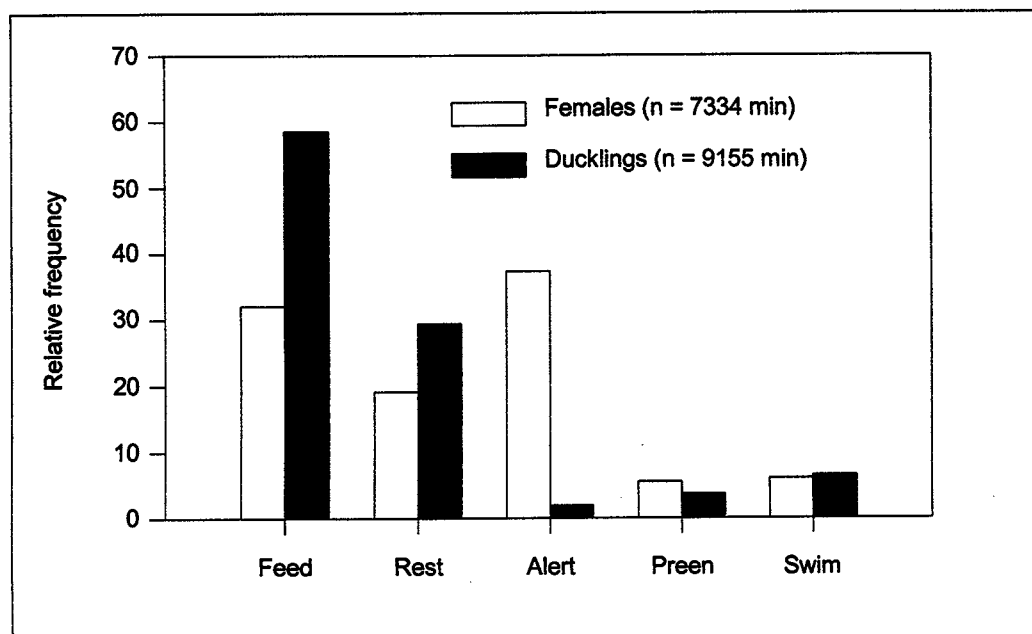


Table 1
Behaviour of adult female Surf Scoters in relation to time of day and brood age

Time of day	Relative frequency (%)										Length of observation (minutes)	
	Feed		Rest		Alert		Preen		Swim			
	Class I	Class II	Class I	Class II	Class I	Class II	Class I	Class II	Class I	Class II	Class I	Class II
05:00–09:00	24.4	81.2	28.4	0.0	39.5	7.4	4.9	11.5	2.7	0.0	958	49
09:00–13:00	25.3	59.0	19.4	6.5	46.3	24.7	4.1	5.0	5.0	4.8	2796	805
13:00–17:00	26.8	38.6	23.9	1.2	35.2	35.4	4.8	23.0	9.4	1.8	1392	151
17:00–21:00	25.6	75.1	21.3	10.0	40.4	2.5	3.7	4.6	8.9	7.8	1078	105
	25.6	58.5	22.6	5.0	41.0	22.2	4.3	10.3	6.5	4.0	6224	1110
Global	32.1		19.1		37.3		5.5		6.0		7334	

hens and broods was observed with a spotting scope from a blind hidden on the shore.

The behaviour of the hen and the dominant activities of the brood were classified as feeding, alert, resting (including sleeping), preening (including other comfort movements), social interaction, and swimming (locomotion). Data were recorded at one-minute intervals. For each female observed, we recorded the number and age of ducklings accompanying her. The age of ducklings followed the classification of Gollop and Marshall (1954). Data were compiled on a per brood and per observation period basis to ensure independence of the data.

We estimated a total population of 10–15 broods, based on a maximum count of 80 young on 18 July. The number of young per brood varied throughout the period because of frequent exchange of young between broods.

Two-way analysis of variance (ANOVA) was used to compare the mean feeding and resting periods of broods for four time periods (05:00–09:00, 09:00–13:00, 13:00–17:00, 17:00–21:00) and two age classes (class I: ≤ 21 days; class II: ≥ 22 days; Lesage et al. 1997). The average lengths of feeding

and resting bouts for each brood were transformed using the natural logarithm to normalize the data. We also verified the homogeneity of variances. Two-way ANOVA was also used to analyze the time budgets of females and broods in relation to time of day and brood age. Data were transformed using the arcsine value of the square root of the proportions. When this failed to normalize the data, we performed non-parametric ANOVA on ranked values. Two-way interactions were examined in all cases. However, in no analysis were they significant, so they are not presented.

3.0 Results

Time budgets of females and broods were different (Fig. 1). Young spent nearly twice as much time feeding, more time resting, but a similar amount of time preening and swimming. The most common activity of the adult female was watching over her brood (Alert, 38%).

Female behaviour was different over the day and between brood ages (Table 1). Females fed more (ANOVA ranked values, $F = 26.4$, $P = 0.0001$) and rested less

Table 2
Behaviour of Surf Scoter broods in relation to time of day and brood age

Time of day	Relative frequency (%)										Length of observation (minutes)	
	Feed		Rest		Alert		Preen		Swim			
	Class I	Class II	Class I	Class II	Class I	Class II	Class I	Class II	Class I	Class II	Class I	Class II
05:00–09:00	53.3	72.9	36.9	18.6	0.6	0.0	3.5	5.9	5.7	2.6	1318	90
09:00–13:00	53.3	76.2	35.5	13.1	2.2	1.1	2.5	5.8	6.5	3.8	3340	1104
13:00–17:00	50.4	71.0	35.8	19.3	1.9	0.0	3.1	7.9	8.8	1.8	1785	151
17:00–21:00	64.7	68.7	20.3	17.9	4.4	0.0	2.4	7.5	8.2	5.9	1162	205
	54.7	73.4	33.0	15.9	2.2	0.5	2.8	6.6	7.3	3.6	7605	1550
Global	58.5		29.4		1.9		3.6		6.5		9155	

(ANOVA ranked values, $F = 12.1$, $P = 0.0008$) when accompanying class II broods than with class I broods. Neither feeding ($F = 0.82$, $P = 0.48$) nor resting ($F = 0.38$, $P = 0.77$) varied significantly with time of day. Females with older broods were less alert than those with younger broods (ANOVA, $F = 14.2$, $P = 0.0003$). Alert behaviour was marginally influenced by time of day ($F = 2.33$, $P = 0.08$), but a clear pattern was evident only for females with class II broods. They were more frequently alert during the late morning and early afternoon. Preening appeared to occur more frequently in females with class II broods than in those with class I broods; however, this difference was not significant (ANOVA ranked values, $F = 1.23$, $P = 0.26$), nor was there evidence of changes in the frequency of preening behaviour over the course of the day ($F = 1.75$, $P = 0.16$).

Brood behaviour varied with brood age but not with time of day (ANOVA, $P \geq 0.74$), except for alert behaviour ($F = 4.74$, $P = 0.004$) (Table 2). Older broods (class II) spent more time feeding (ANOVA, $F = 4.17$, $P = 0.044$) and rested less (ANOVA, $F = 4.53$, $P = 0.036$) than younger broods (class I). There was a tendency for older broods to be less alert (ANOVA ranked values, $F = 3.61$, $P = 0.06$) and preen more (ANOVA ranked values, $F = 3.82$, $P = 0.054$).

We also examined the behaviour of the female when her young were either feeding or resting (Fig. 2). To some degree, the behaviours of females and their young were similar. Female behaviour also differed with the age of her brood. When her young were feeding, she fed more, was less alert, and rested less with older ducklings than with younger ones (Fig. 2). When her young were resting, she fed and preened more, rested less, and spent less time alert with older ducklings than with younger ones (Fig. 2).

During the day, young alternated feeding and resting bouts. Transitions from resting to feeding bouts (Fig. 3) were more abrupt and rapid than those from feeding to resting (Fig. 3). It was during the transition from feeding to resting that most preening occurred.

Feeding bouts averaged longer than resting bouts (Tables 3 and 4). Length of feeding bouts did not vary significantly with brood age (ANOVA, $F = 0.14$, $P = 0.71$) or time of day ($F = 1.60$, $P = 0.20$) (Table 3). Resting bouts also did not vary with time of day ($F = 2.26$, $P = 0.11$; not including 05:00–09:00) but were, however, significantly shorter for older broods ($F = 12.8$, $P = 0.0005$) (Table 4).

4.0 Discussion

Time budgets of females and broods at Lake Malbaie were similar to those measured in northern Quebec, the centre of the breeding distribution in the province (Savard and Lamothe 1991; Bergeron et al. 1995), suggesting that the values measured reflect well the general behaviour of Surf Scoter broods. In most waterfowl species studied, females usually spend less time feeding and resting and more time alert than young (White-winged Scoter *Melanitta fusca*, Brown and Fredrickson 1987; Bufflehead *Bucephala albeola*, Gauthier 1993; Ring-necked Duck *Aythya collaris*, Maxson and Pace 1992).

In contrast to our findings, Hickey and Titman (1983) reported that female American Black Ducks *Anas rubripes* with class II ducklings spent less time feeding and more time resting than those with class I ducklings. Female Surf Scoters spent nearly half as much time in alert when accompanied by class II broods than with class I broods, whereas female American Black Ducks remained equally alert with ducklings of both those age classes (Hickey and Titman 1983).

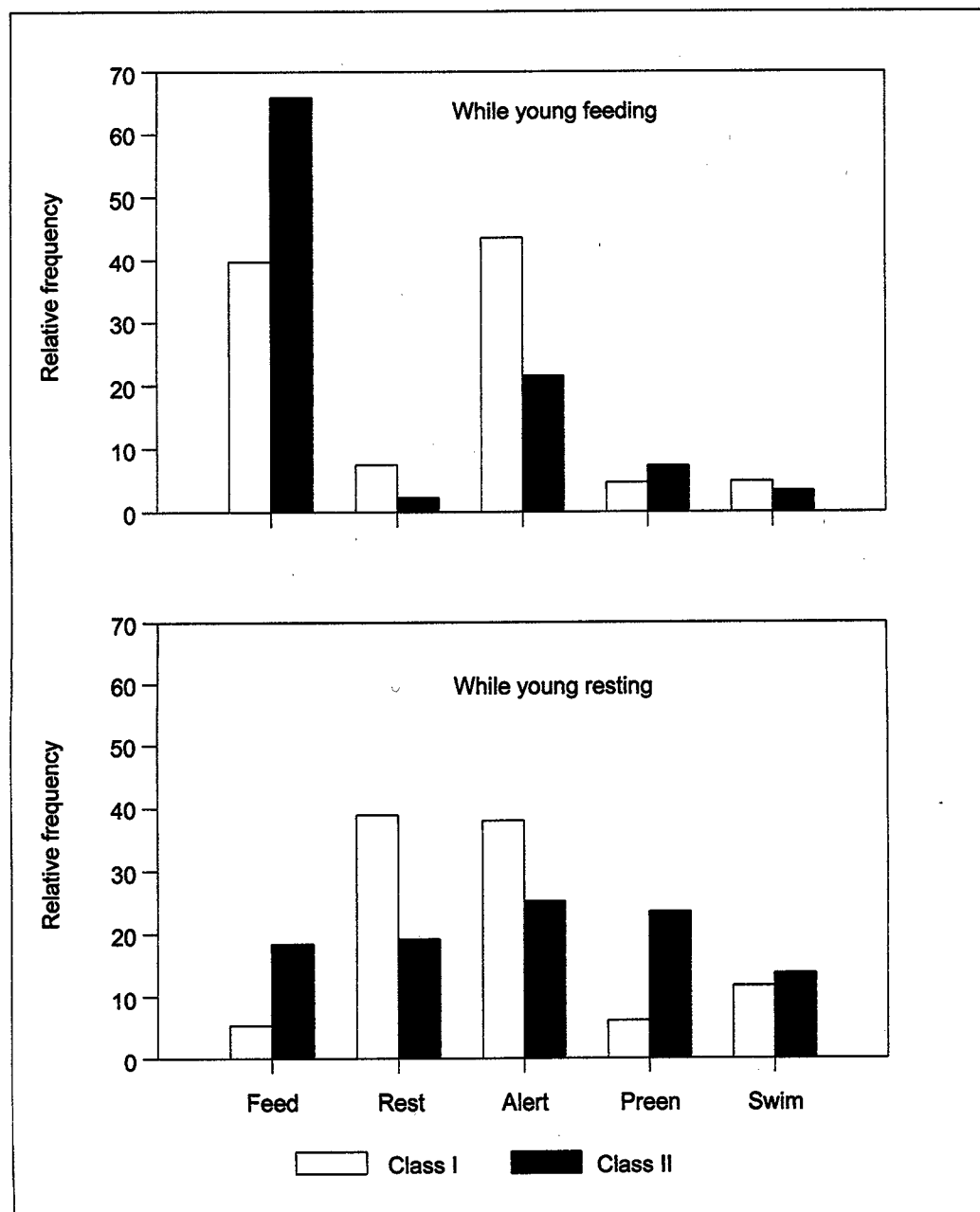
The increase in preening in older ducklings seems to be a general trend in waterfowl (Hickey and Titman 1983; Eberhardt et al. 1989) and is thought to result from the acquisition of their new plumage.

Feeding bouts of class I broods averaged slightly shorter than those measured in northern Quebec (30.2 ± 3.7 minutes, $n = 50$ vs. 37.3 ± 3.6 minutes, $n = 28$; t -test, $t = 8.27$, $P = 0.0001$). In both areas, resting periods were shorter than feeding periods (Savard and Lamothe 1991). The differences in the length of feeding bouts between these two studies may reflect ecological differences at the two study sites. Durations of Surf Scoter brood feeding bouts were much shorter than those of Wood Ducks *Aix sponsa*, Ring-necked Ducks, or American Wigeon *Anas americana* measured in Michigan (Beard 1964).

The amount of time spent by females in alert behaviour did not seem to differ between Lake Malbaie, where boat traffic by anglers was frequent, and northern breeding areas, where human disturbance was minimal (Savard and Lamothe 1991; Bergeron et al. 1995). Overall, time budgets of Surf Scoter broods are similar to those of other waterfowl broods.

Figure 2

Behaviour of adult female Surf Scoters while young were feeding (class I, n = 3759 minutes; class II, n = 929 minutes) and resting (class I, n = 2645 minutes; class II, n = 181 minutes)



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Figure 3

Behaviour of Surf Scoter broods during transitions from feeding bouts to resting bouts and vice versa. Behaviour presented by five-minute periods: five minutes prior to change, five minutes after change, 5–10 minutes after change. Numbers above bars represent the number of minutes of observation.

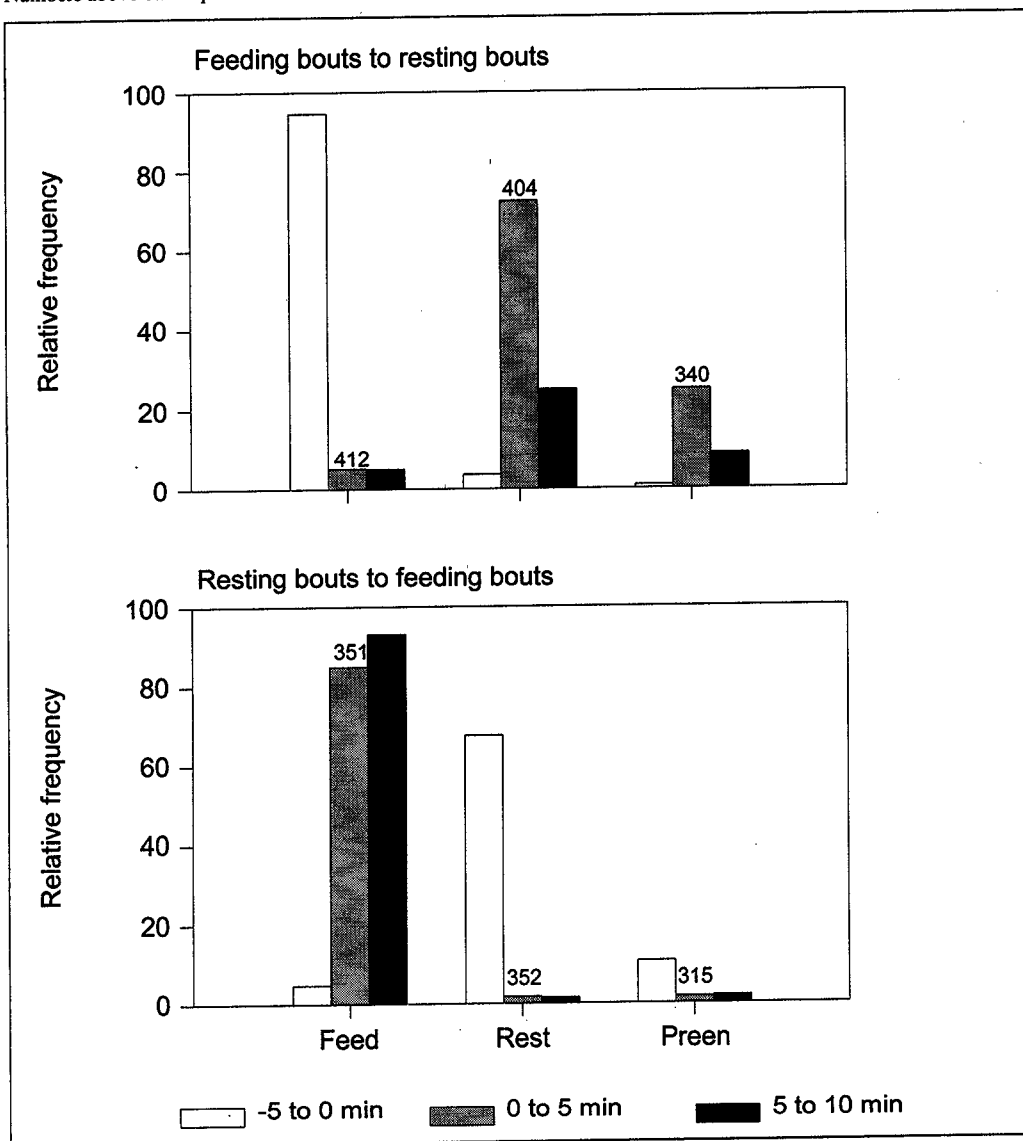


Table 3
Mean length of feeding bouts by Surf Scoter broods (in minutes) versus time of day and brood age^a

Class	Time of day				Mean
	05:00–09:00	09:00–13:00	13:00–17:00	17:00–21:00	
I	29.2 ± 5.5 (9)	35.9 ± 8.4 (18)	24.3 ± 5.9 (14)	28.8 ± 5.6 (9)	30.2 ± 3.7 (50)
II	27.0 (1)	52.4 ± 18.7 (4)	10.9 ± 5.1 (2)	18.2 ± 5.7 (3)	31.3 ± 9.2 (10)
Mean	29.0 ± 4.9 (10)	38.9 ± 7.6 (22)	22.7 ± 5.3 (16)	26.1 ± 4.6 (12)	30.4 ± 3.4 (60)

^a Sample size in parentheses.

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Table 4
Mean length of resting bouts by Surf Scoter broods (in minutes) versus time of day and brood age^a

Class	Time of day				Mean
	05:00–09:00	09:00–13:00	13:00–17:00	17:00–21:00	
I	26.4 ± 5.8 (7)	22.3 ± 2.5 (23)	24.2 ± 4.6 (15)	20.3 ± 4.5 (8)	23.1 ± 1.9 (53)
II	–	13.9 ± 1.6 (8)	12.1 ± 4.4 (3)	6.3 ± 2.3 (2)	12.3 ± 1.5 (13)
Mean	26.4 ± 5.8 (7)	20.2 ± 2.0 (31)	22.2 ± 4.0 (18)	17.5 ± 4.0 (10)	21.0 ± 1.7 (66)

^a Sample size in parentheses.

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Habitat associations of nesting Spectacled Eiders on the Arctic Coastal Plain of Alaska

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Abstract

We studied nesting Spectacled Eiders *Somateria fischeri* and their habitats on the Colville River Delta and in the Kuparuk Oilfield on the Arctic Coastal Plain of Alaska in 1992–1995. On the Colville River Delta, most Spectacled Eider nests were found in aquatic sedge with deep polygons, nonpatterned wet meadows, and wet sedge–willow tundra. Most nests were located <1 m from water. In the Kuparuk Oilfield, we found 69% of all nests in basin wetland complexes, a mosaic of water bodies with stands of emergents and complex shorelines with numerous islands and peninsulas. Other habitats used for nesting included the margins of *Carex* ponds, *Arctophila* ponds, shallow ponds without emergents, and deep open lakes. As on the Colville River Delta, nests were usually located near water.

Résumé

De 1992 à 1995, nous avons étudié les Eiders à lunettes nicheurs (*Somateria fischeri*) et leurs habitats dans le delta de la rivière Colville et dans les champs pétrolifères de Kuparuk, dans la plaine côtière de l'Arctique en Alaska. Dans le delta de la rivière Colville, la plupart des nids d'Eiders à lunettes se trouvaient parmi des carex aquatiques avec des polygones profonds, en sol de prairie humide irrégulier et en toundra humide de carex et de saule. La plupart des nids étaient situés à moins de 1 m de l'eau. Dans les champs pétrolifères de Kuparuk, nous avons trouvé 69 p. 100 des nids dans des complexes de bassins en terres humides, une mosaïque de plans d'eau aux peuplements émergents et complexes comprenant de nombreuses îles et péninsules. Les autres habitats de nidification comprenaient les bords d'étangs *Carex*, les étangs *Arctophila*, les étangs peu profonds sans émergent et les lacs profonds ouverts. Comme dans le delta de la rivière Colville, les nids se trouvaient généralement près de l'eau.

1.0 Introduction

Spectacled Eiders *Somateria fischeri* have recently undergone severe declines in abundance in Alaska, particularly on the Yukon–Kuskokwim Delta (Stehn et al. 1993). Because of this decline, the species was listed under the *Endangered Species Act* as a "threatened species" on 9 June 1993 (U.S. Fish and Wildlife Service 1993). Prior to the

listing, little research had been conducted on Spectacled Eiders in the northernmost portion of their breeding range (i.e., the Arctic Coastal Plain) in Alaska. Spectacled Eiders were included, however, in more general studies of waterbirds in the National Petroleum Reserve – Alaska (Derksen et al. 1981), at Storkersen Point, near Prudhoe Bay (Bergman et al. 1977), and in the early monitoring studies in the Prudhoe Bay area (ABR, Inc., unpubl. data; D.M. Troy, pers. commun.). Johnson and Herter (1989) reviewed the status and distribution of Spectacled Eiders along the Arctic Coastal Plain, including their abundance in the oilfields.

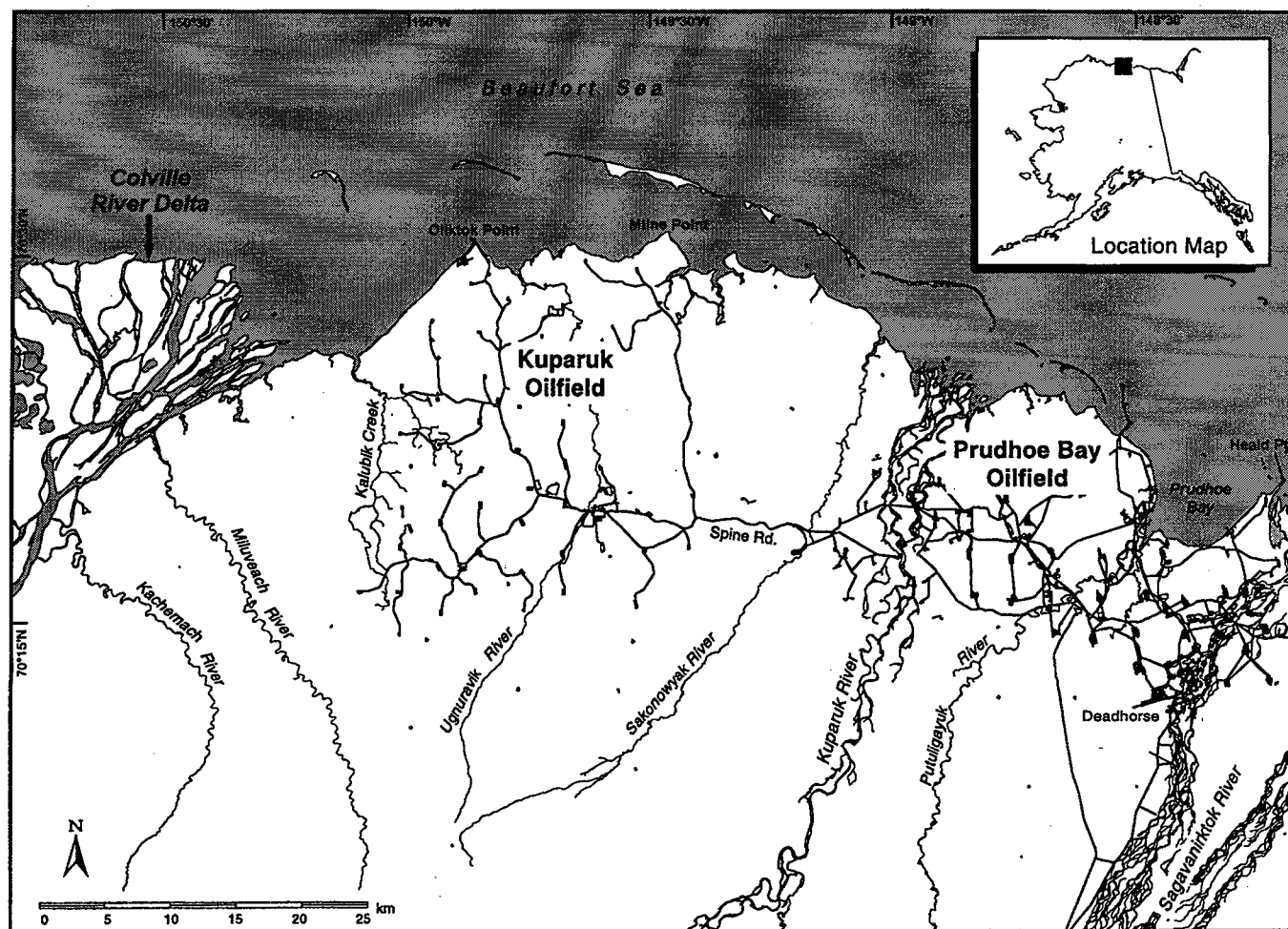
The general lack of data on breeding Spectacled Eiders on the Arctic Coastal Plain of Alaska and the interest of federal agencies in monitoring endangered species in areas of industrial development (e.g., the North Slope oilfields) spurred an increase in research on eiders in the oilfields and elsewhere on the coastal plain. Whereas the U.S. Fish and Wildlife Service has focused its research efforts on aerial surveys for eiders across the entire coastal plain, we and other biologists working in the oilfields have concentrated our research on determining breeding populations within the oilfields, monitoring nesting effort and success, and identifying habitats used by breeding eiders. In this paper, we present the results to date (1992–1995) of our studies on nesting habitats and discuss the habitat associations that we have determined for nesting Spectacled Eiders on the Arctic Coastal Plain of Alaska.

2.0 Study areas

The Colville River Delta is the largest river delta in arctic Alaska (~600 km²); its drainage basin encompasses 60 000 km², or 30% of all drainages on the Arctic Coastal Plain of Alaska (Walker 1983). The high discharge volume and heavy sediment load of the river produce a dynamic deltaic system that is characterized by diverse geomorphological and biological processes, creating a mosaic of wetland habitats. Some habitats unique to river deltas on the coastal plain have been formed, such as tapped lakes (lakes that are connected to the river by a narrow channel) and wetlands composed of coalesced ice-wedge polygons that retain permanent water (Walker 1983).

The Kuparuk Oilfield is located approximately 65 km west of Prudhoe Bay, between the Colville and Kuparuk rivers (Fig. 1). The area is dominated by landforms and habitats created by thaw lake cycles, fluvial process from the

Figure 1
Location of the Colville River Delta and Kuparuk Oilfield on the Arctic Coastal Plain of Alaska



ivers, and coastal processes of erosion, sediment deposition, and flooding. Wetland types created by the thaw lake cycle include large, wind-oriented thaw lakes, small ponds, drained lake basins, and seasonally flooded lowland areas (Walker and Acevedo 1987). Predominant wetland community types include wet sedge (*Carex* spp.) meadows, moist sedge-dwarf shrub (*Salix* spp.) meadows, and emergents (*Carex* and the pendant grass *Arctophila fulva*) along the margins of ponds and lakes. In coastal areas, brackish ponds and halophytic (saline) wet meadows (often referred to as arctic salt marshes) and salt-killed tundra also occur. Landforms and vegetation in the general region are similar to those described for the Prudhoe Bay area (Walker et al. 1980).

The habitat classification system used for our studies is a hierarchical system developed originally for the Lisburne Terrestrial Monitoring Program in the Prudhoe Bay Oilfield and modified to include habitat types found on the Colville River Delta that do not occur in the oilfields (Murphy et al. 1989; Johnson et al. 1996). The habitat classification system incorporates three components of the landscape to differentiate habitat types: landscape structure, hydrology, and vegetative composition. The habitat system incorporates a hierarchical system of vegetation composition similar to that used by Walker and Acevedo (1987) for the Prudhoe Bay area. Water bodies were classified similarly to Bergman et al. (1977) and included identification of important emergent

species (e.g., *Carex* spp. or *Arctophila fulva*) in each type. Habitat types discussed in this paper are described in Appendix 1 at the end of the paper.

3.0 Methods

We used two methods to locate nests of Spectacled Eiders during our studies. On the Colville River Delta in 1992, we searched two 10-ha study plots randomly located in areas under consideration for exploratory drilling on the delta. We searched each plot by walking the edges of all water bodies and walking systematically (observers spaced 2 m apart) across areas away from water bodies. In subsequent years, we searched areas where we found nests in previous years and areas where we saw breeding pairs during aerial surveys. In the Kuparuk Oilfield, we searched only in the vicinity of water bodies where we had seen breeding pairs of Spectacled Eiders during pre-nesting surveys or in areas where we had found nests in previous years. During the first year (1993) of our study in the oilfield, we searched within 400 m of the water bodies containing breeding pair sightings; because we found all nests <5 m from the edge of water bodies, however, we limited our searches in subsequent years to within 25 m of water bodies. Both methods were successful at locating eider nests, although not all water bodies used by pre-nesting eiders later supported a nest. When we found

Table 1
Number of Spectacled Eider nests by microsite and macrosite habitats on the Colville River Delta, Alaska, 1992–1995

Macrosite habitat	Microsite habitat				Total	
	Salt-killed tundra	Aquatic sedge with deep polygons	Nonpatterned wet meadow	Wet sedge-willow meadow	n	%
Brackish water		5			5	20
Tapped lake with high-water connection				1	1	4
Salt marsh			1		1	4
Salt-killed tundra	1	1		1	3	12
Shallow open water without islands		1			1	4
Aquatic sedge with deep polygons		7			7	28
Nonpatterned wet meadow		2	3		5	20
Wet sedge-willow meadow				2	2	8
Total						
n	1	16	4	4	25	
%	4	64	16	16		

nests after they had been destroyed, we determined species (either Spectacled Eider or King Eider *Somateria spectabilis*) by examining contour feathers left in the nest.

Once a nest was located, we described the habitat within 1 m of the nest site (the microsite habitat) and the larger-scale habitat surrounding the nest (the macrosite habitat). Whereas the microsite habitat was the habitat type immediately at the nest site, the macrosite habitat was determined by identifying the primary habitat type in a 0.25-ha area surrounding the nest site. This area for the macrosite habitat was considered to be the minimal mapping size for the scale (1:18 000) of aerial photographs available for the study area, and thus the habitat type that would be identified during any habitat mapping used for planning purposes in the oilfield. At each nest, we also recorded the landform on which the nest was situated (e.g., island, peninsula, polygon ridge) and estimated the distance to permanent open water.

