Diet and breeding success of Great skuas (catharacta skua) on bjørnøya, norway

Diett og hekkesuksess for storjo (catharacta skua) på bjørnøya, norge

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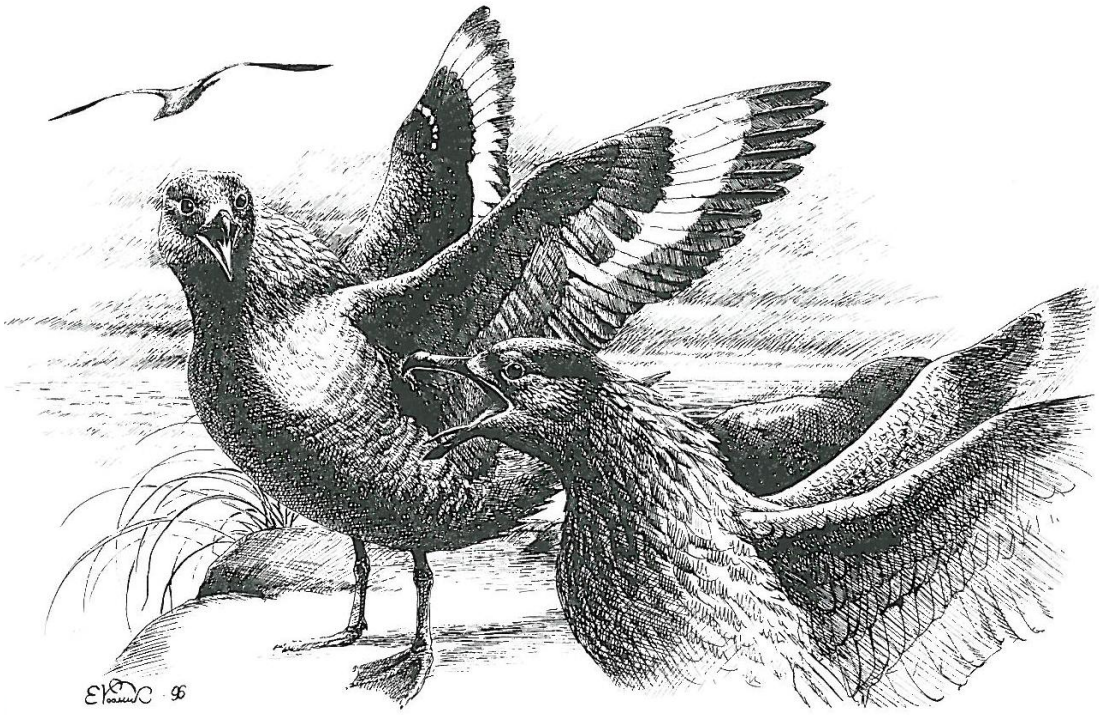

Norwegian University of Life Sciences (UMB)

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Arnstein Engemyr Knutsen

Preface

I thank Hallvard Strøm and Geir Wing Gabrielsen at The Norwegian Polar Institute (NP) for having me writing a masterthesis at their institute. I thank my supervisor at the Department of Ecology and Natural Resource Management (INA), Norwegian University of Life Sciences (UMB), Geir A. Sonerud for support especially during the statistical analysis and the results. I also want to dedicate a thanks to the field group consisting of Knut Olsen, Veronica Nygård, Tore Nordstad and Lena Ringstad Olsen who helped me collect all the data used in this thesis during the field seasons of 2008 and 2009. I also want to thank my father, Arnt Olaf Knutsen for correction reading, Robert Barrett for help regarding issues with otoliths, Anders Skoglund at NP who made the illustrative map over my study area and my fellow student Gry Gasbjerg helping me with laboratory work and support.

This study provides baseline data for future studies on Great skua ecology at a high-latitude colony in an internationally important seabird conservation site. The study was conducted within the framework of the SEAPOP (SEAbird POPulations) programme (Anker-Nilssen et al. 2005), a long-term monitoring and mapping programme for Norwegian seabirds, and the project "Factors of importance for bioaccumulation and effects of new- and old persistent organic pollutants (POPs) in a seabird predator: the Great skua (*Catharacta skua*), a British, Icelandic and Norwegian project financed by the Norwegian Research Council (NFR). The programme makes an important base for Norwegian and international management and research related to the condition of seabirds and their role as bioindicators of environmental changes (Lorentsen & Dalsgaard 2009).

The drawing on previous page is made by Eugeny Koblik, Zoological Museum, Moscow.

Abstract

The last 40 years there has been a marked increase in the number of Great skuas (*Catharacta skua*) in Norwegian territory, and it seems as if the core distribution area is shifting, from Iceland and Shetland, northwards to the Barents Sea region. As a generalist and top predator in the marine ecosystem the Great skua has a broad range of available prey, and their impact on prey species, particularly other seabirds, is poorly understood. The diet of Great skuas during winter is largely unknown, because they live mostly out in the open ocean. As they come to shore to breed, it is possible to obtain an estimate of the diet during the breeding season through analysis of regurgitated pellets. The pellets were collected from a total of 25 Great skua nests in 2008 and 2009. Each nest was visited every fifth day from hatching, and chicks were weighed and measured at each visit. Almost all pellets contained remains from birds while 38 % contained remains from fish. On average, 62 ± 3.7 % of pellets from a pair contained only seabird remains. In 2008, dietary specialization toward seabirds was found in 33 % of the pairs, compared to 62 % in 2009. The overall diet composition did not differ between years, but the proportion of fish in pellets varied between pairs within years. As the breeding season progressed the probability of fish being found in pellets decreased. Body mass, tarsus length and wing length of chicks were negatively correlated with the proportion of pellets with only fish. Hatching dates varied between years, being delayed in 2009. Breeding success was higher in 2008 than in 2009. There was no relationship between the number of chick survival to age 15 days (D (15) = fledging success) and differences in specialization, but in 2009 there was a positive relationship between the survival of chicks at the end of the field work and a specialist diet. This indicates that dietary specialization among Great skua pairs on Bjørnøya can have positive effects on fledging success, and hence also breeding success.

Sammendrag

Antall Storjo (*Catharacta skua*) i norsk territorium har økt de siste 40 årene, og det kan se ut som hovedtyngden av utbredelsesområdet er i ferd med å forflytte seg fra Island og Shetland nordover mot Barentshav-regionen. Som generalist og topp predator i det marine økosystem utnytter Storjoen et vidt spekter av tilgjengelige byttedyr, men Storjoens påvirkning på byttedyr, spesielt på andre sjøfugl, er lite kjent. Dietten til Storjoen vinterstid er også lite kjent, da de lever det meste av tiden på åpent hav. I hekkeperioden er det mulig å få en indikasjon på diett ved analyse av gulpeboller. De innsamlede gulpebollene kom fra 25 Storjo reir fra 2008 og 2009. Hvert reir ble besøkt hver femte dag fra klekking og kyllinger ble veid og målt ved hvert besøk. De aller fleste gulpebollene inneholdt rester av fugl, mens 38 % inneholdt rester av fisk. I gjennomsnitt inneholdt 62 ± 3.7 % av gulpebollene rester bare fra sjøfugl. I 2008 var 33 % av parene spesialister på predasjon på andre sjøfugl mot 62 % i 2009. Samlet diett varierte ikke mellom år, men det var forskjell i mengden fisk i gulpebollene mellom par innen år. Det ble funnet en stadig mindre andel fisk i gulpebollene utover i hekkesesongen 2009. Vekt, tarslengde og vingelengde til kyllinger var negativt korrelert med andel gulpeboller med bare fisk. Klekkedato i 2009 var markant forskjellig og forsinket sammenliknet med 2008. Hekkesuksessen var høyere i 2008 enn i 2009. Det var ingen sammenheng mellom antall overlevende kyllinger ved 15 dagers alder (D (15) = utflygningssuksess) og forskjeller i diettspesialisering, men i 2009 var det en positiv sammenheng mellom overlevelsen av kyllinger ved endt feltarbeid og diettspesialisering. Dette gir en indikasjon på at diettspesialisering blant Storjo på Bjørnøya kan ha positiv påvirkning på utflygnings suksess, og derav også på hekkesuksess.

Introduction

Natural selection favours individuals with the highest fitness, and maximizing foraging efficiency is important to reproductive success (Krebs & Davies 1978). Seabirds are long-lived, and trade-offs between cost of current reproduction versus maintaining reproductive value are of great importance (Shultz et al. 2009). It is essential for high-latitudinal seabirds to time reproduction with seasonal peaks in food availability (Shultz et al. 2009). All seabirds are central place foragers during the breeding season, and low prey availability close to breeding sites would force birds to seek more distant food resources (Weckler 2009). These are, largely driven by ocean conditions (Montevecchi 2007), and may be unevenly distributed both temporally and spatially at sea (Suryan et al. 2000).

Seabirds are excellent bioindicators of changes in the marine environment as they are essential components of marine ecosystems (Furness & Monaghan 1987, Furness & Camphuysen 1997, Piatt et al. 2007). Fluctuations in prey availability are often reflected in breeding population size, reproductive success, adult survival, and diet (Montevecchi 1993, Barrett et al. 2007). In particular marine top predators have been suggested as indicators of ecosystem states (Croxall & Prince 1979, Harris & Wanless 1990, Montevecchi 1993, Furness & Camphuysen 1997, Wanless et al. 2007), partly because they are conspicuous and breed in easily accessible colonies easy to monitor. The Great skua (*Catharacta skua*) is a marine top predator, and makes an excellent species to study when examining the state of the marine environment.

The Great skua was a rare bird in the North Atlantic before the 1800s, and has been stated as a newly arrived breeding species to the northern hemisphere (Furness 1987). Since the end of the 1960's there has been an increase of Great skua spreading from Shetland (Vader 1980, Furness 1987, Bakken et al. 2003) and northwards along the coast of Norway, Jan Mayen, the archipelago of Svalbard and the Kola Peninsula (Russia). The first breeding record of Great Skua on Bjørnøya was observed in 1970 (Vader 1980, Furness 1987), and the population has been increasing (Strøm 2006). Furness & Ratcliffe (2004) suggest that the core distribution of the Great skua seems to be shifting from the British Isles and Iceland to

the Barents Sea. In 2006 the breeding population on Bjørnøya was estimated to about 350 breeding pairs (Strøm 2007).

