Degree project thesis

Feeding behaviour in two sympatrically living *Larus* gulls in areas with and without an elevated adult mortality

David Schönberg Alm
Department of Systems Ecology, Stockholm University

Contents

Feeding behaviour in two sympatrically living *Larus* gulls in areas with and without an elevated adult mortality

David Schönberg Alm
Department of Systems Ecology, Stockholm University, Sweden

An elevated adult mortality in waterfowl along the coasts of Sweden has been the cause of some concern recent years. First discovered in 2000 in eastern Sweden, the hitherto unexplained mortality has raised the question of the condition of the Baltic Sea. Herring gull *Larus argentatus* is by far the most affected species, although other bird species are found among the dead as well. Toxicological reasons have been the main focal point up to this date but it is possible that several factors might influence the state of the birds. In this study, ecosystem changes are addressed as possible reasons for this mortality. In order to understand how marine ecosystems work; one must study the interactions of the species in the food web. This study aims at achieving a deeper understanding of the spatial and temporal differences in feeding behaviour of two gull species e.g. their association with fish in the Baltic Sea. Field studies were conducted on Stora Karlsö (no documented elevated adult mortality) during the breeding season of 2005 where Herring gull and Lesser Black-backed gull *Larus fuscus* were studied. Food samples were collected from both species on Stora Karlsö and additional food samples from Herring gulls in Blekinge and Skåne were collected (in colonies with documented elevated adult mortality). We found that Herring gulls on the mainland fed much more on human waste than did those on Stora Karlsö. Clupeids were the most common food item for both gull species on Karlsö. This conclusion was supported by field observations of feeding behaviour. Herring gulls on Stora Karlsö showed a rather strong tendency to feed on offal and refuse from the fishing industry while no food sample from Blekinge and Skåne contained offal/refuse. Observational data showed that Herring gulls fed chicks extensively on earthworms, which could not be seen in food samples. Sprat abundance in Lesser Black-backed gull stomachs decreased markedly between 2003 and 2005 whereas herring abundance changed little during the same time period.

Introduction

Background

During the recent years, adult seabirds in the Baltic Sea have suffered from an unexpected and alarmingly high mortality. In the spring of 2000, the first signs of this disease were seen in colonies in Blekinge on the Swedish east coast. Birds were found dead or affected and the latter showed typical behaviour: drunkenness, cramping and occasional diarrhoea. Jointly for a great mass of affected birds are symptoms of malnutrition and a decrease in over-all state of health. According to the study made by Mörner et. al (2005), the stomachs of the birds that have been found dead are mostly empty. This indicates that they are suffering from starvation, a state that derives from the impaired ability to move, thus gather food. It seems as though the birds have such a weakened immune system, due to malnutrition, that they die from common diseases they can handle during normal conditions. Larids, and especially Herring gull *Larus argentatus*, are among those species that have shown great susceptibility to this predicament (Hario et al. 2004, Lif et al. 2005). Besides Herring gulls, other Larids such as Mew gull *Larus canus*, Lesser black-backed gull *Larus fuscus*, Great black-backed gulls *Larus marinus*, and Black-headed gull *Larus ridibundus* have been affected as well as ducks and geese. The symptoms have since been observed in seabirds along the eastern coastline of Sweden as well as in larger inland lakes. Colonies with increased mortality are also found on the west coast of Sweden (Mörner et al. 2005).

Possible reasons

Pathological studies have revealed that some of the affected birds were struck by botulism, a disease caused by the bacteria *Clostridium botulinum*. This disease is commonly found in Herring gull colonies (Mörner et al. 2005). *C. botulinum* is a spore producing bacteria that grows in anaerobe environments. Both bacteria and spores are present in soil and animal faeces. It is when the spores grow in an oxygen free environment that they produce a strong neurotoxin that blocks nervous impulses and eventually causes failure in the respiratory muscles (SMI 2005). There is a possibility that when gulls are feeding on decomposing birds or other cadavers, they are poisoned from the ingestion of insect larvae (Mörner et al. 2005). Conditions favouring botulism is also encouraged by the discharge of garbage and sewage water (Murphy et al. 2000). Botulism is however considered to be an effect of this elevated mortality rather than a reason for it as only a few of the examined birds has died from the toxin (Mörner et al. 2005).

A possible connection to the salmon (*salmo salar*) disease M74 has been investigated, as the symptoms are similar (Mörner et. al 2005). M74 is a neurological disease that causes reproductive failure in salmon due to vitamin B_1 (thiamine) deficiency (Koski et al. 2005). The disease can be cured by thiamine treatment (Bengtsson & Hill 1999). According to Mörner et. al (2005), M74 could cause the same deficiency in the birds of the Baltic Sea, much as it does with salmon. *Larus* gulls have feeding preferences similar to that of salmon, which opens for a common cause for the disease. When given thiamine, some of the birds did recover, a fact that further strengthens this shortage theory. Birds that were fed and given water recovered in some cases as well. Although the symptoms are similar, there is not sufficient evidence to prove that M74 is causing the mortality in adult gulls as of today (Mörner et al. 2005).

In the Gulf of Finland, the nominate race of Lesser black-backed gull *Larus f. fuscus* (hereafter referred to as LBBG) has seen a drastic decrease in numbers and are now locally close to extinct (Hario et al. 2000, 2004). Studies have revealed that increased chick mortality is the underlying reason for this reduction in numbers. Recent work shows a strong relation between elevated levels of DDE/PCB ratio and mortality in LBBG chicks. This suggests that LBBG in Finland are exposed to DDT to a greater extent than other circumpolar birds. The levels of DDT in The Baltic Sea have been decreasing steadily since the 1970´s which indicate that the gulls are exposed to the toxins elsewhere. The LBBG winters in Africa where the usage of DDT and PCB is still common and might thus affect the gulls negatively (Hario et al. 2004).

The level of PCB in The Baltic Sea has been decreasing as well, although not as rapidly as DDT. In the works of Hario et al. (2000, 2004), PCB is considered to be a factor influencing the reproductive failure in LBBG in the Gulf of Finland. Studies on Herring gull (hereafter referred to as HG) and LBBG in the U.S. shows a decrease in thyroid functionality in the former species due to exposure to PCB. The LBBG did however not show the same change (Rolland 2000). According to Mörner et. al (2005), a toxin is a most likely contributor to the disease, if not the sole reason.

Cod (*Gadus morhua*) has decreased drastically in the Baltic Sea during the last two decades due to abiotic factors as well as human influence. Reduced salinity caused by a diminished inflow of saline- and oxygen rich water from the North Sea causes weak reproduction (Matthäus & Franck 1992, Harvey et al. 2003, Casini et al. 2005). Over-fishing has further decreased the cod stock, which in turn has caused an increase in sprat stock biomass (Kornilovs et al. 2001). Sprat, being the main prey species of cod, thrives due to a lower predation pressure (Möllmann & Köster 2002, Möllmann et al. 2004). This has in turn led to a greater intraspecific competition for prey as the zooplanktivorous sprat increase in number but still have to share the same amount of available food. Sprat in the Baltic Sea has thus increased in numbers but decreased in size (Casini et al. 2005, Möllmann et al. 2004).

Studies on the ecologically similar Kittiwake *Rissa tridactyla* addresses the problem of energy spent on foraging and chick-rearing during the breeding season (Bech et al. 2002, Moe et al. 2002). Kittiwakes, which are ecologically similar to LBBG and HG, deplete their energy reserves during breeding season as caring for the young are prioritised before self-maintenance.

Important in the study of ecosystem changes are links between adjacent trophic levels. In order to understand a species susceptibility to fluctuations in its surroundings, it is crucial to understand its basal behaviour. Knowledge of breeding behaviour and food preference in LBBG and HG are scarce. This information is necessary in order to be able to gain further knowledge about other aspects of the species' biology and its effect on the ecosystem (Götmark 1984, Schwemmer & Garthe 2005). The amount of offal and discards from fisheries has increased and over-fishing of larger predatory fish might have influenced gulls positively as the number of smaller fish has increased (Kubetzki & Garthe 2003). Discards from fish industry are an important underlying factor for the increase in HG numbers on the British Isles (Furness et al. 1992, Mitchell 2001). The importance of waste products and fishery discards as food of choice for a number of gull species, especially so HG, are well documented in different locations in Europe (Götmark 1984, Furness et al. 1992, Pons 1993, Kilpi & Öst 1998, Mitchell 2001, Kubetzki & Garthe 2003, Gilliland et al. 2004).

