Volume 30/Number 2/February 1995

REPORTS

Pergamon

0025-326X(94)00182-0

Marine Pollution Bulletin, Vol. 30, No. 2, pp. 109–115, 1995
Elsevier Science Ltd
Printed in Great Britain
0025-326X/95 $9.50+0.00

Domestic Waste and TBT Pollution in Coastal Areas of Ambon Island (Eastern Indonesia)

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Coastal areas of the island of Ambon (eastern Indonesia), but especially Ambon Bay, were polluted by domestic waste. There was severe beach litter pollution and contamination of inshore waters. High incidences of the isopod ectoparasite *Renocila* sp. on the coral reef fish *Abudefduf saxatilis* were probably indirect consequences of pollution stress. Symptoms of imposex, presumably caused by tributyltin compounds leaching from the anti-fouling paints used on boat hulls, were severe in some whelk populations in Ambon Bay but were mild or absent from populations elsewhere on the island.

Coastal pollution, and the over-exploitation of natural resources, are global problems but are particularly severe in areas of high population density and those adjacent to semi-enclosed and shallow seas. There are, for example, serious problems along much of the north coast of Java. The island has an enormously dense population accounting for only 6.9% of the land area of Indonesia but supporting 60% of its total population of 176 million people. The most acute problems are in Jakarta Bay which receives pollutants from the city of Jakarta. It suffers from heavy metal and sewage pollution (Sutamihardja, 1988; Thayib & Razak, 1988), the destruction of coral reefs by fishermen using explosives and mining of reefs for construction materials (Ongkosongo & Sukarno, 1986), coastal erosion (Stoddart, 1986), loss of fish diversity (Hutomo & Adrim, 1986) and beach litter pollution (Willoughby, 1986). Islands in the eastern part of Indonesia are relatively sparsely populated and, although there are centres of population, such as the Ambon, the region has more extensive seas than the western part of the country (Wyrtki, 1961) (Fig. 1). The extent to which the coastal areas of the eastern islands are polluted is less well known, and the object of the present study was to assess coastal pollution on the island of Ambon (128.1°E, 2.8°S). The island measures approximately 20×10 km and has a population of 1.5 million. The main town, which is called Ambon, is the capital of the Malukus Province.

There were three complementary measures of pollution: *1.* beach litter; *2.* the effects of tributyltin from anti-fouling paints on populations of whelks; and *3.* organic pollution of inshore water and the incidences of parasitic isopods on the coral reef fish *Abudefduf saxatilis*. In each case, data were collected from several sampling sites around the island. For comparative purposes, sites were grouped into those in Ambon Bay (i.e. from Hattu to Amahusu), those along the south-east coast (i.e. from Latuhalat to Liang), and those on the north coast (i.e. from Morella to Asilulu) (Fig. 1). Backgrounds to the studies were as follows:

1. Beach litter pollution. The advent of synthetic non-biodegradable products has led to the accumulation of rubbish on shorelines, especially in developing countries where efficient garbage disposal systems are lacking (e.g. Willoughby, 1986; Khatib *et al.*, 1990; Lucas, 1992; Corbin & Singh, 1993). It is a serious problem which threatens human health (e.g. Daniel *et al.*, 1989; Ferrinho *et al.*, 1991; Sahlu & Lawson, 1992; Yohannes *et al.*, 1992), endangers wildlife, especially marine mammals and seabirds (e.g. Fuller, 1987; Laist, 1987), inhibits the development of tourism (Garrity & Levings, 1993) and hampers artisanal coastal fisheries (Nash, 1992). In the present study, the extent of beach litter was correlated with the densities of human populations in adjacent coastal areas and with the degree of exposure of shores of wave action.

2. Toxins from anti-fouling paints. Tributyltin (TBT) compounds, have been used extensively as biocides in anti-fouling paints. They leach slowly from them and can have dramatic effects on populations of marine

