Journal of the Andaman Science Association Vol. 21(2):77-86 (2016)
ISSN 0970-4183, Printed in India

Impact of Solid Waste and Ghost Nets on the Coastal Biota of Andaman Islands – An UnderestimatedThreat for the Island Ecosystem

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Abstract

This study highlights the effects of solid waste and ghost nets by identifying, quantifying and analyzing their impact on the biotic community from six ecologically important habitats around Andaman Islands in the Indian EEZ. Plastic items were the dominant waste in all the beaches with more than 60% of waste originating from plastic. Plastic bags alone comprised 21% of all solid wastes while cloth was the least(2%). North Bay received the highest quantity of solid waste (22%) and Chidiyatapu the least (12%) amongst the six stations. It is to be noted that North Bay is a popular tourist spot and fishing activity is high in the area. Chidiyatapu is also a tourist spot but it is under a forest reserve and so dumping of solid waste is checked. While snorkeling close to these beaches, solid wastes were clearly visible which might have been carried away by rain or wind into the sea. Ghost nets are a common sight in reef areas of South Andaman especially North Bay, Hut Bay etc. where fishing activity is more. It was observed that ghost nets lying over reefs easily entangled branching corals especially *Acropora* spp. and hampered their natural growth. A total of 21 ghost nets were recorded out of which 7 were recorded from North Bay alone. Macroalgae was seen overgrown in most discarded nets over coral reefs. Some crustaceans (juveniles of crabs and prawns) and fishes (eels, juveniles of Apogonidae, Pemphridae etc.) were observed taking shelter inside ghost nets.

Keywords: *Solid waste, Ghost nets, Plastic, Reef, Andaman Islands*

Introduction

National Oceanic and Atmospheric Administration (NOAA) has defined *Marine Debris* as any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed off or abandoned into the marine environment. With the introduction of synthetic materials, natural fibers have been almost fully replaced in the manufacture of fishing nets, line and in all our everyday items. The low cost, light weight, and long life of new synthetic materials have resulted in more items being discarded and their movementinto the coastal waters possessa much dangerousthreat to the marine organisms. The seas in all parts of the world are littered with man-made debris and most are plastics, which are almostnon-degradable (Gregory 1999).

Ghost nets are fishing nets that have been abandoned at sea, lost accidentally or deliberately discarded (Brown et al. 2005) by fishermen. 'Ghost fishing' is the continuation of fishing by the fishing gears that have been lost or abandoned in the sea which is largely confined to 'passive gears' such as gillnets, trammel nets, wreck nets, and traps (Brown et al. 2005). As they are unattended and roam freely with the help of currents, waves, wind etc. they fish indiscriminately. A fishing gear continues to fish even after it has been lost and the fisherman has lost control. For example, Breen (1987) estimated that ghost fishing traps caught an amount equivalent to 7% in weight of the reported commercial catch of Dungeness crab. Similarly, lost fish traps were estimated to catch a quantity equivalent to 3-13.5% of the total Kuwait landings (Mathews et al. 1987). There are numerous records of mammals such as dolphins, whales, seals and sea lions other than fishery resources also getting tangled with such fishing gears (Henderson 1984, Gerrodette et al. 1987, Carr and Harris 1994, Nielson 2006) and forms a serious threat to the ecosystem. Once entangled the movement of any marine organism gets restricted and thereby leading to death if not rescued in time.The presence of ghost nets in the oceans and their effects is a relatively new topic. Though it was first observed in the 1970s by fishery scientists, remedial work hasn't been

of any significance till date and with time the burden of ghost nets is more than ever in all our seas and oceans. The impact of lost fishing gear on the environment has aroused considerable concern in recent years (Laist 1997, Nielson 2006). Lost and discarded marine debris, particularly items made of persistent synthetic materials are now recognized as a major form of marine pollution as recognized first in the 1984 International Workshop on the Fate and Impact of Marine debris (Shomura and Yoshida 1984).Compiled for the first time at the 1984 workshop, the information highlighted two fundamental types of biological interaction -

1. *Entanglement*, whereby the loops and openings of various types of debris entangle animal appendages or entrap animals
2. *Ingestion*, whereby debris items are intentionally or accidentally eaten and enter the digestive tract.