Habitats of Spectacled Eider nests on the Colville River Delta were determined from a digitized habitat map prepared for the delta (Johnson et al. 1996). For nests in the Kuparuk Oilfield, we delineated habitat types on acetate overlays of true-colour aerial photographs (1:18 000) to determine the proportion of each habitat type within a 250-m radius surrounding the nest. We used a 250-m radius buffer size because it was sufficiently large to encompass all habitats near the nest that are likely used by eiders during nesting. A few wetlands in the oilfield supported 2–5 nesting pairs of Spectacled Eiders each year. We have called these areas “colonies,” although the term is used only in its most general sense to mean sites supporting more than one nesting pair of eiders. Because 250-m buffers around nests within these colonies could overlap both within and between years and tend to overemphasize the importance of some habitats, we described habitats for the entire wetland (as visible on the aerial photograph), rather than individual nest sites. This approach was also used because we were interested in determining the habitat characteristics of the wetlands that supported greater numbers of nesting eiders, which then could be used to identify potentially important wetlands to eiders in areas proposed for future oilfield developments. As for individual nests, we mapped habitats within the wetland on acetate overlays of true-colour aerial photographs. A geographic information system program was then used to

determine the areal coverage of each habitat type for individual nests and for the colony wetlands.

4.0 Results

We located 25 nests of Spectacled Eiders in a variety of habitat types on the Colville River Delta during nest searches in 1992–1995 (Table 1). The primary microsite habitat of eider nests was aquatic sedge (*Carex* spp.) with deep polygons containing permanent water. The importance of polygonized ground on the delta to nesting eiders was apparent, because 84% of all nests were in microsite habitats that included some variant of this landform (essentially all microsite habitats except nonpatterned wet meadows). At the macrosite level, 80% of all eider nests occurred in four habitat types, including two types influenced by input of marine waters from the Beaufort Sea (brackish water and salt-killed tundra) and two wet tundra types (aquatic sedge with deep polygons and nonpatterned wet meadow). Most (84%) nests were located ≤ 1 m from water; only one nest was located ≥ 10 m from water. Eider nests were located primarily on small islands (48%), but peninsulas (24%) and polygon ridges (28%) were also commonly used.

In the Kuparuk Oilfield, we found 45 Spectacled Eider nests during searches in 1993–1995 (Table 2). The primary microsite habitat for most (78%) nests was nonpatterned wet meadow, with the remaining nests occurring in low-relief and high-relief moist meadows. Landforms used for eider nests included shorelines of water bodies (33%), islands (33%), peninsulas (24%), polygon rims (7%), and hummocks (2%). Vegetation at nest sites was similar to that of the surrounding tundra and was dominated by sedges (*Carex* spp.), mosses, and lichens. Willows (*Salix* spp.) occurred at 14 of 45 nests. Although a variety of macrosite habitats were used by nesting Spectacled Eiders, basin wetland complex was the most common habitat (69% of all nests). The importance of basin wetland complexes is further supported by the analyses of habitat composition within the buffers around nests (Table 3). In all years, basin wetland complex was the primary habitat within 250 m of nests and accounted for a mean of 35% of total area (SD = 22, $n = 18$). Basin wetland complex was also an important habitat component of the wetlands supporting small nesting colonies in the Kuparuk Oilfield and represented the primary

Table 2
Number of Spectacled Eider nests by microsite and macrosite habitats in the Kuparuk Oilfield, Alaska, 1993–1995

Macrosite habitat	Microsite habitat			Total	
	Nonpat- terned wet meadow	Moist meadow			
		high relief	low relief	n	%
Deep open lake	1		1	2	4.4
Shallow open water					
Without islands	1			1	2.2
With islands	1		1	2	4.4
Aquatic sedge					
Without islands			1	1	2.2
With islands	3			3	6.7
Aquatic grass					
Without islands	2			2	4.4
With islands	3			3	6.7
Basin wetland complex	24	1	6	31	68.9
Total					
n	35	1	9	45	
%	77.8	2.2	20		

habitat in three of five sites (Table 4). Both the habitat composition around individual nests and that at nesting colonies indicated that a variety of habitat types were used by nesting Spectacled Eiders, including terrestrial (wet and moist meadows) and aquatic habitats (deep open lakes and water bodies with emergent sedges and grasses). As on the Colville River Delta, Spectacled Eider nests in the Kuparuk Oilfield were located near water (58% at ≤ 1 m, 40% at >1 –10 m, and 2% at >10 m; $n = 45$).

5.0 Discussion

Nesting Spectacled Eiders used a variety of habitats on the Arctic Coastal Plain of Alaska, and the most commonly used habitats differed between our two study areas. On the Colville River Delta, most eider nests are located in habitats that are formed of coalesced polygons supporting permanent water or on the polygonized margins of more distinct water bodies. Much of the Arctic Coastal Plain is composed of ice-wedge polygon tundra that forms from freeze–thaw processes (Walker et al. 1980). On the Colville River Delta, these polygons form in ice-rich, fine-grained sediments that become unstable and are affected by thermokarst processes, eventually slumping to produce deep (>1 m), permanently flooded polygon centres (Walker 1983). In some areas, the polygon fields gradually erode into adjacent water bodies such as deep open lakes or tapped lakes, forming a distinctive margin of coalescing polygons. On the delta, polygonized habitats provide a rich variety of nesting sites for eiders in the form of water bodies containing complex shorelines with many peninsulas and small islands (usually formed from remnant polygon ridges) and stands of emergent vegetation. The coastal influences of the Beaufort Sea are more pronounced on the Colville River Delta than in the neighbouring Kuparuk Oilfield, primarily because of the influence of the major channels and distributaries of the Colville River. Spectacled Eiders nest in several coastally influenced habitats on the delta, including salt marsh, salt-killed tundra, brackish water (which includes coalesced polygon fields — as described above — that contain brackish

water), and tapped lakes (lakes that are breached periodically by channels of the Colville River and receive input of saline water).

In the Kuparuk Oilfield, Spectacled Eiders nest most commonly in basin wetland complexes that, like the polygonized habitats on the Colville River Delta, are complex habitats with extensive shorelines, islands, and islets. Basin wetland complexes are also important nesting habitats for other large waterbirds on the Arctic Coastal Plain, including Red-throated *Gavia stellata* and Pacific *G. pacifica* loons, Brant *Branta bernicla*, King Eiders, Oldsquaw *Clangula hyemalis*, and Glaucous *Larus hyperboreus* and Sabine's *Xema sabini* gulls (Bergman et al. 1977; ABR, Inc., unpubl. data).

The nesting habitats used by Spectacled Eiders in other parts of their breeding range (i.e., western Alaska and Siberia) are superficially similar to those used by eiders on the Arctic Coastal Plain of Alaska. On the Yukon–Kuskokwim Delta in western Alaska, Spectacled Eiders nest on shorelines, islands, and peninsulas, in areas dominated by sedges, and usually within 2 m of water (Johnsgard 1964; Dau 1974; Mickelson 1975). Dau (1974) concluded that the physical characteristics of the site and the distance to water were more important than the surrounding vegetation in affecting the location of nests. Johnsgard (1964) found most eider nests on the shorelines of ponds, but a few were on islands. He also noted that several females nested in the same wetland and that nests tended to be “slightly clustered,” with the closest nests being only 4 m apart.

On the Indigirka River Delta of northeastern Russia, Kistchinski and Flint (1974) found two types of nesting habitat used by Spectacled Eiders: scattered locations on the tundra (“rich in lakes”) and islets in lakes where several females usually nested close together, which they suggested indicates a degree of incipient colonization. They also found that eider nests on islets in lakes were often associated with breeding colonies of gulls (Glaucous, Sabine's, Herring *Larus argentatus*, and Ross' *Rhodostethia rosea*), Arctic Terns *Sterna paradisaea*, and Pacific Loons. Vegetation near the islet nests was a dense growth of *Dupontia psilosantha*, *Carex stans*, and *Arctophila fulva*. Eider nests that were scattered on “uniform” (polygonized) tundra also were found near ponds and often were located on wet mossy tussocks. Coastally influenced habitats (up to 40–50 km from the coast) on the Indigirka River Delta appeared to support more nesting eiders than inland areas. In Chaun Bay, northeastern Russia, Kondratyev and Zadorina (1992) found Spectacled Eiders nesting singly near lakes of the Chaun River Delta and on coastal tundra and in small colonies in larger lakes that also supported gulls (*Larus* spp.).

Although the specific vegetation types and habitats used by nesting Spectacled Eiders do differ somewhat across their breeding range, eiders tend to place nests on shorelines, peninsulas, and islands close to water. The results of our studies on the Colville River Delta and in the Kuparuk Oilfield support this general conclusion. The results of our more detailed habitat mapping at nesting colonies and at solitary nests also suggest the importance of a variety of different habitat types in areas used by nesting Spectacled Eiders. The small colonies of nesting Spectacled Eiders that we found in the Kuparuk Oilfield appear to be similar to the incipient colonies described for the Yukon–Kuskokwim Delta in western Alaska and for Russia (Johnsgard 1964; Kistchinski and Flint 1974; Kondratyev and Zadorina 1992).

Table 3
Habitat composition in a 250-m radius surrounding solitary Spectacled Eider nests in the Kuparuk Oilfield, Alaska, 1993–1995

Habitat	Habitat composition (% of total area)											
	1993			1994			1995			All years		
	Mean	SD	Rank ^a	Mean	SD	Rank ^a	Mean	SD	Rank ^a	Mean	SD	Rank ^a
Deep open lake	14.5	20.2	3	5.4	12.1	7	13.3	18.3	4	11.7	17.2	3
Shallow open water												
Without islands	3.7	6.0	6	10.0	11.8	4	8.9	11.5	5	6.9	9.4	5
With islands	1.6	4.6	9	8.3	11.8	5	5.9	13.2	6	4.7	9.5	7
Lower perennial stream	0.1	0.2	13							0.1	0.1	15
Aquatic sedge												
Without islands	2.0	4.0	8				1.3	2.9	10	1.2	3.0	12
Aquatic grass												
Without islands	3.7	8.1	6	2.6	3.6	10	1.4	3.2	9	2.8	5.8	9
With islands	15.8	19.6	2	13.8	16.1	2	16.4	23.1	2	15.4	18.6	2
Basin wetland complex	23.0	40.3	1	33.8	16.8	1	31.9	23.3	1	34.9	22.4	1
Wet meadow												
Nonpatterned	10.4	20.7	4				13.4	29.5	3	8.4	20.2	4
Low relief	1.3	3.0	10	10.2	9.4	3	3.2	7.2	7	4.3	7.2	8
High relief				3.1	6.9	9	2.4	5.3	8	1.5	4.4	11
Moist meadow												
Low relief	7.4	8.4	5	7.1	6.9	6	1.1	1.6	11	5.6	7.0	6
High relief	1.0	2.2	11	3.5	3.7	8	0.6	0.9	12	1.6	2.6	10
Gravel fill	1.0	1.8	11	1.5	2.1	11	0.1	0.2	13	0.9	1.6	13
Partially vegetated sod				0.6	1.3	12	0.1	0.3	13	0.2	0.7	14
Number of nests	8			5			5			18		

^a Ranks are the relative contribution of each habitat type (1 = greatest mean area).

Table 4
Habitat composition of colony locations used by nesting Spectacled Eiders in the Kuparuk Oilfield, Alaska, 1993–1995

Habitat	Habitat composition									
	Colony 1		Colony 2		Colony 3		Colony 4		Colony 5	
	ha	% ^a	ha	% ^a	ha	% ^a	ha	% ^a	ha	% ^a
Shallow open water										
Without islands	0.3	0.4	4.7	6.5	6.5	15.4	17.0	6.2		
With islands	24.8	31.8			3.2	7.5	19.5	7.1		
Lower perennial stream							0.3	0.1		
Aquatic grass										
Without islands					2.5	6.0	1.5	0.6		
With islands			18.9	26.5	2.6	6.2	22.8	8.3	8.4	10.9
Basin wetland complex	24.4	31.3	16.6	23.3	24.9	58.6	125.7	45.6	33.4	43.5
Wet meadows										
Nonpatterned	6.9	8.8			1.3	3.0	27.2	9.9	22.3	29.0
Low relief	19.9	25.5	31.0	43.6			22.6	8.2	4.3	5.5
High relief							19.0	6.9		
Moist meadow										
Low relief	1.7	2.2	0.0	0.0	1.4	3.4	7.6	2.7	7.3	9.5
High relief							12.1	4.4	1.3	1.6
Total	77.9		71.2		42.5		275.4		76.9	
Mean number of nests/year	2		4.3		2		2		2	

^a Percentage of total area.

Additional research will be required to determine whether nesting in these small colonies, often in association with gulls and other waterfowl, provides some benefits to the eiders.

Acknowledgments

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Appendix 1

Descriptions of habitat types used to quantify habitat associations at Spectacled Eider nest sites, Colville River Delta and Kuparuk Oilfield, Alaska

Habitat class	Habitat description
COASTAL ZONE	
Brackish water	Coastal ponds and lakes that are flooded periodically with salt water during storm surges. Salinity levels are often increased by subsequent evaporation of impounded saline water. The substrate may contain peat, reflecting its freshwater/terrestrial origin, but this peat is mixed with deposited silt and clay. This type may contain aquatic sedge with deep polygons that contain brackish water.
Tapped lake with high-water connection	Water bodies that have been partially drained through erosion of banks by adjacent river channels, but which are connected to rivers by distinct, permanently flooded channels. The connecting channels are dry during low water, and the lakes are connected only during flooding events. Water tends to be fresh. Small deltaic fans are common near the connecting channels as a result of deposition during seasonal flooding. Deeper lakes in this habitat do not freeze to the bottom during winter. These lakes provide important fish habitat.
Salt marsh	On the Beaufort Sea coast, arctic salt marshes generally occur in small, widely dispersed patches, most frequently on fairly stable mudflats associated with river deltas. The surface is flooded irregularly by brackish or marine water during high tides, storm surges, and river flooding events. Salt marshes typically include a complex assemblage of small brackish ponds, halophytic sedge and grass wet meadows, halophytic dwarf willow scrub, and small barren patches. Dominant plant species usually include <i>Carex subspathacea</i> , <i>C. ursina</i> , <i>Puccinellia phryganodes</i> , <i>Dupontia fisheri</i> , <i>P. andersonii</i> , <i>Salix ovalifolia</i> , <i>Cochlearia officinalis</i> , <i>Stellaria humifusa</i> , and <i>Sedum rosea</i> . Salt marsh is important habitat for brood-rearing and moulting waterfowl.
Salt-killed tundra	Salt-killed tundra occurs along the Beaufort Sea coast in areas where saltwater inundation, caused by storm surges, has killed much of the original vegetation, but where salt-tolerant plants are colonizing. Colonizing plants include <i>Puccinellia andersonii</i> , <i>Dupontia fisheri</i> , <i>Braya purpurascens</i> , <i>B. pilosa</i> , <i>Cochlearia officinalis</i> , <i>Stellaria humifusa</i> , <i>Cerastium beerlingianum</i> , and <i>Salix ovalifolia</i> . Typically, this habitat occurs either on low-lying areas that originally supported wet sedge-willow meadows and basin wetland complexes or, less commonly, along drier coastal bluffs that formerly supported moist sedge-shrub meadows or upland dwarf shrubland. Plant cover is generally <5%, but vegetation may be more abundant around pond margins.
FRESH WATER	
Deep pen water (lakes and ponds) / with islands or polygonized margins	Deep (≥ 1.5 m) water bodies ranging in size from small ponds in ice-wedge polygons to large open lakes; most have resulted from thawing of ice-rich sediments, although some are associated with old river channels. Emergent vegetation is present in <5% of the lake surface, and generally the lakes are larger than 10 ha. Deep lakes have jagged, low bluffs along a portion of the shoreline and remain frozen until at least late June. / On the Colville River Delta, margins of this habitat may be composed of polygons that grade into the lake surface, forming peninsulas and islands.
Shallow open water / without islands / with islands / polygonized margins	This habitat includes ponds and small lakes <1.5 m deep with emergent vegetation present in <5% of the area. Owing to shallow water depths, ice cover melts by early to mid-June, and summer temperatures are warmer than in deep water. / For this habitat to be considered to be with islands, it must have at least one island larger than 0.5 m ² that is at least 5 m from shore. / On the Colville River Delta, margins of these habitats may be composed of polygons that grade into the lake surface.
Aquatic sedge / without islands / with islands / deep polygons with permanent water	Aquatic sedge habitat includes both uniform sedge marshes and small ponds in which sedges are present in at least 5% of the pond; at least 70% of the emergents must be sedges. <i>Carex aquatilis</i> is the dominant emergent sedge and occurs in water 10–30 cm deep. Water and bottom sediments of this habitat freeze completely during the winter, but ice melts in early June. / Islands as described above. / On the Colville River Delta, this type may be composed of coalesced polygons that retain permanent water (>1 m deep).
Aquatic grass / without islands / with islands	The habitat includes small ponds, lake margins, and marshes in which <i>Arctophila fulva</i> is present in at least 5% of the pond and in which at least 30% of the emergents are grasses. Areas of open water >1 ha in pond centres are classified separately as open water. Owing to shallow water depths (<1 m), the water freezes to the bottom in winter and ice melts by early June. / Islands as described above.
Lower perennial stream	In this stream habitat, water is slow-moving, and the gradient of the stream is low. This habitat is not tidally influenced, and some water flows throughout the summer month; the stream is frozen during winter. Stream substrates consist primarily of sand and mud, although some gravel does occur.
BASIN WETLAND COMPLEX	Basin wetland complexes form in drained, thaw lake basins and are characterized by high interspersions of open water, water with emergents, and wet and moist meadows. This habitat complex has at least three habitat types present, although no single habitat type dominates (>70%) the area.
MEADOWS	
Wet meadows / nonpatterned / wet sedge-willow / low relief / high relief	These habitats typically are found as extensive meadows within younger drained lake basins, as narrow stands adjacent to receding water bodies, and along edges of small stream channels. / Nonpatterned wet meadows have not yet undergone extensive ice-wedge polygonization and hence are subject to more movement of groundwater and surface water than are polygonized areas. Disjunct polygon rims and strangmoor (undulating raised sod ridges) cover less than 5% of the area. The surface generally is flooded during early summer (depth <0.3 m) and drains later, but movement of water and dissolved nutrients results in more robust growth of sedges than in polygonized habitats. / Wet sedge-willow meadows include low-centred polygons occurring on lowland areas within drained lake basins and on level to gently sloping floodplains and terraces. Polygon rims and strangmoor are <5 cm high and cover <30% of the area. Lower microsites are dominated by wet sedge tundra, whereas higher microsites are dominated by moist tundra. / Low-relief wet meadows have polygon rims and strangmoor <0.5 m high and cover <30% of the area. / High-relief wet meadows are similar to above, but polygon rims are higher than 0.5 m.
Moist meadows / low relief / high relief	Moist meadows occur on better-drained upland areas between thaw basins, on riverbanks, on the lower slopes of pingoes on thaw lake plains, and on foothill slopes. This habitat is free of surface water during the summer, although some sites may be inundated briefly during breakup. Moist sedge-shrub tundra covers less than 70% of the area. / For low-relief meadows, micro-topographic relief is <0.5 m. / High-relief meadows are found on upland areas between thaw basins and are distinguished by the presence of high-centred (>0.5 m) polygons. This habitat is more complex than low-relief moist meadows and usually contains high-centred polygons that support sedge-dwarf shrub vegetation, interspersed with polygon troughs and thermokarst pits, which support wet and aquatic sedge vegetation.
ARTIFICIAL	
Gravel fill	This human-made habitat has resulted from gravel fill placed on natural terrain during industrial development. Most fill consists of gravel roads and pads 1.5 m thick.
Partially vegetated sod	This human-made habitat includes "peat" roads and overburden stockpiles that have organic material mixed in with the mineral soil. Vegetation covers 5–30% of the surface.

Periodic nonbreeding of Steller's Eiders near Barrow, Alaska, with speculations on possible causes

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Abstract

Steller's Eiders *Polysticta stelleri* nested near Barrow, Alaska, in 1991, 1993, and 1995, but not in 1992 or 1994. Available information indicated that this pattern was similar to that observed in one area on the Siberian nesting grounds during 1991–1995. Possible causes of periodic nonbreeding at Barrow include variability in 1) body condition, 2) weather, and 3) the numbers and species of predators present on the nesting grounds. We do not have annual data on body condition; however, nesting by Steller's Eiders in Barrow coincided with years in which lemming densities were high. It is not known whether Steller's Eiders travel elsewhere to nest when they do not nest near Barrow; aerial surveys conducted throughout potential nesting habitat elsewhere in Alaska did not locate nesting Steller's Eiders. Steller's Eiders are long-lived and may maximize individual fitness by foregoing breeding in years when reproductive success may be low and adult mortality high.

Résumé

Les Eiders de Steller (*Polysticta stelleri*) ont niché près de Barrow, en Alaska, en 1991, en 1993 et en 1995, mais pas en 1992, ni en 1994. Les renseignements disponibles ont indiqué que cette tendance était semblable à celle observée dans un secteur des lieux de nidification de Sibérie de 1991 à 1995. Les causes possibles de ces périodes de non-reproduction à Barrow comprennent les variations 1) de la condition physique, 2) du climat et 3) du nombre et des espèces de prédateurs présents sur les lieux de nidification. Nous ne disposons pas de données annuelles sur la condition physique. Toutefois, les années de nidification des Eiders de Steller à Barrow coïncidaient avec celles au cours desquelles la densité des populations de lemmings était élevée. On ignore si les Eiders de Steller vont nicher ailleurs quand ils ne nichent pas près de Barrow; des relevés aériens menés dans les habitats propices à la nidification ailleurs en Alaska n'ont pas permis de repérer des sites de nidification d'Eiders de Steller. Ces derniers vivent longtemps et peuvent se maintenir en bonne santé en évitant de se reproduire les

années où les chances de succès sont faibles et la mortalité adulte est élevée.

1.0 Introduction

Steller's Eiders *Polysticta stelleri* currently nest in northern Alaska and Russia, wintering mainly along the Alaska Peninsula and Aleutian Islands. The primary breeding area is believed to be the coast of northern Russia, from the Chukotsk Peninsula (Bellrose 1976) in the east to the Yamal Peninsula (Yesou and Lappo 1992) in the west. Historically, the primary breeding area in Alaska was the Yukon-Kuskokwim Delta (Conover 1926; Brandt 1943; Kertell 1991); however, between 1975 and 1995, only one nest was found there (P. Flint, pers. commun.). Barrow, Alaska, is the only known nesting area in North America currently in consistent use by Steller's Eiders. Causes of a decline in the number of Steller's Eiders nesting in Alaska and a reduction in the breeding range of the species within the state are not known.

Every year within most waterfowl populations, some portion of breeding-age birds attempt to breed with varying degrees of success; these frequencies depend upon conditions in wintering, staging, and/or nesting areas (Barry 1962; Coulson 1984). Coulson (1984) studied a population of Common Eiders *Somateria mollissima* in which as many as 65% of the breeding-age adults did not attempt to nest in some years and suggested that periodic nonbreeding of long-lived birds may be widespread. Jaegers (*Stercorarius* spp.) and Snowy Owls *Nyctea scandiaca* are well-known examples of arctic birds that exhibit periodic nonbreeding when lemmings, their preferred prey, are scarce (Parmelee 1992). Other arctic birds, not dependent on lemmings for food, have also been reported as periodic nonbreeders. In Greenland, Bertram et al. (1934) and Bird and Bird (1940) found nonbreeding in King Eiders *Somateria spectabilis*, Red-throated Loons *Gavia stellata* (reported as *Colymbus stellata*), Pink-footed Geese *Anser brachyrhynchus*, and Oldsquaw *Clangula hyemalis*. In those years when waterbirds did not nest, passerines and shorebirds were observed to have nested normally (Bertram et al. 1934; Bird and Bird 1940).

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In this paper, we report on the breeding density, nest success, and periodic nonbreeding of Steller's Eiders during five consecutive summers near Barrow, Alaska. We then explore possible relationships among Steller's Eider reproductive performance, variation in lemming density, predator numbers, and weather.

2.0 Methods

2.1 Study area

The study was conducted at the extreme northwestern corner of the Alaska Coastal Plain near Barrow, Alaska (71°18'N, 156°40'W). A 19-km road (Gaswell Road) was used for road surveys and access to nesting areas. The Barrow area is underlain by continuous permafrost (Bunnell et al. 1975), and the landscape is dominated by ice-wedge polygons, shallow northwest-southeast-oriented lakes, and drained lake basins. Maximum topographical relief occurs with remnant beach ridges and shores of drained lakes, stream banks, and berms caused by repeated use of trails by heavy equipment. The remaining tundra is of low relief, mostly less than 2 m. Plant communities include upland meadow, wet meadow, and marshes with emergent vegetation and open water in numerous small ponds and lakes (Bunnell et al. 1975).

Terrestrial mammalian fauna in the Barrow area is less diverse than in other coastal and inland areas of northern Alaska. One species, the brown lemming *Lemmus trimucronatus*, undergoes large population fluctuations. Collared lemmings *Dicrostonyx groenlandicus* are also present, usually in lower numbers. When lemming numbers are high, they support breeding mammals (arctic foxes *Alopex lagopus*, least weasels *Mustela nivalis*, and short-tailed weasels *M. erminea*) and predatory birds (Snowy Owls, Pomarine Jaegers *Stercorarius pomarinus*, and Short-eared Owls *Asio flammeus*). Glaucous Gulls *Larus hyperboreus* are present in large numbers regardless of lemming numbers, although most appear to be nonbreeders.

2.2 Breeding pair densities

We conducted road surveys along Gaswell Road during June and July, 1991 through 1995, from all-terrain vehicles. Observers drove the length of the road, stopping frequently to scan for eiders using 10×40 binoculars. Both sides of the road were surveyed out to 300 m. Road surveys covered 11.5 km² and took approximately four hours to complete. Pair densities were calculated based on the assumption that each male represented a breeding pair. Twelve surveys were conducted between 15 June and 16 July 1991, five between 12 and 19 June 1992, 28 between 8 June and 7 August 1993, 10 between 18 June and 14 July 1994, and 15 between 12 June and 19 July 1995.

2.3 Spring chronology

Spring chronology from 1992 to 1995 was determined by using the dates at which nearby breeding bird study plots were snow-free (Suydam and Wesselmann 1993; Wesselmann and Suydam 1993; Johnson et al. 1994, 1995). In 1991, breeding bird plots were not surveyed; therefore,

snowmelt data recorded by the Climate Diagnostics Monitoring Laboratory of the National Oceanic and Atmospheric Administration (NOAA) were used (E. Dutton, pers. commun.).

2.4 Nest searches

We found nests by observing female behaviour and by searching areas where pairs were consistently observed. Searches were not confined to the road survey area. Nest searching began on 19 June 1991, 17 June 1993, and 14 June 1995. In 1992, the only pair of Steller's Eiders observed was seen only once; therefore, no nest searches were conducted. In 1994, Steller's Eiders remained flocked on a lake. When pairs or small groups of birds were seen away from the flock, that area was searched for nests. Nest searches consisted of walking the margins of ponds and tundra in the area where birds had been observed. Nest searches continued throughout the season until well after hatch (August). Nests that failed before discovery were identified as those of Steller's Eiders by the presence of very dark down, characteristic contour feathers, and/or the presence of Steller's Eider eggs or eggshells; nests without down or eggs were excluded.

2.5 Nest success

We tried to avoid flushing females when nests were discovered, and nest data were recorded quickly to minimize disturbance. Nests were monitored approximately once a week to determine nest fate, although no regular schedule was used. As the expected hatching date approached, nests were monitored more frequently to accurately determine nest fate and incubation period. During revisits, nests were observed from a distance, and females usually were not flushed from nests. Nest success was calculated using the Mayfield method (Mayfield 1961, 1975).

2.6 Nest predation

The cause of nest failure was determined whenever possible by direct observation of nest predation or was interpreted from characteristic evidence left by avian and mammalian predators. Arctic foxes generally remove all eggs, leaving no eggshells (Quinlan and Lehnhausen 1982; Burgess 1984); if eggshells remain, they are usually broken and licked clean (this study). In contrast, jaegers scatter eggshells and down about the nest site, and eggshells are usually found with holes poked through them and with some residual contents (this study). Common Ravens *Corvus corax* have been observed to remove whole Steller's Eider eggs from nests (this study). The degree to which weasels and Glaucous Gulls may be predators of Steller's Eider eggs is unknown, as is any characteristic evidence implicating them.

2.7 Lemming densities

Snowy Owl nest density was used as an index of relative lemming density (R. Suydam and D. Norton, unpubl. data; D. Holt, unpubl. data). Large numbers of Snowy Owls nest only when lemmings are abundant, although a few owls may nest when lemmings are moderately abundant (Parmelee 1992).

Table 1

Lemming densities, breeding densities of Steller's Eiders and predatory birds, and weather parameters near Barrow, Alaska, 1958, 1975–1980, and 1991–1995

Year	Lemming density	Steller's Eiders	Snowy Owls	Pomarine Jaegers	Snowmelt date	Deviation from normal June (°C) ^a
1958 ^b	Low	None	No	No	15 June ^c	+0.1
1975 ^d	Moderate (5–10)	Moderate	Yes	Yes	12–19 June	+0.4
1976 ^e	High (50–60)	High	Yes	Yes	14–17 June	+0.1
1977 ^f	Low (<1)	None	No	No	9 June	+0.6
1978 ^g	Low (<5)	Low	Low	Yes	12 June	0.0
1979 ^h	Low	Low	No	No	9–14 June	–0.3
1980 ⁱ	Low	Low	No	No	10–12 June	+2.2
1991	0	High ^j	0.47 ^k	Yes ^j	15 June ^j	+2.0
1992	Low	None ^j	No ^m	No ^j	8 June ⁿ	+1.4
1993	+	High ^j	0.11 ^m	Yes ^j	11 June ^o	+1.3
1994	Low	None ^j	No ^m	No ^j	24–28 June ^p	–0.8
1995	0	High ^j	0.11 ^m	Yes ^j	16 June ^q	+1.4

^a National Weather Service, Barrow, Alaska.

^b Myres (1958).

^c Dutton and Enders (1991).

^d Myers and Pitelka (1975a, 1975b) (estimated lemmings per hectare).

^e Myers et al. (1977a, 1977b) (estimated lemmings per hectare).

^f Myers et al. (1978a, 1978b) (estimated lemmings per hectare).

^g Myers et al. (1979a, 1979b, 1979c) (estimated lemmings per hectare).

^h Myers et al. (1980a, 1980b) (lemmings too low to support avian predators).

ⁱ Myers et al. (1981a, 1981b, 1981c) (lemmings too low to support avian predators).

^j This study.

^k R. Suydam and D. Norton, unpubl. data (Snowy Owl nests per square kilometre).

^l E. Dutton, pers. commun.

^m D. Holt, unpubl. data (Snowy Owl nests per square kilometre).

ⁿ Suydam and Wesselmann (1993); Wesselmann and Suydam (1993).

^o Suydam et al. (1994); Johnson et al. (1994).

^p Johnson et al. (1995); MacLean et al. (1995).

^q R. Suydam, unpubl. data.

3.0 Results

3.1 Breeding pair densities

We estimated the breeding pair density of Steller's Eiders to be 1.5 pairs/km² in 1991, 3.0 pairs/km² in 1993, and 1.6 pairs/km² in 1995. During 1992 and 1994, no evidence of nesting was observed. In 1992, only one pair was present for only one day (pair density of 0.1 pairs/km²). In 1994, smaller groups and a few pairs were observed, but no nests were found (pair density of 1.9 pairs/km²). No broods were seen during the normal brood-rearing period in 1992 or 1994. Researchers studying Snowy Owls and shorebirds spent a good deal of time in our study area and often reported Steller's Eider nests and broods; no nests or broods were found by them in 1992 or 1994.