The aim of this study is to investigate the food intake of HG on Stora Karlsö and to compare it with that of HG in Blekinge and Skåne. As of today, adult mortality on Karlsö is of low frequency, whereas Blekinge has a high frequency of adult mortality. The hypothesis is that prey choice differs between HG on the mainland and Stora Karlsö and that the energy content in prey in Blekinge and Skåne is lower than that of prey on Stora Karlsö. In addition, food intake of LBBG on Stora Karlsö has been investigated between 2003-2005 and this information has been compared to changes in related fish stocks. The hypothesis being that preferred food is correlated to the most abundant species. Studies made on Great skua in the North Sea showed a strong relationship between food availability and presence of foodstuff in stomach samples (Votler et al. 2004) If the gulls' main prey species are of a lesser energy value than before, it is plausible to assume that it could affect the gulls' condition negatively. An over-all state of fatigue from the demands of breeding paired with a possible exposure to toxins during wintering might induce this adult mortality.

Subject species

Herring Gull

The Herring Gull *Larus argentatus* is a circumpolar Larid that occupies a wide range of habitats. They preferable live on rocky coastlines on cliffs and sand dunes but occupy inland areas as well, mainly on moorland and lake islands. Increasing numbers of HG are finding a niche in urbanized areas (Mayr 1963, Svensson et al. 1999, Mitchell et al. 2001). HG are opportunistic generalists and feed on human refuse as well as on fields and on fish. They are often seen foraging on refuse dumps and on offal from fish industries and fishing boats (Götmark 1984, Furness et al. 1992, Pons 1993, Kilpi & Öst 1998, Kubetzki & Garthe 2003, Gilliland et al. 2004, Mitchell 2001). The number of HG in Europe has increased during the 20th century and has locally been subject to intensive control measures. The reason for this increase is often attributed to the fishing industry as well as the growing numbers of refuse dumps (Furness et al. 1992, Lyngs 1992). Scandinavian HG in the north of the Baltic Sea moves to the southern Baltic during winter, whereas those breeding in the southern parts migrates to Great Britain or stay in the same area (Svensson et al. 1999, Coulson et al. 1983). In the late nineties there were between 50.000 and 100.000 HG in Sweden (Svensson et al. 1999). They are on the Swedish Red list of species, classified as LC – least concern (Gärdenfors 2005).

Lesser Black-backed gull

The nominate Lesser Black-backed gull *Larus f. fuscus* is a circumpolar Larid, closely related to HG and Yellow-legged gull *Larus michahellis* in the Mediterranean Sea (Liebers & Helbig 2002). They choose breeding habitats similar to HG and are opportunistic feeders but not to the same extent (Mitchell et al 2001). They are known to follow fishing vessels but catch fish naturally as well. As with the HG, they are seen foraging on refuse dumps and on fields (Götmark 1984, Garthe & Scherp 2003, Mitchell et al. 2001). The LBBG populations in the Baltic Sea have been subject to dramatic fluctuations in numbers in the second half of the 20th century. In 1990 the numbers of breeding pairs at Graesholmen, near Bornholm in the Baltic Sea, were down to 4-5 pairs whereas in 1940 there had been 1200 pairs. Here, the reason is said to be because of predation by HG as well as food shortage and a possible exposure to negative factors during wintering (Lyngs 1992). In Norway, a likewise negative trend can be seen throughout the second part of the 1900's (Strann & Vader 1986, 1988). Studies on feeding behaviour has been carried out between 2003 and 2005 on Stora Karlsö in an attempt establish a solid base of knowledge about LBBG basic ecology.

Material and Methods

Data were collected in 2005 between May 2nd and July 5th at Stora Karlsö (57°17`N, 17°58`E), located in ICES sub division 27. Three gull colonies were selected: Östra Suderslätt, Gjaus Häll and Langdal. Nests were marked with a metal pin and a plastic note with a unique number. The colony at Östra Suderslätt consisted of HG only. Gjaus Häll comprised both HG and LBBG while the colony in Langdal was occupied by LBBG only. In Gjaus Häll there was also one couple of Great black-backed gulls *Larus marinus*. Observations were only made at Gjaus Häll and Langdal but weighing of chicks and collecting of pellets and regurgitations were done at all sites.

To study the birds, hides were placed at the edges of the colonies, this to disturb the birds as little as possible. At Gjaus Häll the hide was placed in a thicket with the entrance facing away from the colony. Crawling through a path in the thicket accessed it. Furthermore, the hide was placed on an elevated platform for a better view while in Langdal it was placed directly on the ground. The colony at Langdal had to be entered in order to access the hide.

Each observation period lasted four hours and a rolling schedule was made to cover as much of the day as possible. At least two study periods every day were made, one at each site. Whole day studies were made the 14th, 16th, 18th, and 20th of June and begun at dawn and ended when it was too dark too see. During the observations we noted basic parental behaviour such as (1) roosting/guarding the young (2) breeding (3) feeding (4) flying off and (5) coming back. The time for each event was marked in a protocol. When parents fed their young the time was noted, which parent was feeding, what kind of food and how much it was, how many chicks that ate and if there were any leftovers.

Once a day we walked through all study sites to count eggs and weigh the young birds, if they were not too recently hatched in which case we noted their birth but did not touch them. Weighing was done with spring balance. On days with unfavourable weather these walkthroughs were not made. All HG chicks were marked on one leg with tape and each tape was given a unique number. These tapes had to be replaced after two to three days. The LBBG were ringed with a steel ring and in some cases with a colour ring. While walking through the colonies pellets were collected in plastic bags marked with date and nest number. Handling the young gulls sometimes caused them to throw up and these samples were also collected and marked in the same fashion. All samples were then put in a freezer. At no point was adult birds part of the handling on Stora Karlsö.

Food samples were also collected in Blekinge and Skåne close to the mainland of southeastern Sweden. Samples were gathered on the 14th, 16th, 28th and 30th of June on different locations (table 1). Food samples were collected from chicks, juveniles and adults alike. Pellets were gathered from the ground when found and some of the birds were forced to regurgitate. The only observational data from Blekinge and Skåne was of food residues around the nests.

Sample analysis

When the field study was finished, the regurgitations were sent to The National History Museum in Gothenburg. All samples went through the same process. The samples were added boiling water to separate the soft parts. When the temperature was below 40 °C, an enzyme was added, Enzyrim, and the samples were then left in room temperature for 3-4 hours. A potassium hydroxide was then added along with a colouring agent, Alizarin. The agent colours skeletal parts red and makes them easier to separate. All bones in each sample were studied in order to define what species of fish they originated from and how many individuals there had been. By using otolithes it was possible to identify species (Härkönen 1986). Other parts such as the last vertebrae in clupeids further helped identification. Mouthparts (maxillare, dentale and articulare), otic capsules and scales were used in the process as well. For analysis, a stereomicroscope was used. Almost all samples from Blekinge and Skåne could be identified with the naked eye since they mainly consisted of large items.

It was not possible to discern, which pellet came from which nest or if it came from a chick or a parent. But instead of discarding all data from the pellets, it was included in the regurgitations and analysed accordingly. Only one food sample was collected from the LBBG colony at Gjaus Häll. It consisted of one herring and to simplify the data analysis it was included in the samples from Langdal.

Data analysis

To be able to compare different food items, frequency of occurrence was calculated when human refuse and such none-quantifiable items were used in the same analysis as fish and other quantifiable items. All statistical testing was performed by using the χ^2 method.

Feet from pigs and hens, products clearly produced by humans (meat balls, sausages, bread, plastic items and the like) were grouped together as human refuse.

Due to the gulls' feeding habits, cod are assumed to be offal or discards from fishing industry (Furness et al. 1992, Garthe & Scherp 2003) Gulls are shallow feeders and usually cannot dive deep enough to catch cod. Throughout this work, gadeids are therefore considered to be non-natural food, i.e. food items not originally caught by the gulls.

The amount of observation time that was not a part of the four days of whole day studies was inconsequent when it came to comparing nr of feeds with chick-hours. It was however possible to do a rough estimation of feeds/hour and chick for all observing days for HG in Gjaus Häll. This was done by extracting the mean number of feeds per chick-hour (nr of feeds/chick*hour) for every day. It was then plotted in a diagram and used as a simple way of estimating differences in feeding rate during the light hours of the day. LBBG in the same colony, as well as in the second colony at Langdal, yielded too few observed feeds to be of interest.

During observations, it was not possible to differentiate chicks from one another when members of the same family were fed. When it was possible to, regurgitated food items were identified down to species or genera. Other food items than fish were noted as earthworm, grain or 'other'.

