# SOUTHERN GIANT PETRELS *MACRONECTES GIGANTEUS* DIVING ON SUBMERGED CARRION

JOHN VAN DEN HOFF & KYM NEWBERY

*Australian Antarctic Division, 203 Channel Highway, Kingston, 7050, Tasmania, Australia*
*(John.vandenhoff@aad.gov.au)*

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**SUMMARY**

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We filmed Southern Giant Petrels *Macronectes giganteus* as they pursuit dived on a submerged Weddell Seal *Leptonychotes weddellii* carcass. We suggest that a floating oily slick produced by the decomposing carcass was the olfactory cue used by the birds to rediscover the carcass after it had become submerged in about three metres of water. Our results suggest that the foraging habitat of Southern Giant Petrels is broader than currently thought, especially in shallow-water coastal regions.

Key words: Southern Giant Petrel, *Macronectes giganteus,* olfactory detection, feeding, fisheries, Antarctica

## INTRODUCTION

Relatively little is known of the diving abilities of procellariiform seabirds (albatrosses and petrels). Brooke (2004) summarizes depth data for only 18 species, a list that does not include the giant petrels *Macronectes* spp., although occasional surface diving has been reported for the genus (Harper 1987).

Food of giant petrels includes seal meat and blubber, seabirds, fish and squid (e.g. Johnstone 1977, Hunter 1983, Hunter & Brooke 1992). At sea, giant petrels typically forage by surface seizing (Harper 1987, Brooke 2004), with olfactory detection being suggested as an important mechanism for locating prey (Nevitt 1999). Experimental manipulations and field observations confirmed Northern Giant Petrels *M. halli* are capable of diving (Hemmings & Bailey 1985, Harper 1987). Both species of giant petrels dived to a depth of three metres on an experimentally submerged seal *Arctocephalus* sp. carcass (Berruti & Kerley 1985). However, at-sea observations of both Northern and Southern *M. giganteus* Giant Petrels feeding behind a fishing vessel suggested that only Northern Giant Petrels dive to obtain food under natural conditions (Harper 1987).

We give a descriptive account of our observations of Southern Giant Petrels diving to and feeding on a submerged Weddell Seal *Leptonychotes weddellii* carcass. We also present dive-duration statistics and provide some evidence to support the hypothesis that olfactory detection played a part in the manner by which the petrels rediscovered this food source after it became submerged.

## STUDY AREA AND METHODS

Our *ad hoc* observations were made on Béchervaise Island, Holme Bay, Mac. Robertson Land, Antarctica (Fig. 1) between 10 January and 1 February 2005. The island is separated from another smaller unnamed island by a narrow channel, which is covered for most of the year by ice 1.5–2.0 m thick. The edge of the ice is anchored to the rocky shoreline, and thus cracks and ridges form in the ice cover under tidal action, acting as haul-out sites and breathing holes for Weddell Seals.

At approximately 15h00 (local time) on 26 January 2005, we positioned a tripod-mounted digital video camera to record Southern Giant Petrel behaviour for one hour as the birds dived on a submerged Weddell Seal carcass. We measured the dive duration and interval between dives from the time-stamped video tape. Dive interval is the time elapsed between a bird surfacing and its next dive. We judged dives as "successful" if a bird surfaced with food and consumed it, and "unsuccessful" if not. We used meteorologic data at Mawson, three kilometres away, as a record of the weather at Béchervaise Island.

We used the nonparametric Mann-Whitney *U*-test to test for statistically significant differences, because log transformation of the dive data failed to restore data normality (Shapiro-Wilks tests: unsuccessful dive duration $W = 0.93$, $P = 0.17$; successful