Entanglement, ingestion and ghost fishing are well documented biological damages caused by marine debris. The major concern is the danger posed to rare and endangered species of marine mammals, sea birds and turtles (DeGange and Newby 1980, Henderson 1984, Millner 1985, Carr and Cooper 1987, Perrin et al. 1994). Many seabirds are extremely long-lived and they are susceptible to chronic effects from low levels of pollutants accumulated over the long term (Azzarello and Van Vleet 1987, Jones et al. 1996, Auman et al. 1997). They also provide valuable information on the pollutant loads of marine resources consumed by humans (Montevecchi 1993, Burger and Gochfeld 2004, Blais *et al*., 2005). It has also been estimated that millions of sea birds and thousands of turtles and marine mammals die every year when entangled or trapped in lost fishing gears (NOAA2015).

Marine debris suffocates the benthic communities on soft and hard bottom but for some communities such debris provides a positive opportunity creating new habitats like small floating islands (Parker 1990). Biological impacts of marine debris have been studied worldwide since the last quarter of the last century when it was understood that such debris do more harm than good to marine flora and fauna (Fritts 1982, Carr *et al*., 1985, Day *et al*., 1990, Beck and Barros 1991, Croxall 1995, Hall 2001, Donohue and Schorr 2004).

Andaman and Nicobar Islands are geographically located in the Bay of Bengal of Indian Ocean and are one of the Union Territories of India. The economy of Andaman and Nicobar mainly depends on two things -*Tourism* and *Fisheries* which are the major source of income for the state. Unfortunately, both are also the main source of pollution in these island groups and the surrounding seas. For example, large quantity of solid waste was observed in Snake Island (a small uninhabited island off Port Blair) during a study of the biodiversity of the island (Malakar *et al*., 2015). Malakar and Venu (2015) reported entanglement of ghost nets in the coral reefs of South Andaman especially pieces of nets entangled to small branching coral colonies thereby hampering their natural growth. Much is yet to be understood of the characteristics and distribution of marine debris in these bay islands. This study was undertaken to understand the status of solid waste in six of the famous beaches of Andaman and that of ghost nets in the adjacent coral. In India and in the Andaman and Nicobar islands, works related to ghost nets and debris is negligible. Due to the above mentioned deleterious effects, surveys, studies and clean ups of ghost nets and marine debris have to be given importance immediately.

Methodology

The study was carried out from December 2013 to March 2014 at 6 different stations from Andaman group of Islands namely Diglipur (13º 13' 13.34" N, 93º 02' 46.62" E) Burmanullah (11º 34' 28.62"N, 92º 44' 27.22"E), Chidiyatapu (11º 29' 27.19" N, 92º 42' 32.33" E) North Bay (11º 42' 15.20" N,92º 44' 33.30" E) Wandoor (11º 35' 44.71" N, 92º 36' 26.19" E) and Hut Bay (10º 75' 00.22" N, 92º 50' 00.31" Eº). All these stations are accessible to tourists and locals alike and are frequented by them throughout the year.

Figure 1. Map of Andaman with the study stations

The solid waste observation-transect method was modified from Lippiatt *et al*., (2013). A single transect was laid for 60 meters and all the marine debris along the transect was noted precisely. On the shore line, a straight transect was laid. This was repeated for three times for each station. A classification was devised based on the data collected during the pilot study, keeping in mind the most abundant marine debris in these islands.

Free swimming surveys were conducted by snorkeling in a zig-zag pattern. All the ghost nets encountered were noted on slates underwater. All ghost nets encountered in the study area were first analysed and the smaller ones were retrieved as whole while samples were taken by cutting a piece from the bigger ones using a swiss knife. Thereafter the samples collected from all the nets were characterized following the Olive Ridley Project (www. oliveridleyproject.org).

Results

Solid Waste

The data compiled from the observation-transect method for solid wastes from the shorelines of the stations are summarized below. Plastic bags form the maximum percentage (21%) of solid wastes in all the stations (Fig 2). Miscellaneous/other wastes including styrofoam pieces, paper bits, wrappers of packaged foods, cardboard bits etc. formed the nextalong withplastic bottles (19% each) in the solid wastes.

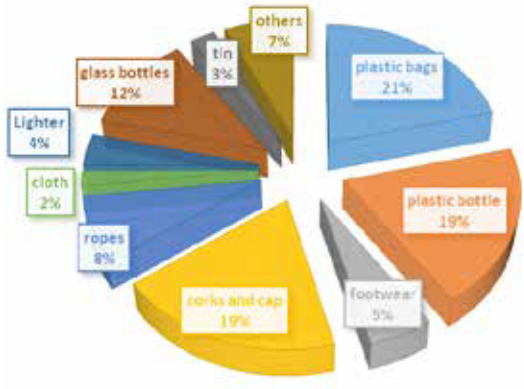

Figure 2. Percentage composition of various marine litters in all stations

Cloths were the least prevalent solid waste (2%) in all the study stations. It is acknowledged here, however that if the miscellaneous items were identified and placed in separate groups, this may probably shift the individual shares of each of these categories in the overall percentage of solid waste. But it could not be done due to the unidentifiable nature and negligible percentage of the various items in the category.