Great skuas are dietary generalists, exploiting a wide range of prey including kleptoparasiting or scavenging on discarded fish around fishing boats. Their diet consists predominantly of small shoaling fish, eggs, chicks and or adults birds, and invertebrates (Bayes et al. 1964, Phillips et al. 1999a, Votier et al. 2004a and b). However, dietary specialization of Great skua pairs and colonies has been recorded (Bayes et al. 1964, Phillips et al. 1997, Votier et al. 2004a). Dietary variation between individuals has been observed in several bird species (Watanuki 1992), and in gulls individuals showing dietary specialization had a higher breeding success than individual that were food generalists (Pierotti & Annett 1990, Watanuki 1992, Spear 1993). Colonies housing individuals that have specialized on preying upon seabirds are often small, found at high latitudes and has a high growth rate, while individuals in larger colonies feed predominantly on fish with diminishing growth rates (Furness & Ratcliffe 2004). Green et al. (2008) showed that a diet dominated of fish was positively correlated with chick growth, while Votier et al. (2004a) emphasize that the high caloric content of bird meat makes it preferable. Great skuas that specialize in predation on birds breed earlier, lay a larger first egg in the clutch and have heavier chicks (Votier et al. 2004a). However there is uncertainty to whether dietary specialization has any effect on breeding success.

Due to the Great skua's role as a top predator and its recent arrival to the Norwegian seabird community, it is important to obtain knowledge of its diet and reproductive performance (Votier et al. 2004b). The importance of this is underlined by the fact that its core distribution seem to move northwards, and the possible negative effect predation by Great skuas might impose on other seabirds. A negative effect on the breeding success of Black-legged Kittiwakes (*Rissa tridactyla*) due to predation by Great skuas has been suggested (Oro & Furness 2002, Votier et al. 2008), but this predator-prey relation is poorly known (Votier et al. 2004b).

This study attempts to reveal the diet composition of the Great skua in a high-latitude colony at Bjørnøya. Due to a poor breeding season in 2009, data from 2008 was included in the

study. Knowledge of the diet composition was obtained by analyzing regurgitated pellets from the breeding season in 2008 and 2009, with a special interest in highlighting any dietary specialization between individuals. Variation in diet was further studied in relating to breeding success.

Material and methods

Study area

Bjørnøya is an island covering 176 km^2 situated in the Barents Sea at 74.30° N 19.01° E. The island is pretty flat on the northern half and more mountainous on the southern part. Misery Mountain is the highest peak, reaching 536 m above sea level. The island is protected as a nature reserve (Lovdata 2010).

Fig. 1. Location of Bjørnøya in the Barents Sea and study area (marked in red on enlarged area).

About 600 small lakes are scattered over mostly the northern part of the island. Bjørnøya's shoreline consists mostly of steep cliffs, which provides excellent breeding grounds for seabirds ((1) NPweb 2010), and Bjørnøya is home to some of the largest seabird colonies in the Barents Sea region ((2) NPweb 2010). Despite its high latitudinal location, the island has a mild climate with mean temperature for August (the warmest month) of 4.4°C, and - 7.4°C for January (the coldest month) ((1) NPweb 2010). The most important breeding area for Great skuas on Bjørnøya is located in the north-western part (Fig. 1). The study area is in the northern part of the important breeding area in the northwestern part of Bjørnøya, surrounding the small and shallow lakes of Flatmyrvatna. This is also the first area on Bjørnøya colonized by the Great Skuas in the 1970s (Vader 1980).

Study species

The Great Skua is the largest and heaviest of the northern skuas, weighing up to 1650 grams and a wingspan of 140 cm (Svensson et al. 2004), almost the size of a Herring Gull (*Larus arentatus*) (Olsen & Larsson, 1997, Krasnov & Lorentsen 2000). The counterparts of the species belonging to the genus *Catharacta* are confined to the southern hemisphere. However, the Great skua is the only species of this genus found on the northern hemisphere and has been recorded breeding on Iceland, The Faeroes and Shetland islands, along the western coast of Norway (Runde, Røst, Hjelmsøya and Loppa), Spitsbergen, Bjørnøya to Novaya Zemlya (Krasnov & Lorentsen 2000). The Great skuas stay offshore outside the breeding period (Isaksen & Bakken 1995), and the birds that breed on Bjørnøya are migrating to the coast of Newfoundland or stay out at sea west of Ireland (E. Magnusdottir pers. comm. 2010). The Great skua is an opportunistic feeder (Bayes et al. 1964, Olsen & Larsson, 1997; Phillips et al. 1999b), and Atlantic puffins (*Fratercula arctica*) and Black-legged Kittiwakes (*Rissa tridactyla*) are heavily chased, and the former often killed.

Depending on the snow melting at Bjørnøya (Isaksen & Bakken 1995), the one or two eggs (Andersson 1975) are laid in late June or early July (Isaksen & Bakken 1995) in a depression on the ground. The incubation period is 28-30 days (Vader 1980, Furness 1987) and the

semi-altricial chicks stay in the area around the nest and are fed until fledged, usually 6-7 weeks after hatching (Vader 1980, Isaksen & Bakken 1995).

The British population of Great Skuas has been increasing during the 20th century, probably due to more discards from fisheries (Furness & Hislop 1981, Furness 1987) and to the increase in Sand-eel (*Ammodytes marinus*) stocks, as a consequence of the commercial fisheries on Mackerel (*Scomber scombrus*) and Herring (*Clupea harengus*), which prey upon the Sandeel (*Ammodytes marinus*) (Furness & Hislop 1981, Furness 1987, Olsen & Larsson 1997). The Great skua became protected around 1900 (Furness 1987, Krasnov & Lorentsen 2000, Furness & Ratcliffe 2004), and included in the IUCN red list of threatened species in 2007 (Jones et al. 2008). Ringing recoveries (Vader 1980) and genetic studies (R. Furness pers. comm. 2010) suggest that most of the Norwegian recruits originated from colonies on the Shetland Islands (Vader 1980, Furness 1987, Furness & Ratcliffe 2004).

Field work

The field lasted from 6 June until 26 July in 2008, and from 13 June until 10 August in 2009. In order to locate nests within the study area two persons walked abreast. Each nest found was marked with a small flag (grey duck tape on a 8" nail) with an identification number. Nest site coordinates was recorded on a GPS for later relocation. Daily walking routes to nests were made and egg parameters were recorded (weight, length and width) to determine the date of hatching, which is 28- 30 days after laying date using the method described by Furness & Furness (1981). To decrease stress on breeding birds, time spend in study area was restricted to visits to nests with eggs close to hatching, or to nests with chicks that were close in age to a follow-up day (D (x)= x days after hatching of oldest chick), which was every fifth day from the hatching date of oldest chick until death of all chicks in a nest or to the end of field work.

Collection of pellets

Assessment of the Great skua's diet was conducted by analyzing the indigestible material in regurgitated pellets following Votier et al. (2004a). In 2008 pellets were collected around the nest sites at two dates (7 and 19 July). The pellets collected for each date and nest were put into one large zip-lock bag, marked with identification numbers, and stored in a freezer at -18°C for later dietary analysis. In 2009 pellets were collected around nest site at D (0), and every fifth day until the end of the field work. The bags containing pellets was marked with date, nest- ID number and the number of pellets in each bag. Keeping pellets for each nest separate was done to be able to analyse for specialization. At last the pellets were stored in a freezer at - 18°C, to preservation until later dietary analysis.

Growth of chicks

Each chick was marked with a small tag in its web to avoid mixing with other chicks when it started moving around. The chicks were put in a cotton bag and weighed with a Pesola handheld spring balance scale. The length of beak, tarsus, and total head (from back of head to tip of beak) were measured with a slide gauge, while flattened wings were measured, with a ruler. These measurements were taken every fifth day from D (0) until death or the end of field season. Hatching success was recorded by visiting the marked nests on a daily basis before hatching date until the clutch had hatched.

Laboratory work

Approximately 415 pellets were collected from 38 nests in 2008, and 1201 pellets were collected from 24 nests in 2009. The analysis was limited to pellets from 12 nests from 2008 and 13 nests from 2009, picked out by a random draw. To obtain a representative collection each pellet collected at every date was given a certain number that was placed in a bowl, and a person naive to the study drew numbers. A minimum of four pellets from each of the

12 nests and a total of 128 pellets were analyzed from 2008. From 2009, four pellets from each collection date were analyzed, which amounted to 222 pellets from 13 nests.

When analyzing a pellet I used a thin probe, two tweezers and a Petri-container. The pellet was pulled apart and bony or other hard parts were sorted out. The content was organized into three main prey categories; birds, fish and others. Bird remains were identified to the lowest possible taxon bases on the morphology of legs, feet, wings and beaks, and from feathers (colour, size, aroma) (Phillips et al. 1997, Votier et al. 2003). Fish otoliths were identified to family if possible, based on Breiby (1985), and comparable reference material from the University of Tromsø otolith collection. There have been no attempts to quantify the number of prey in pellets.

In order to state any dietary specialization of each pair of Great Skuas, three dietary categories were made (Votier et al. 2003); specializing on birds (≥ 70 % of pellets contained bird remains), specializing on fish (≥ 70 % of pellets contained fish remains) or generalists (< 70 % of pellets contained either bird or fish remains).

Breeding success

Due to time limitations it was not possible to follow the chicks to fledging. For comparable purposes our measurement of fledging success is defined as “chick survival to 15 days of age” (D (15)), even though there were losses after this age. In order to measure breeding success, hatching success and fledging success were measured.

Statistics

The raw data (Appendix 4 and 5) from the analysis were recorded in Microsoft Office Access 2003 (database) then exported to Microsoft Office Excel 2003 (spreadsheet) and further to JMP 4.0 (SAS, 2000) for statistical analysis.

