Available online at www.sciencedirect.com
ScienceDirect
Marine Pollution Bulletin 54 (2007) 1087–1104
MARINE POLLUTION BULLETIN
www.elsevier.com/locate/marpolbul

Review

Marine debris review for Latin America and the Wider Caribbean Region: From the 1970s until now, and where do we go from here?

Juliana A. Ivar do Sul, Monica F. Costa *

Laboratory of Ecology and Management of Estuarine and Coastal Ecosystems, Oceanography Department, Federal University of Pernambuco, Av. Arquitetura s/n, CEP 50740-550 Recife, Pernambuco, Brazil

Abstract

The available literature on marine debris from Latin America and the Wider Caribbean Region was collected and linked, reviewing their methodologies and principal results (quantities, composition and spatial–temporal patterns). The study region comprises 52 coastal countries of which only 14 had registers of works on marine debris. A total of 70 works were available and 69 had their full contents accessed. Brazil dominated the available literature with 70% of the documents. Beaches were the most studied environment, and plastics the prevalent form of contamination in the whole region. The exposure of marine biota (species, type of contact, consequences) was highlighted. The studied region, although still little exploited by this sort of research, shows the same contamination patterns observed worldwide. We also contacted 40 researchers in the area, collecting scientific contributions, opinions and suggestions for improvement of this research field. Further advances and new (urgently needed) lines of research are also discussed.

Keywords: Literature review; Researchers opinion; Risk to marine life; Perspectives for the future; Capacity building; Coastal environment; Risk to human health

1. Introduction

Solid wastes in the marine environment have only recently been treated as a complex scientific problem. For decades, waste disposal was no more than a municipal policy and not an environmental issue since, apparently, debris disposed in the marine environment would simply disappear. The prediction that plastics (and other persistent petroleum products such as nylon, polystyrene, rubber, etc.) would be one of the most important environmental pollutants by the turn of the XXIst Century is now a widely recognized fact. Plastics pollution is not only ubiquitous, but also conspicuous and pervasive. The marine environment is no exception. The pollution of every single habitat in the marine environment by plastics has been frequently reported in the scientific literature over the last decades. All of the World's oceans have been cited in these works. Watersheds, estuaries, coastal regions and platform areas of Latin America and the Wider Caribbean Region also appear in the listings of sites polluted by plastic debris. Although scattered in time and space this literature was recognized as capable of describing the past and present situation concerning marine debris, especially plastics, in these areas.

We set off to collect and link all the available literature related to Latin America and the Wider Caribbean Region countries dealing with marine debris and its many effects. The significant growth of plastic debris generation and disposal into the marine environment begins with World War II and, associated with a weak regulation, accelerated the accumulation of solid wastes in coastal habitats. Probably, the first scientific works in this area were motivated by

* Corresponding author. Tel.: +55 81 2126 7218; fax: +55 81 2126 8225.
E-mail addresses: julianasul@gmail.com (J.A. Ivar do Sul), mfc@ufpe.br (M.F. Costa).

0025-326X/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.marpolbul.2007.05.004

visual impacts produced by debris on beaches and on the ocean surface, although at the time (1970s), the real impact was actually underestimated.

From the 52 coastal countries in the study region only 14 have produced works available in the scientific literature about marine debris which were used in this review. From these, only Chile did not sign MARPOL Annex V. Some small insular countries of the Wider Caribbean Region, which have not yet gained full independent status, still abide by their ruling countries in Europe and have therefore adopted the Annex V. The Annex V of the International Convention for Prevention of Pollution from Ships – MARPOL 73/78 – came into effect in 1988 and regulates the operational discharges of waste from ships.

The objective of the present work was to carry out an up to date review of the marine debris works in Latin America and the Wider Caribbean Region, collecting, grouping and summarizing the most relevant literature. Opinions of specialists were also collected and suggestions of patterns of distribution and new (urgently needed) lines of research were made. This work intends to contribute to the understanding, control and mitigation of such pollutant in the special socio-economic and environmental conditions of this group of nations.

2. Materials and methods

2.1. Literature analysis

The scientific literature was searched through conventional academic internet facilities, particularly "Science Direct", "Web of Science", the Brazilian CAPES database (www.capes.gov.br), *Marine Pollution Bulletin* specific database, and other open access sites. First priority was given to articles published in international and widely available journals, preferably in English. Secondly to articles published in regional journals and/or in other languages that were also available in the above cited databases. The book by Coe and Rogers (2000) was often consulted and cited along the preparation of this article. Recent official documents which cite the issue of marine debris in Latin America and the Wider Caribbean Region were also compiled, if not for data collection, at least for ancillary information which could help to interpret the data. Finally Monographs, Dissertations and Theses were included if their contents are not published.

The documents more easily accessed were included. Some works, which were available in two or more document types, were considered only under their international or regional journal form. Works by Brazilian authors published in conferences (abstracts or extended abstracts) were also retrieved.

The results of the literature search were classed according to the main focus of the work: environmental pollution and contact with marine biota. Works in each of those broad categories were analyzed for their geographical area (North to South), date, depth of the discussion, country, type of document (article, official document, book, conference works and academic documents), environment studied, debris categories (plastic, pellets, foreign, lightsticks and all), species or taxonomic group and type of contact (ingestion and entanglement). Each work had its main results highlighted, according to its geographical area and date of study (when the work was actually performed).

Works on tar on beaches and other marine environments were not considered at this time, in spite of being a category of marine debris. Although this kind of pollution is poorly explored in Latin America, in the Wider Caribbean Region the problem is well documented and the majority of papers approaching the theme are available on the internet.

2.2. Interview

An open questionnaire, developed for use through e-mail, was sent to 40 selected researchers. We gave priority to first authors of articles published in journals or scientists who we knew to have worked with marine debris as supervisors or important guests of papers. Brazilians authors of Monographs, Dissertations and Theses, and first authors of works published on regional and international conferences were also selected. If any researcher working in this area or student contacted us during the course of the work he/she also became a recipient.

A covering letter was attached to the e-mail, explaining our objectives, presenting the questionnaire and encouraging recipients to forward the message to other colleagues working in the field of marine debris research in Latin America and the Wider Caribbean Region.

The questionnaire consisted of 10 questions, presented in both English and Portuguese. The questions approached the scientific history of the recipient, working procedures and plans for future research in the field of marine debris. At the end of the questionnaire the researchers could also list their own references and/or send us documents.

Answers were grouped into broad categories that could identify trends in marine debris research in the studied region. A preliminary analysis of these groups was made to determine what the community has to offer, and expects, from this area of research.

3. Results

3.1. Literature review

3.1.1. Wider Caribbean Region (WCR)

The first available data was generated in Jamaica (Wade et al., 1991) (Table 1, Fig. 1). Debris were sampled on fifty beaches in 1m wide transects and by a pelagic neuston net. The debris were identified, classified according to the type of material, counted, measured, weighed and grouped according to the major source-relate categories (household, recreational or marine). Plastics were the most abundant in type (60%) and weight in all beaches. Although marine

Table 1
Environmental pollution results of the WCR literature research on marine debris ordered by region (north to south), date and depth of the discussion

Reference	Country	Documents	Debris category	Environment	Main focus
Silva-Iñiguez and Fischer (2003)	ME	MPB	All	Beach	Spatial distribution of debris abundance and composition. Belt transects. More debris on the strandline. Thirty-one percent had their sources recognized (18% land and 13% marine-based). Wood was the most abundant, followed by organic matter and plastics
Lara-Domínguez et al. (1994)	ME	RJ	All	Beach	Debris collected along three following years (Cleanup Day). Plastics and other petrol products were the most abundant (60%), mainly from recognizable land-based sources
UNESCO (1994)	WCR	OFF	All	Mixed	Background work. Main sources and effects, strategies for minimization, legislation and urgently needed actions
IMO (1996)	WCR	OFF	All	Mixed	Wider Caribbean as a "Special Area". Marine-based sources (especially commercial and cruise ships) abatement, legislation (MARPOL), urgently needed actions
Coe et al. (1997)	WCR	BC	All	Beach	CEPPOL and CMC data of debris composition from Colombia, Puerto Rico, Mexico, Barbados, St. Lucia and Dominica. Plastic was always the most abundant type
Wade (1997)	WCR	BC	All	Ocean	Existing legislation on debris management. Challenges for the "Special Area" Status implementation. Difficulties to receive and disposal ship-generated debris
Chaparro and Vélez (1997)	WCR	BC	All	Beach	Marine debris sources at Puerto Rico. Recognized as mainly land-based sources
Singh and Xavier (1997)	WCR	BC	All	Beach	Marine debris at British Virgin Islands, St. Lucia and Dominica (transects). Recognized as mainly land-based sources. Plastics were the most abundant, except at Dominica (driftwood attributed to fishing village)
Wade et al. (1991)	JA	IJ	All	Beach	Transects and pelagic nets. No pelagic debris found. Plastics were the most abundant in number and weight. Fifty-eight percent had their sources recognized (>90% land- and <10% marine-based sources). 31.5% had 10–15 cm
Corbin and Singh (1993)	SD	MPB	All	Beach	Five meters wide transect. Plastics were the most common in number and weight at St. Lucia and driftwood at Dominica. Plastics dominated in non-recreational beaches. Most land-based sources
Cruz et al. (1990)[a]	HO	RJ	–	–	
Debrot et al. (1999)	CO	MPB	All	Beach	Transects of various widths, depending on contamination level. Wind exposed beaches had higher levels of contamination (60 items m^{-1}). Foreign debris. Debris were small and plastics dominated (64%). 27.5% had 5–10 cm in all beaches
Nagelkerken et al. (2001)	CO	MPB	All	Reefs	Two meters wide underwater (up to 10 m) transects (four replicas) across the reefs. Public beaches had significantly more debris than private beaches. Forty-seven percent were plastics
Garrity and Levings (1993)	PA	MPB	Plastics	Beach	50 × 1 m wide transects. Plastic fragments were the most common in number and weight. 10% had their origin recognized (43% from Panama). Debris residence time ~9–15 months on beach. Accumulation time after cleaning = 6 months. Medical wastes (n = 42) present

Country: CO = Curaçao, HO = Honduras, JA = Jamaica, ME = Mexico, PA = Panama, SD = St. Lucia and Dominica, WCR = Wider Caribbean Region. Type of document: BC = book chapter, IJ = international journal, MPB = *Marine Pollution Bulletin*, OFF = official documents, RJ = regional journal.

