HABITAT AND ARTIFICIAL SHELTER USE BY AMERICAN EIDER (*Somateria mollissima dresseri* Sharpe) NESTING ON THE EASTERN SHORE OF NOVA SCOTIA

BY

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ABSTRACT

American Eider nesting habitats were studied within the Eastern Shore Islands Wildlife Management Area of Nova Scotia in 1992 and 1993. The importance of island size, distance to the mainland and presence of other nesting seabirds to nesting eider were investigated at an island scale. The use of natural cover types, the value of artificial shelters as alternative nesting sites and the reproductive importance of natural cover types and artificial shelters were all examined.

Islands surveyed ranged from 0.8 to 14.8 hectares in size and from 1.3 to 7.1 kilometres in distance from the mainland. Neither characteristic was an accurate predictor of eider nesting populations. Eiders and gulls nested on the same islands in the WMA. Gull presence did not appear to limit eider nesting populations.

The largest proportion of nests were recorded for shrub growth of gooseberry. Nests were sparsely scattered in barren cover while beach and forest cover were generally avoided as nesting cover. Deadfalls were particularly important for nests in sparse vegetative cover, with 59% of nests in barren cover recorded under deadfalls.

Low shelter use (0 to 1.4%) on most islands was attributed to the placement of shelters in cover normally avoided by eiders. Use of shelters was much higher (38%) on Inner East Bird Island where shelters were located throughout tall grasses and ferns. There was a high rate of reuse of nesting sites under shelters in consecutive years.

Clutch sizes were significantly lower in beach cover than under gooseberry cover. Nests in the least favored cover types were the most vulnerable to predation. Overall nest loss was 16% in 1992 and 17% in 1993. Nests under beach cover were the most vulnerable while nests under tuckamoor and shelters were most likely to hatch successfully.

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I would like to dedicate this thesis to Cyril Coldwell, a true gentleman, fondly remembered.

I. INTRODUCTION

The Common Eider, *Somateria mollissima* (Linnaeus), nests primarily on isolated coastal islands of temperate North America, Europe and Asia. The breeding range of the American subspecies, *S. m. dresseri* Sharpe, extends from south-central Labrador, Newfoundland and eastern Quebec to Nova Scotia, New Brunswick and Maine (Lock 1986). The highest known concentration of nesting eider in Nova Scotia occurs on the eastern shore between Clam Harbour and Tor Bay with a number of important nesting islands located in the Eastern Shore Islands Wildlife Management Area (hereafter referred to as the WMA).

Eiders have been observed to use a variety of nesting habitats throughout their breeding range, from unvegetated sand and gravel barrier islands on the Central Beaufort Sea coast of Alaska (Johnson *et al.* 1987) to softwood forest in the Grand Manan Archipelago of New Brunswick (Minot 1976). Several studies have documented the importance of grasses as eider nesting cover (Gross 1944, Milne and Gorman 1974) while others have found that eiders exhibited a preference for nesting in patches of woody shrubs (Reed 1964, Sabean 1972, van Dijk 1986).

Sparse vegetative cover has been found to be associated with high levels of nest predation, particularly by avian predators (Bourget 1973, van Dijk 1986, Götmark and Åhlund 1988). Artificial nest shelters have been used for protection of nest sites for eider in areas of poor natural cover. Manmade stone shelters have been used in Norway and Iceland to protect nesting females of the Northern race, *S. m. borealis* (Brehm), from avian predators (Munro 1961, Doughty 1979). Clark (1968) found that American Eiders nesting under wooden shelters in Penobscot Bay, Maine, had significantly higher nesting success than nests in natural vegetation. A later study conducted by Korschgen (1976) in Penobscot Bay, reported that older females not only nested under artificial shelters but also produced significantly greater clutch sizes than hens nesting in natural cover. American

Eider readily use artificial wooden shelters in the St. Lawrence Estuary (Lacroix and Smallwood 1989) and off the coast of Newfoundland and Labrador (Gilliland *et al.* 1996).

The size of an island and the distance from an island to the mainland have also been considered important for eiders nesting in Maine (Blumton *et al.* 1988) where there is a high incidence of recreational use by boaters and cottage owners on large islands close to shore. Although human disturbance may not yet be as common along the coastline of Nova Scotia, island size and distance to the mainland may still be of importance where the distribution of predators, such as corvids and mustelids, may also be a factor.

Common Eider - gull interactions have been found to range from beneficial (Schamel 1977, Gerell 1985) to neutral (Pimlott 1952, Götmark and Åhlund 1984) and detrimental for nesting eider (Bourget 1973, van Dijk 1986). If there is a relationship between eider and gull nesting populations on islands in the study area it may be helpful in determining island suitability in other areas. Similarly, an island which is capable of supporting a nesting colony of cormorants may also offer favorable or unfavorable conditions for nesting eiders.

The Wildlife Division of the Nova Scotia Department of Natural Resources has undertaken annual breeding seabird surveys on selected islands within the WMA since 1977 (Austin-Smith *et al.* 1987, 1991). As a result of these surveys, estimates of eider breeding populations exist for islands along this part of the coast. Less is known about breeding populations in other parts of Nova Scotia. An understanding of eider nesting habitat within the WMA can be applied to the monitoring of breeding populations elsewhere in the province. Knowledge of the physical characteristics of nesting islands and the vegetation cover types most often used as nesting cover may be applicable in determining which unsurveyed islands possess suitable nesting habitat and are potential candidates for ground surveys. The distance between an island and the mainland, the size of an island, and the presence of nesting seabirds were chosen for examination at an island scale. The type of vegetative cover used by nesting eider was chosen for study at the scale of an individual nest site. To determine if eider would use artificial nesting shelters on Nova Scotian islands, wooden and plastic shelters were erected on a number of islands in the WMA. Shelter effectiveness was assessed by comparing use and reproductive success among natural vegetation cover types and artificial shelters. The general objective of this thesis was to further knowledge concerning habitat use by breeding American Eider along the eastern shore of Nova Scotia.

With respect to characteristics of nesting islands, the following questions were posed:

(1) Was there a quantifiable relationship between the size of an island or distance from the mainland and the number of nesting eider?

(2) Was there a quantifiable relationship between the number of nesting gulls or cormorants and the number of nesting eider?

With respect to nest site selection in natural cover types, the following questions were examined:

(1) What vegetation cover types were most often used by nesting eider?

(2) How important were deadfalls as a component of eider nesting habitat?

With respect to artificial nest shelters, the following questions were considered:

(1) Did eiders nest under artificial nest shelters in the WMA? If so, what percentage were used and was there variation among different shelter types?

(2) How often were nest sites under shelters reused in consecutive years?

(3) Did shelter presence result in an increase in eider breeding populations?

With respect to reproductive success, the following questions were considered:

(1) Was there variation in clutch size among natural cover types? Were clutch sizes higher under artificial shelters than in natural cover types?

(2) Did the rate of nest predation vary among natural cover types? Were shelters effective in decreasing nest predation?

(3) Did overall nest success vary among natural cover types? Were shelters effective in increasing nest success?

II. DESCRIPTION OF STUDY AREA

The Eastern Shore Islands Wildlife Management Area was established in 1976 because of its importance as a breeding area for several species of seabirds. The WMA contains approximately 50 vegetated islands and 10 non-vegetated islets or ledges and stretches from Round Island off Beaver Harbour at 44°51' 62°24' to Little White Island off Marie Joseph Harbour at 44°54' 62°06' (Figure 1). Islands in the WMA range between 0.50 hectare to 31.50 hectares in size and from 1.35 km to 7.10 km in distance from the mainland.

Vegetation on islands within the WMA ranged from dense forest to sparse herbaceous growth. Wooded areas (Figure 2) were dominated by White Spruce, *Picea glauca*, and Balsam Fir, *Abies balsamea*, with scattered Black Spruce, *Picea mariana*, Mountain-Ash, *Sorbus americana*, Yellow Birch, *Betula alleghaniensis*, and Red Maple, *Acer rubrum*. The understory in wooded areas was primarily Bunchberry, *Cornus canadensis*, Wood Fern, *Dryopteris spinulosa*, Star-Flower, *Trientalis borealis*, and Wood-Sorrel, *Oxalis montana*. Krumholtz or tuckamoor was characterized by stunted, windblown softwoods with low bough cover (Figure 3). Standing dead softwoods were commonly associated with patches of Wild Raspberry, *Rubus strigosus* (Figure 4). Skunk-Currant, *Ribes glandulosum*, and Gooseberry, *Ribes hirtellum* (Figure 5), were abundant on some islands. Patches of American Dune-Grass, *Elymus mollis*, Cotton-Grass, *Eriophorum* spp., Blue Flag, *Iris versicolor*, and Cinnamon Fern, *Osmunda cinnamomea*, were also common on some islands (Figure 6). Tall herbaceous growth was dominated by Fireweed, *Epilobium angustifolium*, Curled Dock, *Rumex crispus*, and Meadow-Rue, *Thalictrum polygamum*. Black Crowberry, *Empetrum nigrum*, and short herbaceous growth of Sheep-Sorrel, *Rumex acetosella*, Yarrow, *Achillea lanulosa*, Spotted Touch-Me-Not, *Impatiens capensis*, Lion's-Paw, *Prenanthes trifoliolata*, Common Chickweed, *Stellaria media*, and Scotch Lovage, *Ligusticum scothicum*, were found on most islands (Figure 7). Beach vegetation was primarily Bindweed, *Convolvulus sepium*, Seaside Goldenrod, *Solidago sempervirens*, Seaside Aster, *Aster novi-belgii*, Cow-Parsnip, *Heracleum lanatum*, Beach Pea, *Lathyrus japonicus*, Seashore-Plantain, *Plantago juncoides*, and Silverweed, *Potentilla anserina* (Figure 8). A complete list of the plant species recorded during ground surveys in the WMA is presented in Appendix A.

In addition to American Eider, a number of seabirds nested on islands within the WMA. These included Leach's Storm Petrel, *Oceanodroma leucorhoa*, Great and Double-crested Cormorants, *Phalacrocorax carbo* and *P. auritus*, Arctic and Common Terns, *Sterna paradisaea* and *S. hirundo*, and Black Guillemot, *Cepphus grylle*. Greater Black-backed and Herring Gulls, *Larus marinus* and *L. argentatus*, commonly nested in the WMA and were important predators of eider nests and hatchlings. Other common breeding species included Osprey, *Pandion haliaetus*, Spotted Sandpiper, *Actitis macularia*, and Willet, *Catoptrophorus semipalmatus*. A pair of Bald Eagles, *Haliaeetus leucocephalus*, have nested on Brokenback Island since the spring of 1991. The American Crow, *Corvus brachyrhynchos*, and Northern Raven, *Corvus corax*, nested and predated eider nests on forested islands in the WMA.

The only resident mammal on most islands was the Meadow Vole, *Microtus pennsylvanicus*. Some of the larger wooded islands supported populations of introduced Snowshoe Hare, *Lepus americanus*, and transient White-tailed Deer, *Odocoileus virginianus*. Grey and Harbour Seals, *Halichoerus grypus* and *Phoca vitulina*, both pupped on islands in the area. Important mammalian predators of eider nests, hatchlings and adults were American Mink, *Mustela vison*, and River Otter, *Lutra canadensis*. Appendix B contains a complete list of the fauna observed in the WMA.

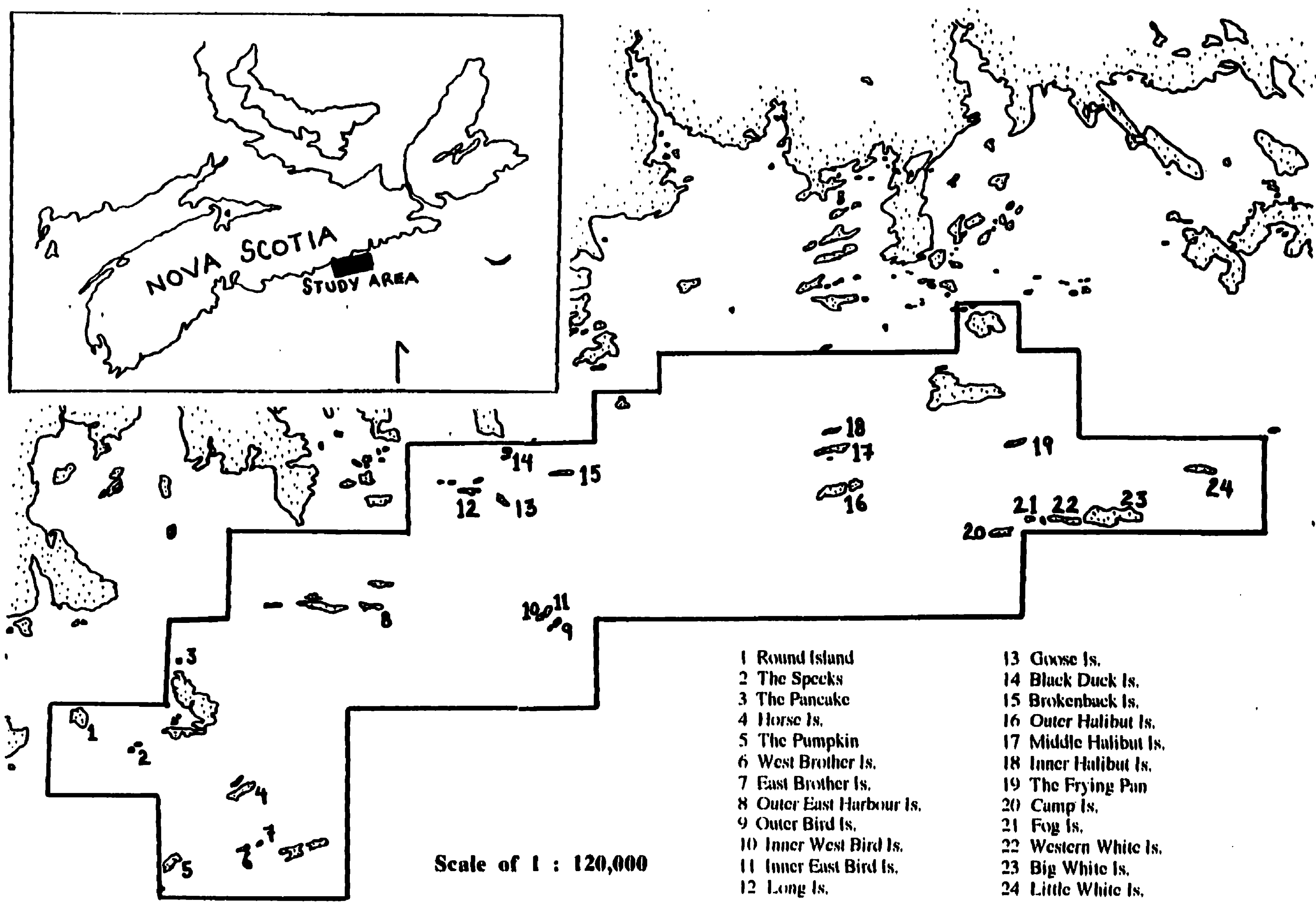


Figure 1: Map of Nova Scotia and the location of the principal study islands within the Eastern Shore Islands Wildlife Management Area (represented by the dark solid line).

Figure 2: Softwood forest on Outer East Harbour Island, June 1992.

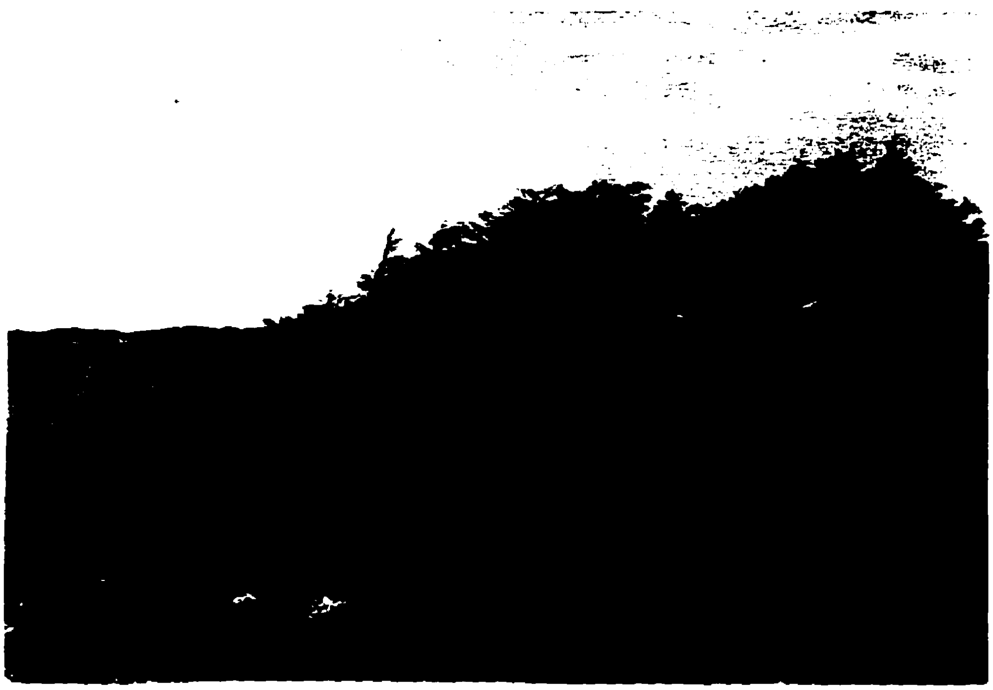


Figure 3: Tuckamoor on Middle Halibut Island, May 1992. The foreground is dominated by crowberry and sparse raspberry cane.

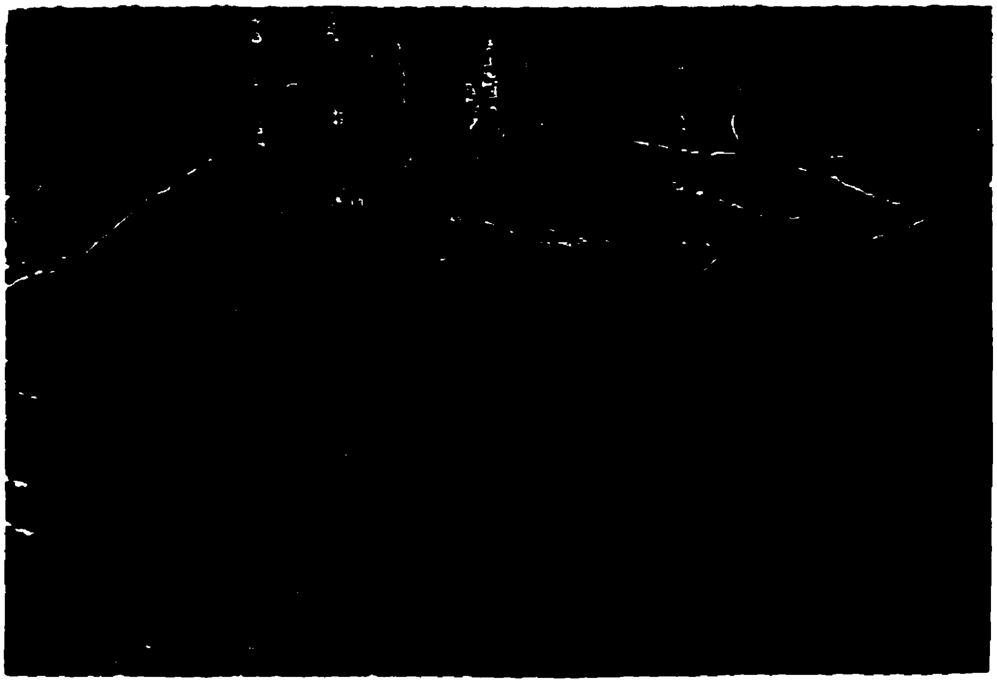


Figure 4: Standing deadwood and raspberry cover on Middle Halibut Island, May 1992.

Figure 5: Gooseberry cover on Inner Halibut Island, July 1992.

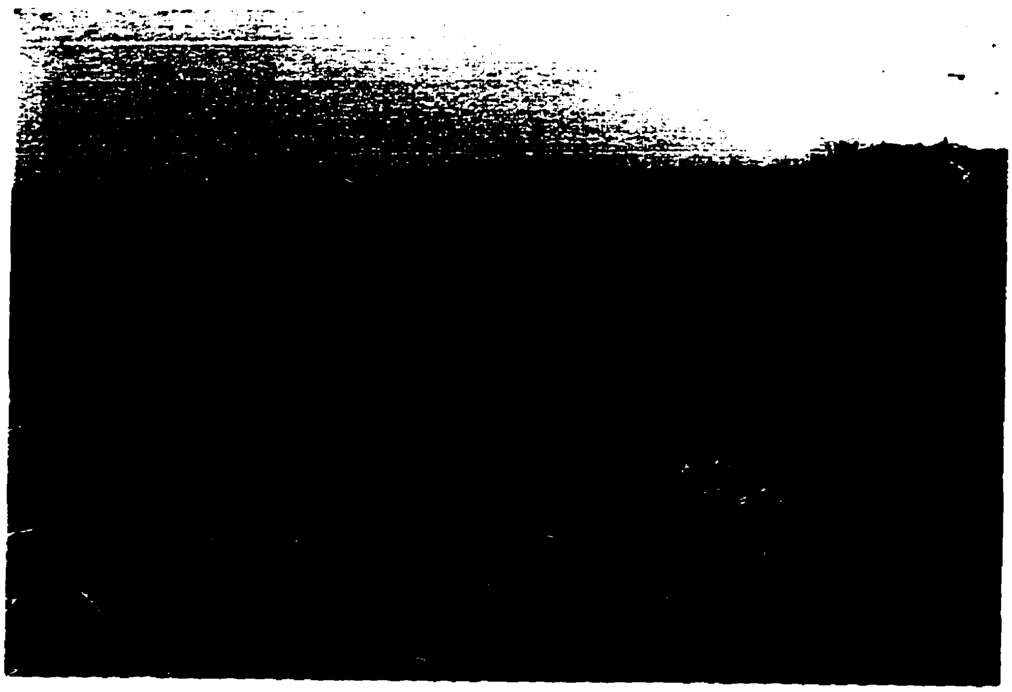


Figure 6: Tall grass on Inner East Bird Island, July 1992. A wooden nesting shelter can be seen on the hill in the background.

