SHORT NOTE

Relatively infrequent seabird aggregation at nearshore fronts and tidal plumes at locations around Banks Peninsula, New Zealand

Foraging seabirds are often reported to be highly correlated with the presence of physical features in oceanic (Schneider 1982; Haney and McGillivary 1985) and coastal waters (see Hunt *et al.*, 1990). Such physical phenomena increase prey accessibility for foraging seabirds and include fronts, and tidal plumes and rips (see Zeldis and Jillett (1982) for a more extensive list). The key feature that tidal plumes and rips have in common are boundaries ("fronts") marked by water convergence or divergence (Franks 1992). In a convergent front, waters from both sides of the front flow towards each other where they are subducted below the surface. River plumes have convergent fronts along both sides of the plume (Garvine and Monk 1974). A convergent front will frequently accumulate scum, pieces of seaweed, and (importantly) seabird prey (Pingree *et al.* 1974); fronts can also be seen as sharp colour changes, or as the boundary between rough and smooth water. Divergent fronts do not accumulate seabird prey. Typical front locations include headlands, along the continental shelf break, and river mouths and areas seaward of estuaries.

Previous New Zealand reports of seabird association with frontal systems have emphasised tidal rips (Falla 1965; Secker 1969; Thoresen 1969; Bartle 1974; Gaston and Scofield 1995). Exceptions include Jenkins' (1974) postulation that Buller's Shearwaters (*Puffinus bulleri*) fed in a convergence zone off the West Auckland coast, and P. A. Langlands' observation (reported in O'Donnell and West 1995) of Black-fronted Terns (*Sterna albostriata*) feeding along a front in Akaroa Harbour. Gaston and Scofield (1995) identified spatial segregation of species feeding in tidal rips near the Brothers Islands in Cook Strait, and correlated dive times for Diving Petrels (*Pelecanoides urinatrix*) with differences in the turbulence of rips.

This paper examines the seabird community associated with fronts and tidal plumes at locations around Banks Peninsula. Comments on the significance of fronts and tidal plumes are made in the context of previous results (Hawke 1994). These showed association with Hector's Dolphins and working trawlers as the dominant seabird aggregation mechanism at Godley Head.

Three clifftop observation sites were chosen around Banks Peninsula (Fig 1): Godley Head (105 m asl), Tumbledown Bay (100 m asl), and Steep Head (156 m asl). Observations using 9 x 25 binoculars and a 15 x 60 telescope were made in low wind conditions. I noted the extent of any visible fronts and tidal plumes up to distances of approximately 3 km, and recorded seabird aggregations ($\geq$10 birds). At Godley Head, 22 observation sessions were made from July 1994 to February 1996 at fortnightly-monthly intervals. Each observation period lasted 60 minutes. Of special relevance in this phase of work was a front/plume system frequently seen projecting offshore from Adderley Head (Fig 1). This area had previously been regarded as out of range, because dolphins could not be counted reliably. How-