[a] Article reference found and no access to the document.

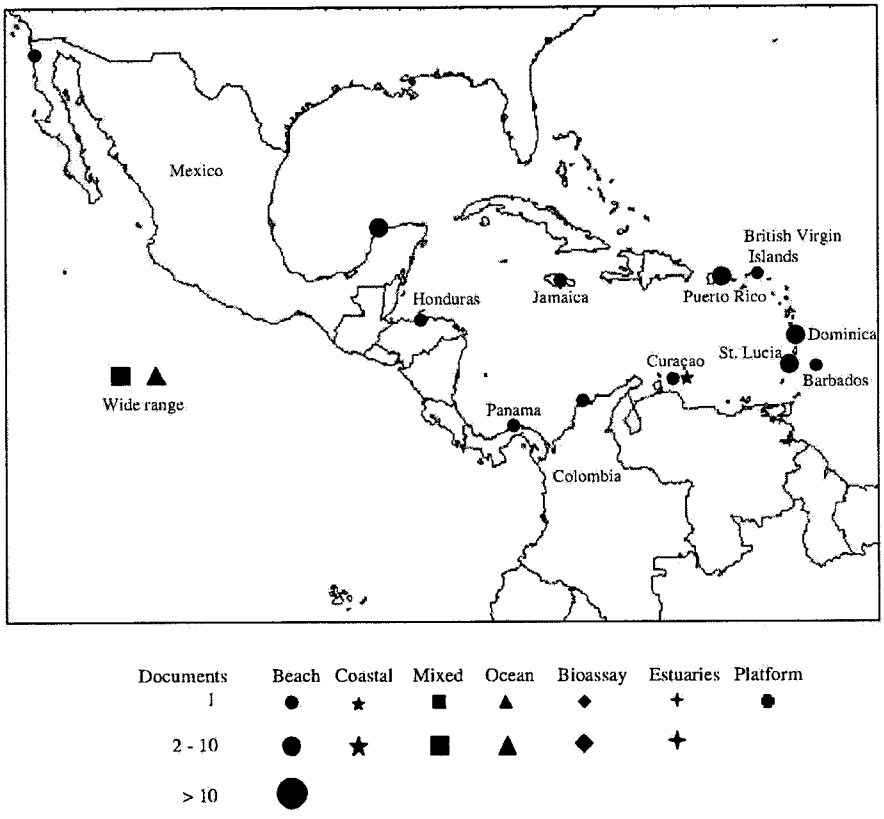

Fig. 1. Distribution of the available literature on Marine Debris for the Wider Caribbean Region by type of environment studied (beach, coastal including reefs, mixed, ocean, bioassay, estuaries and platform) and number of documents produced for each one of them. Documents dealing with the subject in general, but not focused on a particular environment or geographical area have been included under "wide range".

debris distribution was uneven, plastic bottles were predominant. Most items had between 10 and 15 cm and the size classes showed a Gaussian distribution. More than 90% of debris were associated to household and recreational activities and only 8.6% were associated to fishing activities.

In 1990 and 1991, a survey registered the amounts, types and distribution of marine debris in six regions of the WCR. The CEPPOL, IOC/UNEP Caribbean Marine Pollution Assessment and Control Programme, selected primarily, in each region, beaches which were not contaminated by beach users, not subject to periodic cleanings and far away from rivers (Coe et al., 1997). Under these circumstances, land-based debris found on sampled beaches were actually underestimated. On each beach, 12 random 5 m wide transects were sampled. Marine debris were classified according to the type of material, counted and weighed.

In Colombia, plastics accounted for 59% of all debris, followed by polystyrene (12%) and anthropogenic wood (9%). Although fishing related activities showed a significant percentage (11–31%) the most abundant items were related to land-based sources. In Puerto Rico, marine debris categories followed the same pattern of Colombia, with an average of 55% of plastics. In Barbados, Mexico (Yucatán Peninsula) and St. Lucia (where fixed transects were surveyed), plastics dominated with 70%, 34% and 51% of all debris, respectively. In Mexico plastics were closely followed by metals (Coe et al., 1997). Only in Dominica, driftwood dominated both in number and weight (Corbin and Singh, 1993). This characteristic was related to the proximity of fishing villages and abandoned wooden vessels (Corbin and Singh, 1993; Coe et al., 1997). In St. Lucia, most plastics were associated with land-based sources. Moreover, Corbin and Singh (1993) associated the debris distribution in St. Lucia and Dominica with the direction of prevailing winds and ocean currents.

Another quali-quantitative work which provides important information is the Caribbean Coastal Cleanups coordinated by the CMC. As of 1994, 25 Caribbean states participate, including Colombia, Puerto Rico, Barbados and Mexico (Coe et al., 1997). In general, results reported by CMC were similar to those reported by CEPPOL (Table 1, Fig. 1). In Colombia, plastics were the most frequent items and mixed sources were associated to beach debris (Coe et al., 1997), although in Puerto Rico, sampled items suggested that more than 80% of the marine debris derived from land-based sources (Chaparro and Vélez, 1997). In Mexico, the cleanup day started in 1986 (Lara-Domínguez et al., 1994) and still happens every year. Lara-Domínguez et al. (1994) established the principal sources of marine debris in Campeche (Caribbean Sea) in three following

years. The predominant debris were plastics and other petroleum-based products (60%), most were plastic bags and bottles, with tourism and land-based sources.

No CMC data was provided for St. Lucia and Dominica, but additional data including the British Virgin Islands (BVI) was established via IOCARIBE financed by the Caribbean Environmental Health Institute (CEHI) (Singh and Xavier, 1997). Two types of beaches, based on high use and isolation, were selected, and four fixed 5 m wide transects were sampled, a distinct method from CEPPOL. St. Lucia east cost beaches had the highest levels of debris though they were non-recreational beaches. On all sampled beaches, plastics were the most abundant and apparently had land-based sources. It appears that absent or inadequate solid wastes collection and disposal is a major contributor to the marine debris problem in this region (Singh and Xavier, 1997) and in all the WCR (Coe et al., 1997).

In the Caribbean Sea south border, Garrity and Levings (1993) worked on the coast of Panama registering the origin, types and weight, with special attention to the presence of medical wastes in 1 × 50 m wide transects (Table 1, Fig. 1). They recognized the residence time of some items (~9–15 months on beaches) and the dynamics of debris on undisturbed and cleared beaches, where debris accumulation were similar after 6 months monitoring. Plastics were the most common (56%), followed by polystyrene (31%) and glass (8%), mainly in fragments. Approximately 10% of all items had its origin recognized, 57% being foreign debris.

Debrot et al. (1999) monitored and compared marine debris on beaches exposed and non-exposed to winds and waves in Curaçao, also finding foreign debris. Transects varied between 8.5 and 150 m width, depending on beach size and the level of pollution. Leeward beaches generally had far lower levels of debris pollution, number of foreign items and had greater debris sizes, but plastic domination occurred windward and leeward (Garrity and Levings, 1993; Debrot et al., 1999). Leeward beaches were also monitored by Nagelkerken et al. (2001) prioritizing submerged debris. Transects 2 m wide perpendicular to the beach and extending from the waterline (low tide mark) to 10 m water depths (across the reefs) were sampled on public and closed beaches. Public beaches had significantly more debris, in number and weight, than closed beaches, showing that beach users were an important source of debris to the shallow reef environment (Nagelkerken et al., 2001).

In Mexico, Silva-Iñiguez and Fischer (2003) evaluated the debris composition, by means of sampling 1 m wide transects parallel to the waterline, on the Municipal Beach of Ensenada, Baja California (Pacific Border). In this study wood, and not plastics, represented the most common debris on the beach, followed by organic matter and then plastics. Wetter areas presented the smallest debris abundance, attributed to the exportation by winds, tides and currents. Thirty one percent, approximately, of all debris had their sources recognized: 18% were land-based and 13% were marine-based sources.

The problems in the WCR were closely associated with deficiencies in the management of debris from marine-based as well as land-based sources (UNEP, 2005). Since many countries had a direct economic dependence with tourism, the debris problem has been discussed and aesthetic values were prioritized. No studies were available on the contamination of the biota for the WCR.

3.1.2. South America

The Pacific border of South America includes four countries. Chile, the southernmost, and Colombia had works available on marine debris area (Tables 2 and 3; Fig. 2), but because of its geographical position, Colombia was treated as part of the WCR.

Bourne and Clarke (1984) reported the occurrence of floating debris at the Humboldt Current front, near Valparaiso, Chile (Table 3). Debris were mainly plastics, concentrated at a scum line 500 m from shore, where more than one thousand seabirds were feeding. A brief survey in 1985 also registered the occurrence of large quantities of containers, pellets and fragments on the Chilean shore (in Gregory and Ryan, 1997) (Table 2). Floating debris were observed in 2003, when a research vessel sailed the entire Chilean coast (18° lat S–50° lat S) (Thiel et al., 2003). Plastics were again the most abundant items (86%), as observed by Bourne and Clarke (1984) 20 years earlier. More marine debris were reported for the northern area, as expected, because in the southern area (>40° lat S) population densities are significantly lower (Gregory and Ryan, 1997; Thiel et al., 2003). No specific sample design for sources determinations was made, but the authors linked the debris sources to commercial fishing vessels and poor sewage systems because plastic bags were by far the most abundant item. A correlation with the debris as substrata to marine invertebrates was also attempted.