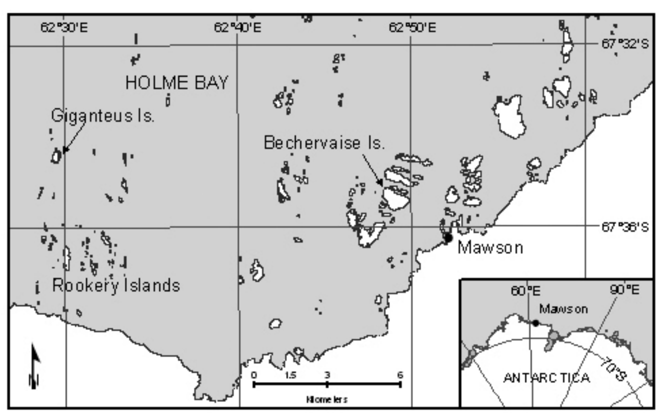


**Fig. 1.** Map of Holme Bay, Antarctica, showing the study site relative to the location of the Southern Giant Petrel breeding colony at Giganteus Island.

dive duration $W = 0.87$, $P < 0.01$). We report means plus or minus standard deviation. We used Statistica Version 7 (Statsoft 2005) to perform all statistical analyses.

## RESULTS

### General observations and chronology of events

On 10 January 2005 we saw 80 Southern Giant Petrels either grooming, resting or feeding upon a Weddell Seal lying dead upon the ice at a tide crack in the channel between Béchervaise Island and the unnamed island. The seal's head had been crushed—presumably because of a shift in the sea ice as the seal attempted to breathe or haul out at the tide crack. No other birds accompanied the Southern Giant Petrels, despite breeding by South Polar Skuas *Catharacta maccormicki,* Wilson's Storm-Petrels *Oceanites oceanicus* and Snow Petrels *Pagodroma nivea* on Béchervaise Island at the time of this study. Antarctic *Thalassoica antarctica* and Pintado or Cape *Daption capense* Petrels also breed 15 km from Béchervaise Island at the Rookery Islands (Fig. 1). Southern Giant Petrel numbers remained relatively constant between 70 and 80 individuals for the next six days.

For a 33-hour period between 15 and 16 January, a relatively persistent 20-knot wind originating from the Antarctic continental ice plateau blew along the channel (Fig. 2). During this period, the seal carcass slipped from the ice into about three metres of water and disappeared beneath ice floes covering the channel. Southern Giant Petrel numbers decreased to zero at this time. One day later (17 January), the wind pattern changed, and the ice shifted position so that we could clearly see the seal carcass resting on the bottom of the channel [Fig. 3(A)]. No birds were seen in the area at this time. The weather then undertook a diurnal katabatic pattern (Fig. 2) for the next seven days, and no Southern Giant Petrels were seen feeding at the submerged carcass site.

The established katabatic wind pattern broke on the morning of 24 January, when the wind speed increased to about 30 knots, and the direction shifted to a bearing of 280 degrees, in line with the direction of the northern Rookery Islands from Béchervaise Island (Fig. 2). On 24 January, we once again saw Southern Giant Petrels in the channel, and by this time they had commenced actively diving on the submerged seal carcass. By now the number of Southern Giant Petrels was consistently between three and 20 individuals. An oily slick emanating from the submerged seal carcass was clearly visible streaming downwind on the water surface, and 23 Wilson's Storm-Petrels were feeding within the slick. On 25 January, wind speeds of up to 50 knots made the carcass invisible to us. However, the Southern Giant Petrels still managed to locate the submerged carcass, and they dived to it successfully. Feeding on the submerged carcass continued for a further five days until all but the bones had been consumed.

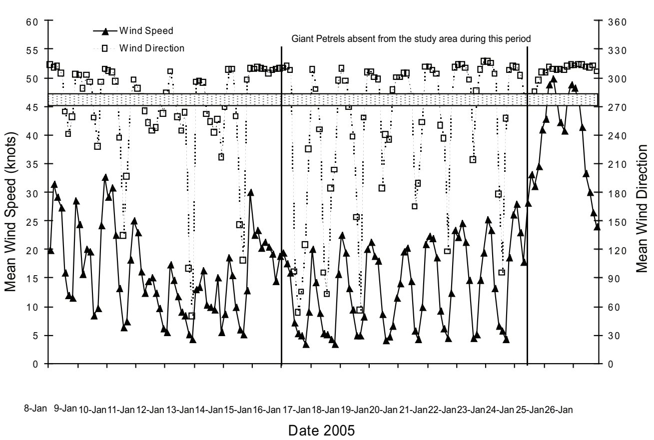


**Fig. 2.** Three-hourly mean wind speed (knots) and direction at Mawson Station, east Antarctica between 8 and 26 January 2005. The stippled bar between 270 degrees and 280 degrees represents the actual bearing from Béchervaise Island to Giganteus Island where Southern Giant Petrels breed. Vertical lines on 16 and 23 January 2005 represent the dates between which the giant petrels were not seen foraging above the submerged Weddell Seal carcass.

