MARINE FOOD OF KELP GULLS, LESSER SHEATHBILLS AND IMPERIAL CORMORANTS AT MARION ISLAND (SUBANTARCTIC)

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INTRODUCTION

The three resident bird species of Marion and Prince Edward Islands, the Kelp Gull *Larus dominicanus*, Lesser Sheathbill *Chionis minor* and Imperial Cormorant *Phalacrocorax atriceps* are important predators of intertidal and inshore marine organisms. The birds' diets are little affected by human activities and pollution. One polluting factor is waste food, normally thrown out by the staff of the research station, which is eaten by local gulls, sheathbills and Subantarctic Skuas *Catharacta antarctica*. During the major part of this study all waste food was retained and frozen for removal by the relief ship. The installation of an incinerator for food disposal has been recommended.

The Kelp Gulls feed mainly on marine animals but also scavenge and prey on terrestrial invertebrates (Burger 1980). The terrestrial Lesser Sheathbills are wide niched feeders which use the intertidal zone as one of their feeding habitats. Imperial Cormorants feed exclusively on marine species and this study is only a preliminary assessment of their diet. The inshore marine environment is thus important to the livelihood of these three avian species and the aim of this study is to describe their trophic relationships with sea life. The work presented here is part of an ongoing project investigating the marine food web operative at Marion Island shores.

MATERIALS AND METHODS

All shells of the limpet *Nacella* (*Patinigera*) *delesserti* which had been deposited by feeding gulls on Boulder Beach, a 150 m stretch of rocky beach in front of the research station, were collected in October 1979. Subsequent monthly collections were made until May 1980 and were sorted into 5 mm size classes to provide information on the size distribution and numbers of *Nacella* preyed upon. Timed observations of gulls hunting and consuming *Nacella* provided data for the estimation of individual feeding rates.

Intact regurgitations were collected from sites where Kelp Gulls congregated. The lengths of regurgitated *Nacella* shells were recorded for comparison with the beach samples. Regurgitations consisting solely of crushed shells of the bivalve *Gaimardia trapesina* were dried at 60°C for 24 h and then weighed to the nearest 0,1 g. Fresh samples of over 100 *Gaimardia* were disected and flesh and shells dried separately at 60°C to determine the number of *Gaimardia* represented in an average regurgitation.

Further observations of gull feeding activities were made elsewhere at Marion Island and also at Prince Edward Island.

Lesser Sheathbill faeces were collected on 17 different occasions from the intertidal and splash zones between January and May 1980. Prey remains were sorted to species level and all invertebrates counted. The percentage volume of seaweeds and invertebrates was estimated by eye. Starfish *Anasterias rupicola* which had been attacked by Lesser Sheathbills were collected and examined in the laboratory to assess which parts had been eaten. Observations of sheathbills feeding in the intertidal zone provided additional qualitative information on their diet. *Nacella* shells from sheathbill nests were measured and counted.

Two regurgitations from adult cormorants and the stomach contents of a dead chick were examined for prey species composition. Observations of the feeding habits of this species were made where possible.

RESULTS

Kelp Gulls

Kelp Gulls fed mainly on intertidal *Nacella* and the offshore bivalve *Gaimardia trapesina*. Starfish *Anasterias rupicola* and the fish *Harpagifer bispinis* and *Notothenia macrocephala* were also eaten. The gulls hunted for limpets in shallow water during calm conditions. They floated on the surface within a few metres of the shore looking into the water directly beneath them. After stabilizing their position over a suitable limpet, they plunged their heads and sometimes most of their bodies into the water to capture a limpet from depths of up to 400 mm. Observations on seven gulls showed that a total of 77 dives in 175 minutes resulted in the capture and ingestion of 25 *Nacella*, indicating that one in three dives was successful and about seven minutes were needed to search for, catch and consume one *Nacella* including unsuccessful capture attempts. Small limpets were swallowed whole and shells regurgitated later, whilst larger specimens were carried to the shore and the soft parts eaten there. It took gulls one to two minutes to eat a captured limpet. Generally *Nacella* with shell lengths ranging from 40 mm to 55 mm were most heavily preyed on (Fig. 1). Regurgitated shells were comparatively rare.

Empty *Nacella* shells accumulated on the beach; 2 089 shells were removed during the initial clearing and thereafter a mean monthly total and standard deviation of 441 + 236 was found from November 1979 to May 1980. No data were collected for March when unusually heavy seas swept the entire beach. No more than three gulls were ever seen hunting limpets simultaneously at Boulder Beach and the shells deposited on the beach were probably the result of feeding by the six to 15 gulls usually counted in the vicinity of the research station. Specific sites were chosen for the consumption of limpets on the shore. Large numbers of shells (up to 400) were collected from small eating sites (approx. 0,5 m^2) elsewhere on the island, i.e. Paddy Rocks, Trypot Beach, Kildalkey Bay and at Prince Edward Island.