The Atlantic border of South America includes Argentina, Uruguay and Brazil. All of them had at least one work on marine debris (Tables 2 and 3, Fig. 2). Two surveys were conducted from south Uruguay to Tierra del Fuego, Argentina, in the early 1990s (Gregory and Ryan, 1997). Eleven beaches were sampled for all debris categories. Around Tierra del Fuego (54°48′ lat S – 68°18′ long W), abundance and composition of beach debris varied strongly among beaches (average of 253 items km^{-1}) but, in general, plastics were the most abundant items.

Under the Rio de la Plata influence, plastics were in general 70% of total debris sampled on beaches. Marine debris sources were estimated but no specific sample design for sources determination was made. The Rio de la Plata system probably contributed with household and domestic related debris from Buenos Aires and Montevideo. The authors suggested that the abundance of this debris category appears to decrease with distance from these two cities (in Gregory and Ryan, 1997). Although, at Mar Chiquita and Puerto Valdés coasts, two important recreational beaches, the primary debris source was beach users (in

Table 2
Environmental pollution results of Latin America literature research on marine debris ordered by region (north to south), date and depth of the discussion

Reference	Country	Documents	Debris category	Environment	Main focus
Costa et al. (2005)	BR	IC	All	Beach	Land-based sources accounted for almost the totality of the items found on Pernambuco State beaches. Marine debris as indicators of environmental quality
Costa et al. (2004)	BR	BC	All	Beach	General definition, types and sources of marine pollution. Marine debris on beaches
Leal (2002)	BR	M	All	Beach	Semi-open socio-economic questionnaires. Seventy percent related debris to beach users. Fifty-eight percent attributed the responsibility to the local administration and suggested rubbish bins on the beach
Silva et al. (in press-a)	BR	IJ	Plastics	Beach	Strandline survey. Most plastics (60%), followed by paper (cigarette butts). Land-based sources (51% of beach users). Debris quantities varied with beach morphology
Silva et al. (in press-b)	BR	IJ	Plastics	Beach	Ten meters wide transects. Mostly plastics (40%). Frequent beach users related items (plastic cups and drinking straws) selected as flag items (28% of the total)
Soares et al. (2007)	BR	IC	Plastics	Beach	Strandline survey. Mostly plastics (73%-including cigarettes butts) attributed mainly to beach users. Small items are not removed by cleaning services
Araújo and Costa (2003)	BR	SNL	All	Beach	Plastics were 85% on a tourism beach. Main effects: visual impact, human diseases, impacts on fishing activities and marine biota. Presence of medical wastes
Araújo and Costa (2004a)	BR	RJ	All	Beach	Direct relationship between debris amount and beach users. 2 items person^{-1} day^{-1} before and after the deployment of rubbish bins
Araújo and Costa (2004b)	BR	RJ	All	Beach	Ten meters wide transects. Accumulation of plastics on the vegetation. Debris related to multiple sources
Araújo et al. (2006)	BR	MPB	Plastics	Beach	Fifty meters wide transects sub-divided (0–2.5 m, 2.5–5 m, 5–10 m, 10–15 m, 15–20 m, 20–30 m 30–40 m, 40–50 m). Ideal width = 20 m to monitor quantities, categories and sources of plastic debris on beaches
Araújo and Costa (2006a)	BR	IJ	Plastics	Beach	Fifty meters wide transects including backshore vegetation. Before and after cleaning services. Benefits of cleaning services
Araújo and Costa (2006b)	BR	IJ	Plastics	Beach	Fifty meters wide transects. Most frequent categories were food packaging (with land- and marine-based sources), fishing (marine-based source), house cleaning and sewage (land-based sources). No significant difference between rainy and dry seasons
Araújo and Costa (2007a)	BR	IJ	All	Beach	Belt transects to locate contamination hot-spots
Araújo and Costa (2007b)	BR	IJ	Plastics	Beach	Fifty meters wide transects. Most frequent categories food packaging, sewage/hygiene and house cleaning. Rainy season significantly more contaminated. River as permanent and significant source of debris
Santos et al. (2005a)	BR	MPB	All/ Foreign	Beach	Presence of foreign debris (USA, Italy and South Africa, 14.6 items km^{-1}). Identification by bar code. Apparently from ships. Plastics were the most common, with prevalence of bottles. Most diverse record of foreign debris
Ivar do Sul (2005)	BR	M	All	Beach	10–100 m wide (varied with contamination level) transects. Plastics, mainly fragments, were the most abundant. Eighty-two percent of all debris had sources recognized (54% marine-based). Eighty-six percent of all debris <100 cm^2
Santos et al. (2005)	BR	RC	All	Beach	Belt transect with sampling 1 km apart. Plastics were present in 87% of the sampling sites. Mixed (land- and marine-based) sources

Figueiredo et al. (2001)	BR	RJ	All	Estuary	Floating debris, most from land-based sources, at Guanabara Bay
Machado and Fillmann (2004)	BR	RC	All	Coastal waters	9 m ∅ circle in 9–13 m depth and belt transect on adjacent shore. More debris inside than outside the CU. Most debris from fishing sources
Machado (2006)	BR	M	All	Coastal waters	9 m ∅ circle in 9–13 m depth and belt transect on adjacent shore. On the bottom debris had fishing sources (52% of fishing lines). On the shore polystyrene was the most abundant followed by plastics (inside and outside the CU). Marine and land-based sources
Widmer et al. (2004)	BR	RC	All	Beach	50 × 2 m wide transects. Plastics were the most common. Fouling on 4% of items. Mainly land-based sources
Mariano et al. (2000)	BR	RC	All	Beach	Shoreline survey. More debris on primary dunes (60%), mostly plastics. Methods suggestions for future works
Gomes (1973)	BR	RJ	Plastic pellets	Beach	Plastic pellets on Rio Grande do Sul coast related to offshore cleaning by ships
Pianowski (1997)	BR	M	All/pellets	Beach	5 and 1 m wide (plastic pellets) transects. Dominance of plastics (57%) including CU. Plastics pellets present all year (1.06–112.3 m^{-1})
Pianowski et al. (1997)	BR	RC	All/pellets	Beach	5 and 1 m wide (plastic pellets) transects. Plastics were the most common
Santos et al. (2001)	BR	RJ	–	Beach	Open questionnaires. Better socio-economic profile related to knowledge about the consequences of marine debris. Thirty-six percent had some problem with debris on beaches (injuries)
Santos et al. (2003a)	BR	RJ	–	Beach	Open socio-economic questionnaires. Forty-three percent admitted to have littered the beach. Ninety percent related debris to beach users ignore. Thirty-six percent had problems with debris on the beach and 44% suggested rubbish bins on the beach
Santos et al. (2003b)	BR	RJ	All	Beach	5 m wide transects sampled before and after the permanence of beach users. Plastics dominated (37%) with predominance of fragments (not removed by cleaning services). Generation of debris reached 2.2 items day^{-1} $person^{-1}$ and 3.09 items m^{-1} day^{-1}
Wetzel et al. (2004)	BR	IJ	All	Beach	5 m wide transects. Average contamination 7.4 items m^{-1}. Plastics dominated in number of items and weight. Beach users appear as the main source
Ivar do Sul et al. (2004)	BR	RC	Plastics/pellets	Beach	10 m wide transects (plastic pellets). Twenty-five percent had their sources recognized as land (51%) and marine–based (49%) sources. Plastic pellets present during all year (0.06–2.41 items m^{-1})
Santos et al. (2005b)	BR	IJ	All	Beach	5 m wide transects sampled before and after the permanence of beach users. Open socio-economic questionnaires. Debris pointed out as the main problem of the beach. Debris generation attributed to beach users. Twenty-five percent admitted to have littered. Average debris generated 2.9 items $person^{-1}$ day^{-1}
Gregory and Ryan (1997)	AR and CL	BC	Plastics and synthetics	Beach	Amounts, distribution and sources of marine debris of the Southern Hemisphere (Chile, Argentina and Uruguay)
Thiel et al. (2003)	CL	MPB	All	Coastal waters	Observation from ships. Mostly plastics (86%). Land- and marine-based sources. Debris density (items km^{-2}) is lower in latitudes >40°S. Debris as substrata to marine invertebrate
Acha et al. (2003)	AR	MPB	All	Estuary	Bottom trawl and 20 m wide transects on the shore. Highest concentration coincides with river front salinity and a similar trend on the shoreline. Mostly plastics (74% in weight). Negative correlation between debris concentration and distance from shore

Country: AR = Argentina, BR = Brazil, CL = Chile. Type of document: BC = book chapter, IC = international congress, IJ = international journal, M = monograph, MPB = *marine pollution bulletin*, RC = regional congress, RJ = regional journal, SNL = scientific newsletter.