### Diving

We recorded aspects of 113 dives performed by 10 adult Southern Giant Petrels in one hour of foraging on the submerged Weddell Seal carcass [Fig. 3(A)]. Wind conditions were 15 knots or less. Of all dives recorded, 18% were unsuccessful, 80% were successful, and the remainder could not be categorized. Dive duration depended on feeding success; successful dives were significantly longer (4.48 ± 0.88 s; range: 3–7 s; n = 90) than were unsuccessful dives (3.25 ± 1.52 s; range: 1–7 s; n = 20; Mann-Whitney *U*-test: $Z = 3.74$, $P < 0.01$). The mean dive interval was 21 ± 16 s (range: 2–124 s), and the dive interval was influenced by the time the birds required to swallow food or to defend their position on the water over the submerged carcass, or both. We also witnessed attempts by subordinate birds to steal food from successful diving birds, which added to the dive interval.

Southern Giant Petrels performed pursuit dives (Harper 1987) using their wings and feet to swim underwater [Fig. 3(B–D)]. While sitting on the water with wings outspread and tail spread, birds gave an energetic push with both feet, which lifted the body from the water and gave momentum to the dive. At the same time, the head and neck were aimed downward, and the body arched forward with the wings one third to one half folded [Fig. 3(B)]. Once in this position, momentum was increased with a strong wing flap and continuation of the push with the feet, webs spread, as the bird submerged [Fig. 3(C)]. The birds surfaced headfirst, with wings open, tips down, and the tail remaining spread [Fig. 3(D)]. The bird's entire body would often clear the surface as it used its feet to settle on the water with wings outspread for added stability. A head shake or tilt indicated food being swallowed. Each bird remained above the carcass until it was excised from the diving area by an aggressive bird posturing in forward and upright threatening positions. Aggressive displays, such as those reported by Warham (1962), occurred either on the water or in the air as birds flew over the diving assembly area.

Usually a single bird dominated and dived on the carcass, but on one occasion, we saw two birds diving in tandem or serially. We made no attempt to follow any hierarchy of dominance throughout the study. Not all birds appeared capable of diving. "Incapable" birds made attempts to submerge by mimicking dive preparation behaviours such as arching the back and extending the wings, sometimes pushing themselves below the surface for very short periods.

### Other procellariiforms feeding in the study area

We observed 24 Wilson's Storm-Petrels, three Pintado Petrels and one Antarctic Petrel scavenging on small scraps of blubber and oil resulting from the feeding by the Southern Giant Petrels. Pintado and Antarctic Petrels sat on the water as they seized particles from the water's surface and occasionally dip dived [Fig. 3(E)]. Wilson's Storm-Petrels flew upwind as they fed by dipping [Fig. 3(F)] and by pattering for small pieces of blubber or perhaps oil droplets found in the greasy slick emanating from the carcass site.

## DISCUSSION

We observed Southern Giant Petrels under natural conditions pursuit diving (Harper 1987) to submerged carrion. Southern Giant Petrels were capable of diving to *c.* three metres to strip flesh from a submerged Weddell Seal carcass, returning to the surface to swallow it. Diving birds used their wings and feet to propel themselves underwater for as long as seven seconds.