Figure 7: Barren area of low herbaceous growth on Little White Island, June 1992.

Figure 8: American Eider nest in beach vegetation on Inner East Bird Island, June 1992.

III. METHODS

III. 1 CHARACTERISTICS OF NESTING ISLANDS

Island sizes (area in hectares) were determined by digitizing 1 : 5,000 and 1 : 10,000 scale aerial photos with software provided by the Nova Scotia Department of Natural Resources. The digitizing program was developed by the Plant Examination Division of the Surveys and Mapping Branch and was run on a Commodore 40 computer. The accuracy of the digitizer was tested by taking repetitive measurements of the same area during four successive days of digitizing. These tests indicated that errors were compensatory and within ± 5% of the mean.

To examine the importance of the distance to the shoreline in nest site selection on larger islands, a transect survey was carried out during post-hatch in 1993 on Big White Island. Big White Island was the only predominantly wooded island on which eiders nested in any number within the WMA. Although nest densities within the woods were low, a large amount of nesting habitat was provided by the large size of the island (31.50 hectares). The outer side was bounded by tall grass and patches of raspberry and gooseberry along the forest edge. Transect lines were established across the width of the island. Each transect was divided into smaller 50 by 15 metre plots which were searched for active eider nests. The number of nests within 50, 100 and 150 metres from the shoreline were then tallied. A total of 21 plots, seven in each distance category, represented a total sampled area of 15,750 m^2.

The distance between an island and the nearest point on the mainland was measured from a 1 : 10,000 scale Nova Scotia Department of Natural Resources Forestry Inventory Map.

Breeding seabird surveys carried out in the spring and summer of 1992 and 1993 provided data on the number of nesting eiders, gulls and cormorants on each island surveyed. Islands were systematically ground searched by three or more observers to the edge of the strand line on the beach. The numbers of nests present were recorded by species. Surveys were carried out from June 9 to 11 and July 1 to 30 during the 1992 field season and from May 27 to June 9 and July 2 to 20 in 1993. Fourteen islands were surveyed in the WMA during the spring and summer of 1992. Twenty islands were surveyed in the WMA during the spring and summer of 1993. There was some overlap with eight islands being surveyed both in 1992 and 1993. A total of 26 different islands were surveyed for breeding seabirds during the two field seasons. Appendix C provides a summary of the type of data collected on each of these islands during the 1992 and 1993 field seasons.

III. 2 VEGETATION COVER TYPE USE AND AVAILABILITY

III. 2. 1 Description and Sampling of Vegetation Cover Types

Vegetation cover types were separated into the following eight categories: (1) **Softwood forest** consisted of mature stands of White Spruce and Balsam Fir. Fir thickets near the shoreline and mixed coniferous and deciduous woods were included in this category; (2) **Tuckamoor** or krumholtz referred to stunted, windswept conifers with low branches not present in the more open softwood forest; (3) **Standing Deadwood** was composed of standing dead trees and deadfalls. Dead and blown down trees in mature forest were placed under this category; (4) **Gooseberry** also included other woody shrubs such as Lambkill, *Kalmia angustifolia*, and Bayberry, *Myrica pensylvanica*; (5) **Raspberry** and Skunk-Currant ranged from sparse to dense cane cover and were commonly associated with standing deadwood. Standing deadwood and raspberry were grouped together in 1992 but were treated as separate categories in 1993; (6) The **Tall Grass** category contained both new growth and stems from the previous year. Fireweed and ferns were also placed in this category; (7) Crowberry, short grass and herbaceous growth less than 20 cm in height were recorded as **Barren** cover. This category also included rock outcrops and crevices and areas around active cormorant colonies which lacked vegetation; (8) **Beach** herbaceous growth was sparse on sand, cobble and bedrock shelves.

Plant species abundance was sampled with the Braun-Blanquet quadrat method (cited in Shimwell 1971) for each of the major vegetation cover types. Vegetation surveys were carried out during the summer of 1992, from July 9 to August 14, after hatchlings had left for feeding areas near the mainland. A total of 140 quadrats were examined using a stratified random sampling method. Quadrats were located on 11 different islands. Quadrat sizes varied by vegetation cover type as follows:

(1) Tuckamoor and Forest (10m by 10m);

(2) Tall Grass, Raspberry, Gooseberry and Standing Deadwood (7m by 7m);

(3) Beach and Barren (5m by 5m).

Percent cover was determined visually and recorded for each species. Vertical stratification levels are presented along with the results of the vegetation surveys in Appendix D.

III. 2. 2 Availability of Vegetation Cover Types

To determine the area of each vegetation cover type available for use by nesting eider on the islands surveyed, 1 : 5,000 and 1 : 10,000 scale aerial photos were examined using an Old Delft Scanning Stereoscope (OD SIII) at 4.5x magnification. Cover maps were constructed for all of the islands in the WMA which had been surveyed for nesting eider in 1992 and 1993. An example of these cover maps is presented in Appendix E. The area of each type of vegetation available was calculated using digitizing software provided by the Nova Scotia Department of Natural Resources (Section III. 1).

III. 2. 3 Nest Surveys

Eider nest surveys were made in the spring during mid-incubation and in the summer after hatching. Ten islands known to have nesting populations of eider were surveyed in the spring of 1992 from June 9 to 11. In the spring of 1993 (May 27 to June 9), 11 of 17 islands surveyed were found to have eider nests. Eider nests were recorded by vegetation cover type during these mid-incubation surveys. Eider nests were also recorded post-hatch by cover type for seven of nine islands surveyed in the summer of 1992 (July 1 to 30) and for 15 islands in the summer of 1993 (July 2 to 20).

Care was taken during mid-incubation to place as little stress as possible on nesting females. No surveys were made in wet weather due to the obvious danger to exposed eggs. Surveys were carried out as quickly as possible to minimize nest abandonment by hens. Eggs were covered with down after being recorded by the observer. Human activity on nesting islands has been shown to increase encounters between ducklings and avian predators immediately following disturbance (Keller 1991). To avoid this, mid-incubation surveys were halted once hatchlings were observed in the WMA and post-hatch surveys were not started until hatchlings had left the islands.

The number of eider nests located under deadfalls was recorded by vegetation cover type for ten of the islands surveyed during post-hatch surveys in 1993. Deadfalls were defined as any form of fallen dead trees (i.e. blowdowns, fallen logs or stumps) or driftwood. This should be differentiated from standing deadwood which refers to the overall vegetation type category composed of both standing dead trees and deadfalls. A nest was recorded as being under a deadfall if at least 50% of the nest was obstructed from overhead view.

III. 2. 4 Use of Vegetation Cover Types Relative to Availability

As a measure of the relative use of different vegetation types, the total nest density was calculated for each cover type. The total number of eider nests recorded during nest surveys was divided by the total area of that cover type available as determined from aerial photographs.

Mean nest densities were also calculated for each vegetation type as the average across all surveyed islands with that particular cover type. Mean nest densities were calculated for nine islands in 1992 and for eight islands in 1993. Islands with nest shelters were not included in nest density calculations. In 1993, six predominantly wooded islands were surveyed. A total area of 21.89 hectares of forest were surveyed and only one eider nest was found. These six islands were not included in calculations for nest densities or in utilization and availability analyses. Areas of forest cover on islands with a variety of cover types were included.

The method of Neu *et al.* (1974) was applied to determine which cover types were utilized more or less frequently than expected based on their availability for nine islands in 1992 and eight islands in 1993.

III. 3 ARTIFICIAL NEST SHELTERS

III. 3. 1 Shelter Construction and Placement

Artificial nest shelters were first placed on islands within the WMA by the Nova Scotia Department of Lands and Forests in 1985 and 1988. As part of the present study, an additional 286 single plastic shelters were placed on four islands in the WMA in 1992 (Table 1).

Five different types of artificial nest shelters were available for use by eider in 1992 and 1993. The typical wooden artificial shelter was built using 1.3 cm thick plywood for the top and 2.5 cm by 18 cm boards for the sides with an overall dimension of 61 cm wide by 81 cm deep. A double wooden shelter of similar construction measuring 122 cm wide by 81 cm deep was also used. The entrance height of wooden structures ranged between 15 cm and 20 cm high. Figure 9A shows the typical design of a double wooden shelter.

Single plastic nesting shelters were originally constructed from plastic fish boxes measuring 30 cm high by 46 cm wide by 81 cm long. These were turned upside down and an entrance 18 cm high by 30 cm wide was cut at one end. Only five of these fish box structures were constructed and all were on Inner East Bird Island.

All other plastic artificial shelters were made from juice concentrate barrels (54 U.S. gallon) which had been cut in half lengthwise to produce a dome. One end of the structure was cut out to provide a single entrance. The shelter measured 98 cm long and was 39.5 cm wide at the ends and 66 cm wide in the middle with an entrance height between 18 cm and 23 cm high. Double plastic shelters were constructed by placing domes side by side and strapping them to a wooden frame. Only six of these double plastic shelters were placed in the WMA and all were located on Inner East Bird Island.

Plastic shelters were held down with 1.5 cm diameter rebars. Wooden boards (10 cm wide by 91 cm long by 3 cm thick) were laid under the structure. The steel rebars were fitted through holes in the dome and wood into the ground. The last 7 cm of the 58 cm long rebars were bent at a right angle to hold the shelter down. Two bars were located in the front and one in the back. Figure 9B is a diagram of the typical design of a single plastic shelter. Driftwood and flat cobble were placed on shelters to weight them down and each structure was painted with a large number so shelter use and nest success could be recorded on an annual basis.

Several guidelines were followed when placing shelters on an island. Shelters were not placed in areas which already possessed dense natural cover but were concentrated near the periphery of these areas in more open cover. Colonies of Double-crested Cormorant were present on three of the seven islands on which shelters were located. Shelters were placed at a minimum distance of three metres from these colonies.

III. 3. 2 Shelter Use by Nesting Eider

Eider nests found under artificial nest shelters were recorded during the spring and summer breeding seabird surveys (Section IV. 2. 3) for four islands in 1992 and six islands in 1993. The shelter type and shelter number were also recorded so that shelter use in consecutive years could be followed. Historical data from surveys made by the Department of Natural Resources on the Bird Islands (Austin Smith *et al.* 1991) were examined to compare nesting populations before and after the addition of artificial shelters.

Table 1: Number and year of placement of different shelter types on islands in the WMA.

Island	Year of placement	Plastic Single	Plastic Double	Wooden Single	Wooden Double	Total
Outer East Harbor	1985	30	0	0	0	30
Western White	1985	0	0	0	8	8
Inner East Bird	1985	23	6	12	12	53
Little White	1988	0	0	0	93	93
Little White [a]	1992	104	0	0	0	104
The Specks	1992	30	0	0	0	30
East Brother	1992	74	0	0	0	74
West Brother	1992	78	0	0	0	78
Total		339	6	12	113	470

[a] 51 single plastic shelters were placed on Little White in April and were available for use during the breeding season. The remaining 53 shelters were placed on the island in August after ducklings had hatched and left the area.

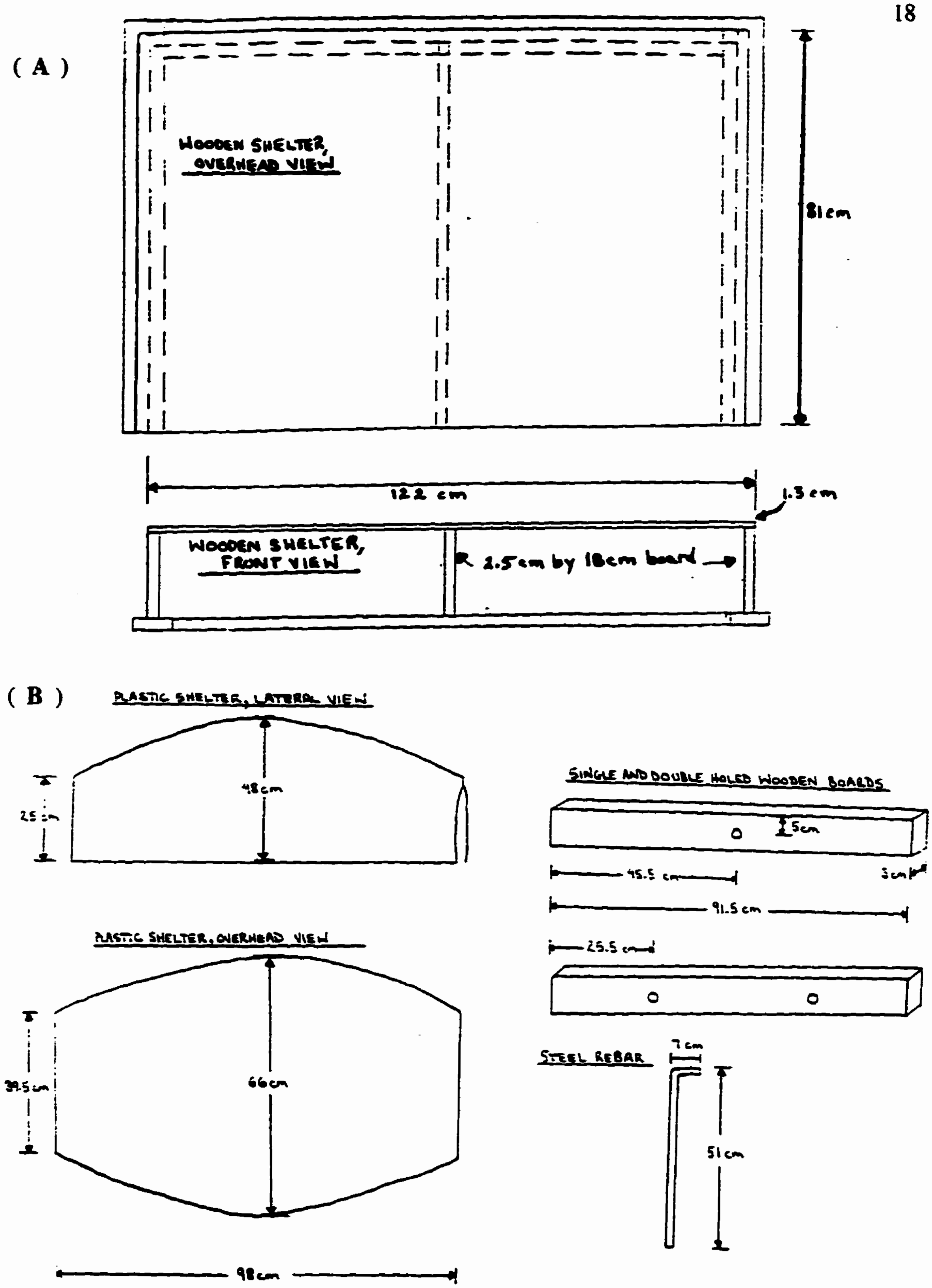


Figure 9: A diagram of the typical design of (A) a double wooden shelter and (B) a single plastic shelter.

III. 4 REPRODUCTIVE SUCCESS

Clutch sizes were recorded as the number of eggs per nest (ranging from one to 11) during mid-incubation surveys for ten islands in 1992 and 11 islands in 1993. Incomplete nests were therefore included, as were nests containing eggs laid by more than one hen (multiple clutches). The surrounding vegetation cover type was recorded for all nests.

Predated nests were recorded by vegetation cover type for eight of the islands surveyed during mid-incubation surveys in 1993. Nests were recorded as being predated if no hatched membranes were found and there was obvious sign of predation such as scattered down or eggs pecked apart.

The number of corvids sighted during eider nest surveys were recorded during mid-incubation in 1992 and 1993. These were compared among islands with and without forest cover. A third category was included for islands without forest cover but adjacent (within 500 metres) to forested islands.

Eider nest fates were recorded by vegetation cover type as either successful or unsuccessful during post-hatch surveys for seven islands in 1992 and 15 islands in 1993. A nest was considered successful if one or more newly hatched membranes was found in or near it (Girard 1939). The shell membranes of successfully hatched eggs easily separated from the shell and could be found in the nests as a leathery membrane. The shell lining or membrane of an egg that was broken before hatching remained tightly attached to the shell after exposure to the elements. Nests which showed signs of having been destroyed or abandoned and/or which did not contain at least one hatched membrane were considered to have been unsuccessful.

III. 5 STATISTICAL ANALYSES

An ANCOVA was applied to test the relationship between eider nesting populations and island size, distance from the mainland and presence of nesting gulls.

A one-way factorial ANOVA followed by a Bonferroni / Dunn post hoc test was applied to test the effect of cover type on mean nest density. A log likelihood ratio test for goodness of fit was used to test the hypothesis that nesting eiders utilized each cover type in exact proportion to its occurrence within the study area.

A log likelihood ratio test for goodness of fit was applied to determine if proportions of nests under deadfalls differed among cover types. If significance was detected, pairwise comparisons were then made among cover types using the Bonferroni corrected p-value (Sokal and Rohlf 1995). Similar methods were used in analyzing the proportion of nests which were predated and unsuccessful and to determine if occupancy rates differed significantly among artificial shelter types.

Nonparametric Kruskal-Wallis and Mann Whitney *U* -Tests were applied to compare median clutch sizes for nests in different types of natural vegetation and under nesting shelters (Zar 1984). The Bonferroni method was used to correct significance levels and limit the probability of making a Type I error (Sokal and Rohlf 1995).

All tests were performed with the StatView® 4.01 statistical package and all hypotheses were tested at the 5% level of significance. All means were reported ± one standard deviation (S. D.) unless otherwise indicated.

IV. RESULTS

IV. 1 CHARACTERISTICS OF NESTING ISLANDS

IV. 1. 1 Island Size

The number of eider nests was recorded for 14 islands in 1992 and 20 islands in 1993. Island size ranged from 1.0 to 8.3 hectares (3.6 ± 2.3 hectares) in 1992 and 0.8 to 14.8 hectares (3.6 ± 3.4 hectares) in 1993. The number of eider nests on these islands ranged from 0 to 541 (111 ± 156) in 1992 and from 0 to 97 (39 ± 34) in 1993. There were no observable patterns in the numbers of nesting eider over the size range of islands surveyed. No relationships between island size and number of eider nests were observed in 1992 or 1993 (Figure 10). Island size was not a significant variable for explaining the number of eider nests when using an ANCOVA model (Table 2). The interaction term for island size and distance to the mainland was non-significant: (ANCOVA, $F_{1,17}=0.03$, $p=0.86$).

Of the 21 nests found during the transect survey of Big White Island in 1993, ten (48%) were within 50 m of the shoreline (Figure 11) while significantly fewer nests (four nests or 19%) were found more than 100 m from the shoreline (Log likelihood ratio test, DF = 1, G-statistic = 3.95, P = 0.05).

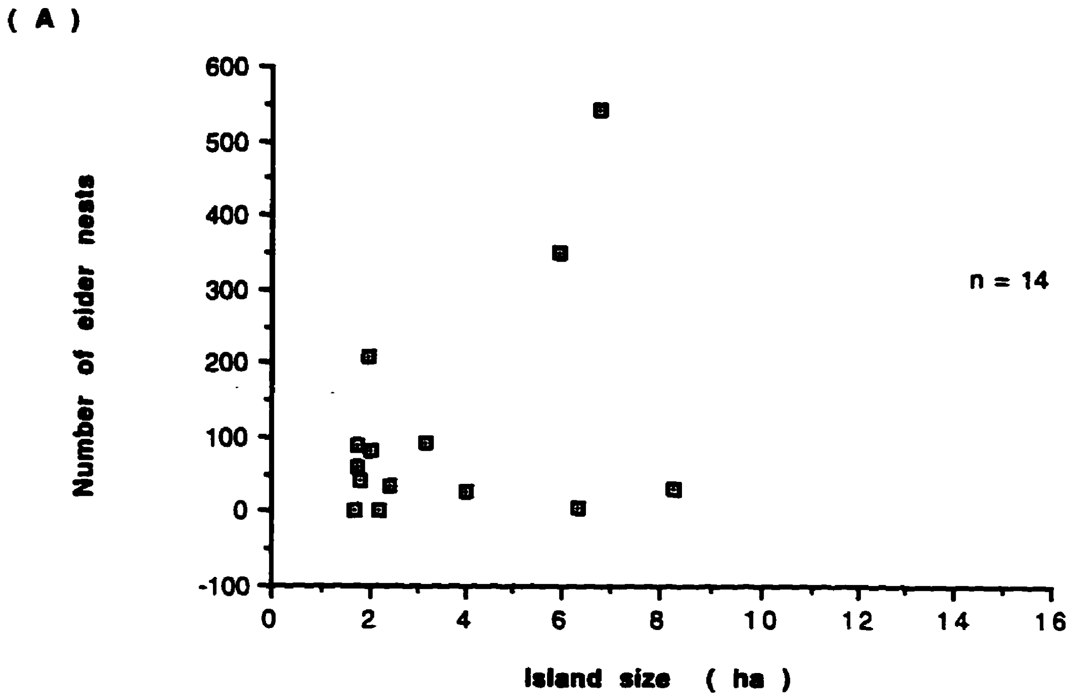
IV. 1. 2 Distance from the Mainland

Distance from the island to the mainland was not a significant predictor for number of eider nests in 1992 or 1993. Island distance from the mainland ranged from 1.7 to 7.1 kilometres (4.5 ± 1.6 km) for the fourteen islands surveyed in 1992 and from 1.3 to 7.1 km (3.8 ± 1.9 km) for the twenty islands surveyed in 1993. The number of eider nests on these islands ranged from 0 to 541 (111 ± 156) in 1992 and from 0 to 97 (39 ± 34) in 1993. There were no observable differences in eider nest number over the range of distances to the mainland examined. No relationships between island distance from the mainland and number of eider nests were observed in 1992 or 1993 (Figure 12). Island distance to the mainland was not a significant variable for explaining the number of eider nests when using an ANCOVA model (Table 2). As mentioned in Section IV. 1. 1, the interaction term for island size and distance to the mainland was non-significant.

IV. 1. 3 Presence of Nesting Seabirds

The number of gull nests was recorded for thirteen islands in 1992 and for nineteen islands in 1993. The number of gull nests ranged from 0 to 118 (48 ± 41) in 1992 and from 0 to 111 (26 ± 32) in 1993. The number of eider nests on these islands ranged from 0 to 541 (111 ± 156) in 1992 and from 0 to 97 (39 ± 34) in 1993. Although no relationships between the number of gull nests and the number of eider nests were observed in 1992 or 1993 (Figure 13), no gull nests were found on any of the six islands lacking nesting eider in 1993. Number of gull nests was not a significant variable for examining the number of eider nests using an ANCOVA model (ANCOVA, $F_{1,13}$=0.43, p=0.52). The interaction terms for number of gull nests, island size and distance to the mainland were all non-significant (Table 3).