Table 3
Contact with marine biota results of the Latin America literature research

Biota	Type of contact	Environment	Debris category	Main focus	Reference	Country	Documents
S. magellanicus	I	Beach	Plastics	Stomach analysis. Sixteen percent contaminated with plastics pieces, elastic bands and pellets which were associated with squids. Items ranged from 2.5 to 14.5 cm. Plastics related with fishing	Azevedo and Schiller (1991)	BR	IJ
Seabirds	I	Ocean	All	Observations of floating rubbish and plankton-eating seabirds at the Humboldt front	Bourne and Clarke (1984)	CL	MPB
C. mydas, *C. caretta*, *D. coriacea*	I	Beach	All	Stomach and esophagus analysis. Sixty percent of the *C. mydas* contaminated (highest rate in the literature). Mostly plastic bags and nylon ropes. External injuries related with fishing	Bugoni et al. (2001)	BR	MPB
M. giganteus	I	Platform	All	Stomach analysis. Seventy-three percent contaminated. Plastics dominated in number and weight. Related with fishing activities (trawlers and/or jiggers)	Copello and Quintana (2003)	AR	MPB
S. guianensis	I	Beach	Plastics	Stomach analysis. 20 cm^2 transparent plastic bags	Geise and Gomes (1992)	BR	IC
C. mydas	I	Beach	Plastics	Stomach and intestine analysis. Sixty-six percent contaminated. Intestine with 96% debris. Mostly plastic bags (49%). White and transparent (64%) indicating probable confusion with natural prey	Guebert et al. (2004)	BR	RC
Artemia sp. –	–	Bioassay	Lightsticks	Nauplii and eggs exposed to lightstick contents and elutriate. Both presented hazardous potential	Ihara et al. (2005)	BR	IC
C. granulata	E	Estuary	All	Areas populated with crabs retain more plastics as the surface and buried. Crab borrows as passive traps for marine debris	Iribarne et al. (2000)	AR	MPB
Wistar rats	–	Bioassay	Lightsticks	Skin tests with lightstick contents, UV radiation and seawater. Occurrence of erythemas, oedemas and vesicles	Ivar do Sul et al. (2005)	BR	IC
Wistar rats	–	Bioassay	Lightsticks	Histopathological alterations in rats exposed to lightstick contents, UV radiation and seawater	Ivar do Sul et al. (2006)	BR	RC
L. olivacea, *C. mydas*	I	Beach	Plastics	Stomach analysis. *L. olivacea* with hard plastic pieces and a piece of plastic bag. External injuries. *C. mydas* defecated pieces of hard plastics and bags. Perforation on duodenum	Mascarenhas et al. (2004)	BR	MPB
P. glauca	E	Ocean	Plastics	Plastic rings around body (gills). Rings 16–33 cm related to fishing activities. Nine percent entangled	Montealegre-Quijano et al. (2004)	BR	RC
Seabirds	I	Beach	All	Stomach analysis. Fifty-eight percent contaminated. Mostly plastic (68%) followed by pellets (23%) transparent or white coloured (77%)	Pedroso et al. (2004)	BR	RC
K. schubartii	–	Bioassay	Lightsticks	Explosion to lightstick contents on sediment and seawater resulted in expressive hazard potential	Portz et al. (2005)	BR	IC

Fouling	-	Ocean	Plastics	Introduction of alien species by floating plastic debris. Special danger to Antarctica	Santos (2005)	BR	SNL
Sharks and seals	E	Ocean	Plastics	Plastic rings, related to fishing activities on sharks and marine mammals	Santos (2006a)	BR	SNL
Sea turtles and seabirds	I	Ocean	All	Plastics ingestion by turtles (bags) and birds (pellets). Possibly confusion with natural prey	Santos (2006b)	BR	SNL
R. lalandii	E	Ocean	Plastics	Plastics rings (36–42 mm) around gills or mouth. Related to fishing activities. Possibly compromising ventilation and feeding	Sazima et al. (2002)	BR	MPB
M. densirostris	I	Beach	Plastics	Stomach analysis. Bundle of plastic threads (35 cm^3)	Secchi and Zarzur (1999)	BR	IJ
Procellariiformes	I	Beach	Plastics	Stomach analysis. Sixty-five percent contaminated. Fifty-five percent brown and black nibs. Forty-five percent plastic fragments	Zarzur (1995)	BR	M
Procellariiformes	I	Beach	Plastics	Stomach analysis. Sixty percent contaminated. Most plastics	Zarzur and Vooren (1995)	BR	IC

References ordered alphabetically. I = ingestion, E = entanglement. Country: AR = Argentina, BR = Brazil, CL = Chile. Type of document: IC = international congress, IJ = international journal, M = monograph, MPB = *Marine Pollution Bulletin*, RC = regional congress, RJ = regional journal, SNL = scientific newsletter.

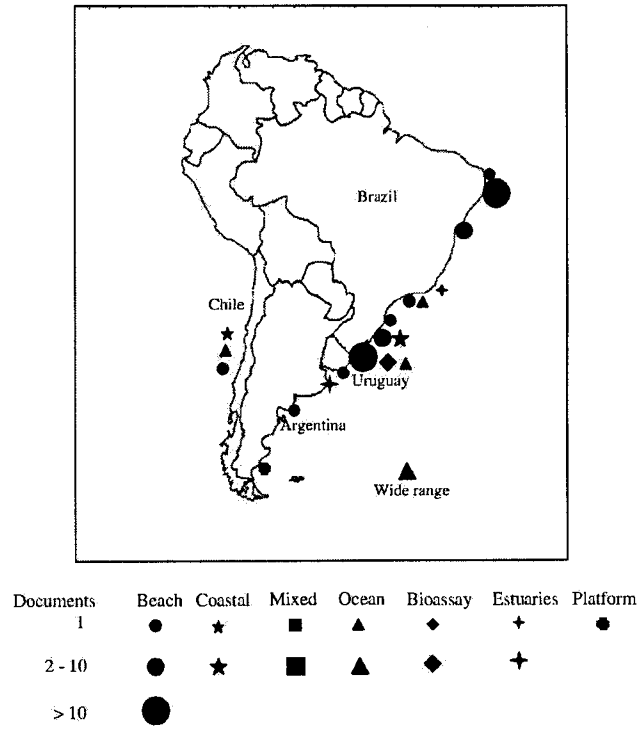

Fig. 2. Distribution of the available literature on Marine Debris for Latin America by type of environment studied (beach, coastal including reefs, mixed, ocean, bioassay, estuaries and platform) and number of documents produced for each one of them. Documents dealing with the subject in general, but not focused on a particular environment or geographical area have been included under "wide range".

Gregory and Ryan, 1997), as on Mar del Plata beach (Iribarne et al., 2000).

Plastics were the main items in weight and quantity in 73% ($n = 73$) of live *Macronectes giganteus* chicks sampled at Patagonia (45°00′ lat S–65° 50′ long W), Argentina (Copello and Quintana, 2003) (Table 3). The debris in the stomachs were associated with fishing activities, most trawlers and/or jiggers.

The Rio de la Plata system was object of a long-term study (Acha et al., 2003) covering different habitats (bottom and beaches), using bottom trawl nets and beach sampling. The work hypothesis was that the bottom salinity front trapped debris, which later accumulates in the adjacent coastal area or upriver. Anthropogenic debris were restricted either to freshwater or estuarine environments, both on the bottom and on the shore, corroborating observations made more than 10 years earlier (Table 2).

Crab burrows in intertidal mudflats at Mar Chiquita lagoon also trapped debris (Iribarne et al., 2000). These authors carried out a complete experiment evaluating, under field conditions, the effect of the crab *Chasmagnathus granulata* burrows on trapping debris (mainly plastics) and the amount of debris buried in the sediment in areas with different crab densities. In fact, both the amount of plastics trapped and buried in areas inhabited by crabs were significantly larger.

3.1.3. Brazil

Brazil is the largest country of South America, stretching from 4° lat N–34° lat S, with more than seven thousand kilometers of a continuous coastline that constitutes the South Atlantic Ocean Western Boundary (Fig. 2). About 70% of the 190 million inhabitants live on the coast, distributed in seventeen states. From these, 13 state capitals are large coastal cities, some with densely populated metropolitan regions. Eight of the seventeen states (Rio Grande do Sul, Santa Catarina, Paraná, São Paulo, Rio de Janeiro, Bahia, Pernambuco and Paraiba) had at least one marine debris work in international journals, regional journals or conference (Tables 2 and 3). The East coast of Brazil has important ports in Latin America such as Santos, Salvador, Paranaguá and Rio de Janeiro.

In the early seventies, small polystyrene pellets were found at Rio Grande do Sul coast (Gomes, 1973), with an average of 31.75 pellets m^{-2}. The author suggested that the main source was regular offshore cleanings on ships (Table 2). This work, probably, is the first systematic data published in Brazil about marine debris. Nearby, at Santa Catarina, Azevedo and Schiller (1991) reported the ingestion of plastic pieces, elastic bands and pellets in 16.4% ($n = 67$) individuals of *Spheniscus magellanicus* found dead on beaches in 1987 and 1988, showing the immediate environmental consequences of marine debris to the biota (Table 3). Although the authors related the ingested items to fishing activities, Widmer et al. (2004), also in Santa Catarina, associated plastic pollution (20 items 100^{-1} m^{-2}) with land-based sources. The mean percentage of fouling items was 4% and most of them were plastic debris. Santos (2005) has also explored the theme of marine debris fouling and its consequences for the marine environment. In São Paulo, Brazilian Southeastern coast, Geise and Gomes (1992) found a plastic bag in the stomach of a *Sotalia guianensis* found still alive on the beach in 1988. The large piece of plastic (20 cm^2) occupied the whole stomach cavity, and was later pointed as the *causa mortis* of the animal.

Systematic studies have been done on Rio Grande do Sul coast and provided more evidences of contact between marine debris and marine biota. Twenty-five years later then Gomes (1973), Pianowski (1997) and Pianowski et al. (1997) reported marine debris pollution, including plastic pellets, along the whole state, considering coastal conservation units (CU). Tourist beaches (Cassino, Grande and Guarita) presented the highest total amounts, although plastic pellets were more frequent in coastal protected areas (Taim). The most common colour of the almost 5000 pellets sampled was white. Evidences of debris pollution on the north cost were also registered by walking on the shoreline using a specific spreadsheet and a recorder (Mariano et al., 2000). More debris were found on the primary dunes region (60%), and plastics were by far the most common type of items. Bugoni et al. (2001) recovered and examined the esophagus and stomach of dead marine turtles along the same coast, and concluded that more than 60% of the animals were contaminated by debris, especially plastic bags and plastic ropes. The author reported that 39% of the plastic bags were transparent, followed by white and black (29.9% and 18.4%, respectively). The ingestion of anthropogenic debris accounted for the death of 13.2% of the *Chelonia mydas* examined. This work reported the highest rate of impacted biota in the literature consulted by the authors. Guebert et al. (2004) examined twelve dead *Chelonia mydas* on Paraná coast, finding eight (66%) with anthropogenic debris in the stomach and intestine. Almost 50% of the ingested items were plastic bags, followed by rigid plastic fragments (22%). The authors emphasized that more than 60% were transparent or white coloured items.