The size of the breeding population of Great skuas differed between the two years, thus affecting the number of nests, eggs and chicks monitored. The number of breeding pairs in 2008 was 77 compared to 40 in 2009.

Figure 2 and all tables were produced in Microsoft Excel (2003). Figure 3 and figure 4a, b and c were produced together with all statistical analysis in JPM 4.0 (SAS, 2000). Means are reported with standard error (SE) and level of significance is taken to mean $p < 0.05$.

Results

Diet

The ingestible material in pellets was dominated by bird and fish remains, with a very small proportion of other prey types. Remains from birds were found in 97.7 % of the pellets, and remains from fish in 38.3 %. Remains from other types of prey were found in 4.3 % of the pellets (n= 350).

In 2008 four pairs out of 12 showed dietary specialization on seabirds (≥ 70 % pellets contained only seabird remains) (Fig. 2. a), compared to eight pairs out of 13 in 2009 (Fig. 2. b). On average, 62 ± 3.7 % of the pellets from a pair contained only seabird remains (n= 25, Fig. 2). There was no difference between years in regards to percentage of pellets from a pair containing only seabird remains (one-way Wilcoxon test, n= 25, S= 136.5, Z= - 1.04, p= 0.30).

Of the 128 pellets from 2008, 123 had remains of birds, but 101 of these did not have identifiable bird remains. Of the 22 pellets that had, 15 contained remains from Northern Fulmars (hereafter Fulmars) or Black-legged kittiwakes (hereafter Kittiwakes), four contained remains from Alcidae and three from Arctic terns (*Sterna paradisaea*). Twenty otoliths were detected in pellets from 2008, nine from Gadiformes while the remaining 11 had an unknown origin. Three pellets contained remains from crustaceans, and remains from squid-beaks were found in seven pellets (Appendix 4).

Out of 222 pellets from 2009, 215 had remains of birds, but 117 of these did not have identifiable bird remains. Of the 98 pellets that had identified bird remains, 97 contained remains from either Fulmars or Kittiwakes. The remaining identifiable bird remains belonged to Alcidae. Out of the 13 otoliths found, 12 belonged to Gadiformes, and one was from a Capelin (*Mallotus villosus*). One pellet contained krill (*Thysanessa* ssp.). Remains from squid beaks were found in two pellets, while a wasp (Hymenoptera) was found in one pellet (Appendix 5).

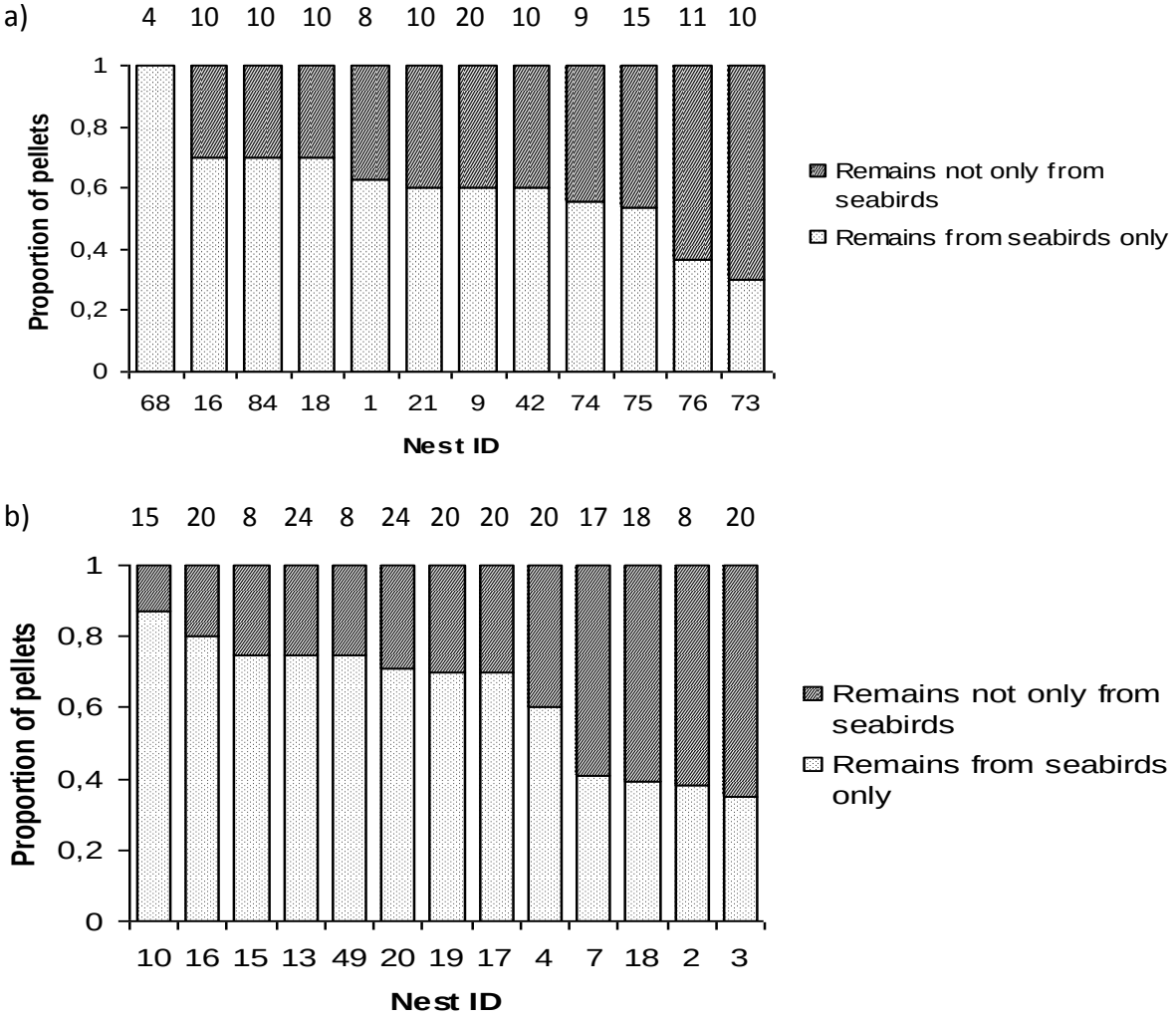


Fig. 2. Proportion of pellets from each nest containing only seabird remains in 2008 (a) and 2009 (b). Nests are ranked in descending order from left to right according to proportion of pellets with only seabird remains. Number above each bar denotes sample size (number of pellets), and number under each bar denotes nest ID.

To determine possible differences in the content of pellets between years or within a year nominal logistic regression models were made. Explanatory variables included year and nest ID (random effect) and the response variable was whether a pellet contained remains from a prey type or not. The probability of finding remains from fish in a pellet varied significantly between pairs (df= 22, χ^2= 42.66, p= 0.0052), but not between years (df= 1, χ^2= 0.38, p= 0.54). The probability of finding remains from birds in a pellet did not vary between pairs (df= 22, χ^2= 24.23, p= 0.34) or between years (df= 1, χ^2= 2.68, p= 0.1).

The probability that a pellet contained remains from fish decreased as the season progressed (Nominal logistic regression, p= 0.0016) (Fig. 3). There were a significant effect of pairs (random effect), but not of date (Table 1), which means that each pair did not change their diet as the season progressed, but rather than pairs that started to breed later had a smaller proportion of fish in their diet. However, although it was a negative relationship between proportion of fish in pellets and hatching date in 2009, it was not significant (linear regression, n= 13, R^2= 0.02, p= 0.63).

Table 1. Nominal logistic regression model of variable significantly affecting the probability that fish remains were detected in pellets. Whole model: n = 222, df = 13, x^2 = 33.15, p = 0.0016. Data from 2009.

	Whole model			Parameter estimates			
Variable	df	x2	p	Estimate	SE	x2	p
Intercept				-0.48	1.18	0.16	0.69
Nest ID (random effect)	12	29.07	0.004				
Days after 1st of July	1	0.53	0.47	-0.017	0.023	0.53	0.47

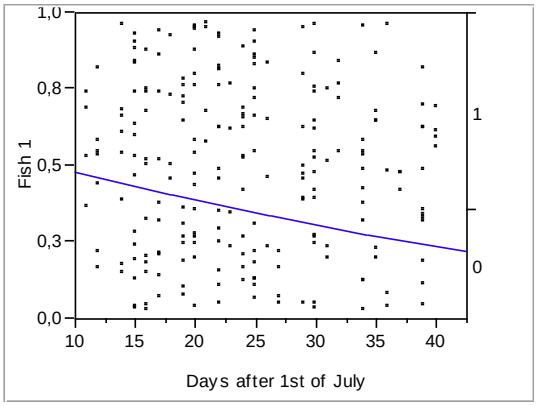


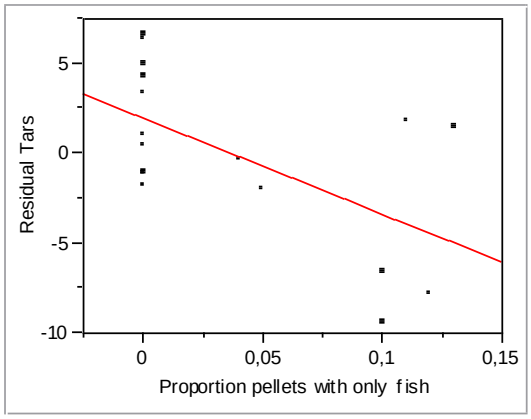
Fig. 3. The probability of finding fish remains in a pellet as a function of date in breeding season (days after 1 July). The curve describes the logistic regression model. Whole model: N= 222, df= 13, x^2= 33.15, p= 0.0016. Data from 2009.