Four of the twenty islands surveyed in 1993 supported active cormorant colonies (Table 4) ranging from 35 to 314 nests (123 ± 129). Eiders nested in moderate numbers (57 ± 14) on all four islands. Eider nests were also found on sixteen other islands lacking cormorant colonies in 1993.



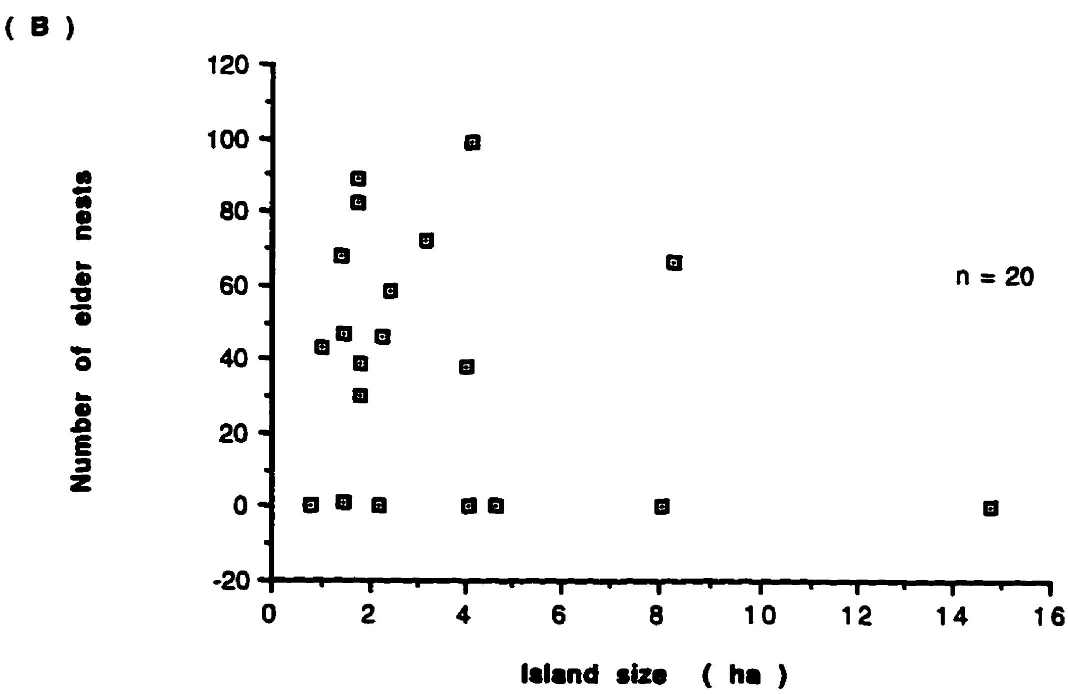


Figure 10: Relationship between island size and the number of eider nests in (A) 1992 and (B) 1993. The number of eider nests could not be predicted by island size (see text).

Table 2: ANCOVA model for the effects of island size and distance from the mainland on the number of eider nests.

Variable	Source	DF	Means squared	F-value	P-value
Eiders	Size	1	11729.232	0.84	0.37
	Distance	1	13775.584	0.99	0.33
	Size*Distance	1	437.733	0.03	0.86
	Year	1	49887.873	3.59	0.07
	Error	21	13880.883		

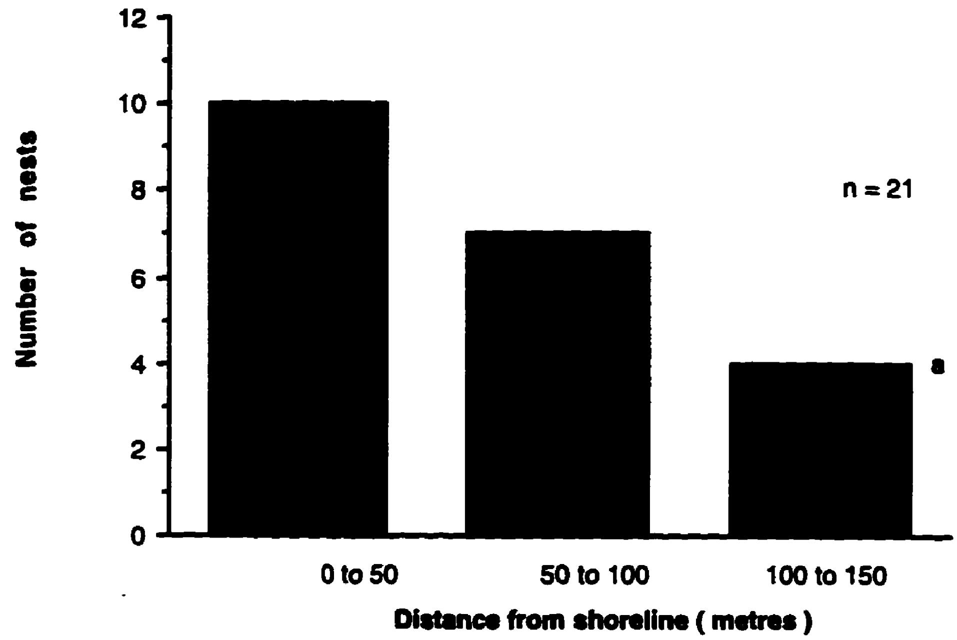


Figure 11: The number of eider nests located at different distances from the shoreline on Big White Island in the summer of 1993. A total of 21 plots, seven in each distance category, represented a total sampled area of 15 750 m^2.

[a] significantly different from the number of nests 0 to 50 m from the shoreline at $p = 0.05$

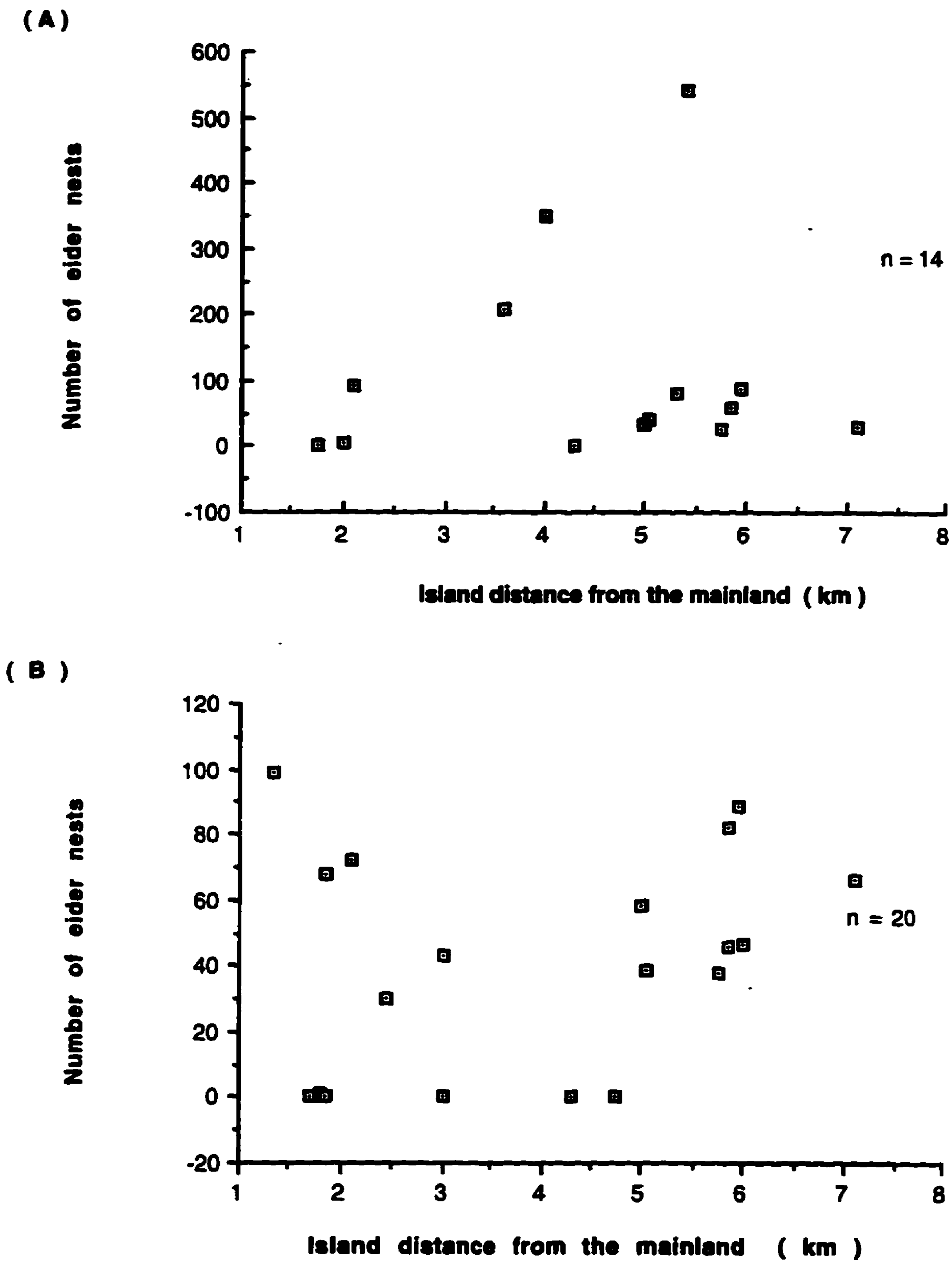


Figure 12: Relationship between island distance from the mainland and the number of eider nests in (A) 1992 and (B) 1993. The number of eider nests could not be predicted by island distance from the mainland (see text).

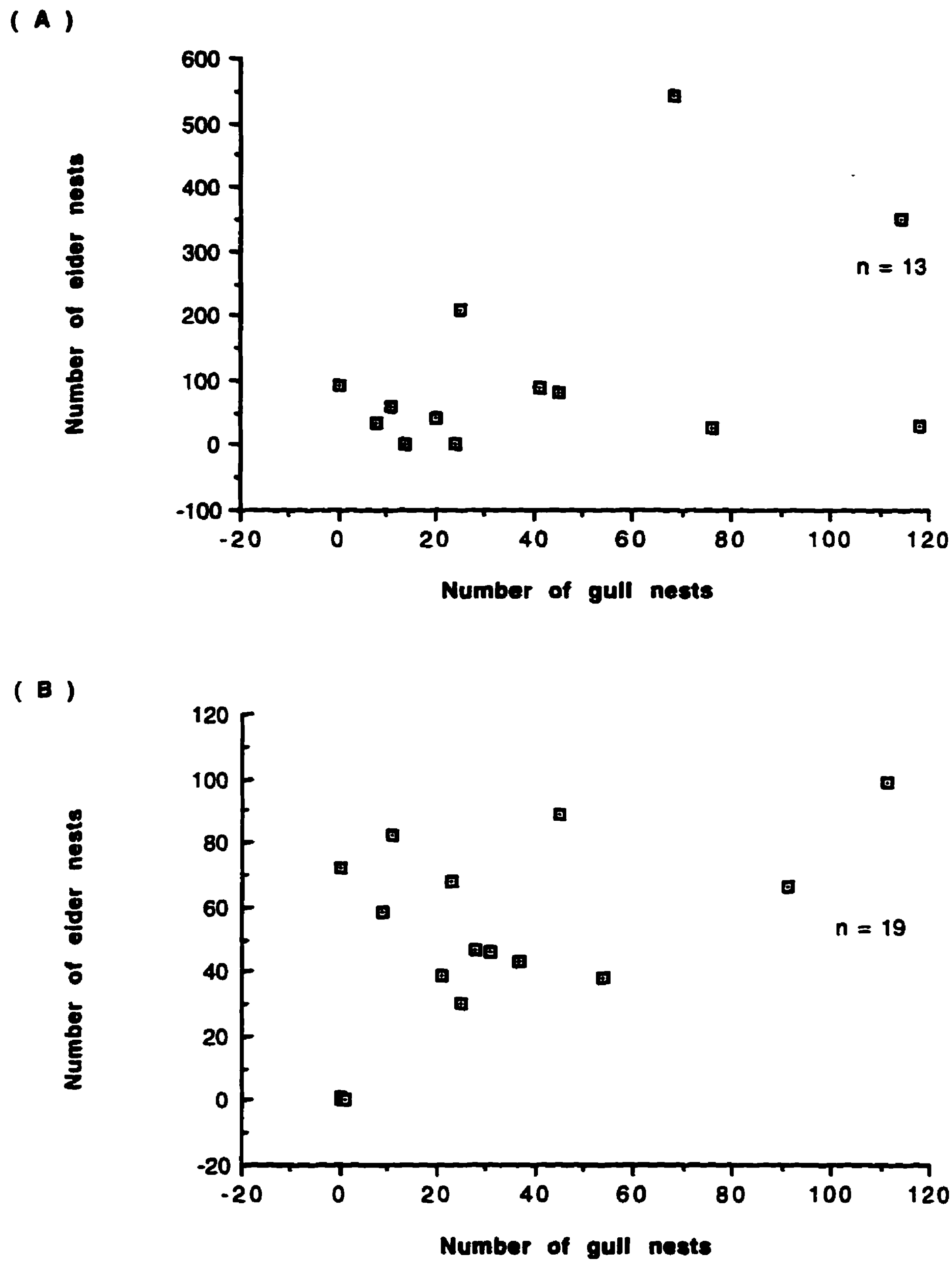


Figure 13: Relationship between the number of gull nests and the number of eider nests in (A) 1992 and (B) 1993. The number of eider nests could not be predicted by the number of gull nests (see text).

Table 3: ANCOVA model for the effects of the number of gull nests and island size and distance from the mainland interactions on the number of eider nests.

Variable	Source	DF	Means squared	F-value	P-value
Eiders	Gulls	1	4441.166	0.43	0.52
	Gulls*Size	1	17908.112	1.72	0.21
	Gulls*Distance	1	801.234	0.08	0.42
	Gulls*Size*Distance	1	8006.507	0.77	0.39
	Year	1	20316.418	1.95	0.18
	Error	18	10437.073		

Table 4: Location and size of cormorant colonies on islands in the WMA surveyed for nesting eider in 1993.

Island	Number of eider nests	Number of cormorant nests
Specks	43	85
West Brother	46	57
Long	72	35
Little White	66	314

IV. 2 NESTS IN NATURAL SITES

IV. 2. 1 Availability and Use of Vegetation Cover Types

1992

During post-hatch surveys in 1992 (July 1 to 30), 656 eider nests were recorded by vegetation cover type for seven islands. The number of eider nests per island ranged from 23 to 233. Seven cover types were available for use by nesting eider and all were used to some degree. In addition to natural cover, 53 shelters were located among the different vegetation types on one of the islands (Inner East Bird) surveyed post-hatch in 1992. During these surveys, 248 eider nests were recorded in gooseberry; 206 nests in raspberry; 131 nests in grass cover; 30 nests in barren cover; 19 nests under tuckamoor; and 18 nests under shelters (Figure 14A). Only 3 nests were found among cobble or sparse vegetation on the beach and a single nest was found in forest cover.

Total eider nest densities were calculated by dividing the total number of eider nests recorded during nest surveys by the total area of that cover type surveyed. The total nest density for all the vegetated area surveyed in 1992 was 91.3 nests per hectare (Table 5). Highest total nest densities were found for gooseberry with 370.2 nests per hectare and for raspberry with 119.4 nests / ha. The lowest nest density was recorded for beach cover with 6.2 nests / ha.

Mean eider nest densities ± 1 standard error were calculated for each cover type as the average across all surveyed islands with that particular cover type. Similar patterns were recorded as with total nest densities with the exception that tuckamoor cover had the second highest mean density with 255.7 ± 99.2 nests per hectare (Table 5). Barren cover had the lowest mean density with 9.6 ± 2.9 nests / ha. The mean nest density for gooseberry was significantly greater than that for barren cover and beach cover (14.2 nests per hectare) at p=0.001.

Using the method of Neu *et al.* (1974) to compare utilization with availability, there were considerable differences among vegetation cover types in 1992 (Log likelihood ratio test, DF=6, G-statistic = 1928.2). Following the terminology of Neu *et al.* (1974), barren, beach, forest and grass cover were considered to be avoided while gooseberry and raspberry cover were preferred (Table 6).

1993

During post-hatch surveys in 1993 (July 2 to 20), 990 eider nests were recorded by cover type for 15 islands. The number of eider nests per island ranged from 24 to 155. Eight cover types were available for use by nesting eider and all were used to some degree. In addition to natural cover, 440 shelters were located among the different vegetation types on six of the islands surveyed post-hatch in 1993. During these surveys, 264 eider nests were recorded in gooseberry; 256 nests in raspberry; 189 nests in grass cover; 95 nests in barren cover; 61 nests under standing deadwood; 42 nests under tuckamoor; and 42 nests under shelters (Figure 14B). Thirty-nine nests were found among cobble and sparse raspberry vegetation on the beach and two nests were found in forest cover.

The total nest density for all the vegetated area surveyed in 1993 was 58.5 nests per hectare (Table 7). Highest total nest densities were found under gooseberry with 221.6 nests per hectare and under standing deadwood with 134.8 nests / ha. The lowest nest density was recorded for barren cover with 2.6 nests / ha.

Similar patterns were recorded for mean nest densities with the exception that tuckamoor cover had the second highest mean density with 237.9 ± 98.0 nests per hectare. Forest cover had the lowest mean density with 2.1 ± 2.1 nests / ha. There were no significant differences among mean eider nest densities in 1993. There were also no significant differences between mean nest densities in each cover type for 1992 and 1993. Similarly, there was no significant difference (ANOVA, $F_{1,15}$=1.21, p=0.29) between mean nest density for the total amount of vegetated area in 1992 (86.3 ± 16.1 nests / ha) and 1993 (64.1 ± 11.4 nests / ha).

Using the method of Neu *et al.* (1974) to compare utilization with availability, there were considerable differences among vegetation cover types in 1993 (Log likelihood ratio test, DF=8, G-statistic = 525.3). Barren, beach, and forest cover were considered to be avoided while standing deadwood and gooseberry cover were preferred (Table 8).

IV. 2. 2 Use of Deadfalls

Of 912 eider nests recorded during post-hatch surveys on ten islands in 1993, 234 or 25.7% were found under deadfalls. There was considerable variation in the proportion of nests located under deadfalls among different natural cover types (Figure 15). Nests in barren and standing deadwood cover were most commonly located under deadfalls with 58.8% and 49.3% of nests being under deadfalls respectively. These proportions were significantly greater at $p=0.01$ than all other cover types. A significantly greater (at $p=0.002$) proportion of nests were under deadfalls in raspberry cover (35.4%) than were under deadfalls in beach (11.4%) and gooseberry (15.7%) cover. The lowest use of deadfalls was under tuckamoor at 3.4%.

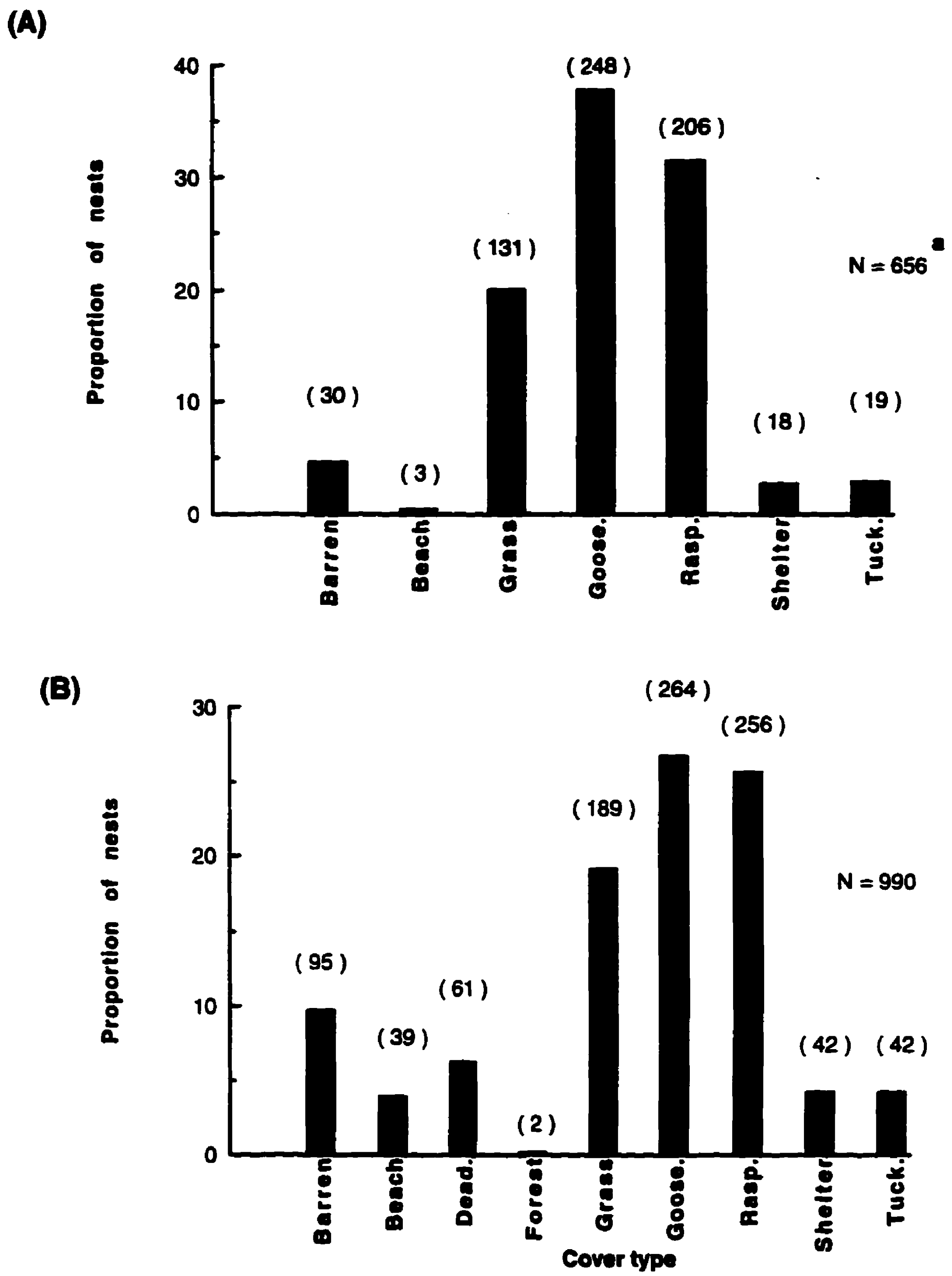


Figure 14: Use of vegetation cover types by nesting eider during post-hatch surveys for (A) seven islands in 1992 and (B) 15 islands in 1993. The total number of nests recorded in each cover type is presented above each column.