Observational data on choice of prey was used to complement the collected data as far as it was possible to do so. The proportion of clupeids and sandeel in regurgitations was possible to correlate to proportion of clupeids and sandeel in observed feeds. This was done in order to validate collected data as far as possible.

The samples from 2003 and 2004 were collected by Mattias Lif and analysed by Leif Johnson in Gothenburg. The methods used in 2003 and 2004 were the same as in 2005 with the difference being that pellets consisting of grass or other dry parts from plants ('grain' throughout this work) were not collected.

Michelle Casini at The Swedish Board of Fisheries provided size data on Baltic sprat and sandeel as well as data on sprat and herring abundance in the Baltic Sea. The energy content of sprat and sandeel was calculated with equations originally intended for sprat and sandeel from the North Sea. These equations were however the only ones possible to obtain, wherefore they are used in this work to calculate energy values on Baltic Sea sprat and sandeel. North Sea sprat and sandeel differ somewhat from their conspecifics in the Baltic Sea in that they have a higher fat content and this source of bias was taken into consideration.

All data on energy has been derived from sprat and sandeel caught in ICES subdivision 25 and 27. Data on fat content has been derived from sprat and herring caught in the same areas.

The data from Blekinge and Skåne proved to be too small for statistical testing at some points during analysis. When small data sets have been used, it is noted in the results.

In some of the tests, sample numbers from HG on Stora Karlsö, as well as LBBG, have been modified. Unidentified clupeids were proportionally distributed between sprat and herring, based on the ratio observed in samples. When this is done, it is noted in the results.

RESULTS

HG on the mainland, compared to HG on Stora Karlsö

From the data collected during 2005 it can be seen that fish was no less common in HG stomachs than any other food item on the mainland, than it was on Stora Karlsö ($p>0.05$, $df=1$, $\chi^2_c=2$). Food samples from HG in Blekinge and Skåne are shown in table 2. Data from these sites was too small to test accurately for sprat as being less common on the mainland than on Karlsö. However, when tested there was no significant difference in the amount of sprat found in samples between the two sites ($p>0.5$, $df=1$, $\chi^2_c=0.2$). For this test, unidentified clupeids in samples from Karlsö were proportionally distributed between sprat and herring.

As far as human refuse is concerned, the difference between the two areas was significant ($p<0.001$, $df=1$, $\chi^2_c=16.1$). Human refuse was present in 67% of the samples in Blekinge and Skåne, as compared to 6% on Karlsö. Difference in numbers between the other food items could not be tested statistically due to a too small data set. However, there seem to be no obvious difference in numbers as the items range between 1 and 2, regardless of the type of item or method of quantification (table 2). Items termed as ‘human refuse’ differed noticeably between the mainland and Karlsö. The samples from the mainland contained foodstuff that obviously derived from human food. Items such as meatballs, sandwiches and processed meat products made up the bulk of the waste products whereas the gulls on Karlsö showed no such tendencies to feed on this type of human refuse.

Food intake of HG on Stora Karlsö was noticeably different from that of HG in Blekinge and Skåne. Birds on Karlsö had a more diverse menu and showed no preference towards human refuse as only 6% of the samples contained this food item. There was a statistically strong difference between the two study sites in proportions of natural food and food not originally caught by the gulls (table 3).

In column B, table 4, all unidentified clupeids have been proportionally distributed between sprat and herring. These numbers were used when sprat was compared to all other species in order to discern if sprat is the preferred choice of prey on Karlsö, compared to Blekinge and

Skåne. No significant difference in sprat preference could be shown between the mainland and Karlsö (p>0.5, df=1, χ^2_c=0.2). Neither was there any difference between the sites in the number of herring when it was compared to all other fish (p>0.5, df=1, χ^2_c=0.4). However, a weak significance could be shown when the exact amount of herring (column A) was used in analysis (p=0.05, df=1, χ^2_c=4), which could indicate a preference for herring among gulls on Karlsö. Once again, the number of observations is very limited.

Fish offal/refuse from fisheries were found in nine samples (n=49) on Stora Karlsö. In addition, one sample (n=9) from Blekinge and Skåne contained offal. There was no significant difference when this was tested. However, data from the mainland might be inadequately distributed, wherefore the results are uncertain.

On Stora Karlsö, 12 food samples (n=49) contained grain. This constitutes 24% of the samples (based on freq. of occ.). Grain was not found in any food sample from Blekinge and Skåne. Based on this information, gulls from Karlsö are therefore assumed to forage on fields to a greater extent than gulls on the mainland. As there are no fields on Karlsö where grain can be had, this means that they travel elsewhere to forage on this particular food item.

Insects were present in eleven food samples from Stora Karlsö (n=49). In Blekinge and Skåne, food samples were void of insects. As insects were found in 22% of the samples, they constitute a large proportion of the analysed items (compared to the items that was most abundant: unidentified clupeids and grain, both 24%, freq. of occ.).

HG on the mainland

Leftovers from garfish are common in the HG colonies on the mainland according to Lars Carlsson (pers. comm.), who claims that it is the gulls' main choice of food there. This could not be shown with the samples collected in Blekinge and Skåne, as garfish was not more common than any other food item. Not listed in the samples from the mainland are items that did not readily fit in any of the categories, such as plastic bags, golf balls, children's toys. They were not found in actual samples, but rather observed lying around nests. One food sample contained feet from poultry together with sawdust. These items were considered to be non-natural food

It was not possible to do fitting calculations on energy values on food items from Blekinge and Skåne as they mostly consisted of refuse from humans. Neither was it possible to compare the energy contents in food items from Blekinge and Skåne to those from Stora Karlsö.

HG on Stora Karlsö

Of all the fish species found in HG stomachs on Stora Karlsö, sprat was the most common species and clupeids the most common genera. A total number of 65 fish were found in HG stomachs. All food items from Stora Karlsö and the mainland are shown in table 5.

The seemingly large amount of stickleback is somewhat misguiding as it came from one sample only. It was the only sample containing stickleback from all sites, and so it is treated as unrepresentative.

In the article by Kubetzki and Garthe (2002), HG in the North Sea showed a preference in food choice towards bivalves and crustaceans. The food samples from Karlsö showed no such preference as only one sample contained a crustacean.

Detailed observations of HG at Gjaus Häll

A total of 23 nests were marked in the colony at Gjaus Häll. 45 chicks hatched (i.e. weighed and/or observed) and of those 30 were marked. 37 chicks and all nests were used in data analysis. The highest number of observed chicks on the same day was 17, whereas on the last day of observation, 2 chicks were present. All in all, 168 hours of observations were made.

The number of feeds was equally divided between the parents (male=91, female=90, n=181). Parents ate from the food they regurgitated for the chicks in 80 out 187 feeds. There was a weak significance indicating a difference between the sexes. Male gulls in the colony fed more often than females on leftovers (table 6).

Observations

Observational data complements the information gathered from food samples as items that were not found in stomach analysis could be obtained this way (figure 1). Parents feeding their chicks with earthworms (not found in stomach analysis) were observed in 25 out of 114 feeds in Gjaus Häll. Earthworms seem to constitute quite a large amount of the food items that were fed to chicks. It was not possible to discern if earthworms and grain were fed simultaneously, which would if observed, indicate a connection between the two items. Observed number of times fish were fed to chicks was 63. In 33 of those observed feeds it was possible to identify the prey down to genera: 29 Clupeidae, 4 Ammodytes and 1 unidentified stickleback. A total of 89 clupeids were seen fed to the chicks.

Feeding frequency fluctuated throughout the day with peaks approximately between 02.00-06.00 and 16.00-20.00 (figure 2). The number of feeds/chick and day decreased as the chicks grew older. This would be expected as chicks are left to tend for themselves as they grow. It might however be due to the dramatic decrease in chick numbers later in the study period. No observations were made on the 13th, 16th, 20th, 21st, 22nd, 23rd and 25th of June.

The number of feeds/chick and day during the whole study period are shown in figure 3. Zero values on the 2nd, 4th and 15th are due to no observed feeds.

Dawn-dusk observations

14th June

A total of 22 feeds were observed from 03.00 and 23.00 and ten chicks were present (figure 4). The mean number of feeds/hour was 1,05. The mean number of feeds/chick/hour was 0,1.

18th June.

12 feeds were observed from 03.30-23.00 and seven chicks were present (figure 4). The mean number of feeds/hour was 0,57. The mean number of feeds/chick/hour was 0,08.

LBBG

Sprat was the most common choice of prey for LBBG on Stora Karlsö between 2003-2005, whereas herring was the second most common food item (table 7).