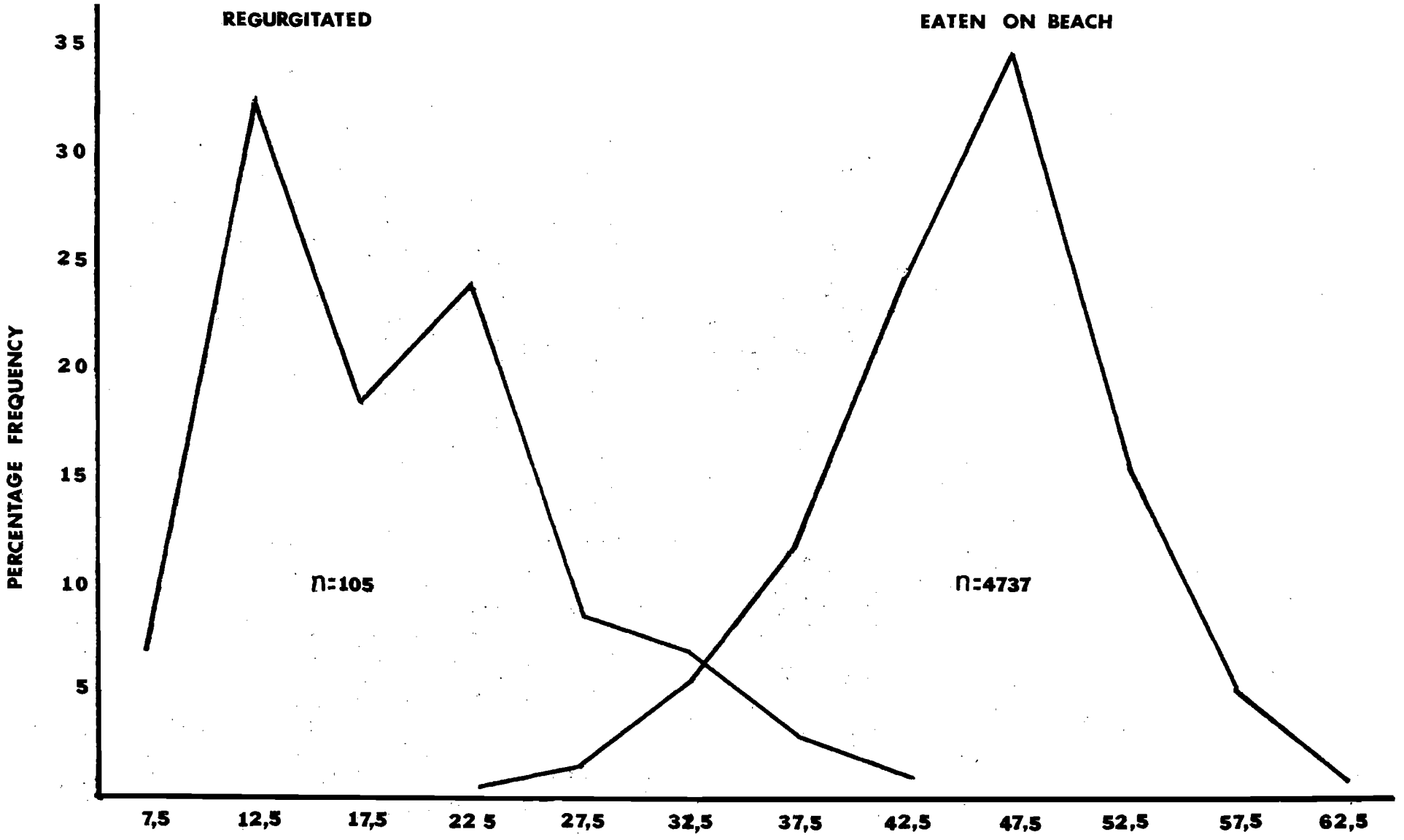

Figure 1

Size class distribution of *Nacella* shells regurgitated by Kelp Gulls *Larus dominicanus* (N = 105) versus shells deposited on the beach by feeding gulls at Marion Island (N = 4 737)

The gulls also flew to the *Macrocystis* kelp beds (50 - 150 m offshore) to feed on the fragile pink bivalve *Gaimardia trapesina*. *Gaimardia* formed dense colonies on *Macrocystis* fronds and the gulls removed whole shells (15 - 30 mm long) from the upper fronds and swallowed them. The shells were crushed in the stomach and regurgitated later. Regurgitations after feeding on *Gaimardia* usually consisted entirely of *Gaimardia* shells indicating that the gulls fed to capacity on this bivalve, although any soft-bodied prey would not have been represented in regurgitations. A sample of 13 whole *Gaimardia* disected from Marion Island Kelp Gull stomachs had a mean longitudinal shell diameter and standard deviation of 22,9 $\pm$ 1,9 mm (J. Cooper, unpubl. data). Thirty-two intact *Gaimardia* regurgitations had a mean dry mass of 9,6 $\pm$ 2,5 g which would represent the shells of 8,5 $\pm$ 4,8 *Gaimardia* from the 20 - 25 mm size class. The extent of gulls' predation on *Gaimardia* is especially noticeable at Prince Edward Island where regurgitated *Gaimardia*, *Nacella* shells and odd bones have formed layers in the peat and built up into series of strata 500 mm deep.