3.2 Spring chronology

Dates when plots became snow-free indicated that the onset of spring was similar in 1991 (15 June), 1993 (11 June), and 1995 (16 June). The snow-free date in 1992 was earlier than in other years (8 June), albeit not much earlier than in 1993, but in 1994 it was much later (approximately 26 June) (Table 1). In 1992, the sea ice conditions were severe, with few nearshore leads open near Barrow during May (Philo et al. 1994). Aerial surveys of the wintering grounds near the Alaska Peninsula found Steller's Eiders unusually concentrated during May 1992 because of heavy ice conditions there as well (Larned et al. 1994). The same survey in 1993 found no such concentration, indicating an

early breakup with no perceived obstructions to spring migration (Larned et al. 1994). Extensive sea ice along the spring migration route may have delayed migration in 1992 and precluded nesting that year; however, King and Common eiders migrated past Barrow on schedule (R. Suydam, unpubl. data).

In 1994, Steller's Eiders were present on the nesting grounds prior to 18 June, more than a week earlier than the snow-free date. Some nesting habitat was available during the normal nest initiation period; however, no nests were found. Passerines and shorebirds that could have been similarly affected by late snowmelt were observed to nest. Shorebird nest densities were lower on one plot, probably because of the effects of unusually late snow and standing water (MacLean et al. 1995).

3.3 Nest success

For nesting years, nest success ranged from 14.6% (n = 13) in 1993 to 71.3% (n = 6) in 1991 (Table 2). Nest search effort was lower in 1991, and some nests were missed, as indicated by the number of broods seen in August. Even though the sample sizes were low, 1991 appeared to have the highest nest success of any year during this study.

3.4 Predation

Although we do not know how fox numbers varied with fluctuations in lemming numbers, avian numbers varied widely among years (Table 1). Arctic foxes were assumed to be responsible for nest predation in cases where entire

Table 2
Fate of Steller's Eider nests near Barrow, Alaska, 1991–1995

	1991	1992	1993	1994	1995
Nests found	6	0	20	0	78
Nests found active	6		13		25
Successful nests	5 ^a		4		9
% success (Mayfield)	71.3	0	14.6	0	15.3
Unsuccessful nests	1		16		69
Failed after found	1		9		17
Abandoned	0		2		2
Avian predation	1		1		5
Fox predation (suspected)	0		5		7
Hen mortality	0		0		1 ^b
Unknown predator	0		1		2
Unknown cause	0		0		0
Failed before found	0		7		52
With no eggs ^c	–		6		35
With egg(s) ^d	–		1		17

^a Two and possibly three of these nests were partially depredated by Common Ravens.

^b The hen was killed by a Snowy Owl, causing the nest to fail.

^c No eggs or eggshells were associated with these nests when found, but eggs could have been removed by predators.

^d Whole or broken eggs were found in or near the nest bowl.

clutches disappeared at once and were suspected to have caused the failure of 44% ($n = 27$) of Steller's Eider nests in all years (Table 2). We found that the primary avian predators of Steller's Eider eggs were Pomarine Jaegers. Common Ravens were observed removing whole eggs from attended and unattended Steller's Eider nests. Common Ravens may be capable of removing an entire clutch of eggs in several trips and therefore could be responsible for some predation attributed to arctic foxes. Glaucous Gulls may be predators of Steller's Eider eggs as well; however, this has not been documented. For nests that failed after we discovered them, avian or mammalian predators were implicated in the single nest failure in 1991, seven of nine nest failures in 1993, and 15 of 17 nest failures in 1995 (Table 2).

Avian predators have been the predominant natural cause of adult Steller's Eider mortality on the breeding grounds. Of eight Steller's Eider carcasses where an avian predator was suspected, Snowy Owls were responsible for three of the deaths, Peregrine Falcons *Falco peregrinus* for two, and a Gyrfalcon *F. rusticolus* for one; for two others, the species of the avian predator was unknown.

4.0 Discussion

4.1 Explanations for nonbreeding at Barrow

Steller's Eiders nested near Barrow in 1991, 1993, and 1995, but not in 1992 or 1994. Little is known about nest site fidelity of Steller's Eiders, so it is not known whether those eiders nesting near Barrow in some years nest elsewhere in other years. Few Steller's Eiders have been seen on the Arctic Coastal Plain outside of Barrow during aerial surveys conducted between 1992 and 1995 (W. Larned and G. Balogh, pers. commun.; R. King, unpubl. data). In 1992 and 1994, Steller's Eiders were not found nesting elsewhere in northern Alaska.

The possibility that Steller's Eiders move between Russia and Alaska can be addressed indirectly by comparing nesting on the Lena River Delta with that in Barrow. In 1995,

the number of pairs was low in Russia (D. Solovieva, pers. commun.) and high in Barrow. However, 1991 and 1993 were good nesting years and 1992 and 1994 were poor nesting years in both locations. Although the evidence is limited, it does not support a movement of Steller's Eiders between Russian and Alaskan nesting areas.

Weather may have prevented Steller's Eiders from nesting in Barrow during some years, but no pattern emerges when comparing snowmelt dates or June temperatures for Barrow with the presence or absence of nesting Steller's Eiders (Table 1). In 1992, only one pair of Steller's Eiders was observed on the tundra and for only one day. Severe sea ice conditions, resulting in scant open water offshore of Barrow during May 1992 (Philo et al. 1994), may have prevented Steller's Eiders from reaching the breeding grounds, although these conditions did not preclude migration of other eider species. In 1994, when Steller's Eiders were present on the breeding grounds but did not nest, snowmelt was the latest recorded during our and other studies near Barrow (Table 1). The late snow melt-off may have prevented access to some suitable nesting areas; however, passerines and shorebirds nested normally. Poor body condition resulting from inadequate food on the wintering grounds in some years may also be a factor in determining whether or not Steller's Eiders breed. We have no data to address this possibility.

During this study, Steller's Eiders nested only in years when lemming numbers were high, as indicated by the number of nesting Snowy Owls. Nesting Steller's Eiders were absent from Barrow during two years when lemming populations were low, but weather conditions during migration in 1992 and upon arrival in 1994 were extreme.

Arctic foxes were present on the breeding grounds every year and are known to flush incubating female waterfowl to depredate nests (Quinlan and Lehnhausen 1982; Burgess 1984). Arctic foxes are also capable of killing and eating adult eiders (Elander and Blomqvist 1986) and probably have the greatest influence on the breeding success of ground-nesting arctic birds (Larson 1960), including Steller's Eiders. Indeed, we believe foxes may have caused more total nest failures than any other predator during this study. It is likely that there has been strong selective pressure for Steller's Eiders to develop strategies to decrease nest predation by foxes. If fox predation has exerted strong selective pressure on Steller's Eider nesting behaviour, possible strategies to avoid fox predation may include 1) nesting only when and where sufficient other prey (i.e., lemmings) are present and 2) nesting in association with species that exhibit effective antipredator defences.

4.2 Evaluation of nesting strategies

4.2.1 Nest only when and where alternative prey are present

Arctic foxes are dependent on lemmings (Larson 1960); however, when lemmings are not abundant (and sometimes even when they are), foxes prey on birds, their eggs, and other items opportunistically (Chesemore 1968; Stickney 1991). Larson (1960) concluded that predation pressure by arctic foxes was a major influence in the distribution of arctic breeding birds. Species that did not possess adaptations to avoid fox predation were absent or low in numbers in areas without lemmings. Barrow is well-known

Table 3
Some reported cases of waterbirds nesting in association with bird species that exhibit antipredator defence

Protected species	Predator providing protection	Reference
Red-breasted Goose <i>Branta ruficollis</i>	Peregrine Falcon <i>Falco peregrinus</i> and Rough-legged Hawk <i>Buteo lagopus</i>	Kostin and Mooij (1995)
Brant <i>B. bernicla</i>	Snowy Owl <i>Nyctea scandiaca</i>	Underhill et al. (1993)
King Eider <i>S. spectabilis</i>	Long-tailed Jaeger <i>Stercorarius longicaudus</i>	Blomqvist and Elander (1988)
	Snowy Owl <i>Nyctea scandiaca</i>	Summers et al. (1994)
Eurasian Curlew <i>Numenius arquata</i>	Eurasian Kestrel <i>Falco tinnunculus</i>	Norrdahl et al. (1995)
Bristle-thighed Curlew <i>N. tahitiensis</i>	Long-tailed Jaeger	McCaffery and Gill (1992)
Bar-tailed Godwit <i>Limosa lapponica</i>	Long-tailed Jaeger	Maher (1959)

for its brown lemming cycles, and numerous studies have been conducted there (Rausch 1950; Pitelka et al. 1955; Thompson 1955a, 1955b; MacLean et al. 1974; Batzli and Pitelka 1983). The Inupiat Eskimo name for Barrow is Ukpeagvik, which means "place to hunt Snowy Owls," implying that Snowy Owls have occurred regularly near Barrow for many years, likely in response to lemming availability. It may be that years of lemming abundance occur with greater frequency and amplitude near Barrow than at other places on the Alaska Coastal Plain. The Prudhoe Bay oilfield, another Arctic Coastal Plain location where the fauna has been studied, had one year when lemmings were high (D. Troy, pers. commun.) within the five-year period when Barrow had three years of lemming highs.

In years when records are available for both Steller's Eider nests and lemming numbers, nesting by Steller's Eiders near Barrow has been correlated with lemming numbers (Table 1). Although high lemming numbers may attract more foxes and avian predators, they may also decrease predation pressure on Steller's Eiders and their eggs by providing abundant primary prey. On the Lena Delta, lemmings were at moderate levels in 1993, a good nesting year for Steller's Eiders, and at low levels in 1994 and 1995, which were poor nesting years for breeding Steller's Eiders (D. Solovieva, pers. commun.). Observations elsewhere on other species support this explanation as well. Summers and Underhill (1987) concluded that the breeding success of Brant *Branta bernicla bernicla* in arctic Russia was more strongly correlated with lemming abundance than with spring feeding conditions or with weather on the breeding grounds. In a review of six incidences of nonbreeding in several species of waterbirds in eastern Greenland, all were found to coincide with poor lemming years; these same species bred during good lemming years (Bertram et al. 1934). Another study conducted from 1936 to 1938 in northeast Greenland (Bird and Bird 1940) found waterbirds nesting in 1936 and 1937, but not in 1938, which was a poor lemming year. Pehrsson (1986) found that peaks in Oldsquaw duckling production in northern Sweden were better correlated with microtine abundance than with weather parameters. Underhill et al. (1993) studied Brant and shorebirds in 1991 and 1992. Spring arrived late in both years, but 1991 was a good nesting year and 1992 was a poor nesting year, corresponding with high lemming densities in 1991 and decreasing lemming densities in 1992.

4.2.2 Nest in association with species that exhibit effective antipredator defences

Pomarine Jaegers are known predators of Steller's Eider eggs (this study), but jaegers are not known to displace females from their nests to prey on eggs. When the nest is unattended (such as during the laying period), jaegers often remove some eggs without destroying the entire nest. Pomarine Jaegers and Snowy and Short-eared owls are aggressive in defence of their nest territories and harass all intruders that are potential predators of their eggs and young. This may cause foxes to avoid the territories of owls and jaegers, or the foxes may be so distracted by the attacks that their effectiveness as predators on Steller's Eider nests is reduced. Thus, species with no antipredator defences of their own may gain protection from foxes by nesting in association with species that exhibit these defences (Table 3). Therefore, nesting in association with Pomarine Jaegers and/or owls may result in greater nest success for Steller's Eiders, even if they lose some eggs to jaegers. Koskimies (1957) argued that such a relationship could become established if young raised in association with a certain species recognized the presence of that species as a critical component of nest site selection.

5.0 Conclusion

Steller's Eiders are long-lived sea ducks that may maximize their individual fitness by foregoing breeding in years when reproductive success may be low and adult mortality high. In years when lemming numbers are low and avian predators do not nest, Steller's Eiders and their nests likely become more vulnerable to fox predation. This study and data from previous studies (Table 1) suggest a relationship between lemming numbers and nesting Steller's Eiders at Barrow. Although we cannot rule out the possible influences of environmental factors and body condition on nest success and periodic nonbreeding, we conclude that abundant lemmings may benefit Steller's Eiders by providing foxes with an easy or preferred prey alternative to Steller's Eider eggs and/or by attracting species that defend their territories from arctic foxes. Although Steller's Eiders probably do not evaluate lemming abundance directly, they may respond to the presence or absence of territorial jaegers and/or owls.

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Philopatry of Harlequin Ducks moulting in southern British Columbia

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Abstract

We captured 26 male and two female moulting Harlequin Ducks *Histrionicus histrionicus* in coastal British Columbia with a modified funnel trap. The trap and wings were attached to aluminum poles supported by shelf brackets and set in a rocky intertidal area at low tide. Two small boats were used to drive birds into the trap at high tide. Sightings of marked birds between August 1986 and August 1989 indicated that males and nonbreeding females shared moulting sites, which were also used during winter, and that birds returned to the same moulting and wintering sites in subsequent years.

Résumé

Nous avons capturé 26 mâles et deux femelles Arlequins plongeurs (*Histrionicus histrionicus*) muant dans la région côtière de la Colombie-Britannique au moyen d'un piège en entonnoir modifié. Le piège et les ailes étaient attachés à des poteaux d'aluminium soutenus par des consoles pour tablettes et placés dans une zone intertidale rocheuse à marée basse. On a utilisé deux petites embarcations pour pousser les oiseaux dans le piège à marée haute. L'observation d'oiseaux marqués entre août 1986 et août 1989 a indiqué que les mâles et les femelles non reproductrices partageaient les mêmes sites de mue, également utilisés pendant l'hiver, et que les oiseaux retournaient au même site de mue et d'hivernage dans les années subséquentes.

1.0 Introduction

Harlequin Ducks *Histrionicus histrionicus* breeding in the Pacific Northwest moult and winter along rocky shorelines and exposed areas from northern California to Alaska (Bellrose 1976; Campbell et al. 1990; Breault and Savard 1991). Breeding males and nonbreeding females begin moult in June and July, whereas breeding females moult from late July to September (Palmer 1976; Robertson et al. 1997). The exact duration of the period for which the birds are flightless is unknown. There is also confusion as to whether Harlequin Ducks moult and winter in the same geographical area (Palmer 1976; Robertson et al., this volume).

We undertook an ancillary banding program to study moulting and wintering of Harlequin Ducks in coastal British

Columbia. Moulting birds were captured with a funnel trap adapted for use on rocky coastal areas. Captured birds were assigned a moulting score (see Ginn and Melville 1983) and weighed. This paper describes the use of moulting and wintering areas by 28 marked individuals.

2.0 Methods

2.1 Capture technique

We used a modified funnel trap (McTaggart-Cowan and Hatter 1952) to capture Harlequin Ducks. The holding unit was made of four separate wooden frames (1.2 × 2.4 m) hooked together. Black nylon netting (4 × 4 cm mesh) was used for the front door and the two side panels, whereas the back panel was made of 1-cm-thick transparent Plexiglas. We used 50-m-long black netting for each of the two lead nets. We attached four 20 × 20 cm shelf brackets with metal clamps to the base of each aluminum pole. The shelf brackets stabilized the poles and provided support to trap and lead nets on rocky shorelines. Additional anchor was obtained by placing rocks on these brackets.

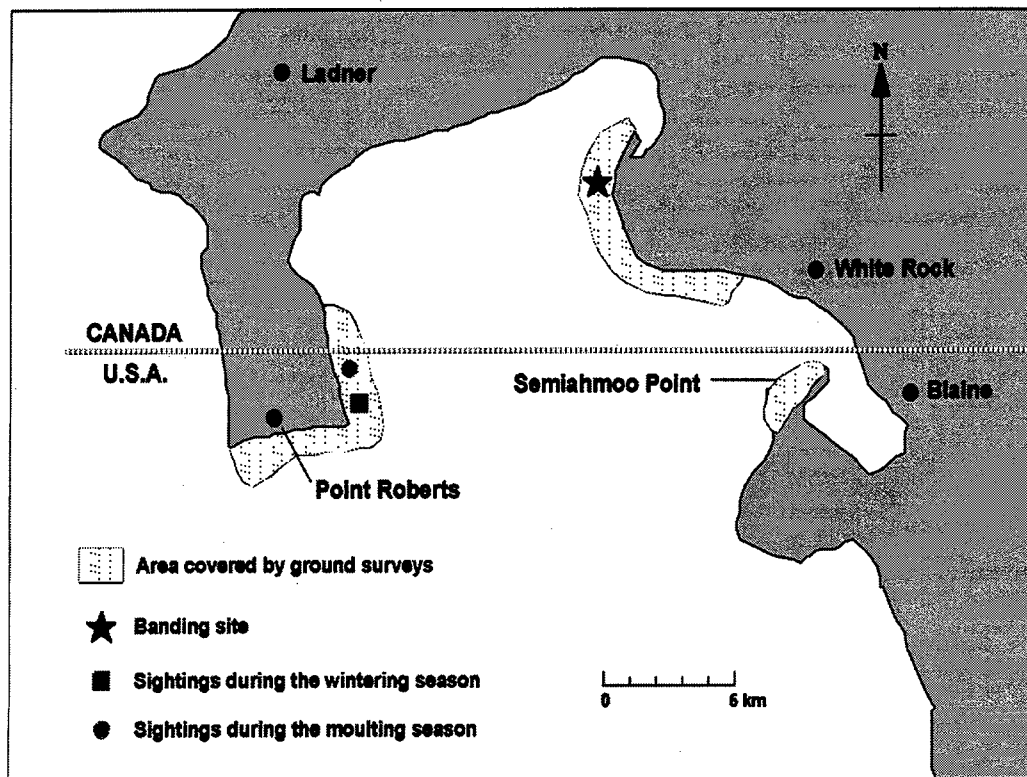
Trap and lead nets were placed in the intertidal area at low tide. Harlequin Ducks were driven into the trap from an inflatable boat and a canoe at low tide on 5 and 6 August 1986 in White Rock, British Columbia (see Fig. 1). Harlequin Ducks were individually marked with plastic nasal discs (Lokemoen and Sharp 1979). Individuals were weighed to the nearest 10 g upon capture with a portable 1000-g Pesola scale. Molt scores (from Ginn and Melville 1983) were assigned to each set of primary and secondary feathers.

2.2 Use of moulting and wintering areas

One of the authors conducted 32 ground surveys between 12 August 1986 and 4 August 1989 in the study area (White Rock, British Columbia, and Point Roberts and Semiahmoo Point, Washington) (Fig. 1) in order to locate marked individuals. Individuals observed at least once between July and September (inclusive) were assumed to be moulting, whereas individuals observed once between October and April (inclusive) were assumed to winter at that particular site. Sightings made during the remaining months (May and June) were assumed to represent birds during the breeding season.

Figure 1

Areas surveyed in the moulting and wintering Harlequin Duck study in British Columbia and Washington, 1986–1989



3.0 Results

3.1 Capture of moulting individuals

In total, 26 males and two females were captured on 5 and 6 August 1986. All individuals were flightless and undergoing wing moult. One female and one male captured on 5 August were recaptured on 6 August. Moulting males were significantly heavier (mean \pm SE: 650 ± 8 g, $n = 26$) than moulting females (535 ± 5 g, $n = 2$) (t-test, $P < 0.01$). Most birds had similar moult scores, indicating that wing moult is synchronized in at least some individuals (see Table 1).

3.2 Philopatry to moulting sites

Most male Harlequin Ducks returned to the same moulting site in consecutive years, although a small number ($n = 2$) returned to an adjacent area to moult in 1987 (Table 2). Neither marked female was sighted during moult after 1986. The two males sighted in 1989 had moulted at the same site for four consecutive years, while five of the seven birds sighted in 1988 had moulted at the same site for three consecutive years. This, coupled with the low survey effort, indicates a strong philopatry to moulting site for some males.

3.3 Moulting and wintering site overlap and philopatry to wintering sites

Twenty-five out of the 28 marked individuals were observed in the study area on or after the first winter following banding (Table 3). The two marked females and 19 out of 23 marked males wintered at the moulting site,

indicating that moulting and wintering sites can be the same (Table 3). A small number of individuals did move to nearby areas ($n = 3$ in 1986–1987, $n = 1$ in 1987–1988, and $n = 1$ in 1988–1989) or outside the study area ($n = 2$ in 1986–1987), indicating that, following moult, some Harlequin Ducks will distribute over a wider area. Five males were resighted at the same wintering site the second winter after banding, indicating a strong philopatry to wintering sites.

3.4 Coastal sightings during the breeding season

In the first summer following banding, 14 marked individuals (13 males and one female) were observed at the banding site during May and June (Table 4). Because the birds were not aged at the time of capture, it is not clear whether those individuals were immature or adult birds, although it is very likely that the female was a nonbreeder. Males spend little time on breeding areas, and the number and timing of the May and June surveys are insufficient to determine the reproductive status of the males observed during this period. However, repeated sightings of some males from May to July suggest that these birds may not have bred in the summer of 1987 (Fig. 2). Departures to breeding areas did not appear to be synchronized, and no overall pattern could be determined from observations of marked individuals. Of nine males for which there are sufficient data, two were last seen on 8 April, one on 25 April, five on 1 May, and one on 27 May.

Table 1
Moult scores of Harlequin Ducks banded on 5–6 August 1986 at White Rock, B.C.

Moult score ^a	Males		Females	
	Primaries	Secondaries	Primaries	Secondaries
0				
1	8	5		
2	15	11	1	1
3	2	9	1	
4	1	1		1
5				

^a Moult scores were assigned as follows: old wing feathers (0), no feathers (1), stages of wing feather regrowth (2–4), and completely regrown (5) (Ginn and Melville 1983).

Table 2
Use of moulting areas by 26 male Harlequin Ducks banded in 1986

Year	Number of surveys	Male seen at same moulting site	Male seen at adjacent moulting site	Total
1987	4	9	2	11
1988	2	7	0	7
1989	1	2	0	2

4.0 Discussion

4.1 Capture technique and banding success

The modified funnel trap was an effective technique to capture moulting Harlequin Ducks in shallow rocky coastal areas. The trap itself was relatively compact and could fit in a single boat, and it could be easily installed on a gently sloping rocky beach. The method could easily be applied to other coastal locations, provided that wave action and tide and currents are low and the site is shallow enough to allow placement of the wings.

The capture technique is also likely to be effective with other species undergoing wing moult, provided they respond positively to being herded by boats. The use of nasal discs allowed easy tracking of marked individuals, and subsequent sightings of those individuals suggest minimum impacts from the discs.

4.2 Moult and philopatry to moulting sites

All captured individuals were in a similar state of moult, indicating some degree of moult synchrony. The lack of differences in moult scores between males and females suggests that captured females could be deferred breeders, subadults, or juveniles, as breeding females moult later than males (Palmer 1976; Robertson et al. 1997). We cannot at this time interpret the moult scores we recorded, as those were assessed only once, during banding.

We observed a high degree of asynchrony in departures by males in spring from the wintering area. This indicated that 1) moulting and wintering males at White Rock originated from several breeding areas, 2) there are extensive differences in physiological condition prior to migration to breeding areas, and/or 3) timing of breeding is asynchronous within a given area. Data on the sex ratio of Harlequin Ducks in the same area in 1981 suggested that most breeding birds had left this wintering site by late May and that some females started to return to the wintering site in late August (Savard 1989).

4.3 Philopatry to wintering areas

In Iceland, individual birds are suspected of moving between wintering areas within the same year (Bengtson 1966). We did not observe this, but rather noticed high philopatry to wintering sites. Male Harlequin Ducks are philopatric to both moulting and wintering grounds, although their wintering range was more extensive in this study.

Table 3
Winter distribution of 26 male and two female marked Harlequin Ducks from 1986 to 1988

Sighting period	Number of surveys	Sex	Wintering location			Total
			Banding site	Nearby site ^a	Away ^b	
October 1986 – April 1987	10	M	19	3	2	23 ^c
		F	2	0	0	2
October 1987 – April 1988	3	M	6	1	0	7
October 1988 – June 1989	1	M	0	1	0	1

^a Might include individuals also observed at the moulting site in the White Rock area.

^b Individuals not observed between October and April in the White Rock area but subsequently observed.

^c Includes one male observed both at the banding site and at a nearby area on different surveys.

Table 4
Sightings of marked Harlequin Ducks in coastal British Columbia in May and June 1987

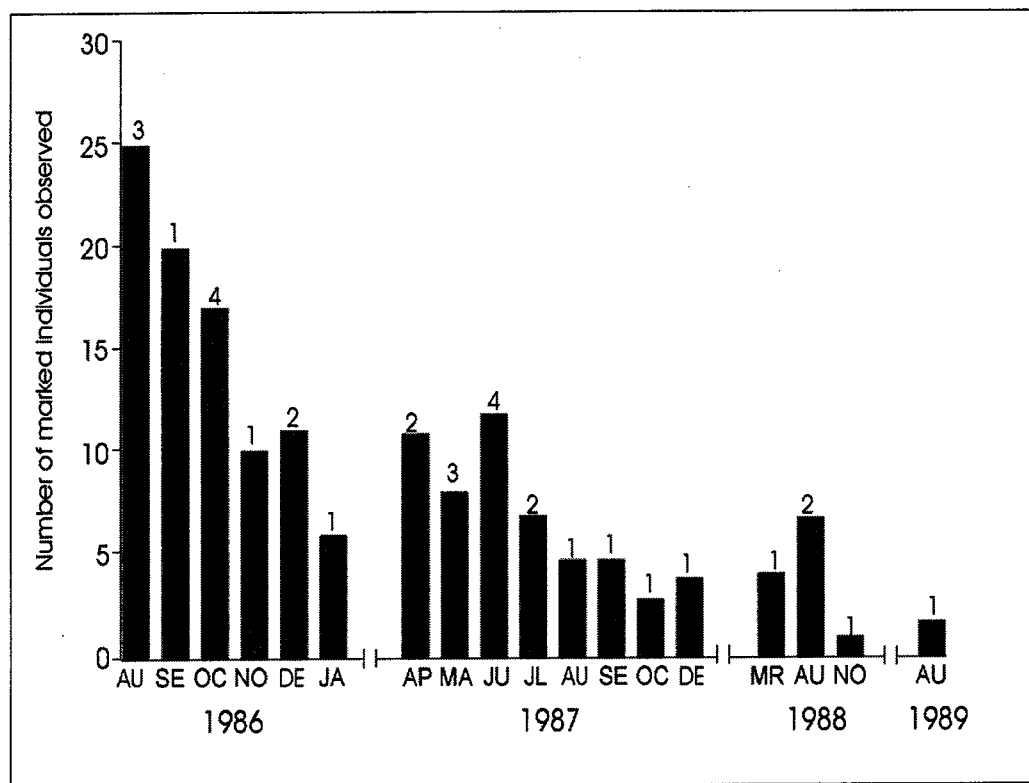
Sighting period	Number of surveys	Sex	Moulting location			Total
			Banding site	Nearby site ^a	Away ^b	
May 1987 – June 1987	7	M	13	0	0	13
		F	1	0	0	1

^a Might include individuals also observed at the moulting site in the White Rock area.

^b Individuals not observed between October and April in the White Rock area but subsequently observed.

Figure 2

Number of Harlequin Duck sightings in the study area from August 1986 to August 1989. Number of surveys is indicated above bars.



4.4 Location of wintering and moulting areas

Following moult, marked males and females remained in or near the moulting area, indicating that, for at least some birds, wintering areas partially overlap with moulting areas. A better understanding of the wintering and moulting ecology of Harlequin Ducks will aid in the management of this species. For example, strong philopatry to wintering sites indicates the need to manage at a sub-population level.

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Within-year fidelity of Harlequin Ducks to a moulting and wintering area

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Abstract

A small population of moulting and wintering Harlequin Ducks *Histrionicus histrionicus* was monitored between July 1994 and May 1995 near White Rock, British Columbia. Seventy-two of these birds were captured during the wing feather moult and banded with unique tarsal bands. Three patterns of habitat use over the nonbreeding season were observed: some individuals spent the entire period (August–May) in the study area; other birds permanently left the area in the fall, soon after the end of the moulting period (before 1 November); and, finally, some birds appeared to leave the study area in the winter (November–February), only to reappear in the spring (after 1 February). Unpaired males were seen at a greater variety of sites than paired males. Before pairing, males were seen at a greater variety of sites than females. Within-season observations of individuals show that individuals use very specific stretches of shoreline.

Résumé

On a observé une petite population d'Arlequins plongeurs (*Histrionicus histrionicus*) muant et hivernant entre juillet 1994 et mai 1995 près de White Rock, en Colombie-Britannique. Soixante-douze de ces oiseaux ont été capturés durant la mue des plumes des ailes et bagués d'une bague tarsienne unique. On a observé trois types d'utilisation de l'habitat au cours de la saison non reproductive : certains individus ont passé toute la période (d'août à mai) dans le secteur étudié; d'autres oiseaux ont définitivement quitté le secteur à l'automne, peu après la fin de la période de mue (avant le 1^{er} novembre); enfin, certains oiseaux ont semblé quitter le secteur étudié pendant l'hiver (de novembre à février), seulement pour réapparaître au printemps (après le 1^{er} février). On a observé des mâles non accouplés dans une plus grande variété de sites que les mâles accouplés. Avant l'accouplement, on a observé les mâles dans une plus grande diversité de sites que les femelles. Des observations d'individus au cours de la même saison montrent que ceux-ci utilisent des endroits très précis de la côte.

1.0 Introduction

Female philopatry to breeding grounds in waterfowl species is high. There is a tendency for female waterfowl to return to the same breeding area year after year and also to return to the area where they hatched for their first breeding effort (Anderson et al. 1992). Male waterfowl do not return to familiar breeding grounds with the same frequency as females, except in the case of males in long-term pair bonds, such as geese and swans.

This pattern of female-biased philopatry is opposite to that of other birds, where male birds exhibit higher rates of breeding and natal philopatry (Greenwood 1980; Greenwood and Harvey 1982). Male birds returning to familiar territories have an advantage over conspecifics (Pärt 1994). Waterfowl are assumed to be an exception to the rule of male-biased philopatry, because males cannot economically defend breeding territories. This inability to defend breeding territories results in males following females to the breeding grounds (Rohwer and Anderson 1988). Higher female mortality in waterfowl (Sargeant and Raveling 1992) results in populations with high proportions of males, thereby making females a limiting resource. Strong selection for males to pair early and retain their mates has led to the evolution of pairing in winter for some waterfowl and/or the maintenance of long-term pair bonds (e.g., geese and swans).

Waterfowl that pair in the fall or winter may not be expected to show the same patterns of sex-biased philopatry to the wintering grounds. In fact, if males can defend territories during the nonbreeding season, as is the case for Barrow's Goldeneye *Bucephala islandica* (Savard 1988), and there are fitness benefits for females in using these defended resources, a system of male-biased philopatry to the area where pairing occurs can evolve. To date, very few studies have looked at philopatry in waterfowl outside of the breeding period, particularly sex differences in winter philopatry (Robertson and Cooke 1999).

In this paper, we begin to examine the possibility that male sea ducks show higher levels of philopatry to their wintering grounds than females. To do so, we look at the within-year site tenacity of Harlequin Ducks *Histrionicus histrionicus* to their moulting and wintering grounds. Specifically, the objectives of this paper are 1) to document

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patterns of moulting and wintering area use by individual Harlequin Ducks, 2) to document within-site and between-site movements of Harlequin Ducks, and 3) to document relationships of movement patterns with the sex and/or pairing status of individual birds.