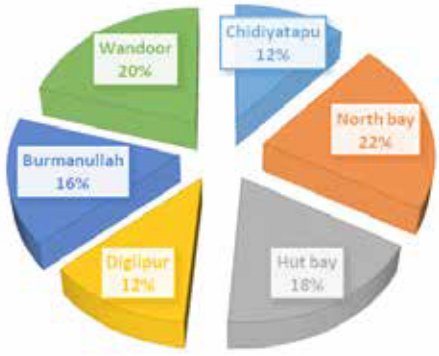

Figure 3. Station wise percentage composition of solid wastes

Maximum percentage of solid waste was observedin North Bay (22%), followed by Wandoor (20%) and Hut Bay (18%) (Fig 3). Chidiyatapu and Diglipur (12% each) contributed least to the overall percentage of solid wastes.

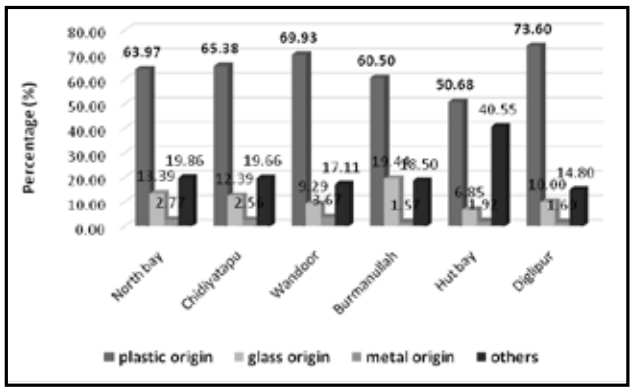

Figure 4. Percentage composition of marine litter based on the origins among the study stations

While analyzing the percentage composition of marine litter based on their origin, the plastic based wastes were the maximum type of wastes (Fig 4) followed by glass and wastes of other origin. Solid wastes originating from metal were the least.

Impact of Solid waste: In all the beaches the solid waste were lying above the high tide mark and gradually their quantity was increasing eventually this creates an unhealthy and dirty environment but also becomes the primary source of wastes that gradually move into the sea. The action of wind and rain are the two main natural causes that carries these waste into the sea. While snorkeling,a lot of debris was either observed floating in the water column or lying in the sea bottom (Fig 5). These debris are mostly plastic in origin followed by glass, clothes etc. Such debris acts as an substrate for marine succession wherein bacteria and micro algae settles over them followed by settlement of invertebrates like sponges, corals, small crustaceans (barnacles etc.) and at times macro as well as filamentous algae. This was observed in all the stations in the intertidal as well as sub-tidal regions from depth 0 to 7m where surveys were carried out. When debris were large and hollow larger invertebrates like crabs, shrimps, sea urchins and some fishes (gobids, blenids, pomacentrids etc.) were seen taking shelter around or inside such floating or sunk articles.

