Editorial

FOOD AND FEEDING ECOLOGY OF SEABIRDS OFF THE NORTH-EAST AUSTRALIAN COAST

G. C. SMITH

Fauna Conservation and Ecology Section, DPI Forest Service, 80 Meiers Road, Indooroopilly, Qld 4068

Where do they go fishing? What do they eat? How much do they eat? How much food is derived from human activities? Although seabirds are a conspicuous component of the tropical and subtropical waters adjacent to the Queensland coast, there is little information on where seabirds in this region go to obtain their food, the specific components of their diet, how these change seasonally, the amount of food consumed and how human activities have modified their feeding habits, particularly in relation to trawling.

We hope that this issue of *Corella*, and *Corella* 17(3), help to unfold some of that story by bringing together important information on the distribution of seabirds along the Queensland coast and the oceanographic patterns that shape their foraging habits. Much of the distributional data on seabirds in this region were collected by Brian King and Terry Walker before their untimely deaths. Brian and Terry worked tirelessly as seabird ecologists, making significant additions to the knowledge and understanding of seabirds in the vast ecosystem that lies off the Queensland coast and their data-bases are sound foundations for the future.

THE SEABIRD COMMUNITY

Twenty-two species of seabird (excluding wading birds such as Reef Heron *Egretta sacra*) breed in the seas adjacent to the Queensland coast (Table 1), an area which includes waters from the eastern seaboard to the outermost reefs of the Great Barrier Reef and the Gulf of Carpentaria. Six species breed on islands that occur in the Coral Sea (Table 1). An estimated 554 000 breeding pairs (all species combined) occur within this total area (data derived from the Seabird Island Series of *Corella*). While many of these birds probably forage well beyond the continental shelf off the Queensland coast and beyond the Coral Sea during their non-breeding season, the half-million odd breeding seabirds imply that considerable marine resources must exist in the area.

Much is known of the general types of prey taken by these seabirds from work elsewhere (Table 1) but little is known of the species taken in this region or of the seasonality and reliability of food supplies.

It is crucial to wildlife management of the Great Barrier Reef, that this lack of information be redressed.

AVAILABILITY OF PREY

The region contains a diverse array of marine environments that support an equally diverse range of marine communities. These include the important coral reef communities of the Great Barrier Reef, the soft bottom communities between reefs and, in the Gulf of Carpentaria, the inshore seagrass communities, the deep oceans seaward of the Great Barrier Reef and the submerged seamounts capped with coral reefs in the Coral Sea.

Many of the seabirds (particularly terns) which occur in this region probably feed on fast growing bait fish (Clupeids and Atherinids), as they do in other places through their range (Table 1). Flying fish (Exocoetids) and squid are fed on by boobies and tropicbirds, and krill (or small Crustaceans) are an important food for species such as the Wedge-tailed Shearwater *Puffinus pacificus*.

While the types and abundance of prey will determine seabird densities and composition in the region, so too do the interactions of various marine organisms with each other and their environment. These interactions can determine whether prey are available to predatory seabirds.

Hulsman (1988), for example, drew attention to the role that predatory fish such as Bonito *Euthunnus affinus* and Yellow Finned Tuna *Neothunnus macropterus* have in driving bait fish to the surface so that they become available. Without these large predatory fish, Black Noddies *Anous minoutus* could starve.

Other prey becomes available as tides change. Black-naped Terns *Sterna sumatrana*, for example, prefer to forage on rising tides in the

TABLE 1

The foraging behaviour of seabirds of the Great Barrier Reef (GBR).