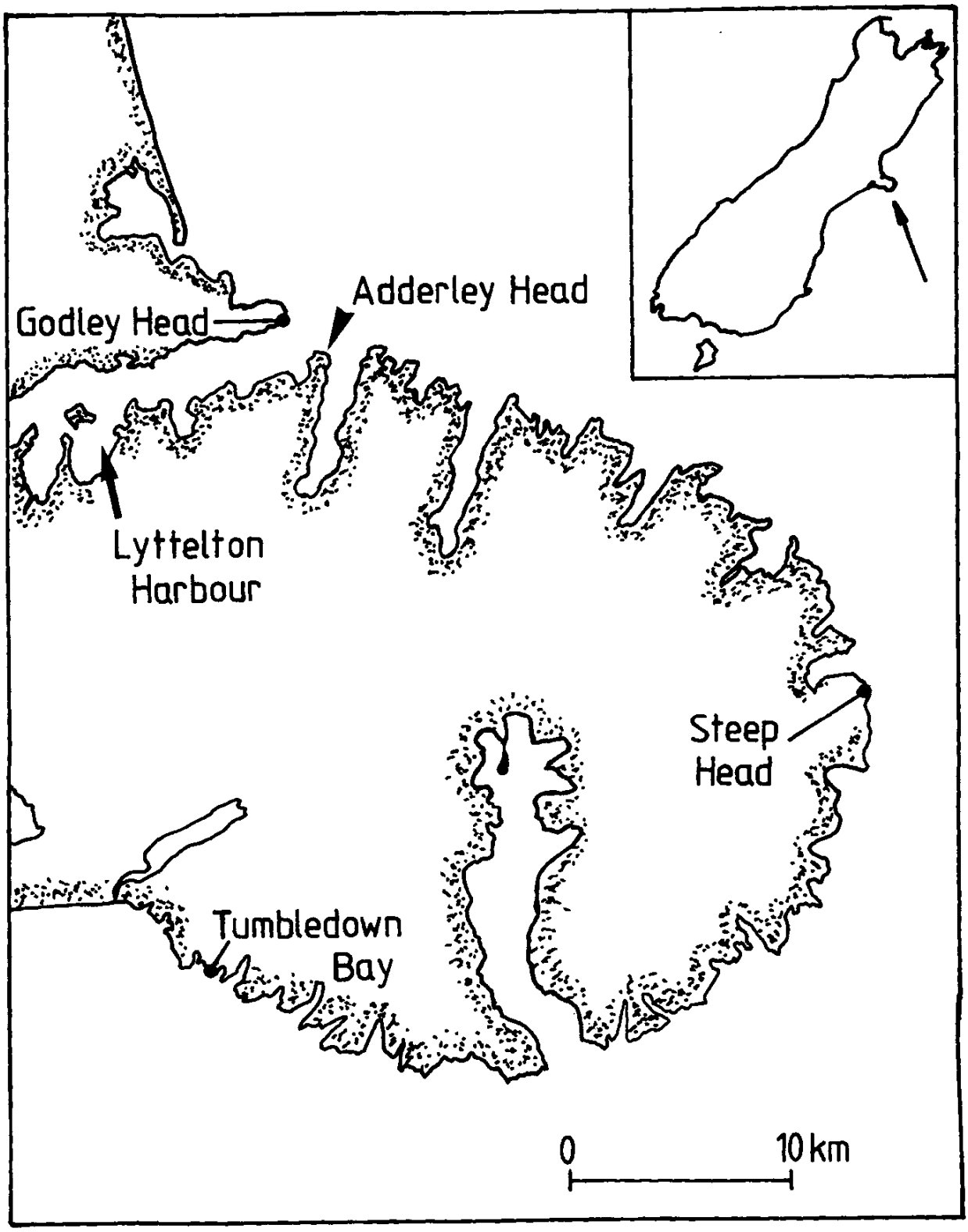

FIGURE 1 - Banks Peninsula, showing the observation sites plus places mentioned in the text. Lake Ellesmere and the Rakaia River discharge into the sea to the southwest (upcurrent) of Banks Peninsula. The inset shows the location of Banks Peninsula on the east coast of the South Island.

ever, observing lighter coloured seabirds was feasible, as well as darker species in good conditions or if the birds were flying. Observations of seabird aggregations with the Hector's dolphin - working trawler association reported previously (Hawke 1994) were also made. At Tumbledown Bay, 13 observations of about 15 minutes each were made at 4 to 6 weekly intervals from October 1994 to February 1996. Because of its remoteness, only one observation (of 60 minutes) was made from Steep Head, in December 1993.

Fronts or tidal plumes were observed on 19 of the 22 observation periods at Godley Head, 11 of the 13 observation periods at Tumbledown Bay, and on the only observation period at Steep Head. In contrast with the high proportion of observation periods on which fronts or tidal plumes were seen (31 out of 36, or 86%), seabirds were seen aggregated with tidal fronts or plumes on only 6 of the 31 occasions (19%) when tidal fronts or plumes were present. This compares with aggregations on 4 of the 6 (67%) occasions when Hector's dolphins were observed in the hauling zone of working trawlers (the corresponding result from Hawke (1994) was 73%).

