of the Chestnut-breasted Quail-thrush be modified to the general area of the lower Maranoa River valley, Queensland.

Acknowledgements

I thank Maurice French (University of Southern Queensland) and Dariel Larkins for putting me on the track of some obscure references, the staff of the Mitchell Library, State Library of New South Wales, for access to Leichhardt's diary of his Maranoa excursion of 1847 and to Gilbert's diary of the Port Essington Expedition. I thank Walter Boles and Richard Schodde who read early drafts of this note.

References

Anon. 1847. The New Country. Moreton Bay Courier, 16 October 1847. Vol. II. No. 70, [2].

Archer, T. 1897. Recollections of a Rambling Life. Japan Gazette Printing Works, Yokohama.

Beale, E. 1983. Kennedy. The Barcoo and Beyond. 1847. Blubber Head Press, Hobart.

Blakers, M., Davies S.J.J.F. & Reilly, P.N. 1984. The Atlas of Australian Birds. RAOU and Melbourne University Press.

Cheyne-Macpherson, W. 1934. The Macphersons of Keera, experiences of a pioneer squatter in 1847. [No. I]. Sydney Mail, 11 April 1934. Vol. XLV (n.s.). No. 1150, 10-11, 13; No. II. Sydney Mail 18 April 1934. No. 1151, 10-11; No. III. Sydney Mail 25 April 1934. No. 1152, 9; No. IV. Sydney Mail 2 May 1934. No. 1153, 43; No. V. Sydney Mail 9 May 1934. No. 1154, 16; No. VI. Sydney Mail 16 May 1934. No. 1155, 43.

Chisholm, A.H. 1945. Birds of the Gilbert Diary. Part 2. Emu 44, 183-200.

Condon, H.T. 1962. Australian quail-thrushes of the genus *Cinclosoma*. Records of the South Australian Museum 14, 337-370.

Ford, J. 1974. Taxonomic significance of some hybrid and aberrant-plumaged quail-thrushes. Emu 74, 80-90.

Ford, J. 1983. Evolutionary and ecological relationships between quail-thrushes. Emu 83, 152-172.

French, M. 1989. Conflict on the Condamine. Aborigines and the European Invasion. Darling Downs Institute Press, Toowoomba.

Gould, J. 1849. Description of a new species of *Cinclosoma*. Proceedings of the Zoological Society of London, 28 November 1848, 139. [published 1 June 1849].

Gould, J. 1855. The Birds of Australia, Supplement. Part II. Author, London.

Leichhardt, L. 1847a. Dr. Leichhardt. Sydney Morning Herald, 11 October 1847. Vol. XXII. No. 3, 242, [2].

Leichhardt, L. 1847b. Fitz Roy Downs. Sydney Morning Herald, 29 October 1847. Vol. XXII. No. 3, 258, [4].

Nix, H.A. & Austin, M.P. 1973. Mulga: a bioclimatic analysis. Tropical Grasslands 7, 9-21.

Roderick, C. 1988. Leichhardt the Dauntless Explorer. Angus & Robertson, Sydney.

Rogers, J. 1847. [Untitled letter.] Moreton Bay Courier, 11 December 1847. Vol. II. No. 78, [2].

Webster, E.M. 1980. Whirlwinds in the Plain. Ludwig Leichhardt — Friends, Foes and History. Melbourne University Press.

Plastics in Nests of Australasian Gannets *Morus serrator* in Victoria, Australia

F.I. Norman, P.W. Menkhorst and V.G. Hurley

Department of Conservation and Natural Resources, Flora and Fauna Branch, 123 Brown Street, Heidelberg, Vic 3084

EMU Vol. 95, 129-133, 1995. Received 14-2-1994, accepted 14-5-1994

Numerous studies have indicated the prevalence of plastic detritus in the marine environment (e.g. Colton et al. 1974; Bourne 1976; Pruter 1987), including subantarctic waters (Gregory 1990). Although the source of some of this material may be from the land, a considerable amount is deposited as ships' waste or as the discarding or break-up of fishing gear (Pruter 1987; Vauk & Schrey 1987; Gregory 1990; Montevecchi 1991). Quite apart from loss of human-perceived amenities around beaches, some forms of plastic debris may affect marine vertebrates either by entanglement or ingestion (Laist 1987; Pemberton et al. 1992). Some seabird

species are more prone to obtain and ingest plastics as a result of feeding methods: surface feeders show a higher incidence of ingested plastic than birds using other foraging strategies (Day et al. 1985; Fry et al. 1987; Ryan 1988).