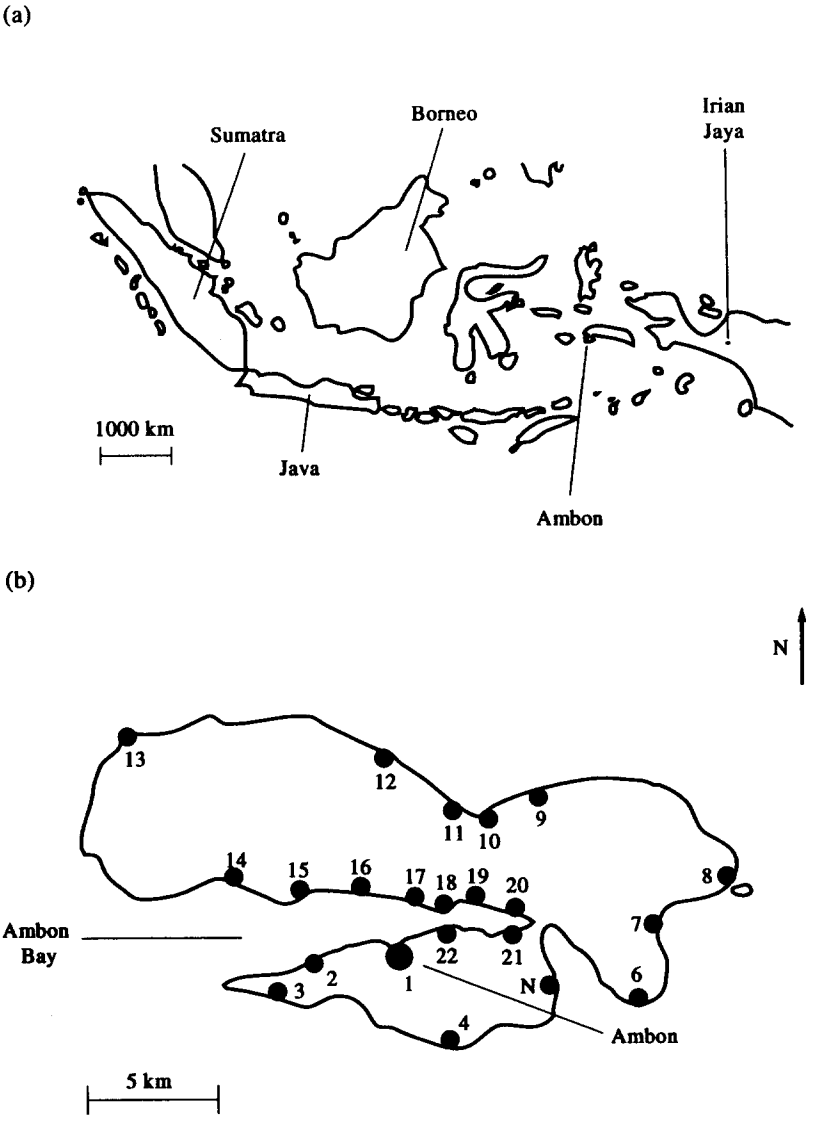

Fig. 1 (a) Map of Indonesia showing some of the major islands and the location of Ambon. (b) Ambon Island showing Ambon Bay (AB) and other places mentioned in the text: 1, Ambon (town); 2, Amahusu; 3, Latahulat; 4, Hukurila; 5, Toisapu; 6, Tial; 7, Waai; 8, Liang; 9, Morela; 10, Hitu; 11, Wakal; 12, Hila; 13, Asilulu; 14, Hattu; 15, Batubaderi; 16, Hatiwe Besar; 17, Wayame; 18, Poka; 19, Hunut; 20, Negerilima; 21, Lateri; 22, Galala.

organisms (Gibbs *et al.*, 1987). The best-documented cases are those of their impact on the Pacific Oyster *Crassostrea gigas* (Thunberg), which has suffered from shell thickening, distorted growth and reproductive failure in areas of high boating activity (Alzieu *et al.*, 1989), and the dogwhelk *Nucella lapillus* (L.), which has suffered from a condition known as imposex in similar places. Female dogwhelks develop male sexual characters, sometimes resulting in sterilization, premature death and, in severe cases, to the local extinction of the species (Bailey & Davies, 1989). Regulations restricting the use of paints containing TBT to large commercial vessels has led to the recovery of some populations of *N. lapillus* in the UK (e.g. Douglas *et al.*, 1993; Evans *et al.*, 1994) but the use of these paints is not controlled in Indonesia. TBT can be effective at such low concentrations (<2 ng l^{-1}; see Gibbs *et al.*, 1987) that it is difficult to detect by chemical analysis and biological assay (i.e. measurement of imposex) has often been used in its place (Foale, 1993). In the present study, imposex was measured in samples of gastropods in the genera *Thais* and *Vasum* collected from the littoral zones of rocky shores.