Giant petrels are not commonly thought of as obtaining their food through diving; they are most often observed feeding ashore on carrion. At-sea, their foraging is characterized by surface seizing and scavenging behaviours (Johnstone 1977), although Northern Giant Petrels have been observed diving for food near a fishing boat (Harper 1987). Diving to about two metres in pursuit of inanimate, sinking food was also witnessed for the Northern Giant Petrel by Hemmings & Bailey (1985). Voisin & Shaughnessy (1980) reported Northern Giant Petrels diving and swimming underwater to avoid capture, and Southern Giant Petrels diving through near-shore waves. Both species were enticed experimentally to dive to a depth of about three metres to a submerged skinned fur seal carcass; Southern Giant Petrels dominated, by making more successful dives to a greater depth (Berruti & Kerley 1985). Our observations of Southern Giant Petrels pursuit diving to feed on a submerged seal carcass were made as this species foraged under natural, unsolicited

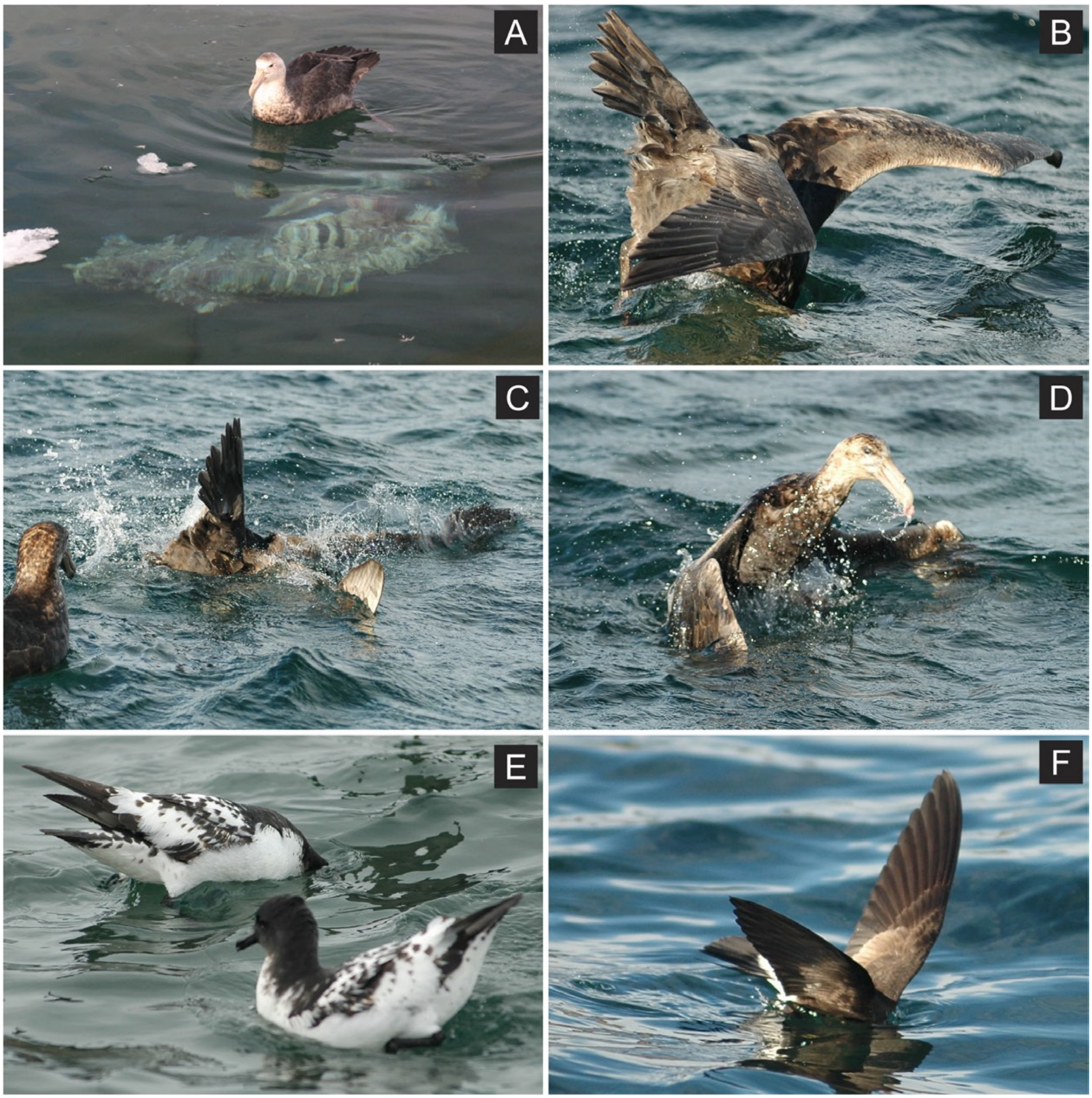


**Fig. 3.** (A–D) Attitudes of Southern Giant Petrels as they dive to the submerged Weddell Seal carcass; (E,F) Pintado Petrel (E) and Wilson's Storm Petrel (F) feeding on subsurface particles in the oil slick emanating from the submerged Weddell Seal carcass.

conditions. In so doing, some Southern Giant Petrels (but not all) showed their capability to expand their foraging niche to below the water line when an opportunity presents itself.

