SHORT NOTES

Sexual segregation of foraging zones in procellariiform birds: implications of accidental capture on commercial fishery longlines of Grey Petrels (*Procellaria cinerea*)

The sex of procellariiform birds can seldom be distinguished at sea and so we cannot easily tell whether males and females feed together, or separately like many terrestrial (especially forest) birds. However, most adult male and female Snowy Albatrosses (*Diomedea exulans chionoptera*) can be distinguished by plumage. Studies in the South Indian Ocean (Weimerskirch & Jouventin 1987) have shown that, whereas adult male Snowy Albatrosses are widely distributed around the breeding islands and south to the Antarctic continent, the smaller females predominate along a relatively narrow band in subtropical waters, well north of the Convergence. Sexual segregation of foraging zones signifies that future food studies of procellariiforms should be broken down by sex. For example, major differences in diet between male and female giant petrels (*Macronectes* spp.) at South Georgia were described by Hunter (1983).

A significant finding from my long-term study of the Westland Black Petrel (*Procellaria westlandica*) has been the great difference in survival between sexes. Both adult and subadult (pre-breeding) males have a much higher survival than females. This may reflect different foraging, resulting in greater risks for females. One hypothesis was that the smaller females would be at a disadvantage in competing with males for scraps of food behind trawlers, which provide a great deal of their diet (Bartle 1974, 1985).

Information just received suggests a more convincing explanation. During 10 days (19-28 June 1989), MAFFish observers recovered one female Wandering Albatross (*D. exulans*), eight juvenile (4 male and 4 female) New Zealand Black-browed Mollymawks (*D. melanophrys impavida*) and 16 Grey Petrels (*Procellaria cinerea*) on three southern bluefin tuna longline vessels fishing in subtropical waters beyond the continental slope off East Cape. The weather situation at this time was nearly identical with that shown by Jenkins & Greenwood (1984) for 16 July 1984, when larger than usual numbers of Grey Petrels and other Southern Ocean species were encountered in the same area. On 21 June 1989, a steep pressure gradient had built up between a large anticyclone centred on Tasmania, essentially occupying the entire Tasman Sea, and low pressure systems to the south and east of the Chatham Is. Strong SW winds between these systems were indicated by the unbroken pattern of isobars extending north from 60° S to 40° S immediately east of and parallel to the NZ coast.

Of the 16 Grey Petrels, 15 were adult females with convoluted oviducts, indicating that eggs had been laid. Despite having follicles no longer than 2.0 mm in diameter, these were thought to be breeding birds. After laying, individual follicles become increasingly difficult to distinguish with the naked eye (Lofts & Murton 1973). Most had bare brood patches (S. Triggs, pers. comm.).

At this time of year Grey Petrels are breeding on subantarctic islands, far to the south. The largest New Zealand population is that of the Antipodes

Is, between 1134 and 1460 km due south of the capture locality. Evidence from the foraging ranges of albatrosses in the Indian Ocean (Weimerskirch *et al.* 1988) and on the distribution of Grey Petrels there in winter (J.-C. Stahl, pers. comm.) shows that the subtropical waters off East Cape are within the potential foraging range of Grey Petrels breeding on the Antipodes. On islands on or near the Subtropical Convergence, such as Tristan da Cunha and Gough, Grey Petrels breed over a longer period than on islands further south (Elliott 1957, Barrat 1974), and in late June eggs are still hatching. The timing of breeding of Grey Petrels on the Antipodes is not known but is thought to be roughly synchronous with Tristan (Warham & Bell 1979, Imber 1983).

Watson *et al.* (1971) combined all seasons when summarising records of Grey Petrels throughout the Southern Ocean. They were found to be widely distributed in the Atlantic, Indian and Pacific from 35°S to 63°S, with northern extensions of range off the east coast of South America to 18°S, and across the Indian Ocean to near 30°S.

Grey Petrels occur regularly to the east of New Zealand. In summer and autumn (November to May) they are rarely found north of 45°S (Robertson & Jenkins 1981, Jenkins 1981, Clark 1986, Bartle unpubl. data), but in winter and spring (June to October) they are normally encountered quite far north. Although Summerhayes (1969) found none in the northern Tasman, he saw several in September between 32°S and 34°S, far to the north of East Cape. Hansen (1978) also noted the species there at 34°S 179°E in August. Off the east coast of the North Island, Fleming (1950) recorded them north of the Convergence at 41°S in July and at 36°S and 37°S in October, not far from East Cape. Grey Petrels are not frequently seen close inshore around East Cape in winter, but large numbers can occur (Jenkins & Greenwood 1984). By far the highest rate of recovery of Grey Petrels on beach patrols is reached in the Bay of Plenty (Powlesland 1989), where several other Antipodes I. species are regularly cast ashore (Hellyer *et al.* 1973).

Upwelling of cool water over the Ranfurly Bank off East Cape has long been known and appears to be a permanent feature (Garner 1959, Heath 1975), causing increased primary productivity and a high zooplankton biomass over shelf and near-slope waters (Bradford *et al.* 1982). This creates favourable conditions for shelf-feeding birds around East Cape itself. However, the most outstanding features of this general area are the small, apparently stable, warm-core eddies east of East Cape near the Brodie Seamount (37°30'S; 179°W) and 100 km ESE of Portland Island (Bradford *et al.* 1982). Associated with the warm-core eddy east of East Cape is a massive area of elevated nutrients, chlorophyll a, primary production and greatly increased zooplankton biomass, especially in spring (Burkholder & Burkholder 1967, Bradford & Roberts 1978, Bradford *et al.* 1982). Eleven of the Grey Petrels caught were scattered along 179°W between 38°and 39°30'S, south of the Brodie Seamount, in an area where there has been a valuable fishery for southern bluefin tuna since the 1960s (D.M. Gibson *in* Bradford *et al.* 1982).