Growth of chicks

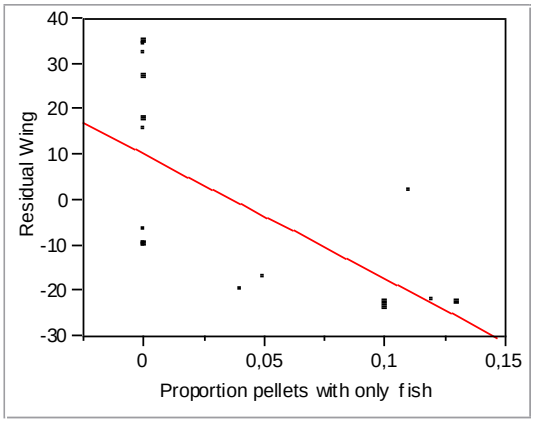
Insufficient biometrical data on chicks in 2008 restricted the analyses concerning biometrical measurements to data from 2009. Because chicks from different nests were counted, weighed and measured at different ages, original data on tarsus length, wing length and body mass could not be used in the analysis. Instead, these data were regressed on chick age for each year separately, and the residuals were used in the analysis. Only data from the last visit at each nest were used. Variables that significantly affected these residuals were found using stepwise regression, with backward and forward elimination. The following variables were tested: year (random effect), proportion of pellets with remains only from birds, proportion of pellets with remains only from fish, proportion of pellets with remains from fish and birds, proportion of pellets with remains from birds, and proportion of pellets with remains from fish. Variables were included in the model until ΔAIC decreased by < 2.0. The only variable that was included in the models for residual tarsus, residual wing and residual weight, was the proportion of pellets with only fish.A significant negative relationship was found between residual tarsus length and the proportion of pellets with only fish (linear regression, n= 17, R^2= 0.35, p= 0.012) (Fig. 4. a), and between residual wing length and the proportion of pellets with only fish (n= 17, R^2= 0.41, p= 0.0056) (Fig. 4. b). In addition, there was a strong trend for a relationship between residual body mass and the proportion of pellets with only fish (n= 25, R^2= 0.15, p= 0.052) (Fig. 4. c).Thus, when chicks had a larger

proportion of fish remains recorded in pellets, they had shorter tarsus, shorter wing and were lower in body mass.

a)



b)



c)

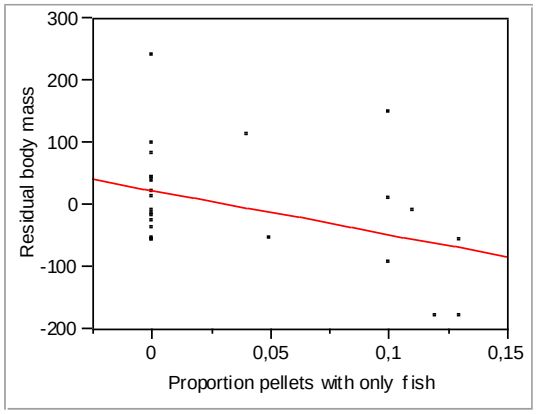


Fig. 3. Relationship between residual tarsus length (a), residual wing length (b) and residual body mass (c) and the proportion of pellets with only fish. Data from 2008 and 2009.

Breeding success

The hatching period started and ended at later dates in 2009 than in 2008. Hatching dates differed significantly between years (one-way Wilcoxon test, n= 25, S= 89.5, Z= - 3.6, p= 0.0003), and compared to previous breeding seasons 2005 - 2007 (Appendix 2), the 2009 season was delayed. This seems to be reflected in lower hatching success, chicks per nest and fledging success (D (15)), thus effecting overall breeding success in 2009. In general the Great skuas had a better breeding success in 2008 (Table 2), with significantly larger brood

size after hatching (one-way Wilcoxon test, n= 23, S= 203.5, Z= 3.01, p= 0.0026) and survival of chicks to the age of 15 days (D (15)) (fledging success) than in 2009 (one-way Wilcoxon test, n= 23, S= 174, Z= 2.76, p= 0.0057).

Table 2. Hatching success and fledging success in 2008 and 2009.

Year	2008	SE	2009	SE
Chicks hatched per nest	1.92	± 0.08	1.31	± 0.13
Hatching success (%)	100		89	
Fledging success (%)	61		41	

Mean number of days survived by Great skua chicks for in 2008 were 18 ± 1.5 days (n= 12), and 14 ± 2.2 days (n= 13) in 2009. In 2008, ten nests had surviving chicks until D (15); four nests had two chicks and six nests had one chick at the last visit. Thus, 14 out of 23 chicks (61 %) survived D (15) (Table 1 and Appendix 1). Three chicks with a bird specialist diet survived until D (15), compared to seven chicks with a generalist diet. In 2009 seven nests had surviving chicks until D (15), and hence only seven chicks out of 17 (41 %) survived until D (15). Six chicks with a bird specialist diet survived until D (15), while only one chick with a generalist diet survived. There was no relationship between the number of chick survival to D (15) and differences in specialization, when both years were included (one-way Wicoxon test, n= 23, S= 132, Z= 0.033, p= 1.0), or within 2008 (n= 12, S= 23, Z= - 0.105, p= 0.835) or within 2009 (n= 12, S= 23.5, Z= - 1.59, p= 0.093). However, in 2009 there was a significant difference between the survival of chicks at the end of the field work in relation to diet (one-way Wicoxon test, n= 13, S= 47.5, Z= 1.88, p= 0.049). There was no similar relationship in 2008 (one-way Wicoxon test, n= 12, S= 26, Z= 0.098, p= 1.0).

Discussion

Pellet analysis

This study is based on analysis of pellets, a common method in dietary studies which reflects the dietary composition with reasonable accuracy (Phillips et al. 1999a, Barrett et al. 2007). This was demonstrated in a study on Slaty-backed gulls (*Larus schistisagus*), when a high proportion of seabirds in pellets or food remains were detected in food loads delivered to chicks (Phillips et al. 1999a). Finding pellets is often restricted to breeding colonies or roosts (Barrett et al. 2007), and Votier et al. (2001) suggest that many pellets go undetected. To minimize short-term fluctuations in diet that may obscure longer term-patterns, sampling must take place over an extended period (Bearhop et al. 2001, Barrett et al. 2007). In this study the sampling period is restricted to the field season which is two months during breeding, thus reflecting the diet only during breeding. Analyzing pellets tends to overestimate the importance of prey with resilient and hard body parts (Furness & Hislop 1981, Phillips et al. 1999a, Bearhop et al. 2001), and pellets clearly suggest a bias towards birds due to the strong resilience of bird feathers (Votier et al. 2001). Small otoliths can be difficult to notice in a pellet, and some end up in excrements rather than in pellets, and thereby go undetected (Barrett et al. 2007). However, claim that even small otoliths from Sandeels, a similar sized fish as Capelin, are regurgitated in a pellet. Only one otolith from Capelin was detected when analyzing pellets. Bird remains dominated the content in almost every pellet, indicating that birds were the most abundant and easiest available prey on Bjørnøya in both seasons.

Diet and Breeding success

There were no differences in diet between years, however there were variations in diet regarding the proportion of fish remains detected in pellets between pairs. Great skuas are known as dietary generalists, however specialization between pairs was found on Bjørnøya. Within every population there is a possibility for individuals to change their utilization of available prey, which might increase their reproductive success (Votier et al. 2004a). Dietary

variation between pairs is not uncommon (Watanuki 1992) and it is expected that the preferable prey will give the greatest energy gain per unit time foraging (Krebs & Davies 1978, Furness & Hislop 1981). Several studies (Bayes et al. 1964, Hamer et al. 1991, Phillips et al. 1997, Furness and Ratcliffe 2004, Votier et al. 2004a) have documented dietary specialization between and within Great skua colonies, which may be a response to variation in prey availability or caused by individual variation in foraging behaviour (Votier et al. 2008). In general, Great skua colonies with individuals specializing on birds are often small, located at higher latitudes and have rapid population increase, while individuals in larger colonies feed predominantly on fish and population increase seems to stagnate (Furness & Ratcliffe 2004), indicating a higher cost of foraging in larger colonies (Votier et al. 2007). In the latter there is an increased predation upon seabirds when availability of fish is reduced (Furness & Ratcliffe 2004). Hamer et al. (1991) and Green et al. (2008) found a positive relationship between rapid chick growth and a diet dominated by fish, while Votier et al. (2004a) emphasize that the higher caloric content of bird meat than fish meat makes predation on birds preferable. This is dependent on how much energy is used by the predator in order to catch and handle prey (Krebs & Davies 1978). Further, in a comparative study of breeding performance, Votier et al. (2004a) found that Great skuas specializing in bird predation breed earlier, lay a larger first egg, produce heavier chicks and spend less time foraging than those feeding predominantly on fish. These parameters all indicate that the breeding pairs are in excellent condition or that environmental conditions are favourable or both (Coulson 1968, Perrins 1970, Gill et al. 2002). However, Votier et al. (2007) did not find any phenotypical superiority in birds breeding in small colonies preying upon birds. Dietary studies on gulls found higher breeding success among specialized birds (Pierotti & Annett 1990, Watanuki 1992, Spear 1993).

Due to insufficient knowledge regarding prey availability around Bjørnøya, it is unclear whether a high proportion of birds in diet was a response to food availability. As Great skuas are generalists it is likely and one might assume that seabirds are the easiest prey available at Bjørnøya. In pellets from late June to early August, bird remains were present at all times while the proportion of fish remains declined as the breeding season progressed. The variations in the proportion of fish between pairs can not be explained by date in the breeding season. Thus each pair does not seem to change its diet during the breeding

season. However, pairs that started to breed later did not have a smaller proportion of fish in their diet. Seasonal variation in diet was documented in a colony on Shetland where eggs, birds and barnacles (*Lepas anatifere*) were most important in the start and end of the breeding season, which suggests poor food availability during these periods (Furness & Hislop 1981), because a large proportion of barnacles in the diet indicate poor feeding conditions (Furness 1987). Barnacles are present in the Barents Sea (L. B. Mortensen pers. comm. 2010), but were not observed in pellets at Bjørnøya, which may indicate sufficient availability of other prey types. Adult seabirds are available prey throughout the breeding season (Furness & Hislop 1981), and a generalist's ability to switch between a wide range of available prey may make them less vulnerable to changes in the availability of marine resources (Votier et al. 2007). One interpretation of the diminishing proportion of fish remains in pellets as the season progressed could be, as the chicks grow they require more energy, and the adult "chooses" to prey upon birds due to their higher caloric content (Votier et al. 2004a). In addition the availability of easy available prey like chicks, especially of Kittiwakes, increases throughout July and August. This also allows Great skuas to catch fewer but high quality prey, thus spend less time foraging and more time guarding their chicks. Also, the availability of fish may simply decrease or fluctuate due to fluctuations in oceanic conditions (temperature and current), and shoaling fish (e.g. Capelin) migrate northwards following the productive polar front as the season progresses (Gjøseter 2009). A dietary study on Kittiwakes at Kongsfjorden, Svalbard, found a variation in the proportion of Capelin in diet between the incubation and chick rearing period (Gasbjerg 2010). Thus, it is reasonable to assume that the occurrence of bird remains increase in pellets from Great skuas as a response to the lower availability of fish and the simultaneously increase in chicks available to prey upon.