3. The incidence of fish parasites. There is widespread evidence that the introduction of toxic substances into the seas has negative effects on the health of fish populations. It appears to have led to increases in the incidences of epizootic liver neoplasms, viral and bacterial skin diseases and parasites (Esah *et al.*, 1974; Verhaak, 1986). In the present study, assessments were made of the incidence of the isopod ectoparasite *Renocila* sp. on the Sergeant Major Fish *A. saxatilis*. This relationship was chosen because *A. saxatalis* is abundant at most shallow water sites around Ambon and the parasite is large and conspicuous. It was

possible therefore for SCUBA divers to count the numbers of the ectoparasites on individual fish.

Methods

Field work was undertaken during the period from July to September 1993 inclusive

Beach litter. Shores were sampled by making transects 100 m long immediately above and parallel to the strand line. There were 10 equally spaced quadrats along each transect. These were normally 1.0×1.0 m but where the area above the strand line was fore-shortened by, for instance, rocky outcrops or sea defences, quadrats measured 0.5×2.0 m. Records were kept of the numbers of litter items per quadrat and the percentage cover of items in four litter categories: synthetic materials (metal and plastic objects), organic materials (including faecal material), glass (including ceramics) and paper (including card). The sizes of human populations inhabiting towns and villages adjacent to study sites were obtained from *Statistics of Malukus 1992.* Shores were also categorized qualitatively as follows in relation to their exposure to wave action and substrata:

1. Sheltered mud flats (e.g. estuaries, mangroves)
2. Open mud flats
3. Fine sand/sheltered bays
4. Coarse sand (open beaches)
5. Shingle beaches
6. Pebble beaches
7. Boulder shores
8. Rocky shores

Overall 56 sites were surveyed, many distant from human habitation; data presented in Table 1 and Fig. 3 (below) are based on them. Comparisons of litter on shores in Ambon Bay, the south-east coast and the north-east coast (see Table 2 below) were however restricted to 21 sites immediately adjacent to villages.

Imposex in gastropod molluscs. Assessments were made of imposex and male female ratios in samples of between 13 and 50 whelks collected from each of 24 study sites. Searches were made at two additional sites but no whelks were found. Whelks were taken back to the laboratory for dissection, so that individuals could be sexed and measurements made of the penis length. The relative penis size index (RPSI) (a standard measure of imposex) was then calculated. The RPSI compares female penis length with that of the male using the following formula (Gibbs *et al.*, 1987):

$$\frac{\text{mean cubed female penis length}}{\text{mean cubed male penis length}} \times 100.$$

Relative abundance was estimated by calculating the numbers of whelks found per minute of collecting time at each site. Preliminary identification of gastropods were made in Ambon but samples were taken back to the UK and identified by Dr John Taylor at the British Museum of Natural History, London.

Fish parasites. Assessments of the abundance of *A. saxatilis* and the incidence of the parasite *Renicola* sp. were made by SCUBA divers swimming within 100 m of the shore. Abundance of *A. saxatilis* was based on the numbers observed per minute of time spent searching. Each of 26 study sites was given a rating based on organic pollution as follows: three grossly polluted; two moderately polluted; and one relatively clean. The parasite was identified at the Zoological Museum, Copenhagen with the assistance of Dr Niel Bruce.

TABLE 1

Abundance of major litter types (i.e. those recorded 20 or more times).*

Synthetic materials

Food wrappings (206), string/rope (163), cloth (179), plastic fragments (136), carrier bags (104), sandals (100), plastic bottles (70), polystyrene (70), tin cans (66), hessian sacks (60), polyethylene (57), cigarette boxes (45), scrap metal (39), aluminium cans (38), plastic cartons (30), shoes (27), table coverings (21), tin foil (20).

Mean number per m^{-2}: 2.8.
Percentage cover: 8.3.

Organic matter

Kitchen waste (271), wood (204), sago (192), cane (41), human faeces (35), bones/mollusc shells (25).

Mean number per m^{-2}: 1.4.
Percentage cover: 8.0.

Glass

Glass (91), ceramics (24).

Mean number per m^{-2}: 0.2.
Percentage cover: 0.5.

Paper

Paper (52), card (32).

Mean number per m^{-2}: 0.2.
Percentage cover: 0.4.

*Figures in parentheses indicate the total number of times that items were recorded (in 560 quadrats).

TABLE 2

Litter pollution (percentage cover) in different coastal areas of the island.