A total of 11 aggregations with fronts or tidal plumes was observed on the six occasions when these phenomena were present. Five aggregations were associated with fronts or tidal plumes at Godley Head, and six at Tumbledown Bay. Aggregations were observed in December, January, April and May. No aggregation was observed at Steep Head. Nine of the 11 aggregations involved only single species. All four common inshore seabird species seen around Banks Peninsula were aggregated at least once with fronts and tidal plumes. Spotted Shags (*Phalacrocorax punctatus*) were the most common, making up four aggregations (of >100, 40, 15 and 10 birds respectively). Black-backed Gulls (*L. dominicanus*) made up three aggregations of 24, 11 and 10 birds, while Red-billed Gulls (*L. novaehollandiae*), were seen in two aggregations of 40 and 18 birds. On 21 May 1995, > 100 Spotted Shags, 20 Black-backed Gulls, and 10 White-fronted Terns (*S. striata*) were observed together. On 12 December 1995, >400 Spotted Shags, 50 Red-billed Gulls, 30 White-fronted Terns, and five Black-backed Gulls were observed together. In contrast, separate aggregations of 24 Black-backed Gulls, 18 Red-billed Gulls, and 10 Spotted Shags were observed aggregated with the same front at different times over the same 60 minute observation period on 10 December 1994 at Godley Head.

Published results (Slooten and Dawson, 1988; Hawke 1994) for Hector's Dolphin around Banks Peninsula showed association with White-fronted Terns, Spotted Shags and Black-backed Gulls (but not Red-billed Gulls). The numbers of seabirds involved was within the range reported in the present paper for fronts and tidal plumes.

The relatively low frequency of seabird aggregation at nearshore fronts and tidal plumes could be due to the properties of the fronts themselves (e.g. relatively weak convergent flow; see Schneider *et al.*, 1987), the absence of inaccessibility of potential prey (Hunt *et al.*, 1990), the presence of undetected prey, or more favourable foraging elsewhere (including fronts or tidal plumes outside the area of sea observable from each observation site). The low proportion of observations of multi-species aggregations (two of 11, or 18%) at fronts/plumes is consistent with

the open ocean results of Kinder *et al.* (1983). These authors showed that not all seabirds within a given assemblage associate with any given front. Kingsford and Suthers (1994) found that accumulation of small fish and plankton in coastal plumes and fronts varied day to day. The variable seabird species association I observed (even those in the same place, on the same day) was also consistent with variable prey communities associated with fronts and plumes.

Only two of the single species aggregations (one each of Spotted Shags and Red-billed Gulls) involved birds which were actively foraging. In none of the three aggregations involving Black-backed Gulls were these actively foraging. In the mixed aggregations, the Spotted Shags, White-fronted Terns and Red-billed Gulls (if present) were foraging while again the Black-backed Gulls were not. While actual feeding was rarely observed, its seems reasonable to assume that either feeding had recently occurred, or the birds had an expectation of foraging opportunity.

At Steep Head, three procellariform species (Giant Petrel, *Macronectes* sp., Buller's Mollymawk, *Diomedea bulleri*; Hutton's Shearwater *P. huttoni* or Fluttering Shearwater *P. gavia)* were observed flying along a headland front. None of these species were observed away from the immediate frontal region. Although I have occasionally seen each of the species at the other two locations, Steep Head was the only location where procellariform species were observed associating with a front. The environment at Steep Head, at the eastern extremity of Banks Peninsula, probably has greater oceanic character. The presence of a headland front, with its associated foraging opportunities, may be a factor in the presence of oceanic birds.

In conclusion, my results showed a widespread occurrence of fronts and tidal plumes at Godley Head and Tumbledown Bay but only infrequent aggregation of seabirds. This contrasted with the frequent association (and aggregation) of seabirds with Hector's dolphins at Godley Head (Hawke 1994). This may indicate that the spatial scale of prey variability associated with fronts and tidal plumes was greater than the area surveyed at each location. Thus, seabirds may simply travel outside each of the immediate locations to forage at fronts or tidal plumes. Further observations would be required to examine this possibility.