Locally, within Australian coastal, subantarctic and antarctic waters, seabirds have been found with ingested plastic beads or fragments (Brown et al. 1986; Skira 1986; Van Franeker & Bell 1988; Dann 1990; Slip et al. 1990). Other species have become entangled by plastic yokes from drink container packs or in fishing nets (Dann 1990; Woehler 1990) but few systematic studies indicating the extent of such pollutants have been conducted in Australia. Montevecchi (1991) discussed the incidence of widespread, persistent plastic pollutants at nest sites of the Northern Gannet *Morus bassana*. He found that 97% of nests examined had incorporated plastic material, primarily cordage derived from fishing gear but also packaging plastics (including strapping). This study reports on a similar survey of the incidence of plastics in nests of the Australasian Gannet *M. serrator* and considers of the value of the species as an indicator of such pollutants in the local environment.

Materials and methods

The colony of Australasian Gannets at Lawrence Rocks (38°25′S, 141°40′E), about 2 km off the west coast of Victoria (and some 10 km, by sea, from the city of Portland), was visited briefly on 12 November 1993, when nests contained an egg or chick. A small sample (42) of nests was examined visually for the presence of plastics incorporated into the nest; several nests were also probed with a metal rod in an attempt to reveal additional plastic material hidden by other nest components. Procedures during this, and a subsequent visit on 14 January 1994, when a further 100 nests were examined and probed for the presence of plastics, followed those outlined by Montevecchi (1991) as closely as possible. Locations of sample nests at Lawrence Rocks were categorised as being peripheral, inner or in the centre of the colony; they were also categorised on the basis of bowl height as being 'old' (i.e. >12 cm high), or 'new' (<10 cm). The colony at Lawrence Rocks may now exceed 3000 pairs (PWM), having expanded substantially since the count of 1456 occupied nests in 1978 (Harris & Norman 1981).

All existing nests (196) at the two gannet colonies established on artificial platforms (Pope's Eye and Wedge Light) in Port Phillip Bay (38°16′S, 144°42′E; for colony locations and descriptions see Norman & Menkhorst 1995) were examined similarly on 23 November 1993. At the low-lying sites in Port Phillip Bay, where many nests are rebuilt between (or during) breeding seasons (Norman & Menkhorst 1995), nests were classified on the basis of structure (old nests were mainly formed of guano with seaweed around the rim or forming the bowl, whereas new nests were of seaweed only). At Pope's Eye, nests were also regarded as being on rocks, or on the old or newer platforms. Once found, plastic materials were counted and classified as presumably originating from fishing activities or from other sources: cordage diameters were usually estimated to 1 mm. Other man-made materials found around nest sites were also recorded.

The colonies in Port Phillip Bay were established after 1965; there were about 50 (Wedge Light) and 120 (Pope's Eye) nest sites in 1992, expansion being limited by available space (Norman & Menkhorst 1995). Removal of a central structure in 1993 allowed a small increase in available nesting area at Wedge Light. The Victorian colonies represent about half of the Australasian Gannets breeding in Australia (Ross et al. 1995).

Records of resighted, recaptured or recovered Australasian Gannets held by the Australian Bird and Bat Banding Scheme (ABBBS) were examined for the prevalence of entangled birds in the 1984 –93 period.

Results

At Lawrence Rocks, 34.5% (49 of 142) of nests incorporated plastic material, compared with 24.1% (35 of 145) at Pope's Eye and 23.5% (12 of 51) at Wedge Light, or 24% for the colonies in Port Phillip Bay generally (Table 1). There were no significant differences in the incidence of plastic debris in nests between individual sites ($\chi^2 = 4.495$, $d.f. = 2$, $P = 0.106$), but nests in Port Phillip Bay together had a significantly lower incidence ($\chi^2 = 4.488$, $d.f. = 1$, $P = 0.034$) than those at Lawrence Rocks. For the 338 nests examined in this study, the mean number of plastic items found was low (0.31 ± 0.504 for all nests; 1.07 ± 0.261 in the 96 containing plastic items).