	No. sites surveyed	Mean exposure score	Mean population	Percent litter cover				
				Synthetic	Organic	Glass	Paper	Total
Ambon Bay	10	4.7 ±0.5	5826 ±1161	13.6 ±3.2	19.4 ±6.3	0.5 ±0.4	0.7 ±0.4	34.2 ±8.5
South-east coast	6	5.2 ±0.9	5626 ±1115	6.5 ±3.9	5.8 ±3.0	0.1 ±0.1	0.5 ±0.5	12.9 ±5.1
North coast	5	4.4 ±0.6	3388 ±106	8.7 ±3.6	6.5 ±1.9	0.4 ±0.2	0.2 ±0.2	15.8 ±4.9

Results

Beach litter

Litter is a severe problem along much of the island's shoreline. Overall, the mean density of objects was 4.6 m^{-2}, consisting predominantly of synthetic items, especially plastic ones, and organic matter (Table 1). The percentage cover of litter varied from < 1% at some sites distant from human habitation, and at the village of Latuhalat, to 28% at Hila (north coast), 31% at Waai (south-east coast), 28% at Hunut, 28% at Lateri, 52% at Batubaderi, 59% at Negerilima, and 92% at Poka (all in Ambon Bay). Local human populations were almost certainly the source of at least synthetic materials because there was a high correlation between their occurrence on the shore and the sizes of populations in the adjacent coastal area (Fig. 2). There were also positive correlations between organic matter and paper (separately), and human populations but they were not statistically significant. The degree of exposure to wave action of the shore also affected litter pollution since paper and glass cover each correlated negatively with it (Fig. 2).

Beach litter was worse adjacent to villages around Ambon Bay than along the south-east and north coasts (Table 2).

Imposex in gastropods

Whelks, *Thais* spp. or *Vasum turbinellus*, were found at 24 of 26 sampling sites. Searches were also made at Poka and Galala (in Ambon Bay) but they were found at neither of these places. Overall four gastropod species were recorded, each of which tended to be site specific. *Vasum turbinellus* was found on shores where coral rock was covered with algae, *T. kieneri* occurred on boulder shores in sheltered areas, *T. savignyi* was characteristic of boulder shores at moderately exposed sites and *T. tuberosa* was found on exposed shores.

Imposex was recorded in three gastropods, *T. kieneri*, *T. savignyi* and *V. turbinellus* and at 9 of 24 sampling sites (37.5%) at which whelks were present. Symptoms were most severe within Ambon Bay (Fig. 3; Table 3). Imposex was evident in all female *T. kieneri* sampled from the shore at Hunut and at Ambon itself, and occurred in some females at Wayame and Amahusu. It was not present in samples taken from two out of three sites on the north coast, and close to the mouth, of Ambon Bay (Fig. 3). There was mild imposex, however at a series of sites between Hukurila and Toisapu on the

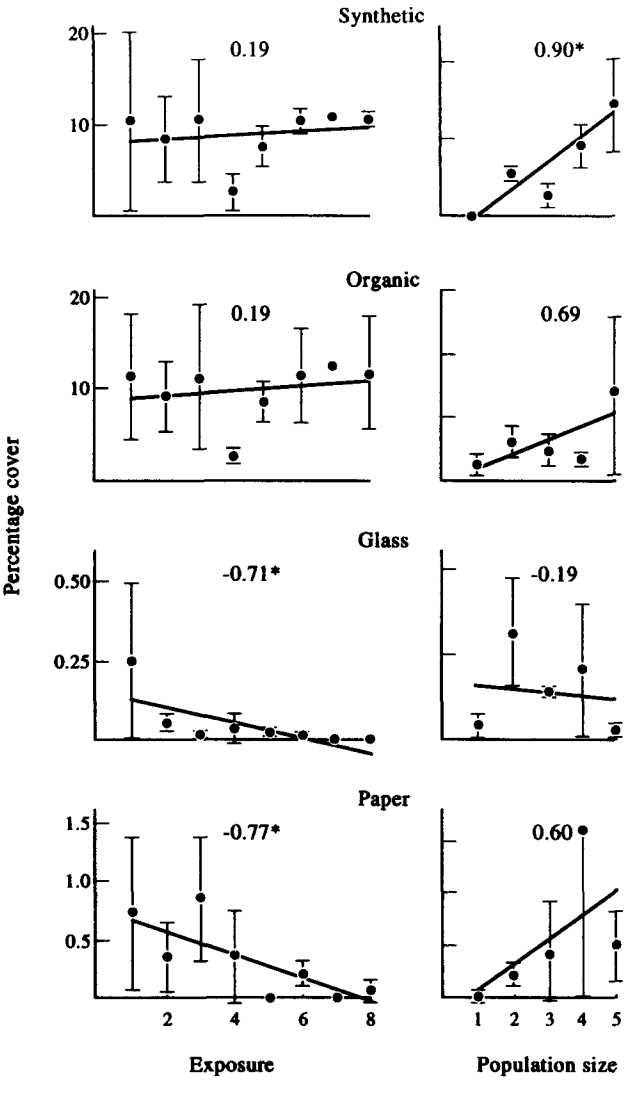

Fig. 2 Relationship between beach litter of four different kinds (synthetic objects, organic matter, glass and paper), sizes of human populations in adjacent coastal areas, and exposure of shores. Regression lines and coefficients of correlation are shown on each graph. *Denotes significance at $p < 0.05$. Population sizes are as follows: 1, < 2000; 2, 2000–3999; 3, 4000–5999; 4, 6000–7999; 5, > 8000. Note the different scales for percentage cover.