2.0 Study area

The main study area is a 5-km stretch of rocky shoreline located west of White Rock, British Columbia. This stretch of shore is bordered by a 4-m-high rock dike, along a railway line, which provides continuous access. The high intertidal sections are generally rocky with either cobbles or boulders as the dominant substrate. The lower intertidal sections vary along the shore; some areas are sandy with pebbles, whereas other sections are covered with cobbles, similar to the high intertidal. Large boulders, some of which are always exposed, are scattered about the shoreline. At the outer limits of this stretch of shore, the habitat becomes muddy and/or sandy. Harlequin Ducks have not been found locally with any regularity outside the main study site. Potential prey items present at the study site include green *Hemigrapsus oregonensis* and purple *H. nudus* shore crabs, hermit crabs (*Pagurus* spp.), isopods (*Idotea* spp.), periwinkles (*Littorina* spp.), and limpets (*Collisella* spp. and *Notoacmaea* spp.). Immature buffalo sculpins *Enophrys bison* are consumed in the fall season (B. Gowans, pers. commun.) and Atlantic herring *Clupea harengus* roe in the spring. Vermeer (1983) and Gaines and Fitzner (1987) provide further details of Harlequin Duck diets in the Pacific Northwest.

White Rock experiences warm dry summers and mild wet winters. Temperatures below 0°C can occur for short periods in the winter, but ice does not form at the study site. The maximum tidal amplitude is 6 m, resulting in an average exposure of 50 m of intertidal habitat at the lowest tides.

3.0 Methods

3.1 Capture of moulting Harlequin Ducks

Harlequin Ducks were captured using a drive trap erected along the shoreline. Moulting birds were corralled into the trap by 3–5 people in sea kayaks (see Clarkson and Goudie 1994 for details). In the first drive on 26 July 1994, 39 males and four females were captured. Two of the males captured had been previously banded at White Rock in 1986 (Breault and Savard, this volume). The second drive on 6 September 1994 netted 25 new females, four new males, and two males captured in the first drive. Birds were sexed by plumage. Age was determined by measuring the depth of the bursa of Fabricius using a blunt probe. The bursa of Fabricius is a small blind sac, posterior to the urogenital opening, and can be examined during standard cloacal examination (Peterson and Ellarson 1978). The bursa recedes during maturation and is absent in adult individuals (Petersen 1980). Birds were identified as second-year birds if the probe could be inserted over 20 mm. Birds with bursa depths of 5–10 mm were considered third-year birds. Birds with no bursa opening were considered adults (see also Petersen 1980). All birds were banded with standard U.S. Fish and Wildlife Service aluminum bands on one leg and a plastic

tarsal band bearing two unique alphanumeric characters on the other.

3.2 Survey data collection

Harlequin Ducks at White Rock were monitored for the entire nonbreeding season until the departure of the birds to the breeding grounds in spring. Data were collected by an observer with a pair of binoculars and a 15–60× zoom telescope walking along the entire shoreline. The observer recorded the time, the tidal stage, and the weather at the beginning and end of each survey. Observations of Harlequin Ducks were segregated by sex (and age for males in hatch year or after hatch year plumage; see Palmer 1976 for a description of these plumages) and whether the bird was paired. The banding status of the birds was recorded as 1) legs not seen (bird never left the water), 2) unbanded, 3) banded but not able to read band, and 4) banded with code read. The location of the bird(s) was recorded to the nearest tenth of a mile (160 m), using the mile markers already in place on the railroad tracks.

At least one survey per week was attempted. During poor weather conditions, especially windy days, birds did not haul out of the water, so band reading was not possible. Therefore, surveys were opportunistically done on fair-weather days. A minimum of three and up to nine surveys were done each month.

3.3 Estimating the number of banded and unbanded birds present

As the banding status of all birds could not be directly observed, the proportion of banded birds present in the study area each month was modelled using a generalized linear model of a binomial distribution. Maximum likelihood estimates of the proportion of banded birds present in each month were obtained from PROC GENMOD using a binary distribution and a logit link function (SAS Institute Inc. 1993). Model fit was assessed from the significance of the model deviance; insignificant values reflect good model fit. The importance of explanatory variables was assessed by log-likelihood ratio testing; a significant log-likelihood ratio test indicates that the variable explains a significant portion of the variation in the data. The parameter estimates and 95% confidence interval for each month were back-transformed from a logit transform to obtain the proportion of banded birds present in each month. The absolute number of banded birds present in a month was obtained by multiplying this proportion by the mean number of birds sighted that month.

3.4 Identifying resident and transient birds

If an individual bird is not seen in the study area for a period of time, it could be because the bird has left the study area (or died) or the bird is present but not seen. Therefore, we calculated monthly probabilities of missing individually banded birds. The resight probability for each survey was estimated by dividing the number of birds whose legs were seen (the potential for an identification) over the total number of birds present during the survey. For example, if three birds could have potentially had their bands read and the legs could not be seen for seven birds, 70% of all banded

Table 1

Probabilities of missing a particular individually marked bird that is actually present in each month over the study period for each sex. These probabilities are based on the number of birds that could be identified at each survey and the total number of birds present.

Month	Number of surveys	Females	Males
August	9	0.034	0.004
September	8	0.009	0.003
October	7	0.004	0.038
November	4	0.316	0.359
December	3	0.743	0.745
January	7	0.318	0.400
February	5	0.604	0.572
March	7	0.043	0.071
April	9	0.001	0.001
May (until 16th)	9	0.003	0.012

birds present would have been missed (see Robertson et al. 1997 for further details). Monthly probabilities of missing a particular individually banded bird are a product of the values for each survey (Table 1). A cumulative probability for missing individuals over the winter is the product of the monthly probabilities for November through February. This method assumes that there is no difference in the probability of any particular individual bird hauling out. This value corresponds to 0.045 for females and 0.061 for males. Therefore, 95.5% of females and 93.9% of males present over the winter should have been resighted. Birds not sighted in any of these four months are considered to have left the study area for at least a part of this period, with 95.5% and 93.9% confidence, respectively. As a result of good weather conditions, the probabilities of missing birds in March and April were very low, and birds not seen in these two months were considered to be absent from the study area, with over 99.9% confidence. Individuals were classed into three categories: birds present throughout the entire study, birds present in fall and again in the spring, and birds that permanently left in the fall.

3.5 Assessing within-site movement patterns

As the study site is linear (5 km of shoreline), the variance in the location of the sightings of individuals was used as an index of relative amount of movement. Individuals seen at a greater variety of sites would have a higher variance. The variance calculated for each individual was used in comparisons between sexes and between paired and unpaired birds. A randomization approach (Manly 1997) was used to test whether individuals were using only specific sections of shore. We used the distribution of sightings of all marked birds over the winter as the null distribution (Fig. 1). To test whether an individual was using the habitat randomly, the variance in location calculated for each bird was compared with a distribution of pseudo-variances calculated from 1000 random samples from the sex-specific baseline distribution (Fig. 1). If the variance calculated for the individual was in the bottom 5% (one-tailed test) of observations of this distribution, then it was assumed that the individual was significantly underutilizing the available habitat and was showing site tenacity within the habitat.

4.0 Results

4.1 Population size and structure over the nonbreeding season

4.1.1 Males

The number of males present at the study site fluctuated around 40 birds for most of the winter (Fig. 2). There was a noticeable decline in the number of males present in late September, down to 30 birds; by October, however, the number of males returned to between 40 and 50 birds. A decline in the number of males is apparent from the middle of March onwards; however, large numbers of males appeared at the study site on some days in April (Fig. 2).

4.1.2 Females

Females began returning from the breeding grounds in August through September (Fig. 2). A departure of females occurred in late October. Afterwards, a slow increase in the number of females occurred until February. The number of females consistently declined after February, until the last birds were seen in late May (Fig. 2).

4.1.3 Both sexes

A fifth-order polynomial regression was fitted to the population counts of males and females. A fifth-order polynomial was used, as all terms of lower orders were significant, whereas the sixth-order term did not explain a significant amount of variation (Fig. 2). The model fit for females ($R^2 = 0.826$, $n = 68$) was significantly higher than for males ($R^2 = 0.392$, $n = 63$) ($Z = 5.58$, $P = 0.0001$), showing that male population numbers varied more than female numbers.

4.1.4 Banded and unbanded birds

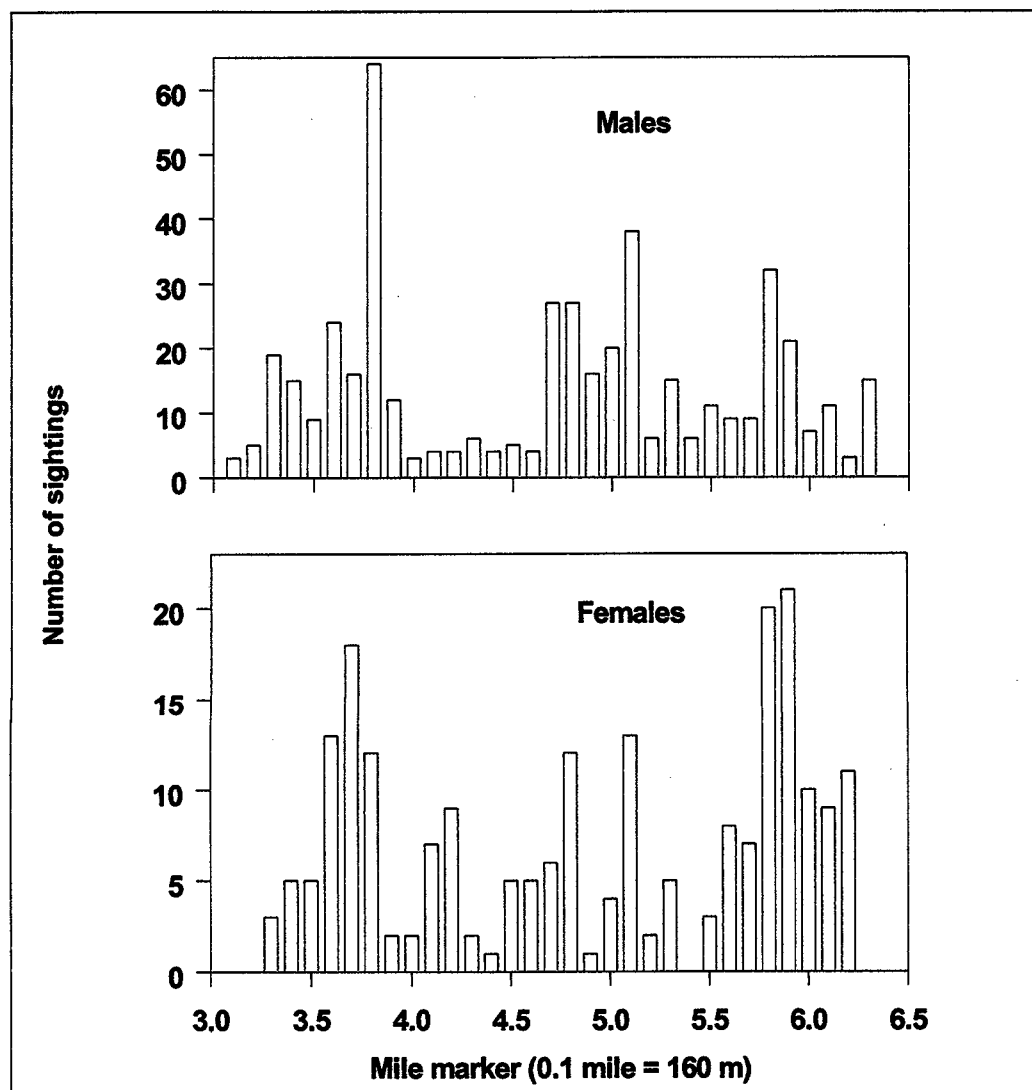
Figure 3 shows the estimated number of banded and unbanded birds in the study area. Numbers of banded males fluctuated over the season. The number of unbanded males present in the study area increased sharply through September and October; afterwards, it remained stable until the decline in the spring. A departure of both unbanded and banded females appeared to occur in the fall. An arrival of unbanded females occurred in December. The estimated number of banded males in December is very high but represents a biased sample from only three surveys, on one of which seven banded males were seen and no unbanded males. The month in which a survey was conducted explained a significant proportion of the variation in the ratio of banded to unbanded birds in males ($\chi^2 = 125.5$, $df = 9$, $P = 0.0001$) and females ($\chi^2 = 37.0$, $df = 8$, $P = 0.0001$). The model including month as the explanatory variable to explain the proportion of banded birds in the population fit the data well for females ($\chi^2 = 47.3$, $df = 40$, $P = 0.198$); the fit for males was poor ($\chi^2 = 82.8$, $df = 50$, $P = 0.0024$), suggesting that other factors exist to explain the variation in the proportion of banded males present at the study site.

4.2 Residency patterns of individuals

Individually marked birds exhibited three general patterns of habitat use: some birds left after the moult, not to be seen again; other birds were seen consistently throughout

Figure 1

Number of individually marked Harlequin Ducks identified at each location from August 1994 to May 1995 at the study area near White Rock, B.C.



the fall, winter, and spring; and, finally, some birds were not seen over the winter, but were seen again in the spring. Table 2 presents the numbers of birds, of each sex, exhibiting each habitat use pattern. There is a significant difference between the sexes in their habitat use patterns ($G = 6.1$, $df = 2$, $P = 0.047$). A higher proportion of females remained at the study site after they moulted, although the number of birds wintering at the study site after they moulted was less than half for both sexes. Of the birds that left the study site in fall, a higher proportion of males returned in the spring (Table 2).

4.3 Within-site movements

Unpaired males were seen at a greater variety of sites than paired males once pair formation was under way (by 1 November) (Robertson et al. 1998) ($U = 179$, $n = 9$, 20 , $P = 0.0004$). Before pairing, males were seen at a greater variety of sites than females ($U = 357$, $n = 28$, 20 , $P = 0.005$).

Using the randomization approach described above, 20 of 25 (80%) females and 32 of 42 (76%) males

significantly underutilized the available habitat. Therefore, individual birds used specific areas of the shoreline for the entire winter. For example, a female that was seen 22 times over the winter was never seen outside a 1100-m stretch of the 5 km of available shoreline, and 18 of the 22 sightings were within a 320-m section of the shoreline.

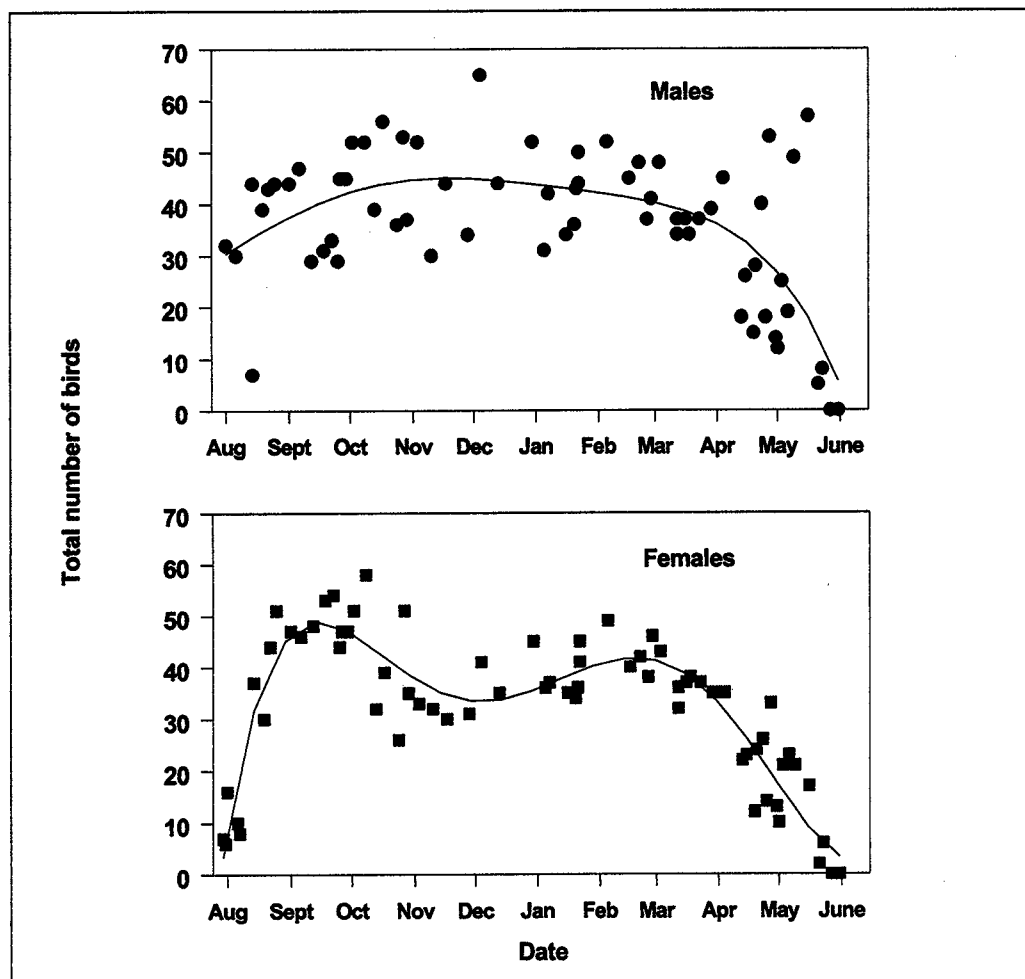
5.0 Discussion

5.1 Population structure, turnover, and residency patterns

The number of males present at the White Rock study site showed considerably more variation from one survey to the next than did the number of females. Males may be more mobile within the nonbreeding season, on a day-to-day basis, whereas females may spend more time at an area once they arrive there. Counts of males on any particular day may represent only a portion of the males using the habitat. Observations that males are seen at a greater variety of sites within the study area also suggest that males are more

Figure 2

Number of males and females observed at each survey near White Rock, B.C., from August 1994 to June 1995



mobile. There are two likely places to which the males may go when not present at White Rock. There are other suitable sections of shoreline habitat within 50 km of the study site. A few banded Harlequin Duck individuals have been observed at these sites (Breault and Savard, this volume; G.J. Robertson, unpubl. data). Additionally, males may also spend time out on the open water, out of sight from shore. Recent observations of radio-marked male Harlequin Ducks have shown that they do, on occasion, move offshore to roost and feed (W.S. Boyd, unpubl. data). During April, large numbers of males were periodically seen at White Rock, whereas the numbers of females seen during this period steadily declined as birds left for the breeding grounds. This population of males was composed of unpaired adult and young males. Presumably, this was a population of bachelor males, possibly looking for potential mates or prospecting for a potential moulting/winter site for next season.

Departure of birds from the moulting site probably reflects dispersion to the winter quarters. Therefore, a link between the moulting and wintering site exists for some, but not all, birds (Breault and Savard, this volume). All combinations of moulting and wintering habitat use were exhibited by Harlequin Ducks at the study site. More than half of the birds remained for the entire nonbreeding period. Other birds, especially males, used the area as something similar to a

migrational stopover site, spending the fall and spring, but not the winter. Other birds used the area only as a moulting site. Based on the influx of unbanded birds, a certain segment of the population used the study area as a wintering site but did not moult there. Finally, some males appeared to briefly stop over at the study area during the spring. Green-winged Teal *Anas crecca* wintering on the southern high plains of Texas showed a somewhat similar pattern of winter habitat use (Baldassarre et al. 1988). Birds captured after December had a higher chance of being resighted than those banded earlier. Presumably, the only birds in the area in December were those spending the entire winter.

5.2 Winter territories and mating systems

Males may be more mobile than females and explore local areas to look for concentrations of females and/or to assess the quality of other males. Regardless of the reasons, the fact that males do move around considerably before pairing suggests that they do not form a winter territory. Observations on the breeding grounds show that male Harlequin Ducks vigorously defend their mates, but not territories (Inglis et al. 1989). The observation that unpaired males move around more at the end of the season, presumably looking for females, also strongly suggests that males

Figure 3

Estimated number of banded and unbanded males and females present at White Rock, B.C., from August 1994 to May 1995. Point estimates and 95% confidence intervals were based on back-transformed binomial logit parameter estimates from a model with month as a nominal dependent term. See Table 1 for sample sizes.

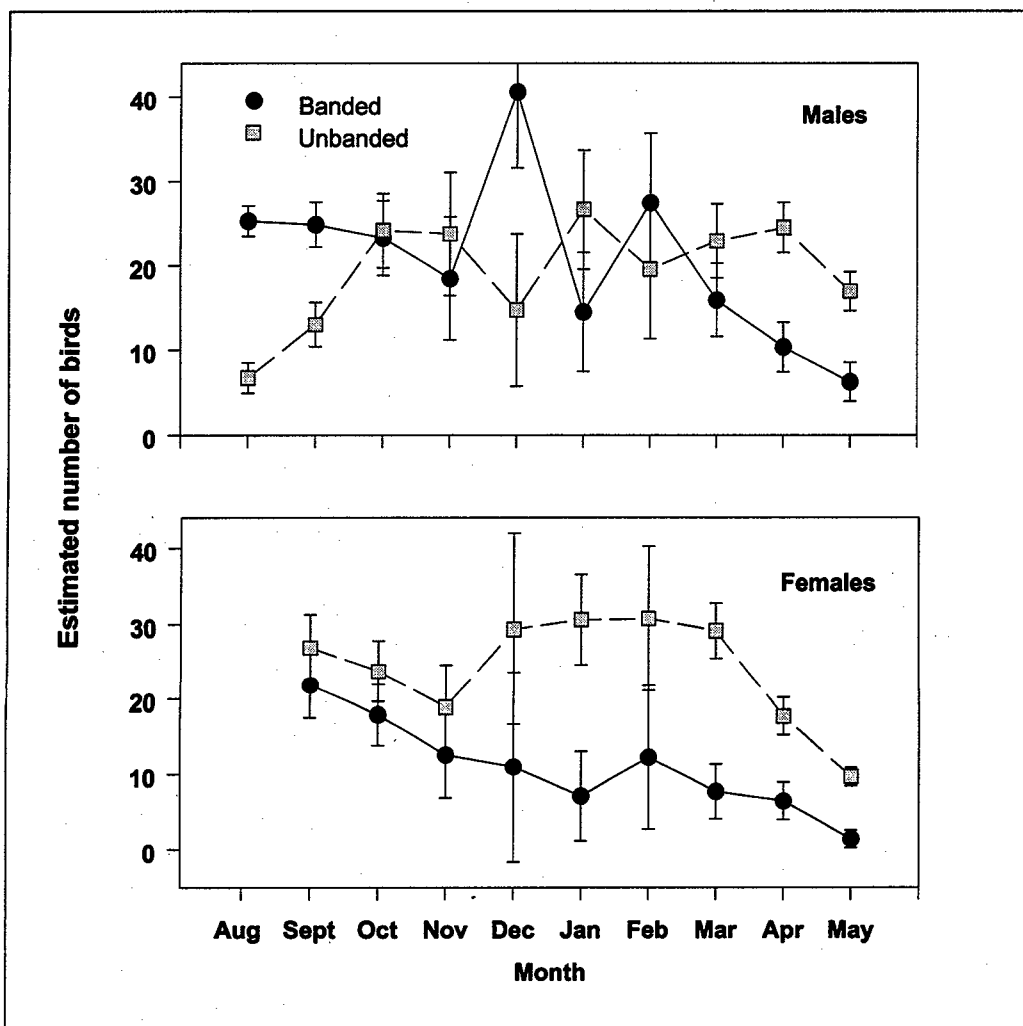


Table 2

Patterns of winter habitat use by the 72 marked Harlequin Ducks over the 1994–1995 winter season at White Rock, B.C. Actual numbers and percentages are presented.

	Winter resident	Leave in fall, return in spring	Depart in fall
Males	15 (35%)	15 (35%)	13 (30%)
Females	13 (45%)	3 (10%)	13 (45%)

are not establishing territories to attract mates; rather, a scramble type of mating system exists, where males search for less abundant females (Emlen and Oring 1977).

5.3 Within-site fidelity

Individual birds, even within a relatively small area (5 km of linear habitat), show strong site tenacity. This observation strongly suggests that local knowledge of an area is valuable and may help ensure high survival of individuals remaining in a familiar site. Potential benefits of local knowledge of an area may include 1) location of high-quality or

abundant food sources, 2) location of predator refugia, 3) knowledge of local predators and their movements, and/or 4) knowledge about neighbouring conspecifics. Rocky coastal habitats are very stable, with little change, or at least predictable changes, in food abundance and habitat structure between and within years. Philopatry to these stable habitats would be favoured once a good-quality site was found. Of all waterfowl, those species whose populations are highly sensitive to adult mortality and use stable habitats would be expected to have higher philopatry rates than short-lived species using more ephemeral habitats.

6.0 Conclusions

Harlequin Ducks use coastal habitats in a variety of ways and for different purposes. Although general censuses of ducks at the study site showed relatively constant population sizes, observations on individually marked birds revealed considerable population turnover. To adequately assess the importance of any given patch of habitat to Harlequin Ducks, the habitat must be monitored throughout the entire nonbreeding season. As adult survival has the greatest impact on the population dynamics of Harlequin

Ducks (Goudie et al. 1994), care must be taken to protect nonbreeding habitats and ensure high annual adult survival.

Individual Harlequin Ducks show strong site tenacity, even within a relatively small study area; hence, conservation must be applied at the local level. The mating system of Harlequin Ducks appears based on scramble competition and mate defence. This allows the less abundant females to remain in preferred locations, and unpaired males must disperse to search for available females. Once males are successful in establishing a pair bond, they remain with the females in traditional locations.

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Foraging strategies and habitat use of sea ducks breeding in northeast Russia

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Abstract

Twelve species of sea ducks occur in northeast Asia. This paper examines habitat relationships and foraging strategies used by both diving and sea duck species. Greater Scaup *Aythya marila* are seen in a greater number of habitats than Tufted Ducks *A. fuligula*; however, the foraging strategies and diet of these two diving ducks are similar when they are found in the same habitat. King *Somateria spectabilis* and Spectacled *S. fischeri* eiders share similar diet and habitats; however, King Eiders tend to be more restricted to coastal areas. King and Spectacled eiders and Harlequin Ducks *Histrionicus histrionicus* use more foraging techniques than other sea ducks, to take advantage of food sources in shallow water. White-winged Scoters *Melanitta fusca* tend to have a restricted distribution, whereas Black Scoters *M. nigra* are spread out widely across their range. Both have similar feeding habits, consuming highly concentrated prey items. Oldsquaw *Clangula hyemalis*, Common Goldeneye *Bucephala clangula*, Smew *Mergellus albellus*, and mergansers (Common *Mergus merganser* and Red-breasted *M. serrator*) all capture prey in the water column. Species that are more active hunters (mergansers) spend more time searching for their prey. Overall, the distribution of sea ducks seems to be closely tied to their specific foraging abilities.

Résumé

On compte douze espèces de canards de mer dans le nord-est de l'Asie. Le présent document étudie les relations entre les habitats et les stratégies alimentaires appliquées par les canards plongeurs et les canards de mer. Les Fuligules milouinans (*Aythya marila*) sont observés dans un plus grand nombre d'habitats que les Fuligules morillons (*A. fuligula*); toutefois, les stratégies alimentaires et le régime alimentaire de ces deux canards plongeurs sont semblables quand ils occupent le même habitat. L'Eider à tête grise (*Somateria spectabilis*) et l'Eider à lunettes (*S. fischeri*) partagent un régime alimentaire et des habitats semblables. Toutefois, l'Eider à tête grise a tendance à rester davantage dans les zones côtières. L'Eider à tête grise, l'Eider à lunettes et l'Arlequin plongeur (*Histrionicus histrionicus*) ont recours à plus de techniques d'alimentation que les autres canards de mer afin de profiter des sources d'aliments des eaux peu profondes. Les Macreuses à ailes blanches (*Melanitta fusca*)

ont tendance à avoir une répartition limitée, tandis que les Macreuses noires (*M. nigra*) se répartissent largement sur l'étendue de leur territoire. Les deux présentent des habitudes alimentaires semblables, consommant des proies se trouvant réunies dans de grandes concentrations. L'Harelde kakawi (*Clangula hyemalis*), le Garrot à œil d'or (*Bucephala clangula*), le Harle piette (*Mergellus albellus*) et les harles (Grand Harle [*Mergus merganser*] et le Harle huppé [*M. serrator*]) capturent tous leurs proies dans la tranche d'eau. Les espèces qui chassent plus activement (harles) passent davantage de temps à chercher des proies. Dans l'ensemble, la distribution des canards de mer semble plus étroitement liée à leurs habiletés alimentaires spécifiques.

1.0 Introduction

Of the 29 species of Anseriformes breeding north of 60° latitude in northeast Asia, 12 are sea ducks (Dement'ev and Gladkov 1952). Of these 12 species, distributed among eight genera, up to nine can occur in any given local fauna (Kistchinski 1973) (potentially 40–45% of all Anseriformes). This species richness is the highest for sea ducks in the Palearctic, but lower than that for sea ducks in North America (Palmer 1976).

Sea ducks (Mergini) are distributed unevenly in northeast Asia. In eoactic tundra landscapes (coastal plains), only two species — King Eider *Somateria spectabilis* and Oldsquaw *Clangula hyemalis* — are typical residents. The coastal Common Eider *S. mollissima* and riverine-coastal Spectacled Eider *S. fischeri* are found only along the coast and in estuaries of large rivers. Steller's Eiders *Polysticta stelleri* are also known to breed on large river deltas; otherwise, they are very rare or accidental in other parts of eoactic tundra landscapes. Hypoactic landscapes (non-coastal plains) have even less species diversity, sea ducks being represented only by Oldsquaw (hemiarctic species) and Black Scoter *Melanitta nigra americana*. The latter is a typical hypoactic species in distribution (Kistchinski 1988). The White-winged Scoter *M. fusca* is also hypoactic in its geographical range (Kistchinski 1988). However, it is distributed in a more complicated way, with no clear connection with low-bush tundra; rather, it is associated with certain types of lakes within this zone (Kistchinski 1980; Krechmar et al. 1991).

The highest species diversity occurs within forested riparian habitats. Common Goldeneye *Bucephala clangula*

and Smew *Mergellus albellus* are associated with boreal lakes, whereas Common Mergansers *Mergus merganser* exploit riverine habitats in the forest zone. All three species are obligate cavity nesters. This distinguishes them from the other riverine specialists, Harlequin Ducks *Histrionicus histrionicus* and Red-breasted Mergansers *Mergus serrator*, which occur mainly in treeless mountain landscapes with turbulent rivers, common along the Bering Sea and Okhotsk Sea coasts. Harlequin Ducks and Red-breasted Mergansers may be considered true riverine species (Kistchinski 1988).

The highest diversity of sea ducks occurs in areas of forested mountain rivers interspersed with coastal maritime tundra and hypoarctic low-bush tundra. This habitat is common along the north coast of the Okhotsk Sea, where nine species of sea ducks occur. The lowest species diversity is in areas of low-arctic tundra, such as northern Kolyma, where Oldsquaw and King, Spectacled, and occasionally Steller's eiders breed (Krechmar et al. 1991). Low diversity is also observed in areas of hypoarctic high-bush tundra and boreal lakes, where only Common Goldeneye, Smew, and Black Scoter breed regularly. These landscapes are present on the vast plains in Middle Kolyma and along the north coast of the Okhotsk Sea (Krechmar et al. 1978). Overall, in terms of generic diversity, on average three and at most seven genera occur together.

Within the sea duck tribe, three genera are represented by more than one species. *Somateria* are generally distributed along arctic coastal habitats, *Melanitta* species are found in hypoarctic areas, and *Mergus* are riverine in their distribution. The range overlap of congeners quite often takes place in areas of low overall species diversity of sea ducks. For example, in areas of sympatry of eiders and mergansers, the overall diversity is rather low (four species). Areas of sympatry between congeneric species include most of their breeding range. Patterns of life history strategies in areas of sympatry may show us the mechanisms that influence the patterns of geographical distribution of species within, and among, genera.