For nests (336) categorised as old or new, there was no significant difference in the incidence of plastic items, and probing did not increase the level of plastics recorded ($\chi^2 = 0.092$ and 1.085, $d.f. = 1$, $P > 0.05$). At Pope's Eye, where nests were formed both on artificial wooden platforms as well as on rocks or concrete struc-

Table 1 Numbers of plastic items in nests of Australasian Gannets at Victorian breeding colonies and incidence (% of nests) of various categories of plastic in 338 nests examined.

	Colony					
	Lawrence Rocks	Pope's Eye (Port Phillip Bay)	Wedge Light (Port Phillip Bay)	All Port Phillip Bay nests	All sites	
Plastic category	No. of items	No. of items	No. of items	No. of items	No. of items	Incidence (%)
Net	2	1	1	2	4	3.9
Rope	51	30	12	42	93	78.4
Line		1		1	1	<1.0
Baling twine	2		3	3	5	3.9
Packaging tape	6				6	4.9
Plastic bag	1				1	<1.0
Drinking straw		3	1	4	4	2.9
Onion bag		1		1	1	<1.0
Other		2	4	6	6	2.9
Total items	62	38	21	59	121	

tures, there was no significant difference in the occurrence of plastic in nests on the older platform, on the rocks or on the newer platform ($\chi^2 = 1.147$, $d.f. = 2$, $P > 0.05$; $n = 145$), nor were there differences with nest location ($\chi^2 = 4.949$, $d.f. = 2$, $P = 0.084$; $n = 105$) even when those on the rocks, walkway and beacon were also considered as peripheral ($\chi^2 = 4.817$, $d.f. = 2$, $P = 0.090$; $n = 145$). However, at Lawrence Rocks, the mean number of plastic items varied significantly (Kruskal-Wallis, $H^d \approx \chi^2 = 6.605$, $P = 0.036$) with location; central nests contained more items than inner nests or those at the periphery of the colony.

During nest examinations, 121 plastic items (Table 1) were found in nests. Of these items, 93 (76.8%) were cordage fragments presumably derived from fishing gear, and a further four were of netting (of 20 and 60 mm mesh, one (Port Phillip Bay) perhaps being a fragment from a beach-seine net). Most cord or rope pieces were short (<200 mm), with diameters generally ≤5 mm (80.2% of 101 pieces estimated); in several instances, the incorporated plastic items were of unwound filaments rather than solid fragments. For all plastic items found, the immediate source of some 81% was considered to be associated with fishing activities. Baling twine (used by fishermen, and others) was recorded at five nests and strapping (used for bait boxes, and other purposes) at six nests at Lawrence Rocks. Relatively few plastics from potentially land-based uses were found (drinking straws, four pieces; hard, woven plastic, one piece; cassette tape, two pieces; onion bag, one piece), all at the colonies in Port Phillip Bay.

Apart from plastics in nests, one piece of plastic sheeting was found at a site in Port Phillip Bay, and a 'six-pack' yoke at Lawrence Rocks. A rubber seal (automotive light) and pieces of raw wool were found at Lawrence Rocks.

In the 1984–93 period, 322 band numbers of Australasian Gannets were reported to the ABBBS. Discounting those records where only bands were found or causes of death were unknown (92), or birds were retrapped or resighted (56), 'causes' of capture or death were given for 174 gannets. Many birds were beach-washed or sick (131), injured or exhausted (21) but 13 birds (7.5% of 174) were reported (mostly alive) as being tangled in fishing gear and two more in 'human' objects. Occasional gannet chicks have been found at Lawrence Rocks entangled in fishing gear used in lobster fisheries (C. Cooper pers. comm.).