Common name	Feeding method	General prey type	Specific prey on GBR	Prey size
Herald Petrel	Recorded feeding with Wedge-tailed Shearwaters.	Cephalopods.		4 cm
Wedge-tailed Shearwater	Contact-dipping, surface-seizing, rarely deep plunges.	Mostly fish, some cephalopods, few insects, jellyfish, prawns.	—	—
Australasian Pelican	Surface-seizing, scavenging.	Mostly fish, opportunistic carnivore.	—	—
Masked Booby	Deep-plunge 12–100 m.	Fish, cephalopods	Flying fish, cephalopods *(Symplectoteuthis oulaniensis)*.	—
Red-footed Booby	Deep-plunge to 8 m, follows boats.	Fish, cephalopods	Fish *(Cypselurus melanocerus)*, cephalopods *(S. oulaniensis)*.	—
Brown Booby	Deep-plunge, horizontal pursuit.	Fish, cephalopods	Fish *(C. melanocerus)*, cephalopods *(S. oualeniensis)*.	
Pied Cormorant	Deep-surface dive.	Fish.	—	—
Little Pied Cormorant	Deep-surface dive.	Fish.	—	—
Great Frigatebird	Feed on wing, rarely enter water.	Flying fish, cephalopods.	—	—
Least Frigatebird	Feed in flight, aerial piracy.	Mostly fish, some cephalopods.	30 regurgitations at Raine Is.: 60% flying fish, 37% cephalopods, 3% cuttlefish.	—
Red-tailed Tropicbird	Deep vertical plunge, diving.	Fish, cephalopods.	Flying fish.	15 × 4 cm.
Silver Gull	Mainly scavenging, surface-dipping, kleptoparasitism.	Fish, crustaceans, refuse, eggs, chicks.	Fish, crustaceans from terns, tern eggs and chicks.	—
Caspian Tern	Aerial dive with partial and full submersion, contact-dip.	Fish.	—	—
Roseate Tern	Aerial dive with partial and full submersion, contact-dip.	Fish.	—	—
Black-naped Tern	Aerial dive with partial and full submersion, contact-dip.	Fish, prawns.	Mainly Engraulids, Atherinids, Hemiramphids, Pomacentrids, Exocoetids, Clupeids.	Chicks fed prey up to 200 mm in length. Most prey 25–75 mm.
Sooty Tern	Contact-dip.	Fish, prawns, cuttlefish.		
Bridled Tern	Contact-dip.	Fish.	Mostly anchovies *(Engraulis australis)*, and monocanthids *(Atrolepis filicauda)*.	Average weight of chick's meal 8.7 g.
Little Tern	Aerial dive with partial submersion.	Fish.	—	—

Common name	Feeding method	General prey type	Specific prey type	Prey size
Crested Tern	Aerial dive with partial and full submersion, contact-dip.	Fish, prawns, insects.	Mainly Clupeids, detailed species list Domm and Recher (1973).	Chicks fed prey up to 125 mm length, most prey 50–100 mm.
Lesser Crested Tern	Aerial dive with partial and full submersion, contact-dip.	Fish.	Atherinids *(Pranesus capricornensis)* main item.	—
Common Noddy	Contact-dip.	Fish.	—	—
Black Noddy	Contact-dip.	Fish.	Atherinids (4 spp.), anchoveys *(Engraulis australis)*, and occasionally blenny.	—

Sources: Barker and Vestjens (1989), Domm and Recher (1973), Hulsman (1988), Hulsman (pers. comm), Hulsman and Langham (1985), Marchant and Higgins (1990), Smith (unpubl. data).

early morning and late afternoon, and catch most fish when the tide is rising (Smith 1990). On the other hand, Lesser Crested Terns *S. bengalensis* feed mainly on the falling tide (Hulsman 1988). It is at these times that fish cross shallow waters of the reef crest and become easy prey from above.

FORAGING STRATEGIES

Foraging strategies adopted by each species of seabird also determine the prey that they consume. During breeding, seabirds use the two-dimensional space of the ocean off the Queensland coast in different ways. Some species, such as the smaller terns (e.g. Black-naped Terns) feed mainly within the vicinity of their breeding colonies (Hulsman and Smith 1988; Smith 1990), while the larger Crested Terns *S. bergii* feed close to colonies and well offshore (Hulsman 1988; Smith, 1993). Other species, such as Bridled Terns *S. anaethetus* tend to feed mainly away from their colonies (Hulsman and Langham 1985). Such foraging strategies are known as inshore and offshore methods respectively (Ricklefs 1983; Hulsman and Smith 1988). Other species range far out to sea away from their colonies, typically off the continental shelf. These species are called pelagic feeders (e.g. Wedge-tailed Shearwaters).

The ephemeral sites of feeding (e.g. upwelling systems) need to be found and the reasons for their existence determined. Satellite imagery techniques, which can detect sea surface temperatures and chlorophyll content, can indicate foci of primary production will do much to enhance such knowledge.

Different seabird species utilize different strata of their marine environment and the fish contained therein. Some species, such as the Masked Booby *Sula dactylatra* are capable of deep plunges, diving to 35 metres, while the Brown Booby *S. leucogaster* plunges to only a few metres below the water surface. Some seabirds (including most of the terns, *Sterna* spp.) dive and only become partially submerged, while others, such as the Bridled Tern, merely contact-dip the water with their bill, taking prey only from the upper 20 cm of surface water (Hulsman and Langham 1985).

Other species chase their neighbours and rob them of their prey (Least Frigatebirds *Fregata ariel* and Roseate Terns *S. dougallii*, Hulsman 1976), or rob nests (Silver Gulls *Larus novaehollandiae*, Smith 1991).

Silver Gulls also scavenge along the tideline, at waste depots and from picnic areas. The numbers of Silver Gulls that occur in the vicinity of resorts have increased because of waste disposal methods. Increases have been reported in the Capricorn-Bunker group of islands (Walker 1988) and in the vicinity of Lizard Island (Smith 1991). Other species scavenge discards from trawling (e.g. Crested Terns, Blaber and Wassenberg 1989). Diet switching as a result of man's activities can produce imbalances. The Silver Gull population explosion is one such example (Smith 1992). It is likely that some of the abundant populations of seabirds off the east Australian coast, as well as unseasonal mass mortalities, may be the result of fishing activities.