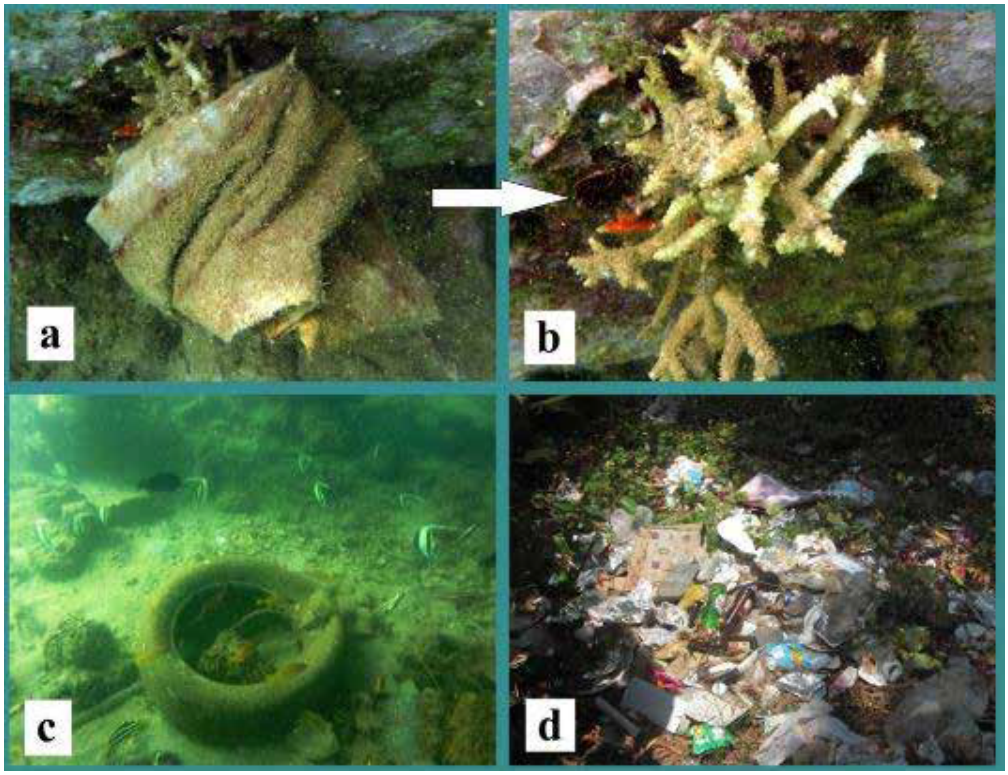

Figure 5.a. A cloth entangled *Acropora* colony **b.** The bleached colony as seen after the removal of the cloth piece **c.** A rubber tyre lying at the bottom **d.** Solid waste lying in the beach of Wandoor

Ghost Nets

A total of 21 ghost nets were recorded from all the stations. Most nets were recorded from North Bay and least in Chidiyatapu (Annexure 1). These nets were recorded from reef areas which were mainly attached to rocks and corals both live and dead. Mostly small pieces were obtained which suggest that these pieces either drifted and got attached to shallow water coral reefs after discarding or got attached when fishermen tried to fish close to reef areas. Analysis of these nets suggests that 80% of them werepart of gill nets (Annexure 1). All the nets found were knotted type in construction and North Bay with the highest number of ghost nets all of which were monofilament nets that have a single strand whereas other stations had both monofilament and twisted type. These nets also had double English knot (D/K), whereas Hut Bay had only twisted type and single English knot (S/K) (Table 1).

Table 1: Summarized data of Ghost Nets collected during the study.

Study Area	Diglipur	Chidiyatapu	Burmanullah	North Bay	Hut Bay	Wandoor
Number of Nets Found	4	4	3	7	3	0
Construction type	Knotted	Knotted	Knotted	Knotted	Knotted	-
Webbing Dimensions (mm)	15-230	25-150	75-100	70-120	55-120	-
Diameter of Twine (mm)	0.5-2	0.5-2	0-1	0.5-1	1.5-2	-
Number of ply	5 - 8	3 – 8	0 - 1	0	5 - 8	-
Number of Strands	1-3	1-3	0-1	0 - 1	0 - 3	-
Type of Knot	D/K	D/K	D/K	D/K	S/K	-
Type of twine	twisted	twisted	twisted	twisted	twisted	-
Direction of Twist	s twist	s twist	s twist	s twist	s twist	-

* **Webbing Dimensions:** The distance between two knots when fully stretched.
* **Ply:** Number of plies means total number of single yarn twisted together to compose strand.
* **Strands:** Number of strands means total number of strands used toconstruct twine.
* **Type of Knot:** (a) Single English Knot (S/K). (b) Double English Knot (D/K).
* **Direction of Twist**: There are two directions of twist namely "Z" type is generally called LEFT twist and "S" type called RIGHT twist

Impact of Ghost Nets: All the ghost nets encountered during the study were carefully analyzed and their impact on the biotic community was noted (Table 2 and Fig 6). A fresh ghost net will shelter juveniles as well as it can act as a passive fishing gear and result in entanglement of large fishes, turtles, mammals and sea birds. Growth of turf algae on the ghost nets indicates their presence underwater for a long time. Most of the fishes which take shelter under ghost nets were found to be juveniles.

Table 2: Impact of Ghost Net on the Biotic Community

No.	Organisms	Impact	Stations observed
1.	Macro algae	Macro algae (*Hypnea sp.*, *Turbinaria sp.*, *Halimeda sp.* etc.) including turf algae were observed over grown in most of the ghost nets. Coralline algae was also seen attached.	All stations
2.	Corals	The major observation was that of entanglement of small fragments of monofilament nets over *Acropora sp.* and other branching species Nets lying over *Porites sp.*, *Favia sp.*, *Favites sp.* also seen.	No. of entangled colonies North Bay -25, Hut Bay- 15, Burmanullah- 3, Diglipur- 1
3.	Crustaceans	Juveniles of crabs and prawns were observed taking shelter among the ghost nets.	All stations
4.	Molluscs	*Lambis sp.* was observed entangled in some ghost nets.	North Bay – 7 alive Burmanullah – 2 alive and 3 dead
5.	Fishes	Juvenile fishes of Pemphridae, Apogonidae and Pomacentridae were observed taking shelter in fresh fragments of ghost nets. Only one entanglement of fish recorded in Chidiyatapu.	North Bay and Chidiyatapu
6.	Turtles and Mammals	Not observed during the study. But solid waste and ghost nets have potential to impact them in all the stations.	-