Discussion

Australasian Gannets obtain nest material (various macrophytic algae or seagrass species) from the sea surface, or within colonies from neighbouring undefended nests (Norman & Menkhorst 1995). Results

from nests examined in Victoria showed that gannets now incorporate plastic refuse. Whereas the incidence of plastic is generally low by comparison with results for *M. bassana* in the Atlantic (20%, Bourne 1976; up to *c.* 75%, Nelson 1978; 97%, Montevecchi 1991), and the numbers of individual items per nest are small, results of this study indicate a form of anthropogenic pollution previously unrecognised at Australian seabird breeding sites. Apparently, most plastic material originated primarily from fishing activities but, given the size of items found and their universal use, it is not possible to identify the individual fisheries involved. Trawl, gill-netting, jigging for squid and calamari, beach and lobster fishing all occur along the Victorian coast, as does extensive recreational fishing (particularly within Port Phillip Bay): all may provide plastic refuse (accidentally or deliberately) as found here, as indeed may dispersal of waste material from net-repair or manufacture. Since the foraging range of the species may extend up to 450 km (at least in New Zealand, Wingham 1985), sources of plastic refuse may be distant from nesting colonies if such material is gathered while feeding. Again, since offshore waters move generally west to east in winter, and perhaps variably westwards in summer (Gibbs 1992), gannets breeding in Victoria may be sampling material originally discarded at distant sites. Equally, if they forage only for short distances specifically for nesting material then plastics may be obtained locally.

Some 4.6 million items of floatable litter enter Melbourne drainage waterways each year (McKay & Marshall 1993); more presumably comes from other catchment areas around Port Phillip Bay and directly from beaches. Australasian Gannets forage within the Bay, particularly in the southern area (Norman 1992). That few urban-derived items were found in the Port Phillip Bay colonies may suggest that nesting material was obtained either distant from colonies, that vegetation (for nest material) from the local sea surface was abundant or selectively taken (i.e. most urban-derived material is not suited to nest construction), or that plastic material in the southern portion of the Bay is rapidly diluted and dispersed into Bass Strait (McKay & Marshall 1993).

Several points of interest arise from this study. First, until foraging ranges (if similar to those undertaken for nesting material) of the species from Victorian colonies are known it is impossible to determine the source of plastics eventually incorporated into nests. Second, nests clearly identifiable as 'new' (e.g. those on Pope's Eye, formed essentially of macrophytes and re-established frequently), or materials used in annual nest refurbishment, may be most likely to provide an indication of current marine plastic pollution (at least of a size acceptable as nesting material by gannets, and available within their foraging range). However, it is apparent that more plastic items accumulate in presumably 'older' nests at the centre of the colony at Lawrence Rocks where, compared with those at Pope's Eye, rebuilding each season is reduced. Third, although there is no suggestion from this study that plastic refuse of the size found at nests presents a threat to the species, the presence of plastic remains from fishing gear in nests may indicate that larger fragments are present in local waters. Such remains, if they lead to entanglement, may pose a problem for feeding birds rather than those collecting nest material. Indeed, the (minimum) incidence of entangled gannets reported to the ABBBS indicates that this problem currently exits, as it does in the Northern Gannet (Schrey & Vauk 1987).

Acknowledgements

We thank J. Fisher and C. Cooper, officers of the Department of Conservation and Natural Resources (DCNR, Portland office), for their assistance in visiting Lawrence Rocks, and for discussion relating to the colony there. We are also grateful to J. Barker (Fisheries Branch, DCNR) for providing details of the Victorian fishing industry. Petina Pert (DCNR) and Simon Ward (University of Melbourne) assisted in the field work, and P. Dann, R. Gales and P.G. Ryan kindly commented on the manuscript. The Secretary (ABBBS) searched records of recovered gannets for information relating to plastic entanglement.

References

Bourne, W.R.P. 1976. Seabirds and pollution. Pp. 403-502 in Marine Pollution. Ed. R. Johnston. Academic Press, London.

Brown, R.S., Norman, F.I. & Eades, D.W. 1986. Notes on Blue and Kerguelen Petrels found beach-washed in Victoria, 1984. Emu 86, 228-238.

Colton, J.B., Knapp, F.D. & Burns, B.R. 1974. Plastic particles in the surface waters of the northwest Atlantic. Science 185, 481-497.

Dann, P. 1990. Plastic pollution and penguins. Australian Ranger Bulletin 5, 49-50.