Most of the otoliths found in pellets were from Gadiformes. However, most of the species within this genus that are present around Bjørnøya are mid-water or bottom dwelling species (Pethon et al. 1989) and are therefore only available to Great skuas through discards from commercial fishing vessels (Furness & Hislop 1981). Scavenging on discards from commercial fishing activities makes up a substantial proportion of the diet of Great skua around the British Isles (Furness 1987, Phillips et al. 1999a, Votier et al. 2004a and b), but it is unclear how important this source of food is to the Great skua population on Bjørnøya.

In 2009 breeding was delayed, affecting both hatching and fledging dates. The overall breeding success was lower in 2009 than in 2008, but this could not bee explained by dietary variation between years. There was no relationship between the number of chick survival to D (15) (fledging success) and differences in specialization in any year. However, in 2009 there was a marked difference between survival of chicks at the end of field work and diet. Chicks fed by adults that were dietary specialists had higher survival than chicks fed by adult generalists.

Reproduction is costly, and a trade-off between allocating resources to chick rearing and maintenance of body condition (Hamer et al. 1991). The Great Skua is a long-lived iteroparous species, and should not increase breeding effort in one season beyond their ability to buffer themselves against reduced survival or lower future breeding success (Hamer et al. 1991). Behaviour and diet respond to reduced food supply at a higher level of resource than breeding success, while adult survival is buffered against effects of food shortage (Furness & Camphuysen 1997). As a response to food shortage, some seabird in the Arctic, e.g. Arctic terns and in Jaegers, do not breed. However, on Shetland Great skuas made breeding attempts even in years with food shortage (Oro & Furness 2002). The 2009 breeding season was delayed, and since breeding success declines with laying dates, also seen among large gulls (Perrins 1970), it is most beneficial to increase the investments made when breeding starts early (Furness 1987). Food shortage could explain the few and poor breeding attempts in 2009, but there was no conclusive evidence making this explanation a matter of course. Adult survival was also high between the two years (Olsen 2009), suggesting no difference in numbers of breeding pairs between years.

Hatching dates differed between years, starting and ending later in 2009. Older experienced birds mating for successive years breed earlier than younger birds, and as the breeding season progresses the ability to replace lost offspring decreases (Perrins 1970, Hamer & Furness 1993). Young birds are usually less successful breeders, and the lower success of broods started later in a season could be due to their being laid by young adults (Perrins 1970). The latter observation could cause the low breeding success in 2009, but based on ringing recoveries most of the breeding birds were experienced breeders (Olsen 2009).

Environmental and genetic factors influence the size and growth of Great skua chicks, and chicks that hatch from large eggs are bigger, grow faster and survive better than chicks from smaller eggs and late-hatched chicks (Perrins 1970, Furness 1983, Catry et al. 1998). Eggs of Great skuas on Bjørnøya are the largest compared with other study sites in Iceland and Shetland (E. Leat pers. comm. 2010), suggesting fast growth of chicks and good prey availability prior to egg laying, but the eggs in 2009 were smaller than usual (Olsen 2009). However, the chick growth curves were similar for both years regardless of the late hatching dates in 2009 (Olsen 2009). Hatching success is not affected by changes in food supply (Hamer et al. 1991) but varies between 60- 73 % for all skua species depending on the frequency of severe weather such as snow and storms, and predation by the Arctic fox and neighbouring skuas (Olsen & Larsson 1997). Predation by the Arctic fox seemed to increase on Bjørnøya in 2009, and this coincides with the overall higher numbers of encounters with Arctic foxes during the field work (Olsen 2009). Nest predation is the most important cause of breeding failure for many birds, including the Great skua (Furness 1984, Hamer & Furness 1993), and increases with nest density and when food availability becomes low (Furness 1984). Hatching success was higher on Bjørnøya in both years compared to Hamer et al. (1991).

Great skua pairs showed a normal aggressive behaviour in 2008, while many pairs showed little or no aggression toward us during field work in 2009 (Olsen 2009). This further supports the low breeding success in 2009, as there is a close negative relation between time spent away from nest and brood size (Furness & Hislop 1981). The aggressive display toward intruders is well known among Skua species and is positively related to hatching success which increases with experienced birds and better body condition of the breeding birds (Hamer & Furness 1993). Death rate of chicks decreases after ten days of age in gulls (Perrins 1970) and Great skuas (Green et al. 2009), and in Kittiwakes there is a positive correlation between fledging success and chick survival between day 10 and 15 (B. Moe pers. comm. 2010). Normally the Great Skua has a fledging success of 80-95% (Furness 1987), depending on predation. The field work ended before the chicks fledged in both years, hence the measurement of fledging success was taken as chick survival to age 15 days (D (15)), even with losses after this day. Thus the real fledging success is even lower than

presented in this study. The fledging success was not within the range given by Furness (1987) in any year, and there are probably complex interactions between biotic and abiotic factors (e.g. weather, prey availability, predation) needed to be considered to fully explain poor fledging success (Jones et al. 2008). Unfortunately, data regarding weather and prey availability around Bjørnøya was not obtained. However, the apparent increasing population of Arctic fox seem to play a substantial role on Bjørnøya in reducing fledging success.

As top predators Great skuas accumulate high concentrations of contaminants, but so far there have not been any obvious and detrimental effects on survival or breeding success (Furness & Ratcliffe 2004).

Today the population of Great skuas is stable on Iceland, the growth in the Faeroes seem to have stopped several decades ago, and there has been a spread northwards to the Barents Sea region (Vader 1980, Furness & Ratcliffe 2004). Rates of population growth have been high in Svalbard, including Bear Island and Norway, and continue to increase (Strøm et al. 2006), possibly due to adaptations to low temperatures (Vader 1980, Furness & Ratcliffe 2004). The core breeding distribution seems to move from the British Isles and Iceland northwards to the Barens Sea region, and the fact that the number of breeders varies markedly between regions could be explained by demographic differences or natal dispersal. According to Furness & Ratcliffe (2004), colonies at higher latitudes predominantly prey upon seabirds, which correlate well with the results presented in this study. However when preying predominantly on seabirds, the Great skuas might slowly deplete their food basis which ultimately limit the increase in Great skua populations. If the Great skuas at high latitudes manage to utilize Capelin, as Sandeels are utilized in Shetland, the population increase could continue (Furness & Ratcliffe 2004).

Management implications

Considerable attention has been focused on the relationship dynamics between raptors and their avian or mammalian prey in terrestrial ecosystems. Much less is known about the interaction between their ecological counterparts in marine ecosystems (predatory gulls,

skuas, giant petrels), and the impact they may have on seabird populations (Phillips et al. 1999b). Predation mainly acts as a stabilizing effect on numbers in prey populations, and usually acts selectively on young, old or weak individuals (Spear 1993). Even though the total population of the Great Skua seems too small to affect other seabirds (Furness 1987), lower breeding success on a local scale in e.g. Kittiwakes is probably due to predation by Great skuas (Oro & Furness 2002, Votier et al. 2008). If this also is the case at Bjørnøya, an internationally important breeding ground for several seabird species, the future existence of several seabird species will be uncertain and might be in jeopardy (Votier et al. 2004b).

Conclusion

Even though Great skuas are dietary generalists, this study suggests dietary specialization between individual pairs, and there were indications of increased breeding success due to dietary specialization in 2009. Two field seasons are a short period in terms of variance in environmental conditions, and to minimize possible short-term fluctuations which might obscure longer-term patterns, further research over several years is needed. In addition, a larger sample size analyzed would decrease the effect of outliers and hence increase the reliability of the statistical analysis. Sufficient data regarding the availability of possible prey species around Bjørnøya would be of great interest to make better analysis. Unfortunately, this type of data was not obtained. However, this study provides a base of knowledge regarding the diet of the Great skua on Bjørnøya that can further be used in Norwegian and international management of the Great skua. In addition, this baseline knowledge of diet can be brought to use when assessing the impacts that the predation by Great skuas might impose on prey species, in particular other seabirds.