[a] A single nest was found under forest cover in 1992.

Table 5: Eider nest densities recorded by vegetation cover type for nine islands surveyed in 1992 in the WMA.

Cover type	Number of islands with cover type	Mean nest density (nests/ha ± 1 S.E.) [1]	Total nest density (nests/ha) [2]
Barren	9	9.6 ± 2.9 [a]	9.4
Beach	9	14.2 ± 14.2 [b]	6.2
Forest	2	10.7 ± 10.7	16.7
Gooseberry	6	299.2 ± 70.9 [a b]	370.2
Grass	8	170.9 ± 82.1	73.9
Raspberry	9	134.5 ± 40.9	119.4
Tuckamoor	7	255.7 ± 99.2	106.7
All vegetated cover	9	86.3 ± 16.1	91.3

[1] calculated as the mean of nest densities on each island for which the cover type was present

Mean densities with the same letter were significantly different from one another at $p=0.001$.

[2] calculated by dividing the total number of nests found in the cover type on all islands by the total area of that cover type surveyed in 1992

Table 6: Occurrence of eider nests relative to availability of vegetation cover types on nine islands in the WMA in 1992.

Cover type	Proportion [a] of total area (p_o)	Expected no. [b] of nests	Observed no. of nests	Proportion observed (p_i)	Confidence interval [c] on proportion of occurrence (p_i)	Cover type preference
Barren	0.351	506	52	0.036	$0.023 \leq p_1 \leq 0.049$	Avoided
Beach	0.094	135	9	0.006	$0.001 \leq p_2 \leq 0.012$	Avoided
Forest	0.023	33	6	0.004	$-0.001 \leq p_3 \leq 0.009$	Avoided
Gooseberry	0.130	187	762	0.529	$0.493 \leq p_4 \leq 0.564$	Preferred
Grass	0.194	279	224	0.155	$0.130 \leq p_5 \leq 0.181$	Avoided
Raspberry	0.175	252	331	0.230	$0.200 \leq p_6 \leq 0.259$	Preferred
Tuckamoor	0.034	49	57	0.040	$0.026 \leq p_7 \leq 0.053$	Expected
Total		1441	1441			

[a] Proportions of total area represent the percentage of each vegetation type available for use by nesting eider

[b] Calculated by multiplying proportion p_o x Total n (i.e., 0.351 x 1441 = 506)

[c] p_i represents theoretical proportion of occurrence and is compared to the corresponding confidence interval to determine if hypothesis of proportional use is accepted (i.e., $p_o = p_i$) or rejected .
(G - test value calculated = 1928.19; tabular value, 6 df, 0.05 level of probability = 12.59). Therefore we reject the hypothesis that all habitats are being used equally.

Table 7: Eider nest densities recorded by vegetation cover type for eight islands surveyed in 1993 in the WMA.

Cover type	Number of islands with cover type	Mean nest [1] density (nests/ha ± 1 S.E.)	Total nest [2] density (nests/ha)
Barren	8	20.5 ± 12.7	2.6
Beach	6	8.0 ± 5.9	38.8
Deadwood	7	103.5 ± 48.0	134.8
Forest	2	2.1 ± 2.1	3.1
Gooseberry	3	246.8 ± 29.5	221.6
Grass	5	174.0 ± 73.7	63.5
Raspberry	6	90.6 ± 36.1	69.3
Tuckamoor	5	237.9 ± 98.0	72.2
All vegetated cover	8	64.1 ± 11.4	58.5

[1] calculated as the mean of nest densities on each island for which the cover type was present

[2] calculated by dividing the total number of nests found in the cover type over all islands by the total area of that cover type surveyed in 1993

Table 8: Occurrence of eider nests relative to availability of vegetation cover types on eight islands in the WMA in 1993.

Cover type	Proportion [a] of total area (p_o)	Expected no. [b] of nests	Observed no. of nests	Proportion observed (p_i)	Confidence interval [c] on proportion of occurrence (p_i)	Cover type preference
Barren	0.310	156	7	0.014	$-0.001 \leq p_1 \leq 0.028$	Avoided
Beach	0.165	83	54	0.108	$0.069 \leq p_2 \leq 0.146$	Avoided
Deadwood	0.123	62	143	0.285	$0.229 \leq p_3 \leq 0.341$	Preferred
Forest	0.037	18	1	0.002	$-0.004 \leq p_4 \leq 0.007$	Avoided
Gooseberry	0.057	28	114	0.227	$0.175 \leq p_5 \leq 0.279$	Preferred
Grass	0.115	58	66	0.131	$0.090 \leq p_6 \leq 0.173$	Expected
Raspberry	0.151	76	91	0.181	$0.134 \leq p_7 \leq 0.229$	Expected
Tuckamoor	0.042	21	26	0.052	$0.024 \leq p_8 \leq 0.079$	Expected
Total		502	502			

[a] Proportions of total area represent the percentage of each vegetation type available for use by nesting eider

[b] Calculated by multiplying proportion p_o x Total n (i.e., 0.310 x 502 = 156)

[c] p_i represents theoretical proportion of occurrence and is compared to the corresponding confidence interval to determine if hypothesis of proportional use is accepted (i.e., $p_o = p_i$) or rejected .

(G - test value calculated = 525.28; tabular value, 8 df, 0.05 level of probability = 15.51). Therefore we reject the hypothesis that all habitats are being used equally.

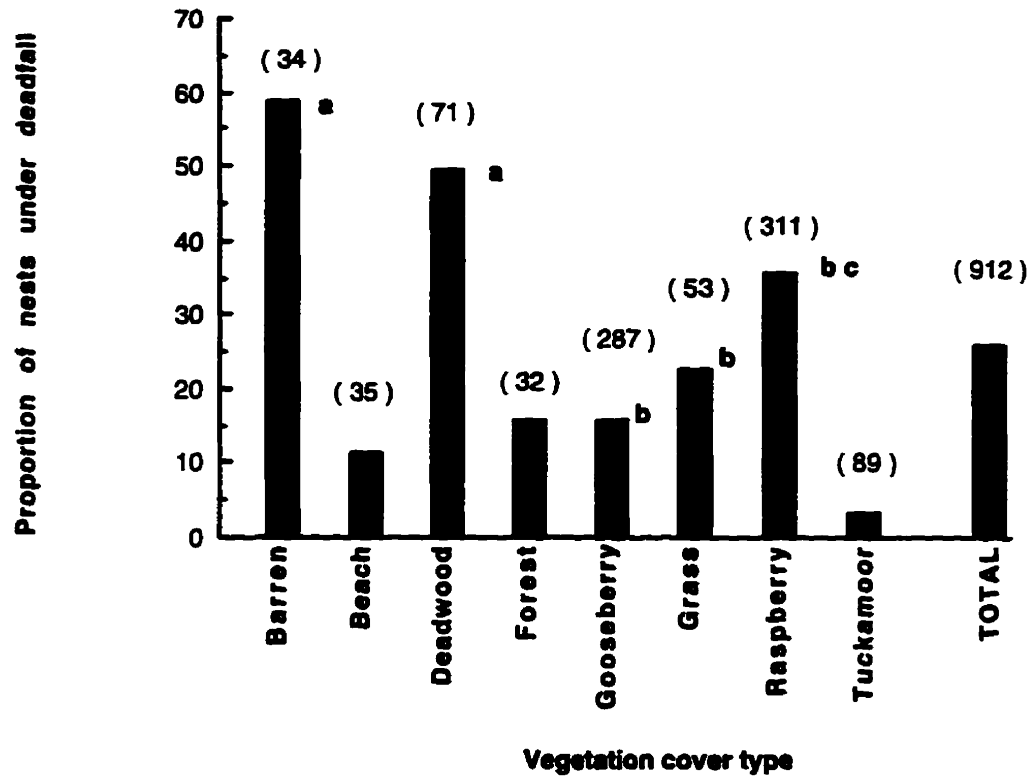


Figure 15: Use of deadfalls by nesting eider in different vegetation cover types for ten islands surveyed in 1993. The total number of nests recorded in each cover type is presented above each column.

[a] Significantly greater than nests in all other cover types at p-value of 0.01.

[b] Significantly greater than nests in tuckamoor cover at p-value of 0.0003.

[c] Significantly greater than nests in beach and gooseberry cover at p-value of 0.002.

IV. 3 ARTIFICIAL NEST SHELTERS

IV. 3. 1 Occupancy

1992

Artificial nest shelters were available for use by nesting eider on four islands in the WMA in 1992. Shelters were used on two of the four islands. Although 235 shelters were available, only 18 (7.7%) were used by nesting eider. Fifteen shelters were used by a single hen while three were used by two females (Table 9). Eider nests were found under 15 of 53 available shelters (28.3%) on Inner East Bird Island and under only three of 144 shelters (2.1%) on Little White Island.

All four shelter types were used by nesting eider to some degree (Figure 16A), although variation on Inner Bird Island was observed where use of double wooden shelters (8.3%) was lower than the other three shelter types (30.4, 33.3 and 50.0%). Differences in occupancy rates were not significant (Log likelihood ratio test, DF=3, G-statistic=4.41, P=0.22). Only single plastic and double wooden shelters were present on Little White Island and both were infrequently occupied by nesting eider.

1993

Artificial nest shelters were examined for use by nesting eider on six islands in the WMA in 1993. Shelters were used on five of the six islands. Of the 440 shelters available, 40 (9.1%) were used by nesting eider. Thirty-seven shelters were used by a single hen while three shelters were used by two females (Table 9). Eider nests were found under 20 of 53 available shelters (37.7%) on Inner East Bird Island and under only three of 197 shelters (1.5%) on Little White Island. Shelter use on the other islands ranged from none of eight to four of 78 (5.1%) to three of 30 (10.0%) and ten of 74 (13.5%).

Similar to 1992, all four shelter types were used by nesting eider to some degree (Figure 16B). Use of double wooden shelters on Inner East Bird Island was significantly lower (8.5%) than occupancy of double plastic shelters (66.7%) at the corrected Bonferroni p-value of 0.0125. Use of single plastic and wooden shelters was 30.4 and 33.3% respectively. Only single plastic and double wooden shelters were present on Little White Island and both were infrequently occupied by nesting eider. Single plastic shelters had been placed on West and East Brother Islands and the Specks prior to the 1993 season and received relatively low use (ranging from 5.1 to 13.5%) by nesting eider.

IV. 3. 2 Reuse in Consecutive Years

The rate of reuse of the same nest site in consecutive years was relatively high (Table 10). It was not known whether reuse was by the same or different hens.

On Inner East Bird Island, six of the nine sites (66.7%) used by nesting eider under shelters in 1991 were also used in 1992. Similarly, 16 of the 18 (88.9%) sites used under shelters in 1992 were also used in 1993. Five of the nine sites (55.6%) used under shelters in 1991 were used by nesting eider during both 1992 and 1993.

On Little White Island, one of the three sites (33.3%) used in 1992 was used again in 1993.

IV. 3. 3 Effect on Nesting Populations

Shelters had been placed on Inner East Bird Island in 1985. In 1987, the proportion of nests under shelters at 6.7% was much lower than the 37.9% recorded in 1993. The number of nests placed under shelters had increased while the number of nests placed in natural cover had decreased. Figure 17 shows the relative proportion of nests in natural cover and under shelters from 1986 through 1993 on Inner East Bird Island. The proportions of nests recorded in natural cover and under shelters converged over time. This occurred without an overall increase in the total number of nests on the island. Nest surveys before 1985 reported a mean annual nesting population of 69.2 ± 8.0 nests (n=4) compared with 43.7 ± 19.6 nests (n=8) after shelters had been placed on the island. The increased use of nest shelters over time did not reflect an overall increase in total nesting eider population on this island.

On Little White Island, the proportion of nests under shelters has remained low (less than 1.4% of nests under shelters) from 1988 through 1993. The overall nesting population has remained steady on Little White Island at 38 ± 12.9 nests (n=6). Thirty-eight nests were found in 1988 and 32 nests were found in 1993.

Shelters have not been placed on the nearby islands of Outer Bird and Inner West Bird Islands. These islands were left as control islands for comparison with Inner East Bird Island. Annual nesting populations on Inner East Bird Island and the control islands are presented in Figure 18. Nest numbers on Inner East and Inner West Bird Islands followed a similar pattern until 1981. Nest numbers on Inner East Bird Island decreased sometime between the 1981 and 1986 surveys. After the addition of nest shelters on Inner East Bird in 1986, nest numbers on both islands increased and followed similar patterns thereafter. Nesting populations on Inner East and Outer Bird Islands experienced the same annual fluctuations. Nesting populations on all three islands follow similar annual patterns and the addition of shelters on Inner East Bird Island did not appear to have affected the total nesting population relative to the control islands.

Table 9: Use of artificial nest shelters by eider in the WMA during the 1992 and 1993 nesting seasons.

Island	Year	Number of Shelters		Occupancy		Number of nests
		Available	Used	Single	Double	
Outer East Harbor	1992	30	0	0	0	0
Western White	1992	8	0	0	0	0
	1993	8	0	0	0	0
Inner East Bird	1992	53	15	12	3	18
	1993	53	20	17	3	23
Little White	1992	144	3	3	0	3
	1993	197	3	3	0	3
The Specks	1993	30	3	3	0	3
East Brother	1993	74	10	10	0	10
West Brother	1993	78	4	4	0	4
Total	1992	235	18	15	3	21
	1993	440	40	37	3	43

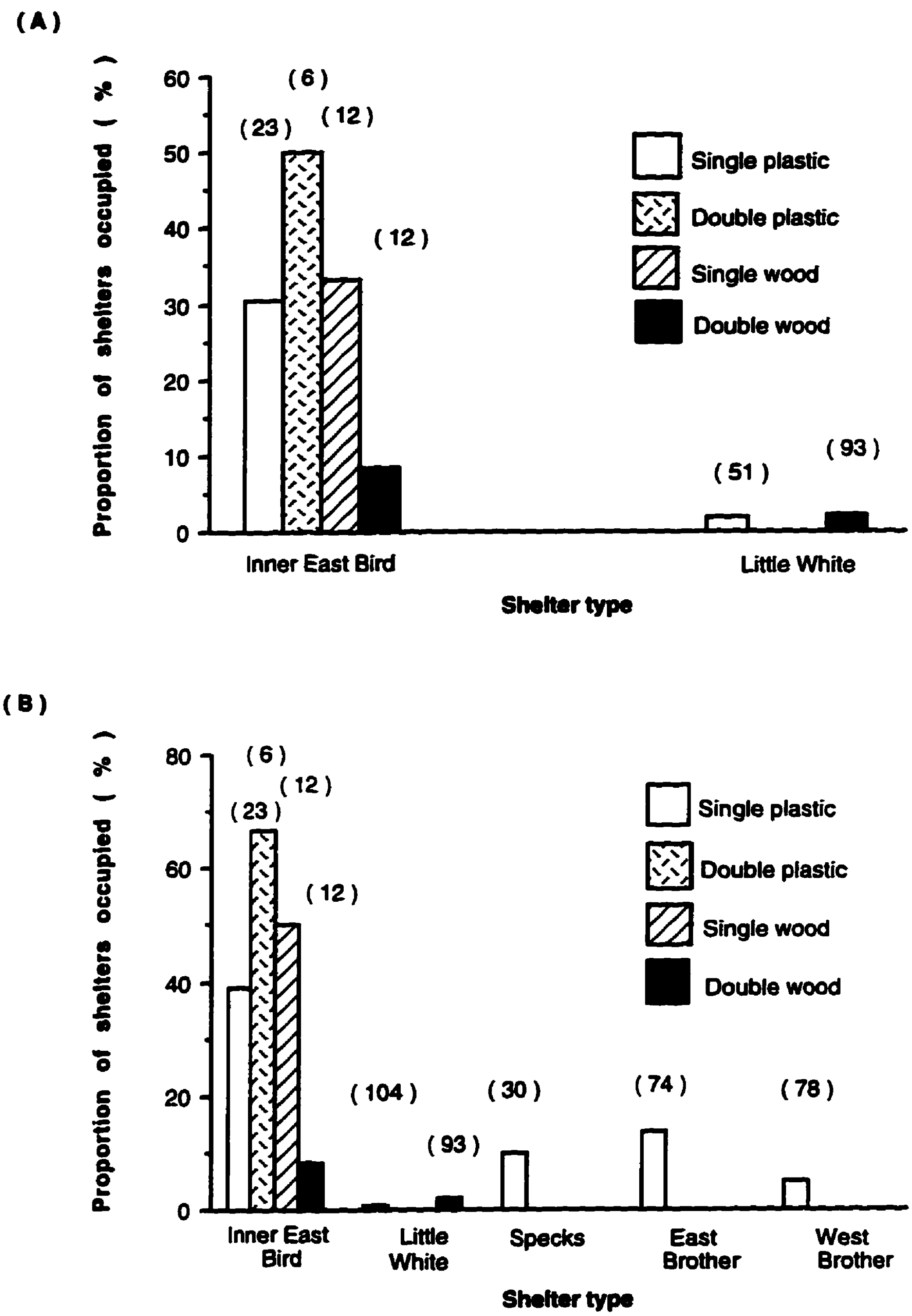


Figure 16: Proportion of each type of nesting shelter used by eider in (A) 1992 and (B) 1993. The total number of shelters which were available are presented above each column.

Table 10: Reuse of the same nest site by eider under artificial shelters in consecutive years from 1991 through 1993.

Island	Year	Sites used	Same sites used in preceding year	Sites used in all three years
Inner East Bird	1991	9		
Inner East Bird	1992	18	6	
Inner East Bird	1993	23	16	5
Little White	1992	3		
Little White	1993	3	1	

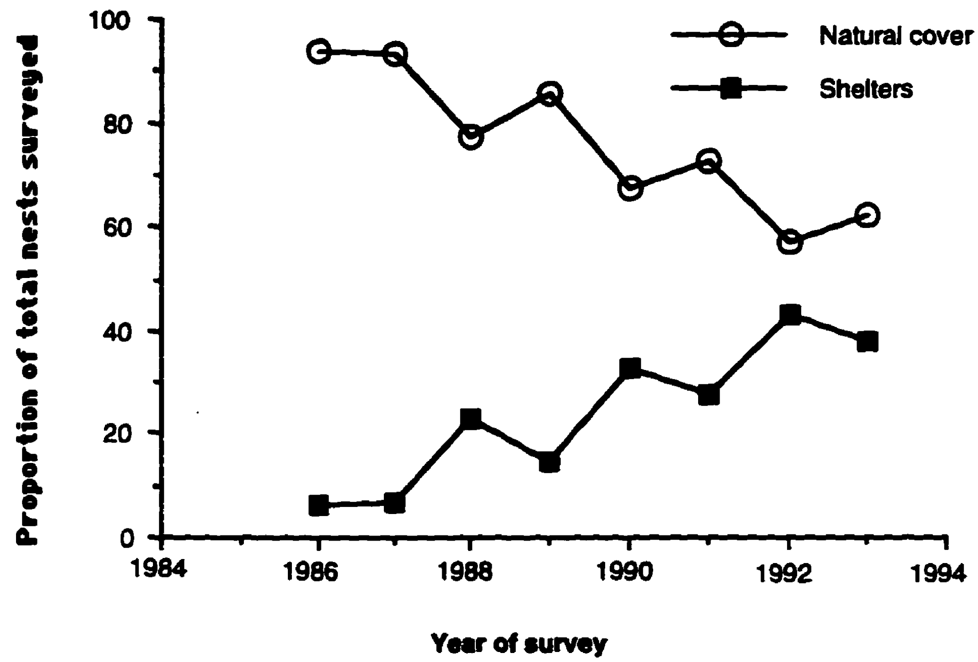
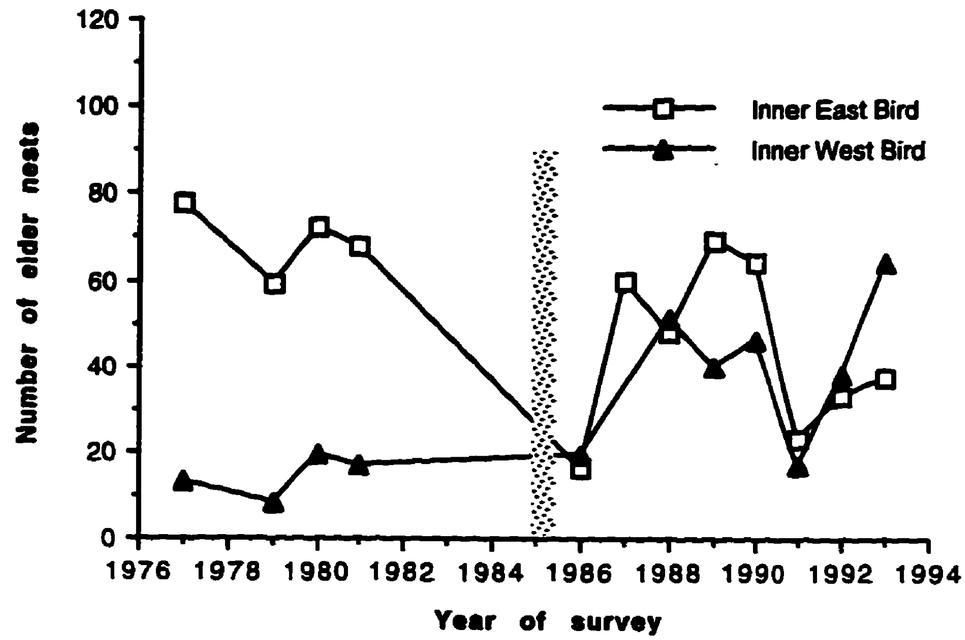


Figure 17: Relative proportion of eider nests in natural sites and under nest shelters on Inner East Bird Island from 1986 to 1993.