Between 2003-2005 there is a significant decrease in sprat numbers found in LBBG stomach contains and/or pellets (table 8). This could indicate a decline in sprat abundance in the Baltic Sea, locally within the gulls' feeding area or in the Baltic as a whole. Almost all food items show a decrease from 2003-2005 except insects and grain. The latter was however probably excluded from analysis during 2003 and 2004 and therefore not comparable with 2005.

Herring on the other hand differs only slightly in abundance in the Baltic Sea between 2003 and 2004 (figure 5), whereas it differs noticeably in numbers found in gulls' stomachs. There was no significant difference between the amount of sprat and herring in the years of 2003-2005 ($p>0.1$, $df=4$, $\chi^2_c=2$). In all, sprat made up the bulk of the fish species found (table 7, actual amount of fish for all years) and was found in more than half of the samples collected from all years (table 7, freq. of occ.). All food items collected from LBBG between 2003-2005 are shown in figure 6 and table 7.

4 out of 8 food samples from LBBG and 12 out of 49 from HG contained grain in the samples from 2005. The difference between the two species was not significant and therefore no preference for feeding in fields in either species could be proved ($p>0.05$, $df=1$, $\chi^2_c=3$).

As seen in table 9, female LBBG showed a greater tendency to feed on regurgitations than did the males. This could indicate that females have depleted their energy resources to a greater extent than males during the first stages of the breeding season.

Detailed observations of LBBG at Gjaus Häll

30 nests were marked at Gjaus Häll. 13 eggs hatched and nine chicks were marked. All nests and 10 chicks were used in data analysis.

The colony at Gjaus Häll yielded only one sample (one herring), which was included in the data from the colony at Langdal to simplify counting.

Contrasting to the other colonies where the number of feeds was equally divided between the sexes, the females were the dominant sex at Gjaus Häll (m=4, f=18, n=22).

Mean number of feeds/chick and hour over the day, for all days of observation, are shown in figure 7.

Observations

The only identifiable items that were observed fed by parents in both Langdal and Gjaus Häll were fish. In all, 20 fish were seen fed and of those, 14 were clupeids. The other fish were not possible to identify.

Dawn-dusk observations

June 14th

A total of 16 feeds were observed between 03.00 and 23.00 (figure 8). Two chicks were present in the colony on this day. The mean number of feeds/hour was 0.76. The mean number of feeds/chick/hour was 0.4.

June 18th

Observations started 03.00 and ended at 23.00 (figure 8). One feed was observed and the number of chicks present this day was 3. The mean number of feeds/hour was 0.05 and the mean number of feeds/chick/hour was 0.02.

Detailed observations of LBBG at Langdal

100 nests were marked in the colony at Langdal. In total, 99 eggs hatched and 66 chicks were ringed. Not all nests were visible from the hide wherefore only those that were (n=15) are

included in analysis. In those 15 nests, a total of 31 chicks hatched and were used in sampling. Of the 99 hatched eggs, only one chick was observed the last day of field study.

There was no difference between the amount of feeds carried out by the male and the female as they performed 11 feeds each. Mean number of feeds/chick and hour over the day, for all observation days, are shown in figure 9.

Dawn-dusk observations

June 16^{th}
Observations started 03.00 and ended 23.00 (figure 10). 4 feeds were observed and the number of present chicks was 4. The mean number of feeds/hour was 0.19. The mean number of feeds/chick/hour was 0.05.

June 20^{th}
Observations started 03.00 and ended at 23.00 (figure 10). 6 feeds were observed and 5 chicks were present. Mean number of feeds/hour was 0.29 and the mean number of feeds/chick/hour was 0.06.

Energy and fat contents

Energy content was only possible to obtain from sprat and sandeel. It was calculated for those samples where length was possible to deduce from the bones. When calculating energy content the equations provided by Wanless et al. (2005) was used:

Sprat (kJ)= 0.0096*length $(cm)^{3.845}$

Sandeel (kJ)= 0.0081*length $(cm)^{3.427}$

Calculations of energy content in sprat were only possible to make in 6 individuals, all other samples were impossible to use. The mean energy content in sprat from Stora Karlsö in 2005 was 104.3 kJ. The mean energy content as calculated from sprat taken from subdivision 27 and 25 was 128.6 kJ (data provided by Michele Casini at the Swedish Board of Fisheries). Mean energy content in sandeel was 132.2 kJ and was calculated in 5 individuals.

Fat content was possible to obtain from sprat and herring, but not from sandeel. It was calculated as a proportion between fat weight and fish weight (fish without head). Mean fat content in sprat from ICES subdivision 27 and 25 was 15.2 g/100 g fish. Mean fat content in herring in ICES subdivision 25 and 27 was 6.8 g/100 g fish.

Discussion

HG feeding preferences

The differences in food taken by the gulls on the mainland compared to those on Stora Karlsö were marked. Gulls in Blekinge and Skåne fed more extensively on human refuse than did those on Stora Karlsö. HG are often observed feeding on garbage heaps but show generalist behaviour, as they are seen fishing as well as feeding off fishing vessels (Götmark 1984, Furness et al. 1992, Pons 1993). The items found in the food samples from Blekinge/Skåne and Stora Karlsö respectively, clearly shows a difference in food composition. In Blekinge and Skåne, 67% of the samples contained human refuse, whereas only 6% of the samples from Stora Karlsö contained the same food item. The most probable explanation for the difference between Stora Karlsö and mainland gulls is a closer proximity to refuse dumps for the latter and thus a greater availability, rather than a difference in preference. The data analysed in this study shows that HG on the mainland do not forage on fields as there were no food samples containing that particular food item. This might be due to the small data set from the mainland, rather than because gulls in that area never feed on fields.

Clupeids were the most common fish found in HG stomachs. Sprat was found in samples slightly more often than herring. Together they made up almost 50% of the species found. However, as this is the first year of observation, not much can be said about fluctuations in the food web. Both sprat and herring are increasing in numbers as of today, although herring has been decreasing the past 40 years. Garfish is said to be the main choice of prey for HG in Blekinge and Skåne (Lars Carlsson, pers. comm.) This could not be confirmed by the samples collected this year since only two garfish were found in the nine samples that were collected. Mr Carlsson noted that large amounts of leftovers from garfish were lying around the HG nests at the different locations in Blekinge and Skåne. This is however not researched further in this study.

LBBG feeding preferences

Clupeids are the food item most often found in LBBG stomachs on Stora Karlsö, as well as in HG stomachs. It could however not be shown that sprat is the main choice of prey on Stora Karlsö with the present data samples. Sprat constitutes an important food item as it was found in almost one out of five food samples. The samples from LBBG in 2003 and 2004 differed from the samples of 2005. This indicates a difference in food composition in the gulls´ main foraging area. The differences in sprat occurrence in LBBG stomachs from 2003-2005 shows a markedly high number of sprat in 2003 compared to the other years. In 2005, only two sprat were found. It is however not possible to derive from the small data set that the differences are due to a decline in sprat stock in the Baltic Sea. The fact that the sprat spawning stock biomass has increased and reached historically high numbers since the beginning of the nineties makes the differences more likely an effect of local fluctuations in sprat abundance.

The whole day studies were meant to be the basis of all analysis of feeding behaviour but the data turned out to be somewhat difficult to use. As a complement, a rough estimation of feeding frequency per observed hour and day throughout the whole period was made. This shows a peak in feeding during the first quarter of the day (03.00-07.00) as well as in the fourth quarter (17.00-23.00) in all colonies. This correlates well with the expected vertical movements of sprat and herring (Nilsson et al. 2003).

LBBG on Lilla Karlsö has shown an increasing tendency to fly inland and feed on fields, whereas no such pattern has been observed when HG are concerned (pers. comm. Måns

Hjernquist). This year's field study showed that LBBG and HG stomachs contained grain in 4 (n=8) and 14 (n=49) samples respectively. No significant difference could be shown wherefore no difference between the two species can be assumed as far as preference towards feeding on fields is concerned.

The mean feeding rate (0.4 feeds/hour and chick) from LBBG at Gjaus Häll the 14th of June was very high compared to all other mean feeding rates. It might look as though there were a greater activity in the colony on that day, as far as feeding is concerned. This was not the case however; it was rather due to the low number of chicks (n=2) observed that day and the high amount of feeds (n=4) between 19.00 and 20.00.

