# DIET CHOICE AND REPRODUCTIVE SUCCESS OF GREAT BLACK-BACKED GULLS (*Larus marinus*) AND IMPACTS ON LOCAL BREEDING SEABIRD POPULATIONS



BRIAN G. VEITCH

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# DIET CHOICE AND REPRODUCTIVE SUCCESS OF GREAT BLACK-BACKED GULLS (*Larus marinus*) AND IMPACTS ON LOCAL BREEDING SEABIRD POPULATIONS

by

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## Abstract

The relationship between Great Black-backed Gull (*Larus marinus* ) diet selection and reproductive success, measured as chick growth and fledge rates, was undertaken on 2 colonies in the Northwest Atlantic; Gull Island, Newfoundland and the Gannet Islands, Labrador in 2000 and 2001. Habitat and nesting density proved not to be related to diet or reproductive success. Although statistically insignificant, Great Black-backed Gulls that mainly fed their chicks seabirds had in increased growth rates and decreased fledging rates.

Great Black-backed Gull diet was partially composed of seabird eggs, chicks, and adults. Great Black-backed Gulls had no significant effect on the breeding population of seabirds at the Gannet Islands Ecological Reserve, Labrador. However, at Gull Island, Witless Bay, Newfoundland gulls depredated 2.2% of kittiwake adults and 22.3% of the eggs/chicks of Black-legged Kittiwakes (*Rissa tridactyla*), consistent with observations that kittiwake populations have been declining since the 1990s. Great Black-backed Gull predation seemed to have no significant effect on other seabird populations at Gull Island.

**Acknowledgements**

Without the funding from the Canadian Wildlife Service, Northern Studies Training Program (NSTP), and the Atlantic Co-operative Wildlife Ecological Research Network (ACWERN) this research would not have been possible I would like to thank Greg Robertson for his expertise and guidance during the research and writing of this thesis; Ian Jones for his constructive criticism on this manuscript; Anne Storey for her expertise on the ecosystem in the Witless Bay Ecological Reserve and her constructive criticism on this manuscript.

For his help in the field I would like to thank my assistant Paul Taylor for his endless patience with me, and his help, which proved to be essential for collecting data in the 2001 field season. Without the logistical support and unlimited hospitality of Randy Cahill I would have been hard pressed to get myself and my gear to the Gannet Islands from Cartwright, and for that I would like to sincerely thank him. During my time at the Gannet Islands, the other members of the camp took time from their busy schedule to help me when they could. For their help I would like to thank Johanne Dussureault, Rosanna Parades, and Andy Higdon.

## Chapter 1

### 1.1 Introduction and Overview

Diet choice among animals may be either innate or learned, or a combination of both (Cassini 1994). Some organisms may have a natural preference for certain types of food but how efficient they find, process, and balance their search time and nutrient requirement is often related to the experience of the individual (Fragaszy and Boinski 1995, Randolph and Cameron 2001). Regardless of how diet is selected, individuals that ingest highly nutritious food are usually healthier and likelier to have higher reproductive success (Annett and Pierotti 1999, Randolph and Cameron 2001).

In an ecosystem, organisms spend time foraging for food that would sustain their energy demands (caloric intake), requirements for body maintenance (protein, fatty acids, etc.), and necessary nutrients for reproduction (other essential minerals and nutrients). However, humans can provide an increase in the choice of available food by allowing easy access to vast supplies of nutritious food (such as refuse, crops, etc.) for some opportunistic animals. This may lead to a reduction of foraging time, which conserves energy that could possibly be allocated to reproduction. Over time, a consistent supply of human food could result in inflated populations of organisms that feed upon these food sources, such as the exploding snow goose population that feeds upon grain crops in central North America (Cooke et al. 2000), and gull populations that have shown substantial increases in North America and Europe which exploited fish offal and garbage dumps from the 1960s until the mid 1990s (Drury 1973, 1974; Blokpoel and Tessier 1986).

Great Black-backed Gulls (*Larus marinus*) are opportunistic feeders that live mainly on natural prey items such as marine invertebrates; fishes; mammals; insects; and adults, chicks and eggs of other seabirds and ducks (Good 1998). These birds will scavenge on anthropogenic food sources by congregating on landfills and taking advantage of fishery offal associated with fish plants and vessels. Other gull species that feed upon natural prey items such as fish are more successful breeders than those that feed on garbage (Pierotti and Annett 1991, Annett and Pierotti 1999). The reason for this increase was probably due to the minerals and amino acids found in natural prey items, which are essential for bone development and growth of chicks (Pierotti and Annett 1991). However, garbage contains a lot of fast food that has a very high caloric value, which would probably be good for fully-grown gulls that do not have the same nutrient demands as chicks. Therefore, human produced waste could have sustained or at least aided a growing population of Great Black-backed Gulls in the breeding season, through fishery offal, and during the non-breeding season, through landfill garbage, in Newfoundland and Labrador. As these gulls feed upon the adults and young of other seabirds as well the level of predation may have increased to levels where there is significant impacts on other seabird populations.

The aim of this study was two-fold. Firstly, in chapter two, I examine the effect of diet choice by an opportunistic predator, the Great Black-backed Gull, on its reproductive success. Secondly, in the third chapter, I examine how these choices impact prey populations of locally breeding seabirds. To accurately determine the effect of diet on Great Black-backed Gull reproductive success I had to consider other variables, namely differences in nesting habitat, and both inter- and intra-specific nesting density. This study was conducted at two seabird colonies with large populations of breeding alcids, which differed in the variety of food that the gulls had to choose from. Gull Island, Witless Bay, Newfoundland provided a large variety of diet choice because of its proximity to local dumps, large populations of petrels, locally spawning capelin (*Mallotus villosus*) and available intertidal zone with its associated invertebrate community that could be utilized as a food source. The Gannet Islands, Labrador had none of the food sources mentioned for Gull Island. Rather, it is a natural system where Great Black-backed Gull chick diet was dependant upon auks and the food loads brought back for their chicks.

## 1.2 Co-authorship Statement

The following thesis, which consists of two research papers was designed, researched, and analysed by myself. Greg Robertson guided me with both research and data analysis and in conjunction with Ian Jones and Anne Storey constructively criticized the manuscript resulting in the finished product.

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## Chapter 2

## The influence of diet choice on reproductive biology of Great Black-backed Gulls (*Larus marinus*) in two colonies in the Northwest Atlantic.

### 2.1 Introduction

Gulls (*Larus* spp.) are opportunistic omnivores able to utilise fish, intertidal invertebrates, and other seabirds, including eggs, young, and adults of smaller species (Good 1998). They also scavenge upon human refuse, fishery offal and discards as easily accessible food sources (Lock 1973, Roy 1986, Gilliland 1990, Good 1998, Robertson et al. 2001). As a result of increased levels of available food through poor waste management and the Migratory Bird Convention Act in 1917, which made harvesting seabirds and their eggs illegal, larid populations increased along eastern North American in the 20$^{th}$ century (Drury 1973,1974; Blokpoel and Tessier 1986).

However, in the last two decades many of these gull populations have either stabilized or decreased due to reduced available fishery offal and discards (Oro and Martinez-Vilalta 1994, Chapdelaine and Rail 1997, Robertson et al. 2001, Carscadden et al. 2002). This is exemplified in south eastern Newfoundland where the collapse of cod (*Gadus morhua*) stocks and the subsequent ground fish moratorium in 1992, and the late arrival of capelin, an important food source for many seabirds, over the last decade has led to a decline in Herring Gull (*Larus argentatus*) populations (Robertson et al. 2001). However, Great Black-backed Gull (*Larus marinus*) populations have remained stable despite similar breeding biology and habitat requirements between the two species (Roy

1986, Robertson et al. 2001, Carscadden et al. 2002). Conversely, in southern Labrador populations of Great Black-backed Gulls have dropped substantially in the last 25 years (Robertson and Elliot 2002).

Although breeding biology and habitat requirements are similar in these two species, Great Black-backed Gulls are able to take advantage of their superior size by predating larger food items, such as adult Atlantic Puffins (*Fratercula arctica*) or even Herring Gulls. The ability to handle such large prey puts Great Black-backed Gulls on a higher trophic level than Herring Gulls (Lock 1973, Russell and Montevecchi 1996, Good 1998). Being the largest larid, Great Black-backed Gulls are also able to take advantage of their size to out compete other species for food on landfills. Herring Gulls that nest amongst Great Black-back Gulls have reduced breeding success due to nest displacement, which occurs when Great Black-backed Gulls take over Herring Gull nest sites, and predate their eggs and/or young (Lock 1973, McGill 1977, Roy 1986). These reasons may explain why Great Black-backed Gull populations are not declining throughout their range, despite a drastic decrease in food (Robertson et al. 2001).

In order to understand how diet choice affects Great Black-backed Gull reproductive success, I measured clutch and egg size, growth rate, age fledging size was reached and fledging size of chicks of Great Black-backed Gulls. I also recorded the influence of environmental factors, including the effects nesting habitat, as well as number and species of neighbouring gulls had on fledging rates and growth rates of chicks six to thirty-five days old. This study was done at the Gannet Islands, Labrador and Gull Island, Newfoundland. The comparisons of the two breeding colonies; which differ in their nesting density, food availability, and habitat; were designed to help us isolate how diet choice and human waste disposal practices influences Great Black-backed Gull reproductive success.

## 2.2 Materials and methods

### 2.2.1 Study site

Gull Island, Witless Bay (47° 16'N 52° 47'W) is a 1.6 x 0.8 km seabird colony with steep rocky margins, a rim of Atlantic Puffin slopes crowned with occasional flat grassy meadows that encircles a coniferous forest of black spruce (*Picea mariana*) and balsam fir (*Abies balsamea*). Forest habitat, which encompasses most of the island, is home to a large breeding population of Leach's Storm-petrels (*Oceanodroma leucorhoa*) (Table 2.1). This island, the largest in the Witless Bay Ecological Reserve, is located approximately 30 km south of St. John's, 2.5 km off the coastline, 9 km from the Bay Bulls town dump and 40 km from the City of St. John's dump in Robin Hood Bay.

The other study site was the small cluster of 6 islands in the Gannet Islands Ecological Reserve (53° 56'N 56° 30'W), located approximately 50 km east of Cartwright, Labrador. Like Gull Island, the Gannet Islands have steep rocky margins, which surround a rim of puffin slopes. Unlike Gull Island, the Gannet Islands are treeless. These islands are composed of either exposed bedrock or meadow habitat.