Ossicles of the starfish *A. rupicola* occurred in about 5 % of the regurgitations studied and on two occasions gulls were observed to peck and soften starfish before swallowing them. Only one gull was observed catching a fish *H. bispinis* (60 mm long) which it caught in a shallow intertidal pool by quickly seizing it in its beak and a single specimen of the fish *N. macrocephala* (90 mm long) was recovered from a gull chick at a nest site.

Lesser Sheathbill

The Lesser Sheathbill regularly consumed intertidal organisms on the Marion Island shore. The analysis of faeces showed that seaweeds, especially *Porphyra*, formed the major portion of the diet (Table 1). The limpet *Kerguelenella lateralis*, amphipod *Hyale grandicornis*, beetle *Ectemnorrhinus similis* and small *Nacella* were the most important animal components of the diet. The Lesser Sheathbill was seen to remove intertidal *Nacella* up to 35 mm long from rocks and to eat their flesh. They also fed on the starfish *A. rupicola* from shallow gullies at low tide. Twenty-six starfish which had been attacked by sheathbills had a mean diameter and standard deviation of 42,9 $\pm$ 15,6 mm. Parts of the arms were pecked from 54 % of the sample, stomach and pyloric caecae removed from 46 % and gonads from 27 %. One sheathbill was seen to peck and soften a small (15 mm) starfish and swallow it whole but otherwise only selected parts of larger starfish were consumed. Sheathbills also fed on the polychaete *Platynereis australis* which they removed from their tubes at low tide. This was seen on nine occasions during eight months of fieldwork. They also ate the remaining flesh from *Nacella* shells left by gulls. A mean and standard deviation of 9,1 $\pm$ 4,6 *Nacella* shells were found at eight sheathbill nests but their large size ($\bar{x}$ = 44,4 mm) suggests that these shells were taken there from gull feeding sites rather than representing predation by sheathbills. Lesser Sheathbills are known to decorate their nest entrances with various pale coloured objects (Burger 1979).

TABLE 1

ANALYSIS OF LESSER SHEATHBILL *CHIONIS MINOR* FAECES FROM MARION ISLAND. N = 140 FAECES

Species	Counts	% Volume
Seaweeds		
Porphyra		87
Ulothrix		3
Rhodymenia		4
Lithothamnia		< 1
Invertebrates & others		
Hyale grandicornis	210	
Kerguelenella lateralis	96	
Ectemnorrhinus similis	78	
Insect larvae	31	
Stones & gravel	30	
Jassa falcata	17	5
Nacella delesserti	8	
Kelp flies	5	
Shakeltonia sp.	2	
Laevilitorina caliginosa	1	
Exosphaeroma gigas	1	
Gaimardia trapesina	1	

TABLE 2

COMBINED ANALYSIS OF TWO REGURGITATIONS AND ONE SAMPLE OF STOMACH CONTENTS FROM THE IMPERIAL CORMORANT *PHALACROCORAX ATRICEPS* AT MARION ISLAND

Prey Species	Frequency	Wet Mass (g)	% Wet Mass
Nauticavis marionis	33	14,0	10
Harpagifer bispinis	13	31,2	22
Squid beaks	9 prs	(1,5)	(1)
Notothenia macrocephala	3	77,5	56
Polychaete (unident.)	2	13,5	9,6
Salp (unident.)	1	2,0	1,4

Imperial Cormorant

Imperial Cormorants dived for fish and other prey in the shallow subtidal amongst bull kelp *Durvillea antarctica* and in the deep *Macrocystis pyrifera* kelp holdfast zone (10 - 15 m deep) and probably even further and deeper offshore. The results show that the fish *H. bispinis* and *N. macrocephala* formed the largest part of the cormorant diet although they also took the shrimp *Nauticavis marionis*, squid and polychaetes (Table 2). Mean body length and standard deviation of the 13 *H. bispinis* was 53,2 $\pm$ 12,2 mm and 114,7 $\pm$ 9,1 mm for the three *N. macrocephala*.