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LITERATURE CITED

BARTLE, J. A. 1974. Seabirds of eastern Cook Strait, New Zealand, in autumn. Notornis 21: 135-166.

FALLA, R. A. 1965. Distribution of Hutton's Shearwater in New Zealand. Notornis 12: 66-70.

FRANKS, P. J. S. 1992. Phyloplankton blooms at fronts: patterns, scales, and physical forcing mechanisms. Aquat. Sci. 6: 121-137.

GARVINE, R. W.; MONK J. D. 1974. Frontal structure of a river plume. J. Geophys. Res. 79: 2251-2259.

GASTON, A. J.; SCOFIELD, P. 1995. Birds and tuatara on North Brother Island, Cook Strait, New Zealand. Notornis 42: 27-41.

HANEY, J. C.; McGILLIVARY, P. A. 1985. Aggregations of Cory's Shearwaters (*Calonectris diomedea*) at Gulf Stream fronts. Wilson Bull. 97: 191-200.

HAWKE, D. J. 1994. Seabird association with Hector's Dolphins and trawlers at Lyttleton Harbour mouth. Notornis 41: 206-209.

HUNT, G. L. Jr; HARRISON, N. M.; COONEY R. D. 1990. The influence of hydrographic structure and prey abundance on foraging of Least Auklets. *Stud. Avian Biol. 14*: 7-22.

HUNT, G. L. Jr; SCHNEIDER, D. C. 1987. Scale-dependent processes in the physical and biological environment of marine birds. Pp 7-41 *in* CROXALL, J. P. (ed). Seabirds: feeding ecology and role in marine ecosystems. Cambridge Univ. Press, Cambridge.

JENKINS, J. A. F. 1974. Local distribution and feeding habits of Buller's Shearwater (*Puffinus bulleri*). Notornis 21: 109-120.

KINGSFORD, M. J.; SUTHERS, I. M. 1994. Dynamic estuarine plumes and fronts: importance to small fish and plankton in coastal waters of NSW, Australia. Continental Shelf Res. 14: 655-672.

KINDER, T. H.; HUNT, G. L. Jr; SCHNEIDER, D.; SCHUMACHER, J. D. 1983. Correlations between seabirds and oceanic fronts around the Pribilof Islands, Alaska. Estuar. Coast Shelf Sci. 16: 309-319.

O'DONNELL, C. F. J.; WEST, J. A. (compilers) 1995. Classified summarised notes. South Island, 1 July 1992-30 June 1993. Notornis 42: 53-77.

PINGREE, R. D.; FORSTER, G. R.; MORRISON, G. K. 1974. Turbulent convergent tidal fronts. J. Mar. Biol. Assoc. U.K. 54: 469-479.

SCHNEIDER, D. 1982. Fronts and seabird aggregations in the southeastern Bering Sea. Marine Ecol. - Prog. Ser. 10: 101-103.

SCHNEIDER, D.; HARRISON, N. M.; HUNT, G. L. Jr 1986. Variation in the occurrence of marine birds at fronts in the Bering Sea. Estuar. Coast. Shelf Sci. 25: 135-141.

SECKER, H. L. 1969. Procellariforms in Cook Strait, New Zealand. Emu 69: 155- 160.

SLOOTEN, E.; DAWSON, S. M. 1988. Studies on Hector's Dolphin, *Cephalorhynchus hectori*: a progress report. Rep. Int. Whaling Comm. (Special Issue) 9: 325-338.

THORESEN, A. C. 1969. Observations on the breeding behaviour of the diving petrel *Pelecanoides u. urinatrix* (Gmelin). Notornis 16: 241-260.

ZELDIS, J. R.; JILLETT, J. B. 1982. Aggregation of pelagic *Munida gregaria* (Fabricius) (Decapoda, Anomura) by coastal fronts and internal waves. J. Plankton Res. 4: 839-857.

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