(A)



(B)

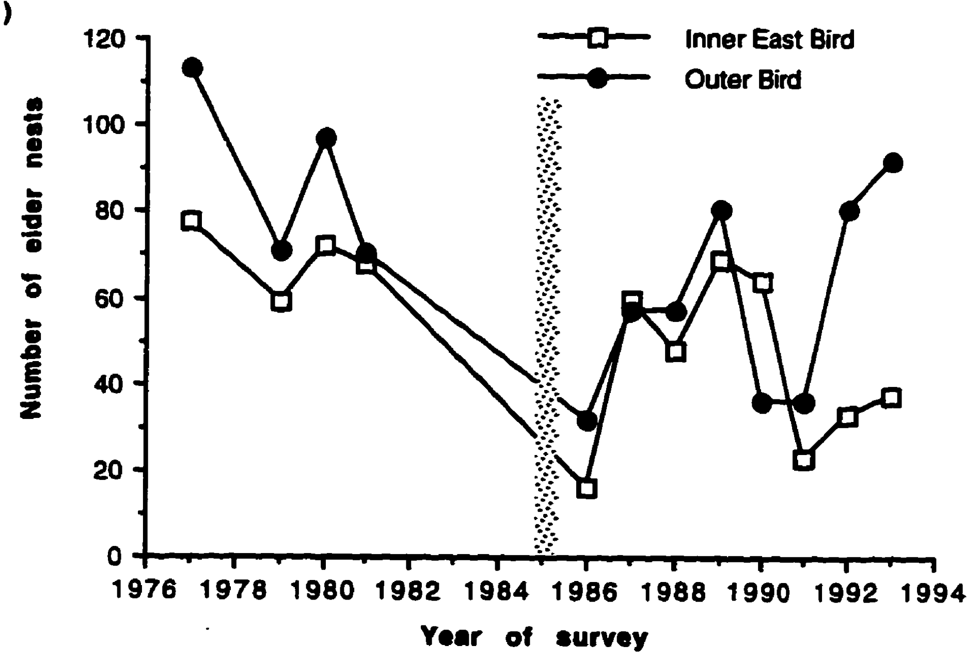


Figure 18: Trends in eider nest numbers on (A) Inner East and Inner West Bird Islands and (B) Inner East and Outer Bird Islands from 1977 to 1993. Nest shelters were first placed on Inner East Bird Island in 1985 as represented by the dotted vertical line.

IV. 4 REPRODUCTIVE SUCCESS

IV. 4. 1 Clutch Sizes

Clutch sizes were recorded for 1414 nests on ten islands during mid-incubation surveys in 1992 (Table 11) and for 552 nests on 11 islands in 1993 (Table 12). The surrounding cover type was recorded for all of these nests.

The number of eggs per nest ranged from one to 11 in 1992 and one to seven in 1993. Less than 0.35% of nests in 1992 had greater than seven eggs and the effect of nests with multiple clutches was therefore regarded as minimal.

In 1992, clutch sizes did not vary among cover types (Kruskal-Wallis, DF=7, H=5.48, P=0.60). The mean clutch size for all nests ± one standard deviation in 1992 was 3.79 ± 0.03.

In 1993, clutch size for nests in beach cover (3.00 ± 0.19, median=3.00) was significantly lower than for nests under standing deadwood (3.94 ± 0.12, median=4.00), gooseberry (3.69 ± 0.09, median=4.00) or grass cover (3.63 ± 0.10, median=4.00) at the corrected Bonferroni level of $p<0.005$. Clutch size in beach cover in 1993 was also significantly less than that in beach cover in 1992 (3.88 ± 0.27, median=4.00). The mean clutch size for all nests in 1993 was 3.56 ± 0.05.

Median clutch size for all nests was 4.00 in both 1992 and 1993.

IV. 4. 2 Nest Predation

The proportion of predated nests was recorded by cover type for 441 nests during mid-incubation surveys on eight islands in 1993. Nest predation ranged from 1.6% of 61 nests under gooseberry cover to 18.0% of 50 nests in beach cover (Figure 19). Nests in beach (18.0%) and raspberry (14.3%) cover were significantly (Log-likelihood ratio test, corrected Bonferroni level of $p<0.005$) more likely to be predated than nests under gooseberry (1.6%) or grass (3.2%) cover. None of ten nests under artificial nest shelters had been predated. Two nests were recorded in forest cover and neither had been predated. Of the 441 nests in total, 38 (8.6%) had been predated.

Eighteen corvids were sighted on islands adjacent to forested islands in 1992 and 1993 (Table 13) while ten corvid sightings were made on predominantly forested islands. The greatest number of predated eggs were found on islands with corvid activity.

IV. 4. 3 Overall Nest Success

Nest fates were recorded for 661 nests on seven islands during post-hatch surveys in 1992. Of these, 106 or 16.0% were recorded as not having hatched successfully. Nest fates were recorded for 909 nests on 15 islands during post-hatch surveys in 1993 (Figure 20). The surrounding cover type was recorded for all 909 nests. Of these, 159 or 17.5% were recorded as not having hatched successfully.

The proportion of nests which did not successfully hatch in 1993 ranged from 7.9% of 38 nests under tuckamoor to 39.5% of 38 nests in beach cover. Only 9.8% of the 41 nests under artificial shelters were not successful. Two nests were recorded under forest cover, both of which hatched successfully. Nests in beach cover (39.5%) were significantly (Log-likelihood ratio-test, corrected Bonferroni level of $p < 0.006$) more likely to be unsuccessful than nests in all other cover types except for grass (19.0% unsuccessful) and raspberry (18.6%) cover.

Table 11: Mean and median clutch sizes of eider nests recorded by vegetation cover type in 1992. Ten islands were surveyed for clutch size.

Vegetation cover type	Mean clutch ± 1 S.E.	Median clutch	Number of nests
Barren	3.72 ± 0.12	4.00	69
Beach	3.88 ± 0.27	4.00	17
Forest	4.33 ± 0.80	4.00	6
Gooseberry	3.83 ± 0.04	4.00	761
Grass	3.77 ± 0.07	4.00	247
Raspberry	3.66 ± 0.07	4.00	250
Shelter	3.67 ± 0.33	3.50	12
Tuckamoor	3.88 ± 0.15	4.00	52
Total	3.79 ± 0.03	4.00	1414

Table 12: Mean and median clutch sizes of eider nests recorded by vegetation cover type in 1993. Eleven islands were surveyed for clutch size.

Vegetation cover type	Mean clutch ± 1 S.E.	Median clutch	Number of nests
Barren	3.37 ± 0.18	4.00	57
Beach	3.00 ± 0.19	3.00	44
Deadwood	3.94 ± 0.12	4.00 [a]	69
Forest	4.50 ± 0.50	4.50	2
Gooseberry	3.69 ± 0.09	4.00 [a]	104
Grass	3.63 ± 0.10	4.00 [a]	137
Raspberry	3.47 ± 0.11	4.00	109
Shelter	3.36 ± 0.27	3.50	14
Tuckamoor	3.44 ± 0.22	3.00	16
Total	3.56 ± 0.05	4.00	552

[a] Significantly greater than in beach cover at corrected Bonferroni level of 0.005.

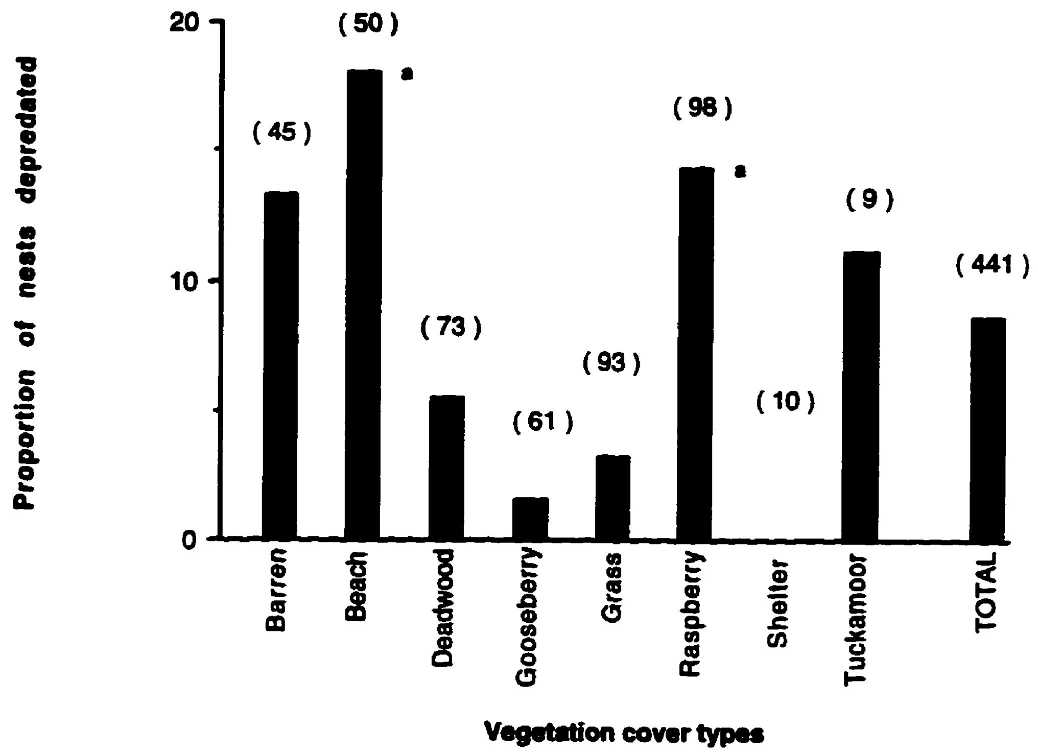


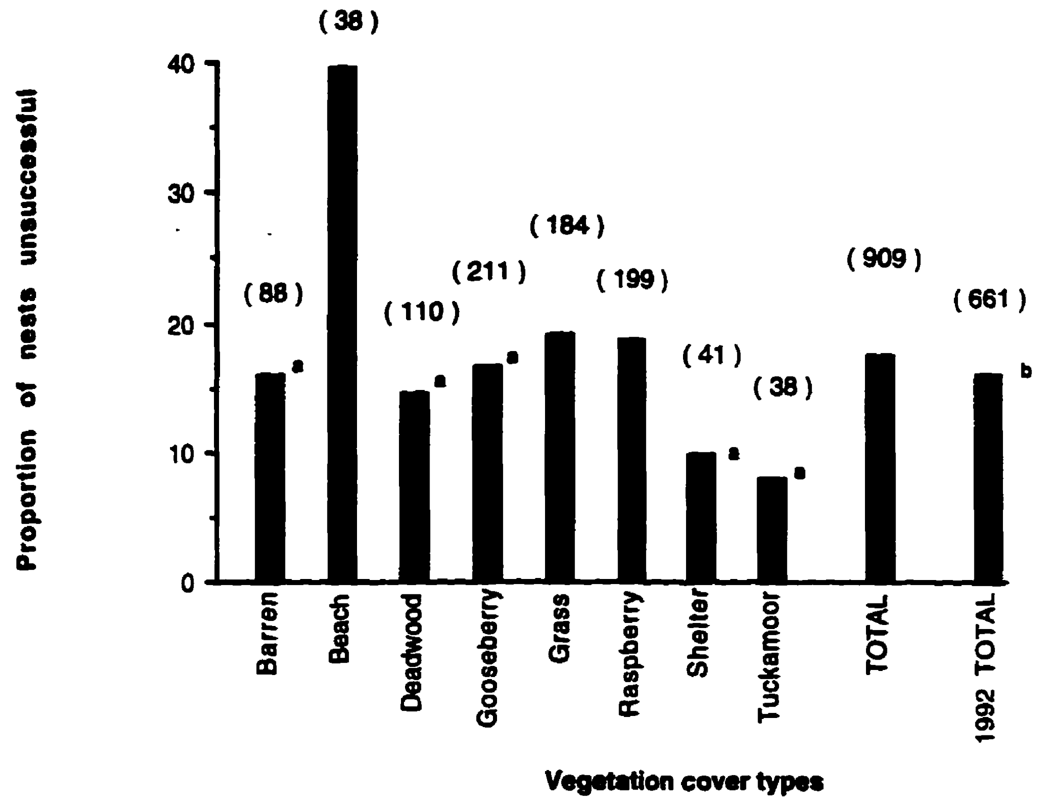
Figure 19: Proportion of nests predated by avian predators recorded by vegetation cover type in 1993. Proportions were recorded during mid-incubation surveys for eight islands in the WMA. The total number of nests recorded in each cover type is presented above each column.

[a] Significantly greater than for nests in gooseberry and grass cover at corrected Bonferroni p-value of 0.005.

Table 13: Corvid observations during mid-incubation surveys in the WMA in 1992 and 1993.

Island cover	Number of islands	Raven	Crow	Predated eggs
Open	8	0	0	27
Adjacent to forested	7	3	15	121
Forested	11	4	6	175 [1]

[1] Also recorded were 29 predated cormorant eggs and eight predated petrel eggs.



<u>Figure 20:</u> Proportion of unsuccessful nests recorded by vegetation cover type in 1993. Unsuccessful nests were those which were abandoned, predated by avian predators or contained down without any sign of a successful hatch. Proportions were recorded during post-hatch surveys for 15 islands in the WMA in 1993. The total number of nests recorded in each cover type are presented above the columns.

[a] Significantly less than nests in beach cover at corrected Bonferroni p-value of 0.006.

[b] Proportion of unsuccessful nests recorded for seven islands in 1992.

V. DISCUSSION

V. 1 PHYSICAL CHARACTERISTICS OF NESTING ISLANDS

Observations made by authors in other eider studies have suggested that an island's distance from the mainland and the size of an island were important characteristics for nesting populations (Blumton *et al.* 1988, Schmutz *et al.* 1983). There was no evidence for this in the present study along the eastern shore of Nova Scotia. Islands surveyed in the WMA in 1992 and 1993 were located 1.3 to 7.1 kilometres from the mainland and ranged from 0.8 to 14.8 hectares in size. Neither distance from the mainland nor island size were accurate predictors of eider nesting populations for these islands.

In Maine, American Eider nested on small, isolated islands and the distance to the mainland and island size were considered important factors (Blumton *et al.* 1988). A high level of human recreational activity occurred along coastal Maine. Large islands and islands close to the mainland were more likely to have cottages and to be disturbed by recreational boaters. This type of pressure did not exist along the eastern shore of Nova Scotia. Islands examined during this study were protected within a wildlife management area during the breeding season. While island size and distance from the mainland were important characteristics of eider nesting islands in Maine, they were not as crucial within the WMA where human disturbance was of a lower intensity.

It is generally accepted that eiders nest on offshore islands as protection from mammalian predators (Ahlén and Andersson 1970, Gerell 1985, Schmutz *et al.* 1983, Schamel 1977). There was no evidence of mainland mammalian predators such as Red Fox, *Vulpes vulpes*, Coyote, *Canis latrans*, or Raccoon, *Procyon lotor*, on any of the islands surveyed in the WMA. A distance of 1.3 kilometres from the mainland represented a safe distance from such predators for nesting eider. The fact that no eider colonies were known to exist closer to the mainland suggested that islands within 1.3 kilometres may have been accessible to these predators and unsuitable for nesting eider.

Mink and otter were common on offshore islands within the WMA and there was evidence of predation on nesting hens by both mustelid species during the 1992 and 1993 nesting seasons. Distance from the mainland did not provide a barrier to either mink or otter for the range of distances examined in this study. The large number of islands within the WMA meant that mustelids could usually move between islands to reach islands furthest from the mainland. Active mink dens and the remains of hen eiders were found on four islands ranging from 1.8 to 5.0 kilometres from the mainland. It is interesting to note that the natural mink population in the area was regularly supplemented by escaped mink from a nearby farm on the mainland (Levy pers. comm.). Active otter dens and dead eiders were also found on several islands. Two dead hens were found near an otter den in 1993 on an island 5.9 kilometres from the mainland. McAloney (1973) reported that mink were responsible for killing hens during his two year study period on Tobacco Island, two kilometres from the nearest point on the mainland. Mink were considered major predators of eider hens and hatchlings on islands within 2.1 km of the mainland in southern Sweden (Gerell 1985). Although it was felt that mink predation may have been a contributing factor in the decline of eider nesting populations on a few islands within the WMA (Milton pers. comm.), overall eider populations do not appear to be threatened by the presence of mustelids. Similarly, Gerell (1985) concluded that nesting eiders were able to coexist with resident mink. Since eider nesting populations on all study islands were likely to encounter predation by mustelids, distance from the mainland was not a major factor in reducing hen predation.

Within the WMA, islands of all sizes supported nesting populations and although nest densities may have been greater on some small islands, large islands still supported substantial numbers of nests. Gerell (1985) reported that although highest nest densities were found on small islands in southern Sweden (less than 1.5 ha), large islands still represented an important source of eider production. Eiders were found to nest on all sizes of islands in West-Spitsbergen, providing they were not so small as to become affected by wave action nor so large as to support resident Arctic Fox, *Alopex lagopus* (Ahlén and Andersson 1970).

As an island increases in size, the area of nesting habitat further from the shoreline increases (Schmutz *et al.* 1983). The relationship between island size and amount of available cover within easy access of the shoreline was not likely to have been a major factor in choice of nesting islands by eider in the WMA. The majority of islands were less than 8.0 hectares in size with access to the water from most areas of the island. Access to the shoreline would be most difficult on wooded islands. Regardless of island size, eiders did not nest on forested islands in the WMA in any substantial numbers. To determine if forest cover on large islands had an effect on eider nest placement, transects were surveyed on the lone large wooded island within the WMA known to have a substantial number of nesting eider. Forty-eight percent of recorded nests were within 50 metres of the shoreline while 81% were within 100 metres. Schmutz *et al.* (1983) found that Hudson Bay Eiders preferred to nest on promontories near the shore on larger islands with more than 70% of nests being located within three metres of the shoreline.

V. 2 PRESENCE OF NESTING SEABIRDS

Although no quantifiable relationships were found between number of nesting eider and number of nesting gulls and/or cormorants, all commonly nested on the same islands within the WMA.

Herring and Great Black-backed Gulls were observed to predate eider nests within the WMA. Gull colonies were not large (<120 nests) and eiders nested in protective cover abundant on most islands. Choate (1966) found that the physical barrier provided by the stems and branches of shrubs hindered gull movement. Hence, predation pressure by gulls in the WMA was not considered intense enough to have had deleterious effects on overall eider nesting populations. Although predation on eider eggs by both Herring and Black-backed Gulls was common in southwest Sweden (Götmark and Åhlund 1988), the level of predation was not severe enough to have had an effect on eider populations. Increases in both eider and gull nesting populations can occur on the same island (Bruemmer 1979).

Herring and Great Black-backed Gulls are major nest predators throughout the eider's range (Guignion 1967, Clark 1968, Bourget 1970, Milne and Gorman 1974, Götmark and Åhlund 1988). Both gull species commonly predate eider nests in Nova Scotia (Lewis 1959, Sabean 1972). However, there was no negative correlation between numbers of nesting eider and gulls within the WMA. Gull presence did not appear to be a serious limiting factor for overall eider nesting populations, presumably because adequate protective nesting cover was available.

In some cases, eiders have been found to nest within or close to larid colonies. Schamel (1977), found that eiders nested in highest densities inside the perimeter of Glaucous Gull, *Larus hyperboreus*, colonies where they were afforded protection from other avian predators. Spectacled Eider, *Somateria fischeri*, also nested within gull and tern colonies on the Indigirka Delta (Kistchinski and Flint 1974). General observations from the present study suggest that nesting gulls and eiders rarely overlapped in their habitat use on islands in the WMA. Gulls generally nested in the open beach and barren habitats with little vegetative growth while eiders most often nested in vegetation with greater cover. A positive correlation found between the nest density of eiders and gulls in southwest Sweden (Gerell 1985) was felt to be due to both colonies being restricted to the same habitat type. White-winged Scoters, *Melanitta fusca*, nested alongside larids in Saskatchewan. This association was also thought to be due to an overlap in habitat and not to some form of attraction between the two (Brown and Fredrickson 1989).

Double-crested and Great Cormorants nested on islands throughout the WMA. Double-crested Cormorants were the more common of the two and often nested in living and dead softwoods. Eiders nested on islands with and without active cormorant colonies. Researchers in the lower St. Lawrence (Thurston 1991), found that cormorant colonies destroyed forested cover used by nesting eider. Since eiders rarely nested under forest cover in the WMA, the presence of cormorant colonies may actually be beneficial. Considerable movement of cormorant colonies has occurred within the WMA with old colony sites being abandoned for nearby treed islands (Lock and Ross, 1973). Trees killed by cormorant guano remained as dead and fallen softwoods. The resulting deadfalls and new shrub growth of raspberry and gooseberry provided nesting cover for eiders. With a few exceptions, islands within the WMA were able to recover after loss of forest cover with new growth of *Ribes* and *Rubus* spp. and regenerating fir and spruce (Austin-Smith, pers. comm.).

V. 3 NESTS IN NATURAL SITES

V. 3. 1 Availability and Use of Vegetation Cover Types

Although all vegetation cover types were used by nesting eiders to some degree, the largest number of nests and the greatest total nest densities were recorded in gooseberry and raspberry associated with standing deadwood. Use of gooseberry relative to its availability suggested that it was selected for as nesting cover. Studies of American Eider have consistently shown that, while eiders will nest in a number of different cover types, they most often nest in cover types which provide the greatest amount of protective cover. On islands in Penobscot Bay, Maine, Gross (1944) observed that shrubs (*Ribes*, *Rubus* and *Rosa* spp.) provided excellent nest cover. Previous studies along the eastern shore of Nova Scotia found that shrub cover of *Ribes* and *Rubus* intermixed with fallen, dead softwoods provided the most often used cover type (Sabean 1972, Milton 1986). In the St. Lawrence Estuary, eiders also showed a strong preference for nesting in protective cover of shrubs and tall grass (Reed 1975, van Dijk 1986). Hudson Bay Eiders nested under dwarf willow and birch (Guild 1968). European studies have shown that eiders seldom nested under deciduous forest cover but most commonly nested under shrubs (Errington 1961, Swennen 1976, Gerell 1985). Other large bodied seaducks such as White-winged and Black Scoters, *Melanitta nigra,* commonly nested under the dense, thorny cover provided by gooseberry bushes (Brown and Fredrickson 1989).