Day, R.H., Wehle, D.H.S. & Coleman, F.C. 1985. Ingestion of plastic pollutants by marine birds. Pp. 334-386 in Proceedings of the Workshop on the Fate and Impact of Marine Debris, Honolulu, Hawaii. Eds R.S. Shimura &

H.O. Yoshida. NOAA Tech. Mem. NMFS-NOAA-TM-NMFS-SWFC-54.

Fry, D.M., Fefer, S.I. & Sileo, L. 1987. Ingestion of plastic debris by Laysan Albatrosses and Wedge-Tailed Shearwaters in the Hawaiian Islands. Marine Pollution Bulletin 18, 339-343.

Gibbs, C.F. 1992. Oceanography of Bass Strait: implications for the food supply of Little Penguins *Eudyptula minor*. Emu 91, 395-401.

Gregory, M.R. 1990. Environmental and pollution aspects. Pp. 291-324 in Antarctic Sector of the Pacific. Ed. G.P. Glasby. Elsevier, Amsterdam.

Harris, M.P. & Norman, F.I. 1981. Distribution and status of coastal colonies of seabirds in Victoria. Memoirs of the National Museum of Victoria 42, 89-106.

Laist, D.W. 1987. Overview of the biological effects of lost and discarded plastic debris in the marine environment. Marine Pollution Bulletin 18, 319-326.

McKay, P. & Marshall, M. 1993. Backyard to Bay: tagged litter report. Melbourne Water, Melbourne.

Montevecchi, W.A. 1991. Incidence and types of plastic in gannets' nests in the northwest Atlantic. Canadian Journal of Zoology 69, 295-297.

Nelson, J.B. 1978. The Sulidae: Gannets and Boobies. Oxford University Press, Oxford.

Norman, F.I. 1992. Distribution and abundance of seabirds off Phillip Island and within Port Phillip Bay, Victoria, 1986–1988. Emu 91, 377-394.

Norman, F.I. & Menkhorst, P.W. 1995. Aspects of the breeding and feeding ecology of the Australian Gannet *Morus serrator* in Port Phillip Bay, Victoria, 1988–92. Emu 95, 23-40.

Pemberton, D., Brothers, N.P. & Kirkwood, R. 1992. Entanglement of Australian fur seals in man-made debris in Tasmanian waters. Wildlife Research 19, 151-159.

Pruter, A.T. 1987. Sources, quantities and distribution of persistent plastics in the marine environment. Marine Pollution Bulletin 18, 305-310.

Ross, G.J.B., Burbidge, A.A., Brothers, N., Canty, P., Dann, P., Fuller, P.J., Kerry, K.R., Norman, F.I., Menkhorst, P.W., Pemberton, D., Shaughnessy, G., Shaughnessy, P.D., Smith, G.C., Stokes, T. & Tranter, J. 1995. The status of Australia's seabirds. Pp. 167-182 in The State of the Marine Environment for Australia. Technical annex: 1 The Marine Environment. Eds L.P. Zann & P. Kailola. Great Barrier Reef Marine Park Authority, Townsville.

Ryan, P.G. 1988. The incidence and characteristics of plastic particles ingested by seabirds. Marine Environmental Research 23, 175-206.

Schrey, E. & Vauk, G.J.M. 1987. Records of entangled gannets (*Sula bassana*) at Helgoland, German Bight. Marine Pollution Bulletin 18, 350-352.

Skira, I.J. 1986. Food of the Short-tailed Shearwater, *Puffinus tenuirostris*, in Tasmania. Australian Wildlife Research 13, 481-488.

Slip, D.J., Green, K. & Woehler, E.J. 1990. Ingestion of anthropogenic articles by seabirds at Macquarie Island. Marine Ornithology 18, 74-7.

Van Franeker, J.A. & Bell, P.J. 1988. Plastic ingestion by petrels breeding in Antarctica. Marine Pollution Bulletin 19, 672-674.

Vauk, G.J.M. & Schrey, E. 1987. Litter pollution from ships in the German Bight. Marine Pollution Bulletin 18, 316-319.

Wingham, E.J. 1985. Food and feeding range of the Australasian Gannet *Morus serrator* (Gray). Emu 85, 231-239.

Woehler, E.W. 1990. Two records of seabird entanglement at Casey, Antarctica. Marine Ornithology 18, 72.