Differences in latitude and the subsequent one month difference in lay date allowed me to work at both sites in the spring/summers of 2000 and 2001. I arrived at Gull Island on 9 May 2000 and 2001 and on the Gannet Islands on 27 June 2000 and 6

**Table 2.1. Estimated numbers of breeding seabird pairs found at Gull Island, Witless Bay, Newfoundland and the Gannet Islands, Labrador.**

| Species | Gull Island | Gannet Islands |
|---|---|---|
| Great Black-backed Gull (*Larus marinus*) | 90[a] | 35 (2000)[a]<br>25 (2001)[a] |
| Herring Gull (*Larus argentatus*) | 2698[b] | 0[b] |
| Atlantic Puffin (*Fratercula arctica*) | 71 000[c] | 34 612[d] |
| Common Murre (*Uria aalge*) | 1700[e] | 19 360[d] |
| Thick-billed Murre (*Uria lomvia*) | 0[e] | 1337[d] |
| Razorbill (*Alca torda*) | 217[e] | 9808[d] |
| Leach's Storm Petrel (*Oceanodroma leucorhoa*) | 351 886[f] | 0[d] |
| Black-legged Kittiwake (*Rissa tridactyla*) | 5204[e] | 54[d] |
| Northern Fulmar (*Fulmarus glacialis*) | 3[e] | 19[d] |
| Black Guillemots (*Cepphus grylle*) | 2[e] | 2[d] |

[a] This study
[b] Robertson et al. 2001
[c] Rodway et al. 1996
[d] Robertson and Elliot 2002
[e] CWS unpublished data
[f] Robertson et al. 2002

July 2001. In the 2001 field season my field assistant remained on Gull Island until the chicks fledged (July 22) while I went to the Gannet Islands to start the study there. In 2000, I left the Gannet Islands on August 8 and on August 27 in the second field season.

### 2.2.2 Data collection

#### 2.2.2.1 Breeding biology

Upon arrival on both colonies we marked Great Black-backed Gull nests with a wooden stake painted with florescent orange paint. The location of each nest was marked and checked every three days for hatch dates and additional egg-laying. If additional nests were discovered at this time they were marked and included in the study. One nest at each colony was not used because of potential disturbance to breeding Common Murres (*Uria aalge*).

#### 2.2.2.2 Clutch and egg size

Clutch size was the maximum number of eggs found in the nest at one time that were to believed to be laid by the breeding pair occupying the particular nest. Each egg was marked for identification with either a number or a letter with a felt pen. The maximum length (L) and maximum breadth (B) of each egg was measured using Vernier calipers to the nearest 0.02 mm. Egg volume (V) in mL was calculated using a k-value of 0.0005 in the equation $V = kLB^2$ (Bolton et al. 1992).

In the summer of 2001, due to logistical constraints, I arrived at the Gannet Islands too late to record clutch and egg size because a high proportion of the chicks had already hatched.

#### 2.2.2.3 Chick growth and fledging

Upon hatching, chicks were measured every three to five days. Gull chicks have an outstanding ability to hide, which made them quite hard to find in the 2000 field season. This problem was overcome in 2001, for the most part, by using two people equipped with binoculars and/or spotting scopes and radios to find the chicks. At least one person hid in a blind, in natural cover, or at a very long distance in order to locate the chicks with a spotting scope before the person measuring them would approach. Upon approach, using a VHF radio, the measurer was guided to the chick by the observer.

Captured chicks were banded at approximately ten days of age on the left leg with a metal USFWS band. Before ten days of age the chicks had two tips of their toe-nails clipped as a way of identifying each of the nestlings. Toe nails were not cut into any living tissue, just the tip of nail was cut. Upon capture mass, head-length, culmen-length, bill-depth, tarsus-length, and wing-length were measured. Each chick was put in a bag and mass was taken using a spring scale to the nearest 10g then the mass of the bag was subtracted. Wing length was recorded using a wing bar to measure the unflattened wing chord the nearest mm. When a chick had down, but no feathers, down was not included in wing-length. I measured head-length as the distance from the occipital lobe to bill tip; culmen as the distance from bill tip to the bill nail when measured along the top of the upper mandible; bill depth was measured as the depth of the bill at the gonys, and tarsus length was measured as the length of the tarsal bone (tarsometatarsus bone) along the outside of the leg using Vernier calipers to the nearest 0.02 mm.

The natural logarithm of head-length, tarsus length, and wing length were combined in principle component analysis (PCA) and the first principle component axis (PC1) was used as an index of body size. The natural logarithm was used to decrease the amount of variation between measurements. PC1 values are measures of how far the points fall from the line of best fit in the three-dimensional space created by analysis of three variables. Repeated measures analysis, using SAS, enabled us to analyse chick growth, defined as size (PC1) over time (age in days), as a series of logistic growth curves (Gilliland and Ankney 1992), each representing an individual chick, rather than a single growth curve that acted as a 'line of best fit' for the entire population. Knowing the growth curve for each individual chick is more accurate than a line of best fit for the entire population because if there were a single, easily caught, chick with a lot of repeated measurements that were extremely low or high then the line of best fit would be biased.

From hatching to fledging, the body size of Great Black-backed Gulls as represented by PC1 of a PCA have been shown to best follow the logistic growth curve (Gilliland and Ankney 1992). Growth parameters for each were calculated for the entire chick growth period using Sigma Plot 2000, which fit the following equation:

$$y = a / (1 + (x / x_0)^b)$$

where a is the asymptote or maximum size reached, $x$ is the age in days, $b$ is the growth rate at $x$, $x_0$ is half the age when asymptote is reached, and $y$ is the size (PC1). Obtaining the parameters for growth was difficult for every chick because we needed to obtain measurements from hatching to fledging during before and after both points of inflection.

Since it was difficult to consistently find each chick during its entire growth period I used the rate of growth between the ages of 6 and 35 days, which was determined to be the linear phase of chick growth by examining the growth curves. For the linear phase of growth I required fewer measurements to obtain a growth rate thus increasing the sample sizes enabling an accurate comparison of individual chick growth rate for different explanatory variables. Using these parameters I obtained a sample size of 125 chicks on Gull Island and 34 chicks on the Gannet Islands.

Chicks were considered to be fledged at 16 days old because very little predation took place after that age. Fledge rate were determined as the number of chicks that fledged per the number hatchlings per nest.

#### 2.2.2.4 Diet

Whenever I visited the gull's nest site nest debris that was regurgitated or eaten (i.e. adult puffin and kittiwake carcasses) was identified, recorded, and removed. Captured chicks that did not immediately regurgitate food were forced to regurgitate by insertion of the researcher's finger into the proventriculus of the chick and removing all its contents. Since gulls that nest in areas where vegetation is low tend to have chicks that are more easily found than gulls that nest in areas of thick vegetation, I was concerned that there may be a correlation between Great Black-backed Gull nesting habitat and diet as found in Herring Gulls (Pierotti and Annett 1991). Thus, after the 2000 field season, we were sceptical of the reliability of these data so we added feeding bout watches in the

2001 field season to augment the diet data set.

Three observation blinds were used. Twenty-eight of ninety nests were monitored on Gull Island to record feeding bouts from these blinds. Watches were randomly-assigned between my assistant and me in two-hour intervals, for at least four hours per day per person. On the Gannet Islands, inter-island observations were made on six of twenty-five nests from the island inhabited by researchers (GC2) to the island 300 m to its west (GC1) (Figure 2.1). Observation times were done in the same manner as on Gull Island except that once a week we conducted an all day, non-stop feeding watch. Watches were deemed to be the most reliable data for identifying items brought back to the chick because nest debris consisted mainly of non-digestible regurgitated items and egg shells; and chicks were only able to regurgitate items they had recently eaten. When all the diet data were combined I placed most emphasis on feeding watches, next on chick regurgitation, and finally nest debris. Chick regurgitation and nest debris were used to identify diet in nests that were located in places that could not be watched. An example of how I used my data to determine gull diet is as follows: if I had ten feeding bouts for any particular nest then I would use the feeding watch data for all ten bouts if possible. If there were less than ten feeding bouts that watches could not be used for, then regurgitations would be used for the remaining observations. Nest debris was used only if I did not have ten bouts using feeding watches and regurgitations.

Adult Great Black-backed Gulls were captured using enlarged drop traps (90 x 60 x 36 cm) as described by Mills and Ryder (1979). We started to use the traps

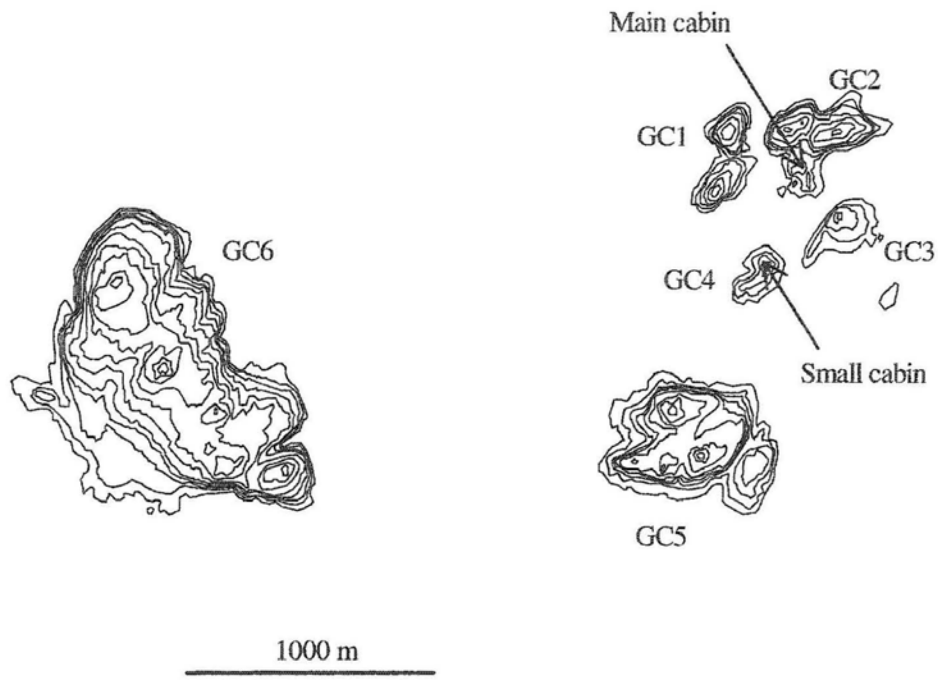


**Figure 2.1: Gannet Islands Ecological Reserve, Labrador (53° 56'N 56° 30'W).**

approximately two weeks before hatching and up until hatching. Eggs were taken out of the nest, placed in a foam insert inside a cooler, and replaced with wooden eggs in order to prevent damage to the eggs. The captured adult was measured and banded with both a metal band (right leg) and an orange plastic band engraved with a black letter-letter combination (left leg). The plastic band made it possible for the local birding community to identify the gulls at local dumps, fish plants, and inter-tidal zones that also helped us determine diet.