The foraging behaviour of guilds of ducks may be inspected from different perspectives. In contrast to the variable foraging strategies and feeding behaviour of dabbling ducks (Pöysä 1983, 1987; Dubowy 1988; Monda and Ratti 1988), the single main foraging technique of diving ducks is diving. In this paper, I analyze resource distribution and utilization patterns in areas of sympatry between congeneric diving ducks (*Aythya* spp.) to investigate niche overlap (Sugden 1973; Siegfried 1976).

Knowledge of the diet of sea ducks ranges from poor (e.g., Steller's Eider and Black Scoter) to very good (Common Eider and Common Goldeneye) (Eriksson 1978, 1979; Bustnes and Erikstad 1988). The overall picture is not yet known (Eriksson 1976; Pehrsson 1976), and I do not feel that diet can be used effectively to evaluate habitat use overlap.

It is necessary to analyze and compare foraging behaviour more precisely, and the approach presented here is based on the assumption that resource utilization patterns reflect the foraging strategies in some species-specific way. Further, I supplement the data with direct observations of foraging techniques used by the adults and ducklings of a variety of species. Thus, the data collected and described in recent papers (Kondratyev 1989; Kondratyev and Zadorina 1992) have been reexamined with the purpose of selecting

specific features of prey abundance and distribution that are important in determining habitat selection of diving and sea ducks.

2.0 Methods

Comparative analyses were undertaken from 1983 to 1995 in different areas of northeast Asia, where sympatric pairs of congeneric species were common enough to ensure adequate sample sizes. Data to analyze the relationship of King and Spectacled eiders were collected at Chaun Bay. The hypoarctic forest-tundra landscape of Middle Anadyr was used to compare Tufted Duck *Aythya fuligula* and Greater Scaup *A. marila* as well as Black and White-winged scoters. Data were collected in many riverine landscapes to compare Red-breasted and Common mergansers, as well as monogeneric Oldsquaw, Harlequin Duck, Common Goldeneye (monogeneric in the Palearctic), and Smew.

I collected data on 1) length of feeding bouts, 2) diving duration, 3) diving intensity, and 4) swimming speed during feeding for a number of species at a variety of sites. Simultaneous diving is a feature that might be considered in an analysis of group foraging, but I have not included it here. To ascertain prey species taken by ducks, I used the analysis of invertebrate fauna in selected habitats and some esophageal contents taken occasionally from ducks in the lakes with known fauna, in addition to what is known from the literature.

3.0 Results

3.1 Description and timing of events in the study area

The foraging habits of all diving duck species in freshwater habitat of tundra and forest-tundra lacustrine landscapes share a number of common features connected with their feeding on invertebrates. The most numerous invertebrates in spring (May–June, i.e., pre-laying to incubation stage) are chironomids and Trichoptera larvae. The former are abundant everywhere, whereas the latter are numerous only in some places. The mass emergence of adult chironomids usually takes place by the end of June. After that, when ducklings hatch and broods appear, crustaceans become more abundant and an important food source for ducks. The most common crustaceans in tundra landscapes are from the following families: Notostraca, Cladocera, Conchostraca, Phyllopoda, Isopoda, and Amphipoda. As a result, these groups are the most common prey types consumed by ducks in July–August. Some of them are more numerous in July and rare in August (fairy shrimps), whereas others (i.e., *Lepidurus*) reach their highest biomass by August or later. Insects and molluscs are not as important in this summer period, with some particular exceptions, such as water boatmen (Corixidae), which are common in riparian habitats by the end of summer, trichopteran larvae and molluscs, which are heavily used by *Aythya* in riparian habitats, and simuliid larvae, which are consumed by Harlequin Ducks in riverine habitats (Bengtson 1972). These prey items have different patterns in distribution between and within the lakes, leading to specific patterns of distribution of sea ducks.

Specific behavioural and morphological adaptations are needed to specialize to these different prey types, so we

may expect that different species of sea ducks select habitats and prey types according to some specific features of their foraging behaviour. In this case, it is not important whether summer or winter feeding conditions had led to the development of their species-specific foraging strategies.

3.2 Comparisons among species

3.2.1 *Greater Scaup and Tufted Duck*

In the breeding season, these two species forage in freshwater lakes. The Greater Scaup's range extends farther north and east than that of the Tufted Duck; if both are present in an area, scaup are more abundant and are seen in a greater variety of habitats (Fig. 1). The distribution of Tufted Ducks is restricted primarily to lakes of later succession stages in riparian habitats. Foraging techniques and diving parameters are very similar (Table 1), and large differences in diet were not apparent when both species were compared in riparian habitats (Fig. 1).

3.2.2 *King and Spectacled eiders*

During the pre-nesting period, both species of eiders forage on shallow lakes of coastal marshes and spring-flooded wet moss areas on tundra plains. They occupy similar habitats, have similar feeding methods, and consume similar prey species; however, the distribution of King Eiders in Chaun Bay appeared to be more restricted to the narrow coastal zone (Fig. 2). Feeding methods for eiders and Harlequin Ducks include upending and head-and-neck submerging, common among dabbling ducks; their feeding methods are thus more varied than those of other diving ducks (see also Goudie, this volume). After hatching, both eider species use similar types of habitats, although King Eiders are largely restricted to small thermokarst lakes of early succession stages. Spectacled Eiders use a wider range of habitats, whereas their feeding methods are similar (Table 1). The diet of both species was similar when they used the same habitats, but the total feeding spectrum of Spectacled Eider is wider (Fig. 3), probably because of the greater diversity of selected habitats.

3.2.3 *Harlequin Duck*

Harlequin Ducks are well adapted to strong turbulent waters of mountain streams and sea surf. They demonstrate a tendency to feed on localized, concentrated patches of food. My fragmented observations during different periods of their life cycle indicated that they prefer dense patches of food in areas of calm water scattered among currents (stream or surf) — similar to eiders, which also prefer benthic patches along the water edge or on shoals.

3.2.4 *Black and White-winged scoters*

Both species of scoters have been examined in an area of sympatry at Middle Anadyr. High-bush riparian habitats with deep lakes (formed by old river branches segregated and developed by thermokarst) were the only habitats in this area used by the White-winged Scoter. Other habitats used in northeast Asia are deep lakes in mountains and highlands (Kistchinski 1980) and boreal lakes of forest tundra in Yakutia (Krechmar et al. 1978). The scarcity of these habitats results in White-winged Scoters being rare or

uncommon in the region. In contrast, Black Scoter is a rather common species everywhere in low-bush and high-bush tundra, both in riparian habitats and on plateaus (Fig. 4). The feeding methods of both species are, nevertheless, very similar (Table 1). The consumption of benthic invertebrates with high available biomass (Brown and Fredrickson 1986), concentrated in dense patches at great depth, demands little searching once the food patch is discovered, but requires long dive times at certain localities. This method is effective only where high concentrations of food are present in certain types of lakes; thus, broods aggregate at such lakes. The diet consists mainly of benthic animals (Fig. 4) and may explain the late breeding of scoters, which seems to be tied to the late appearance of high concentrations of benthic invertebrates (especially *Lepidurus*).

3.2.5 *Oldsquaw*

Throughout the summer, Oldsquaw use their habitat extensively, constantly moving and intensively diving (Table 1), while foraging on sparsely distributed prey from the water column (Fig. 5). The close ties of Oldsquaw to fairy shrimps (Alison 1976; Pehrsson 1976; Kondratyev 1989) may explain the early breeding of this species.

3.2.6 *Common Goldeneye*

The foraging strategy of Common Goldeneyes is similar to that of Oldsquaw, but some features, especially searching behaviour, are more similar to those of Smew and mergansers. The searching behaviour of goldeneye ducklings, first shown by Eriksson (1976) as an adaptation for catching the moving insects from the water column, is also exhibited by Smew and merganser ducklings. Common Goldeneyes, as well as Oldsquaw, Smew, and mergansers, may be distinguished from scaup, eiders, scoters, and Harlequin Ducks by their ability to catch prey in the water column. However, the general pattern of habitat use during feeding bouts resembles that of Oldsquaw (Table 1). Diving duration and intensity are similar to those of the Oldsquaw, as is the characteristic of low brood cohesion, as ducklings spread over the entire lake during feeding (Table 1).

3.2.7 *Smew and Red-breasted and Common mergansers*

The foraging strategy of Smew and mergansers is adapted to active hunting of moving prey in the water column. Their constant rapid movements along the water edge while actively searching for food (Anderson and Michael 1974; Sjöberg 1985, 1988; Wood and Hand 1985a, 1985b) distinguish them from all other species of the tribe (Table 1). Searching behaviour was least extensive in Common Goldeneyes and most extensive in Common Merganser (Table 1, Fig. 6) and was correlated with the increasing average prey size from Common Goldeneyes to mergansers.

4.0 Discussion

Foraging strategies of sea ducks can be mapped onto their phylogenetic tree (Livezey 1986) and may be considered in terms of consecutive steps. Sea duck foraging strategies are oriented to the resources they consume, the simplest pattern being shown by eiders and Harlequin Ducks, which

Figure 1
Diet and habitat use of Greater Scaup and Tufted Duck at Middle Anadyr

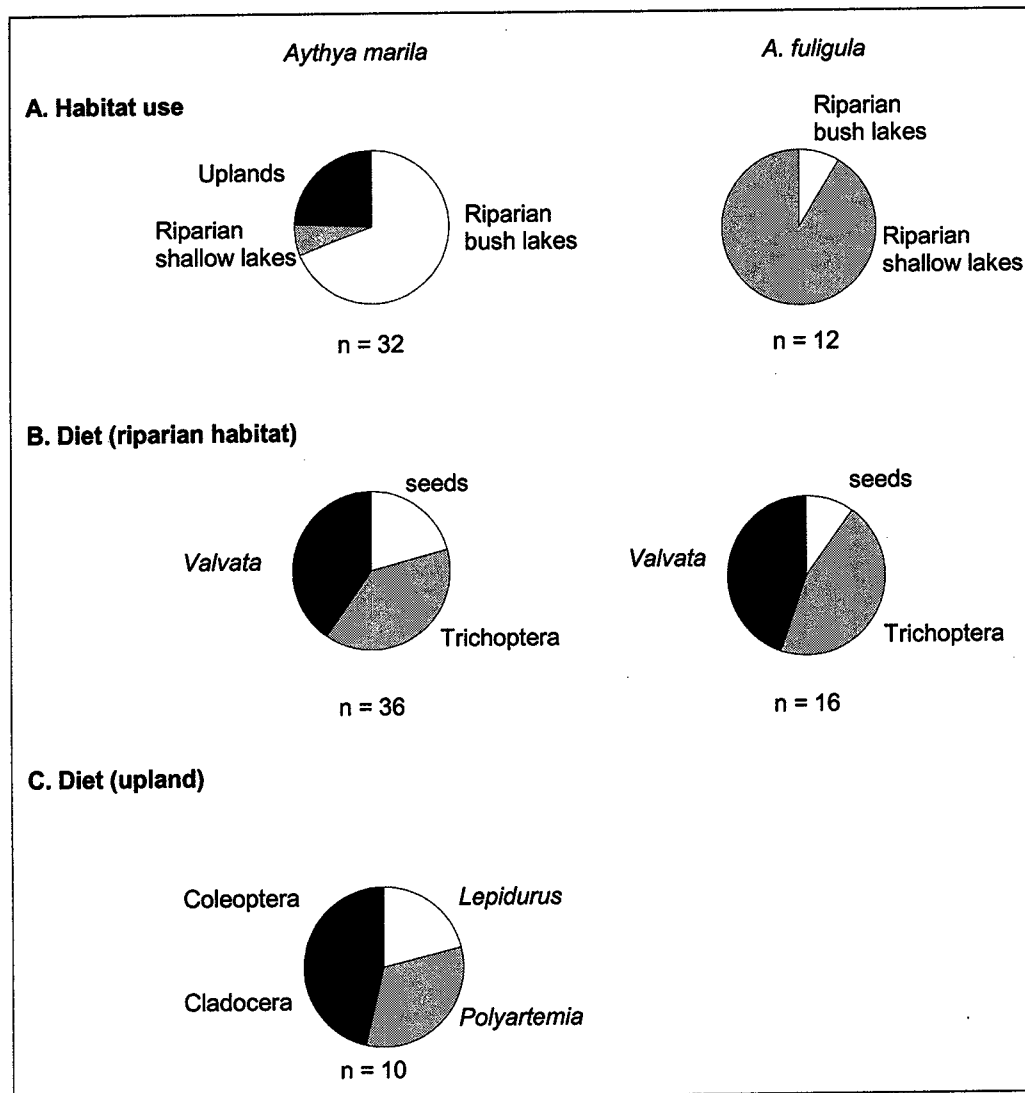
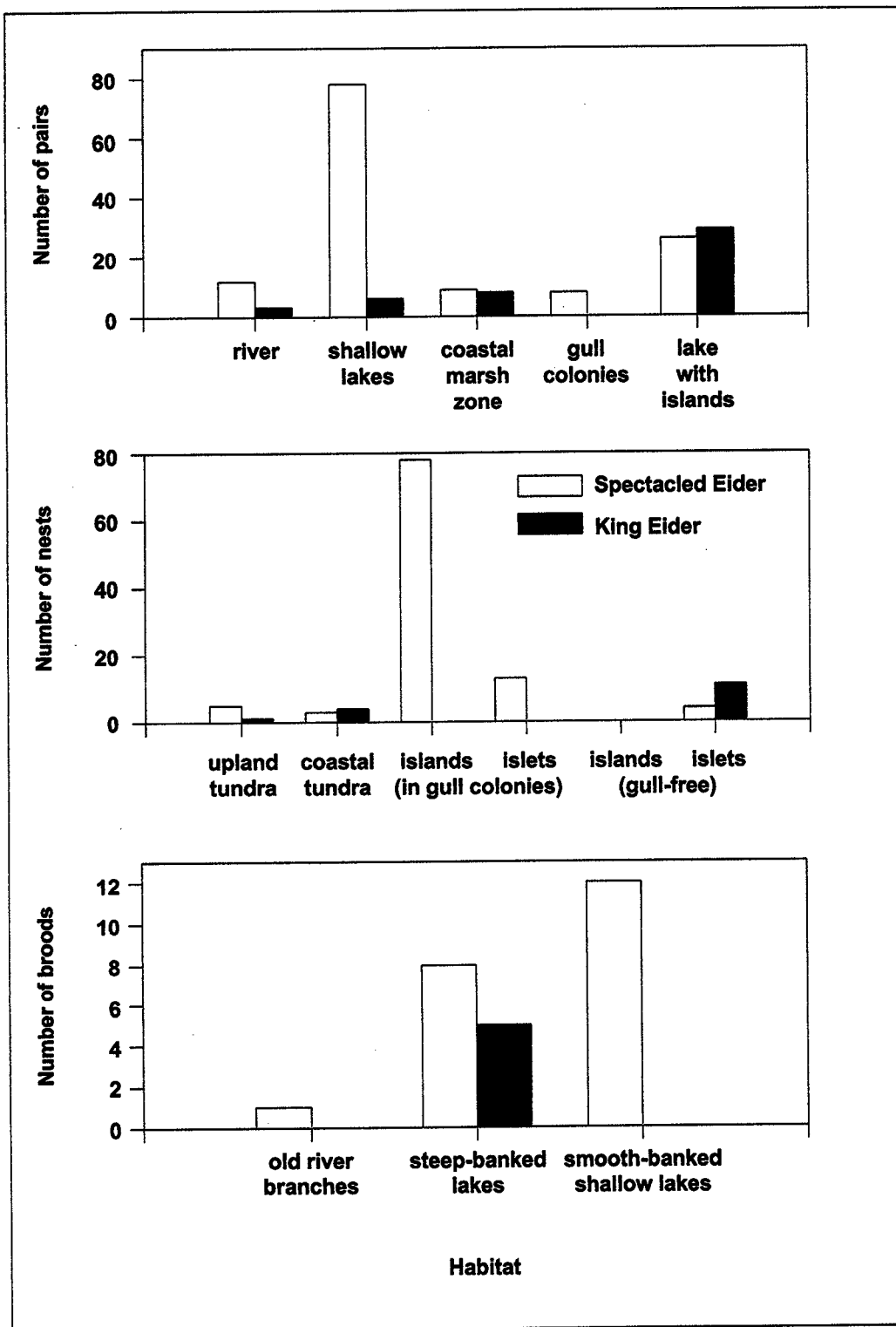


Table 1
Foraging behaviour of selected diving and sea ducks in northeast Russia

	Head/neck submerging ^a	Upending ^a	Diving of ducklings ^a	Diving of adults ^a	Searching (s)	Swimming speed (m/min)	Maximum brood diameter (m)
<i>Aythya marila</i>	no	no	10	20	no	3.3	5
<i>A. fuligula</i>	no	no	7	20	no	3.3	5
<i>Somateria fischeri</i>	5.5 (75%)	7.8 (80%)	3	13 (56%)	no	3	5
<i>S. spectabilis</i>	5.3 (75%)	rare	no data	13 (60%)	no	3	5
<i>Histrionicus histrionicus</i>	3.4 (40%)	rare	no data	17 (56%)	no	1	5
<i>Melanitta nigra</i>	no	no	10 (62%)	26 (66%)	no	1.5	5
<i>M. fusca</i>	no	no	12.5 (48%)	38 (68%)	no	2.5	5
<i>Clangula hyemalis</i>	no	no	5.3 (64%)	28 (82%)	rare	10	50
<i>Bucephala clangula</i>	no	no	7.5	25	2.5	3	50
<i>Mergellus albellus</i>	no	no	5	18	3.1	12	5
<i>Mergus serrator</i>	no	no	7	18 (65%)	3.4	15	5
<i>M. merganser</i>	no	no	7	25 (45%)	4.8	15	5

^a Values are time(s) engaged in feeding behaviour (% of time devoted to behaviour in feeding bout).

Figure 2
Habitat use of Spectacled and King eiders at Chaun Bay



consume patchily distributed invertebrates in shallow waters, more typical of dabbling ducks and *Aythya* spp. Showing various adaptations to a range of habitats and conditions, eiders and Harlequin Ducks use upending in shallows where possible, and they usually move slowly within the food patch, diving with moderate efficiency.

Different species of scoters are adapted to different habitats but utilize resources in a similar manner — i.e.,

consuming concentrations of large benthic invertebrates in very dense patches by long dives, sometimes to considerable depths. Once the food patch is discovered, it is used intensively. Synchronous dives are often observed in foraging groups (Schenkeveld and Ydenberg 1985; Kondratyev 1989). This manner of intensive use of a discovered food patch is also observed in winter during the marine part of their life

Figure 3
Diet of Spectacled and King eiders at Chaun Bay

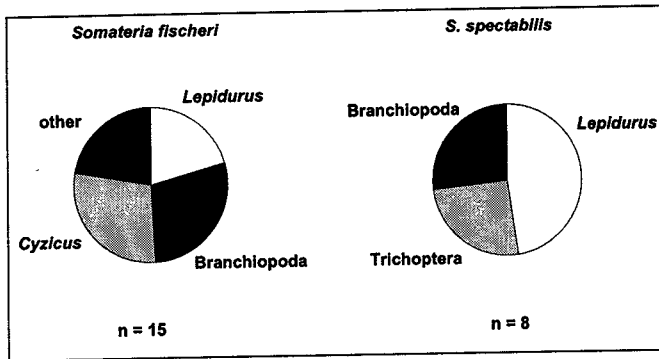
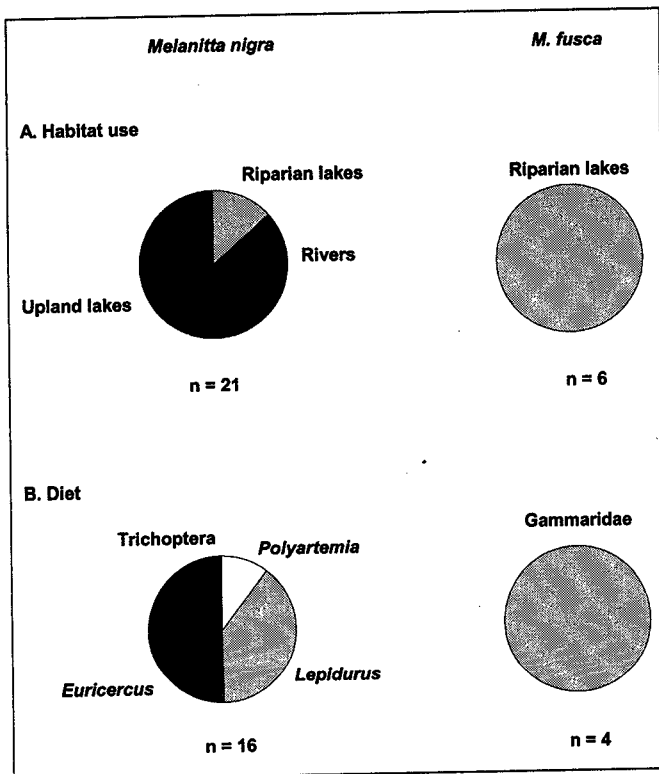


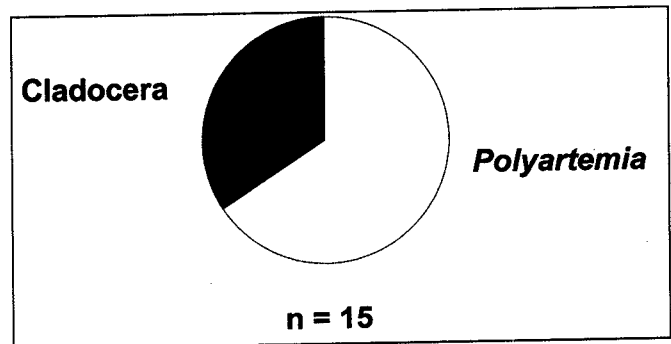
Figure 4
Habitat use and diet of Black and White-winged scoters at Middle Anadyr



cycle (Vermeer 1983; Vermeer and Bourne 1984; Goudie and Ankney 1986).

Another foraging method shown by sea ducks involves a shift from shallows and shoreline (eiders and Harlequin Ducks) and deep-water habitats (scoters) to the use of the water column. Species feeding in the water column include Oldsquaw and Common Goldeneye (Pehrsson 1974; Alison 1976; Snell 1985; Pehrsson and Nyström 1988). They can also feed effectively on benthic invertebrates, notably in winter (see Goudie and Ankney 1986), but the ability to feed on sparsely distributed prey (both on the bottom and in the water column) and to use the water surface area extensively distinguishes them sharply from eiders and scoters. This ability to forage on sparsely distributed prey has also been shown in different areas and during different periods of their life cycle (Suter 1982; Sanger and Jones 1984; Goudie and Ankney 1986). The ability to catch prey in the water column

Figure 5
Diet of Oldsquaw at Middle Anadyr (upland lakes)



is found in all sea duck species, and young eiders and scaups also feed on macroplankton invertebrates, such as *Polyartemia forcipata* and *Cyzicus* spp. The duration of this method of foraging during duckling growth varies from days to weeks. The ability to feed on swimming prey lasts longer in Oldsquaw, goldeneyes, and mergansers during the growing period, and the importance of these kinds of resources in the diet of adults is also higher. Feeding in the water column is connected with changing from "grazing" to "hunting" tactics and, finally, to a specialization to active hunting of big and fast-moving prey in the water column (Smew and mergansers). In this final group, there are specialized behavioural features, such as collective hunting (Anderson and Michael 1974; Rad 1981; Wood and Hand 1985b; Wood 1987a, 1987b).

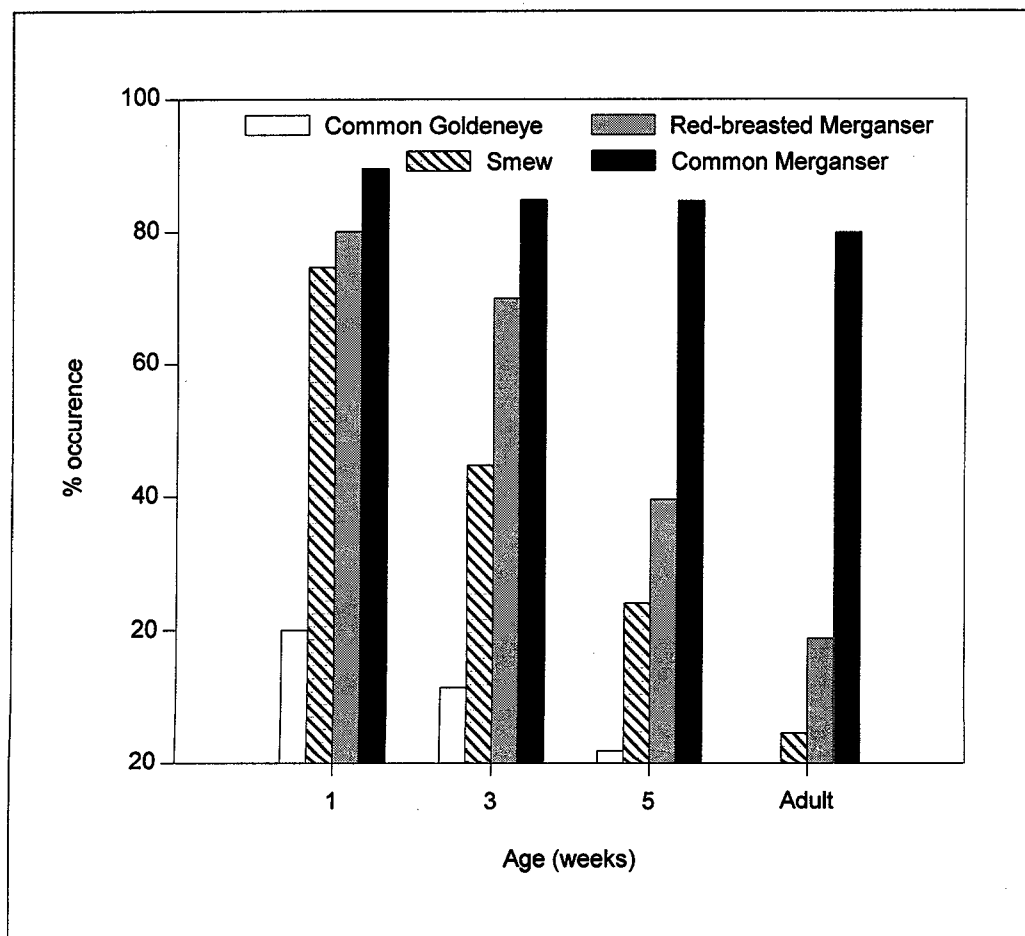
So, we may speculate that the evolution of the Mergini tribe can be expressed as a continuum from ancestral shallow feeding through deep-water diving to water column foraging and active hunting. The species' habitat use patterns might be explained as a result of selection of the proper microhabitat with certain types of prey distribution, appropriate to the species-specific feeding method.

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Figure 6

Occurrence of searching behaviour while foraging in goldeneye, Smew, and merganser ducklings in relation to age



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Spring and early summer distribution of scoters and eiders in the St. Lawrence River estuary

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Abstract

We studied the spring and summer distributions of scoters and eiders within the St. Lawrence estuary with a combination of aerial and ground surveys. Aerial surveys were designed especially for scoters; they were flown higher (150 m) and covered a wider area (unlimited distance) than conventional waterfowl surveys. These surveys yielded nearly 10 times as many scoters as did conventional surveys. Approximately 40 000 scoters (the largest number observed in the aerial surveys) were counted in the study area on 9 May 1995. By 23 May, most scoters had departed for their breeding areas. In early May, scoters were most numerous along the north shore of the eastern portion of the St. Lawrence River estuary, and few birds used the south shore. Ground surveys suggest that most male scoters were back in the estuary by the end of June. During wing moult, the distribution of scoters was more clumped than in spring; as well, the south shore was more heavily used, and several sectors were avoided. Both Surf Scoters *Melanitta perspicillata* and Black Scoters *M. nigra* are abundant in spring, but the summer scoter population is composed mostly of Surf Scoters. Important staging areas include the underwater plateaus around Île Patte de Lièvre, where birds also moult, and a few areas east of Forestville (Îlets Jérémie, Pointe-aux-Outardes). In the spring, scoters also concentrate south of Île aux Fraises, a well-known spawning site for Atlantic herring *Clupea harengus*. During the moult, scoters were seen east of Île du Chafaud aux Basques, east of Île Patte de Lièvre, and at Îlets Jérémie and Papinachois on the north shore; and at L'Anse au Sable, Archipel des Rasades, and Saint-André-de-Kamouraska on the south shore.

Résumé

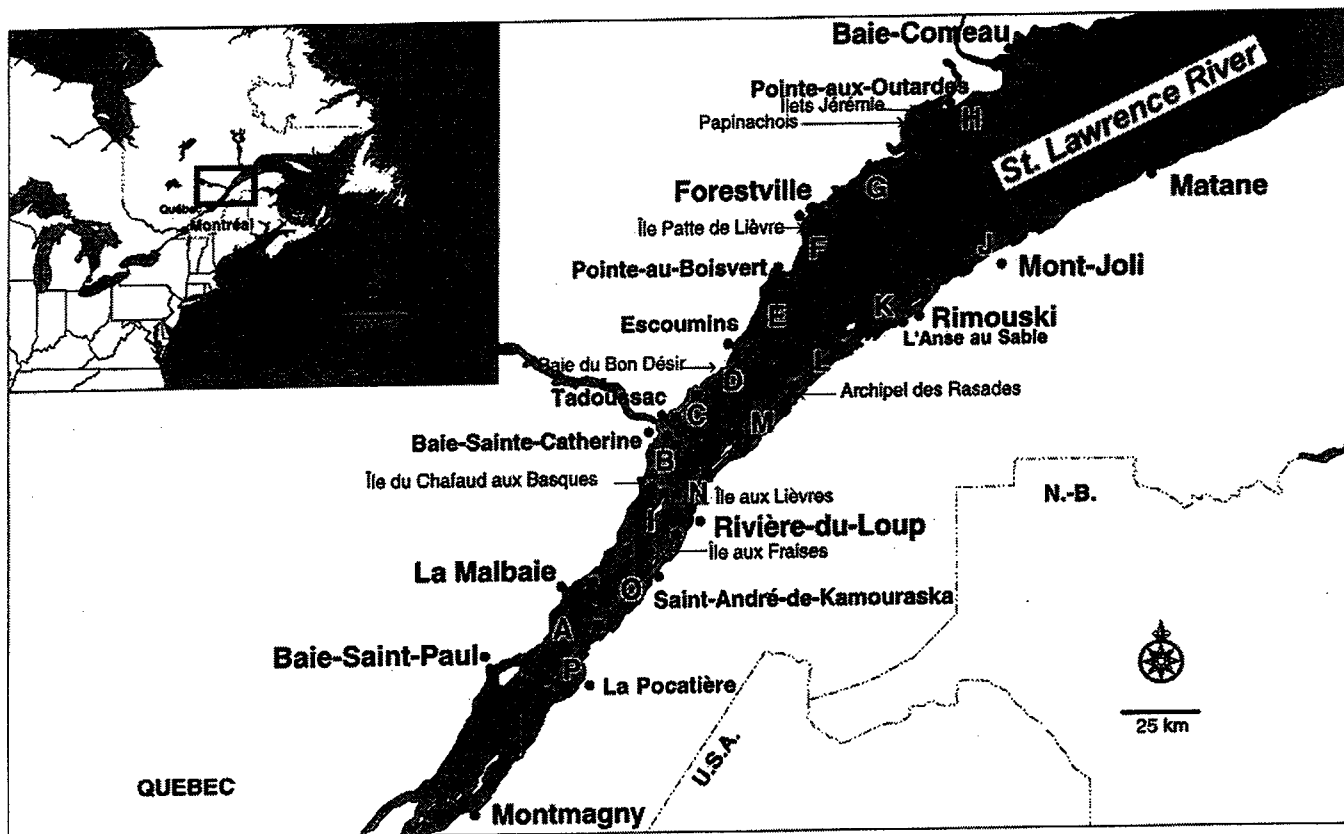
Nous avons étudié la distribution des macreuses et des eiders au printemps et en été à l'estuaire du Saint-Laurent au moyen de relevés aériens et au sol. Les relevés aériens étaient conçus spécialement pour les macreuses; ils étaient pris de plus haut (150 m) et couvraient une plus grande surface (distance illimitée) que les relevés habituels de sauvagine. Ces relevés ont permis de repérer près de 10 fois plus de macreuses que les relevés habituels. On a dénombré environ 40 000 macreuses (le plus grand nombre jamais observé dans des relevés aériens) dans le secteur couvert par l'étude effectuée le 9 mai 1995. Au 23 mai, la plupart des

macreuses étaient parties pour leurs aires de reproduction. Au début de mai, les macreuses étaient très nombreuses le long de la côte nord de la partie est de l'estuaire du Saint-Laurent, et peu d'oiseaux utilisaient la côte sud. Les relevés au sol indiquent que la plupart des macreuses mâles étaient revenues à l'estuaire vers la fin de juin. Au cours de la mue des ailes, la distribution des macreuses présentait davantage de rassemblements qu'au printemps; en outre, la côte sud était plus fréquentée et plusieurs secteurs étaient évités. Les Macreuses à front blanc (*Melanitta perspicillata*) et les Macreuses noires (*M. nigra*) sont abondantes au printemps, mais la population estivale de macreuses se compose principalement de Macreuses à front blanc. Les importantes aires de repos comprennent les plateaux submergés entourant l'Île Patte de Lièvre, où les oiseaux muent également, et quelques secteurs à l'est de Forestville (Îlets Jérémie, Pointe-aux-Outardes). Au printemps, les macreuses se concentrent également au sud de l'Île aux Fraises, une fraye bien connue du hareng de l'Atlantique (*Clupea harengus*). Durant la mue, des macreuses ont été vues à l'est de l'Île du Chafaud aux Basques, à l'est de l'Île Patte de Lièvre et aux Îlets Jérémie et Papinachois sur la côte nord, et à l'Anse au Sable, à l'archipel des Rasades et à Saint-André-de-Kamouraska sur la côte sud.