Tuckamoor and grass cover were common on most islands in the WMA and supported substantial numbers of nests. Tuckamoor and grass were considered important sources of nesting cover on predominantly barren islands. In Labrador, eiders nested in patches of grass and umbelliferous herbs on islands lacking tuckamoor cover (Gilliland *et al.* 1996). In Penobscot Bay, Maine, nests outside of shrub cover were most commonly found in grasses or under the low, spreading branches of softwoods near the shoreline (Gross 1944, Choate 1967, Korschgen 1977). Eiders originally nested in shoreline grasses on Kent Island, New Brunswick until increasing gull populations caused a shift to nesting under thick spruce-fir woods (Grubb 1974). Heather and rush cover were preferred by eiders nesting on moorlands in Scotland (Milne and Gorman 1974).

Nests were sparsely scattered in barren cover which represented the dominant cover type on islands within the WMA (>30% of the total area surveyed during both years). Beach cover was generally avoided as nesting cover. Areas near the beach were also most often frequented by nesting and foraging gulls. Eiders have been recorded nesting on exposed sites in study areas where vegetative cover is poor (Hildén 1964, Gabrielsen and Lincoln 1959). Even on islands where most nests were under protective shrub cover, an occasional eider nest was found in an exposed barren or rocky area (van Dijk 1986). In barren cover, eiders generally nested near whatever cover was available in the form of short grasses or rock overhangs (Cooch 1958).

Forest cover was rarely used by nesting eider in the study area. Of nine predominantly forested islands surveyed, only Big White was found to have eider nests. A common characteristic of forested islands was a very dense thicket of fir along the shoreline which may have discouraged hens from nesting within the woods. Much of the forest edge on Big White consisted of stunted tuckamoor with an open understory. On the wooded island of Île de Bicquette in the St. Lawrence, an open undergrowth and a network of trails allowed eider hens easy access to forest habitat across the entire island (Thibault, pers. comm.).

Andersson (1975), suggested that eiders were capable of being unspecialized in their selection of nest sites and were able to nest in both open and sheltered cover due to advantages resulting from their nesting behaviour and biology. The small clutch size of eiders resulting in a short period of egg exposure to predators during laying, and the ability to incubate nests continuously during daylight hours, were both cited by Andersson as being factors which allowed for nesting in open cover. However, most studies of American Eider have suggested that the amount of visual and physical protection afforded to nests by vegetative cover was important in nest site selection (Choate 1967, Bourget 1970, Milne and Reed 1974, Clark *et al.* 1974). The present study tends to support the idea that while eiders were able to use a variety of cover types within the study area, nests were most often located in cover types which offered the greatest amount of protection.

V. 3. 2 Use of Deadfalls

Deadfalls were an important component of eider nesting habitat in the present study. Twenty-six percent of all nests were under deadfalls. Fifty-nine percent of nests in barren cover were under deadfalls suggesting that the additional protection provided by deadfalls was of value to nesting hens. Visual and physical protection from predators (Choate 1967, Milne and Reed 1974) and physical protection from the elements (van Dijk 1986) have been considered important factors in nest site selection. Minot (1976), found that eiders in the Grand Manan archipelago nested most often around blowdowns with secondary shrub growth. Eiders nested under fallen dead spruce trees which provided thick, tangled cover on Kent Island, New Brunswick (Gross 1938). Common Eider also nested under driftwood or next to fallen trees and logs on the central Beaufort Sea coast of Alaska (Schamel 1977, Johnson *et al.* 1987).

V. 4 ARTIFICIAL NESTING SHELTERS

V. 4. 1 Occupancy and Reuse

The literature suggests that eiders will use artificial shelters. Artificial nest shelters provided an alternative to nesting in open cover on barren islands and exhibited a high rate of use (33%) by nesting eider in Labrador in 1995 (Gilliland *et al.* 1996). The high use of shelters was likely due to the lack of high quality nesting cover on the barren islands. Wooden shelters in Penobscot Bay, Maine, were used extensively by nesting eider (Clark *et al.* 1974). Forty-eight shelters were placed on three islands in 1967. Shelter use was consistently very high, ranging from 79 to 85% between 1970 and 1972. Females which came ashore first usually chose sites under the shelters (Korschgen 1976). Shelter use declined significantly as the season progressed since females appeared to prefer natural herbaceous and grass cover once it had developed in height and density. In 1985, 450 wooden nest shelters were placed on Île Blanche in the St. Lawrence Estuary. Use of these shelters was high in the years immediately following placement with approximately 30% of nests being under shelters (Lacroix and Smallwood 1989). Manmade stone shelters were commonly used by nesting eider in Iceland (Munro 1961) and on Baffin Island (Cooch 1965).

Artificial nesting shelters were used by nesting eider on islands in the WMA but the amount of use varied among islands. Shelter use remained relatively low on most islands. This was the case on Little White, Western White and Outer East Harbour Islands. On these islands, shelters have been present for six to eight years with little use (0 to 1.4% occupancy). Part of the reason for low shelter use on these islands may have been their surrounding habitat. Shelters were placed in beach, barren and forest cover normally avoided by eider (Section VI. 3. 1). Work in Table Bay, Labrador has shown preferential use of shelters by nesting eider within different types of cover (Gilliland *et al.* 1996). In Labrador, shelters in barren cover were not used as frequently (17%) as those surrounded by grass cover (51%). Shelter use in the WMA was also low (<14%) in 1993 on islands where shelters had only been available for use for one season.

Artificial nest shelters have been present on Inner East Bird Island for eight seasons. Use of shelters has increased over this time and in 1993 reached a high of 38%. Shelters were scattered throughout ample natural cover in the form of tall grasses and Cinnamon Fern.

Of the five different kinds of artificial nesting shelters placed on islands in the WMA, single plastic and double wooden shelters were the most common. Double wooden shelters were used less frequently than all other shelter types. Small entrance sizes of double wooden shelters may have discouraged nesting hens. The heavier weight of double wooden shelters often caused them to sink into the soil thereby reducing the size of the opening at the front. Clark *et al.* (1974) observed that the entrances of unused wooden shelters in Penobscot Bay, Maine were usually less than 13 cm high.

Artificial nest shelters on Inner East Bird Island were examined to determine whether nest sites under shelters were reused in consecutive years. The high rate of reuse (67% in 1991/1992 and 89% in 1992/1993) in the present study was supported by the literature. Reuse of shelters does not necessarily indicate repeated use by the same female. Milne and Gorman (1974) reported that the same nest sites were used year after year, but not always by the same hen. In the Barent's Sea, eider nests were often surrounded by accumulated debris in the form of an elevated ring which suggested that the same nest was used for many years by the same or different nesting females (Belopol'skii 1956). Similar observations have been made in the WMA with nest sites in natural cover being occupied in consecutive years (O'Brien pers. comm.). A preference was shown by nesting female

Common Goldeneye, *Bucephala clangula*, for nest boxes that had been occupied by other hens in the preceding year (Dow and Fredga 1984). Similar behaviour has also been observed in Buffleheads, *Bucephala albeola* (Gauthier 1990).

Several authors have found that hen eiders exhibited a high level of fidelity to nesting islands. Nesting hens have been banded and recaptured in subsequent years in the same area on the same island in the WMA (Boyd pers. comm.). Cooch (1965), reported that eiders nested on the same islands in consecutive years with 86% of hens nesting within 200 feet of their previous year's nest. Gerell (1985), found that nesting hens in southern Sweden showed a strong tendency to return to the same breeding island each year. Thirty-nine of 41 banded females returned to nest the following year on the same island. Similarly, a study of American Eider in Maine (Wakely and Mendall 1976), revealed that nearly all surviving females returned to the same breeding island year after year.

Nest site fidelity may help explain the mechanism behind nest site selection in different habitats. Female eiders have been shown to exhibit philopatry to their natal islands (Coulson 1984, Baillie and Milne 1989, Swennen 1990) and hens also appear to return to successful nest sites in consecutive years. Eider hens which failed to successfully hatch young were seen to move to new sites the following year (Milne and Gorman 1974). Eiders which lost nests to predators did not return to the same site while 25% of successful nesters returned to the exact nest site the following year (Bustnes and Erikstad 1993). Nest site selection in White-winged Scoters was strongly influenced by nest concealment and previous nest success (Brown and Fredrickson 1989). Adult Wood Duck, Aix sponsa, hens returned to the nesting areas where they last bred successfully and young hens also returned to their natal area to nest. A high proportion of cavities (71 to 89%) having successful nests the year before were selected as nest sites while less than 50% of cavities in which nests were destroyed were used in following years (Bellrose *et al.* 1964). In eiders, a combination of natal philopatry and fidelity to successful nest sites would increase nesting populations in cover types with highest nesting success.

V. 4. 2 Effects on Nesting Populations

Over time, the number of nests under shelters had increased on Inner East Bird Island from 7% in 1987 to 38% in 1993 without an overall increase in the total number of nests on the island. The relative number of nests placed in vegetation had decreased over the same time period. Increased use of nest shelters on an island did not necessarily reflect an overall increase in the total nesting population of eider on that island.

Shelters were placed on Inner East Bird Island but not on the nearby islands of Outer Bird and Inner West Bird Islands. All three islands experienced similar annual changes in nesting populations (increasing or decreasing) whether shelters were present or not. Nesting populations had increased on all three islands between 1991 and 1993. These annual variations were well within the ranges observed by Coulson (1984) on Coquet Island off the east coast of Britain. Coulson found considerable year to year variation related to the proportion of nonbreeding hens which avoided nesting during years of poor body condition.

V. 5 REPRODUCTIVE SUCCESS

V. 5. 1 Clutch Sizes

Mean clutch sizes in the present study were 3.79 in 1992 (n=1414) and 3.56 in 1993 (n=552). These were at the lower end of a range of clutch sizes reported elsewhere. Cooch (1965) reported mean clutches of 3.57 in 1955 and 3.83 in 1956 for eiders nesting on Baffin Island. In the Gulf of St. Lawrence and St. Lawrence Estuary, mean clutches of 4.04 (Lewis 1939), 4.33 (Guignion 1968) and 3.90 (van Dijk 1986) have been recorded. Mean clutches of 4.4 (Gross 1938) and 3.53 (Paynter 1951) have been reported on Kent Island while a mean of 4.06 was recorded on the Wolves Archipelago, New Brunswick by

Gilliland (1990). In Penobscot Bay, Maine, mean clutch sizes have ranged from 3.79 in 1965 (Choate 1966) to 4.11 in 1966 and 3.53 in 1967 (Clark 1968). Geographically closer to the present study area, Sabean (1972) reported a mean clutch of 4.35 on Tobacco Island on the eastern shore of Nova Scotia. Milton (1986) reported an overall mean clutch of 3.96 on islands within the WMA. Coulson (1984) recorded a range in clutch sizes from 3.78 to 5.40 over a 25 year period on Coquet Island off the east coast of Britain. Coulson felt that annual variation in clutch sizes was related to the body condition of hens within the nesting population in a given year.

In the present study, clutch sizes did not vary significantly among cover types in 1992. However, in 1993, nests in beach cover contained significantly fewer eggs (3.00) than nests under standing deadwood (3.94), gooseberry (3.69) and grass cover (3.63).

There are two plausible explanations for the lower clutch size recorded in beach cover in 1993. Older, more experienced eider hens have been shown to be heavier, lay earlier and produce significantly larger clutches (Baillie and Milne 1982). This has been attributed to increased experience in accumulating fat reserves while foraging during the pre-laying period. Other waterfowl species have exhibited similar patterns of older age and increased clutch size (Brakhage 1965, Morse *et al.* 1969). The variation among clutch sizes observed in the WMA in 1993 could be partly due to older females nesting less often in the poorly concealing beach cover.

A smaller clutch size may also have reflected increased partial predation by gulls which commonly foraged along the beach and in herbaceous beach cover. Other studies have reported significantly lower clutches in less concealing cover types. Gerell (1985) found significantly smaller clutches on islands with sparse raspberry cover than on islands with dense cover of *Juniperus communis* in Sweden. Similarly, Milne and Reed (1974) observed lower clutch sizes on islands with open cover, where gull predation on eider nests was greatest, than on shrub covered islands. Milton (1986) found a significantly lower mean clutch for nests in sedges and grasses (3.06) than for clutches under shrub growth

(4.35) on islands within the WMA. Increased avian predation on eider nests was observed by Milton on those islands with reduced nesting cover of low herbs, sparse grass and/or raspberry cane.

If nesting shelters offered an advantage over natural sites, it might be expected that nests under shelters would have higher than average clutch sizes due to either a decrease in egg losses to avian predators and/or choice of shelters by older, more experienced hens in good breeding condition. This was not supported by the present study. Clutches under shelters (3.67 in 1992 and 3.36 in 1993) were not significantly different from any of the other cover types for either year. Although eiders nesting under shelters in the WMA did not produce larger clutches than those in natural sites, both Bourget (1970) and Korschgen (1977) found that nests under shelters in Maine had significantly larger clutch sizes (4.43 and 5.0 eggs) than nests in natural herb and shrub cover (3.37 and 3.9). The mean minimum age of hens nesting under shelters was six years compared to a mean age of two years for hens in natural sites (Korschgen 1977). It was not known whether differences in clutch sizes in Maine were caused by gull predation or whether fewer eggs were actually laid.

V. 5. 2 Factors Affecting Nest Success

Nine percent of the nests recorded during mid-incubation in 1993 had been predated. Average annual nest destruction in Soderskar between 1953 and 1959 was 10% (Grenquist 1959). Swennen *et al.* (1993) reported that 16% of 205 nests on the Island of Vlieland had been destroyed by Carrion Crows, *Corvus corone*. A much higher rate of predation was recorded by van Dijk (1986) on Île aux Pommes, Quebec, with 63% of eider nests having been plundered by gulls.

In the present study, nests in beach cover were the most vulnerable with 18% of nests surveyed during mid-incubation having been predated. Nests under gooseberry cover experienced the lowest predation rate of 1.6%. None of ten nests under shelters had been predated. Milne and Gorman (1974) reported that eider nests in the least favored habitats in Scotland were the most likely to be predated. There was a greater chance of nest predation in grass cover than under cover of heather and rush. The physical obstruction provided by dense shrub vegetation has been found to reduce nest predation by gulls (Reed 1964, Clark 1968, Bourget 1970). Gulls have difficulty moving about in dense vegetation due to their large wingspan and wing structure and have even been found fatally entangled in heavy cover (Guignion 1967). Lewis (1959) reported that well concealed nests on wooded islands were rarely predated while 20% of nests on open islands had been destroyed by predators. At artificial waterfowl nests in Alberta, egg losses to avian predators were inversely correlated to the quality of overhead cover (Dwernychuk and Boag 1972).

The main nest predators within the WMA were larids and corvids. Herring and Great Black-backed Gulls were observed to predate eider nests on islands lacking forest cover. Gulls commonly nested on the same unforested islands as eiders. It was not determined which species was the more important nest predator. Only Great Black-backed Gulls were observed attacking créches to predate eider ducklings. Sabean (1972) reported that Herring Gulls were the most serious predators of eider eggs in his study area on Tobacco Island. Nest predation by gulls was the chief cause of nest failure on Baffin Island (Cooch 1965) and in Maine (Clark 1968). Clark (1968) observed Herring Gulls occasionally entering and predating eider nests under artificial wooden shelters with entrance heights greater than 20 cm. Both Herring Gulls and Carrion Crows predated eider nests in the Sands of Forvie National Nature Reserve, Scotland (Milne and Gorman 1974).

American Crows nested on a few of the larger wooded islands within the WMA and were commonly observed on wooded islands and on open islands adjacent to forested islands. They were considered efficient predators of eider nests on these islands. It was not uncommon during surveys of forested areas to find dozens of predated eider eggs under the forest canopy where they had been discarded by crows. On Tobacco Island, a pair of nesting crows were observed to rely heavily on eider eggs for food and were second only to Herring Gulls in importance as predators of eider nests (Sabean 1972). Corvids predated eider nests in wooded areas of Soderskar (Grenquist 1959), the Gulf of Bothnia (Hildén 1964) and Penobscot Bay in Maine (Choate 1966). Similarly, crows predated eggs on the wooded Brandypot Island but were not seen to be a danger on treeless islands in the St. Lawrence Estuary (Guignion 1967). Gilliland (1990) also reported that crows were important predators on eider nests in the Wolves Archipelago while gulls preyed mainly on ducklings. While gulls were rarely seen to venture into the forest on Île de Bicquette (Bruemmer 1979), the author observed crows predating eider nests in the forest on that island in 1996 (Woolaver, pers. obs.).

Sixteen percent of nests recorded post-hatch in 1992 had not hatched successfully. Similarly, 17% of nests were not successful in 1993. Milton (1986) recorded a low rate of nest loss for islands in the WMA with only 7% of 41 nests being unsuccessful. This was attributed to the high level of overhead and lateral cover provided by the surrounding shrub and tuckamoor cover. Considerable annual variations in nest losses have been reported for other studies. Guild (1974) reported 20% of nests unsuccessful in 1972 and a much higher 52% nest loss in 1973 for Hudson Bay Eiders. Guignion (1967) found nest losses to vary among islands with 48%, 71% and 87% of nests unsuccessful on three islands in the St. Lawrence Estuary. The proportion of unsuccessful nests was also high for eider studies in Penobscot Bay, Maine. Nest losses ranged from 61% in 1964 and 64% in 1965 (Choate 1966) to 61% in 1966 and 87% in 1967 (Clark 1968). Bourget (1973) recorded 55% of nests unsuccessful in the same area. Nest losses in European populations of eider have been intermediate between those observed in Maine and in the present study. In northeast Scotland, 38% of nests were recorded unsuccessful by Milne (1963) while 30% of nests were not successful in Valassarat, Finland (Hildén 1964).

In the present study, nests under beach cover were most vulnerable with 40% of recorded nests not having hatched successfully in 1993. This was significantly greater than all other cover types with the exception of nests under grass and raspberry cover, both with 19% of nests unsuccessful. Nests under tuckamoor and under shelters were the most likely to have a successful hatch with only eight and ten percent of nests unsuccessful. Eider nest success has also been shown to vary among cover types in other studies with greatest nest loss in those cover types which offered the least amount of physical and/or visual protection from predators. Milne and Reed (1974) studied reproductive output of eiders nesting in the St. Lawrence Estuary. They found a direct relationship between the amount of overhead cover at a nest site and nest loss. Unsuccessful nests were most often recorded on rocky islets with sparse grass cover (86% unsuccessful) compared with 75% nest loss on islands covered with grasses and shrubs and 64% on wooded islands. Similar results were reported by Guignion (1967) where 84% of nests on rocky islets had not hatched successfully compared with 64% on islands with grass and shrub cover. Choate (1967) found that nests in cover of grass and nightshade were more often unsuccessful than nests under hardwood shrubs and cow parsnip. Belopol'skii (1956), Grenquist (1959) and van Dijk (1986) all recorded higher nest losses in open sites when compared with more sheltered sites. In Saskatchewan, only 15% of White-winged Scoter nests under shrub cover were unsuccessful compared to 38% nest loss in sparser forb cover (Brown and Fredrickson 1989).

Only 10% of nests under artificial shelters in the WMA were unsuccessful in 1993. Nest shelters offered nest sites of equal quality to that provided by the most successful of natural cover types in the WMA. Artificial nest shelters in Maine have been found to significantly lower eider nest losses by affording increased protection from gull predation (Clark 1968, Bourget 1970). In Bourget's study (1970), nests in natural cover were unsuccessful 46 to 85% of the time compared with only 27 to 39% of the time when located under artificial shelters. Clark *et al.* (1974) concluded that shelters were most beneficial early in the nesting season and on islands lacking natural vegetative cover.

VI. SUMMARY AND RECOMMENDATIONS

American Eider nesting habitats were studied within the Eastern Shore Islands Wildlife Management Area in 1992 and 1993. The importance of island size, island distance to the mainland and the presence of other nesting seabirds to nesting eider were all examined at an island scale. It was determined which vegetation cover types were utilized more or less often than expected relative to their availability. The importance of deadfalls in nest site selection was also examined. Occupancy of different kinds of shelters, the amount of reuse by hens in consecutive years and the effect of shelter presence on nesting populations were all measured to determine shelter effectiveness in providing alternative nesting sites. The reproductive value of natural cover types and artificial shelters were assessed by comparing clutch sizes, nest predation and overall nest loss.

Islands surveyed in the WMA in 1992 and 1993 ranged from 0.8 to 14.8 hectares in size and from 1.3 to 7.1 kilometres in distance to the mainland. Neither characteristic was an accurate predictor of size of eider nesting populations within the WMA where human disturbance (i.e. cottage builders, recreational boaters) was not a major factor.

Islands of all sizes supported nesting eider and although nest densities were greatest on smaller islands, large islands supported substantial numbers of nests. Any island large enough to protect eggs from wave action and to have adequate vegetative growth could support nesting eider.

A distance of 1.3 km from the mainland was felt to represent a safe distance from most mammalian predators. Mink and otter were common within the WMA and eiders nesting on all of the study islands were likely to encounter mustelid predation.

Eiders, gulls and cormorants nested on the same islands in the WMA. Although both Herring and Great Black-backed Gulls were important predators of eider nests, their presence did not appear to limit eider nesting populations. Nesting gull (26 ± 32 nests) and eider (39 ± 32 nests) populations were moderate on islands surveyed in 1993. Eiders and gulls were observed to nest in different habitats and eiders rarely nested within gull colonies. Double-crested Cormorants have converted softwood forest to standing deadwood and shrubbery on some islands and may be regarded as beneficial to nesting eider within the study area. An examination of the relationship between the historical movements of cormorant colonies and the location of present eider nesting habitat would make an interesting future project. A better understanding of the amount of time required for mature forest to regenerate from standing deadwood and shrub growth would be especially valuable.