Great Black-backed Gulls with 80 % or more of their diet consisting of one food type were put into one of five categories of diet. By examining the data I was able to categorize diet as: seabirds, animal prey items, garbage, seabirds and garbage, and generalists. Prey consisting of adult seabirds and/or their eggs/young defined a "seabird diet". "Animal prey" items basically included a mixture of all living organisms including inter-tidal organisms, fish, and any other marine or terrestrial organism that the gulls preyed upon (including seabirds). Garbage was human refuse taken from dumps and fish offal and generalists were birds that fed upon all food categories.

#### 2.2.2.5 Habitat

Nesting habitat was classified into one of the following three categories used by Pierotti (1982) and the forest category used by Robertson et al. (2001). Meadow was defined as open territory with no tree trunks or puffin burrows within one metre of the nest bowl, which had to be made in grass or low scrub. Puffin slope was assigned when a nest bowl was found within one metre of a puffin burrow. Rocky habitat was defined as a nest bowl made on rock. Forest habitat was classified as a nest bowl located within one meter of a live tree trunk.

#### 2.2.2.6 Nesting density

Nesting density was characterized for each individual nest by recording the location of each neighbouring Great Black-backed Gull nest within a 10 m radius. The absence or presence of Great Black-backed Gull neighbours in the encompassing circle was recorded. Herring Gull presence or absence was recorded and matched with presence or absence of Great Black-backed Gulls to determine inter- and intra-specific nesting density.

#### 2.2.2.7 Statistical analysis

T-tests were used to assess differences in egg size and clutch size between the two colonies. $\chi^2$ tests were used to assess whether colony, year, habitat, diet, nesting density, and presence of Herring and Great Black-backed Gulls had an effect on fledging rates. $\chi^2$ tests were pooled into on a 2 X 2 contingency table based on whether the chicks fledged or not for each variable because when contingency tables were done on fledging success for 1-chick broods through 3-chick broods approximately 50 percent of the cells in the table had a value of 5 or less. ANCOVAs were done to examine if colony, year, habitat, diet, nesting density, and presence of Herring Gulls had an effect on growth rates of 6 to 35 day old chicks.

All statistical tests were two tailed, and the p value was considered significant at 0.05.

## 2.3 Results

### 2.3.1 Breeding performance

In 2001 Great Black-backed Gull fledge rate at Gull Island ($0.551 \pm 0.002$, n=127) was 10% higher than that at the Gannet Islands ($0.500 \pm 0.085$, n=34) although the differences were not significant ($G = 0.283$, $p = 0.595$). The differences between clutch and egg size between the Gannet Islands (clutch size $2.4 \pm 0.7$, n = 22; egg volume = $107.2 \pm 7.79$ ml, n= 58) and Gull Island (clutch size $2.5 \pm 0.7$, n = 79; egg volume = $108.12 \pm 9.33$ ml, n = 208) were not statistically significant in 2000 (clutch size $t = -0.88$, $p = 0.380$; egg volume $t = -0.85$, $p = 0.394$). The fledging rate at the Gannet Islands was not significantly different than the fledging rate seen at Gull Island

### 2.3.2 Growth Rate

WhenThe natural logarithm of tarsus, wing, and head length was loaded on PC1 PC1 accounted for 60 % of the variation of Great Black-backed Gull chick growth.

In spite of low sample sizes at the Gannet Islands the results suggest that Gannet Island Great Black-backed Gulls tended to grow to a larger size in a shorter period of time ($p < 0.1$) indicating a higher growth rate. However, there were no significant differences between the growth rates based on the overall logistic growth curve of gulls at the two colonies (Table 2.2).

**Table 2.2. Comparison of Great Black-backed Gull chick growth parameters at the Gannet Islands and Gull Island 2001.**

| Growth Parameter | N | Gannets Islands | N | Gull Island | t | p |
|---|---|---|---|---|---|---|
| a (asymptote) | 7 | 3.07 ± 0.06 | 29 | 2.79 ± 0.07 | 2.02 | 0.052 |
| b (growth rate) | 7 | 6.05 ± 0.48 | 29 | 5.761 ± 0.18 | -0.65 | 0.523 |
| $x_o$ (age in days of ½ asymptote) | 7 | 23.03 ± 0.55 | 29 | 24.73 ± 0.44 | -1.80 | 0.081 |

### 2.3.3 Diet

Diet had no significant effect on fledge or growth rates of chicks on Gull Island (Figure 2.2). However, the results suggested that Great Black-backed Gulls that had general and animal diets tended to have the highest fledging rates while seabird specialists tended to have the highest growth rates but lowest fledge rates. Great Black-backed Gulls that fed their chicks a combination of seabirds and garbage had intermediate growth and fledge rates.

Only Gull Island was analysed for effects of different diets on breeding success because all Great Black-backed Gulls on the Gannet Islands had essentially the same diet.

### 2.3.4 Habitat

There were no statistically significant relationships between nesting habitat and Great Black-backed Gull fledging ($\chi^2 = 3.95$, $p = 0.266$) or chick growth ($F = 0.26$, $p = 0.853$) rates on Gull Island in 2001(Table 2.3).

All the gulls at the Gannet Islands nested in meadow habitat so no comparison between habitats could be made.

### 2.3.5 Nesting Density

All the gulls at the Gannet Islands had no neighbours within a ten metre radius so no comparison of nesting density could be made.

The scoring system devised for quantifying nest density of both herring and Great Black-backed Gulls revealed no significant effect on fledging ($\chi^2 = 1.13$, $P = 0.288$) or

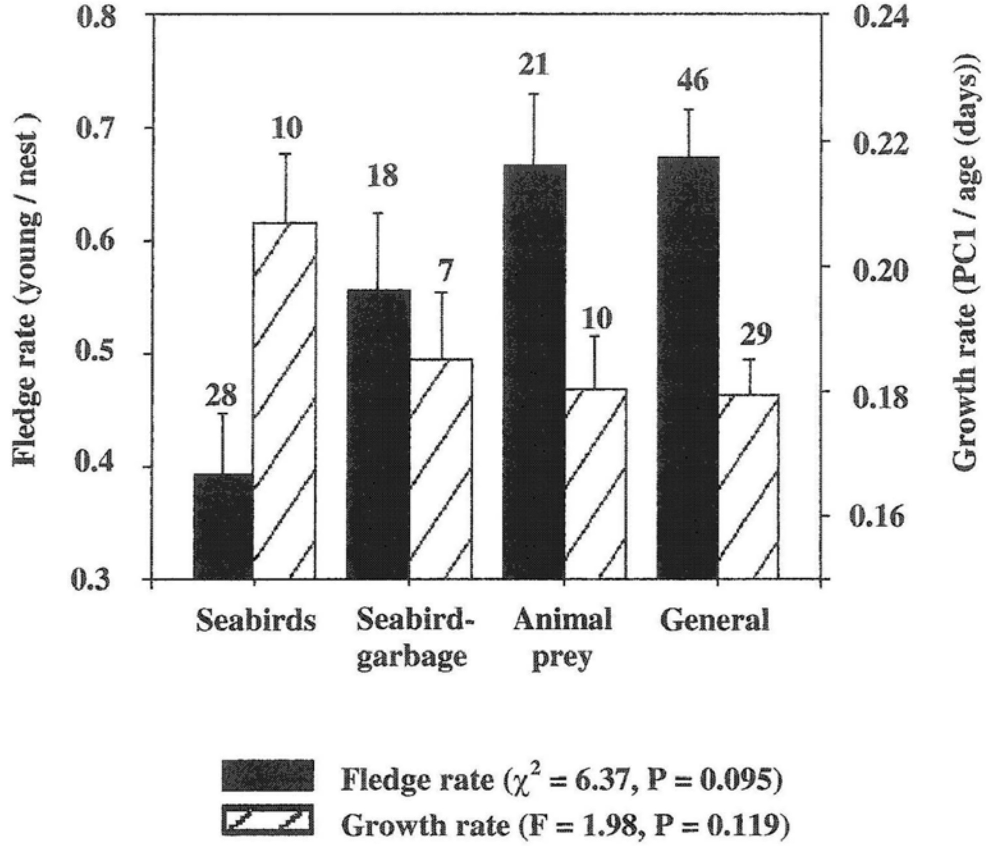


**Figure 2.2: Chick diet and Great Black-backed Gull chick fledging rates and growth rates with standard error bars on Gull Island, 2001. Sample sizes are shown above each bar.**

**Table 2.3. Habitat and Great Black-backed Gull chick fledging and growth rates on Gull Island, 2001. Fledge rate is the proportion of chicks that hatched from each nest that fledged.**

| Habitat | N | Fledge rate | N | Growth Rate |
|---|---|---|---|---|
| Forest | 11 | 0.455 ± 0.133 | 3 | 0.181 ± 0.020 |
| Meadow | 78 | 0.513 ± 0.050 | 37 | 0.186 ± 0.006 |
| Puffin slope | 30 | 0.700 ± 0.081 | 17 | 0.177 ± 0.009 |
| Rock | 6 | 0.667 ± 0.180 | 4 | 0.182 ± 0.022 |

growth rates (F = 0.03, P = 0.975) of Great Black-backed Gull chicks. No nests had both Herring Gull and Great Black-backed Gull neighbours (Table 2.4). When the presence of Great Black-backed Gull neighbours was separately analysed there was no significant effect on either Great Black-backed Gull fledging ($\chi^2$ = 2.50, P = 0.114) or chick growth rates (F = 0.04, P = 0.852). The same result was shown when the presence of Herring Gulls was analysed separately (fledge rate, $\chi^2$ = 2.37, P = 0.123; chick growth rate, F = 0.02, P = 0.883). Although the results were statitistically insignificant, they suggest that Great Black-backed Gulls that nested amongst Herring Gulls and away from conspecifics had higher fledge rates (Table 2.4).