Wetzel et al. (2004) sampled 5 m wide transects from the primary dunes to the waterline, in selected areas at Cassino Beach (south coast) for 1 year, choosing areas with and without beach users. Plastics were the most common in numbers of items and weight in all areas. The authors related beach pollution, mainly lightweight debris, in the summer with the presence of beach users, while heavier debris had a predominantly marine-based source (Table 2). The same areas were sampled once more in 2003/2004, and again, plastics were the most abundant items (Ivar do Sul et al., 2004). The source was identified as being beach users, except at the control area (without beach users), where the quantitative and qualitative amount did not vary along the year. Concomitantly, fifteen of the 26 seabirds sampled on the beach had anthropogenic debris on their stomachs (Pedroso et al., 2004). They were two albatrosses, eleven petrels and two penguins, the last ones already registered by Azevedo and Schiller (1991). Marine birds contamination represents then a chronicle problem in the region. Zarzur (1995) and Zarzur and Vooren (1995) reported that 65% ($N = 139$) of the albatrosses (one specie) and petrels (nine species) were contaminated, mostly by plastic pellets (55%). Contrary to Pedroso et al. (2004), in Zarzur (1995) and Zarzur and Vooren (1995), black and dark pellets were more abundant than the white and transparent ones.

In 1993 a *Mesoplodon densirostris* was found in advanced state of decomposition at Mar Grosso Beach (Secchi and Zarzur, 1999). The stomach analysis revealed a blueish bundle of plastic threads, with both stomach and intestine free of food, indicating that the whale had not feed for some time. The authors suggested that the plastic was incidentally ingested with or as a prey (Table 3).

Although ingestion appears to be the most significant impact on marine biota, reports of entanglements also occurred. Sazima et al. (2002) and Montealegre-Quijano et al. (2004) reported the occurrence of plastic collars, or rings, on gills and/or mouth of different shark species, on the south and southeastern coast of Brazil. On São Paulo coast, three *Rizoprionodon lalandii* were caught with these collars, between 1999 and 2001 (Sazima et al., 2002). One of them probably could not eat because the ring was around its mouth. In the South Atlantic, which includes Rio Grande do Sul slope and Rio Grande Elevation, 10 of the 928 *Prionace glauca* caught in pelagic longlines in

2004 were entangled with similar plastic collars. The authors suggested that the collars were discarded by fishing boats all year long (Montealegre-Quijano et al., 2004) and by recreational boats in the summer (Sazima et al., 2002). The same collars, or rings, were found on the Northeast coast, in Bahia State (Santos, 2006a), and even if there are no registers of entanglement, surely uncountable animals are exposed to this threat.

Costal bays and islands recently entered on the marine debris contaminated areas recorded in Brazil. Figueiredo et al. (2001) reported the occurrence of floating debris, most from land-based sources, at Guanabara Bay, Rio de Janeiro. On Santa Catarina coast, the incidence of debris on the bottom and shore of the Arvoredo Marine Reserve (27°17′ lat S–48°22′ long W) was registered by Machado and Fillmann (2004) and Machado (2006). On the bottom most of the debris had fishing related sources (52% were fishing lines) and on the shore most were polystyrene, followed by plastics from both land- and marine-based sources.

Wetzel et al. (2004) attributed the debris on beaches to its users mainly in the summer. The correlation between beach users and debris generation was investigated by Santos et al. (2001, 2003a,b, 2005b) at Cassino Beach. Santos et al. (2001) applied 224 open questionnaires to assess beach users knowledge about debris on coastal and marine environments. Interviewees were classified according to their socio-economic profile (literacy degree, birthplace, sex and age) and questions such as "What kind of problem can marine debris cause?" were asked. The authors concluded that beach users had little knowledge about the environmental consequences of marine debris on beaches and coastal areas, since they treated the debris problem as an uniquely human one. Such is corroborated by the fact that nobody in the interviews related the debris with the classical problems of ingestion and entanglement (Santos et al., 2001). In general, subjects considered the beach clean, and attributed debris generation to users, but did not admit to discard their own debris on the beach (Santos et al., 2003a).

The interviews were repeated in January and February 2003, in an innovatory study, associated with the quali-quantification of debris data (before and after the beach users arrival) and the estimation of beach occupation (Santos et al., 2003b, 2005b). For this, 169 open questionnaires were applied. Five meters wide transects perpendicular to the waterline and the estimation of the occupation in two distinct areas were made concomitantly. Plastics were the most common item (37%), represented mainly by fragments and drinking straws. Small items such as cigarettes butts, were not effectively removed by cleaning services and remained on the beach (Santos et al., 2003b, 2005b). Only 25% of the interviewees admitted to have littered on the beach and attributed debris generation to beach users (Santos et al., 2003a, 2005b). Cigarette butts, plastics and organic matter were the most abundant items (2.9 items person^{-1} day^{-1}), and were strongly related to socio-economic characteristics of beach users in the area with less favored socio-economic profile (Santos et al., 2003b, 2005b).

The Northeastern Brazilian coast has different climatic and coastal characteristics from the South and Southeastern coast. However, they are similar in the lack of adequate debris management, and are consequently affected by marine pollution problems (Costa et al., 2004), including marine debris on beaches (Costa et al., 2005). The scientific works on marine debris in this region are so far restricted, to Paraíba, Pernambuco and Bahia states.

In Pernambuco, works were carried out on the south and north shores, which are relatively better preserved from the physical impacts of urban occupation, and on the metropolitan sector where the state capital is (Costa et al., 2005). On the south sector, Araújo and Costa (2003, 2004a,b, 2006a,b, 2007a,b) and Araújo et al. (2006) (Table 2) studied the marine debris patterns at Tamandaré, an important tourist beach, which is part of two CU (Araújo and Costa, 2006a). Experiments showed that beach debris accumulation was directly related to the number and socio-economic characteristics of beach users. They left mainly plastics (85%) on beaches, in an average of 2 items person^{-1} day^{-1}, which was not modified by the availability of rubbish bins (Araújo and Costa, 2003, 2004a). All of the 9 km of Tamandaré beaches were sampled by walking on the shoreline in 2001/2002. By visual analysis, the segments were classified according to the debris accumulation (absent, trace, unacceptable and objectionable) varying from 0 items m^{-1} to >10 items m^{-1}. Two different situations were found. Although no sector was classified with 'objectionable', the north and south sectors were more contaminated by marine debris, in spite of the lower urbanization levels. These areas were wider than the center section, what probably favored debris accumulation. The potential for marine debris contamination at the central section may be underestimated due to municipal and private beach cleaning services (Araújo and Costa, 2007a).

The studies were more detailed on the south sector, which, alone, has different characteristics on beach morphodynamics, frequency and density of beach users, presence of vegetation and level of urban occupation. In the begging of 2001, there were no cleaning services and, plastics were the most abundant item (89%) and both land- and marine-based sources were identifiable (Araújo and Costa, 2004b). Although in the rainy season there were 70% more items, the sources represented by the debris categories were the same in rainy and dry seasons. Land-based sources were most representatives (84%) and beach users alone were responsible for almost half of the debris. Marine-based sources were represented exclusively by fishing related items (13%) (Araújo and Costa, 2006b). Since periodical cleaning service started in August 2001, along the course of the study, Araújo and Costa (2006a) analyzed the benefits and costs of this enterprise. Aesthetic, sanitary and environmental benefits were obvious, but definitive

measures promoted by the municipalities within the hydrographic basin (rivers contribute heavily with beach debris pollution) were not put in place. Independently of the source or presence of cleaning services, the plastics categories dominated, by far, the beach debris composition. In general methodologies for quantification of plastics accumulation on beaches derive from ecological studies without much further improvements. To calculate the ideal width of transects for monitoring sources-related categories of plastics, Araújo et al. (2006) sub-divided a 50 m wide transect in eight intervals (0–2.5 m, 2.5–5 m, 5–10 m, 10–15 m, 15–20 m, 20–30 m 30–40 m, 40–50 m), recording in each one the amount of plastic categories. A 20 m wide transect was considered ideal to monitoring all main source-related categories (land- and marine-based). Five meters wide transects were enough only for the qualification of beach debris (Araújo et al., 2006). The riverine contribution to isolated beaches was assessed by Araújo and Costa (2007b).

On the Metropolitan area, two studies were carried out focusing on the strandline (Silva et al., in press-a; Soares et al., 2007), at Boa Viagem beach. Plastics were the most common type mainly represented by straws, lids and lollypop sticks, followed by paper (mostly cigarettes butts). Although there were more items in the summer (beach users related) there were no qualitative differences between rainy (winter) and dry (summer) seasons. Wider and better-preserved parts of the beach accumulated more items, and probably a relationship between beach morphology (sediment balance) and debris accumulation exists (Silva et al., in press-a). Transects perpendicular to the waterline (10 m wide) were used to determine items directly related to beach users, called flag items (drinking straws and cups were 28% of the total debris) (Silva et al., in press-b). Two working days and weekends were sampled weekly during the dry and rainy seasons. Flag items were found to be distributed according to beach users occupation of the territory. Independent of the day of the week, the beach was subjected to the same sort of contamination. Quantitatively, items varied with weekdays and beach users density (Silva et al., in press-b).

Still in Pernambuco (north sector), Leal (2002) carried out interviews with beach users on Itamaracá Island. Semi-open questionnaires ($n = 77$) showed that the majority of beach users (70%) related the debris generation to users, although they did not admitted to have littered. The interviewees (50%) attributed to the local administration all the responsibility for the cleaning of the beach and suggested the deployment of more rubbish bins on the beach. New studies are being done at Goiana River Estuary, Pernambuco, associating environmental parameters (salinity, temperature, Secchi depth, beach profile, grain size) with debris characteristics and accumulation patterns.