Although all vegetation cover types were used by nesting eiders to some degree, the largest proportion of nests and greatest nest densities were recorded for shrub growth of gooseberry and raspberry with standing deadwood. Use of gooseberry (23% of nests in 1993) relative to availability (6% of area) suggested it was highly preferred nesting cover. Grass and tuckamoor cover, although not utilized more or less than expected based on their availability, were considered important sources of nesting cover on predominantly barren islands. Nests were sparsely scattered throughout barren cover while beach and forest cover were both generally avoided as nesting cover. While eiders were capable of nesting in a wide range of vegetation types with varying amounts of cover, there was an apparent selection for thick shrubs and standing deadwood as nesting cover.

Deadfalls were an important component of eider nesting habitat with twenty-six percent of all nests located under deadfalls. Deadfalls were particularly important for nests in sparse vegetative cover with 59% of nests in barren cover recorded under deadfalls.

Use of artificial nest shelters varied among islands in the WMA. Shelter use remained low (0 to 1.4%) on several islands. Low shelter use on these islands was attributed to the placement of shelters in predominantly barren, beach and forest cover normally avoided by eiders. Use of shelters was much higher on Inner East Bird Island where shelters were located throughout tall grasses and ferns. Shelter use had increased on

Inner East Bird Island to a high of 38% in 1993. Shelter use was also low (<14%) in 1993 on islands where shelters had only been available for one season.

Use of double wooden shelters was lower than all other shelter types. Only one of the 12 double wooden shelters (8%) had been occupied on Inner East Bird Island in 1992 while nine of the 23 single plastic shelters (39%) had been used. Small entrance sizes of double wooden shelters may have discouraged nesting hens.

There was a high rate of reuse of nesting sites under shelters in consecutive years (67 to 89%). A combination of natal philopatry and fidelity to successful nest sites was suggested as a mechanism behind nest site selection.

Use of nesting shelters did not necessarily reflect an immediate growth in overall nesting population. On Inner East Bird Island, nest shelter use had increased without an overall increase in eider nests on the island. The number of nests in natural sites declined suggesting that hens moved from natural sites to the shelters. Nesting populations on adjacent islands lacking shelters exhibited similar annual fluctuations as Inner East Bird Island. Use of shelters as a means of increasing nesting populations does not appear to be effective in the short term on islands which already have established populations. While the availability of quality nest sites is an obvious limiting factor, recruitment of nesting eiders is a more complex process relying as much on environmental factors outside of the nesting area (i.e. adult mortality in wintering and staging areas, food availability and weather conditions during pre-laying period).

Clutch sizes did not vary among cover types in 1992. In 1993, clutches under beach cover were significantly lower than under standing deadwood and gooseberry cover. Clutches under shelters were not significantly different from any of the other cover types. Lower clutch sizes in beach cover could be explained by the use of beach cover by younger, less experienced hens producing smaller clutches and/or increased partial predation on nests in beach cover.

Nine percent of nests surveyed during mid-incubation in 1993 had been predated. Predation rates in the present study suggested that nests in the least favored habitats were most likely to be predated. Nests in beach cover were most vulnerable (18% nest loss) while nests under gooseberry were the least vulnerable (1.6% nest loss). None of ten nests recorded under shelters had been predated.

The main predators of eider nests in the WMA were larids and corvids. Herring and Great Black-backed Gulls were most active on open islands and were rarely observed in areas with thick shrub or forest cover. Crows were efficient predators of eider nests on islands with softwood forest cover or on open islands adjacent to forested islands. The extent of eider nest predation by each gull species would provide an interesting and valuable future study. Knowledge of even the relative proportion of each gull species nesting within the WMA would be helpful.

Overall nest loss was 16% in 1992 and 17% in 1993. Nests under beach cover were most vulnerable with 40% of nests unsuccessful. This was significantly greater than all other cover types with the exception of grass and raspberry cover (both 19%). Nests under tuckamoor and shelters were most likely to have a successful hatch with only eight and ten percent nest loss respectively.

American Eider are increasing in popularity among waterfowl hunters in New England and have been under high levels of harvest pressure in Newfoundland and Labrador. Eider populations are also vulnerable to oil pollution and loss of habitat to coastal development. It is important that a close watch is kept on the health of Nova Scotian populations. To this effect, eider management in Nova Scotia should continue to emphasize identification, protection and monitoring of important areas for breeding, overwintering and staging populations. Long-term monitoring of known colonies, identification of critical habitat requirements, and an understanding of the general biology of Nova Scotian populations are essential components of eider management.

Nest surveys should continue to be carried out in new areas along the southwestern shore of Nova Scotia. Long term monitoring of islands within the WMA, particularly those with shelters, should also be continued. It is recommended that mid-incubation surveys be avoided on predominantly grassy islands (i.e. The Brothers) where observer presence may increase nest predation by gulls. Eider nests under shelters and in grass or sparse raspberry growth could be found relatively easily during post-hatch surveys. Mid-incubation surveys on islands where eiders nest in concealing shrub cover (i.e The Halibuts) are necessary and are not likely to encounter the same levels of nest predation. It is also recommended that mid-incubation nest surveys not be carried out unless there are enough observers present to search the island within 1 to 2 hours or else some nest abandonment will occur.

While habitat enhancement programs for breeding populations are not presently as vital a component of eider management in Nova Scotia, they are of value. The information concerning eider nesting habitat requirements which is gained through these programs is important and can be applied elsewhere. Although it is recommended that no new shelters be placed on islands within the WMA, much can still be learned about eider nest site selection and monitoring of shelter use should be continued.

If in the future it is decided that artificial nest shelters are needed, they would be most beneficial if employed in situations where a known population of nesting eider already exist in marginal cover (i.e. grasses, sparse raspberry cane). The high use of deadfalls in barren cover also suggests that shelters would be beneficial if placed in barren habitat where eiders were already nesting under deadfalls. Shelters placed in rarely used cover types (i.e. beach, forest), in the absence of an already established nesting population, would most likely be ineffective in attracting new hens. Since small entrance sizes of double wooden shelters may have discouraged nesting hens, it is recommended that shelters have an entrance opening between 18 and 25 cm high after settling into the substrate.

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APPENDIX A: FLORA RECORDED IN THE WMA DURING BREEDING SEABIRD SURVEYS

Lichens

Cladonia spp.	Reindeer Moss
Usnea spp.	Old Man's Beard

BRYOPHYTA Mosses

Dicranum spp.	Broom Moss
Pleurozium schreberi	Schreber's Moss
Spaghnum spp.	

PTERIDOPHYTA FERNS AND THEIR ALLIES

Osmundaceae Flowering-Fern Family

Osmunda cinnamomea L.	Cinnamon Fern
Osmunda Claytonia L.	Interrupted Fern

Polypodiaceae Fern Family

Athyrium filix-femina (L.) Roth	Lady Fern
Dryopteris spinulosa (O. F. Muell.) Watt	Spinulose Wood Fern
Polypodium virginianum L.	Rock Polypody

GYMNOSPERMS CONIFERS AND RELATED PLANTS

Pinaceae Pine Family

Abies balsamea (L.) Mill	Balsam Fir
Juniperus communis L.	Common Juniper
Larix laricina (DuRoi) K. Koch	Larch
Picea glauca (Moench) Voss	White Spruce
Picea mariana (Mill.) BSP.	Black Spruce
Picea rubens Sarg.	Red Spruce

ANGIOSPERMS FLOWERING PLANTS

MONOCOTYLEDONS

Gramineae Grass Family

Festuceae Tribe

Festuca rubra L.	Red Fescue
Poa pratensis L.	Kentucky Bluegrass

Hordeae (Barley) Tribe

Elymus mollis Trin.	American Dune-Grass
Elymus virginicus L.	Wild Rye

Aveneae (Oat) Tribe

Deschampsia flexuosa (L.) Trin.	Hair-Grass

Agrostideae Tribe

Agrostis palustris Huds.	Creeping Bent-Grass
Ammophila breviligulata Fern.	American Beach-Grass
Calamagrostis canadensis (Michx.) Nutt.	Blue-Joint
Phleum pratense L.	Timothy

Chlorideae Tribe

Spartina pectinata Link.	Broad-Leaf

Cyperaceae — Sedge Family

Carex trisperma Dew.	Three-fruited Sedge
Eriophorum spp. L.	Cotton-Grass

Juncaceae — Rush Family

Juncus balticus Willd.	Seaside Rush
Juncus bufonius L.	Toad-Rush

Liliaceae — Lily Family

Clintonia borealis (Ait.) Raf.	Clintonia
Maianthemum canadense Desf.	Wild Lily-of-the-Valley
Smilacina racemosa (L.) Desf.	False Solomon's Seal
Smilacina stellata (L.) Desf.	Starry False Solomon's Seal
Streptopus amplexifolius (L.) DC.	Green Twisted-Stalk
Streptopus roseus Michx.	Rose Twisted-Stalk

Iridaceae — Iris Family

Iris Hookeri Penny	Seaside Iris
Iris versicolor L.	Blue Flag

Orchidaceae **Orchid Family**

Listera cordata (L.) R. Br.	Twayblade
Spiranthes lacera Raf.	Ladies'-Tresses

DICOTYLEDONS

Salicaceae **Willow Family**

Salix humilis Marsh	Small Pussy-Willow

Myricaceae **Sweet Gale Family**

Myrica gale L.	Sweet Gale
Myrica pensylvanica Loisel.	Bayberry

Corylaceae **Hazel Family**

Alnus crispa (Ait.) Pursh	Downy Alder
Alnus rugosa (DuRoi) Spreng.	Speckled Alder
Betula alleghaniensis Britt.	Yellow Birch
Betula papyrifera Marsh.	Paper Birch

Polygonaceae **Buckwheat Family**

Polygonum arenastrum Jord.	Knotweed
Polygonum scandens L.	Climbing False-Buckwheat
Rumex Acetosella L.	Sheep-Sorrel
Rumex crispus L.	Curled Dock

Chenopodiaceae **Goosefoot Family**

Chenopodium album L.	Lamb's-Quarters
Atriplex patula L.	Orach

Caryophyllaceae **Chickweed Family**

Arenaria lateriflora L.	Sandwort
Arenaria peploides L.	Seabeach Sandwort
Cerastium arvense L.	Field-Chickweed
Sagina procumbens L.	Pearlwort
Spergularia marina (L.)	Sand-Spurrey
Stellaria media (L.) Cyrillo	Common Chickweed

Ranunculaceae	Buttercup Family
Coptis trifolia (L.) Salisb.	Goldthread
Ranunculus acris L.	Tall Buttercup
Ranunculus Cymbalaria Pursh	Seashore Buttercup
Thalictrum polygamum Muhl.	Meadow-Rue

Cruciferae	Mustard Family
Brassica nigra (L.) Koch	Black Mustard
Cakile edentula (Bigel.) Hook.	Sea-Rocket
Capsella Bursa-pastoris (L.)	Shepherd's Purse

Sarraceniaceae	Pitcher-Plant Family
Sarracenia purpurea L.	Pitcher-Plant

Droseraceae	Sundew Family
Drosera rotundifolia L.	Round-Leaved Sundew

Crassulaceae	Orpine Family
Sedum Rosea (L.) Scop.	Rose-Root

Saxifragaceae	Saxifrage Family
Ribes glandulosum Grauer	Skunk-Currant
Ribes hirtellum Michx.	Gooseberry

Rosaceae	Rose Family
Amelanchier Bartramiana (Tausch) Roemer	Bartram's Chuckley-Pear
Aronia prunifolia (Marsh.) Rehd.	Chokeberry
Fragaria virginiana Duchesne	Wild Strawberry
Potentilla Anserina L.	Silverweed
Potentilla norvegica L.	Rough Cinquefoil
Potentilla tridentata Ait.	Three-Toothed Cinquefoil
Prunus pensylvanica L.	Pin Cherry
Rosa virginiana Mill.	Common Wild Rose
Rubus Chamaemorus L.	Bakeapple
Rubus pubescens Raf.	Dewberry
Rubus strigosus Michx.	Wild Raspberry
Sorbus americana Marsh.	Mountain-Ash

Leguminosae	Pea Family
Lathyrus japonicus Willd.	Beach Pea
Lathyrus palustris L.	Wild Pea
Trifolium repens L.	Creeping White Clover

Oxalidaceae	Wood-Sorrel Family
Oxalis montana Raf.	Wood-Sorrel

Empetraceae	Crowberry Family
Empetrum nigrum L.	Black Crowberry

Aquifoliaceae	Holly Family
Nemopanthus mucronata (L.) Trel	False Holly

Aceraceae	Maple Family
Acer rubrum L.	Red Maple
Acer saccharinum L.	Silver Maple

Balsaminaceae	Touch-Me-Not Family
Impatiens capensis Meerb.	Spotted Touch-Me-Not

Hypericaceae	St. John's-Wort Family
Hypericum perforatum L.	Common St. John's-Wort

Violaceae	Violet Family
Viola cucullata Ait.	Blue Violet
Viola pallens (Banks) Brainerd	Small White Violet

Onagraceae	Evening-Primrose Family
Circaea alpina L.	Small Enchanter's-Nightshade
Epilobium adenocaulon Haussk.	Willow-Herb
Epilobium angustifolium L.	Fireweed
Oenothera biennis L.	Evening-Primrose

	Family	Common name
	Araliaceae	**Ginseng Family**
Aralia nudicaulis L.		Wild Sarsaparilla
	Umbelliferae	**Parsley Family**
Heracleum lanatum Michx.		Cow-Parsnip
Ligusticum scothicum L.		Scotch Lovage
	Cornaceae	**Dogwood Family**
Cornus canadensis L.		Bunchberry
	Pyrolaceae	**Wintergreen Family**
Moneses uniflora (L.) Gray.		One-Flowered Shinleaf
Monotropa uniflora L.		Indian-Pipe
	Ericaceae	**Heath Family**
Chamaedaphne calyculata (L.) Moench		Leatherleaf
Epigaea repens L.		Trailing Arbutus
Gaultheria hispidula (L.) Muhl.		Snowberry
Gaultheria procumbens L.		Teaberry
Kalmia angustifolia L.		Sheep Laurel
Ledum groenlandicum Oeder.		Labrador-Tea
Rhododendron canadense (L.) Torr.		Rhodora
Vaccinium angustifolium Ait.		Low Sweet Blueberry
Vaccinium macrocarpon Ait.		Large Cranberry
Vaccinium myrtilloides Michx.		Canada Blueberry
Vaccinium Vitis-Idaea L.		Foxberry
	Primulaceae	**Primrose Family**
Trientalis borealis Raf.		Star-Flower
	Plumbaginaceae	**Leadwort Family**
Limonium Nashii Small.		Sea-Lavender
	Convolvulaceae	**Bindweed Family**
Convolvulus sepium L.		Bindweed

	Labiatae	Mint Family
Galeopsis Tetrahit L.		Hemp-Nettle
Scuttellaria galericulata L.		Skullcap
	Solanaceae	Nightshade Family
Solanum Dulcamara L.		Bittersweet
	Scrophulariaceae	Figwort Family
Euphrasia americana Wettst.		Common Eyebright
Rhinanthus Crista-galli L.		Yellow-Rattle
	Plantaginaceae	Plantain Family
Plantago juncoides Lam.		Seashore Plantain
Plantago lanceolata L.		English Plantain
Plantago major L.		Broad-Leaved Plantain
	Rubiaceae	Madder Family
Galium Aparine L.		Goose-Grass
Galium triflorum Michx.		Sweet-Scented Bedstraw
	Caprifoliaceae	Honeysuckle Family
Linnaea borealis L.		Twinflower
Viburnum cassinoides L.		Witherod
	Compositae	Composite Family
Achillea lanulosa Nutt.		Yarrow
Ambrosia artemisiiflora L.		Common Ragweed
Arctium minus (Hill) Bernh.		Common Burdock
Artemisia Stelleriana Bess.		Beach-Wormwood
Aster novi-belgii L.		New York Aster
Aster puniceus L.		Rough Aster
Aster umbellatus Mill.		Tall White Aster
Chrysanthemum Leucanthemum L.		Ox-Eye-Daisy
Cirsium arvense (L.) Scop.		Canada Thistle
Cirsium vulgare (Savi) Tenore		Bull Thistle
Erechtites hieracifolia (L.) Raf.		Pilewort
Leontodon autumnalis L.		Fall-Dandelion

Matricaria matricarioides (Less.) Porter.	Pineappleweed
Prenanthes trifoliolata (Cass.) Fern.	Lions-Paw
Senecio vulgaris L.	Common Groundsel
Solidago canadensis L.	Canada Goldenrod
Solidago puberula Nutt.	Rough Goldenrod
Solidago rugosa Ait.	Rough Goldenrod
Solidago sempervirens L.	Seaside Goldenrod
Sonchus arvensis L.	Perennial Sow-Thistle
Taraxacum officinale Weber	Dandelion

APPENDIX B: FAUNA RECORDED IN THE WMA DURING BREEDING SEABIRD SURVEYS

AVES

Actitis macularia (Linnaeus)	Spotted Sandpiper
Anas rubripes Brewster	Black Duck
Archilochus colubris (Linnaeus)	Ruby-throated Hummingbird
Ardea herodias (Linnaeus)	Great Blue Heron
Arenaria interpres (Linnaeus)	Ruddy Turnstone
Bombycilla cedrorum Vieillot	Cedar Waxwing
Calidris maritima (Brünnich)	Purple Sandpiper
Catharus ustulatus (Nuttall)	Swainson's Thrush
Catoptrophorus semipalmatus (Gmelin)	Willet
Cepphus grylle (Linnaeus)	Black Guillemot
Clangula hyemalis (Linnaeus)	Oldsquaw
Corvus brachyrhynchos Brehm	American Crow
Corvus corax Linnaeus	Northern Raven
Dendroica coronata (Linnaeus)	Myrtle Warbler
Dendroica magnolia (Wilson)	Magnolia Warbler
Dendroica petechia (Linnaeus)	Yellow Warbler
Dendroica pinus (Wilson)	Pine Warbler
Dendroica striata (Forster)	Blackpoll Warbler
Falco columbarius (Linnaeus)	Pigeon Hawk
Gavia immer (Brünnich)	Common Loon
Geothlypis trichas (Linnaeus)	Common Yellowthroat
Haliaeetus leucocephalus (Linnaeus)	Bald Eagle
Histrionicus histrionicus (Linnaeus)	Harlequin Duck
Icterus galbula (Linnaeus)	Baltimore Oriole
Junco hyemalis (Linnaeus)	Slate-colored Junco
Larus argentatus Pontopiddan	Herring Gull
Larus marinus Linnaeus	Great Black-backed Gull
Loxia leucoptera Gmelin	White-winged Crossbill
Melanitta perspicillata (Linnaeus)	Surf Scoter
Melospiza lincolnii (Audubon)	Lincoln's Sparrow
Melospiza melodia (Wilson)	Song Sparrow
Mergus serrator Linnaeus	Red-breasted Merganser
Oceanodroma leucorhoa (Vieillot)	Leach's Storm Petrel
Pandion haliaetus (Linnaeus)	Osprey
Parus atricapillus Linnaeus	Black-capped Chickadee
Parus hudsonicus Forster	Boreal Chickadee
Passerculus sandwichensis (Gmelin)	Savannah Sparrow
Passerella iliaca (Merrem)	Fox Sparrow
Phalacrocorax auritus (Lesson)	Double-crested Cormorant
Phalacrocorax carbo (Linnaeus)	Great Cormorant
Pluvialis squatarola (Linnaeus)	Black-bellied Plover
Quiscalus quiscula (Linnaeus)	Common Grackle
Regulus satrapa Lichtenstein	Golden-crowned Kinglet
Sayornis phoebe (Latham)	Eastern Phoebe
Seiurus noveboracensis (Gmelin)	Northern Waterthrush
Setophaga ruticilla (Linnaeus)	American Redstart

Sitta canadensis Linnaeus	Red-breasted Nuthatch
Somateria mollissima (Linnaeus)	Common Eider
Sterna dougalli Montagu	Roseate Tern
Sterna hirundo Linnaeus	Common Tern
Sterna paradisea Pontoppidan	Arctic Tern
Sula bassanus (Linnaeus)	Northern Gannet
Tachycineta bicolor (Vieillot)	Tree Swallow
Tringa melanoleuca (Gmelin)	Greater Yellowlegs

MAMMALIA

Balaenoptera acuterostrata Lacépède	Minke Whale
Halichoerus grypus (Fabricius)	Grey Seal
Lagenorhynchos acutus (Gray)	Atlantic White-sided Dolphin
Lagenorhynchos albirostris (Gray)	White-beaked Dolphin
Lepus americanus Erxleben	Snowshoe Hare
Lutra canadensis (Schreber)	River Otter
Mustela vison Schreber	American Mink
Microtus pennsylvanicus (Ord)	Meadow Vole
Myotis lucifugus Le Conte	Little Brown Bat
Odocoileus virginianus (Zimmerman)	White-tailed Deer
Phoca vitulina Linnaeus	Harbour Seal
Phocaena phocaena (Linnaeus)	Atlantic Harbour Porpoise
Vulpes vulpes (Linnaeus)	Red Fox

REPTILIA

Thamnophis sirtalis Allen	Maritime Garter Snake

AMPHIBIA

Plethodon cinereus (Green)	Eastern Redback Salamander

OSTEICHTHYES

Ammodytes americanus DeKay	American Sand Lance
Gasterosteus aculeatus Linnaeus	Threespine Stickleback
Myoxocephalus spp.	Sculpin
Pholis gunnellus (Linnaeus)	Rock Gunnel
Pollachius virens (Linnaeus)	Pollock
Scomber scombrus Linnaeus	Atlantic Mackerel