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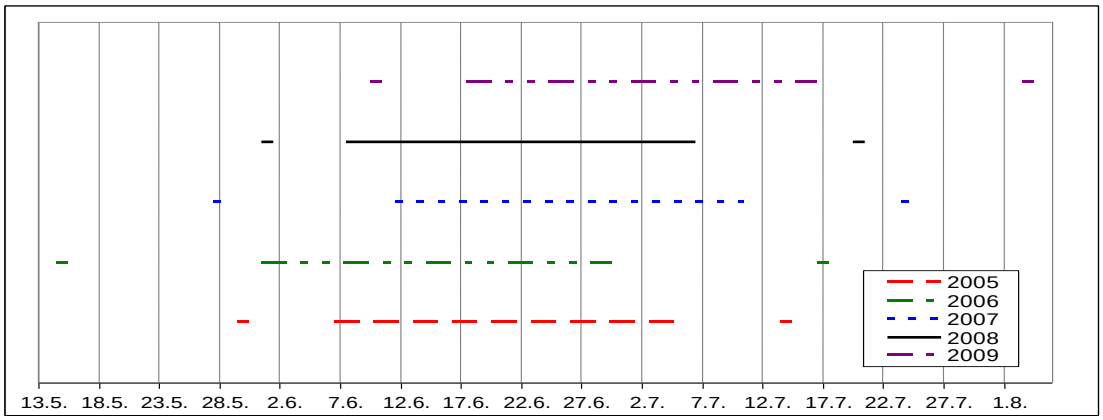
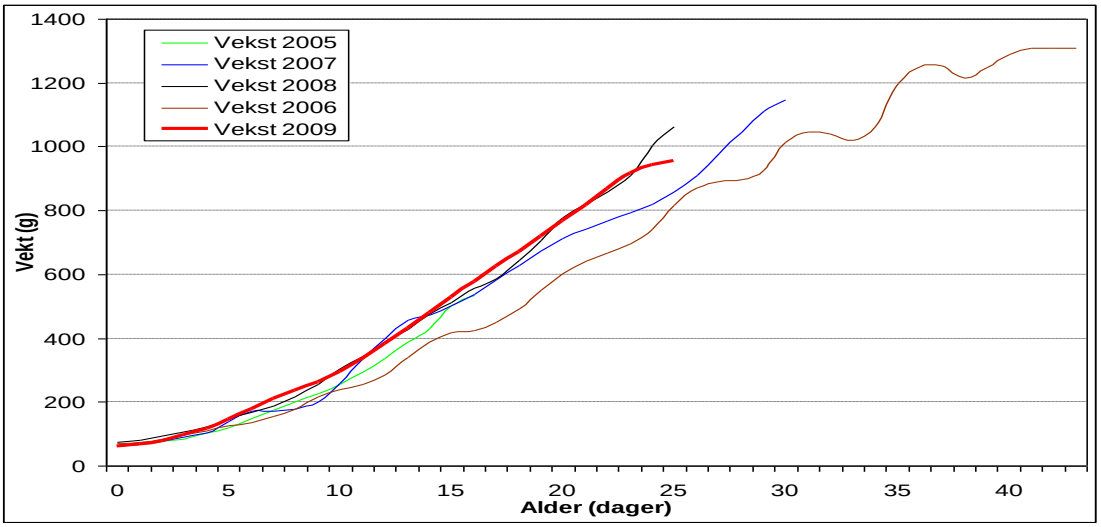
Appendixes

Appendix 1. Data obtained from the breeding Great Skua colony of study at Bjørnøya during the field season 2008 and 2009.

Year	2008	2009
Number of breeding pairs in study	12	13
Number of nests in data set	12	13
Number of eggs in nests	23	19
Number of eggs hatched in nests	23	17
Total number of chicks in data set	23	17
Number of surviving chicks to age 15	14	7
Number of chicks at end of field season	16	4



Appendix 2. Mean incubation period from 2005-2009. Estimated laying date for first egg laid and date for last registered hatching (Olsen 2009).



Appendix 3. Growth curve of chicks from 2005 – 2009 (Olsen 2009).

Appendix 4

Raw data from Microsoft Access 2003

Diett 2008										
ID	**Nest number**	**Date**	**Pellet number**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Other**	**Rock in pellet**	**Comment**
1	1	19.07.08	1			x		Crustaetion, peace of roap	litle	check for squid
2	1	19.07.08	2	x		x			litle	
3	1	19.07.08	3	x					litle	otolith
4	1	19.07.08	4			x	tern (chick)?			
5	1	19.07.08	5			x	tern (chick)?			
6	1	19.07.08	6			x				
7	1	19.07.08	7			x	tern (chick)?			
8	1	19.07.08	8	x		x	kittiwake			otolith
9	68	19.07.08	1			x	kittiwake		litle	
10	68	19.07.08	2			x			alot	
11	68	19.07.08	3			x			litle	
12	68	19.07.08	4			x			alot	
13	75	19.07.08	1			x			alot	
14	75	19.07.08	2			x			alot	
15	75	19.07.08	3			x	kittiwake		litle	
16	75	19.07.08	4	x		x			litle	
17	75	19.07.08	5			x			litle	
18	75	07.07.08	1			x				
19	75	07.07.08	2	x		x				
20	75	07.07.08	3	x		x			litle	
21	75	07.07.08	4			x				
22	75	07.07.08	5			x			litle	
23	75	07.07.08	6	x		x			litle	otolith
24	75	07.07.08	7	x		x			litle	
25	75	07.07.08	8			x				beak
26	75	07.07.08	9							
27	75	07.07.08	10	x		x			litle	
28	75	07.07.08	11	x		x				otolith
29	74	07.07.08	1	x		x				otolith
30	74	07.07.08	2			x				
31	74	07.07.08	3			x		Crustation		
32	74	07.07.08	4	x		x				otolith

Diett 2008										
ID	**Nest number**	**Date**	**Pellet number**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Other**	**Rock in pellet**	**Comment**
33	74	07.07.08	5			x		Crustation		
34	74	07.07.08	6	x		x				
35	74	19.07.08	1			x				
36	74	19.07.08	2	x		x				
37	74	19.07.08	3			x				
38	76	19.07.08	1			x				
39	76	19.07.08	2	x		x	kittiwake	Squid		otolith
40	76	19.07.08	3			x	kittiwake			beak
41	76	19.07.08	4	x		x				
42	76	19.07.08	5	x		x			litle	otolith
43	76	19.07.08	6	x		x				
44	76	19.07.08	7			x		Squid ?	litle	
45	76	19.07.08	8	x		x			litle	otolith
46	76	19.07.08	9			x				
47	76	19.07.08	10	x		x		Squid		otolith
48	76	19.07.08	11	x		x		Squid		otolith
49	73	19.07.08	1	x		x				otolith
50	73	19.07.08	2			x			litle	
51	73	19.07.08	3	x		x			litle	
52	73	19.07.08	4	x		x			litle	
53	73	19.07.08	5	x		x			litle	otolith
54	73	19.07.08	6	x		x			litle	otolith
55	73	19.07.08	7			x		Squid		
56	73	19.07.08	8			x				
57	73	19.07.08	9							
58	73	19.07.08	10	x		x			litle	otolith
59	9	07.07.08	1	x	otolith (Gadiformes)	x				Otolith, fish bone, bird bone, bright to dark feathers
60	9	07.07.08	2			x				bones and remains of feathers (greyish)
61	9	07.07.08	3			x				bright to dark feathers
62	9	07.07.08	4	x	otolith (Gadiformes)	x	kittiwake / fulmar			otolith, fish boned, bright greyish feathers
63	9	07.07.08	5			x				skin- and

Diett 2008										
ID	**Nest number**	**Date**	**Pellet number**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Other**	**Rock in pellet**	**Comment**
										boney remains and bright to dark grey feathers
64	9	07.07.08	6			x				skin- and boney remains and bright dark grey feathers
65	9	07.07.08	7	x		x	fulmar / kittiwake			fish bones, bright light feathers
66	9	07.07.08	8			x	kittiwake (chick)			bones- and grey feather remains
67	9	07.07.08				x	kittiwake			light greyish feathers
68	9	07.07.08	10			x	kittiwake / fulmar	peace of roap		light greyish feathers
69	9	19.07.08	1	x	Otolith (Gadiformes)	x				otolith, fish bones, greysih feathers, skin
70	9	19.07.08	2	x		x				fish bones (small), bright greysish feathers
71	9	19.07.08	4	x		x				fish bones, light feather
72	9	19.07.08	5			x				bright grey feathers
73	9	19.07.08	6			x			litle	grey feathers, bones
74	9	19.07.08	10	x		x				fish bones (small), grey feathers
75	9	19.07.08	11			x				bright grey feathers
76	9	19.07.08	13	x	Otolith (Gadiformes)	x			litle	otolith, fish bones, feathers
77	9	19.07.08	14			x			litle	bones, feathers
78	9	19.07.08	20			x	fulmar / kittiwake			bright grey feathers
79	42	19.07.08	1	x	Otolith (Gadiformes)	x			litle	otolith and fish bones, feathers,

Diett 2008										
ID	**Nest number**	**Date**	**Pellet number**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Other**	**Rock in pellet**	**Comment**
										bones and skin from bird
80	42	19.07.08	2			x			litle	bright feathers
81	42	19.07.08	3	x		x			litle	fish bones, feathers and skin from burd
82	42	19.07.08	4			x	kittiwake / fulmar		alot	stones and feathers
83	42	19.07.08	5			x		plastic thread	litle	feathers, bones and skin
84	42	19.07.08	6			x	kittiwake / fulmar			bright feathers, some grey
85	42	19.07.08	7	x	otolith (Gadiformes)	x			litle	otolith, grey feathers
86	42	19.07.08	8			x			alot	bones, bright and dark feathers, skin
87	42	19.07.08	9	x	otolith (Gadiformes)	x	kittiwake / fulmar			otolith, fish bones, bird bones, bright and grey feathers
88	42	19.07.08	10			x				bright and grey feathers
89	16	19.07.08	1			x				skin, bones and bright feathers
90	16	19.07.08	2	x		x				fish bones and feathers
91	16	19.07.08	3			x	little auk			skull with beak, black feathers
92	16	19.07.08	4			x				fish bones, dark feathers
93	16	19.07.08	5			x				bones and feathers
94	16	19.07.08	6			x				skin and feathers
95	16	19.07.08	7	x	otolith	x				fish bones, part of otolith (posssibly gadid fish), grey feathers
96	16	19.07.08	8	x		x				fish bones and feathers