In Bahia State, works reported the occurrence of foreign debris (Santos et al., 2005a; Ivar do Sul, 2005) and its qualitative analysis (Santos et al., 2005) on the north and south shores. Santos et al. (2005) found plastics in 90% of the sampled points, along Costa das Baleias, 800 km south from Salvador City. The authors sampled a total of 150 km of beaches and reported, but did not quantify, the presence of foreign debris. Santos et al. (2005a) registered the most diverse record of foreign debris found world-wide at Costa dos Coqueiros, 60 km north from Salvador City. During 4 years, semi-quantitative data was registered in different sectors of the beach. The highest debris density was 14.6 containers km^{-1}. Although there were evidences that some containers traveled long distances (Santos et al., 2005a), most of them probably were discarded near the coast by ships. The relative importance of foreign debris at Costa dos Coqueiros was confirmed by an induced analysis (Ivar do Sul, 2005) when 17.3% of all containers found on the beaches were for instance foreign debris. Actually, it represents only ~1% of all items, but could be considered a large amount, because 86% of all debris sampled had 100 cm^2 or less, mostly being hard plastic fragments. These small size categories are responsible for the contamination of the biota via ingestion, as reported for several Brazilian beaches (Azevedo and Schiller, 1991; Zarzur, 1995; Zarzur and Vooren, 1995; Bugoni et al., 2001; Pedroso et al., 2004; Guebert et al., 2004) (Table 3). At Costa dos Coqueiros this problem can have serious consequences because the Brazilian Northeast represents one of the most important nesting areas for marine turtles. And effectively, reports in Paraiba State (Mascarenhas et al., 2004) accounted for *Lepidochelys olivacea* found dead, which stomach analysis showed several pieces of hard plastic and one piece of plastic bag. One individual of *C. mydas* found still alive defecated several pieces (11) of hard plastics and bags (9). Later, the necropsy showed that the stomach was full of food.

In addition to the large occurrence of foreign debris, other singular marine debri type found at Costa dos Coqueiros beaches was the lightstick (Ivar do Sul, 2005). Lightsticks reach the Costa dos Coqueiros beaches and accumulates on the backshore. Local residents do not know the conventional use of them but collect and use it directly on the skin, such as sun protector, sun tanning lotion, massage oil, mosquitoes repellent, medicine for muscle aches, skin marks, vitiligo and others. To analyze the possible effects of these uses and potential synergic effects with environmental variables (UV radiation and seawater), skin irritation and histopathological tests were carried out on *Wistar* rats (Ivar do Sul et al., 2005; Ivar do Sul et al., 2006). Visible reactions (erythemas, oedemas and presence of vesicles) were observed. In spite of the short time experiment, histopathological analysis indicated alterations on rats submitted to lightstick contents. Experiments with *Artemia* sp. and *Kaliapseuds shubartii* were also carried out, showing expressive hazard potential (Ihara et al., 2005; Portz et al., 2005).

3.2. Answers to the questionnaire

From the 40 questionnaires sent, 30 went to Brazilian researchers, 3 to Mexican and Argentineans, 2 to Antil-

leans, 1 to a Chilean and 1 to a Panamanian researcher. We received a total of 12 answers and, as expected, they were mostly from Brazilians (10), followed by Antillean (1) and Chilean (1) researchers. Only one document (an abstract) was accessed for the first time through the questionnaires answers. The other references cited by the respondents on the interviews were already available and accessed. One researcher answered the e-mail, but not the questionnaire.

The majority of the answers (10) were from active researchers who have been publishing papers on marine debris since the end of the 1990's until now. Although this area represents the secondary research priority of most of them, following a global pattern, their answers revealed a great interest in the subject. Usually, they try to associate the marine debris investigations to their main research areas. Some researchers cited the relevance in working in the area by mentioning the social aspects involved. The recent scientific histories of our colleagues also showed that the beach is the preferred environment to work with (10), possibly because it is part of our daily lives, being constantly used and observed. Other possible causes to this preference are the wish to make a contribution to societal goals by subsidizing educational campaigns and public voluntary cleanup activities. Also, the apparent simplicity of sample design and sampling methods might stimulate works at an early training stage of students. Finally, beaches are naturally depositional environments which greatly contribute to the corroboration of marine debris accumulation hypotheses. Other environments were also cited, being restricted to costal ones. Shore-normal transects was the most cited sampling method (6), followed by strandline survey (2). The most common type of biota survey mentioned was stomach contents analysis (2).

Most of the researchers (4) feel that detailed information about marine debris pollution which could help explaining other oceanographic and socio-economic phenomena is missing. Lack of standardization of the sampling methodologies was also pointed out by the researches (3) as a weak point in the field, which complicates or even prohibits comparisons between different works. Seven of our responding interviewees wished to ask questions about marine debris to their colleagues, mainly concerning multilateral cooperation. Five of them demonstrated interest in creating a work group. Two would like to ask about the necessity of methodological consolidation. We believe that methods standardization and the formation of a cooperative group is essential to the conduction of long-term and large scale studies. Concomitantly, only a specialized and experienced research group can really standardize statistically consistent methodologies, including sample design and statistical analysis.

Half of our respondents (6) had, together, trained approximately nineteen students in the marine debris area. Seventeen were Brazilians. Although the majority of them (16) were qualified at graduation level, three Brazilian students were trained at post-graduation level (MPhil), producing three dissertations and publishing their results in the international literature. As far as we know, no student has been trained in marine debris research at Ph.D. level in this region. Marine debris publications were considered "relevant" in the scientific production of five of the researchers. Almost half, victoriously, associated the marine debris investigation with their other research interests, usually within the fields of Chemical Oceanography & Marine Pollution, Biological Oceanography or Integrated Coastal Management. In general (6) they intend to improve their level of scientific production in this area. Others want to decrease their number of scientific works in the area (4) and two declared the intention of maintaining it at a significantly high percentage of their scientific production. Authors of articles did not hesitate try publishing their works in international journals (9). *Marine Pollution Bulletin* was pointed by seven of them as their first choice. Only one of our colleagues had been in a specific meeting in the area. We strongly believe that periodic conferences on marine debris, or special conference sections within marine sciences meetings, with the presence of specialists are urgently needed to improve the number and quality of the publications/contributions in the area.

4. Discussion

A total of 70 documents, covering almost four decades of investigation, were found. Of these, 69 full texts were readily available and accessed. One article published in regional journals could not be accessed. The works analyzed were from regional conferences (10), international conferences (7), eight different regional journals (10), ten different international journals (10) and fifteen contributions were found within *Marine Pollution Bulletin* alone. Five were Monographs, seven book chapters and two official documents. Two groups published their research results in scientific newsletters (4). This was an important initiative to reach researchers from other areas of interest and the general public. Documents were classed as environmental pollution ($n = 49$) and contact with marine biota ($n = 21$).

Thirty-eight of the available works were in English, and readily accessible to the international audience. But another 31 were in Portuguese, and unless their authors are urged to divulge the subject and their results, these will remain limited to the Lusophonic community. Only one work was written in Spanish.

Various environments and habitats were investigated in the environmental pollution works (49). Coastal habitats were more studied (44) especially sandy beaches (38). Other environments were estuaries (2), coastal waters (3), and reefs (1). Two works were developed in oceanic environments, and two others covered more than one environment (mixed). One article was not clear about which environment was studied.

Transects perpendicular to the water line was the preferred method of monitoring debris on beaches (18). The

transect width varied from 1 to 150 m (5 and 10 m wide being the most common). Belt transects (6) were used on assessments of the strandline and/or dunes. For monitoring long beach extensions some works (6) were made by observing marine debris and registering or sampling it at regular intervals along the beach. Two works were carried out by volunteers (Cleanup Day). Three utilized only questionnaires to evaluate beach users knowledge/perception, and three aimed at establishing the marine pollution/debris "background" of a given (geographical) area.

Although the large majority of the works on beaches were quali-quantitative assessments, they were all different from each other. This may be due to the specific objective of the research, method used for sampling debris or field recording sheets. Works still differ on debris categories, register of medical/hospital wastes (syringes, needles, serum flaks, etc.) and foreign debris (label from foreign countries), size assessment, ecological effects concerning marine biota and other specific details. Seven works on beaches created or improved sampling methods procedures, suggesting new methods to measure and analyze marine debris on beaches (Wade et al., 1991; Garrity and Levings, 1993; Debrot et al., 1999; Mariano et al., 2000; Santos et al., 2005; Araújo et al., 2006; Silva et al., in press-b).

Eleven of the available works determined the weight of marine debris. Two of them used it to the characterization of items ingested by marine animals. Nine works also measured debris weight to better define contamination levels, mainly on beaches. These works, however, could not link weight results to depositional patterns observed on the beach, environmental characteristics of the studied area or marine debris spatial and temporal patterns.

Works frequently cited losses of aesthetic value and environmental quality as a consequence of marine debris on beaches. They also associated marine debris to decreases in economic activities or negative impressions from the public. In Latin America and the Wider Caribbean Region marine debris damage or impairment to marine operations were not mentioned in the scientific literature.

The methodologies applied to the works have detected basic materials-related classes, and a number of important source-related marine debris categories. The level of detail reached at source-related categories works pointed out even some rare types of debris such as medical/hospital wastes (Araújo and Costa, 2003; Debrot et al., 1999; Silva-Iñiguez and Fischer, 2003) and foreign items (Santos et al., 2005a; Garrity and Levings, 1993).

All the works point towards well established international trends of marine debris contamination in coastal habitats. Some common conclusions found in the literature are: the undisputable prevalence of plastics and other highly persistent materials (polystyrene, rubber, nylon, etc.); riverine influence; seasonality related to rainfall and/or beach use; prevalence of land-based sources; gradients of contamination starting at large urban areas. In addition, the works used in this review differ in their general results in terms of spatial–temporal patterns, due to the large geographical area considered and total amounts of items found, reflecting that not all the region is equally contaminated. Other marine debris characteristics as size, degree of decay, level and type of fouling and specific contaminations as plastic pellets from the petrochemical industry were less explored but still differ from region to region.