MARINE INVERTEBRATA

Acmaea testudinalis Muller	Tortoiseshell Limpet
Asterias spp.	Asteriid Sea Star
Aurelia spp.	Moon Jelly
Balanus balanoides (Linnaeus)	Northern Rock Barnacle
Buccinum undatum Linnaeus	Waved Whelk
Cancer irroratus Say	Rock Crab
Carcinus maenas (Linnaeus)	Green Crab
Coryphella spp.	Red-gilled Nudibranch
Crangon septemspinosa Say	Sand Shrimp
Crepidula fornicata (Linnaeus)	Common Slipper Shell
Cyanea spp.	Lion's Mane Jellyfish
Gammarus spp.	Scud
Hiatella arctica (Linnaeus)	Arctic Rock Borer
Homarus americanus Milne-Edwards	Northern Lobster
Idotea spp.	Kelp Sowbug
Littorina littorea (Linnaeus)	Common Periwinkle
Littorina obtusata (Linnaeus)	Smooth Periwinkle
Littorina saxatilis (Olivi)	Rough Periwinkle
Lepidonotus squamatus Linnaeus	Twelve-scaled Worm
Modiolus modiolus Linnaeus	Horse Mussel
Mysis spp.	Mysid Shrimp
Mytilus edulis Linnaeus	Blue Mussel
Nereis spp.	Clam Worm
Nucella lapillus (Linnaeus)	Dogwinkle
Pagarus spp.	Hermit Crab
Placopecten magellanicus (Gmelin)	Deep-sea Scallop
Pleurobranchia pileus (Fabricius)	Sea Gooseberry
Spirorbis spirillum (Linnaeus)	Spiral Tube Worm
Stronglyocentrotus droebachiensis Müller	Green Sea Urchin
Tomopteris spp.	Plankton Worm

APPENDIX C: SUMMARY TABLES OF DATA COLLECTED ON ISLANDS SURVEYED IN THE WMA IN 1992 AND 1993

1992	Eider nests	Island size	Main. distance	Gull nests	Nest density	Use vs avail.	Nest by cover	Clutch size	Corvid sight	Unsucc nests
Pumpkin	√	√	√	√	√	√		√	√	
Bald Hbr.	√	√	√	√					√	
Outer East Hbr.	√	√	√				√		√	√
Long	√	√	√	√	√	√	√			√
Inner W. Bird	√	√	√	√	√	√	√	√		√
Inner E. Bird	√	√	√	√			√	√		√
Outer Bird	√	√	√	√	√	√	√	√		√
Frying Pan	√	√	√	√	√	√				
Inner Halibut	√	√	√	√	√	√	√	√		√
Middle Halibut	√	√	√	√			√	√		√
Camp	√	√	√	√	√	√		√		
Fog	√	√	√	√	√	√		√		
West White	√	√	√	√	√	√		√		
Little White	√	√	√	√				√		

1993 ISLAND	Eider nests	Island size	Main. distance	Gull nests	Nest density	Use vs avail.	Nest by cover	Clutch size	Dead fall	Depred nests	Corvid sight	Unsucc nests
Sandy	√	√	√	√	√	√	√	√	√	√	√	√
Round	√	√	√	√							√	
Specks	√	√	√	√			√	√	√	√	√	√
East Brother	√	√	√	√			√	√	√	√	√	√
West Brother	√	√	√	√			√	√	√	√	√	√
Horse	√	√	√	√							√	
Pancake	√	√	√	√	√	√	√	√		√	√	√
Long	√	√	√	√	√	√	√				√	√
Middle Long	√	√	√	√				√	√	√	√	
Deadman's	√	√	√	√							√	
Goose	√	√	√	√	√	√	√	√	√	√	√	√
Black Duck	√	√	√	√							√	
Brokenback	√	√	√	√							√	
Inner W. Bird	√	√	√	√	√	√	√				√	√
Inner E. Bird	√	√	√	√			√				√	√
Outer Bird											√	
Frying Pan	√	√	√								√	
Inner Halibut							√				√	√
Middle Halibut							√				√	√
Camp	√	√	√	√	√	√	√	√	√		√	√
Fog	√	√	√	√	√	√	√	√	√		√	√
West White	√	√	√	√	√	√	√	√	√	√	√	√
Little White	√	√	√	√			√	√	√		√	√

APPENDIX D: VEGETATION SAMPLING BY THE BRAUN-BLANQUET METHOD

Vertical Stratification Layers

T1 (upper tree layer) = plants greater than 3 metres
T2 (lower tree layer) = 1.5 to 3 metres
S (shrub layer) = 1 to 1.5 metres
H1 (upper herb layer) = 40 cm to 1 metre
H2 (lower herb layer) = 10 cm to 40 cm
M (moss layer) = less than 10 cm

Percent Cover Categories

5 = species covered less than 75% of quadrat
4 = 50 to 75% of quadrat
3 = 25 to 50% of quadrat
2 = 5 to 25% of quadrat
1 = less than 5% of quadrat
+ = few individuals, little cover
r = solitary, little cover

Island Abbreviations

BW - Big White Island
IEB - Inner East Bird Island
IH - Inner Halibut Island
IWB - Inner West Bird Island
LW - Little White Island
MH - Middle Halibut Island
OEH - Outer East Harbour Island
OH - Outer Halibut Island
P - The Pumpkin
PAN - The Pancake
R - Round Island

Tall Grass

	IEB1	IEB2	IEB3	P1	P2	IWB1	BW1	BW2	BW3	BW4	BW5	LW1
S												
Epilobium angustifolium				2	2							
Ligusticum scothicum			2									
Osmunda cinnamomea		3	3	2	3							
Picea glauca								#				
Rumex crispus											#	3
Thalictrum polygamum		2	3	2								
H1												
Achillea lanulosa					2							
Ammophila breviligulata	3	2					3	3	3			5
Arenaria peploides	#											
Aster spp.	2	#	1		1	1		#		1	2	#
Calamagrostis canadensis						4				2	3	
Cerastium arvense								#	2		#	1
Convolvulus sepium	2	3						#	1	1	2	2
Deschampsia flexuosa	2			1								
Dryopteris spinulosa				1	1							
Elymus mollis									3	3	3	
Erechtites hieracifolia							#					
Festuca rubra	1						1			#		
Impatiens capensis										2	1	
Iris versicolor	#	2				1	3			1		
Juncus balticus		3						3			2	
Lathyrus palustris								2				
Lathyrus japonicus								3	#			
Ligusticum scothicum			1	2	1		#			#	#	
Osmunda cinnamomea	#	3	2			2				2		
Potentilla norvegica											#	
Prenanthes trifoliolata	1	1	1		#			r	1		#	
Ribes hirtellum				2	2					1	#	
Rosa virginiana				1								
Rubus strigosus		1		1	2			r			1	
Rumex acetosella				1	2							
Solidago spp.	#			1						3	2	
Streptopus spp.										#		
Thalictrum polygamum		3	1	1	2	2	2		2			
H2												
Achillea lanulosa	3	4	4					2			1	
Agrostis palustris							2					1
Aster spp.	2					2	3					#
Cakile edentula									1			
Chenopodium album									2			
Circaea alpina					2							
Convolvulus sepium	1									1	1	2
Cornus canadensis						#						
Deschampsia flexuosa			2		#							
Ligusticum scothicum	2				2		#			#		
Plantago lanceolata	#											
Potentilla anserina								2			#	2
Rosa virginiana							2					
Rubus pubescens				2								
Rumex acetosella				#							#	
Solidago spp.				#								
Thalictrum polygamum						3						
M												
Convolvulus sepium							1					
Cornus canadensis					1							
Deschampsia flexuosa		2	3									
Maianthemum canadense											1	
Polypodium virginianum					#							
Rubus pubescens										2		
Rubus strigosus	#											
Stellaria media			#		#				1		#	
Trifolium repens			#				1				#	
Vaccinium macrocarpon	#						3					
Viola spp.			#							#	#	
Mosses	2		3									
Bare rock / earth	1				2				1			1

Raspberry

	P1	P2	IEB1	MH1	MH2	MH3	MH4	MH5	MH6	PAN1	PAN2	PAN3
T1												
Standing deadwood					+					1		1
T2												
Standing deadwood					+	+				2	2	1
S												
Cirsium spp.						+	1					
Epilobium angustifolium	4	4		5								
Impatiens capensis											2	
Osmunda cinnamomea	3	3	3									
Poa pratensis	2											
Ribes glandulosum				2								
Ribes hirtellum	2			+								
Rubus strigosus			+	3							5	
Rumex crispus						1	+					
Thalictrum polygamum		2	+									
Standing deadwood				r								
H1												
Ammophila breviligulata			1									
Aster spp.			+			+						
Cerastium arvense							+					
Deschampsia flexuosa			2			+		1				
Dryopteris spinulosa				3	1	2	2	2	1			
Elymus virginicus	1											
Epilobium angustifolium					1	+	2		1			
Galeopsis Tetrahit										2		
Impatiens capensis						+			3	2		
Ligusticum scothicum	1	1					2					
Osmunda cinnamomea			3									
Prenanthes trifoliolata		+	2			+						
Ribes glandulosum						2	3					
Ribes hirtellum					+	3	2					
Rubus strigosus	2	2	+		5	3	3	5	5	5		5
Solidago spp.	+	1	+		+	1	2	2				
Sorbus americana					r							
Streptopus spp.		r			1	1	+	+				
Taraxacum officinale							+					
Thalictrum polygamum	1		+									
Deadfall / Stumps				2	2	1	1	2	2	3	2	4
H2												
Agrostis palustris		+		1								
Deschampsia flexuosa		+										
Dryopteris spinulosa				1					1			
Galeopsis Tetrahit										1		
Impatiens capensis								2	1	1		
Ligusticum scothicum			r									
Rumex acetosella							+					
Smilacina stellata			r									
Rock										r		
M												
Galium spp.		1										
Impatiens capensis					3							1
Ligusticum scothicum	+	+										
Maianthemum canadense		+					+					
Rubus strigosus			+									
Rumex acetosella		2										
Solidago spp.	+											
Stellaria media					1							
Usnea spp.											+	
Viola spp.	+	+										
Moss		2		+						3	2	
Bare rock / earth	1			+								

Forest

	BW1	MH1	MH2	OEH1	OEH2	OEH3	OH1	OH2	OH3	OH4	OH5	OH6
T1												
Abies balsamea			2	4	3	3	5	2		4	5	2
Acer rubrum							1		1		2	
Betula papyrifera							1				2	
Picea glauca	3	5	5	4	3	2	2	2	2	3		2
Sorbus americana	2							1	2		2	
Standing dead trees							+			1		
T2												
Abies balsamea			1						4			3
Alnus rugosa						2		2		1		2
Sorbus americana	1											
Standing dead trees				r								
S												
Abies balsamea					4				1			
Acer rubrum								2				
Alnus rugosa					3	2		2				
Osmunda cinnamomea		1	2									
Picea glauca					3							
Prunus pensylvanica		+										
Sorbus americana	+											
H1												
Abies balsamea						1		1	1			
Acer spp.											+	
Alnus spp.									+			
Aster spp.	1											
Betula papyrifera								+				
Dryopteris spinulosa	2		1	1	2	1				1	2	
Iris versicolor		+										
Juncus spp.		1										
Kalmia angustifolia		1										
Picea glauca						1		1				
Prenanthes trifoliolata	+											
Rubus strigosus		1			1							
Rumex crispus		+										
Sorbus americana	1							+				
Streptopus spp.	2							+			r	
Deadfall / Stumps				2	2	2	2				2	3
H2												
Abies balsamea												
Agrostis palustris		+	+									
Aralia nudicaulis											+	
Aster spp.	1			+	+							
Circaea alpina	3		4						2			
Clintonia borealis								1	+			
Dryopteris spinulosa		1					+	2	1			+
Epilobium adenocaulon	+											
Ligusticum scothicum	1	+	1									
Ribes hirtellum		+	+									
Rubus strigosus	1	+		+								
Smilacina stellata								2	1	2		+
Sorbus americana												
Streptopus spp.					+				1		+	
M												
Acer spp.							+		r			
Circaea alpina		1		1	1							+
Cladonia spp.	+					+						
Cornus canadensis			1		+			1	2	2		
Epigaea repens								3	2	2		
Linnaea borealis							+		+	+	1	
Maianthemum canadense		1			+	1						
Oxalis montana	4			1	1	+	+	4	5	2	2	1
Polypodium virginianum											+	
Rubus pubescens										+		
Stellaria media	+											
Usnea spp.	+		+	+		+				2		
Viola spp.	+	+	+	1		+						
Moss	1	2	3	4	5	5	2	5	5	5	5	3
Bare rock / earth		+	3									

Beach

	BW1	BW2	BW3	IEB1	IH1	IH2	IWB1	IWB2	OH1	OH2	PAN1	PAN2
S												
Rumex crispus										2		
H1												
Ambrosia artemisiiflora							#					
Ammophila breviligulata							3	#				
Arenaria peploides						#	3					
Artemisia Stelleriana				#	1						2	#
Aster spp.	#	2	2	#			2					
Atriplex patula										1		
Brassica nigra											2	
Convolvulus sepium			3	#						5		
Elymus mollis		2	1	1								
Impatiens capensis						1						
Iris versicolor	2									1		
Lathyrus palustris			2									
Lathyrus japonicus	#	4	2		2	4				3		2
Ligusticum scothicum	2	#	#				2					
Rumex crispus	#										#	
Solanum dulcamara						1						
Solidago puberula				1			2	#	2			
Thalictrum polygamum		#	#	2								
Deadfall / Stumps				3		2				r	1	
H2												
Achillea lanulosa	2			2			#			2		
Agrostis palustris	#		#		#				#			
Arenaria peploides					#	2						
Atriplex patula	#				#	3		3			2	2
Cakile edentula											2	2
Cerastium arvense						2						
Deschampsia flexuosa										1		
Festuca rubra									1			
Galeopsis Tetrahit	1			1	#							3
Galium aparine			#								2	
Impatiens capensis					1						2	
Iris Hookeri									#			
Leontodon autumnalis	#											
Plantago juncoides					#				2			
Plantago lanceolata								#				
Potentilla anserina	#	2	3		1		2	2			1	
Prenanthes trifoliolata									#			
Rhinanthus Crista-galli	2				#							
Scuttellaria galericulata		#	#									
Stellaria media						2						
Solanum dulcamara					#							
Solidago sempervirens			1									
M												
Empetrum nigrum									1			
Euphrasia americana	1								1			
Galium aparine												2
Rubus pubescens		2										
Stellaria media					1							
Trifolium repens	#	#										
Vaccinium vitis-idaea	3											
Moss									2			
Open cobble	1	2	2	4	3	3	3	3		2	3	
Open bedrock	3				3			1	5		3	
Saltwater pond									2			

Barren

	IEB1	IEB2	IH1	IH2	IH3	LW1	LW2	LW3	LW4	MH1	MH2	MH3
T2												
Standing deadwood				#		r						
H1												
Agrostis palustris						2		2				
Ambrosia artemisiiflora		1										
Aster spp.	3	2			2					1	#	#
Deschampsia flexuosa	4	2								2		
Elymus virginicus									1			
Epilobium angustifolium				3								
Galeopsis Tetrahit										1		#
Ligusticum scothicum		1	2							1		2
Poa pratensis				2	1				1			
Potentilla norvegica							3					
Prenanthes trifoliolata	2	1							4	2	1	2
Ribes hirtellum		1	1	2							1	2
Rosa virginiana		2										
Rumex acetosella	1	#								#		
Rumex crispus					1							
Rubus strigosus				1				3		2	#	
Solidago spp.				2						1		#
Thalictrum polygamum		#	1		2		#					
Deadfall / Stumps				#		2						#
H2												
Achillea lanulosa	2	3	3	1	3	3	4	4	1			2
Agrostis palustris	2	2	2						1	1	#	
Aster spp.	3	2	2			2	#	2	1	1	#	#
Atriplex patula					3							
Capsella bursa-pastoris			1	1								
Cerastium arvense				1	1						#	2
Convolvulus sepium			r									
Deschampsia flexuosa											#	2
Dryopteris spinulosa				2					1			
Empetrum nigrum				1						3	5	#
Epilobium adenocaulon						#						
Euphrasia americana	1	#	3	1						2		2
Fragaria virginiana							#					#
Iris versicolor	#		1	#							#	
Ligusticum scothicum		2	2		2					2	#	#
Plantago spp.					1							
Potentilla norvegica		#	1			3						
Prenanthes trifoliolata		1					2	2		1	#	
Rhinanthus Crista-galli			2									
Rubus strigosus	1							3		#		2
Rumex acetosella	2	#	3	2	1		1	1	1	1		2
Smilacina stellata							1					
Trifolium repens			3			2	4		1			
M												
Maianthemum canadense								1		#	#	
Stellaria media	1	#				4	3	2	2		#	
Taraxacum officinale								#				
Vaccinium angustifolium									1	1		
Vaccinium macrocarpon										1		#
Vaccinium vitis-idaea											1	
Usnea spp.				1								
Mosses				1		1	#		2		5	
Rock / Bare earth		1			2	3			2			

Gooseberry

	IH1	IH2	IH3	IH4	IH5	IH6	P1	P2	P3	P4	P5	P6
T2												
Standing dead trees		r	r	r		1						
S												
Aster puniceus								2				
Convolvulus sepium								1				
Epilobium angustifolium				3		2		2	2		1	
Osmunda cinnamomea							2					
Poa pratensis								3		1		
Ribes hirtellum		3	4	5	4	4						
Rubus strigosus							2					
Rumex crispus			#									
Solidago spp.								1				
Thalictrum polygamum							1		2		2	#
Standing dead trees			1	1		1						
H1												
Aster spp.			#	2				2	2	2	#	#
Athyrium filix-femina									r			
Cerastium arvense		1										
Convolvulus sepium								1	2	2		
Dryopteris spinulosa			2	2	1							
Elymus mollis									#			
Epilobium angustifolium	2				1		2			2		
Galeopsis Tetrahit										2		2
Iris versicolor									2	#	1	2
Ligusticum scothicum	3	4	3	3	2	4	#				1	
Osmunda cinnamomea	2							2	1	2	2	2
Potentilla norvegica	#										1	
Prenanthes trifoliolata											r	
Ribes hirtellum	4						2	3	3	2	2	3
Rosa virginiana							#		1	#		2
Rubus strigosus	1	1	2	1	1	1		3	2	#	2	3
Rumex acetosella			1	1								2
Rumex crispus			1				#		1	1	r	#
Solidago spp.	2	1	2	2	1	1				2	1	
Thalictrum polygamum								2		1		
Deadfall / Stumps	1	2	1	1	3	2						
H2												
Achillea lanulosa	1	3		1		3	2			2	1	2
Agrostis palustris			1									
Aster spp.		1								#	1	
Capsella bursa-pastoris			1									
Chrysanthemum leucanthemum						#						
Circaea alpina				4					3			3
Convolvulus sepium								1				
Deschampsia flexuosa									1			
Dryopteris spinulosa				2				2				
Euphrasia americana	#		1									
Galeopsis Tetrahit		#									1	
Galium spp.									1			
Impatiens capensis		#							2			1
Ligusticum scothicum						3				#		
Maianthemum canadense			1									
Poa pratensis	2		1									
Potentilla norvegica	#	#					2					
Rhinanthus Crista-galli			1									
Rubus strigosus		3	1							#		
Smilacina stellata		1			1			r				
Solidago spp.									1			
Taraxacum officinale	#											
M												
Achillea lanulosa	#	5			1					1		
Circaea alpina							2			#		
Impatiens capensis					#		#			#		
Iris versicolor							1					
Rumex acetosella					#							
Maianthemum canadense		5										
Rosa virginiana										#		
Rubus pubescens							#					
Sagina procumbens	#											
Stellaria media							2			4	1	2
Thalictrum polygamum										#		
Trifolium repens	#											
Usnea spp.			#									
Viola cucullata			1			3						
Bare earth							#					
Bare rock							1				1	#
Mosses	1		1									

Tuckamoor

	BW1	BW2	IH1	IH2	MH1	MH2	OH1	OH2	R1	R2	R3	R4
T2												
Abies balsamea		2										
Picea glauca	2	3	5	3	4	4	4	4	4	4	3	4
S												
Cirsium spp.							2					•
Convolvulus sepium							r					
Kalmia angustifolia						2						
Osmunda cinnamomea					1							
Rumex crispus	•			•						•		1
Standing deadwood							•					
H1												
Achillea lanulosa			3	2	1	•	2		1	4	4	3
Ammophila breviligulat.	2											1
Aster spp.			•		•	•	2	3	1	2	2	2
Convolvulus sepium							2			•		•
Dryopteris spinulosa		1	1			1	2		1		•	
Deschampsia flexuosa						2				•		
Epilobium angustifolium			r								•	
Festuca rubra			•				1					
Impatiens capensis			•	2	2				4	4	3	3
Iris versicolor	1	•		3		1	•			1		
Juncus balthicus	1											
Lathyrus japonicus	•			•			3	2				
Ligusticum scothicum				2	1				1		3	2
Myrica pensylvanica	1											
Picea glauca	•											
Potentilla norvegica	•									2	•	•
Prenanthes trifoliolata					1		r					•
Ribes hirtellum		1	2		3	2	2	1	2		1	1
Rosa virginiana	2	2										
Rubus strigosus		2	3	1	2	1	2		2	1	2	•
Rumex crispus			r	•					•	•	•	1
Smilacina stellata		•							1	•	1	•
Solanum dulcamara			•									
Solidago spp.	•		2							1		
Streptopus spp.		1	•						•			•
Thalictrum polygamum	•									2		
Deadfall / Stumps		1		2			•		1			
H2												
Achillea lanulosa					2	1						
Aster spp.	3	•		1	•	•					•	
Cerastium arvense					•			1			•	1
Circaea alpina		2	5		2				1			
Convolvulus sepium							1	•				•
Cornus canadensis					2	•						
Deschampsia flexuosa						4						
Empetrum nigrum	2				4							
Euphrasia americana			1		2	1						
Galeopsis tetrahit								•				
Impatiens capensis				1	•						2	•
Lathyrus japonicus	1			•			1					
Ligusticum scothicum			1		1		•	•		1	•	
Linnaea borealis											2	
Maianthemum canadense			2			•						
Potentilla anserina							•					
Potentilla norvegica			•									
Prenanthes trifoliolata		•			•			1				
Rubus pubescens					•							
Rubus strigosus							•	2			•	
Rumex acetosella			1	•	1	•		2				
Trifolium repens										1	2	•
Vaccinium macrocarpon	2											
M												
Achillea lanulosa								2				
Agrostis palustris					•			2				
Aster spp.		•						4				
Euphrasia americana			1									
Maianthemum canadense			2			•						
Plantago spp.	•									1		
Stellaria media			2	1	•			1	5	3	4	4
Usnea spp.		1								1		
Viola cucullata			1	•		•			•	•	•	
Bare rock / earth								2			2	
Mosses		1										

APPENDIX E: COVER MAP OF MIDDLE HALIBUT ISLAND

COVER MAP OF MIDDLE HALIBUT ISLAND
Scale of 1: 2675