Diett 2008										
ID	**Nest number**	**Date**	**Pellet number**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Other**	**Rock in pellet**	**Comment**
97	16	19.07.08	9			x				bones , feathers and skin
98	16	19.07.08	10			x			litle	bones and feathers
99	21	07.07.08	1			x			litle	bright grey feathers
100	21	07.07.08	2			x				beak, bones and feathers
101	21	07.07.08	3	x	otolith (Gadiformes)					fish bones, otolith, grey feathers
102	21	07.07.08	4	x		x			litle	fish bones, bird bones, grey feathers
103	21	07.07.08	5	x	otolith (Gadiformes)	x		Squid		otolith, squid ?? Grey feathers
104	21	19.07.08	1			x	little auk (based on feathers)		alot	dark and bright feathers
105	21	19.07.08	2			x				feathers and skin
106	21	19.07.08	3	x		x		Squid	alot	fis bones, bones and feather
107	21	19.07.08	4			x				feathers
108	21	19.07.08	5			x			alot	grey and hvite feathers
109	84	07.07.08	1			x	some species of auk		litle	black and brown feathers, a few bright feathers and bones
110	84	07.07.08	2			x			litle	bones and bright feathers
111	84	07.07.08	3			x				white/ grey feathers, bones
112	84	07.07.08	4			x	kittiwake / fulmar			bright grey feathers and skin
113	84	07.07.08	5	x				Diet sample when caught		big part of fish
114	84	19.07.08	1	x		x				fish bones, grey feathers

Diett 2008										
ID	**Nest number**	**Date**	**Pellet number**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Other**	**Rock in pellet**	**Comment**
115	84	19.07.08	2			x				bones, feathers
116	84	19.07.08	3			x			little	bright and grey feathers
117	84	19.07.08	4			x		white, soft things		skin and feathers
118	84	19.07.08	5	x		x				bird legs, feathers, fish bones
119	18	07.07.08	1			x				bones, claw, grey feathers
120	18	07.07.08	2			x				feathers (white and grey)
121	18	07.07.08	3	x		x				fish bones, bird bones, skin and feathers
122	18	07.07.08	4			x	little auk		little	beak, bones, dark grey feathers
123	18	07.07.08	5	x		x			little	fish bones, grey feathers
124	18	19.07.08	1	x	otolith	x			alot	otoliths, grey
125	18	19.07.08	2			x		hairball		bird bones, hairball, bright grey feathers
126	18	19.07.08	3			x				grey feathers and bones
127	18	19.07.08	4			x	kittiwake / fulmar			grey feathers
128	18	19.07.08	5			x				bright grey feathers

Appendix 5

Raw data from Microsoft Access 2003

Diett 2009											
ID	**Nest number**	**Collect date**	**Pellet no.**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Others**	**Species**	**Rock in pellet**	**Comment**
1	19	19.07.09	2	x ?		x					
2	19	19.07.09	4			x					
3	19	19.07.09	5	X		x					
4	19	19.07.09	6			x				alot	
5	19	24.07.09	3			x	kittiwake / fulmar				
6	19	24.07.09	4			x	kittiwake / fulmar				
7	19	24.07.09	5			x	fulmar				
8	19	24.07.09	6			x					
9	19	29.07.09	4			x	fulmar				
10	19	29.07.09	9			x	kittiwake			alot	
11	19	29.07.09	10			x	kittiwake and guillemot				
12	19	29.07.09	11			x	kittiwake				
13	19	29.07.09	1	X		x					
14	19	03.08.09	4	X		x					
15	19	03.08.09	5			x				alot	
16	19	03.08.09	11	X		x	fulmar				
17	19	08.08.09	2			x	kittiwake				
18	19	08.08.09	3	X	otolith (Gadiformes)	x	kittiwake				
19	19	08.08.09	4			x	fulmar				
20	19	08.08.09	5			x	fulmar				
21	20	15.07.09	4	X		x				little	
22	20	15.07.09	5	X		x					
23	20	15.07.09	7			x					
24	20	15.07.09	10			x	kittiwake / fulmar				
25	20	20.07.09	7			x				one big	
26	20	20.07.09	9			x	fulmar				
27	20	20.07.09	12			x					
28	20	20.07.09	15			x					
29	20	25.07.09	3			x	fulmar				
30	20	25.07.09	6			x				little	

Diett 2009											
ID	**Nest number**	**Collect date**	**Pellet no.**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Others**	**Species**	**Rock in pellet**	**Comment**
31	20	25.07.09	13			x					
32	20	25.07.09	21	X		x				little	
33	20	30.07.09	11			x	kittiwake / fulmar				
34	20	30.07.09	24			x				little	dark grey feathers
35	20	30.07.09	26	X		x	kittiwake / fulmar				white and grey feathers
36	20	30.07.09	30	X		x					grey feathers, spinal chord of fish
37	20	04.08.09	1	X		x	kittiwake / fulmar				grey feathers, spinal chord of fish
38	20	04.08.09	18			x	kittiwake / fulmar				grey/white feathers
39	20	04.08.09	20			x	kittiwake / fulmar			little	grey/white feathers
40	20	04.08.09	21	X		x	kittiwake / fulmar			little	white feathers
41	20	09.08.09	1			x				alot	white/grey feathers
42	20	09.08.09	2			x					dark feathers
43	20	09.08.09	3			x	kittiwake / fulmar			little	bright grey feathers
44	20	09.08.09	4			x				little	white feathers, skin
45	49	03.08.09	3			x	kittiwake / fulmar				white/grey feathers
46	49	03.08.09	4			x	kittiwake / fulmar			alot	white feathers, bones
47	49	03.08.09	6			x	kittiwake / fulmar	round, yellow balls ?		little	white/grey feathers
48	49	03.08.09	8			x	fulmar			little	should have taken nr. 7, (nr. 7 not representable). Grey feathers
49	49	08.08.09	4	X		x					feathers and skin from fish
50	49	08.08.09	5	X							fish (spinal chord)
51	49	08.08.09	6			x				little	grey feathers
52	49	08.08.09	8			x	kittiwake			alot	bright

Diett 2009											
ID	**Nest number**	**Collect date**	**Pellet no.**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Others**	**Species**	**Rock in pellet**	**Comment**
							/ fulmar				feathers with black tips (kittiwake)
53	17	16.07.09	3			x	kittiwake / fulmar				greyish feathers
54	17	16.07.09	4	X		x	kittiwake / fulmar	plastic and a blanck sirkular thing ?		little	fish bones, bird bones and feathers
55	17	16.07.09	6			x	kittiwake				bright and dark feathers
56	17	16.07.09	7			x	fulmar	insect (wasp)			greyish feathers
57	17	21.07.09	2			x					greyish down and feathers
58	17	21.07.09	3			x				little	greyish down and feathers
59	17	21.07.09	4			x				little	grey feathers, skin
60	17	21.07.09	5			x				little	grey feathers
61	17	26.07.09	1			x	kittiwake / fulmar				bright grey feathers
62	17	26.07.09	2	X		x		plastic			fish bones, bright feathers
63	17	26.07.09	3			x					dirty feathers
64	17	26.07.09	4			x	kittiwake / fulmar				bright feathers
65	17	31.07.09	4	X	otolith (Gadiformes)	x					fish bones, grey feathers
66	17	31.07.09	8			x					feathers
67	17	31.07.09	9			x	kittiwake / fulmar				bright feathers
68	17	31.07.09	10	X		x				little	fish bones, grey feathers
69	17	05.08.09	3	X	otolith (Gadiformes)	x				little	fish bones, feathers
70	17	05.08.09	5			x	fulmar			little	greyish feathers
71	17	05.08.09	6	X		x		black plastic peace			fish bones, a few bright feathers
72	17	05.08.09	7			x	kittiwake / fulmar			little	white/ grey feathers
73	13	14.07.09	1			x				little	white/grey/dark feathers,

Diett 2009											
ID	**Nest number**	**Collect date**	**Pellet no.**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Others**	**Species**	**Rock in pellet**	**Comment**
											claw
74	13	14.07.09	2	x		x					greyish feathers
75	13	14.07.09	4			x	fulmar				skin and bones, greyish feathers
76	13	14.07.09	5			x	kittiwake / fulmar				bright(=white)/ grey feathers
77	13	19.07.09	3	x		x	kittiwake / fulmar			little	fish bones, white /grey feathers
78	13	19.07.09	6			x					dark grey feathers
79	13	19.07.09	7	x		x				little	fish bones, a few feathers
80	13	19.07.09	9	x	otolith (Gadiformes)	x	kittiwake / fulmar				alot of fish bones, a few feathers (white/grey)
81	13	24.07.09	1			x					bones and feathers (white/ dark grey)
82	13	24.07.09	4	x							bones
83	13	24.07.09	10			x					bones and feathers
84	13	24.07.09	11			x				alot	bright feathers with a black tip, a few bones
85	13	29.07.09	1			x	kittiwake / fulmar				long white feathers
86	13	29.07.09	2			x				alot	
87	13	29.07.09	3			x	kittiwake / fulmar				long white feathers
88	13	29.07.09	4			x					greyish feathers
89	13	03.08.09	6			x	kittiwake			alot	white feathers with black tips
90	13	03.08.09	10			x				little	dark grey feathers, skin
91	13	03.08.09	13	x		x	kittiwake / fulmar				fish bones, greyish feathers
92	13	03.08.09	18			x	kittiwake			little	white feathers
93	13	08.08.09	1			x	kittiwake				greyish

Diett 2009											
ID	**Nest number**	**Collect date**	**Pellet no.**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Others**	**Species**	**Rock in pellet**	**Comment**
							/ fulmar				feathers
94	13	08.08.09	2			x					dark grey feathers
95	13	08.08.09	3			x	kittiwake				white feathers
96	13	08.08.09	4			x				alot	white and dark feathers, skin
97	2	17.07.09	1	x		x				little	fish bones, bright grey feathers
98	2	17.07.09	2	x	otolith (Gadiformes)	x				little	ffish bones, dark grey feathers
99	2	17.07.09	3			x	kittiwake / fulmar				bright greyish feathers
100	2	17.07.09	4	x		x				little	fish bones, greyish feathers
101	2	22.07.09	1			x	kittiwake / fulmar				bright greyish feathers
102	2	22.07.09	2	x		x	kittiwake / fulmar				fish bones, white feathers
103	2	22.07.09	3			x	fulmar				grey feathers, bones
104	2	22.07.09	5	x	otolith (Gadiformes)	x					fish bones, grey feathers
105	3	12.07.09	2	x	otolith (Gadiformes)	x	kittiwake / fulmar			little	fish bones, bird bones, skin and bright greyish feathers
106	3	12.07.09	3			x	fulmar				bright greyish feathers (smell like fulmar)
107	3	12.07.09	5	x	otolith (Gadiformes)	x					fish bones, otholit, white feathers
108	3	12.07.09	6	x??		x	fulmar				bright greyish feathers
109	3	14.07.09	1	x		x					fish bones, bright