Other observations

Earthworms were fed quite extensively to chicks on Stora Karlsö. After fish it was the most common choice of prey with 22 % of the total amount of observed feeds (n=114). During the time spent walking between the colonies, gulls were seen closer to the middle of the island on early mornings (pers. obs.). On a few occasions at about 03.00, several gulls (unable to identify species due to darkness) were observed foraging in meadows but were not seen inland later the same day. Also, we felt that earthworms were fed more often when it was raining or had been raining during the night, than on days with sunny/dry weather. This could however not proved and so remains a personal observation.

Due to the methods in data sampling, animals such as nematodes and the soft parts of molluscs will not be seen in food samples. In the process to yield bones from fish, soft tissue is dissolved. The samples are thus biased and the number of fish, beetles, crustaceans and other food items that do not dissolve easily might be overestimated. If one would search food samples before adding dissolving solutions it is possible that those numbers would be different. The level of decomposition was however high and the samples heavily mixed, at least those from 2005, which makes it difficult to find and differentiate items from one another. Observing the feeding gulls from the hide made it possible to note such food items. These observations clearly show that earthworms constitute a rather large amount of the items fed to chicks. During observation, it was noted that more than fifty percent of the regurgitations consisted of fish. This together with the data collected from food samples further strengthens the data collected from the food samples, which shows that gulls on Stora Karlsö feed mostly on fish, and of those, clupeids are the most common.

The theory that insects are not a choice of prey but rather a result of the fact that the gulls feed on fields could not be proved with the present data. If this assumption were correct, one would probably find insects and grain together in the same samples to a large extent. The two items should not be found alone in too great a number of samples either. Insects were found in five of the 14 samples containing grain. In addition, grain together with other assorted food items such as fish was present in eight samples. The immediate assumption would therefore be that gulls somehow ingest insects somewhere else than on fields, as grain would be present more often if that were not the case.

Conclusion

As gulls thrive in areas where human waste is abundant one would expect botulism to be more common in gulls in these areas than on more remote sites as Stora Karlsö. This holds true, as no gull on the island has shown the symptoms so far. It has been shown that botulism more likely follow in the wake of an elevated mortality, rather than causing it. The same can be said about M74, which shows strong similarities with the adult mortality. This disease is known to be the cause of some of the deaths during the recent outbreak of mortality, although not enough to be the reason for the disease. Toxins, or harmful compounds, are addressed as contributing factors, although it has not been sufficiently proved. As Hario et al. has pointed out, there are elevated levels of DDE in LBBG chicks in the Gulf of Finland (2004). In the study made by Mörner et al., (2005) the levels of twelve metals were measured in gulls livers and kidneys. The levels were normal.

Hilton et al. (2000) discovered that when LBBG switched from an energy-dense prey (sprat) to an energy-dilute prey (whiting *Merlangius merlangus*), their digestive performance was impaired. Although one would expect a generalist species such as LBBG to have a digestive system that adapts easily to changes in food composition, it did not hold true in this case. When the opposite switch was studied (from whiting to sprat), LBBG did not show a lessened digestive performance. In that study, the digestive performance of the gulls was compared with that of Common guillemot *Uria aalge*, a specialist feeder. The latter showed, somewhat surprisingly, a greater adaptability to switching food than the former. Regardless the fact that these two species differ in their ecological niche, the data provides relevant information about gulls susceptibility to changes in food composition.

In the work made by Harvey et al. (2003) cod abundance is showed to strongly influence the abundance of sprat in the Baltic Sea, but has little influence on herring abundance. As cod recruitment is still low and biomass of sprat has been increasing since the 1990s, one would expect LBBG to thrive under these circumstances. However, if the absence of cod preying on sprat leads to an increase in sprat numbers, this in turn will increase the intraspecific competition among sprat. As numbers of sprat increase, food (zooplankton) will not be available in an equal amount for all individuals. Hence, total amount of sprat will increase and so will the amount of smaller, more nutrient-deplete sprat as well. In an article from 2005, Wanless et al. points out that a low energy value of fish seemed to be one reason for the major seabird breeding failure in the North Sea.

All in all, a probable explanation might be that all or many of these theories have a synergetic effect on the gulls. When LBBG migrates to Scandinavia from Africa they deplete the energy resources they have built up during wintering. As they arrive at the breeding area, they begin courting and breeding in a rapid fashion, which further drain their energy. The hectic period during brooding and chick rearing, still further affect the adult gulls state of well-being. If, up and until this point, the food available to the gulls is of a lower nutrient value, it will cost them dearly to produce young. A possibility is that they keep more food to themselves in order to survive, which might lead to starvation among the young. Furthermore, if the adult birds are exposed to toxins or other compounds that may affect them negatively, during wintering, it is possible that they are weakened already before departure. The contributing factors might very well affect the gulls negatively to a point where their overall state of health is so low that it increases their susceptibility to common diseases. It is not unlikely that the reason as to why there has not been possible to find one sole factor to this disease is that there is no sole factor.

Acknowledgments

I would like to thank Henrik Österblom and Sture Hansson for invaluable inspiration, motivation and support. I also want to thank Jonas Sundberg for indispensable support during fieldwork, as well as comradeship during and after my stay at Stora Karlsö. Emma Capandegui and Eva Kylberg for supporting me, both personally as well as with matters regarding my project. Further thanks go to Leif Johnson at The National History Museum in Gothenburg, Mattias Lif, Lasse Carlsson, and Tom Arnbom for help with fieldwork and expertise. Michele Casini at the Swedish Board of Fisheries, who provided valuable data. I am also grateful towards the Lindberg Foundation for Bird Research, who financed this project through WWF, and Karlsö Jagt och Djurskyddsförening AB for allowing us to perform studies on Stora Karlsö.

References

Bech C, Langseth L, Moe B, Fyhn M, Gabrielsen G W 2002, *The energy economy of the arctic-breeding Kittiwake* (Rissa tridactyla): *a review.* Comparative biochemistry and physiology Part A 133, pp 765-770

Bengtsson B-E, Hill C (eds.) 1999, *Summary of the second workshop on reproductive disturbances in fish.* Nordic research cooperation on reproductive disturbances in fish, TemaNord 1999:530, pp 21-24

Casini M, Cardinale M, Hjelm J 2005, *Inter-annual variation in herring (*Clupea harengus*) and sprat (*Sprattus sprattus*) condition in the central Baltic Sea: what gives the tune?* OÌKOS 00:1-13

Coulson, J C, Monaghan P, Butterfield J E L, Duncan N, Ensor K, Shedden C, Thomas C 1983, *Scandinavian Herring Gulls wintering in Britain.* Ornis Scand 15: 79-88

Furness R W, Ensor K, Hudson AV 1992, *The use of fishery waste by gull populations around the British Isles.* Ardea 80: 105-113

Garthe S, Scherp B 2003, *Utilization and offal from commercial fisheries by seabirds in the Baltic Sea.* Ices Journal of Marine Science, vol 60, issue 5, pp 980-989

Gilliland S G, Ankney C D, Hicklin P W 2004, *Foraging ecology of Great black-backed gulls during brood-rearing in the Bay of Fundy, New Brunswick.* Can. J. Zool. 82, pp 1416-1426

Gärdenfors U (ed) 2005, *Rödlistade arter i Sverige 2005 – The Red list of Swedish Species, Artdatabanken.* SLU, Uppsala

Götmark F 1984, *Food and foraging in five European* Larus *gulls in the breeding season: a comparative review.* Ornis Fennica vol 61, pp 8-16

Hario M, Himberg K, Hollmén T, Rudbäck E 2000, *Polychlorinated biphenyls in diseased LBBG* Larus fuscus fuscus *chicks from the Gulf of Finland.* Environmental Pollution, vol 107, issue 1, pp 53-60

Hario M, Hirvi J-P, Hollmén T, Rudbäck 2004, *Organochlorine concentrations in diseased vs. healthy gull chicks from the northern Baltic.* Environmental Pollution, vol 127, no 3, pp 411-423

Harvey C J, Cox S P, Essington T E, Hansson S, Kitchell J F 2003, *An ecosystem model of food web and fisheries in the Baltic Sea.* ICES Journal of Marine Science, vol 60, issue 5, pp 939-950

Hilton G M, Furness R W, Houston DC 2000, *The effects of diet switching and mixing on digestion in seabirds.* Func. Ecol. 14: 145-154

Härkönen T 1986, *Guide to the otoliths of the bony fishes of the northeast Atlantic.* Danbiu ApS

Kilpi M, Öst M 1998, *Reduced availability of refuse and breeding output in a herring gull* (Larus argentatus) *colony.* Ann. Zool. Fennici 35: 37-42