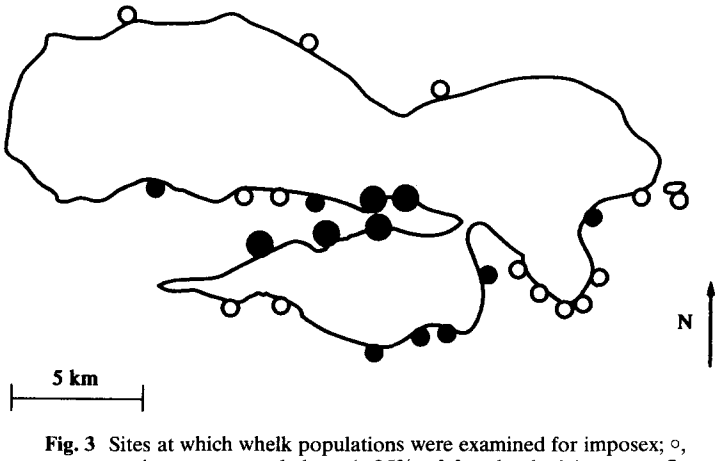

Fig. 3 Sites at which whelk populations were examined for imposex; ○, no imposex recorded; •, 1–25% of females had imposex; ●, either more than 25% of females had imposex or no whelks recorded (see text).

TABLE 3

Symptoms of imposex, abundance (numbers collected per hour) and sex ratios of whelks collected along different parts of the coast.

	Sites at which imposex was not recorded			Sites at which imposex was recorded				
							Percent female whelks	
	n	Abundance ($n\ h^{-1}$)	Sex ratio (♂:♀)	*n*	Abundance ($n\ h^{-1}$)	Sex ratio (♂:♀)	With imposex	RPSI
Ambon Bay								
T. kieneri	1	108.0	1.3	4	78.4 ±40.8	1.0 ±0.2	63.2 ±21.9	3.40 ±2.90
T. savignyi	2	28.6	0.7	0	-	-	-	-
South-east coast								
T. kieneri	0	-	-	1	32.0	0.7	6.7	<0.01
T. savignyi	5	42.4 ±3.5	0.9 ±0.3	2	42.5 ±6.5	0.7 ±0.3	15.6 ±7.5	0.63 ±0.60
T. tuberosa	4	26.4 ±10.0	1.3 ±0.2	0	-	-	-	-
V. turbinellus	0	-	-	2	*	0.7 ±0.3	7.9 ±0.2	0.80 ±0.04
North coast								
T. savignyi	2	20.0	0.4	0	-	-	-	-
V. turbinellus	1	*	0.7	0	-	-	-	-

*No data are available.

south-east coast. In these cases it occurred in *T. savignyi* and *V. turbinellus* but it was present in relatively small proportions of the female whelks examined (Table 3). One female *T. kieneri* at Waai (also on the south-east coast) had imposex. There was no imposex at all in females sampled from the north coast of the island.

Sex ratios tended to be female biased. There was no evidence of high female mortality (which would have been indicated by male-biased populations) or general mortality (which could have been identified by low abundancy of whelks) at sites at which there was imposex (Table 3). That was with the exception of the absence of whelks at Poka and Galala where they may have become locally extinct.

Fish parasites

The host fish *A. saxatilis* was recorded at each of 26 sampling sites. With the exceptions of two sites only, at least some of the fish observed were parasitized by the isopod *Renocila* sp. There was usually a single parasite per host but one *A. saxatilis* carried three ectoparasites. The incidence of parasites was higher at sites which were heavily polluted with organic waste than at less polluted sites (Fig. 4). There was a positive correlation between parasite load and pollution ratings at each of the three coastal areas sampled. Spearman rank coefficients of correlation (r_s) were 0.71 ($p < 0.05$) for Ambon Bay, 0.80 ($p < 0.02$) for the south-east coast, and 0.59 (NS) for the north coast. The abundance of *A. saxatilis* did not correlate with pollution ratings; r_s values were 0.01, −0.20 and −0.20 (NS in each case) for each of the areas, respectively.