## 2.4 Discussion

There were no statistically significant differences between the breeding performance (clutch size, egg size, chick growth rate, and fledging rate) of Great Black-backed Gulls at the Gannet Islands and Gull Island. However the PC1 values accounted for 60% leaving 40% of the variation unanalysed. When habitat, diet, and nesting density were examined separately there were also no large differences in fledging rates or chick growth rate. However, it did appear that generalist feeding Great Black-backed Gulls that nest amongst Herring Gulls and away from conspecifics were most successful. A trend developed between Great Black-backed Gull chicks with increasing growth rates and decreasing fledge rates when diet

**Table 2.4. The effect of combined species nesting density on Great Black-backed Gull chick fledging and growth rates on Gull Island in 2001. Fledge rate is the proportion of chicks that hatched from each nest that fledged.**

| GBBG | HERG | N | Fledge rate | N | Growth rate |
|---|---|---|---|---|---|
| Yes | - | 56 | 0.482 ± 0.042 | 25 | 0.184 ± 0.007 |
| No | - | 69 | 0.623 ± 0.038 | 36 | 0.182 ± 0.006 |
| - | Yes | 36 | 0.667 ± 0.055 | 20 | 0.182 ± 0.008 |
| - | No | 89 | 0.517 ± 0.035 | 41 | 0.183 ± 0.005 |
| No | No | 33 | 0.576 ± 0.079 | 17 | 0.183 ± 0.009 |
| No | Yes | 36 | 0.667 ± 0.075 | 20 | 0.182 ± 0.008 |
| Yes | No | 56 | 0.482 ± 0.061 | 24 | 0.184 ± 0.007 |
| Yes | Yes | 0 | - | 0 | - |

categories were compared (Figure 2.2).

### 2.4.1 Breeding performance

There were no differences in clutch size, egg size, or fledge rates between the two locations. Although the results were not quite statistically significant, Great Black-backed Gull chicks at the Gannet Islands seemed to reach a larger fledgling size at an earlier age. This may be due to the birds at the Gannet Islands being adapted to a shorter breeding season.

### 2.4.2 Diet

In this study, I expected that diet would be influenced by two factors. Firstly there were more gulls and more food sources on Gull Island, suggesting differences in the level of competition, in turn affecting food selection. Secondly, the Gannet Islands gulls had other seabirds as the only food source unlike Gull Island, which had many sources of food.

From our diet analysis individual Great Black-backed Gulls seemed to specialize in a certain type of diet. However, our study determined that this specialization was only in what was brought back to the chicks by adults. There were no data collected to determine differences between male and female food loads, nor what the adults fed themselves.

Great Black-backed Gulls on Gull Island with a general diet also seemed to follow the optimal diet theory since they fed upon a variety of prey items and subsequently had the highest fledge rates, followed by gulls that fed on animal prey items. Seabird specialists had the highest growth rate probably because of high energy values associated with seabird food loads (Watanuki 1992) but those that utilised more food types (animal prey and generalists), although slower growing, were possibly more successful at fledging chicks. Generalist gulls may have been the most successful because their diet may include items high in caloric value such as fatty meat products found in garbage and seabirds, and essential minerals such as those found in crustaceans and eggs (Pierotti and Annett 1991). Foods high in caloric value would be advantageous for chick growth and adult foraging and territory defence. However, the bones found in garbage have calcium stored in the form of apatite, which is a relatively insoluble crystalline lattice that is hard to digest (Karlson 1965, Pierotti and Annett 1991). Minerals, such as manganese and calcium, are essential for proper bone development in chicks and egg development in females (Pierotti and Annett 1991). Bolton et al (1992) found that gulls with increased protein in their diet prior to laying, hatched chicks with a larger skeletal size, indicating that protein as well as minerals is essential for bone development. Higher growth rates associated with lower fledge rates, found in this study, suggest that foods high in caloric value may be good for rapid growth but did not have the essential minerals required for proper bone development resulting in lower fledge rates (Pierotti and Annett 1991). Similarly in other gull populations garbage specialists were not as successful as those that fed on fish (Annett and Pierotti 1999), mussels (Pierotti and Annett 1991), and combinations of seabird chicks and fish (Watanuki 1992). For adult Great Black-backed Gulls the smaller seabird chicks and Storm-petrels may be better quality food items than adult puffins and kittiwakes because less energy was used in obtaining them and the entire bird was swallowed, including the bones, instead of just eating the meat and organs of larger birds. No breeding Great Black-backed Gulls observed at Gull Island fed exclusively on garbage, indicating that they avoided the least favourable food type.

### 2.4.3 Habitat

Habitat selection in marine birds is driven by competition for favourable sites close to feeding areas yet far from predators (Buckley and Buckley 1980). Pierotti (1982) and Rodway and Regehr (1999) found that there were differences in the reproductive success of Herring Gulls that nested in different habitats. Unlike the situation for Herring Gulls, nesting habitat was not related to Great Black-backed Gull breeding success at Gull Island. Although there were differences in the habitat chosen by nesting Great Black-backed Gulls there were certain common characteristics. Most nests were located in open meadow-like areas that were often high, if not the highest point, of a slope or cliff. Some were characterized as rock or forest but these were mainly Great Black-backed Gulls that nested under a lone tree or on a rock in an otherwise meadow habitat. As such, it was no surprise that habitat did not have major effect because the birds essentially nested in very similar habitat. These sites may have been chosen because it gave them a good vantage point to watch for potential prey or incoming seabirds carrying bill loads.

### 2.4.4 Nesting Density

Research on the effect of nesting density on the breeding success of Great Black-backed Gulls has shown that in some colonies low density is better so as to avoid conspecific predation of chicks (Butler and Trivelpiece 1981), while in another higher nesting density was favoured for predator defence (Roy 1986). A clear advantage to nesting in high densities is the increased ability of large numbers of individuals to defend colonial nests against a single avian predator. Mobbing behaviour has been documented with Yellow-footed Gulls (*Larus livens*) mobbing Common Ravens (*Corvus corax*) (Spear and Anderson 1989), Audouin's Gulls (*Larus audouinii*) mobbing Peregrine Falcons (*Falco peregrinus*) (Oro 1996), and we observed mobbing on Gull Island when a Bald Eagle (*Haliaeetus leucocephalus*) arrived causing all gulls to fly in the air while one to five Great Black-backed Gulls actively pursued it. Nesting density in gulls as strategy of predator defence is believed to be related to the physical size of the species of gull. Larger gulls in smaller numbers are believed to be able to defend against predators more effectively than equal numbers of smaller species of gulls (Götmark 1982). Accordingly, Great Black-backed Gulls, the largest member of the larids would not need to nest in dense colonies for predator defence. In fact, in larger gull species, when new territories were colonised in Finland, Great Black-backed Gulls chose to nest solitarily if suitable habitat was available (Bergman 1982). Solitary nesting was probably preferred because of increased conspecific predation of young associated with densely nesting large gulls (Butler and Trivelpiece 1981, Spaans et al. 1987). These indications predict that decreased nesting density would have been favoured to a certain point. Great Black-backed Gulls would still be subject to the advantages of colonial nesting, such as predator defence, but are better suited for low-density colonies.

Inter- and intra-specific nesting density had no statistically significant effect on fledge rates or growth rates. However, they did weakly suggest that Great Black-backed Gulls that nest amongst Herring Gulls but away from Great Black-backed Gulls had the highest fledging rates. Great Black-backed Gulls in other colonies have shown to have reduced fledge rates with increasing intra-specific nesting density (Butler and Trivelpiece 1981) and increasing fledge rates in the presence of Herring Gulls (McGill 1977). Great Black-backed Gulls nesting in areas densely populated with conspecifics were more likely to have chicks predated by conspecifics and therefore spent significantly more time defending the territory and less time foraging for their young (Butler and Trivelpiece 1981). Supporting this explanation, Roy (1986) found that Great Black-backed Gulls on Gull Island that nested amongst conspecifics spent significantly more time nest guarding and were the only Great Black-backed Gulls to have chick mortality after 35 days of age compared to gulls that nested amongst Herring Gulls. Chicks 35 days old could be considered relatively immune to predation by conspecifics but as they continuously expand their territory altercations with neighbouring pairs and sometimes chick predation would be expected (Butler and Janes-Butler 1982).

Great Black-backed Gulls were occasionally observed feeding their young Herring Gull chicks on Gull Island in 2001. Great Black-backed Gull predation of Herring Gull chicks has been documented in the past (Lock 1973, McGill 1977, Butler and Trivelpiece 1981) and this predatory tendency is a possible reason why Great Black-backed Gulls have been maintaining a stable population in the face of reductions of available food sources in the Northwest Atlantic. Regehr and Montevecchi (1997), Regehr and Rodway (1999), and Massaro et al. (2000) reported that food stressed Great Black-backed Gulls took Black-legged Kittiwake (*Rissa tridactyla*) eggs, chicks, and adults as an alternative when fish were not available. In addition to easily available spawning schools of capelin, higher numbers of vulnerable seabirds such as Leach's Storm-petrels, Black-legged Kittwakes, and their chicks should give the Great Black-backed Gulls at Gull Island an advantage over those at the Gannet Islands. However, our study did not show that there was a significant difference in breeding success in the two colonies.

The reason that the fledge rate for Great Black-backed Gulls at the Gannet Islands was approximately the same as Gull Island was probably because at the Gannet Islands there are approximately 872 murre/Razorbill chicks per gull and 0.7 on Gull Island. This includes both species of gull on Gull Island because Herring Gulls are also known to predate seabird chicks. When the auk egg/chick population and puffin food loads are taken into account together, there was enough food for the smaller gull population at the Gannet Islands. Although there were more food sources at Gull Island there were also many more gulls (both Herring and Great Black-backed Gulls) depending on those resources. Studies, including this one, indicate that Great Black-backed Gulls benefited from nesting close to Herring Gulls, but living amongst approximately thirty times as many Herring Gulls, which feed upon many of the same food supplies, has disadvantages as well.

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## Chapter 3

## The influence of Great Black-backed Gull (*Larus marinus*) predation on seabird populations at two colonies in the Northwest Atlantic.