Koski P, Bäckman C, Pelkonen O 2005, *Pharmacokinetics of thiamine in female Baltic salmon* (Salmo salar L.) *broodfish.* Environmental Toxicology and pharmacology, vol 19, pp 139-152

Kornilovs G, Sidrevics L, Dippner J W 2001, *Fish and zooplankton interactions in the central Baltic Sea.* ICES Journal of Marine Science, 58:597-588

Kubetzki U, Garthe S 2003, *Distribution, diet and habitat selection by four sympatrically breeding species in the south eastern North Sea.* Marine Biology 143, pp 199-207

Liebers D, Helbig A J 2002, *Phylogeography and colonization history of Lesser Black-backed gulls* (Larus fuscus) *as revealed by mtDNA sequences.* J. Evol. Biol 15, pp 1021-1033

Lif M, Hjernquist M, Olsson O, Österblom H 2005, *Long-term population trends in the Lesser-Black backed gull* Larus f. fuscus *at Stora Karlsö and Lilla Karlsö, and initial results on breeding success.* Ornis Svecica vol 15, no 2, pp 105-112

Lyngs P 1992, *Ynglefuglene på Graesholmen 1925-90.* Dansk Ornitologisk Tidskrift, 86: 1-93

Mayr E 1963, *Animal Species and evolution.* Harvard University Press, cop.

Matthäus W, Franck H 1992, *Characteristics of major Baltic inflows – a statistical analysis.* Cont. Shelf Res 12:1375-1400

Mitchell P I, Newton S F, Ratcliffe N, Dunn T E 2001, *Seabird Populations of Britain and Ireland.* T&AD Poyser London

Moe B, Langseth L, Fyhn M, Gabrielsen G W, Bech C 2002, *Changes in body condition in breeding kittiwakes* Rissa tridactyla. Journal of avian biology 33, pp 225-234

Möllmann C, Köster F W 2002, *Population dynamics of calanoid copepods and the implications of their predation by clupeid fish in the central Baltic Sea.* Journal of plankton research, vol 24, no 10, pp 959-977

Möllmann C, Kornilovs G, Fetter M, Köster FW 2004, *Feeding ecology of central Baltic Sea herring and sprat.* Journal of fish biology, vol 65, pp 1563-1581

Murphy T, Lawson A, Nalewajko C, Murkin H, Ross L, Oguma K, Mcintyre T 2000, *Algal toxins – Initiators of avian botulism?* Environ. Toxicol. 15:558-567

Mörner T, Uhlhorn H, Ågren, H, Bernodt K, Mattson R, Bröjer C, Nilsson K, Gavier-Widén D, Jansson, D S, Christensson D A, Petersson L, Niemanis A 2005, *Onormalt hög dödlighet bland trutar och annan sjöfågel längs Sveriges kuster och i inlandsvatten.* Svensk Veterinär Tidning, vol 57, no 8-9, pp 11-18

Nilsson L A F, Thygesen UH, Lundgren B, Nielsen B F, Nielsen R, Beyer J E 2003, *Vertical migration and dispersion of sprat* (Sprattus sprattus) *and herring* (Clupea harengus) *schools at dusk in the Baltic Sea.* Aquatic Living Resources 16: 317-324

Pons J-M 1993, *Feeding strategies of male and female Herring gulls during the breeding season under various conditions.* Ethology Ecology & Evolution 6, pp 1-12

Rolland R M 2000, *A review of chemically-induced alterations in thyroid and vitamin A status from field studies of wildlife and fish.* Journal of Wildlife Diseases, 36(4), pp 615-635

Strann K B, Vader W 1986, *Registrering av hekkende sjøfugl i Troms og Vest-Finnmark 1981-1986.* Tromsø

Strann K B, Vader W 1988, *Registrering av sjøfugl i Barents hav Syd AKUP 1985-1988.* Tromsø

Schwemmer P, Garthe S 2005, *At-sea distribution and behaviour of a surface-feeding seabird, the Lesser black-backed gull* Larus fuscus *and its association with different prey.* Marine ecology progress series, vol 285, pp 245-258.

SMI 2005
http://www.smittskyddsinstitutet.se/SMItemplates/Article____2228.aspx

Svensson L, Grant P J, Mullarney K, Zetterström D 1999, *Fågelguiden: Europas och Medelhavsområdets fåglar i fält.* Albert Bonniers Förlag

Votler S C, Furness R W, Bearhop S, Crane J E, Caldow R W G, Catry P, Ensor K, Hamer K C, Hudson A V, Kalmbach E, Klomp N L, Pfeiffer S, Phillips R A, Prieto I, Thompson D R 2004, *Changes in fisheries discard rates and seabird communities.* Nature, vol 427, pp 727-730

Wanless S, Harris M P, Redman P, Speakman J R 2005, *Low energy values of fish as a probable cause of a major seabird failure in the North Sea.* Mar Ecol Prog Ser Vol 294:1-8

Appendix

Table 1. The coordinates where the samples in Blekinge and Skåne were collected

Getskär	6224308-1487311
Torraskär	6216918-1490033
V. Björkskärv	6223768-1461878
Lägerholmen	6204792-1416711
Brödjeholmen	6205032-1415045
Trueskär	6205591-1414197

Table 2. Food samples from HG in Blekinge and Skåne. Percentages in Freq. of occ. derived from total amount of samples collected. Percentages in Number derived from total amount of fish found in samples.

	Sprat	%	Herring	%	Pollack	%	Garfish	%	Human refuse	%
Freq. of occurrence	1	11	1	11	1	11	2	22	6	67
Number	2	33	1	17	1	17	2	33	-	-

Table 3. Number of times natural food and non-natural food occurred in samples at the two HG sites. The difference between the sites was significant ($p<0.001$, df=1, $x^2_c=13$). Difference in occurrence of human refuse in samples differed significantly between the sites ($p<0.001$, df=1, $x^2_c=21$).

	Natural food	Non-natural food	Human refuse	No human refuse
Blekinge and Skåne	3	6	6	3
Karlsö	47	11	3	46

Table 4. Amount of fish found in HG stomachs from Blekinge and Skåne and Stora Karlsö respectively. Column B with clupeids distributed between sprat and herring.

Herring gull	Blekinge and Skåne	Karlsö	
		A	B
Sprat	2	13	22
Herring	1	7	12
Three-spined stickleback	0	1	1
Stickleback	0	12	12
Clupeid spp	0	14	0
Offal/refuse from fish	0	9	9
Eelpout	0	2	2
Garfish	2	0	0
Pollack	1	0	0
Sandeel	0	7	7

Table 5. All food items from HG in Blekinge and Skåne and on Stora Karlsö. Upper half of table shows which species of fish that were found in samples, and the exact amount. Lower half of table shows all food items and the ratio of distribution.

Fish	Blekinge and Skåne	%	Östra Suderslätt	%	Gjaus Häll	%	Karlsö	%
Sprat	2	33	8	31	5	13	13	20
Herring	1	17	6	23	1	3	7	11
Three-Spined Stickleback	-	-	1	4	-	-	1	2
Stickleback	-	-	-	-	12	31	12	18
Clupeid spp.	-	-	6	23	8	21	14	22
Offal/refuse from fish	-	-	2	8	7	18	9	14
Eelpout	-	-	1	4	1	3	2	3
Garfish	2	33	-	-	-	-	-	-
Pollack	1	17	-	-	-	-	-	-
Sandeel	-	-	2	8	5	13	7	11
Total amount of fish	6		26		39		65	

Frequency of occurrence	Blekinge and Skåne	%	Östra Suderslätt	%	Gjaus Häll	%	Karlsö	%
Sprat	1	11	5	21	4	16	9	18
Herring	1	11	6	25	1	4	7	14
Three-spined stickleback	-	-	1	4	-	-	1	2
Stickleback	-	-	-	-	1	4	1	2
Clupeid spp.	-	-	6	25	6	24	12	24
Offal/refuse from fish	1	11	2	8	7	28	9	18
Pollack	1	11	-	-	-	-	-	-
Eelpout	-	-	1	4	1	4	2	4
Garfish	2	22	-	-	-	-	-	-
Sandeel	-	-	1	4	4	16	5	10
Bird	-	-	1	4	2	8	3	6
Grain	-	-	5	21	7	28	12	24
Insects	-	-	5	21	6	24	11	22
Human refuse	6	67	2	8	1	4	3	6
Total amount of samples	9		24		25		49	

Table 6. Number of times that HG males and females were observed to feed from regurgitated food in Gjaus Häll. The difference between the two sexes was significant ($p<0.05$, df=1, $\chi^2_c=4$).