The incidence of parasites was higher in Ambon Bay than along either the south-east coast or the north coast (Table 4).

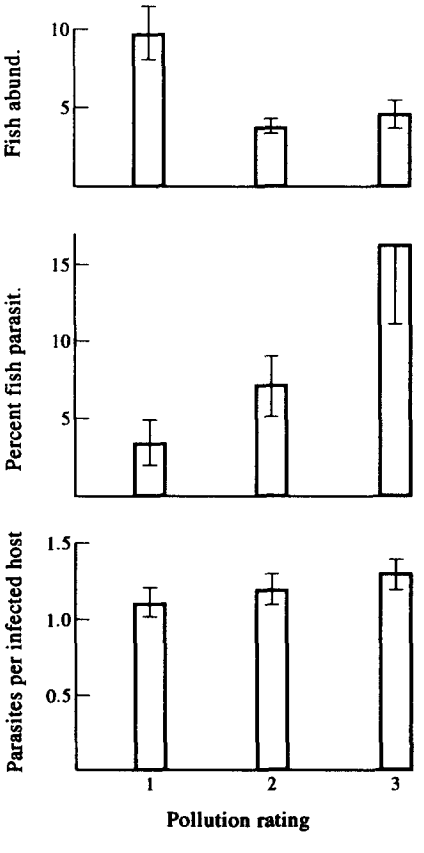

Fig. 4 Abundance of host fish *A. saxatilis*, the abundance of ectoparasites on them, and numbers of ectoparasites per parasitized host, at sites rated as grossly polluted (3), moderately polluted (2) or relatively clean (1).

Discussion

Coastal areas of the island of Ambon suffered from severe pollution from beach litter, especially plastic and metal objects, and organic waste. While comparisons of

TABLE 4

The abundance of the Sergeant Major Fish *Abudefduf saxatilis* and of the ectoparasite *Renocila* sp. along different parts of the coast of the island.

	No. of survey sites	Mean pollution rating	Abundance of *A. saxatilis* (n min^{-1})	Percent fish parasitized	No. parasites per parasitized fish
Ambon Bay	10	2.2 ± 0.3	3.8 ± 1.0	12.2 ± 4.0	1.2 ± 0.1
South-east coast	8	2.1 ± 0.2	5.6 ± 1.0	5.9 ± 3.2	1.2 ± 0.1
North coast	8	1.8 ± 0.3	4.6 ± 0.9	8.0 ± 2.3	1.3 ± 0.1

the results with those of other studies are difficult because of differences in measuring techniques, there is no doubt that Ambon was heavily polluted. The density of polluting objects recorded in the present study (4.6 m^{-2}) was worse than that recorded in Scotland (0.4 m^{-2}) by Caulton & Mocogni (1987), in Nova Scotia (1.7 m^{-2}) by Ross *et al.* (1991), and in the Caribbean (3.6 m^{-2}) by Garrity & Levings (1993). Domestic waste also polluted inshore waters of Ambon and was probably the indirect cause of heavy loads of parasitic isopods *Renocila* sp. on the Sergeant Major Fish *A. saxatilis*. Litter, especially non-biodegradable plastics, can be carried for enormous distances by currents and can pollute beaches far away from the source (Morris, 1980; Gregory, 1983; Shiber, 1982; Willoughby, 1986). In the case of Ambon, however, the island is so distant from other major centres of population that the source of litter is almost certainly local. Some of it may come from ships but the correlation between plastics and the sizes of human populations in adjacent areas suggests strongly that it originated from local villages. While clean-up measures could be achieved by the employment of beach litter collectors, as happens on some of the 'tourist' islands in the Pulau Seribu group (Willoughby, 1986), it is probable that a more effective method in the long term will be to change local attitudes and practices towards litter disposal through community education programmes aimed at village groups (McCarthy, 1993).

Ambon Bay is used extensively as a harbour for fishing, cargo and passenger boats especially along that part of the shore adjacent to the town of Ambon. Although recent studies have shown that TBT is not the sole causative agent of imposex in whelks (see Evans *et al.*, in press), it is probable that imposex in whelk populations within the Bay can be attributed to TBT leaching from the anti-fouling paints used on the boats moored there (e.g. Ellis & Pattisina, 1990). It was surprising therefore that there was no imposex in some nearby whelk populations along the north coast of the Bay (and towards its mouth) and none at all along the north coast of the island. Imposex was recorded at sites along the south-east coast but the symptoms were mild. These results imply that, while imposex is undoubtedly a major problem in the semi-enclosed bodies of water, it is less likely to be significant in oceanic areas, and areas of open sea, such as in the Malukus, where there is sufficient water close to release sites to dilute TBT to below effective concentrations.