Figure 6. a. and b. Coral colonies entangled to ghost nets
c. A *Lambis* sp. entangled to a ghostnet **d.** Juveniles of fishes taking shelter inside a ghost net

Discussion

Plastics being the most prevalent wastes was not unexpected since most of the wastes generated are made up of plastics (Barnes *et al*., 2009, Ivar do Sul *et al*., 2011).Clothes and ropes were in lesser percentage but they could possibly have a similar effect like ghost nets. Ropes from ships on the other hand, due to their high diameter and the presence of big knots, are abrasive on coral surface and if, entangled, break off pieces from them. Clothes entangled to branching coral colonies were observed in Marina Park. North Bay has the maximum amount of solid wastes as seen in this study which can be attributed to the tourism industry and North Bay being closest to Port Blair. In Wandoor it was found that in the sand dune above the high tide mark, relatively large amount of waste was seen than the slope of the beach. Though it is a tourist hotspot, Chidiyatapu had a very less percentage of solid waste compared to North Bay and Wandoor the reason being that the beach in Chidiyatapu falls under a forest reserve and solid waste disposal is well managed by forest department. Among the areas under this study, Burmanullah had the maximum amount (19.4%) of glass based debris. Plastics takes the second longest time span to degrade after glass and plastic debris was found to contribute to 73.6% of the total solid waste in Diglipur. This high amount of plastic waste followed by glass inthe beaches indicates the high anthropogenic activity.Such articles are key source of ingestion and entanglement (Laist 1997, Laist and Liffman2000, Hall 2001, Chiappone *et al*., 2002) by marine organisms like fishes, turtles, mammals and also birds that scavenge marine environment once they move by natural actions (rivers, estuaries, wind, rain etc.) into the sea. Solid waste of metal origin was found to be relatively low across all the study stations and they take the least time to degrade when compared to plastics and glass.

The ghost nets found during the study were primarily made of synthetic materials except for three nets one each in Diglipur, North Bay, and Chidiyatapu most of them were small or average sized. The origin of these nets were estimated to be mainly fragments of gill nets followed by trawl and seine nets. In some cases the head and foot ropes of large gill nets were found to be entangled in coral reefs. Two reasons can be inferred from this study of finding ghost nets mostly in coral reefs:

1. Fishing activities closer to sensitive coral reefs.

2. The rugosity of coral reefs helps in easy entanglements of fishing gears.

It was interesting to know that many of the plastic bottles found scattered in the beaches had labels other than Indian origin in them. Though it cannot be conclusively said that ocean currents are responsible yet this has the highest possibility.Ghost nets and solid waste can have serious impacts on the marine ecosystem. Ghost nets present in marine environment especially in coral reefs have numerous implications on the biota. There was no record of mammal, turtle and sea bird entanglement during this study. It is to be noted that turtle nesting is reported from most of the beaches in Andaman and Nicobar Islands (Baskar and Rao 1992, Andrews and Whitaker 1998, Andrews et al. 2001). In this study, solid wastes and ghost nets of six well-known beaches and the adjutant reef areas as were observed, studied, identified and quantified. It is recommended that more research is to be undertaken to better document and monitor entanglement, ingestion and other impacts of these debris as described by many researchers worldwide (High 1985, Faris and Hart 1994, Hoagland and Kite-Powell 1997,Chiappone *et al*., 2002, Chang-Gu 2003) on marine biotic communities. The effect of the substratum (plastic or rope) on the biology of the encrusting species is to be studied in detail. Ingestion of solid waste needs to be identified and quantified by studying the sea birds, turtles and fishes. The threat of solid and ghost nets should not be underestimated considering the rapid accumulation of the same in the coastal areas. Fishermen are to be advised to report when, where and the circumstances under which nets or traps are lost. Analysis of such information will help us in devising methods to reduce or prevent such incidents which will reduce the amount of ghost nets. Further instructions are to be given to the fishermen to retain all non-useable gear during fishing operation for on-land disposal. Awareness programs are to be conducted for the general public with regard to implication of solid waste and *Ghost nets*.

Acknowledgement

The authors would like to thank Department of Ocean Studies and Marine Biology, Pondicherry University for providing facilities to carry out this work.

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