DIET

Most identification of food items of these seabirds has been from regurgitates. Off the Queensland coast, however, classification has in the main been only to the level of Order or Family, although there is some detail of species. Thus, identification

of fish, squid and crustacean prey to species level is lacking. What is also a crucial need is for more detailed and specific information over time, to enable seasonal effects to be assessed.

The major problem for seabird dietary studies on the Great Barrier Reef is getting to remote locations where seabirds both breed and roost. This can be an expensive and logistically difficult exercise. Once overcome, however, most species are obliging when it comes to delivering material for analysis.

A number of species will regurgitate whole or partially digested fish when caught or scared. It is usually not necessary to induce vomiting because if the bird does not regurgitate it usually means that the crop is empty.

Some species such as the terns and particularly Crested Terns, carry fish to their young at the nest, where prey items are dropped and lie on the ground unretrieved. This usually occurs when chicks have just hatched and adults appear to be in a learning phase as to the correct size of fish suitable for feeding young.

Pellets are an efficient means of obtaining large amounts of data in a relatively short time; but what is a pellet? Because seabirds eat their prey whole, this means that the hard parts, such as fish bones, scales and squid beaks, are also ingested with the meal. Most species (although not all, e.g. Brown Boobies) regurgitate a small ball of undigested hard parts, glued together with mucous. These are fragile and break down quickly. It is the identification of beaks, bones, scales and/or otoliths (or ear bones) within these pellets that provides the clues to the diet of many species of seabird; in particular, the otolith bones are diagnostic and often can be identified to the species level. It is painstaking work to collect the pellets and sort them, and then to identify each against a reference collection; but the results are well worth the trouble as each pellet is packed with data!

Some diet work is currently underway along the Queensland coast; one study is examining the relationship between trawling and seabird diets. But more is required to gain a sound understanding of how these several species exploit the diverse and ephemeral resources of this tropical ecosystem.

REFERENCES

Barker, R. D. and Vestjens, W. J. M. (1989). 'The Food of Australian Birds. 1. Non-passerines.' (Parchment Press Pty Ltd: Melbourne.)

Blaber, S. J. M. and Wassenberg, T. J. (1989). Feeding ecology of the piscivorous birds *Phalacrocorax varius, P. melanoleucos* and *Sterna bergii* in Morton Bay, Australia. *Marine Biology* **101**: 1–10.

Domm, S. and Recher, H. F. (1973). The birds of One Tree Island with notes on their yearly cycle and feeding ecology. *Sunbird* **4**: 63–86.

Furness, R. W. and Monaghan, P. (1987). 'Seabird Ecology.' (Blackie: Glasgow.)

Hulsman, K. (1976). The robbing behaviour of terns and gulls. *Emu* **76**: 143–149.

Hulsman, K. (1977). Breeding success and mortality of terns at One Tree Island, Great Barrier Reef. *Emu* **77**: 49–60.

Hulsman, K. (1988). The structure of seabird communities: an example from Australian waters. In 'Seabirds and other marine vertebrates: competition, predation and other interactions.' (Ed. J. Burger). (Columbia University Press: New York.)

Hulsman, K. and Langham, N. P. E. (1985). Breeding biology of the Bridled Tern *Sterna anaethetus*. *Emu* **85**: 240–249.

Hulsman, K. and Smith, G. C. (1988). Biology and growth of the Black-naped Tern *Sterna sumatrana:* an hypothesis to explain the relative growth rates of inshore, offshore and pelagic feeders. *Emu* **88**: 234–242.

Marchant, S. and Higgins, P. J. (1990). 'Handbook of Australian, New Zealand and Antarctic Birds.' (Oxford University Press: Melbourne.)

Ricklefs, R. E. (1983). Some considerations on the reproductive energetics of pelagic seabirds. *Studies in Avian Biology* **8**: 84–94.

Smith, G. C. (1990). Factors influencing egg laying and feeding in Black-naped Terns *Sterna sumatrana*. *Emu* **90**: 88–96.

Smith, G. C. (1991). Kleptoparasitic Silver Gulls *Larus novaehollandiae* on the northern Great Barrier Reef, Queensland. *Corella* **15**: 41–44.

Smith, G. C. (1992). Silver Gulls and emerging problems from increasing abundance. *Corella* **16**: 39–46.

Smith, G. C. (1993). Feeding and breeding of crested terns at a tropical locality — comparison with sympatric Black-naped Terns. *Emu* **93**: 65–70.

Walker, T. A. (1988). Population of the Silver Gull *Larus novaehollandiae* on the Capricorn and Bunker Islands, Great Barrier Reef. *Corella* **12**: 113–118.