Ambon Bay has poor flushing properties (see Hamzah & Wenno, 1987) and the accumulation of pollutants of various kinds in it is cause for concern. Thayib & Razak (1988) found that it had heavy loads of toxic metals, pesticides and coliform bacteria and the Bay was the most polluted part of the island's coast in each of the four measures made in the present study: beach litter, organic pollution of inshore waters, incidence of fish parasites and imposex.

The authors would like to thank Professor J. L. Nanere, the Rector, and Mr J. M. Nanlohy, Dean of the Faculty of Fisheries, for the hospitality and for use of facilities at Pattimura University. Thanks are also due to Dr John Taylor for identification of whelks, Dr Niel Bruce for his help in identifying *Renicola* sp., Mr John Hall for administrative assistance and Mrs Carol Weiss for typing the manuscript. Financial assistance was received from the Royal Society, British Council, British Ecological Society and the University of Newcastle upon Tyne's Exploration Society.

Alzieu, C. C., Sanjuan, J., Michel, P., Borel, M. & Dreno, J. P. (1989). Monitoring and assessment of butyltins in Atlantic coastal waters. *Mar. Pollut. Bull.* **20**, 22–26.

Bailey, J. K. & Davies, I. M. (1989). The effects of tributyltin on dogwhelks (*Nucella lapillus*) from Scottish waters. *J. Mar. Biol. Assoc. UK* **69**, 335–354.

Caulton, E. & Mocogni, M. (1987). Preliminary studies of man-made litter in the Firth of Forth, Scotland. *Mar. Pollut. Bull.* **18**, 446–450.

Corbin, C. J. & Singh, J. G. (1993). Marine debris contamination of beaches in St. Lucia and Dominica. *Mar. Pollut. Bull.* **26**, 325–328.

Daniel, M., Sixl, W. & Kock, M. (1989). Problems of housing and health of people utilising the garbage in Cairo (Egypt) from the viewpoint of medical etymology. *J. Hygiene Epid. Microbiol. Immunol.* **33** (suppl.), 568–576.

Douglas, E. W., Evans, S. M., Frid, C. L. J., Hawkins, S. T., Mercer, T. S. & Scott, C. L. (1993). Assessments of imposex in the dogwhelk *Nucella lapillus* (L.) and tributyltin along the northeast coast of England. *Invert. Reprod. Devel.* **24**, 243–248.

Ellis, D. V. & Pattisina, A. (1990). Widespread neogastropod imposex: a biological indicator of global contamination? *Mar. Pollut. Bull.* **21**, 248–253.

Esah, G. W., Gibbons, J. W. & Bourque, J. E. (1974). An analysis of relationships between stress and parasitism. *Am. Mid. Nat.* **93**, 339–352.

Evans, S. M., Hawkins, S. T., Porter, J. & Samosir, A. M. (1994). Recovery of dogwhelk populations on the Isle of Cumbrae, Scotland following legislation limiting the use of TBT as an antifoulant. *Mar. Pollut. Bull.* **28**, 15–17.

Evans, S. M., Leksono, T. & McKinnell, P. D. (1995). Tributyltin pollution: a diminishing problem following legislation limiting the use of TBT-based anti-fouling paints. *Mar. Pollut. Bull.* **30**, 14–21.

Ferrinho, P. D. L., Barron, P. M., Buch, E., Gear, J. S. S., Morris, A., Orkin, F. M., Bekker, S. & Jeffrey, A. (1991). Measuring environmental health status in Oukasie (Transvaal, South Africa), 1987. *S. Afr. Med. J.* **79**, 29–31.

Foale, S. (1993). An evaluation of the potential of gastropod imposex as a bioindicator of tributyltin pollution in Port Phillip Bay, Victoria. *Mar. Pollut. Bull.* **26**, 546–552.

Fuller, C. W. (1987). Marine debris and northern fur seals: a case study. *Mar. Pollut. Bull.* **18**, 326–335.

Garrity, S. D. & Levings, S. C. (1993). Marine debris along the Caribbean Coast of Panama. *Mar. Pollut. Bull.* **26**, 317–324.