### 3.1 INTRODUCTION

Although Great Black-backed Gulls are considered opportunistic scavengers (Burger 1988, Buckley 1990), they may specialize on taking seabird eggs (Lock 1973, Regehr 1994, Massaro et al. 2000), young (McGill 1977, Mawhinney and Diamond 1999, Massaro et al. 2000) and even adults of some smaller species (Pierotti 1983, Roy 1986, Howes and Montevecchi 1993, Russell and Montevecchi 1996, Good 1998, Massaro et al. 2000). Great Black-backed Gull populations have been increasing since the turn of the $20^{th}$ century (Good 1998). However, reduction of offal from failed fisheries, late arrival of spawning capelin (*Mallotus villosus*) (Massaro et al. 2000), and improved landfill practices may have decreased these artificial food sources and increased predation on seabird populations in the Northwest Atlantic (Regehr 1994, Regehr and Rodway 1999, and Stenhouse and Montevecchi 1999). In the Northwest Atlantic where artificial food sources have been drastically reduced, gulls are again feeding on natural prey sources (Regehr and Rodway 1999, Massaro et al. 2000, and Stenhouse et al. 2000). Furness (1981) found that Great Skua (*Catharacta skua*) predation on local seabird populations was comparatively low for the numbers of skuas nesting at the Shetlands, because locally breeding skuas were scavenging at fishing vessels. When human made food sources were decreased in this system, skuas turned to predation of seabirds and their young, resulting in population decline of other seabirds. Recently it has been shown that when the skuas were successfully breeding and food supplies were moderate the level of Black-legged Kittiwake (*Rissa tridactyla*) predation increased to the point where it caused a decrease in kittiwake breeding success. However, when the skuas failed to breed because of very low levels of local fishes their demand for food decreased, thus reducing kittiwake predation (Oro and Furness 2002).

In this paper I investigated predation of Great Black-backed Gulls on Thick-billed Murre (*Uria lomvia*), Common Murre (*Uria aalge*), and Razorbill (*Alca torda*) egg and chick predation at Gull Island, Witless Bay, Newfoundland and the Gannet Islands, Labrador. I also monitored the predation of eggs, chicks, and adults of Atlantic Puffins (*Fratercula arctica*), Black-legged Kittiwakes, and Leach's Storm-petrels (*Oceanodroma leucorhoai*) found only at Gull Island. These data were used to compare the impacts of Great Black-backed Gull predation of seabirds, on Gull Island, where there was an available supply of human refuse and capelin, to the Gannet Islands, where seabirds were the only source of food.

## 3.2 METHODS

### 3.2.1 Study site

A complete description of the study sites is presented in Chapter two.

### 3.2.2 Numbers of seabirds fed to chicks

Data collected from feeding watches, chick regurgitation, and nest debris (see Chapter two) were used to determine which breeding pairs had specialized in feeding their young other seabirds. Three observation blinds on Gull Island, from which 28 of 90 nests could be observed, were used to record feeding bouts. Two, two-hour watches were randomly assigned throughout the day (all hours of daylight) for both my assistant and myself, totalling four hours per day per person. We used each blind in rotation to prevent one blind from being favoured over any other. For example, if my assistant started his first watch in blind one, then his second watch would be in blind two. The next day, his first watch would be in blind three and his second watch in blind one. When he did his watches in one blind I was in another but also followed the same scheduling regime.

On the Gannet Islands, inter-island observations were made from one only observation point using a 20-60x spotting scope, on 6 of the 25 total nests from the island inhabited by researchers (GC2) to the island 300 m to its west (GC1). Two-hour feeding watches were randomly assigned throughout the day as on Gull Island except once a week we conducted an all day, non-stop feeding watch. The gulls used for the feeding watches were believed to be representative of the population considering nesting density and habitat.

Watches were deemed as the most reliable method for identifying items brought back to the chick because nest debris consisted mainly of non-digestible regurgitated items and egg shells; and chicks were only able to regurgitate items that that have been eaten recently. When all the diet data were combined I placed most emphasis on feeding watches, next on chick regurgitation, and finally nest debris; as outlined in chapter 2. Chick regurgitation and nest debris were used to identify diet in nests that were located in places that could not be watched.

### 3.2.3 Number of total seabirds taken

Feeding watches provided feeding frequency data that enabled me to quantify how many birds, eggs, or chicks were fed to gull chicks per feeding bout. This information was determined from the birds that could be seen from the blinds or observation points, and was used to extrapolate how many seabirds were being consumed by all breeding Great Black-backed Gull pairs on the colony. For example, if there were five pairs of Great Black-backed Gulls observed feeding each chick one Storm-petrel per feeding bout, and there were, on average, three watch bouts per day while the chicks were 10 to 16 days old, I concluded that unobservable nests frequented with petrel pellets or petrels in chick regurgitates, parents were feeding each ten to sixteen day old chick three petrels per day.

On the Gannet Islands I was able to observe a large proportion of one island from another because of the small size and close proximity of the islands. This allowed me to set up Common and Thick-billed Murre observation plots to compare how many eggs/chicks were being taken from the murre population relative to those brought back to the nests. The plots were large in size and contained both cliff and relatively flat, rocky habitat, which was believed to be representative. The ratio of murre eggs to Razorbill and puffin eggs found as nest debris was used to determine how many Razorbill and puffin eggs were taken from the colony. I believed this to be reliable because it seems likely that a gull would have treated all eggs the same. The total number of seabirds taken, at the Gannet Islands, was calculated using the following equations:

$N_{young}$ = number of eggs or chicks taken from murre plot

$N_{murre}$ = number of breeding murre pairs on murre plot

$N_{tot}$ = total number of murre eggs/chicks in total population

$N_{y\text{-}taken}$ = total number of murre eggs/chicks taken from the population

$N_{found}$ = number of murre eggs/chicks found at the nest site

$N_{R\text{-}P}$ = total number of Razorbill or puffin eggs/chicks taken from the population

$N_{R\text{-}P\,found}$ = number of Razorbill or puffin eggs/chicks found at the nest site

$$N_{y\text{-}taken} = (N_{young} / N_{murre}) * N_{tot}$$

$$N_{R\text{-}P} = (N_{R\text{-}P\,found} / N_{found}) * N_{y\text{-}taken}$$

On Gull Island, one blind was set up to see how many adult puffins a single pair of gulls predated. No other blinds were set up to observe other seabirds being predated for two reasons. Firstly, there was not enough time for additional work using a two-person team because three other blinds were being manned for feeding watches and there was substantial trouble moving around through the thick forest habitat riddled with blown down trees. Secondly, nesting auks were impossible to see from the island itself. Although kittiwake nests were easily seen, two recent studies were done on kittiwakes that could be used as references (Regehr 1994, Massaro et al. 2000). The clutch size of 1.38 used by Regehr (1994) was used to determine the number of kittiwake eggs available to the gulls as food. For the auk eggs, I multiplied the number of breeding pairs by one to determine the number of available eggs. Puffin eggs were included even though they nest underground because some wash out after heavy rain and make up a proportion of the gull diet.

The diet of Great Black-backed Gulls was put into a selectivity index as described by Ivlev (1961) (Table 3.1).

## 3.3 Results

### 3.3.1 Great Black-backed Gull diet

#### 3.3.1.1 Gannet Islands

Through observing Great Black-backed Gulls at the Gannet Islands I noticed they often obtained fish, which made up most of their diet (Figure 3.1), by kleptoparasitising puffins that were returning with Sandlance (Ammodytes spp.) for their chicks. The number of Razorbill and murre eggs predated was of a much higher proportion than what was available in relation to all other seabirds (Figure 3.2). On the other hand, the numbers of puffin eggs/chicks taken were much lower than what was available as prey items. In fact, according to the selectivity index the adult puffins were almost completely ignored (Table 3.1)

#### 3.3.1.2 Gull Island

Unlike the Great Black-backed Gulls on the Gannet Islands, gulls nesting on Gull Island were not as focused on fish to raise their chicks. These gulls were heavily dependent upon garbage and seabirds as sources of food for their chicks (Figure 3.1). The Great Black-backed Gull seabird diet included a large number of Leach's Storm-petrels (Table 3.2). There were roughly half as many petrels in the gull diet in proportion to the numbers of petrels found in the seabird population (Figure 3.3). As seen at the Gannet Islands there was proportionately more murre eggs in the Great Black-backed

Gull diet than what was available in the environment. This was also the case for both kittiwake adults and eggs (Figure 3.3). The selectivity index showed that murre eggs and kittiwake eggs are highly selected and puffin eggs seemed to be ignored or unavailable (Table 3.1).

### 3.3.2 Feeding frequencies

At both locations the mean number of times chicks were fed per day followed the same basic pattern of reduced feedings per chick as time increased (Figure 3.4). The sizes of the food loads given to the chicks seemed to increase over time but could not be measured quantitatively because the information was taken through feeding watches. In both areas the composition of diet over time also changed so that fish was the predominant food at time of fledging (Figure 3.5).

### 3.3.3 Population impacts

#### 3.3.3.1 Gannet Islands

The level of seabird predation at the Gannet Islands was very low (Table 3.2). The highest levels of predation were murre and Razorbill eggs that were taken early in the season (10.9% and 7.3% respectively).