1.0 Introduction

Until recently, scoters were among the least-known waterfowl of North America (Savard and Lamothe 1991; Bordage and Savard 1995). Spring and fall aerial surveys have indicated the presence of several thousand Surf Scoters *Melanitta perspicillata* and Black Scoters *M. nigra* in the St. Lawrence estuary (Lehoux et al. 1985; Dorais and Brault 1995). While the fall distribution of scoters has been quantified (Bédard et al. 1997a), spring distributions remain poorly documented. Scoters are still actively hunted and may be declining in the east (Ad Hoc Sea Duck Committee 1994); thus, it is important to document their distribution and habitat use during their stay in the St. Lawrence estuary. We present here the results of aerial and ground surveys conducted in spring and summer within the St. Lawrence estuary and review what is known of the spring distribution of scoters. We also report counts of Common Eiders *Somateria mollissima* that were detected by our surveys.

Figure 1
Study area showing sections of aerial survey



2.0 Study area

The area surveyed covered most of the St. Lawrence estuary, from Baie-Saint-Paul to Baie-Comeau on the north shore and from Montmagny to Mont-Joli on the south shore (Fig. 1). Shallow waters around Île aux Fraises and the south shore of Île aux Lièvres were also surveyed. The large foreshore in front of Baie-Sainte-Catherine was covered thoroughly with several flight lines, as was the large underwater plateau west of Forestville.

3.0 Methods

In 1994, an aerial survey was conducted on 27 July to find moulting scoters. The survey was designed especially for scoters: the flight line covered all underwater plateaus, avoided marshes, and was flown at a height of 150 m with an unlimited survey width. The survey was done from a twin-engine Highlander. Observers concentrated on spotting flocks of scoters. Once a flock was located, its position was recorded on a map and its size and species composition were estimated. Results were compiled per section of shore (Fig. 1). In 1995, three aerial surveys were conducted in the spring (2, 9, and 23 May) using the same protocol as in 1994. A few localized ground surveys were also conducted in accessible areas. Scoters were counted from observation points on the shore.

4.0 Results

4.1 Distribution of scoters

Nearly 15 000 scoters, mostly Surf and Black scoters, were already present in the estuary by 2 May (Table 1). Numbers increased to nearly 39 500 birds by 9 May. Most scoters had left the estuary by 23 May. Numbers of scoters increased again throughout the summer, reaching almost 13 000 birds on 27 July.

As expected, scoters were not evenly distributed within the estuary. They were, however, more widespread in spring than in summer. Few scoters were observed on the south shore in the spring, most being located along the north shore. In the summer, however, proportionally more scoters used the south shore (Table 1).

In early May, scoters outnumbered Common Eiders by a factor of two (39 526 vs. 18 613) (Tables 1 and 2). The distribution of scoters and Common Eiders differed considerably at this time of the year. The area around Île Patte de Lièvre was the area most frequented by scoters, supporting 66% and 52% of the scoters present in the estuary on 2 May and 9 May, respectively. In contrast, the same area supported <2% of the Common Eiders on the same dates. A ground survey conducted on 4 May 1995 between Pointe-au-Boisvert and Forestville (section F) yielded around 7500 scoters, which compares well with the 9720 birds seen during the aerial survey two days earlier. These observations confirm that this sector is important for scoters in spring.

The only section with more scoters on 23 May than earlier in May was Baie du Bon Désir (section D). On 23

Table 1Abundance of scoters (number of birds observed) as indicated by aerial surveys conducted in the St. Lawrence estuary^a

	North shore sections																South shore sections								Total	
																									North shore	South shore
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P										
2 May 1995	84	363	645	58	124	9 720	3 387	40	64	0	11	73	57	10	10	6	14 485	167								
9 May 1995	358	426	1 431	487	389	20 732	6 046	7 920	1 096	31	92	190	145	80	38	65	38 885	641								
23 May 1995	47	202	294	824	0	228	0	0	82	0	0	0	28	73	30		1 677	131								
27 July 1994	0	1 050	0	0	0	5 000	1 500	2 500	0	0	1 500	250	1 060	0	0	0	10 050	2 810								

^a See Figure 1 for location of sections.**Table 2**Abundance of Common Eiders (number of birds observed) as indicated by aerial surveys conducted in the St. Lawrence estuary^a

	North shore sections																South shore sections								Total	
																									North shore	South shore
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P										
2 May 1995	124	639	154	499	2 396	28	174	109	1 409	143	2 067	110	424	87	20	0	5 532	2 851								
9 May 1995	85	1 869	1 248	576	261	349	1 956	545	3 749	557	6 242	118	936	92	30	0	10 638	7 975								
23 May 1995	139	821	690	219	532	93	553	108	2 712	133	1 214	5	410	36	87	0	5 867	1 885								

^a See Figure 1 for location of sections.

May, most remaining scoters were located in the western portion of the estuary, on both the north and south shores. In the summer, during the wing moult, scoters were more concentrated than in the spring. The area around Île Patte de Lièvre was again the most heavily used, and the sectors east of Forestville were also used by some moulting scoters. Three areas were used more heavily by scoters during the moult than in the spring. The foreshore just east of Île du Chafaud aux Basques had twice as many scoters in the summer than in the spring, and two south shore areas (K and M, Table 1) had nearly 10 times as many scoters in the summer.

In May, all three species of scoters were observed in the estuary. The White-winged Scoter *Melanitta fusca* was the least numerous, with fewer than 1000 birds identified. Both Surf and Black scoters were abundant; however, because of the large number of unidentified scoters in our surveys, we cannot estimate their relative abundance. Other surveys have confirmed the abundance of both species in the spring and the near absence of Black Scoters in the fall (Table 3).

By the third week of May, most scoters had left the St. Lawrence estuary (Table 1). At Île Patte de Lièvre, only a few hundred scoters were seen on 23 May. A ground survey conducted in this area yielded 5000 scoters at 19:00 on 27 June, and a recount at 06:00 on 28 June yielded 6650 scoters distributed in 15 rafts of 200–1500 birds, several kilometres offshore. On 3 July, approximately 1000 scoters were counted at Saint-André-de-Kamouraska, suggesting an early return of birds from the breeding areas.

4.2 Distribution of Common Eiders

As mentioned above, the distribution of Common Eider, a species breeding within the estuary, was quite different from that of scoters (Tables 1 and 2). Scoters' numbers within the estuary decreased from 39 526 on 9 May 1995 to 1808 on 23 May, a 95% decrease. Common Eider

numbers went from 18 613 to 7752, a decrease of 58%, probably because males move to other areas and females are on their nests at this time. As expected, the larger concentrations of eiders were associated with breeding islands. Sections I and K (Fig. 1) contained the most important breeding islands and thus supported the largest concentrations of eiders.

A partial ground survey conducted on 27 June yielded concentrations of Common Eider males at Baie du Bon Désir (1200) and just offshore of Pointe-au-Boisvert (3000).

4.3 Comparisons with other waterfowl surveys

We compared our scoter surveys with general waterfowl surveys conducted in the same areas. Results are quite compelling (Table 4), demonstrating that generalized waterfowl surveys can produce biased estimates for some species. Nearly 10 times more scoters were detected in the scoter survey than in the general survey for the same area.

5.0 Discussion

5.1 Survey efficiency

More scoters frequent the upper portion of the St. Lawrence estuary than previously thought. Previous surveys in this sector had been multispecies surveys concentrating on the waterfowl associated with tidal marshes and flown at only about 75 m altitude (Dupuis 1976; Dorais and Brault 1995). Understandably, these surveys missed offshore flocks of scoters, highlighting the difficulties associated with interpreting multispecies surveys. It is clear that scoters, dabbling ducks, and even goldeneyes cannot be surveyed efficiently at the same time. Savard (1990) reached similar conclusions for wintering populations of American Black Ducks *Anas rubripes* and goldeneyes (*Bucephala* spp.). In light of these observations, multispecies surveys should be interpreted with

Table 3
Spring and fall species composition of scoters in the St. Lawrence estuary

	% of individuals			n ^a	Reference
	Black Scoter	Surf Scoter	Scoter spp.		
Spring					
27 April 1992	67	19	15	2 620	Dorais and Brault (1995)
11 May 1992	29	47	23	34 290	Dorais and Brault (1995)
12 May 1975	32	66	2	11 834	Dupuis (1976)
19 May 1992	18	69	13	41 781	Dorais and Brault (1995)
Fall					
9 September 1991	18	56	26	9 188	Dorais and Brault (1995)
4 September 1975	5	95	0	1 654	Dupuis (1976)
18 September 1975	0	100	0	7 978	Dupuis (1976)
25 September 1975	0	80	20	4 720	Dupuis (1976)
2 October 1975	1	93	6	3 556	Dupuis (1976)
9 October 1975	0	99	1	6 133	Dupuis (1976)
27 October 1975	37	56	7	2 930	Dupuis (1976)
7 November 1991	3	96	1	8 499	Dorais and Brault (1995)

^a Number of scoters observed. Different amount of the estuary covered during the different surveys.

Table 4
Comparison of the number of scoters recorded in aerial surveys conducted in 1992 (Dorais and Brault 1995) and 1995 (this study) in the same sections of the estuary. Surveys conducted in 1992 were designed to survey all waterfowl species, whereas surveys in 1995 were designed specifically for scoters.

	Number of scoters
27 April 1992	1 048
2 May 1995	13 974
11 May 1992	4 512
9 May 1995	37 005

extreme caution, as they may not provide reliable data for some of the species surveyed.

5.2 Distribution

There is some indication that there are slightly more scoters in spring than in fall in the St. Lawrence estuary (Lehoux et al. 1985). However, because no standardized surveys have been done over the whole estuary, this remains to be confirmed. Species composition, however, changes drastically between spring, summer, and fall. Black Scoters, numerous during the spring staging period, are nearly absent in summer and fall. In spring, scoter distributions in the St. Lawrence estuary may be influenced, in part, by Atlantic herring *Clupea harengus* spawning locations and timing. Scoters are often associated with herring spawn on the west coast (Munro and Clemens 1931) and have been used to locate herring spawning sites within the St. Lawrence estuary (J. Munro, pers. commun.). The large number of birds occasionally recorded around Île aux Fraises and at the west point of Île aux Lièvres in the spring (Lehoux et al. 1985; Bédard et al. 1997b) may be feeding on herring eggs. This area, contrary to other sites, is used only during spring migration. This opportunistic use of herring spawning sites may explain in part the more widespread spring distribution of scoters within the estuary (Bédard et al. 1997b). Little is known of moulting scoters and eiders, and typically few aerial surveys

have been conducted in July and August, so their distribution at this time of year is still largely unknown.

In the St. Lawrence estuary, moulting scoters are more clumped than in either spring or fall, although moulting sites are also used by spring and fall migrating birds (Bédard et al. 1997a). Most scoters moulting in the estuary are Surf Scoters, but a few Black and White-winged scoters may moult there as well. Surf Scoters breed farther south than Black Scoters (Savard and Lamothe 1991; Reed et al. 1994; Bordage 1996), and males moulting in the St. Lawrence estuary likely originate from the more southerly breeding sites. In eastern North America, the most important moulting site for Black Scoters is located in James Bay, where the majority of the eastern population is believed to moult (Ross 1982, 1983; Bordage and Savard 1995). No such large moulting concentration has yet been located for Surf Scoters, but there seem to be important moulting flocks along the Labrador coast (Lock 1986; Goudie et al. 1994) and in the St. Lawrence estuary and gulf. Moulting migration is a well-documented phenomenon in sea ducks, which will fly thousands of kilometres to reach suitable moulting sites (Salomonsen 1968; Petersen 1981).

Scoters seen in early June in the St. Lawrence estuary are likely nonbreeders (mostly first- or second-year birds), but there may also be some adult birds. Nonbreeding by adults has been documented in eiders (Coulson 1984) and seabirds (Kaldec and Drury 1968; Wooller and Coulson 1977) and could possibly occur in scoters. Morrier et al. (1997) found that breeding males departed from their breeding lakes as early as the third week of June. Bédard et al. (1997b) reported an increase in scoter numbers at the west point of Île aux Lièvres at the same time, confirming an early arrival of moulting scoter drakes in the St. Lawrence estuary.

The distribution of Common Eiders in the spring confirms earlier observations by Gauthier and Bédard (1976) and Bédard et al. (1986) indicating a concentration around breeding islands. These authors also indicated that more than half the males left the estuary in late May – early June for unknown areas. This accounts, in part, for the lower number of eiders we observed in late May. The moulting sites we observed are the same ones noticed by Bédard et al. (1986), probably indicating a traditional use of these sites. It is

interesting to note that scoters and eiders tend to use different moulting sites. Both, however, are concentrated at this time and often form very tight flocks.

5.3 Important areas

The most important identified site for scoters is the foreshore west of Île Patte de Lièvre, which supports the highest number of scoters in spring, summer, and fall (Bédard et al. 1997a). Moulting sites also included Saint-André-de-Kamouraska and the foreshore east of Île du Chafaud aux Basques. Important moulting sites east of Baie-Comeau remain to be identified. Several sites are used year after year by scoters, indicating the patchy nature of suitable habitats. Black and Surf scoters feed on a variety of shellfish (Stott and Olson 1973; Vermeer 1981; Vermeer and Bourne 1984) abundant in specific habitats. It is important to identify significant areas used by scoters and eiders, for several reasons. First, we may want to avoid locating shellfish aquaculture farms in these sectors, as sea ducks can have a significant impact on their yield (Rueggeberg and Booth 1989; Parsons et al. 1990). Second, we may want to regulate shellfish harvesting in these areas, as overharvesting may affect the food resources available to scoters. Third, we may also want to minimize disturbance by boat traffic in the most important areas. Fourth, we may want to identify these areas as highly sensitive in oil spill contingency plans, as sea ducks are extremely vulnerable (King and Sanger 1979; Hooper et al. 1987; Rodway et al. 1989), especially when moulting. Finally, we may want to create marine protected areas at the most important sites.

5.4 Conclusion

Our study confirmed the abundance of sea ducks in spring and summer in the St. Lawrence estuary and shed some doubts on the reliability of multispecies surveys for estimation of sea duck trends. However, much remains to be known about the ecology of sea ducks within the St. Lawrence estuary.

Acknowledgments

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A case for concern: The eastern population of Barrow's Goldeneye

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Abstract

Data on the eastern population of Barrow's Goldeneye *Bucephala islandica* are scant. Breeding has not been confirmed in eastern Canada, but recent pair surveys on the Laurentian plateau, along the north shore of the St. Lawrence estuary, suggest the possibility of breeding there. Groups of males have been reported at the mouth of some of the inlets of the northeastern Labrador coast, indicating possible moulting locations for drakes. Information on winter distribution indicates the concentration of several hundred birds in the St. Lawrence estuary, a few hundred around Anticosti Island, and small numbers in the Maritimes and eastern coastal United States. No reliable data exist on population trend or size, except to indicate that goldeneyes, as a group, are declining in the east. Harvest rate data are unreliable owing to small sample sizes. Best estimates suggest that the population may be around 3000–4000 birds. Our poor state of knowledge, combined with hunting pressure and logging operations on potential breeding areas, is cause for concern for the continued existence of this population. Research and conservation efforts are urgently needed.

Résumé

Les données sur la population de Garrots d'Islande (*Bucephala islandica*) de l'Est sont rares. Leur reproduction n'a pas été confirmée dans l'est du pays, mais de récents relevés de couples dans le plateau laurentien, sur la côte nord de l'estuaire du Saint-Laurent indiquent la présence possible d'aires de reproduction en ces lieux. On a observé des groupes de mâles à l'embouchure de certains bras de mer du nord-est de la côte du Labrador indiquant des lieux de mue possibles pour ceux-ci. Les renseignements disponibles sur leur distribution hivernale indiquent la concentration de plusieurs centaines d'oiseaux à l'estuaire du Saint-Laurent, de quelques centaines aux environs de l'île Anticosti, et d'un petit nombre dans les Maritimes et sur la côte est des États-Unis. Il n'existe aucune donnée fiable sur les tendances ou la taille de la population, sauf pour indiquer une diminution globale des garrots dans l'Est. Les données relatives au taux de prises ne sont pas concluantes en raison de la petite taille des échantillons. Les évaluations les plus crédibles fixent entre 3000 et 4000 le nombre de ces oiseaux. L'état lacunaire de nos connaissances, combiné à la pression exercée par la chasse et l'exploitation forestière sur les aires

de reproduction possibles est un sujet préoccupant pour l'existence de cette population. Des efforts de recherche et de conservation sont nécessaires et urgents.

1.0 Introduction

Barrow's Goldeneye *Bucephala islandica* has an unusual distribution that mirrors, to some extent, that of the Harlequin Duck *Histrionicus histrionicus* (Palmer 1976). The core (>70%) of the population breeds and winters west of the Rocky Mountains, with two small populations in the east: one in Iceland, estimated at 800 pairs by Bardarson (1987) but at only 600–1200 birds by Rose and Scott (1997), and the other in eastern North America (Savard 1987). The status and size of the eastern population are poorly known. This may be cause for concern in view of the traditional hunting activities in the wintering range of the species in Canada and the United States. This is emphasized by the recent increase in hunting of sea ducks in the eastern United States (U.S. Fish and Wildlife Service 1993) and the apparent decrease in goldeneye numbers in the Atlantic flyway (Serie 1993; Dubovsky et al. 1995). Whereas recent attention has been devoted to Harlequin Ducks, following their listing as an endangered species (Goudie 1989; World Wildlife Fund 1995), little concern has been voiced for Barrow's Goldeneye in eastern North America. The species was not even classified as "vulnerable" in a recent publication on the threatened birds of Quebec, likely because of lack of information (Robert 1989). There are serious questions that need to be addressed. For example, will Barrow's Goldeneye fall into the gaps of our waterfowl management system or those of the existing endangered species program? Do existing data suggest that we should be concerned about this species? In this paper, we briefly review what is known about the eastern population of Barrow's Goldeneye and identify urgent research and management needs.

2.0 Distribution

2.1 Breeding

There is no confirmed breeding record of Barrow's Goldeneye in eastern North America (Erskine 1992; Savard 1995). However, recent inventories conducted in Quebec by the Canadian Wildlife Service along the north shore of the St. Lawrence River revealed the presence of several pairs on

interior lakes at the time of initiation of the breeding season (Fig. 1, Table 1). Therefore, this vast area should be considered as a probable nesting area for part of the eastern population. Also, several pairs were seen north of Charlevoix county in small lakes located at high altitude (Savard 1995). Most pairs were seen on small lakes (10 ha) and rarely with Common Goldeneye *Bucephala clangula* pairs (D. Bordage, unpubl. data). The use of small lakes is consistent with what is known of the western population (Savard 1984, 1987).

2.2 Moulting locations

Moulting Barrow's and Common goldeneye drakes have been reported in inlets of the Labrador coast, especially between Makkovik and Rama Bay (Gilchrist and Chamberlain 1955; Lock 1986; Goudie et al. 1994; P. Linegar, unpubl. data). In 1994, S. Gilliland (unpubl. data) reported 45 Barrow's Goldeneyes in Hebron Fjord and Primo Inlet, 132 in Rama Bay, and 37 in Rowsell Bay; he surveyed only eight of the major inlets. In 1954, 1500 moulting goldeneyes were seen near Nain, of which 50% may have been Barrow's Goldeneyes (P. Linegar, unpubl. data). The exact proportion of Barrow's Goldeneyes moulting along the Labrador coast is still unclear. However, one adult drake banded while moulting there in 1955 was shot 14 years later, in 1968, in Quebec close to the St. Lawrence estuary (Fig. 2). This suggests that birds moulting in Labrador are likely birds from eastern Canada and not from Iceland or Greenland. On 8–9 June 1976, aerial surveys revealed the presence of several small groups of male goldeneyes, totalling 932 birds, along the shores of Anticosti Island. One group of 352 birds was mostly Barrow's Goldeneye (P. Dupuis, unpubl. data). Whether those birds were nonbreeders or postbreeding males on, or moving to, their moulting sites is not known. Clearly, more surveys are needed to elucidate the use of the waters around Anticosti Island by Barrow's Goldeneye.

2.3 Winter distribution

The winter distribution of Barrow's Goldeneye is quite patchy and still clouded in uncertainties (Reed and Bourget 1977; Savard 1987, 1990). Within the St. Lawrence estuary, only two localities harbour significant numbers of wintering Barrow's Goldeneye: Baie-des-Rochers and Baie-Comeau (Savard 1990) (Fig. 3). In 1987 and 1988, numbers near Baie-Comeau ranged between 100 and 500 birds. The group of 500 birds observed on 3 January 1988 was composed of 300 males, 160 females, and 40 subadults. During the same period, numbers in Baie-des-Rochers ranged between 100 and 465 birds. The group of 465 birds was composed of 236 males and 229 females (including subadults). Two other areas are known to support Barrow's Goldeneyes in winter — the coastline near the Forillon National Park, where 185 birds were counted during the 1994–1995 Christmas Bird Count (LeBarron 1995), and Percé, where 148 birds were seen during the 1995–1996 count (LeBarron 1996). Both of these locations are on the Gaspé Peninsula (Table 2).

An aerial survey of the St. Lawrence estuary, the Gulf of St. Lawrence, Anticosti Island, and Gaspé Peninsula in 1976 and 1980 (P. Dupuis and A. Bourget, unpubl. data) indicated that most wintering goldeneyes are concentrated within the estuary, with a few flocks around Anticosti Island

(Dupuis 1976) (Table 3). It is nearly impossible to properly separate the two species of goldeneye from an aircraft at a distance. Because of their aircraft shyness, goldeneyes often flush early, well in front of the aircraft. This shyness, compounded by the large size of flocks, makes identification difficult. In 1976, special efforts were made to identify goldeneyes to species within the St. Lawrence system (Table 3). Within the estuary, where flocks are larger, only 27% of goldeneyes seen were identified to species. Among the birds identified ($n = 2458$), 57% were Barrow's Goldeneyes. This figure may be misleading, as most large flocks of goldeneyes, which are the hardest to properly identify to species, are all Common Goldeneyes (Savard 1990). Also, there is some indication that Common Goldeneyes take off more readily than Barrow's Goldeneyes at the approach of an airplane. The data suggest a greater proportion of Barrow's Goldeneye relative to Common Goldeneye in the Gulf of St. Lawrence (Table 3). However, this area supports many fewer goldeneyes than the estuary (Table 3).

Since the reviews of Hasbrouck (1944) and Griscom (1945), little has been added on the distribution and abundance of Barrow's Goldeneye in the eastern United States. Christmas Bird Count results do not indicate any major wintering concentrations (50 birds and more) in the United States or the Maritime provinces (LeBarron 1992, 1993, 1994, 1995, 1996, 1997). However, given the highly clumped distribution of the species and its apparent specialized habitat, it is possible that a few important wintering concentrations may have been overlooked.

3.0 Population size and trends

In the St. Lawrence estuary, comparisons of winter surveys of goldeneyes suggest a decline in the number of wintering birds (Table 4). Because of the inherent variability of these types of surveys, caution is required in interpreting these data. It is quite likely, however, that there has not been an increase. This is supported by an apparent decline in the number of migrating goldeneyes in the fall along the south shore of the St. Lawrence estuary (P. Dupuis, A. Bourget, and L. Breton, unpubl. data).

Estimates of the wintering population of Barrow's Goldeneye vary according to the ratio of Common to Barrow's used. An optimistic (assuming the 1976 ratios are accurate) estimate yields 5214 in the estuary, 1384 in the gulf, and 275 in Gaspésie, for a total of 6873 birds in 1976 (Table 3). However, as discussed above, besides being highly unreliable, given the large number of unidentified goldeneyes (73% in the estuary and 46% in the gulf), the 1976 species ratio in the St. Lawrence estuary is likely biased towards Barrow's Goldeneye. Winter ground surveys in the estuary yielded a ratio of 14–27 Barrow's for every 100 Common (Table 5), which is probably a more accurate ratio. With a ratio of 14%, the 1976 wintering population becomes 3443 birds, and with a ratio of 30%, 4634 birds for the estuary and gulf of St. Lawrence combined.

Over time, for the estuary between Baie-Saint-Paul and Les Escoumins, using a 30% species ratio, one can calculate 2089 Barrow's in 1976, 1348 in 1988, and 760 in 1994. This, of course, assumes an equal decline of both species and an equal performance of the aerial observers over these years, which are both unlikely. What seems clear is that

Figure 1

Location of probable breeding pairs of Barrow's Goldeneye seen between 1990 and 1995 in May and June

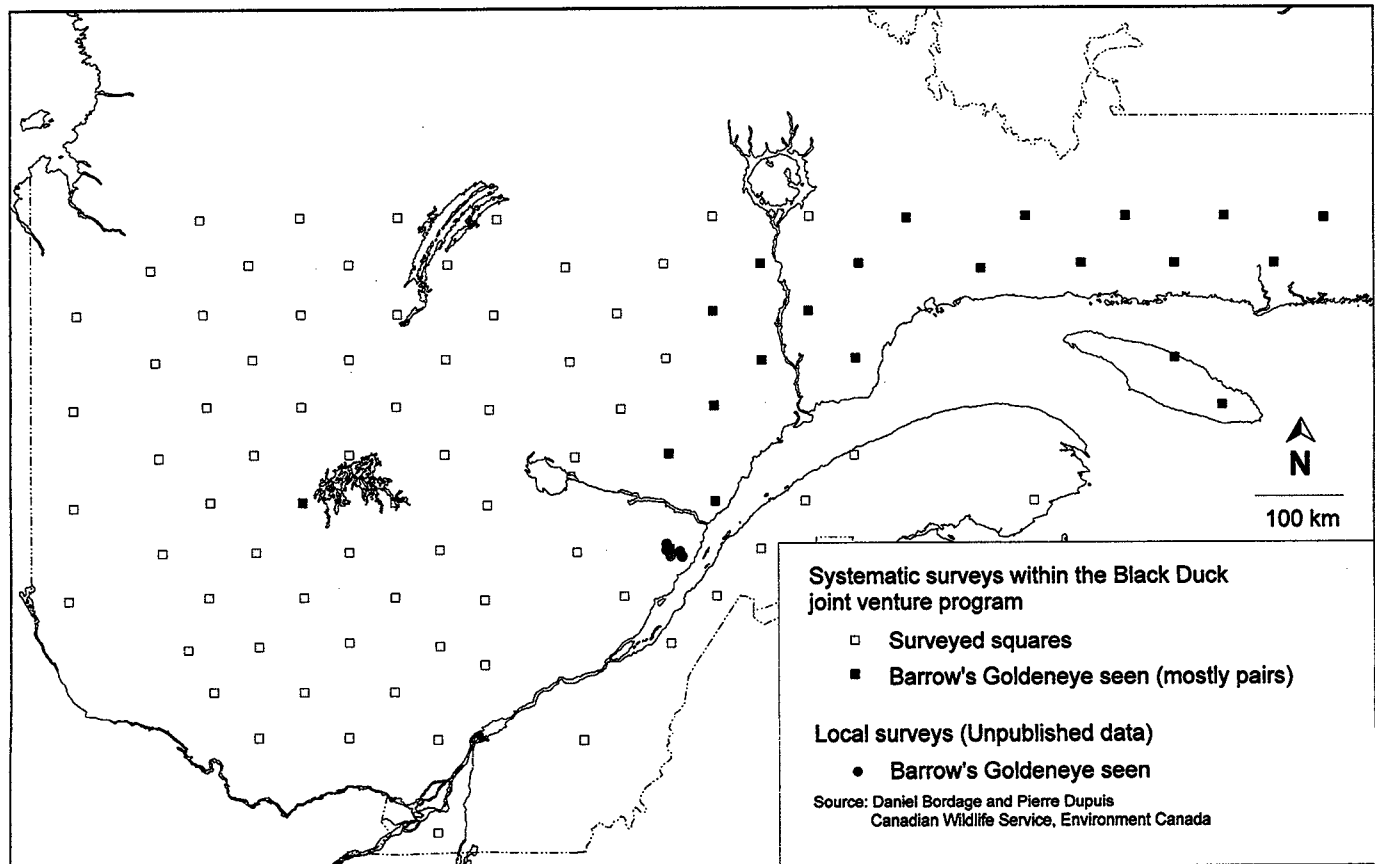


Table 1
Observation of breeding pairs of Barrow's Goldeneye in Quebec^a

Quadrat ^b no.	UTM East	UTM North	1990	1991	1992	1993	1994 ^c	1995 ^c
22								2M 1F ^d
26	457800	5352500	2M 1F			X ^e	X	X
29	452800	5356100			2F	X	X	X
36	407900	5401300		2M 2F	9M 11F			1M 1F
43	451900	5431100			1M 1F	X	X	X
44	553200	5454000			1M 1F	X	X	X
51	504800	5501100	3M 2F	4M 2F			1M 1F	
52	604400	5504500	2M 1F	5M 5F		2M 1F		X
59	451100	5551000			2M	X	X	X
60	550300	5554900	3M 2F	3M 2F		X	X	X
67	500600	5603800			1M 1F			
68	601200	5608100			3M 1F	4M 3F		
69	309100	5608400		3M 3F		5M 2F		
70	401000	5607200	2M 2F	7M 6F	6M 3F			
71	505200	5609900		6M 4F				
72	603200	5603300		1M	6M 3F	1M		
79	653900	5653300	2M 2F	4M 4F	2M 1F	X	X	X
80	350000	5657200		3M 4F	2M 2F	X	X	X
81	458800	5652800	1M 1F	1M	1M 1F	X	X	X
82	554200	5658800			1M 1F	X	X	X
83	657900	5659700		1M 1F		X	X	X
96	505800	5506800	X	X	X	1M 1F	X	X

^a From D. Bordage (unpubl. data).