Gibbs, P. E., Bryan, G. W., Pasare, P. L. & Burt, G. R. (1987). The use of the dogwhelk (*Nucella lapillus*) as an indicator of TBT contamination. *J. Mar. Biol. Assoc. UK* **67**, 502–524.

Gregory, M. R. (1983). Virgin plastic granules on some beaches of Eastern Canada and Bermuda. *Mar. Env. Res.* **10**, 73–92.

Hamzah, M. S. & Wenno, L. F. (1987). Sirkulasi arus di teluk Ambon. In *Biologi, Perikanan, Oseanografi dan Geologi*, pp. 91–101. Balai Penelitian dan Pengembangan Oseanologi, Lembaga Ilum Pengetahuan Indonesia, Ambon, Indonesia.

Hutomo, M. & Adrim, M. (1986). Distribution of reef fish along transects in the Bay of Jakarta and Kepulauan Seribu. In *Human Induced Damage to Coral Reefs* (B. E. Brown, ed.), pp. 135–165. UNESCO, Paris, France.

Khatib, R., Usmani, N. F. & Husain, S. (1990). Evaluation of recyclable materials in municipal waste from Karachi. *Biol. Wastes* **31**, 113–122.

Laist, D. W. (1987). Overview of the biological effects of lost and discarded plastic debris in the marine environment. *Mar. Pollut. Bull.* **18**, 319–326.

Lucas, Z. (1992). Monitoring persistent litter in the marine environment on Sable Island, Nova Scotia. *Mar. Pollut. Bull.* **24**, 192–199.

McCarthy, J. (1983). Bringing the environment back to the village. Some thoughts on environmental education in Indonesia. In *Asian Region Conference on Environmental Education*, pp. 216–219. University of Indonesia, Jakarta, Indonesia.

Morris, R. J. (1980). Floating plastic debris in the Mediterranean. *Mar. Pollut. Bull.* **11**, 125.

Nash, A. D. (1992). Impacts of marine debris on subsistence fishermen: an exploratory study. *Mar. Pollut. Bull.* **24**, 150–156.

Ongkosongo, O. S. R. & Sukarno (1986). Background to the study sites in the Bay of Jakarta and Kepulauan Seribu. In *Human Induced Damage to Coral Reefs* (B. E. Brown, ed.), pp. 56–79. UNESCO, Paris, France.

Ross, J. B., Parker, R. & Strickland, M. (1991). A survey of shoreline litter in Halifax Harbour 1989. *Mar. Pollut. Bull.* **22**, 245–248.

Sahlu, T. & Lawrson, C. (1992). The prevalence and environmental risk factors for moderate and severe trachoma in southern Ethiopia. *J. Trop. Med. Hygiene* **85**, 36–41.

Shiber, J. G. (1982). Plastic pellets on Spain's Costa del Sol beaches. *Mar. Pollut. Bull.* **13**, 409–412.

Stoddart, D. R. (1986). Umbgrove's islands revisited. In *Human Induced Damage to Coral Reefs* (B. E. Brown, ed.), pp. 80–98. UNESCO, Paris, France.

Sutamihardja, R. T. M. (1985). Water quality in the coastal area: the Jakarta Bay experience. In *Environmental Protection and Coastal Zone Management in Asia and the Pacific* (N. Kato, N. Kumamoto, W. H. Matthews & A. Suhaimi, eds). Tokyo University Press, Tokyo, Japan.

Thayib, S. S. & Razak, H. (1988). Pengamatan kandungan bakteri indikator, logam berat dan pestisida di perairan pantai Teluk Ambon, Teluk Banten dan Teluk Jakarta [Observations of bacterial content indicators, heavy metals and pesticide in the coastal waters of Ambon Bay, Bantee Bay and Jakarta Bay]. In *Perairan Indonesia: Biologi, Budidaya Kualitas Perairan dan Oseanografi* (M. K. Moosa, D. P. Praseno & Sukarno, eds). Jakarta, Indonesia.

Verhaak, A. D. (1986). Fish diseases, signals for a diseased environment? In *Reasons for Concern*, pp. 41–46. Proceedings of the 2nd North Sea Seminar Workshop Nordzee, Amsterdam, The Netherlands.

Willoughby, N. G. (1986). Man-made litter on the shores of the Thousand Island Archipelago, Java. *Mar. Pollut. Bull.* **17**, 224–228.

Wyrkti, K. (1961). *Physical Oceanography of Southeast Asian Waters.* Naga Rep. **2**, 195 pp.

Yohannes, A. G., Streatfield, K. & Bost, L. (1992). Child morbidity patterns in Ethiopia. *J. Biosocial Sci.* **24**, 143–155.