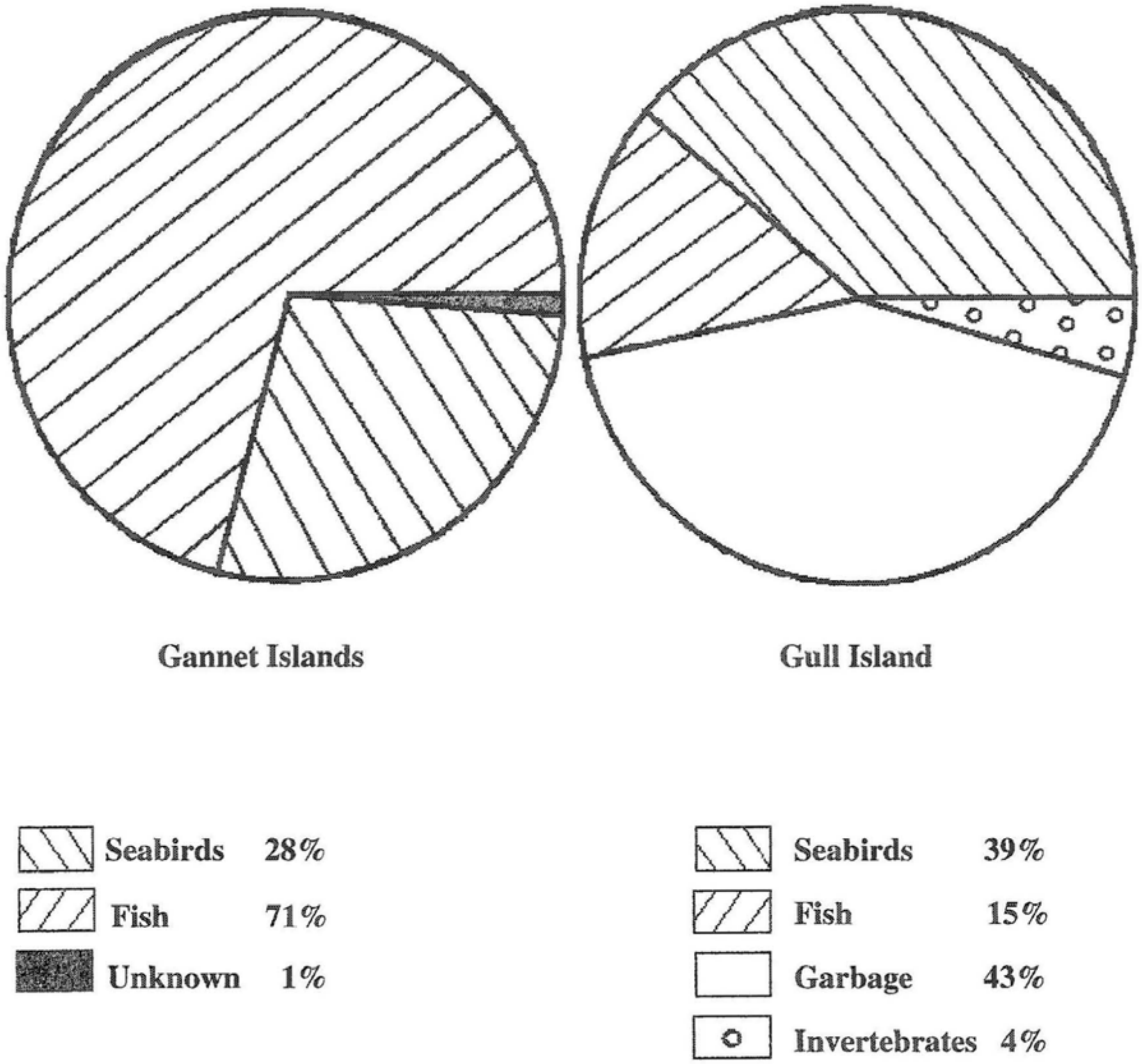
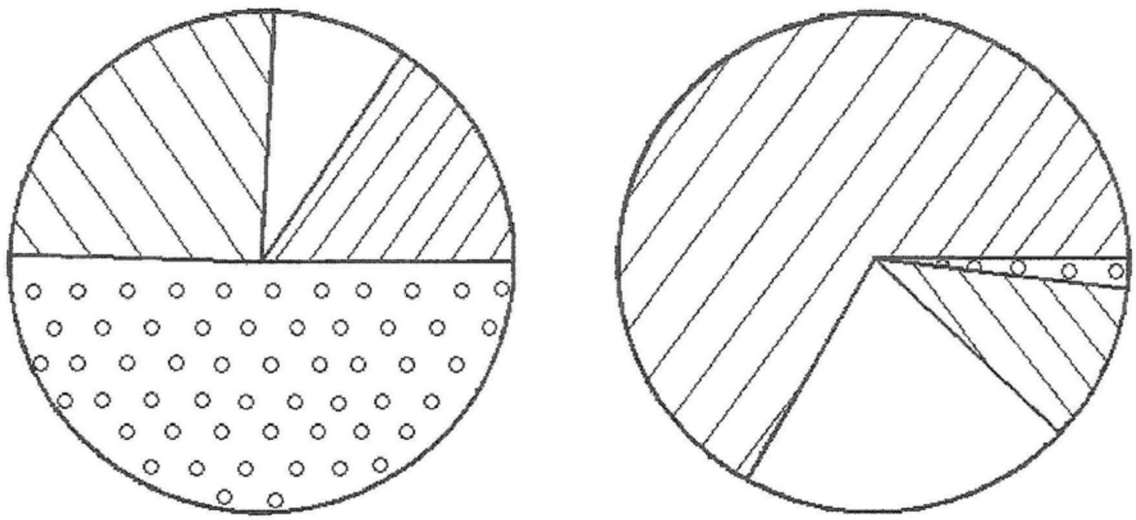



**Figure 3.1: Great Black-backed Gulls chick diet composition at two colonies in 2001, values expressed as percent occurrences.**




| Available prey | | | Diet | | |
|---|---|---|---|---|---|
| Murre eggs | 15.4% | (n = 20697) | Murre eggs | 66.9% | (n = 2259) |
| ATPU eggs | 25.8% | (n = 34612) | ATPU eggs | 10.5% | (n = 353) |
| ATPU adult | 51.5% | (n = 69224) | ATPU adult | 1.5% | (n = 52) |
| RAZO eggs | 7.3% | (n = 9808) | RAZO eggs | 21.1% | (n = 713) |

**Figure 3.2: Available prey items and Great Black-backed gull diet on the Gannet Islands, 2001, values expressed as percent occurrence. Where RAZO means Razorbill (*Alca torda*) and ATPU means Atlantic Puffin (*Fratercula arctica*)**

**Table 3.1: Selectivity index of seabird prey items for Great Black-backed Gulls in the Gannet Islands and on Gull Island, 2001**

| Species | Gull Island | Gannet Islands |
|---|---|---|
| Murre eggs | 0.94 | 0.63 |
| Razorbill eggs | 0 | 0.49 |
| Atlantic puffin adults | 0.17 | -0.94 |
| Atlantic puffin eggs | -0.88 | -0.42 |
| Leach's Storm-petrels | -0.42 | N/A |
| Black-legged kittiwake adults | 0.50 | N/A |
| Black-legged kittiwake eggs | 0.93 | N/A |

Selectivity index was calculated by the equation:

$$E = (r_I - P_I)/(r_I + P_I)$$

where $r_I$ is the percentage of an element in the diet and $P_I$ is the percentage of the element in the environment. In this index a value of −1 describes a food item that is totally ignored and a value of +1 describes a food item that is favoured.

N/A: Not available

**Table 3.2: Estimated number of seabird prey items and level of Great Black-backed predation found at two seabird sanctuaries in the Northwest Atlantic.**

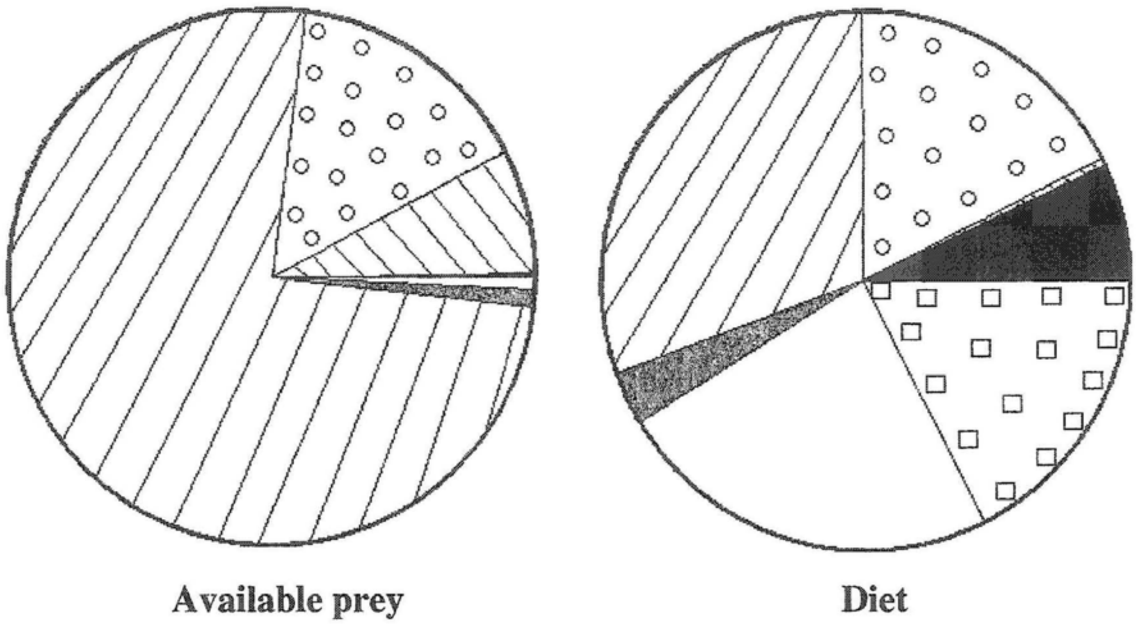
| | Gull Island | | | Gannet Islands | | |
|---|---|---|---|---|---|---|
| Prey Item | Population size | Number predated | % of population | Population size | Number predated | % of population |
| Murre eggs | 1700 | 476 | 28.0 | 20697 | 2259 | 10.9 |
| RAZO eggs | 217 | 0 | 0 | 9808 | 713 | 7.3 |
| ATPU adults | 142000 | 1202 | 0.85 | 69224 | 52 | 0.07 |
| ATPU eggs | 71000 | 25 | 0.04 | 34612 | 353 | 1.0 |
| LHSP adults | 703772 | 2054 | 0.29 | 0 | 0 | 0 |
| BLKW adults | 10408 | 225 | 2.2 | 54 | 0 | 0 |
| BLKW eggs | 7182 | 1603 | 22.3 | 65 | 0 | 0 |

RAZO = Razorbills (*Alca torda*)

ATPU = Atlantic Puffins (*Fratercula arctica*)

LHSP = Leach's Storm-petrels (*Oceanodroma leucorhoa*)

BLKI = Black-legged Kittiwake (*Rissa tridactyla*)




| Available prey | | | Diet | | |
|---|---|---|---|---|---|
| Murre eggs | 0.2% | (n = 1700) | Murre eggs | 7.0% | (n = 476) |
| ATPU eggs | 7.6% | (n=71000) | ATPU eggs | 0.5% | (n=25) |
| ATPU adults | 15.2% | (n = 142000) | ATPU adults | 21.6% | (n = 1202) |
| LHSP adults | 75.2% | (n=703772) | LHSP adults | 30.4% | (n=2054) |
| BLKI adults | 1.1% | (n=10404) | BLKI adults | 3.3% | (n=225) |
| BLKI eggs | 0.8% | (n=7182) | BLKI eggs | 22.3% | (n=1603) |
| | | | Unknown seabirds | 17.4% | (n=1177) |

**Figure 3.3: Available prey items and Great Black-backed Gull seabird diet on Gull Island, 2001, expressed as percent occurrence. Where RAZO means Razorbills (*Alca torda*) ATPU means Atlantic Puffins (*Fratercula arctica*)LHSP means Leach's Storm-petrels (*Oceanodroma leucorhoa*) BLKW means Black-legged Kittiwake (*Rissa tridactyla*)**