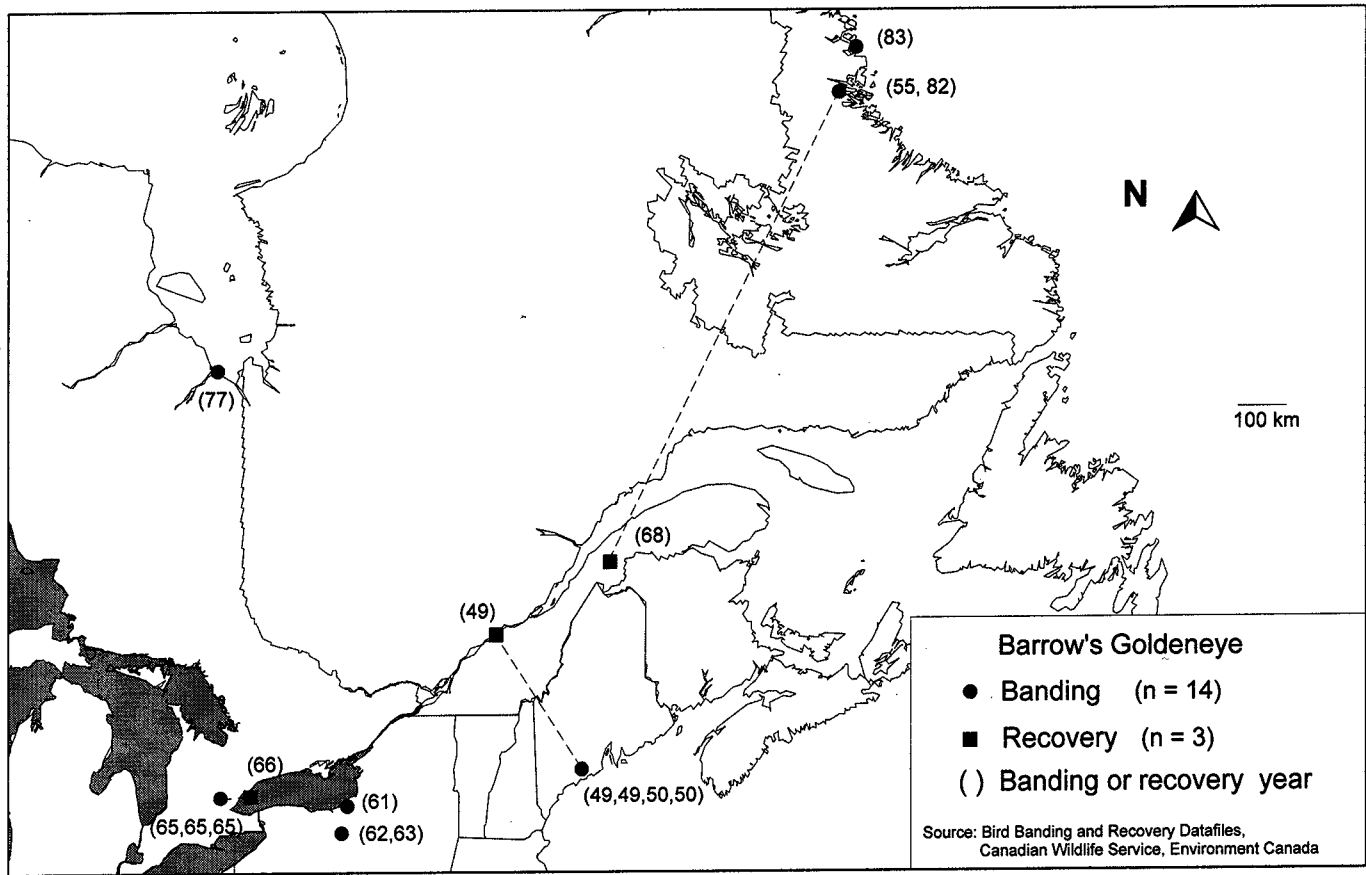
^b Each quadrat is 10 × 10 km.

^c Observers not as efficient in separating the two goldeneye species.

^d M = male; F = female.

^e Not surveyed.

Figure 2
Banding recoveries of Barrow's Goldeneye in eastern North America



the population is certainly not large. Clearly, better and more comprehensive winter surveys are required to better refine our estimates.

4.0 Hunting pressure

Barrow's Goldeneyes are hunted locally on the east coast, and an unknown number of individuals are killed each year (Lehoux et al. 1985). Localized concentrations of Barrow's Goldeneye are reflected by the rarity of Barrow's Goldeneye decoys in Quebec. The few decoys found were mostly from the Tadoussac area, with a few from Maritime Canada (P. Dupuis and A. Bourget, pers. commun.).

Between 1968 and 1993, 223 wings were returned by Quebec hunters in the National Waterfowl Harvest Survey (Cooch et al. 1978). The annual number of wings returned each year is too low to determine adequately the number of Barrow's Goldeneye harvested. Most birds were killed in October and November, and the proportion of adults in the kill increased from September to December (Fig. 4). The geographical distribution of the kill reflects to some extent the presumed breeding distribution as well as the wintering distribution, with one important difference: the regular presence of Barrow's Goldeneye in the upper St. Lawrence and in the Montreal area (29% of wings received) (Figs. 5–7). Barrow's Goldeneyes are not sighted in any great numbers in that sector (Savard 1990), but they show up regularly in the Composition Harvest Survey of that area. Their underrepresentation in regular bird sightings is likely due to the difficulty of differentiating adult female and

immature Barrow's Goldeneyes from Common Goldeneyes in the fall. Most adult males were killed in October and November throughout the St. Lawrence estuary (Fig. 5); however, as adult males are considered trophy birds by waterfowlers elsewhere, they may not show up as they should in the Composition Harvest Survey. Proportionally more adult females than males were killed in September, but most females were killed in November. Some of the females killed inland may indicate possible fall staging areas or breeding areas (Fig. 6). Most young were killed in November, and inland kills may reflect breeding areas (Fig. 7). Adults and young killed were similarly distributed throughout the St. Lawrence.

In contrast to the situation with Common Goldeneye, more Barrow's Goldeneyes are killed in the St. Lawrence estuary (71%) than in the upper St. Lawrence River (Fig. 8). Also, proportionally more adult Barrow's than Common Goldeneye are killed (Fig. 8). This is a cause for concern, as the low and localized hunting pressure has remained more or less stable in the St. Lawrence estuary, while decreasing by nearly 30% in the upper St. Lawrence (Fig. 9). In eastern Canada, most Barrow's Goldeneyes are harvested in Quebec (65%) and New Brunswick (20%), with the remaining harvest distributed among Nova Scotia (8%), Newfoundland (5%), and Prince Edward Island (2%) (n = 325 wings from 1969 to 1993). Based on the 223 wings received from Quebec, more immatures (57%) were killed than adults (43%); among adults, an equal proportion of males (48%) and females (52%) were killed. The situation is quite different in New Brunswick and Nova Scotia, with only 28%

Figure 3

Location of wintering concentrations of Barrow's Goldeneye and aerial survey sections within the St. Lawrence estuary

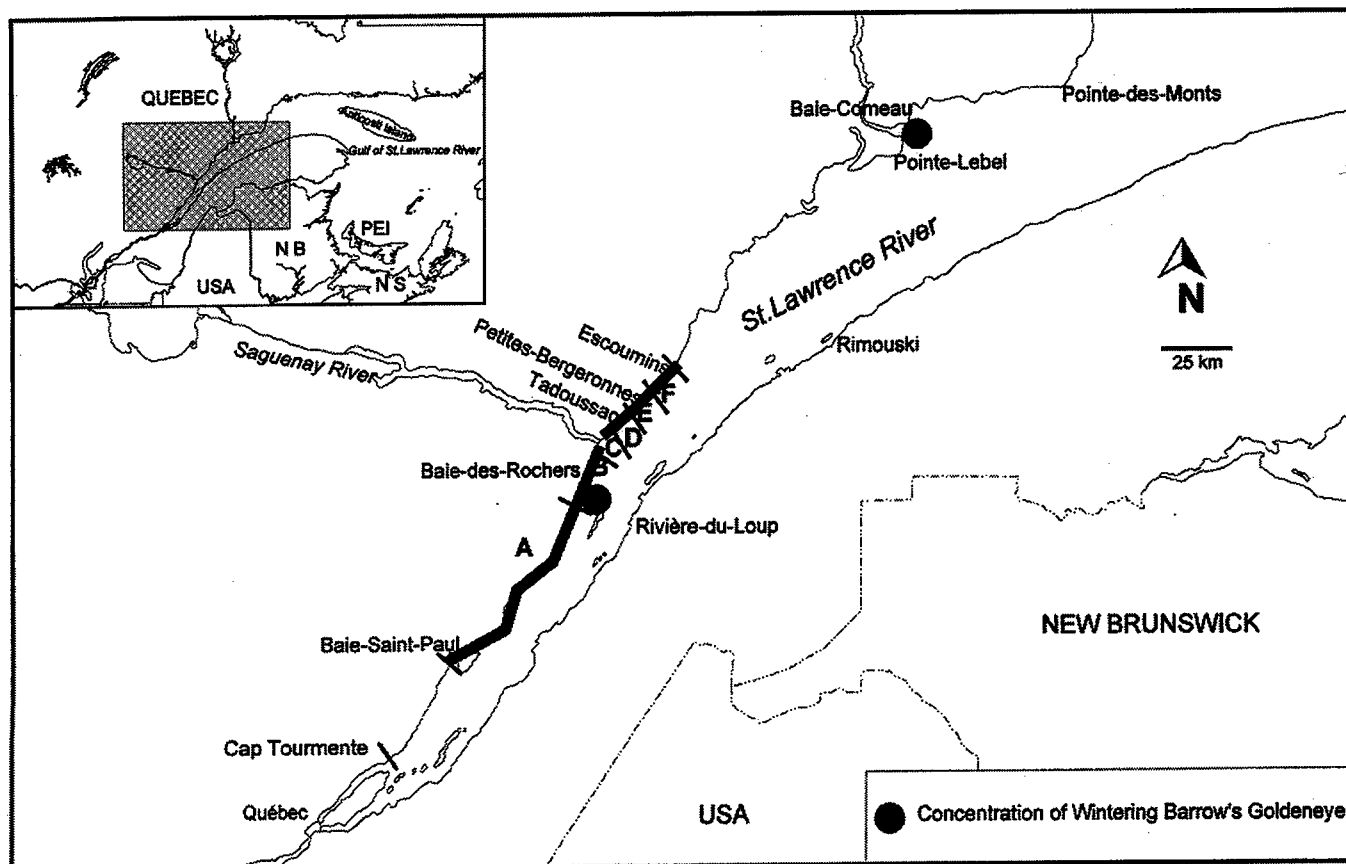


Table 2
Abundance of Barrow's and Common goldeneyes in selected Christmas Bird Counts

		Barrow's Goldeneye		Common Goldeneye	
Location	n ^a	Mean	Maximum	Mean	Maximum
Quebec					
Baie Comeau	3	372 ± 68	495 (1991–1992)	262 ± 154	568 (1991–1992)
Forillon	6	83 ± 25	185 (1994–1995)	49 ± 26	141 (1991–1992)
Percé	6	64 ± 21	148 (1995–1996)	108 ± 24	224 (1995–1996)
Tadoussac	6	8 ± 4	12 (1995–1996)	3064 ± 873	6357 (1995–1996)
Maine					
Mount Desert Island	6	2 ± 1	6 (1992–1993)	168 ± 26	244 (1996–1997)
Orono	6	15 ± 5	34 (1994–1995)	48 ± 9	70 (1996–1997)
Waterville	6	4 ± 1	6 (1991–1992)	103 ± 3	154 (1992–1993)
Massachusetts					
Nantucket	5	5 ± 1	9 (1993–1994)	1823 ± 546	3814 (1993–1994)

^a Based on counts between 1991 and 1997 (LeBarron 1992, 1993, 1994, 1995, 1996, 1997). Year of the maximum is indicated in parentheses.

of the 92 wings received being immature birds and 72% being adults. Among adults, males dominated the harvest (68%, n = 65). These proportions should be used cautiously, given the low sample sizes and the 30-year period over which they were collected.

5.0 Research and action needs

5.1 Breeding areas

It is urgent to identify breeding areas and confirm breeding in Quebec. This will permit an assessment of the breeding distribution of the species and to characterize breeding ponds. Knowledge of the breeding location of the species will also permit the identification of potential threats

Table 3
Proportion of goldeneye identified as Barrow's Goldeneye during the February 1976 survey^a

	Goldeneye						Total
	Common		Barrow's		Unknown		
	No.	%	No.	%	No.	%	
Estuary							
Cap Tourmente – Saguenay	7	(–)	852	(21)	3 253	(79)	4 112
Saguenay – Cap Bon Désir	488	(16)	198	(7)	2 290	(77)	2 976
Cap Bon Désir – Pointe-Lebel	395	(28)	173	(12)	836	(60)	1 404
Pointe-Lebel – Pointe-des-Monts	174	(26)	171	(26)	323	(48)	668
Gulf (North Shore)							
Pointe-des-Monts – Sept-Îles	60	(9)	281	(42)	334	(49)	675
Sept-Îles – Mingan	45	(12)	155	(42)	172	(46)	372
Mingan – Kégaska	10	(2)	355	(68)	159	(30)	524
Lower north shore	0	(0)	4	(25)	12	(75)	16
Anticosti Island	0	(0)	74	(30)	172	(70)	246
Total estuary	1 064	(12)	1 394	(15)	6 702	(73)	9 160
Total gulf	115	(6)	869	(47)	849	(46)	1 833
Gaspé Peninsula	0	(0)	212	(77)	63	(23)	275
Total	1 179	(10)	2 475	(22)	7 614	(68)	11 268

^a From Dupuis (1976).

Table 4
Abundance of wintering goldeneyes in the St. Lawrence estuary in 1976, 1988, and 1994

Section (see Fig. 3)	1976 ^a	1988 ^b					1994 ^c	
	4 Feb.	28 Jan.	5 Feb.	11 Feb.	18 Feb.	25 Feb.	11 Feb.	23 Feb.
A) Baie-Saint-Paul – Baie-des-Rochers	547	–	–	215	457	25	30	258
B) Baie-des-Rochers – Pointe-aux-Alouettes	1253	1104	367	500	215	418	362	478
C) Batture-aux-Alouettes	2339	633	2554	693	2823	983	251	593
D) Tadoussac – Petites-Bergeronnes	169	776	521	612	303	314	655	247
E) Petites-Bergeronnes – Cap du Bon Désir	2626	1417	597	1266	345	648	1233	886
F) Cap du Bon Désir – Escoumins	30	0	0	1	3	1	3	0
Total	6964	3930 (4387) ^d	4039 (4496) ^d	3287	4146	2389	2534	2462
Maximum each year	6964			4496			2534	

^a Dupuis (1976).

^b Savard (1990).

^c Savard et al. (1997); Savard and Falardeau (1997).

^d Total assuming 457 birds for section A.

Table 5
Summary of ground waterfowl surveys conducted in February between Baie-Sainte-Catherine and Godbout by the Manicouagan Ornithology Club^a

	Common Goldeneye	Barrow's Goldeneye	Unknown Goldeneye	Unknown duck	% Barrow's
1984	2563	80	0	1160	3 ^b
1985	2788	174	610	21	6 ^b
1986	2053	333	0	45	14
1987	2255	850	40	0	27
1988	2753	609	0	0	18

^a From Savard (1990).

^b Too many unidentified ducks for an accurate ratio.

to these locations and will facilitate the monitoring of population trends. Among potential threats are clearcutting activities in the presumed breeding areas, which, if significant, may require the implementation of a nest box program.

5.2 Moulting areas

These sites are important, as they concentrate and support most of the males of the population at a vulnerable time during the flightless period. We need to determine if all goldeneye drakes moult along the Labrador coast and which habitats they are using. We also need to devise an effective method to monitor these populations. Moulting sites have often been neglected in waterfowl management, and we know relatively little of this aspect of waterfowl ecology, especially in sea ducks (Savard 1988a).

5.3 Wintering areas

None of the wintering sites has been adequately described in terms of physical structure and food availability. The size and age structure of wintering flocks vary considerably within and between years at these sites, and the

Figure 4
Monthly distribution and age composition of Barrow's Goldeneye harvest in Quebec between 1968 and 1993

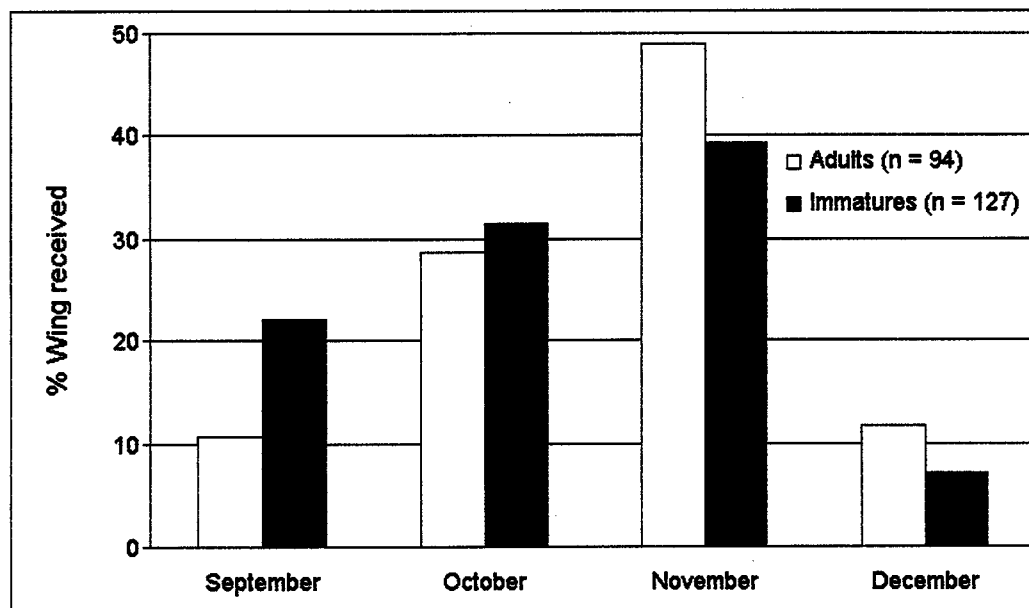
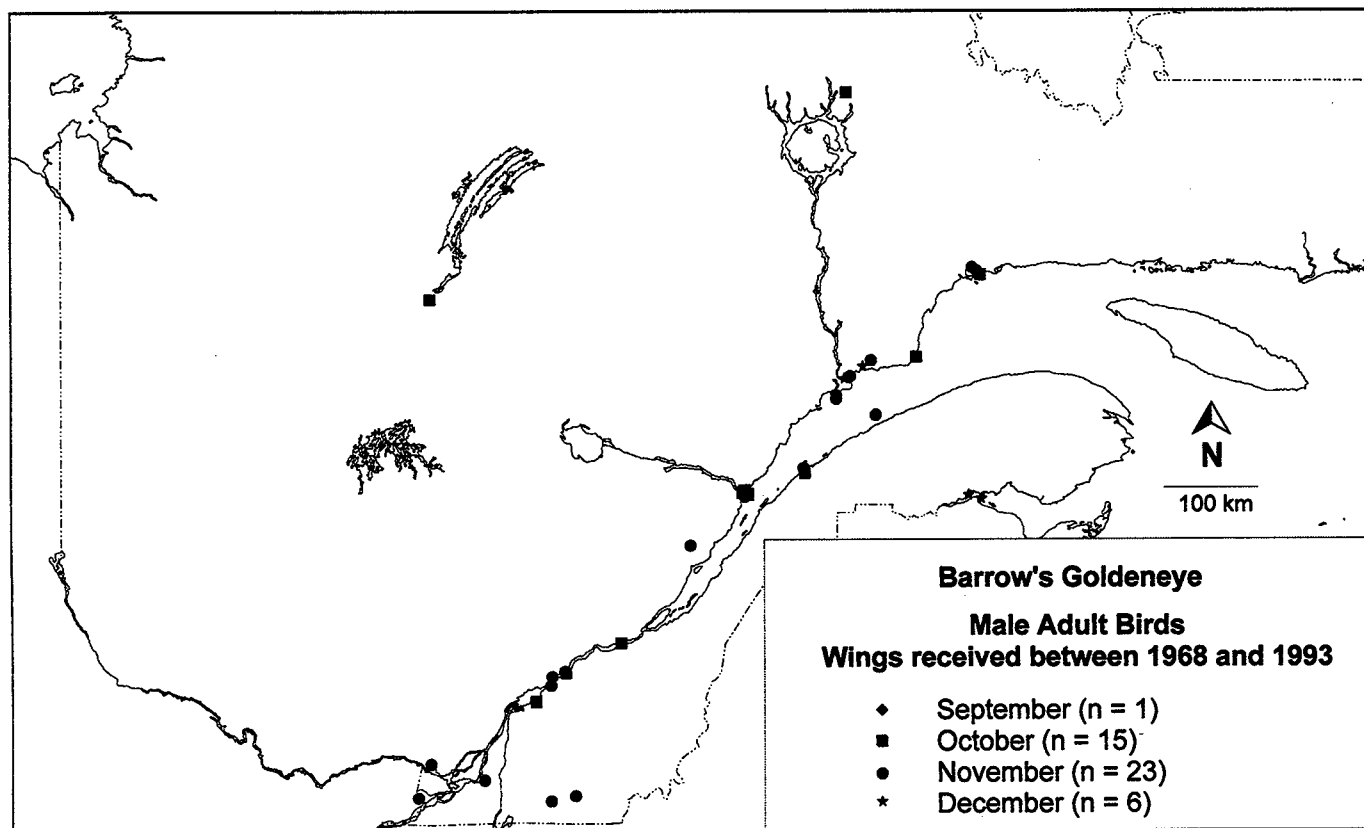


Figure 5
Monthly distribution and location of the harvest of adult male Barrow's Goldeneye in Quebec



dynamics and causes of these changes are unknown. No protective status is currently given at any of the known wintering sites, two of which possibly support as much as 50% of the estimated eastern population. More surveys are needed to assess whether there are other important wintering locations and to monitor population fluctuations. Use of

known wintering sites in relation to tide and ice conditions needs to be documented.

Figure 6
Monthly distribution and location of the harvest of adult female Barrow's Goldeneye in Quebec

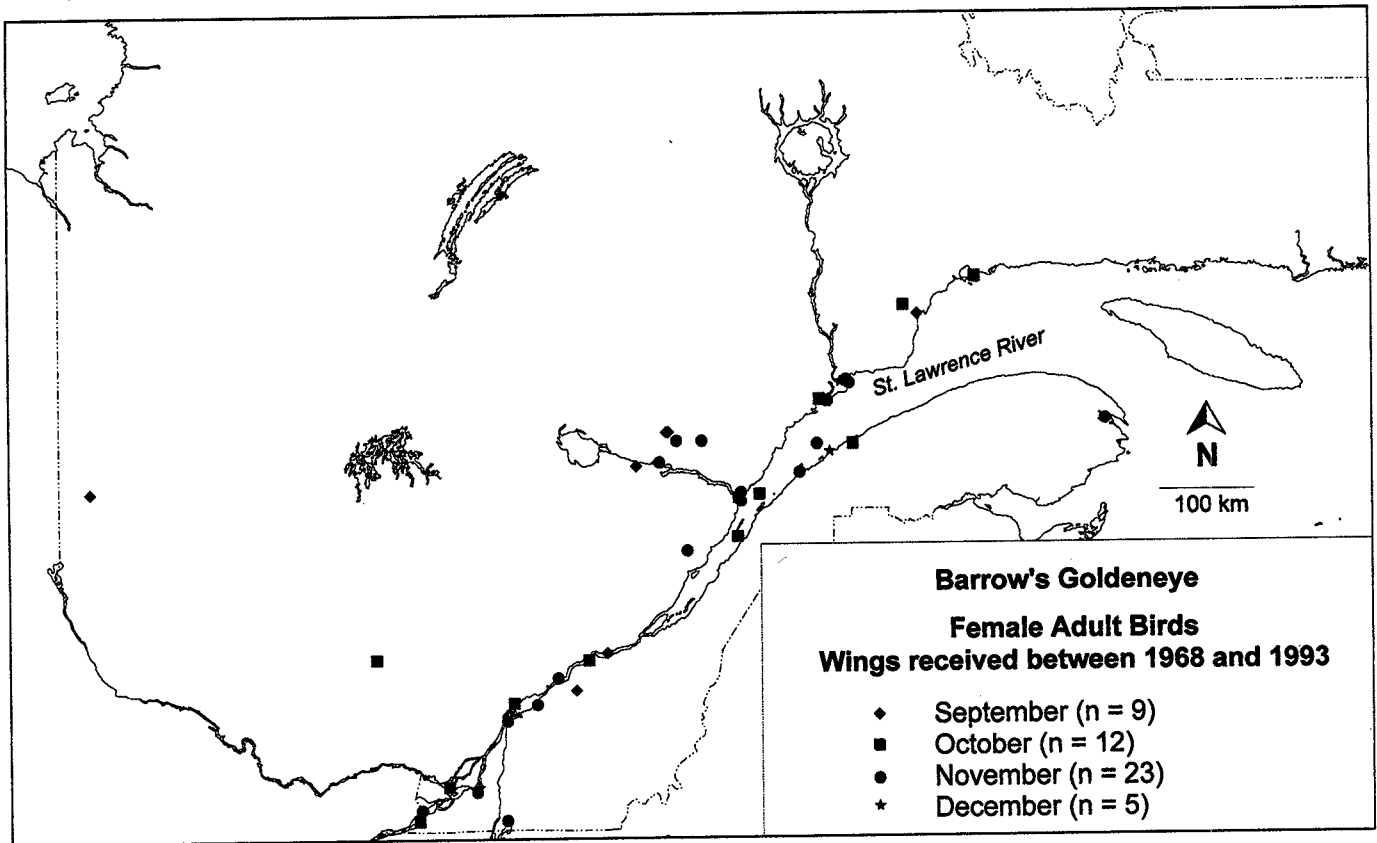


Figure 7
Monthly distribution and location of the harvest of juvenile Barrow's Goldeneye in Quebec

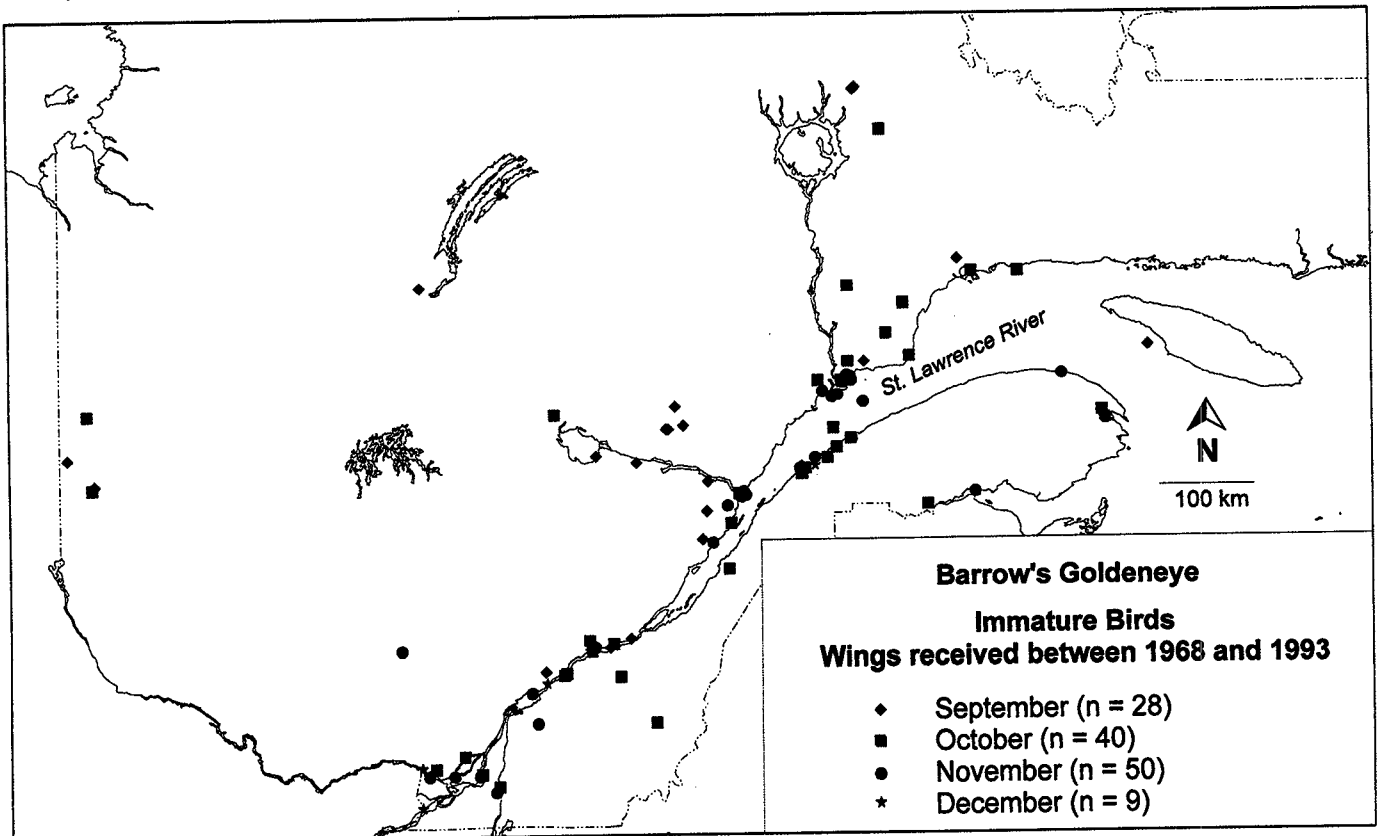


Figure 8

Comparative harvest of Barrow's and Common goldeneyes in Quebec according to hunting area and age

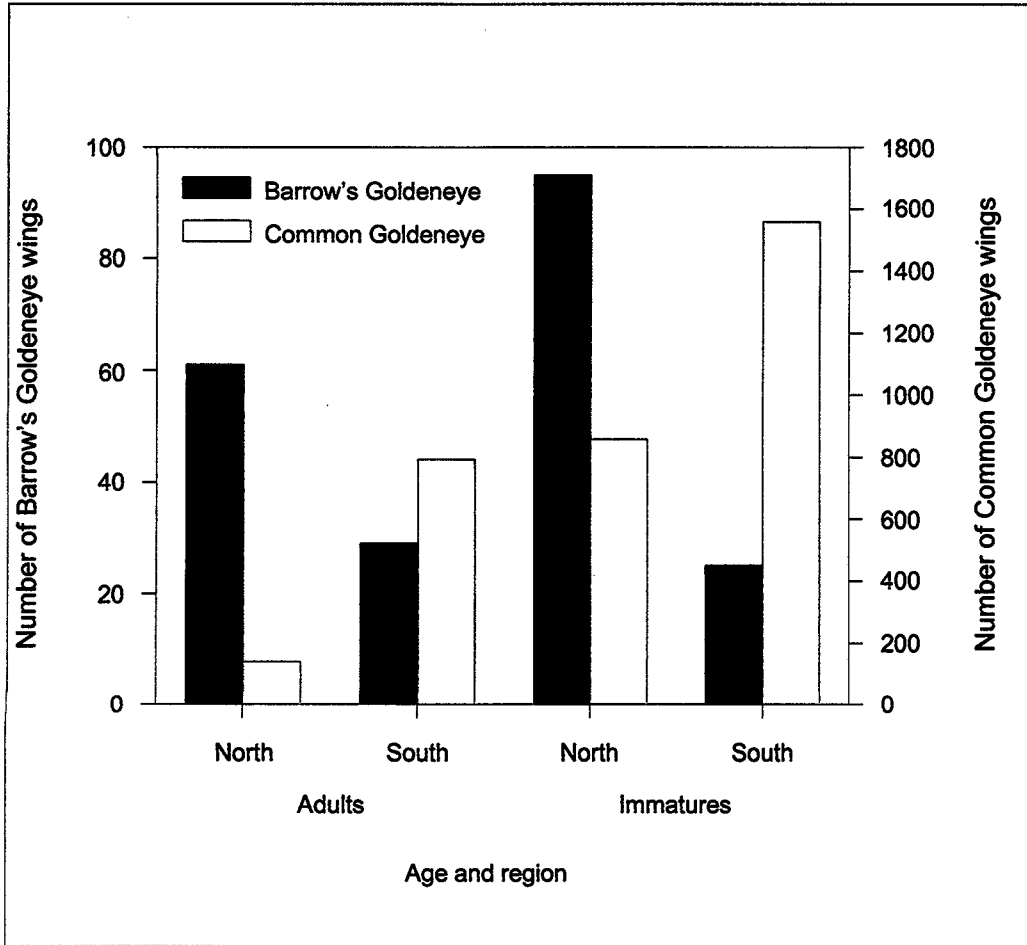
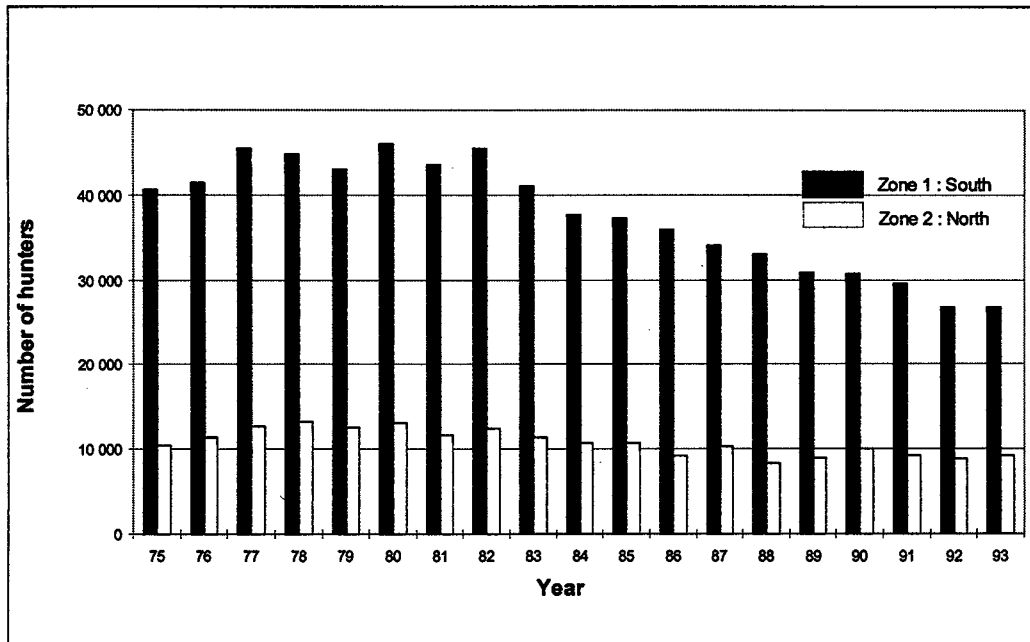


Figure 9

Number of active hunters in Quebec between 1975 and 1993



5.4 Hunting

Hunting mortality has to be better quantified and possibly regulated. Hunters should be informed of the status of Barrow's Goldeneye in the east and encouraged to avoid hunting them or at least participate in the monitoring of the goldeneye harvest. Given the localized nature of the harvest and, occasionally, the specialized equipment needed to hunt goldeneyes, it may be possible to identify groups that target Barrow's Goldeneye in their hunting activities.