The main types of accidental contact/exposure with the marine biota were reported in the works used here: ingestion (12) and entanglement (4). Bioassay works (4) with rats and microcrustaceans were also found in this literature. One work discussed about fouling on floating plastics. Seabirds were the main group reported to be exposed to the harmful effects of marine debris, followed by reptiles and mammals. Birds and turtles were only reported as having ingested items on this literature research. Mammals ingested and were entangled on marine debris. Fishes, restricted here to shark species, and crustaceans were also entangled on debris. The works accessed frequently refer to one animal species (14) and some of them (7) discussed one or more large groups of marine organisms.

Some of the reports about deleterious contact between marine biota and marine debris in the studied region have remained at the anecdotal level. Although not accounted for as being the *causa mortis*, at the Brazilian Amazon region dolphins were found dead with fragments of nets in their stomach and intestines, resulting from attempts to free themselves from fishing nets. Researchers from the REVIZEE project, which worked with sharks from the Brazilian Exclusive Economic Zone, reported to have found pineapple crowns and glass bottles stuck in the throat of large animals. Other colleagues have reported finding polystyrene in the stomach contents of estuarine crabs along the coast of Pernambuco State, and photographical evidence exists at Fernando de Noronha Archipelago (Equatorial Atlantic) of a shark which has incorporated a nylon monofilament thread after being cut by it. In September 2006, two *Trichechus manatus* were found on the coast of Ceará State (NE Brazil) with a large number of plastic bags in their stomachs. One was dead, and very likely starved. The other survived treatment and eventually defecated a number of white plastic bags.

In this literature review the whole region showed registers of works on marine debris. Although they covered a wide geographical region, the distribution was uneven. Many countries have no records on this specific area of research, and possibly have never been investigated.

5. Final remarks

Plastics are highly persistent contaminants, fragmenting in smaller pieces practically forever. This characteristic, associated with the unmeasured and ever growing worldwide plastic production and discarding provides us with a worrying scenario for the near future. Scientific works on marine debris area are essential to modify in a short or long-term this situation, providing sound information about polluted areas and basic data for management

actions. It will then be fundamental to add value to marine debris research within the academic community, through the exploration of statistical resources and associations with the adequate ecological parameters. Only the correct improvement of marine debris investigations will enhance its research creating an urgently needed solid field in the marine sciences. Consolidated academic groups can more easily promote conferences and specific scientific meetings, divulging and attributing the real importance to research in this area. The more frequent inclusion and highlighting of marine debris pollution and its consequences in graduate and post-graduate text books would also acknowledge the importance of this type of contaminant on marine environments.

Since quali-quantification on beaches was already well explored along the different latitudes of Latin America and the WCR, further advances are expected on other marine environments, such as the bottom of the sea and estuaries, concomitantly with the deployment of new methodologies. Novel approaches as debris sizes, level of decay (important for tropical latitudes and extreme climates) and fouling characteristics, as well as long-term monitoring are also urgently required to estimate and monitor the real magnitude of the problem.

Quantitative data on marine debris in the WCR are limited (Coe et al., 1997), but due to its intensive maritime activities and sensitive marine environment (IMO, 1996) the region can be considered strongly contaminated by marine debris. Impacts associated with the presence of marine debris on marine and coastal environments such as loses on tourism activities and damages to humans health were really underestimated for several decades. One reason may be that in the area of marine pollution, ship-generated waste is considered less significant than oil spills or spills of hazardous substances (Wade, 1997), and on the WCR this is not different.

The scientific community has been discussing the relevance in determining the weight of marine debris sampled and their fractioned/total amounts. The Center for Marine Conservation (CMC) recommends interpreting and reporting data based on item counts rather than weight or volume (Coe et al., 1997). This kind of measurement is influenced by a few heavier items (Wade et al., 1991) or if the items are wet.

Organic matter was cited in few works on beaches as a marine debris category. Measurements were restricted to quantification and qualification, and studies identified two distinct sources: environmental (macroalgae, dead marine organisms and parts of it, etc.) and anthropogenic (food scraps, peanut shells, coconut shells, etc.) sources. Besides its unpleasant aesthetic impact, studies could provide further information on seasonal depositional patterns of environmental organic matter and anthropogenic debris. This specific category still has to be treated as a potential substrata for vector of human (or animal) diseases.

Implications concerning humans health and marine debris have been cited world-wide as one of the many effects associated with marine debris on the environment. In spite of that, there is a lack of works that describe and measure this kind of impact. The main types of health issues that can be identified are injuries (cuts and ingestion) and diseases (burns, mycosis, etc.). Measurements of injuries related to marine debris on beaches in Latin America and the WCR were restricted to data from interviews with beach users on tourist beaches and underestimate the potential impact. Cigarette butts, usually appear in marine debris records, sometimes in representative amounts. They are potentially dangerous to children (ingestion) and yet, poorly quantified or treated as a real human health issue. Studies and experiments designed to elucidate the relationships between marine debris and beach users health have never been done.

The constant occurrence and amounts of marine debris on a beach frequently influence beach users choice of return to a place for leisure. Studies concerning this behaviour and other expressions of preference of beach users have been done in many countries, but none in Latin America and the WCR. Also, valuation studies concerning quantification of economic losses related to marine debris contamination on beaches are neglected, although their importance is recognized as eminent.

In our review, biota works were restricted to Brazil, and frequently only related to ingestion and/or entanglement being isolated facts in the environment. Therefore, these records may be grossly underestimating the actual environmental situation. Systematic studies through specific experiments are required to produce reliable evidences of toxicological and/or physical damages to marine biota, as well as quantification of the risk of exposure to populations and communities. Measurements and more accurate estimations of ingestion and entanglements on marine debris would also be improved by reliable registers from scientific groups working with marine animals.

Medical wastes were registered in small quantities on beaches in many of the accessed works in this review, pointing to a serious management problem. Specific works can be an alert to local managers of this unacceptable environmental damage and stimulate the necessary measures which will lead to the further reduction and eventual disappearance of this marine debris category. Buried debris are virtually ignored in Latin America and the WCR. The study of its amounts, composition and distribution, have been almost completely neglected, although it is an important issue. The measurement and identification of microplastics is another field to be investigated in the studied region. The consequences of its contamination by other pollutants (oil and persistent organics) and risks to marine biota are still another new frontier to be explored. Another non-explored subject is the estimation of the magnitude of "influence zones" of marine debris from land-based sources on the continental platform and beyond. Probably, after being discarded to river basins, marine debris travel to estuaries, coastal areas, to the continental platform and then to the sea. Different marine debris follow different routes and have different residence times due to their

various densities. Consequently, we would expect to observe marine debris accumulating at each specific environment, forming a gradient from rivers to the sea.

None of the works used here addressed these questions, although these issues are already registered in the international literature. With the economic development of the region there will be a necessity to measure the implications of these categories of debris on beaches and other marine environments.

Plastic pellets and tar are known to be found at a number of coastal sites all over the world. However, in Brazil their distribution along the coast is uneven. There are reports on pellets at the South, but not in the other regions. At the Brazilian Northeast, where beaches have been the attention of studies about plastics pollution since 1999, they have never been reported. With the arrival of petrochemical facilities to Pernambuco State and the start of their operations along the next decade it is expected that pellets will start to appear on the region shores. As well as plastic pellets, expressive and prevalent amounts of tar have never been reported for Pernambuco, although significant quantities were observed on Bahia State. Monitoring present patterns of pellets and tar is essential to future studies concerning environmental impacts associated to the petrochemical facilities implementation. Works reporting tar on beaches are still scarce on Latin America, but would represent a significant improvement for works with marine debris, at least on the Brazilian coast.

In our review, Brazilian works represented almost 70% ($n = 70$) of all analyzed works. If we considered only regional and international journals, Brazil still contributed with almost the same percentage. Systematic studies are still restricted to some states where there are groups of researchers working in new sampling methods, detailing debris composition and distribution, beach users opinion, discussing sources and procedures to mitigate and minimize marine debris effects on the environment. Recently, more researchers in other states established original projects, extending the coverage of works on marine debris for still another stretch of the Brazilian coast. To extend these actions to other marine debris research groups, not only in Brazil, but on the entire Latin America and the WCR is essential to fortify research on marine debris as a whole, and to attribute the region its real importance in the World scenario of marine debris pollution and its control.

Acknowledgements

The authors would like to thank the questionnaire respondents, who greatly contributed to this scientific review with their opinions.

References

Acha, E.M., Mianzan, H.W., Iribarne, O., Gagliardini, D.A., Lasta, C., Daleo, P., 2003. The role of the Rio de la Plata bottom salinity front in accumulating debris. Marine Pollution Bulletin 46, 197–202.

Araújo, M.C.B., Costa, M., 2003. Lixo no ambiente marinho. Ciência Hoje 32, 64–67.

Araújo, M.C.B., Costa, M., 2004a. Análise quali-quantitativa do lixo deixado na Baía de Tamandaré-PE-Brasil por excursionistas. Revista de Gestão Integrada para Países de Língua Portuguesa 3, 58–61.

Araújo, M.C.B., Costa, M., 2004b. Quali-quantitative analysis of the solid waste at Tamandaré Bay, Pernambuco, Brazil. Tropical Oceanography 32 (2), 159–170.

Araújo, M.C.B., Costa, M., 2006a. Municipal service on tourist beaches: costs and benefits of solid waste collection. Journal of Coastal Research 22 (5), 1070–1075.

Araújo, M.C.B., Costa, M., 2006b. The significance of solid wastes with land-based sources for a tourist beach: Pernambuco, Brazil. Pan-American Journal of Aquatic Sciences 1 (1), 28–34.