Diett 2009											
ID	**Nest number**	**Collect date**	**Pellet no.**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Others**	**Species**	**Rock in pellet**	**Comment**
											greyish feathers
110	3	14.07.09	3			x	kittiwake				leg of a bird (3 toes = kittiwake)
111	3	14.07.09	9			x				little	greyish feathers
112	3	14.07.09	11	x		x	fulmar				fish bones, bright greyish feathers
113	3	16.07.09	1			x	fulmar				bright greyish feathers
114	3	16.07.09	3	x		x					fish bones, bright greyish feathers
115	3	16.07.09	4	x		x					fish bones, dark greyish feathers
116	3	16.07.09	7	x		x				little	fish bones, bird bones, dark grey feathers and down
117	3	22.07.09	1			x	kittiwake				white feathers with black tips (kittiwake)
118	3	22.07.09	2	x		x	kittiwake / fulmar			little	fish bones, bright greyish feathers
119	3	22.07.09	4			x	kittiwake / fulmar				bright greyish feathers
120	3	22.07.09	6	x		x					fish bones, bright greyish feathers
121	3	24.07.09	1	x		x	kittiwake / fulmar	plastic, birch bark		little	fish bones, white and grey feathers
122	3	24.07.09	3	x	otolith (Gadiformes)	x					greyish feathers and down
123	3	24.07.09	4	x		x	kittiwake / fulmar	small yellow-brown strings ?			small fish bones (possibly from kleptoparasiti

Diett 2009											
ID	**Nest number**	**Collect date**	**Pellet no.**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Others**	**Species**	**Rock in pellet**	**Comment**
											sm), white and grey feathers
124	3	24.07.09	7			x	fulmar				bright greyish feathers
125	4	15.07.09	4			x					greyish feathers
126		15.07.09	7			x	kittiwake / fulmar				white feathers
127	4	15.07.09	9	x		x		???		little	fish bones, feathers
128	4	15.07.09	11			x					greyish feathers, cartilage rings, bird bones
129	4	16.07.09	10			x	kittiwake				bones, dark greyish feathers, beak
130	4	16.07.09	13	x	otolith (Gadiformes)	x				little	bones, bright greyish feathers
131	4	16.07.09	21	x		x		plastic peaces		little	fish bones, greyish feathers, skin
132	4	16.07.09	22			x				little	feathers
133	4	20.07.09	1	x		x				little	fish bones, bright greyish feathers, bird bones and skin
134	4	20.07.09	3			x					bones, greyish feathers
135	4	20.07.09	5			x	kittiwake / fulmar			little	bones, bright greyish feathers
136	4	20.07.09	10	x		x					fish bones, bird bones, feathers
137	4	25.07.09	1			x				little	feathers and bones
138	4	25.07.09	5			x	kittiwake / fulmar				white and grey feathers
139	4	25.07.09	7	x		x					fish bones, feathers and skin
140	4	25.07.09	9	x		x				alot	fish bones,

Diett 2009											
ID	**Nest number**	**Collect date**	**Pellet no.**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Others**	**Species**	**Rock in pellet**	**Comment**
											feathers
141	4	30.07.09	5			x				little	bird bones, feathers
142	4	30.07.09	12			x	kittiwake / fulmar				bright greyish feathers, skin
143	4	30.07.09	14			x	kittiwake / fulmar				white feathers
144	4	30.07.09	15	x		x				little	fish bones, bird bones and feathers
145	7	12.07.09	1			x				alot	feathers
146	7	17.07.09	1	x	capelin			krill	thysanoessa…		probably taken by kleptoparasitism
147	7	17.07.09	2	x		x					remains from fish (bones + meat), feathers
148	7	17.07.09	3	x		x				little	fish bones, feathers
149	7	17.07.09	4			x					white and dark feathers, skin
150	7	19.07.09	1	x		x				little	fish bones, white and grey feathers
151	7	19.07.09	3			x					dark grey feathers
152	7	19.07.09	5			x					dark grey feathers
153	7	19.07.09	7	x							fish bones
154	7	22.07.09	1			x				little	grey feathers
155	7	22.07.09	5			x	kittiwake / fulmar				bright greyish feathers
156	7	22.07.09	7	x		x					fish bones, greyish feathers
157	7	22.07.09	8			x				little	white and greyish feathers
158	7	27.07.09	2	x		x					fish and bird remains
159	7	27.07.09	5	x		x					fish and bird remains
160	7	27.07.09	6	x		x					fish and bird remains

Diett 2009											
ID	**Nest number**	**Collect date**	**Pellet no.**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Others**	**Species**	**Rock in pellet**	**Comment**
161	7	27.07.09	7	x		x					fish and bird remains
162	10	12.07.09	1			x					greyish feathers, skin
163	10	12.07.09	2			x					greyish feathers, skin
164	10	17.07.09	1			x					dark/black feathers
165	10	17.07.09	2			x					bird bones, greyish feathers
166	10	22.07.09	1			x	kittiwake / fulmar				bright greyish feathers
167	10	22.07.09	2			x					greyish feathers
168	10	22.07.09	3			x					greyish feathers
169	10	22.07.09	5	x		x				little	fish bones, greyish feathers
170	10	01.08.09	2			x				little	greyish feathers
171	10	01.08.09	3			x	kittiwake				wingfeathers from kittiwake
172	10	01.08.09	5			x	kittiwake / fulmar				greyish feathers
173	10	01.08.09	6			x	kittiwake / fulmar				white feathers
174	10	06.08.09	1			x				very much	alot of rocks, some feathers
175	10	06.08.09	2			x					white and dark greyish feathers
176	10	06.08.09	3			x	kittiwake / fulmar				one feather, to little sample to include in data material ?
177	15	18.07.09	1			x					hreyish feathers
178	15	18.07.09	5			x					bright greyish feathers
179	15	18.07.09	7			x					bird bones, greyish feathers

Diett 2009											
ID	**Nest number**	**Collect date**	**Pellet no.**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Others**	**Species**	**Rock in pellet**	**Comment**
180	15	18.07.09	9			x	kittiwake / fulmar				bird bones, bright greyish feathers
181	15	23.07.09	1			x	kittiwake / fulmar			little	bones, greyish feathers
182	15	23.07.09	3			x		squid		little	bones, bright greyish feathers
183	15	23.07.09	5	x		x					fish bones, greyish feathers
184	15	23.07.09	7	x		x	kittiwake				a few fishbones, white feathers (some with black tips)
185	16	20.07.09	1			x	kittiwake			alot	beak, bones, bright greyish feathers
186	16	20.07.09	2			x	kittiwake / fulmar				cartilage rings (trachea), bright greyish feathers
187	16	20.07.09	3	x		x	kittiwake / fulmar			little	remains from fish, bird bones, bright greyish feathers
188	16	20.07.09	6			x		plastic peace		little	bird bones, greyish feathers
189	16	11.07.09	1	x		x				alot	fish bones, bird bones, dark greyish feathers
190	16	11.07.09	2			x					dark and white feathers
191	16	11.07.09	4			x					bird bones, greyish feathers
192	16	11.07.09	5			x	kittiwake				remains of a beak
193	16	15.07.09	1			x		plastic + squid		little	white and greyish feathers, skin

Diett 2009											
ID	**Nest number**	**Collect date**	**Pellet no.**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Others**	**Species**	**Rock in pellet**	**Comment**
194	16	15.07.09	2			x	fulmar				bright greyish feahters
195	16	15.07.09	4	x						one	fish bones, fishshell, fish meat (diet sample)
196	16	15.07.09	5			x					skin, dark greyish feathers
197	16	25.07.09	2			x	kittiwake / fulmar				bright greyish feathers
198	16	25.07.09	4			x	kittiwake / fulmar				bright greyish feathers
199	16	25.07.09	5			x	kittiwake / fulmar				bright greyish feathers
200	16	25.07.09	6			x	kittiwake / fulmar				skin, bright greyish feathers
201	16	30.07.09	1			x				little	greyish feathers
202	16	30.07.09	2			x	kittiwake / fulmar			little	bones, bright greyish feathers
203	16	30.07.09	3			x	kittiwake / fulmar				one white feather (small sample ??)
204	16	30.07.09	11			x	kittiwake / fulmar				white feathers
205	18	15.07.09	1			x					skin, greyish feathers
206	18	15.07.09	2			x	kittiwake / fulmar or juvenile gull				white feathers with grey pacthes
207	18	15.07.09	3	x		x				little	fish bones, greyish feathers
208	18	15.07.09	5	x		x					fish bones, bird skin, greyish feathers
209	18	20.07.09	4	x		x	kittiwake / fulmar				few small fish bones, white and greyish

Diett 2009											
ID	**Nest number**	**Collect date**	**Pellet no.**	**Fish**	**Fish species**	**Bird**	**Bird species**	**Others**	**Species**	**Rock in pellet**	**Comment**
											feathers
210	18	20.07.09	5	x		x					fish bones, white and greyish feathers
211	18	20.07.09	6	x		x	kittiwake / fulmar				fish bones, white and greyish feathers, bird skin
212	18	20.07.09	7			x					greyish down and feathers
213	18	25.07.09	1	x							remains from fish (bones, meat, shell)
214	18	25.07.09	2	x		x					fish bones, dark feathers
215	18	25.07.09	3	x	otolith (Gadiformes)	x	kittiwake / fulmar				otolith, fish bones, greyish feathers
216	18	25.07.09	4	x		x	kittiwake / fulmar				fish bones, white feathers
217	18	30.07.09	5	x	otolith (Gadiformes)						otolith, bones
218	18	30.07.09	6	x		x					fish bones, bird bones
219	18	30.07.09	7			x	kittiwake				lower part of beak, juvenile
220	18	30.07.09	11			x					bones, part of skull, white feathers
221	18	04.08.09	1			x					grey feathers
222	18	04.08.09	2			x					grey feathers