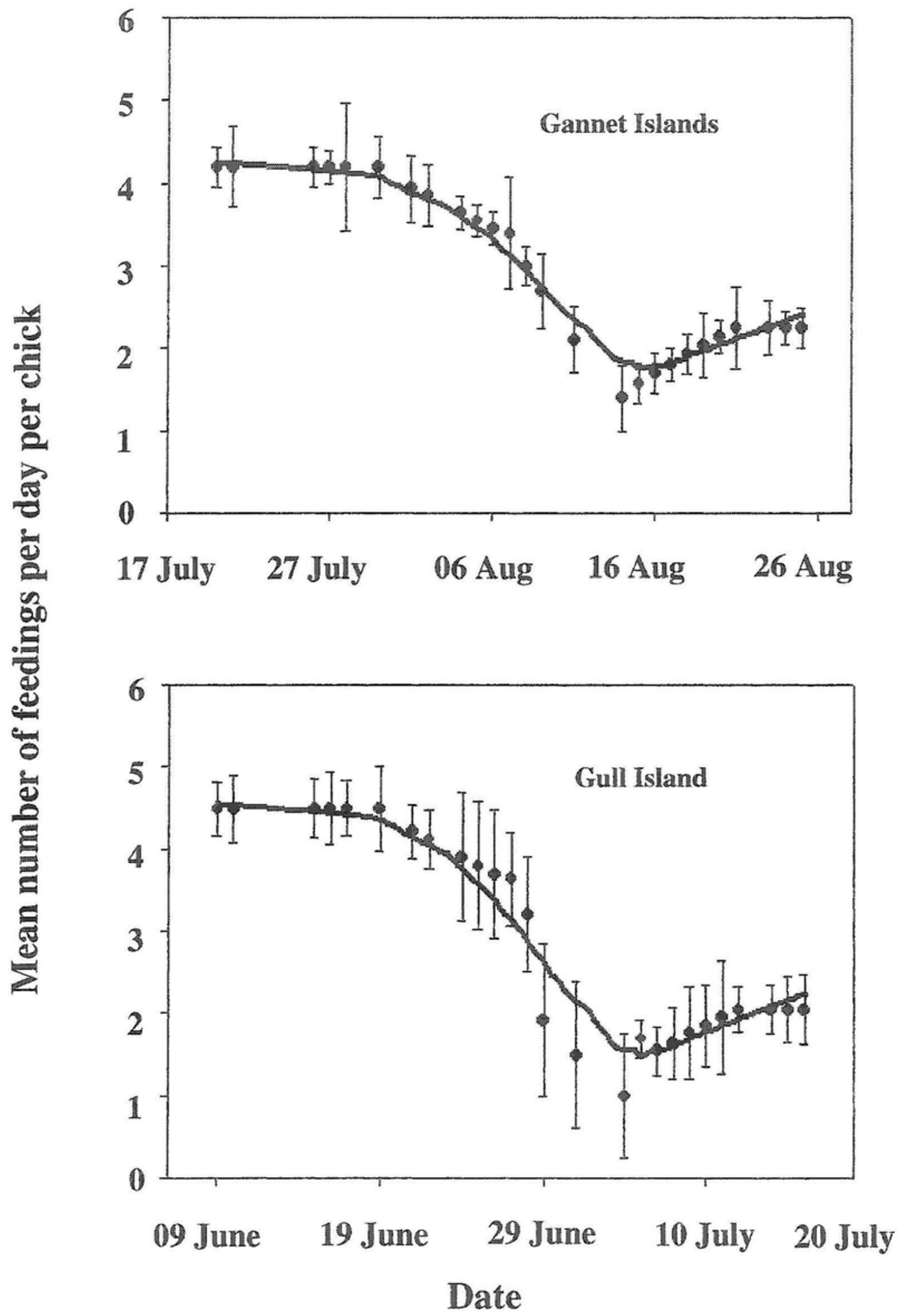



**Figure 3.4: Great Black-backed Gull chick feeding frequency on the Gannet Islands and Gull Island, 2001. Lines shown are bi-square smoothers.**

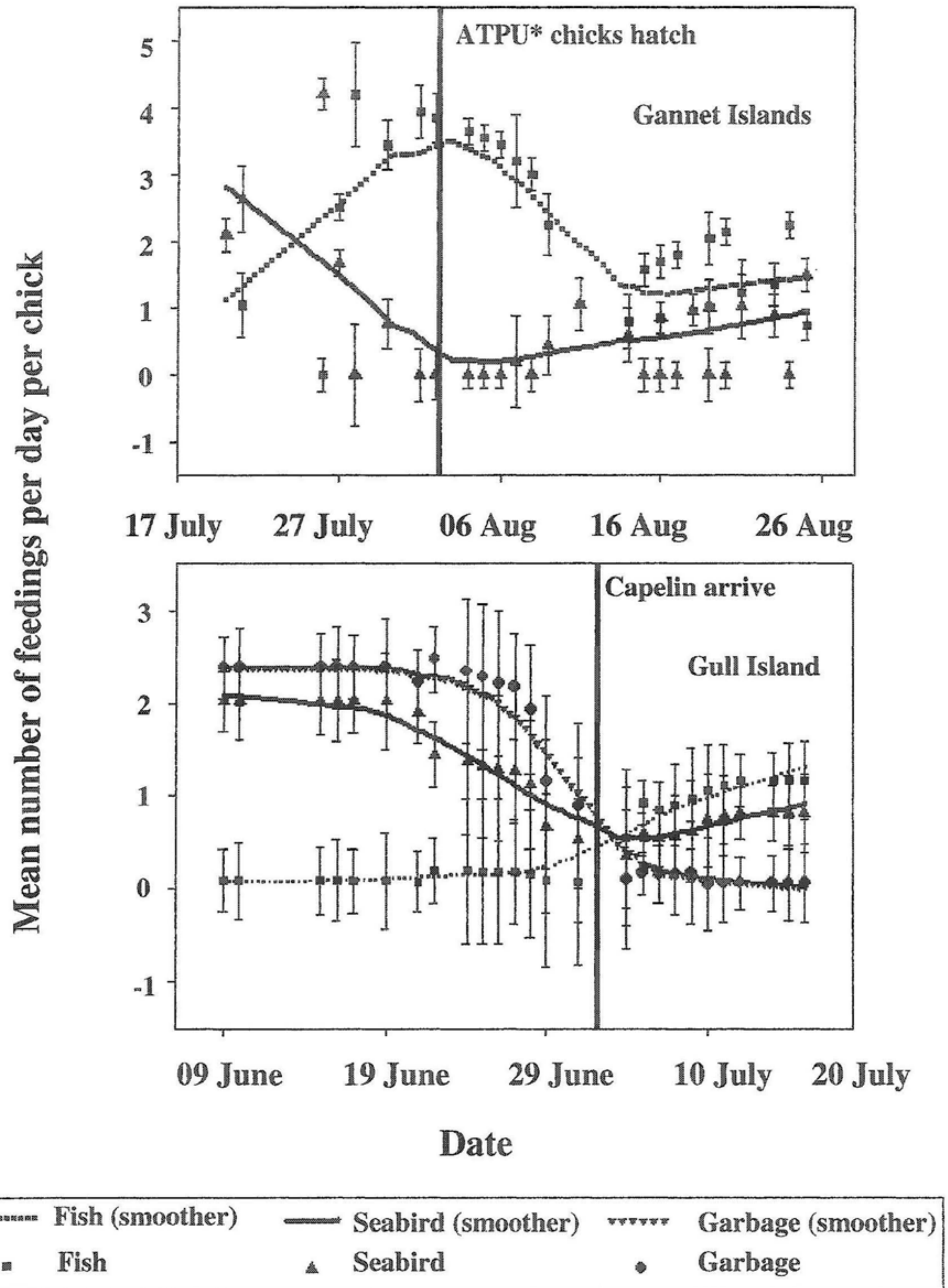



**Figure 3.5: Great Black-backed Gull chick feeding frequencies for separate prey items on the Gannet Islands and Gull Island, 2001. Lines shown are bi-square smoothers. ATPU means Atlantic Puffins (*Fratercula arctica*)**

### 3.3.3.2 Gull Island

The level of murre egg predation at Gull Island was the highest of all the predation seen on Gull Island (Table 3.2). Black-legged Kittiwakes were heavily affected by Great Black-backed Gull predation, many eggs/young were highly taken (22.3%) and breeding adults were taken as well (2.2%) (Table 3.2).

## 3.4 Discussion

There were a few assumptions made to calculate the availability of seabirds in the diet. I assumed that only breeding seabirds were available to gulls, which meant that non-breeding birds were not included causing underestimates in the population sizes of available birds, meaning that the effect of Great Black-backed Gull predation has on seabird populations is actually an over-estimate of population impacts, especially for Atlantic Puffins and Leach's Storm-petrels. Another assumption was that all murres that were in a brooding posture against the cliffs represented a breeding pair.

Fish was the predominant item in the Gannet Island Great Black-backed Gull chick diet. Of the seabirds predated, murre eggs were the most frequently taken item on the Gannet Islands Ecological Reserve, composing of 10.6% of the murre egg population and 66.9% of the gull seabird diet. On Gull Island, garbage (42.5%) was the most common food type but seabirds (38.7%) were also a large portion of the Great Black-backed Gull diet. Petrels were the highest proportion of the Great Black-backed Gull seabird diet on Gull Island but only accounted for 0.29% of the breeding population. Murre and kittiwake eggs were in the highest proportion of the population predated by

Great Black-backed Gulls (28% and 22.3% respectively). Kittiwake adults had the highest proportion of predated seabird adults (2.2%).

I noticed that the susceptibility of seabirds to predation by gulls was largely dependent upon how early seabirds laid in respect to mean lay date for that species and the biology of the species being predated. It has been shown that if murres lose their eggs early in the season they can successfully relay and raise their chicks to fledging (Hipfner 2001, Storey pers. comm.). Other seabirds, such as burrowing seabirds exemplified by Atlantic Puffins and Leach's Storm-petrels would have the lowest egg predation because their eggs are laid in a burrow and accessed only when the young wander out of the burrow or the egg is laid by the entrance, rejected by the parent(s), or washed out during heavy rain. This is why the selectivity index is so low for these food items. Razorbills should also be partially protected from egg predation by gulls because they sometimes nest under boulders (Rowe and Jones 2000). Cliff nesting seabirds would be the most susceptible to egg predation because their eggs are out in the open. Murres nesting in high densities were more effective at defending their eggs than cliff nesting seabirds with low densities, such as Black-legged Kittiwakes (Massaro et al. 2001). Cliff nesting seabirds that laid eggs very early seemed to be most vulnerable to predation, since there were few conspecifics willing to stay at the nest site to defend against predators.