As we observed and recorded the giant petrels diving, we questioned how the birds rediscovered the Weddell Seal carcass after it had become submerged and seemed lost to the birds. We had smelled the decomposing seal as it lay on the ice surface, and we observed that, when the seal had vanished below the sea ice, the smell had gone with it. After a day, the ice had shifted position, and the water clarity was such that the human eye could clearly see the carcass lying on the channel's bottom, but no Southern Giant Petrels were seen at the locality for a further eight days. Visual detection of the carcass was, at this stage, thus ruled out as a mechanism for detecting the submerged prey. We had noticed an oily slick streaming downwind from above the carcass, and a flock of Wilson's Storm-Petrels feeding between the Southern Giant Petrels. One mechanism we hypothesized for the rediscovery of the submerged seal carcass was its long-distance detection by odours emanating from the oily slick.

Changes in wind speed and direction on 24 January 2005 and the subsequent return of the Southern Giant Petrels appear linked (Fig. 2). We saw only tube-nosed birds (procellariiforms) such as Wilson's Storm-Petrels, Pintado Petrels and Antarctic Petrels with the Southern Giant Petrels at the dive site. Procellariiforms are thought to locate prey through odour cues, because they have an elaborate, well-developed olfactory neuroepithelium (Nevitt 1999). Procellariiforms are readily attracted to fishy-smelling odours and are often seen zigzagging their way along odour cues (Nevitt 1999). A change in wind speed and direction at the study site, from a katabatic cycle to a more directed wind travelling toward the Rookery Islands between 270 degrees and 280 degrees (Fig. 2) would bring scent from the oily slick to the birds breeding on that island. The birds could then follow the odour trail to the submerged carcass.

When testing the olfactory capabilities of Antarctic seabirds, Nevitt *et al.* (2004) showed that Wilson's Storm-Petrels, giant petrels and Pintado Petrels could be attracted to scented slicks, and indeed the tube-nosed birds were sighted more frequently at fish-scented slicks than at unscented slicks.

Another possible mechanism that may have alerted the Southern Giant Petrels to the submerged seal carcass was the presence of Wilson's Storm-Petrels foraging in the oily slick. Nevitt & Bonadonna (2005) classed storm-petrels as an "early detector" species, whose presence at a prey patch alters the foraging landscape to a visual one for other open-ocean-foraging seabird species such as giant petrels, the so called "late detector" species. Such a foraging aggregation of Wilson's Storm-Petrels as we witnessed may have provided a foraging stimulus to the Southern Giant Petrels.

Diving on submerged carrion is now recognized as another foraging tactic that Southern Giant Petrel can employ should the opportunity present itself. Plasticity in foraging behaviours is presumably important to this species, particularly when prey may be available for short periods only. Diving extends this foraging period.

**Possible implications for fisheries interactions**

A small percentage (1%) of the total seabird kill attributable to sanctioned fisheries around the Prince Edward Islands constituted giant petrels (Net *et al.* 2002). Large numbers of giant petrels have been observed scavenging at commercial fishing vessels, but no birds were observed diving for discarded offal, bycatch or even baited hooks (G. Robertson pers. comm.). This observation is presumably attributable to the high degree of interspecific competition with other procellariiforms such as albatrosses and White-chinned Petrels *Procellaria aequinoctialis,* which are aggressive feeders and very capable divers for fishery discards (G. Robertson pers. comm.). Nevertheless, should a freer competitive environment exist at a fishing vessel, giant petrels could fill that niche and themselves become an increasing bycatch statistic. Such a competitive environment may eventuate as the successfully competitive species such as those already mentioned are preferentially removed.

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