We need more intensive monitoring of the Barrow's Goldeneye harvest to see whether any special regulations and/or information programs are successful. Also, given the general decline of goldeneyes in the eastern flyway and in Quebec (Wyndham and Dickson 1995), closer monitoring of both goldeneye species is warranted.

5.5 Monitoring

We need to better assess the size of the eastern population and monitor it. Which type of surveys (breeding pair, moulting, or winter) will prove the most efficient remains to be determined.

5.6 Migration and staging areas

Harvest surveys suggest different migration and staging areas for adult males, adult females, and juveniles. Because these patterns affect their vulnerability to hunting, they need to be better understood. Inland areas used by Barrow's and Common goldeneyes in August, September, and October are poorly known in Quebec. Whether the birds are widely scattered or concentrated at a few staging sites needs to be determined.

5.7 Genetic status

There are currently three isolated populations of Barrow's Goldeneye: one in Iceland (600–1200 birds), one in eastern North America (2000–4000 birds), and one in western North America (over 100 000 birds) (Savard 1987). There have been no morphometric or genetic comparisons of these three populations. If eastern North American Barrow's Goldeneyes prove to be genetically distinct, this would provide us with further cause to conserve this unique population.

6.0 Discussion

It is quite obvious that we know little about the eastern population of Barrow's Goldeneye. All evidence suggests a small population (2000–4000 birds) wintering mainly within the St. Lawrence estuary. Some immature birds may winter with large flocks of Common Goldeneye in the upper St. Lawrence River, but this remains to be confirmed and quantified. Based on breeding pair sightings, the Barrow's Goldeneye breeding area may be large in Quebec but could be impacted by intensive logging activities within the boreal forest, as the birds rely on tree cavities for nesting. Whether they require special kinds of breeding lakes is unknown, but a preference for highly productive fishless lakes (as in the western population) is a strong possibility. If

such a preference exists, fish enhancement or introduction programs by outfitters and the provincial government would have to be reviewed. Once breeding areas are confirmed, the impact of logging could be reduced by undertaking a nest box program. Such a program has proved successful in increasing the population in British Columbia (Savard 1988b).

The fact that the species is still hunted is a cause for concern. Possible ways of reducing hunting mortality were considered in the new hunting restrictions implemented in Quebec in 1995. Goldeneye hunting was closed in November and December within the St. Lawrence estuary, a time when most Barrow's Goldeneyes arrive and start concentrating at several known wintering sites. Most of the kill is concentrated at three locations within the St. Lawrence valley, and, along with special regulations, special hunter information programs should be considered for these areas. Because of the difficulties of identifying Common and Barrow's goldeneyes in the fall, a complete ban of Barrow's Goldeneye hunting may prove difficult to achieve without a similar ban on Common Goldeneye hunting. This is why it is urgent to increase our knowledge of Barrow's Goldeneye in the east. By better understanding their ecology, the hunting pressure they endure, and the other threats they face, we may be able to maintain this population without drastic measures. In this approach, the Canadian Wildlife Service has successfully obtained the agreement of small groups of waterfowlers to locally monitor the composition of the goldeneye kill. Prevention was the guiding light in promulgating the new hunting restrictions in Quebec in 1995. However, we currently do not have the necessary mechanisms to more efficiently address the case of the Barrow's Goldeneye.

The concern with populations of Barrow's Goldeneye and Harlequin Ducks in the east highlights some of the weaknesses in our waterfowl management system. Little attention was paid to the eastern population of Harlequin Duck until it was given endangered status by the Committee on the Status of Endangered Wildlife in Canada. Will the eastern population of the Barrow's Goldeneye have to be classified as "threatened" or "endangered" before we spend research and monitoring efforts towards understanding its ecology? It is time that we put more efforts on our vulnerable and sensitive species (species with small populations or species that we know little about). Currently, money diverted to endangered species is spent only on threatened and endangered species, and the program is not set up to address vulnerable or sensitive species. Regular waterfowl management, research, and operations usually focus on the most exploited species, such as American Black Ducks *Anas rubripes* and geese. There are various ways of addressing vulnerable species, but it is crucial that we do so soon. One way of addressing this problem is to create a program devoted to vulnerable and sensitive species. Another way is to make our endangered species programs more forward-looking and productive by putting some efforts into prevention (i.e., 20–25% of endangered species funds allocated to vulnerable and sensitive species). Although this seems an obvious approach, it has not been encouraged. There should be an official list of vulnerable species as well as one for sensitive species, and funds should be allocated within each category so that the prioritization of projects is done within, rather than between, categories.

We need to replace our reactionary approaches with more proactive ones. This problem is not unique to species management but also applies to ecosystem management, where efforts are often concentrated totally on endangered ecosystems with no efforts put towards protecting healthy sensitive ones. Proactive conservation is essential for the long-term efficiency of our actions. It is actively being advocated (Tear et al. 1993; Noss et al. 1995), and it is an essential part of a holistic vision of conservation.

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Appendix 1: Abstracts

The use of nest site shelters by Common Eiders in the St. Lawrence river estuary

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Abstract

We monitored the use of 800 plywood nest shelters by Common Eider *Somateria mollissima* from 1985 through 1995 (6100 shelter-years) on four islands in the St. Lawrence estuary of Quebec. Shelters with and without central dividers received similar use, but large shelters (108 × 72 × 17 cm) were used to a greater extent than narrow ones (108 × 54 × 17). Nests under shelters were initiated earlier and suffered less predation by gulls but were more likely to be abandoned than nests under natural cover. On Blanche Island and on Île-aux-Alouettes, shelter use was high in the first year, fell somewhat after 2–3 years, and then rose again, perhaps as young females born under them were being recruited into the breeding population. Between 35% and 45% of the approximately 1000 nesting females currently use the 200 available shelters on Île-aux-Alouettes, a low gravel bar with sparse herbaceous cover. Five years after installation, all available shelters were in use (average number of nests per shelter on the two islands was 1.75 and 1.93, respectively). On medium-size, grassy (Pommes) or wooded (Gros Pèlerin) islands with a comparatively low density of nesting eiders, nest shelters were largely ignored by females. The technique seems appropriate only on small islands or reefs (<3 ha) with high density of nesting pairs (>500 nests/ha) and a paucity of robust (wooded or herbaceous) standing vegetation that can be used as natural cover. The technique can also be used whenever the natural cover has to be modified and is temporarily deficient.

Résumé

Nous avons surveillé l'utilisation de 800 abris de nidification en contreplaqué par l'Eider à duvet (*Somateria mollissima*) de 1985 à 1995 (6100 abris-années) sur quatre îles de l'estuaire du Saint-Laurent au Québec. Des abris avec et sans séparations centrales ont été utilisés de la même façon, mais les abris de grande dimension (108 cm × 72 cm × 17 cm) ont été plus utilisés que les abris étroits (108 cm × 54 cm × 17 cm). Les nids abrités ont été entrepris plus tôt et ont subi moins de prédation des goélands, mais étaient plus susceptibles d'être abandonnés que les nids sous couvert naturel. Sur l'île Blanche et l'île-aux-Alouettes, les abris ont été fortement utilisés la première année, un peu moins après deux à trois ans et davantage passé ce délai, peut-être occupés par les femelles nées sous ces abris et ayant atteint l'âge de se reproduire. Entre 35 p. 100 et 45 p. 100 des quelque 1000 femelles reproductrices utilisent actuellement les 200 abris disponibles sur l'île-aux-Alouettes, un banc de gravier au couvert herbacé clairsemé. Cinq ans après leur installation, tous les abris disponibles étaient utilisés (le nombre moyen de nids par abri sur les deux îles était de 1,75 et 1,93, respectivement). Dans des îles herbeuses de taille moyenne (Pommes) ou boisées (Gros Pèlerin) présentant une densité relativement basse d'eiders nicheurs, les abris de nidification étaient évités par l'ensemble des femelles. La technique semble appropriée seulement sur les petites îles ou les récifs (moins de 3 ha) présentant une forte densité de couples nicheurs (plus de 500 nids/ha) et une rareté de couvert végétal robuste sur pied (boisé ou herbacé) pouvant servir de couvert naturel. La technique peut également s'avérer utile quand le couvert naturel a été modifié ou est temporairement insuffisant.

Current breeding population of King Eiders in the western and central Canadian Arctic¹

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Abstract

Aerial surveys were conducted on Banks Island, 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. Based primarily on the results of these surveys and similar surveys in Queen Maude Gulf, we estimated a breeding population of 200 000–250 000 King Eiders in the western and central Canadian Arctic. About 65% of the eiders were on Victoria Island and 20% on Banks Island. Our estimate suggests that the western Arctic population of King Eiders that breeds within Canada may have declined by 75% in the last 30 years. However, there are several factors that make it difficult to compare our estimate with the earlier one, including a lack of systematic surveys for the earlier estimate and uncertainty about the accuracy of our visibility correction factor. Nonetheless, our data are one more piece of evidence suggesting that North Pacific Rim eiders are in decline.

Résumé

Des relevés aériens ont été menés sur les îles Banks et Victoria et sur le continent dans l'ouest de l'Arctique canadien de 1991 à 1994 pour établir l'abondance et la distribution des Eiders à tête grise (*Somateria spectabilis*) dans leur aire de nidification. En s'appuyant principalement sur les résultats de ces études et d'études semblables dans le golfe de la Reine-Maude, nous avons estimé la population nicheuse comme comptant entre 200 000 et 250 000 Eiders à tête grise dans l'ouest et le centre de l'Arctique canadien. Environ 65 p. 100 des eiders se trouvaient sur l'île Victoria et 20 p. 100 sur l'île Banks. Notre évaluation indique que la population d'Eiders à tête grise de l'ouest de l'Arctique qui se reproduit au Canada pourrait avoir diminué de 75 p. 100 au cours des 30 dernières années. Toutefois, plusieurs facteurs rendent difficile la comparaison de notre évaluation avec l'évaluation antérieure, notamment le manque d'études systématiques appuyant l'évaluation antérieure et l'incertitude relative à notre facteur de correction de la visibilité. Néanmoins, nos données donnent une preuve de plus de la diminution des eiders sur la côte septentrionale du Pacifique.

¹ Complete results of this study can be found in: Dickson, D.L.; Cotter, R.C.; Hines, J.E.; Kay, M.F. 1997. Distribution and abundance of King Eiders in the western Canadian Arctic. Pages 29–39 in D.L. Dickson (ed.), King and Common eiders of the western Canadian Arctic. Can. Wildl. Serv. Occas. Pap. No. 94, Ottawa.

Parasitism, population dynamics, and hybridization in cavity-nesting sea ducks

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Abstract

Intraspecific and interspecific brood parasitism occur frequently in waterfowl. We examine the consequences of these behaviours on the population dynamics of Barrow's and Common goldeneyes (*Bucephala islandica* and *B. clangula*) during a 10-year study period in central British Columbia. The frequency of parasitism was significantly related to population density and to the availability of nest sites. High levels of parasitism, in turn, resulted in reduced reproductive success of females. Using a simulation model based on field data, we demonstrate that high frequencies of intraspecific parasitism can result in the extinction of local populations. Brood parasitism between species leads to the additional complication that parasite offspring may become sexually imprinted on the host species, thereby facilitating cross-mating and interspecific hybridization. We test this hypothesis using 1) a comparative analysis of the Anseriformes and 2) field studies and molecular genetic analyses of interspecific hybridization in goldeneyes. Our results demonstrate that social interactions such as brood parasitism may play an important role in determining the long-term viability of local populations.

Résumé

Le parasitisme de la reproduction intraspécifique et interspécifique est fréquent chez la sauvagine. Nous examinons les conséquences de ces comportements dans la dynamique de la population de Garrots d'Islande et de Garrots à œil d'or (*Bucephala islandica* et *B. clangula*) durant une étude de dix ans dans le centre de la Colombie-Britannique. La fréquence du parasitisme était étroitement liée à la densité de population et à la disponibilité des sites de nidification. Les niveaux de parasitisme élevés, eux, résultaient de la baisse du succès reproductif des femelles. Au moyen d'un modèle de simulation s'appuyant sur des données recueillies sur le terrain, nous avons démontré que la fréquence élevée de parasitisme intraspécifique peut entraîner la disparition des populations locales. Le parasitisme de la reproduction entre espèces peut apporter une complication supplémentaire, car la progéniture parasite peut porter son choix sexuel à l'espèce hôte, facilitant ainsi l'accouplement et l'hybridation entre espèces différents. Nous mettons à l'essai cette hypothèse au moyen 1) d'une étude comparative des Anseriformes et 2) d'études sur le terrain et d'analyses génétiques de l'hybridation interspécifiques chez les garrots. Nos résultats démontrent que les interactions sociales, comme le parasitisme de reproduction, peuvent jouer un rôle important pour déterminer la viabilité à long terme des populations locales.

Distribution and abundance of sea ducks wintering in Chesapeake Bay

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Abstract

Surveys of sea ducks were flown throughout Chesapeake Bay approximately every two weeks from 14 December 1992 to 3 March 1993. East-west transects extending from shore to shore were flown along every fourth minute of latitude during each two-week period until each minute line of the bay had been surveyed. All birds were counted within a 60-m strip on each side of the Cessna 185 aircraft on floats from an altitude of 43 m. This survey design censused approximately 6% of the bay. This survey allowed us to estimate populations in the mainstream of Chesapeake Bay. A minimum of 115 000 Surf Scoters *Melanitta perspicillata*, 90 000 Oldsquaw *Clangula hyemalis*, 60 000 Bufflehead *Bucephala albeola*, 45 000 Red-breasted Mergansers *Mergus serrator*, 40 000 Common Goldeneyes *Bucephala clangula*, 26 000 Black Scoters *Melanitta nigra*, and 15 000 White-winged Scoters *Melanitta fusca* winter on the bay. By contrast, the mean count of the 1991–1994 midwinter waterfowl survey (conducted only along the shores) found less than 3% of the Oldsquaw and scoters and about half of the Buffleheads, goldeneyes, and mergansers. The time of each sighting was recorded and later integrated with positions from a global positioning system. Sightings were integrated with a coverage of water depths in a geographic information system to determine habitat preferences.

Résumé

On a effectué des relevés aériens des canards de mer de la baie de Chesapeake environ toutes les deux semaines du 14 décembre 1992 au 3 mars 1993. On évaluait des transects est-ouest, allant d'une rive à l'autre toutes les quatre minutes de latitude durant une période de deux semaines jusqu'à ce que chaque minute ait été relevée. Tous les oiseaux ont été comptés dans une bande de 60 m de chaque côté de l'hydravion Cessna 185 d'une altitude de 43 m. Ce relevé a permis de recenser environ 6 p. 100 de la baie et d'évaluer la population dans la partie principale de la baie de Chesapeake. Un minimum de 115 000 Macreuses à front blanc (*Melanitta perspicillata*), de 90 000 Hareldes kakawis (*Clangula hyemalis*), de 60 000 Petits Garrots (*Bucephala albeola*), de 45 000 Harles huppés (*Mergus serrator*), de 40 000 Garrots à œil d'or (*Bucephala clangula*), de 26 000 Macreuses noires (*Melanitta nigra*) et de 15 000 Macreuses à ailes blanches (*Melanitta fusca*) hivernent dans la baie. Par contraste, de 1991 à 1994, le compte mi-hivernal de sauvagine (mené seulement le long des rives) indiquait moins de 3 p. 100 des Hareldes kakawis et des macreuses et environ la moitié des Petits Garrots, des Garrots à œil d'or et des harles. Le moment de chaque observation a été noté et ajouté par la suite aux positions d'un Système de positionnement global. L'observation fut intégrée à une étude des profondeurs aquatiques dans un système d'information géographique pour établir les préférences d'habitats.

Distribution, abundance, and structure of Harlequin Duck populations in Prince William Sound, Alaska

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Abstract

In response to mortality from the 1989 T/V *Exxon Valdez* oil spill, Harlequin Duck *Histrionicus histrionicus* populations were surveyed in Prince William Sound in 1995 to assess the extent of recovery of ducks inhabiting oiled areas and determine if low reproductive success resulted in changes in age and sex structure of the population. Shoreline surveys monitored abundance, distribution, population structure, and productivity in oiled and unoiled areas. Surveys conducted from early May to mid-June compare temporal changes in abundance and population structure (number of breeding pairs, subadult males, unpaired adult males, and unpaired females) within and between oiled and unoiled areas. Breeding pairs were used to evaluate breeding chronology and estimate size of the local breeding population. Plumage patterns in spring were used to age males to one of three classes (one year, two years, adult). Surveys conducted from mid-June through mid-September identify moult chronology and compare changes in sex ratios and abundance. Brood surveys compare productivity. Seasonal changes in population structure throughout the two survey periods provide insights into Harlequin Duck movements to and from the study area.

Résumé

En réaction à la mortalité résultant du déversement de pétrole de l'*Exxon Valdez* en 1989, on a surveillé les populations d'Arlequins plongeurs (*Histrionicus histrionicus*) dans le golfe du Prince-William en 1995 pour évaluer l'étendue de la récupération des individus habitant les zones polluées et établir si la baisse de reproduction a eu pour résultat une modification des structures d'âge et des composantes démographiques. Des relevés sur la rive portaient sur l'abondance, la distribution, la structure de population et la productivité dans des zones touchées et non touchées par le pétrole. Les relevés menés du début de mai à la mi-juin comparent les modifications temporelles de l'abondance et de la structure de la population (nombre de couples nicheurs, de mâles immatures, de mâles adultes non accouplés et de femelles non accouplées) dans les secteurs souillés et non souillés et entre ces derniers. Les couples nicheurs ont servi à évaluer la chronologie de reproduction et à évaluer la taille des populations nicheuses locales. L'observation du plumage printanier servait à déterminer l'âge des mâles (un an, deux ans, adulte). Des relevés menés de la mi-juin à la mi-septembre ont permis d'établir la chronologie de la mue et de comparer l'évolution du rapport entre les sexes et l'abondance. Des relevés des reproducteurs ont permis de comparer la productivité. Les changements saisonniers de la structure de population tout au long des deux périodes de relevé ont apporté des renseignements sur les déplacements des Arlequins plongeurs quittant le site et s'y rendant.

Prebreeding and early breeding behaviour of Steller's and King eiders as related to lemming populations

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Abstract

The breeding ecology of King Eider *Somateria spectabilis* and Steller's Eider *Polysticta stelleri* was studied in June and July, 1993–1995, at the Lena River Delta (Northern Yakutia). In the year with moderate lemming numbers (1993), Steller's Eiders nested in high densities, nest desertion was rare, and males departed by mid-July. Nesting success was low. In years with low (1994) or very low (1995) lemming densities, nesting density of Steller's Eider was reduced to <30% of that observed in 1993. High rates of nest desertion and egg dumping occurred, and many females left the nesting grounds with males in late June. Some males remained on the nesting grounds with females until early August. No successful nests were found. King Eiders nested in similar densities each year. Nest abandonment and egg dumping were rare. Nesting success was variable, with higher success in years with greater densities of lemmings.

Résumé

L'écologie reproductive des Eiders à tête grise (*Somateria spectabilis*) et des Eiders de Steller (*Polysticta stelleri*) a été étudiée en juin et en juillet des années 1993 à 1995, au delta de la rivière Lena (nord de la Yacoutie). Au cours de l'année à population de lemmings modérée (1993), les Eiders de Steller nichaient en forte densité, la désertion des nids était rare et les mâles s'en allaient à la mi-juillet. Le succès de la nidification était peu élevé. Dans les années où la densité de lemmings était basse (1994) ou très basse (1995), la densité de la nidification des Eiders de Steller était réduite à moins de 30 p. 100 de celle observée en 1993. On observait un taux de désertion et d'élimination d'œufs, et un grand nombre de femelles laissaient l'aire de nidification avec les mâles vers la fin de juin. Certains mâles restaient sur les lieux de nidification avec les femelles jusqu'au début août. On ne trouva aucun nid fécond. La densité des nids des Eiders à tête grise restait semblable d'une année à l'autre. L'abandon des nids et l'élimination des œufs étaient rares. Le succès de la reproduction était variable et plus élevé pendant les années de haute densité de lemmings.

Migration of King and Common eiders past Point Barrow, Alaska — spring and summer/fall, 1994¹

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Abstract

King and Common eiders (*Somateria spectabilis* and *S. mollissima*) pass Point Barrow, Alaska, during both the spring and summer/fall migrations. We conducted counts to document the species and sex composition and the timing of both migrations and to monitor trends in population sizes. Both migrations are characterized by the arrival of King Eiders followed by Common Eiders 5–15 days later. Eiders appear to be paired when they pass by Point Barrow in the spring. During the summer/fall migration, males appear in mid-July, followed by females in early August and young of the year after early September. Estimates of the numbers of King and Common eiders were considerably lower in 1994 than estimates from counts conducted at Barrow during the last 40 years; King Eiders numbered ~373 000 in the spring and ~278 000 in the summer, and Common Eiders numbered ~71 000 in the spring and ~62 000 in the fall. A previous estimate from 1976 placed King and Common eider numbers at ~800 000 and ~150 000, respectively.

Résumé

Les Eiders à tête grise et les Eiders à duvet (*Somateria spectabilis* et *S. mollissima*) passent par Point Barrow, en Alaska, durant les migrations du printemps et de celles de l'été et l'automne. Nous avons effectué des comptes pour établir la composition des espèces et des sexes ainsi que le moment des deux migrations, et pour surveiller les tendances de la taille des populations. Les deux migrations sont caractérisées par l'arrivée des Eiders à tête grise, suivie de celle des Eiders à duvet, de 5 à 15 jours plus tard. Les eiders semblent accouplés quand il passent par Point Barrow au printemps. Durant la migration d'été/automne, les mâles font leur apparition à la mi-juillet, suivis par les femelles au début d'août, et les jeunes de l'année suivent au début de septembre. Les évaluations du nombre d'Eiders à tête grise et à duvet étaient beaucoup plus basses en 1994 que celles des 40 années antérieures effectuées à Barrow. Le nombre d'Eiders à tête grise s'élevait à ~373 000 au printemps et à ~278 000 à l'été, tandis que le nombre d'Eiders à duvet s'élevait à ~71 000 au printemps et à ~62 000 à l'automne. Une évaluation antérieure, en 1976, estimait le nombre d'Eiders à tête grise et à duvet à ~800 000 et à ~150 000, respectivement.

¹ Complete results of this study can be found in: Suydam, R.; Quakenbush, L.; Johnson, M.; George, J.C.; Young, J. 1997. Migration of King and Common eiders past Point Barrow, Alaska, in spring 1987, spring 1994, and fall 1994. Pages 21–28 in D.L. Dickson (ed.), King and Common eiders of the western Canadian Arctic. Can. Wildl. Serv. Occas. Pap. No. 94, Ottawa.

Preliminary results of Harlequin Duck breeding population surveys on the Kodiak National Wildlife Refuge, Alaska

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Abstract

Abundance and distribution of Harlequin Ducks *Histrionicus histrionicus* in coastal and freshwater habitats of the Kodiak National Wildlife Refuge were determined in 1994 and 1995. Coastal surveys were conducted within the Exxon Valdez oil spill impact zone, while interior surveys focused on watersheds known to receive the most public use. Surveys covering over 900 km of shoreline in western Kodiak Island archipelago adjacent to Shelikof Straits were conducted twice (May and August) during the breeding seasons of 1994 and 1995. All observations within the 200-m survey zone were logged directly into an onboard computer interfaced with a global positioning system unit. The number of Harlequin Ducks decreased 16% between the May (n = 4369) and August (n = 3684) surveys of 1994, but a 10% increase in total numbers was seen during the same period in 1995 (May, n = 3317; August, n = 3693). Ninety-six sightings of Harlequin Ducks were recorded for five interior watersheds. A minimum of 65 coastal and 11 interior broods containing 248 and 34 young, respectively, was found during the two years of surveys. Coastal densities of Harlequin Ducks declined from 5.1 (May) to 3.7 (August) ducks/km of shoreline in 1994 and remained constant at 4 ducks/km of shoreline during both 1995 surveys.

Résumé

On a établi, en 1994 et 1995, l'abondance et la distribution des Arlequins plongeurs (*Histrionicus histrionicus*) dans les habitats côtiers et d'eau douce du Kodiak National Wildlife Refuge. Des relevés côtiers ont été effectués dans la zone d'impact du déversement de pétrole de l'Exxon Valdez, tandis que des relevés à l'intérieur des terres se concentraient sur les bassins hydrographiques les plus utilisés par le public. Des relevés couvrant plus de 900 km de rive dans l'archipel occidental Kodiak, adjacent au détroit de Shelikof, ont été effectués deux fois (mai et août) durant les saisons de reproduction de 1994 et 1995. Toutes les observations dans une zone de 200 m ont été inscrites directement dans un ordinateur relié à un système de positionnement global. Le nombre d'Arlequins plongeurs a diminué de 16 p. 100 entre le relevé de mai (n = 4369) et celui d'août (n = 3684) en 1994, mais on a constaté une hausse de 10 p. 100 des nombres totaux durant la même période de 1995 (mai, n = 3317; août, n = 3693). Quatre-vingt-seize observations d'Arlequins plongeurs ont été enregistrées pour cinq bassins hydrographiques intérieurs. Un minimum de 65 couvées côtières et de 11 couvées intérieures contenant 248 et 34 jeunes, respectivement, a été trouvé durant les deux années de relevé. Les densités côtières d'Arlequins plongeurs ont baissé de 5,1 (mai) à 3,7 (août) arlequins/km de rive en 1994, et sont demeurées constantes à 4 arlequins/km de rive durant les relevés de 1995.

Population trends of sea ducks wintering in Kodiak, Alaska — a 16-year study

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Abstract

We have conducted shipboard surveys of marine birds in Uyak and Uganik bays on the western shore of Kodiak Island each February since 1980. Birds were censused within 300-m strip transects of 10 minutes' duration run from shore to shore. The same cruise tracts were followed each year, resulting in about 135 transects covering about 110 km², or 19% of the surface of the bays. Population increases were seen in Barrow's Goldeneye *Bucephala islandica*, Harlequin Duck *Histrionicus histrionicus*, Common Merganser *Mergus merganser*, and Red-breasted Merganser *Mergus serrator*. Relatively stable populations were found for Surf Scoters *Melanitta perspicillata*, Black Scoters *Melanitta nigra*, and Oldsquaw *Clangula hyemalis*. White-winged Scoters *Melanitta fusca* have shown a slight decline over the past 15 years. Declines in Barrow's Goldeneye, Oldsquaw, and all scoters were seen following the *Exxon Valdez* oil spill, but not in Harlequin Ducks, mergansers, or Bufflehead *Bucephala albeola*. Little oil actually entered these bays, and many birds had departed for breeding areas by the time the oil arrived. Population variation is compared with the U.S. Fish and Wildlife Service waterfowl breeding population survey and band recoveries.

Résumé

Nous avons effectué des relevés d'oiseaux marins à partir d'embarcations dans les baies d'Uyak et d'Uganik sur la côte nord de l'île Kodiak tous les mois de février depuis 1980. Les oiseaux ont été recensés dans des transects de 300 m dans un parcours de 10 minutes d'une rive à l'autre. Le même parcours a été suivi tous les ans, donnant environ 135 transects couvrant environ 110 km², ou 19 p. 100 de la surface des baies. On a constaté des hausses de population de Garrots à œil d'or (*Bucephala islandica*), d'Arlequins plongeurs (*Histrionicus histrionicus*), de Grands Harles (*Mergus merganser*) et de Harles huppés (*Mergus serrator*). Les populations de Macreuses à front blanc (*Melanitta perspicillata*), de Macreuses noires (*Melanitta nigra*) et d'Hareldes kakawis (*Clangula hyemalis*) étaient relativement stables. Les Macreuses à ailes blanches (*Melanitta fusca*) ont subi un léger déclin au cours des 15 dernières années. On a constaté une baisse des populations de Garrots d'Islande, d'Hareldes kakawis et de toutes les macreuses à la suite du déversement de pétrole de l'*Exxon Valdez*, mais pas d'Arlequins plongeurs, de Harles ou de Petits Garrots (*Bucephala albeola*). Peu de pétrole a pénétré ces baies et de nombreux individus avaient quitté les lieux pour se rendre à des aires de reproduction avant l'arrivée du pétrole. La variation de population est comparée à celle des relevés de sauvagine nicheuse et à la récupération de bagues du *Fish and Wildlife Service* des États-Unis.

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