	Feeding	Not feeding
Male	50	37
Female	37	50

Table 7. Food items found in LBBG stomachs from 2003-2005. Percentages derived from total amount of fish for each year and amount of samples respectively. Upper half of table shows which species of fish that were found in samples, and the exact amount. Lower half of table shows all food items and the ratio of distribution.

Fish	2003	%	2004	%	2005	%	All years	%
Sprat	17	54	7	68	2	13	26	48
Herring	8	15	2	32	4	25	14	26
Clupeid	-	-	-	-	2	13	2	4
Three-spined stickleback	-	-	4	31	8	50	12	22
Total amount of fish found	25		13		16		54	
Freq. Of occ.	2003	%	2004	%	2005	%	All years	%
Sprat	4	67	8	89	1	13	13	57
Herring	2	33	2	22	4	50	8	35
Three-spined Stickleback	3	50	-	-	1	13	4	17
Clupeid	-	-	-	-	2	25	2	9
Insects	1	17	-	-	3	38	4	17
Grain	-	-	-	-	4	50	4	17
Nr of samples examined	6		9		8		23	

Table 8. Difference in food composition between 2003-2005 was statistically significant ($p<0.05$, df=4, $\chi^2_c=9$). Unidentified clupeids (n=2) from 2005 was proportionally distributed between sprat and herring.

	Sprat	Other fish
2003	17	8
2004	7	6
2005	3	12

Table 9. Number of times that LBBG males and females were observed to feed from regurgitated food. The difference between the two sexes was statistically significant ($p<0.002$, df=1, $\chi^2_c=9$)

	Feeding	Not feeding
Male	6	16
Female	16	6

Figure legends

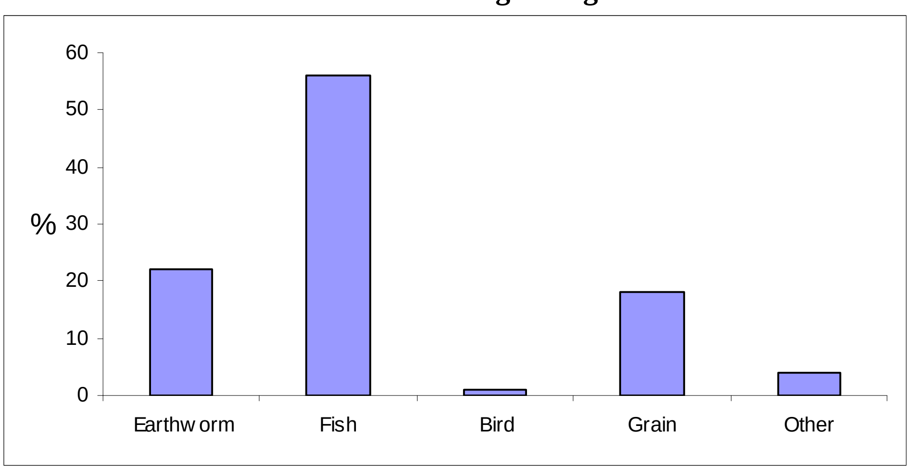


Figure 1. Observed feeds of HG on Stora Karlsö 2005. Derived from the total amount of observed feeds (n=114) where items could be identified.

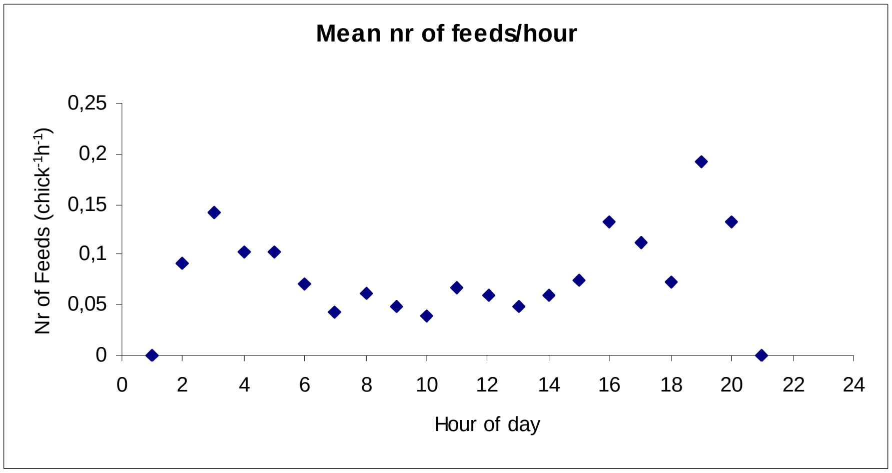


Figure 2. HG in Gjaus Häll. Mean nr of feeds during the day, calculated from all days of observations Zero points on the x-axis indicate observations with no feeds.

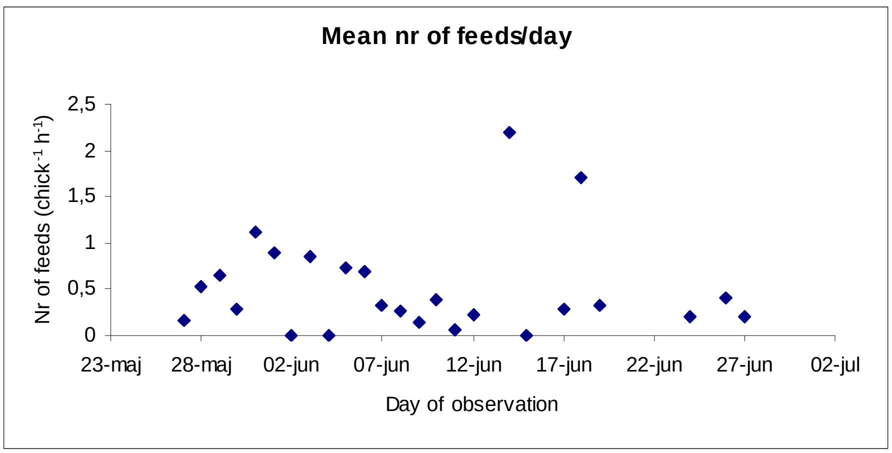
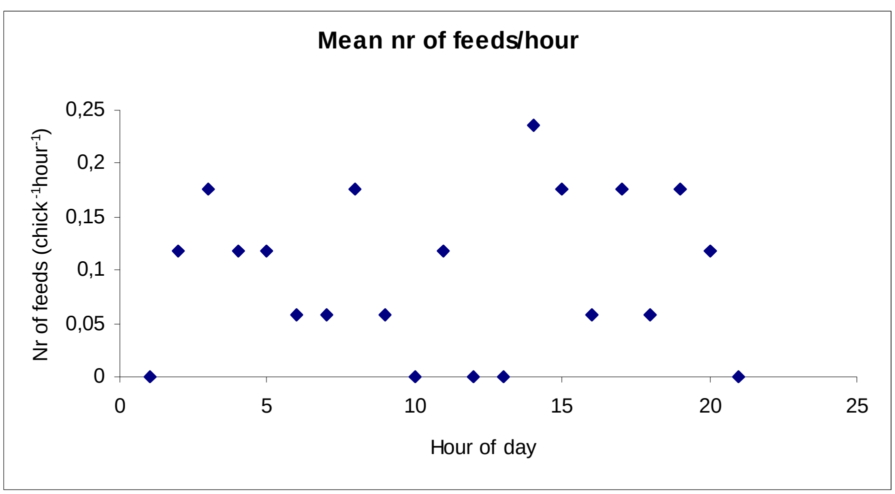


Figure 3. HG in Gjaus Häll. On the 14th and the 18th the whole day observations were made, hence the high number of feeds on those dates.



Fel!

Figure 4. HG whole day observations on June 14th and 18th. Zero points on the x-axis indicate observations with no feeds.

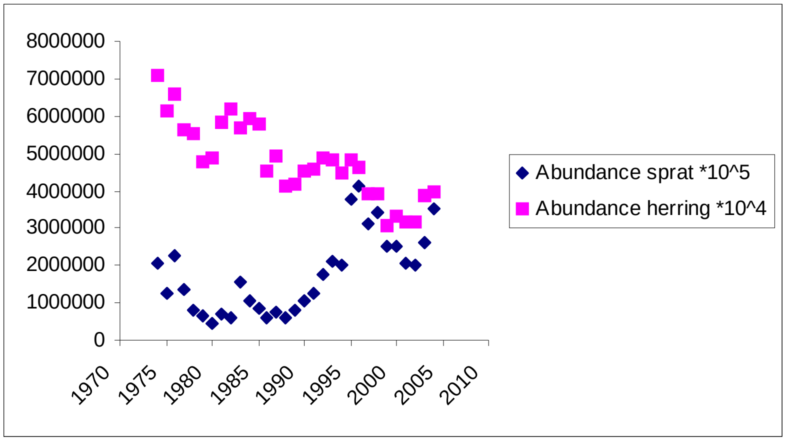


Figure 5. Sprat and herring abundance in the Baltic Sea between 1974-2004. Data supplied by the Swedish Board of Fisheries.