DISCUSSION

The Kelp Gull has a wide distribution in the Antarctic and Subantarctic where limpets form the major part of its food supply (Ealey 1954, Downes *et al.* 1959, De Villiers 1976, Simpson 1976, Maxon & Bernstein 1980). The Kelp Gulls of Marion Island preyed almost exclusively on two marine molluscs *Nacella delesserti* and *Gaimardia trapesina*. The high densities of both these prey species and the regularity with which they are eaten make them an important food source for the gulls. Snorkelling amongst the *Macrocystis* revealed that few *Gaimardia* occupy the upper fronds compared to the dense encrustations two to three metres deeper, suggesting that gulls take a heavy toll of this bivalve near the surface. *Nacella* is abundant in the belt where gulls hunt although less so than in water a metre or two deeper, but this could simply be caused by the shorebreak and not as the result of gull predation pressure. Kelp Gulls thus use two fairly specialized hunting techniques at Marion Island which reward them with a substantial supply of limpets and bivalves. The superior scavenging ability of the aggressive Subantarctic Skua on land has probably put pressure on the gulls to utilize marine organisms.

The Lesser Sheathbill is basically an opportunistic feeder which will investigate any likely source of food. Its littoral diet at other Subantarctic islands is not as well documented as that of the Kelp Gulls but is reported to feed on kelp flies (Ealey 1954), seaweeds (Downes *et al.* 1959) and seaweeds and limpets (Jones 1963). The most comprehensive study on Lesser Sheathbills is that of Burger (1980) who listed the intertidal zone and kelp jetsam as two of their 10 feeding habitats. Similarly Burger (1980) listed 11 basic categories of food consumed by sheathbills of which five were of littoral origin, namely *Porphyra*; limpets, chitons and starfish; amphipods; and kelp flies and larvae. The large quantities of seaweed which they ingest are voided in a fairly undigested state and further research will determine how much food energy they derive from them. Amphipods are plentiful amongst intertidal algae but no unusually high concentrations were found in faeces, suggesting that they are either not readily available for exploitation by sheathbills or they are not actively sought (Burger 1980). Lesser Sheathbills feeding on invertebrates (kelp flies, larvae and aligochaetes) from amongst kelp jetsam was not investigated in this study but Burger (1980) records this food source. Intertidal macroinvertebrates such as limpets, starfish and polychaetes are probably afforded a fair degree of protection against exploitation from sheathbills by the

heavy coverage of the bull kelp *Durvillea antarctica* over gullies and rock pools at low tide.

Little is known of cormorant feeding habits from Antarctic islands and Downes *et al.* (1959) only reported that the stomach contents of the Imperial Cormorant at Heard Island consisted mostly of notothenid fish *Notothenia cyanobranchia*, squid beaks, isopods and amphipods. In the present study Imperial Cormorants were found to be strongly piscivorous and the many small, fairly slow swimming fish which occurred in shallow water were readily pursued and captured. The diet of the cormorants at Marion Island is obviously more complex than described here and the unidentified salp and giant polychaetes in the regurgitations, previously unknown from Marion Island, may originate from much deeper offshore waters. Further work on the food of cormorants at Marion Island will be very useful but the small populations and erratic recruitment would make sampling of gut contents difficult (A.J. Williams, pers.comm.).

There is little possibility of competition for marine food by the three species of birds because they all essentially feed on different kinds of prey from different habitats. No serious attempt was made to assess the impact on marine organisms by the birds although Kelp Gulls seemed to deplete *Nacella* and *Gaimardia* stocks in the zones where they were available as prey. Lesser Sheathbills remove a large amount of *Porphyra* from intertidal and spray zone rocks and possibly eat a significant portion of this species' standing stock each year. Similarly, Imperial Cormorants could have a significant controlling effect on the local fish population. Since the three bird species are the only ones which remain on the island throughout the year and thus are entirely dependent on the local food, it seems likely that intraspecific competition for this food is an important factor controlling their population abundance.

All three species studied must cause some degree of mineral enrichment of island soil by their direct placement of marine derived minerals on to the soil in faeces and regurgitations. Quantitative estimates of guano production by the three species are given by Burger *et al.* (1978). Areas inhabited by Kelp Gulls had soils and plants significantly enriched with nitrogen and phosphorous (Smith 1978). The effect of scattered sheathbill faeces on soil enrichment and vegetation growth is still unknown and cormorants usually colonize cliffs at the ocean's edge, so presumably their guano only enriches their nesting sites before returning to the sea. Future work should be directed at determining the biological significance of these manuring activities.

The littoral environment of Marion Island is a rich source of food for the three resident avian species which forage within it and exploitation of these resources at the primary (seaweeds), secondary (limpets, bivalves, amphipods and shrimps) and tertiary levels (starfish and fish) provides a strong link between the terrestrial and local marine systems.

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