Accidental capture of seabirds was recorded at two quite distinct localities in June 1989. In the first area, over slope waters north of East Cape, between

37 and 75 km offshore, two vessels caught 5 female Grey Petrels together with 8 juvenile NZ Black-browed Mollymawks and 1 immature female Wandering Albatross (identified by C.J.R. Robertson as of the Antipodes I. race). A third vessel, fishing in deep water 160 and 250 km offshore south of the Brodie Seamount (east of East Cape), caught only Grey Petrels, again mostly female.

TABLE 1 — Frequency of accidental capture of seabirds on two southern bluefin tuna longline vessels off East Cape, June 1989

	No. birds caught	No. longline sets
	0	9
	1	4
	2	3
	3	2
	4	1
Totals	20	19

Each southern bluefin tuna longline vessel carries a line about 120 km long with up to 3000 baited hooks clipped to it. Lines are set daily under normal conditions. As the vessel steams ahead the line, with baited hooks, is paid out astern at a low angle. It is at this stage that birds become caught on the hooks, either seizing them on the surface or diving on them as they slowly sink. Once caught, the birds are pulled under and drowned. Thirty southern bluefin tuna longline vessels may operate together off East Cape during the winter (P.Taylor, pers. comm.). Unless the hooking rate of seabirds is systematically recorded it will be difficult to estimate the extent of this accidental mortality. However, an analysis of the notes of observers who also recorded zero catches (Table 1) shows that, on this occasion, half the longline sets caught at least one bird. Twenty percent of birds were caught singly, 30% at a rate of two birds per set, 30% at three birds, and 20% at four birds.

DISCUSSION

The predominance of adult female Grey Petrels in this sample is evidence of sexual segregation of foraging areas during the breeding season. Scattered through the literature are a few additional records of birds collected at sea in winter (e.g. Lowe & Kinnear 1930) which support the idea that female Grey Petrels forage further north than male. Similar behaviour apparently occurs in most other procellariiforms. Marked changes in sex ratio among samples of Wilson's Storm Petrels (*Oceanites oceanicus*) collected by Huber (1971) during their northward migration near Eniwetok Atoll, Marshall Is, indicated differences in time and/or route of migration between males and females, as well as a separation of first year from older birds. Similar patterns were found for 20 species collected off the North Carolina coast by Lee (1989), suggesting that segregation of foraging grounds by age and sex is usual in seabirds. In the Indian Ocean and in the Pacific, at least, it appears that adult female and immature Snowy Albatross (Jouventin *et al.* 1982) and adult female and immature Grey Petrels (this paper) forage in the discrete band of subtropical waters north of the Convergence that also supports the main longline fisheries. This increases their chances of accidental capture on longlines. In Snowy Albatrosses, fishery by-catch is thought to be largely responsible for the lower survival of females, resulting in an excess of males in the pool of potential breeders, and causing a substantial decline in numbers nesting at the Crozet Is (Weimerskirch & Jouventin 1987). Because their life cycles involve a low reproductive rate, high survival, and delayed maturity, procellariiforms are particularly susceptible to even slight changes in adult mortality. Populations of procellariiforms are generally unable to compensate for the accidental deaths of breeding adults, especially since key individuals produce a disproportionate percentage of the total offspring. Thus the high rate of capture of Grey Petrels off East Cape provides a compelling reason to monitor this major fishery because selective mortality of adult females will have an undue impact on the breeding population.

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Observations of fruit eating by Blue Duck

Literature describing the diet of the Blue Duck (*Hymenolaimus malacorhynchos*) lists invertebrates as the main foods. Although faeces with moss and algae (Kear & Burton 1971) and "small brown seeds" (Fordyce 1974) have been recorded, everyone has assumed that the ingestion of plant matter is incidental to the Blue Ducks' feeding on invertebrates.

In this note I describe observations of fruit eating by Blue Ducks and try to quantify the most important of them.

On 4 April 1989, while banding Blue Ducks in the Mingha Valley, Arthur's Pass National Park, Colin O'Donnell, Peter Dilks and I noted abundant seed in Blue Duck faeces. Later that day, while we were banding a pair of adult Blue Ducks, the female passed faeces almost entirely composed of *Coprosma rugosa** seeds. On 5 April, we watched an adult Blue Duck gobbling ripe *Coprosma depressa* fruit from plants sprawling down a damp bank at the edge of Agility Creek, a small tributary of the Mingha River. This feeding activity lasted almost 5 minutes and was followed by brief pecking of seed from a nearby tussock (*Chionochloa conspicua).*

While travelling up the Mingha River on 5–6 April, we tried to quantify this feeding behaviour by counting all Blue Duck droppings seen, recording the number that contained seed, and counting the number of seeds in each dropping. All droppings were less than 1 week old, having been deposited since the last heavy rain (c. 200 mm on 28–29 March), and were from 2–3 pairs of Blue Ducks.

Three habitat zones were sampled:

1. **Alpine** (960–1150 m asl). Small, fast flowing and gorged, the river travels through open tussock grassland and herbfield with subalpine shrubs in sheltered places.

*Nomenclature follows Allan 1961