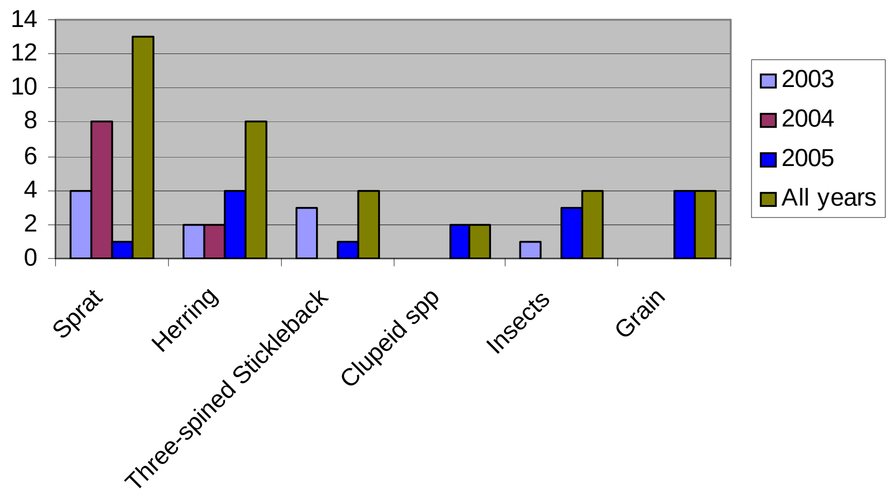


Figure 6. Distribution of food items in LBBG stomachs on Stora Karlsö from 2003-2005.

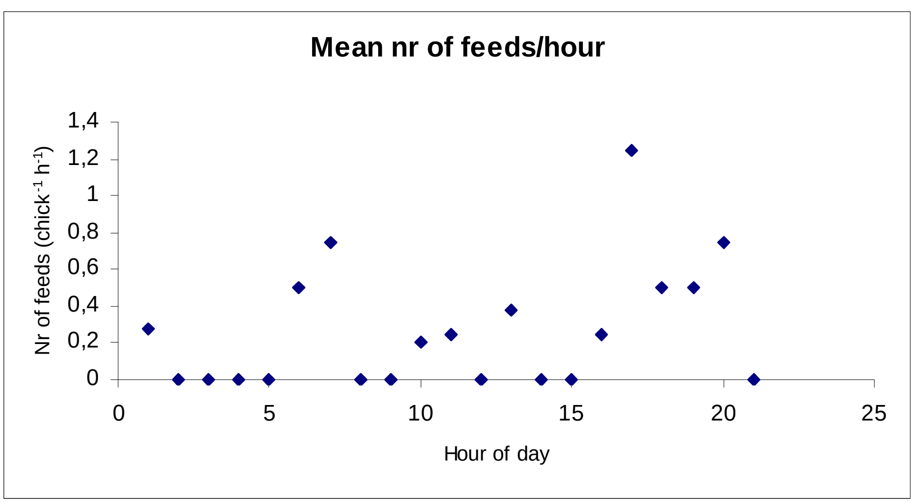


Figure 7. LBBG in Gjaus Häll. Mean nr of feeds for all days of observation. Zero points on the x-axis indicate observations with no feeds.

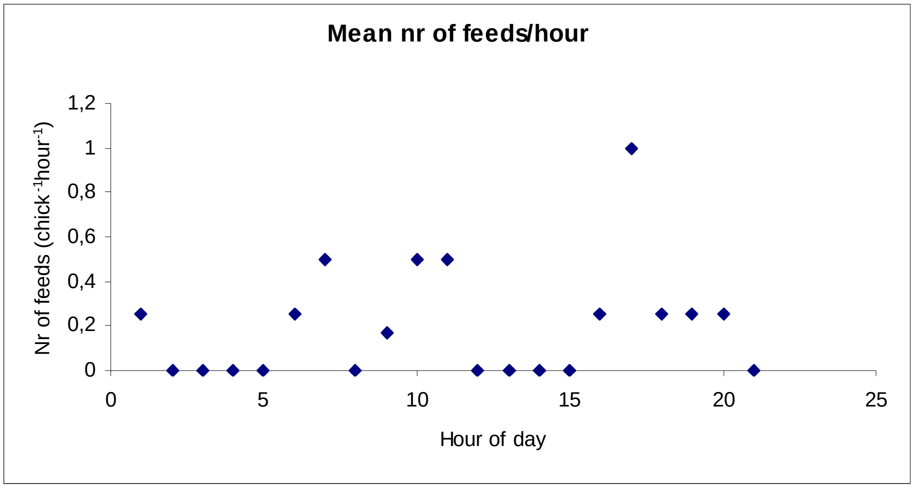


Fig 8. LBBG whole day observations at Gjaus Häll on June 14th and 18th.

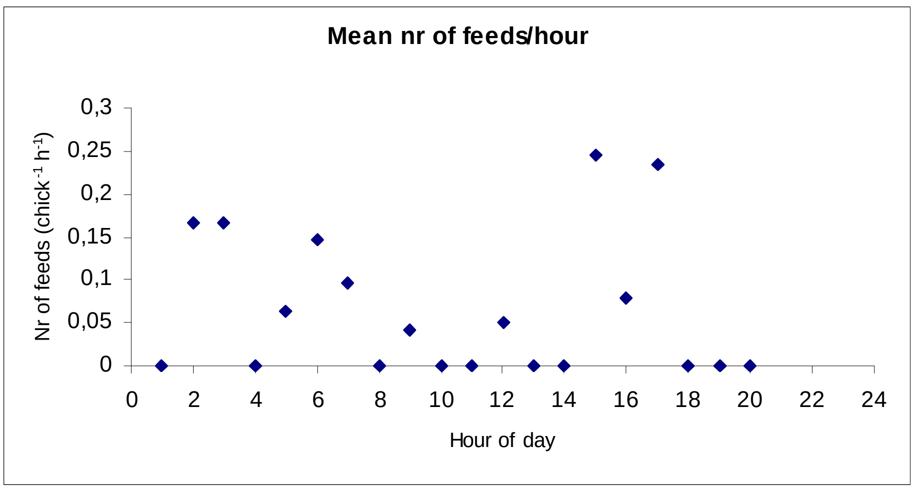


Figure 9. LBBG in Langdal. Mean nr of feeds for all days of observation. Zero points on the x-axis indicate observations with no feeds.

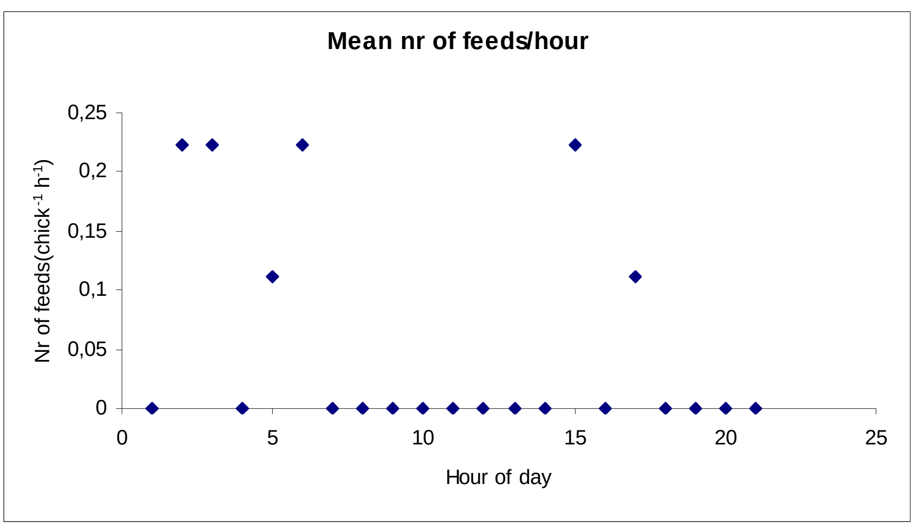


Figure 10. LBBG whole day observations at Langdal on June 16th and 20th.