### 3.4.1 Gannet Islands

The level of seabird predation at the Gannet Islands was lower than expected as seabirds were the only obvious source of food for gulls in that system. However, kleptoparasitism was common indicating that the ability of auks to successfully catch and return with fish was a very important contributor to Great Black-backed Gull reproductive success. The ease with which gulls took food loads from puffins, suggests that the amount of energy gained from kleptoparasitising fish could be much higher than depredating the seabirds themselves. Puffin food loads were taken by a brief foot chase on the puffin slope where the gull pursued the puffin until it dropped the fish, which was usually immediately, or it took them from puffin burrow entrances. Great Black-backed Gulls waited until the slope had enough puffins with food loads to be successful each time. Sandlance, the predominant fish item in the gull diet at the Gannet Islands, had the highest caloric value of all fish consumed by puffins at three colonies in the Northwest Atlantic (Russell 1999). Predominance of an easily obtained, high-energy food source would be expected, as predators should concentrate on the most rewarding prey (Milinski and Parker 1991).

The level of seabird predation at the Gannet Islands was highest at the beginning of the field season for two potential reasons. Firstly, inexperienced auks may not be very attentive parents or they may have chosen to nest at poor nest sites, which allowed for easy predation of eggs. When most of the murres have laid the gulls have reduced success because the murres stay on their nest and effectively keep the gulls at bay as a group by pointing their bills at the gull in unison. In addition to egg loss, murre and Razorbill parents that were successful in incubating an egg to hatch a chick for the first time may not have been attentive enough during fledging and lost their chicks to Great Black-backed Gulls. This could also explain why the proportion of seabirds in the gull diet started to increase later in the season (Figure 3.5). Secondly, Great Black-backed Gulls had little access to fish until auk chicks hatched and gulls had the opportunity to kleptoparasitise parents returning to the colony carrying fish. According to the selectivity index adult puffins seemed to be ignored by gulls as prey, but rather gulls took puffin food loads, which seems to indicate that the anti-predator response of dropping the food load when pursued is highly favoured in this environment.

The low levels of seabird predation by Great Black-backed Gulls at the Gannet Islands are reflected in recent surveys of the seabird populations where Atlantic Puffin and kittiwake numbers have remained constant; Razorbill, Thick-billed Murres are increasing; and Common Murre populations may have declined (Robertson and Elliot 2002a). The apparent decline in the Common Murre population was mainly attributed to changes in the marine ecosystem in the Northwest Atlantic (Bryant and Jones 1999), arctic fox predation, and/ or a variation between surveys (Robertson and Elliot 2002a).

### 3.4.2 Gull Island

Although Storm-petrels made up a large part of the gull diet, they were not preferentially selected. The huge population created an easily available prey, but despite gull predation the Storm-petrel population showed no evidence of change since the last census in 1985, so apparently can sustain these levels of predation (Robertson et al. 2002). The proportion of murre eggs in the diet of Great Black-backed Gulls was very high for the small numbers of breeding murres on Gull Island. However, nearby Green Island, with over 100,000 breeding pairs, is believed to be a source of breeding murres recruiting to Gull Island and possibly a direct source of eggs taken by gulls. It seems that gulls only take eggs early in the season and murres are capable of relaying eggs and successfully raising a chick (Hipfner 2001). I believe that the impact of Great Black-backed Gulls on murres on Gull Island may keep the local population in check but is not a significant threat to the future of the greater murre population in Witless Bay.

The late arrival of capelin, and reduction of fish offal due to the cod moratorium has caused a reduction of food for Great Black-backed Gulls, which caused the low level of Great Black-backed Gull predation of kittiwakes in the 1960s to become the major cause for kittiwake egg/chick loss by the 1990s (Regehr 1994). The level of predation of Black-legged Kittiwakes and their young on Gull Island is probably the most significant impact found in this study because of high egg/chick predation and the highest proportion of breeding adults predated, which directly reduces the breeding population. Russell and Montevecchi (1996) found that, on Small Island, 2.9% of breeding Atlantic Puffins were predated, and a substantial decrease in the population has recently occurred (Robertson and Elliot 2002b). Harris (1980) measured numbers of breeding puffins predated and found that 1.5 % of the Atlantic Puffin breeding population on Dunn Island was killed by Great Black-backed Gulls. When translated into comparable units used by Russell and Montevecchi (1996), the predation at Dunn Island was slightly lower than Small Island, 2.6% in 1975 to 1977 and 2.4% in 1978, which also saw a slight population decline.

The kittiwake population in Witless Bay has recently declined (CWS unpubl. data), which is not surprising given the high predation rates we observed. This was predicted by Regehr (1994) who stated that Great Black-backed Gull predation of kittiwake eggs in combination with low productivity may result in population declines. Kittiwakes were believed to be susceptible to Great Black-backed Gulls because of recent low egg production, which may not have been able to produce a swamping effect on predating Great Black-backed Gulls (Regehr 1994). Storey (pers comm.) found that kittiwake nesting density has dramatically declined since the 1990s. The late arrival of capelin was also linked to poor kittiwake productivity, which in turn made the kittiwakes more susceptible to Great Black-backed Gull predation (Massaro et al. 2000). This may have a snowball effect on the future predation of the falling population of kittiwakes by Great Black-back Gulls as capelin continues to arrive late.

Other factors that have an effect on the predation rates of kittiwakes by Great Black-backed Gulls are the population density of Great Black-backed Gulls near kittiwake nesting sites, and the population density of Herring Gulls near kittiwake nesting sites. Pierotti (1983) found that puffins nesting amongst dense populations of Herring Gulls were less likely to be predated than puffins in low gull density areas because of gull-gull interference. Gull-gull interference would be unlikely to happen in this scenario between kittiwakes and Great Black-backed Gulls because Great Black-backed Gulls are more solitary than Herring Gulls and such high nesting densities are uncommon (Good 1998). Regehr (1994) found that kittiwakes that nested amongst Herring Gulls experienced low levels of gull predation. Although Herring Gulls may have taken a few chicks, they were very effective at deterring Great Black-backed Gulls. However, it is also unlikely that Herring Gulls will be able to deter Great Black-backed Gull predation in the long term because of a recent decline in the Witless Bay Herring Gull population, which is probably due to a reduction in fisheries offal (Robertson et al. 2001). Therefore, it would be expected that reduced numbers of Herring Gulls would indirectly contribute to declining kittiwake breeding success. If capelin arrival is continually delayed, kittiwake nest sites may begin to be concentrated in remaining areas of high Herring Gull densities.

In conclusion, Great Black-backed Gulls at the Gannet Islands did not seem to have a detrimental effect on the seabird population because of a concentration on kleptoparasitising sandlance from puffins rather than feeding on seabirds themselves. On Gull Island kittiwakes were heavily predated and this may be contributing to the declining population. Puffin, murre, and Razorbill populations have all recently increased (CWS unpubl. data); and the unchanging petrel population (Robertson et al. 2002) indicate that Great Black-backed Gull predation did not seem to affect populations of these species at this time.

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## Chapter 4

### 4.1 Summary

For the summer of 2001, Great Black-backed Gulls were equally successful at both colonies, indicating that these birds are highly adaptable to differing situations. Their large size and relatively solitary breeding behaviour may allow them to out compete smaller larids, such as Herring Gulls, without running into major intra-specific competition. Great Black-backed Gull's large size, predatory tendencies, somewhat solitary behaviour, and relatively smaller population size suggests that they are able to feed with a greater trophic depth than Herring Gulls. This means that Great Black-backed Gulls are able to feed on organisms that are higher in the food chain than Herring Gulls, including Herring Gulls themselves. This agrees with Burger (1988) who found that larger gulls have a tendency to have more diverse diets. It is possible to have a single species that feeds upon different trophic levels, exemplified by fish and fresh water invertebrates whose diet is composed of predatory invertebrates and the grazing invertebrates they feed upon (Nyström et al. 2001). Similar examples are seen in the invertebrate community (Petchey 1999) and in this study at Gull Island where Great Black-backed Gulls fed upon many of the same organisms Herring Gulls did, but they also consumed adult puffins and kittiwakes giving Great Black-backed Gulls more trophic depth than Herring Gulls. According to the trophic pyramid, biomass decreases with each trophic level (Krebs 1994). This seems to be the case in the ecosystem at Gull Island with Great Black-backed Gulls near the top of the trophic pyramid with a relatively small population size.

The Great Black-backed Gull population has remained somewhat stable on Gull Island since the late 1970's (Robertson et al. 2001) indicating that their population is not solely dependent upon human sources of food probably because they occupy more than one trophic level allowing them to feed on a larger variety of food than Herring Gulls. According to this reasoning, it would seem that Herring Gulls and kittiwakes would be more affected by changes in food availability than Great Black-backed Gulls, which is supported by recent studies (Burger 1988, Reghr 1994, Massaro et al. 2000, Robertson et al. 2001). If the population of Great Black-backed Gulls does not decrease with the availability of human made food then we may see a higher proportion of Great Black-backed Gulls compared to other gulls at breeding and winter grounds (including garbage dumps). This does not mean that landfill garbage dumps will be overrun by Great Black-backed Gulls but it suggests that the overall number of gulls will be less but proportion of Great Black-backed Gulls will be higher than they were when there was ample food supplied by fishery offal and lax garbage disposal practises. If garbage disposal methods are improved further and the fishery does not make an immediate recovery then recent trends in gull populations predict that Herring Gull populations would continue to decline until the natural food sources could support them.

Decreasing Herring Gull populations and stable Great Black-backed Gull populations does mean that the larid population will have proportionally more Great Black-backed Gulls but that does not mean higher levels of seabird predation. In fact, if there are fewer Herring Gulls on Gull Island then there will be more opportunity for remaining gulls to kleptoparasitise puffins instead of predating adult seabirds, as seen at the Gannet Islands.

In conclusion, if human made food sources were drastically reduced, then gulls would be forced to live in a natural system, away from humans, thus reducing problems associated with human-gull interactions. Within the seabird community there may be fewer gulls at breeding colonies, which may also mean that predation of seabirds would also be reduced once the system has returned to a 'natural' state. As the system returns to its 'natural' state, breeding seabirds that are suffering from reduced human refuse, and natural changes in the ecosystem may show highest population declines as seen in Herring Gull and Black-legged Kittiwake populations respectively.

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