Araújo, M.C.B., Costa, M., 2007a. Visual diagnosis of solid waste contamination of a tourist beach: Pernambuco, Brazil. Waste Management 27, 833–839.

Araújo, M.C.B., Costa, M., 2007b. An analysis of the riverine contribution to the solid wastes contamination of an isolated beach at the Brazilian Northeast. Management of Environmental Quality: An International Journal 18, 6–12.

Araújo, M.C.B., Santos, P.J.P., Costa, M., 2006. Ideal width of transects for monitoring source-related categories of plastics on beaches. Marine Pollution Bulletin 52, 957–961.

Azevedo, T.R., Schiller, A., 1991. Notes on the diet and the ingestion of plastic material by the megellanic penguin *Spheniscus magellanicus* on Santa Catarina Island and mainland (Brazil). Unit. Doc. Zoologie. Seru. Ethol. Psichol. Anim. University of Liège, Belgium. Rapport 457, pp. 1–8.

Bourne, W.R.P., Clarke, G.C., 1984. The occurrence of birds and garbage at the Humboldt Front off Valparaiso, Chile. Marine Pollution Bulletin 15, 343–344.

Bugoni, L., Krause, L., Petry, M.V., 2001. Marine debris and human impacts on sea turtles in Southern Brazil. Marine Pollution Bulletin 42, 1330–1334.

Chaparro, R., Vélez, J., 1997. Upland sources of marine debris on the shorelines of Puerto Rico. In: Coe, J.M., Rogers, D.B. (Eds.), Marine Debris: Sources, Impacts and Solutions. Springer, New York, pp. 367–370.

Coe, J.M., Rogers, D.B. (Eds.), 2000. Marine Debris: Sources, Impacts and Solutions. Springer, New York, p. 432.

Coe, J.M., Andersson, S., Rogers, D.B., 1997. Marine debris in the Caribbean Region. In: Coe, J.M., Rogers, D.B. (Eds.), Marine Debris: Sources, Impacts and Solutions. Springer, New York, pp. 25–34.

Copello, S., Quintana, F., 2003. Marine debris ingestion by Southern Giant Petrels and its potential relationships with fisheries in the Southern Atlantic Ocean. Marine Pollution Bulletin 46, 1513–1515.

Corbin, C.J., Singh, J.G., 1993. Marine Debris contamination of beaches in St. Lucia and Dominica. Marine Pollution Bulletin 26, 325–328.

Costa, M., Araújo, M.C.B., Chagas, A.C.O., Sant'anna Jr., N., Souza, S.T., 2004. Poluição Marinha. In: Ezkinazi-Lessa, E., Neumann-Leitão, S., Costa, M.F. (Eds.), Oceanografia, um cenário tropical. Bagaço, Recife-PE, pp. 287–317.

Costa, M., Silva, J.S., Araújo, M.C.B., Leal, M.M.V, Barbosa, S.C.T., Souza, S.T., Guedes, S.Z., 2005. Solid wastes contamination on tropical beaches: the case of Pernambuco State, northeast Brazil. In: Proceedings of the Rivers to Sea Conference, Redondo Beach, California, USA. (http://conference.plasticdebris.org/whitepapers.html).

Cruz, G.A., Lopez, V., Sosa, C., 1990. Pollution by solid-wastes carried by marine currents to the Caribbean coast of Honduras. Revista de Biologia Tropical.

Debrot, A.O., Tiel, A.B., Bradshaw, J.E., 1999. Beach debris in Curacao. Marine Pollution Bulletin 38, 795–801.

Figueiredo, A.G., Lyra, A.C., Mordo, M.L., Santos, R.H., 2001. Lixo flutuante na Baía de Guanabara, Rio de Janeiro, Brasil. Revista de Gestão Integrada para Países de Língua Portuguesa 1, 13.

Garrity, S.D., Levings, S.C., 1993. Marine Debris along the Caribbean coast of Panama. Marine Pollution Bulletin 26, 317–324.

Geise, L., Gomes, N., 1992. Ocorrência de plástico no estômago de um golfinho, *Sotalia guianensis* (Cetacea, Delphinidae). In: Proceedings of the Third Reunion de Trabajos de Especialistas en Mamiferos Acuaticos de America del Sur, Montevideo, Uruguay.

Gomes, C.M.B., 1973. Lançamento de partículas de polietileno à costa do Rio Grande do Sul. Separatas da Revista Veritas (70/73), 174–206.

Gregory, M.R., Ryan, P.G., 1997. Pelagic plastics and others seaborne persistent synthetic debris: a review of Southern Hemisphere perspectives. In: Coe, J.M., Rogers, D.B. (Eds.), Marine Debris: Sources, Impacts and Solutions. Springer, New York, pp. 49–68.

Guebert, F.M., Monteiro-Filho, E.L., Krul, R., 2004. Poluição marinha por plásticos: um estudo de ingestão desse poluente pela tartaruga verde *Chelonia mydas* no litoral do estado do Paraná. In: Proceedings of the First Congresso Brasileiro de Oceanografia e XVI Semana Nacional de Oceanografia, Itajaí, SC, Brasil.

Ihara, P.M., Ivar do Sul, J.A., Filgueras, A.S., Portz, L.C., Fillmann, G., Matthiensen, A., 2005. Avaliação da toxicidade do conteúdo de atratores luminosos (lightsticks) ao microcrustáceo planctônico *Artemia* sp. In: Proceedings of the Congresso da Sociedade de Química e Toxicologia Ambiental (SETAC), Santigo, Chile.

International Maritime Organization (IMO), 1996. The Caribbean Sea – a very special area. The Caribbean initiative for ship-generated waste.

Iribarne, O., Botto, F., Martinetto, P., Gutierrez, J.L., 2000. The role of burrows of the SW Atlantic intertidal crab *Chasmagnathus granulata* in trapping debris. Marine Pollution Bulletin 40, 1057–1062.

Ivar do Sul, J.A., 2005. Lixo marinho na área de desova de tartarugas marinhas no litoral norte da Bahia: conseqüências para o meio ambiente e moradores locais. Monograph, Fundação Universidade Federal do Rio Grande, 62.

Ivar do Sul, J.A., Pedroso, C.C., Machado, A.A., Fillmann, G., 2004. Caracterização dos resíduos plásticos na Praia do Cassino (RS) em 2003/2004. In: Proceedings of the Second Simpósio Brasileiro de Oceanografia, São Paulo, SP, Brasil.

Ivar do Sul, J.A., Matthiensen, A., Rodrigues, O., Santos, I.R., Fillmann, G., 2005. Efeitos dérmicos observados em ratos expostos ao conteúdo de sinalizadores luminosos utilizados em pesca de espinhel. In: Proceedings of the Congresso da Sociedade de Química e Toxicologia Ambiental (SETAC), Santigo, Chile.

Ivar do Sul, J.A., Matthiensen, A., Rodrigues, O., Santos, I.R., Fillmann, G., 2006. Alterações epicutâneas e histopatológicas em ratos expostos ao conteúdo de atratores luminosos (lightsticks). In: Proceedings of the Congresso Brasileiro de Ecotoxicologia, São Pedro, SP, Brasil.

Lara-Domínguez, A.L., Villalobos Zapata, G.J., Rivera Arriaga, E., Vera Herrera, F., Alvarez Guillén, H., 1994. Origen de los desechos sólidos en las playas de Campeche, México. Revista Sociedad Mexicana de Historia Natural 45, 133–142.

Leal, M.M.V., 2002. "Educação de casa vai à praia": percepção de veranistas e turistas da praia do Pilar – Itamaracá/PE quanto à problemática do lixo. Monograph, Universidade Federal Rural de Pernambuco, 54.

Machado, A.A., 2006. Estudo da Contaminação por Resíduos Sólidos na Ilha do Arvoredo: Principal Ilha da Reserva Biológica Marinha do Arvoredo (RBMA), SC. Monograph, Fundação Universidade Federal do Rio Grande, 50.

Machado, A.A., Fillmann, G., 2004. A contaminação por resíduos sólidos pode ser um problema à reserva biológica marinha do Arvoredo (SC)? In: Proceedings of the First Congresso Brasileiro de Oceanografia e XVI Semana Nacional de Oceanografia, Itajaí, SC, Brasil, pp. 334–334.

Mariano, C.V., Santos, I.R., Absalonsen, L., Schiller, R.V., 2000. Elaboração e avaliação de um método para classificação e quantificação de resíduos sólidos presentes em ambientes praiais – varredura. In: Proceedings of the XIII Semana Nacional de Oceanografia, Itajaí, SC, Brasil.

Mascarenhas, R., Santos, R., Zeppelini, D., 2004. Plastic debris ingestion by sea turtle in Paraiba, Brazil. Marine Pollution Bulletin 49, 354–355.

Montealegre-Quijano, S., Soto, J., Vooren, C.M., 2004. Ocorrência de fitas plásticas enroscadas no tronco de tubarões-azuis (*Prionace glauca*), procedentes do lixo jogado no mar pelos barcos de pesca. In: Proceedings of the First Congresso Brasileiro de Oceanografia and XVI Semana Nacional de Oceanografia, Itajaí, SC, Brasil.

Nagelkerken, I., Wiltjer, G.A.M.T., Debrot, A.O., Pors, P.J.J., 2001. Baseline study of submerged marine debris at beaches in Curaçao, West Indies. Marine Pollution Bulletin 42, 786–789.

Pedroso, C.C., Ivar do Sul, J.A., Machado, A.A., Fillmann, G., 2004. Ocorrência de resíduos sólidos no conteúdo estomacal de aves na praia do Cassino RS em 2003/2004. In: Proceedings of the Second Simpósio Brasileiro de Oceanografia, São Paulo, SP, Brasil.

Pianowski, F., 1997. Resíduos sólidos e esférulas plásticas nas praias do Rio Grande do Sul – Brasil. Monograph, Fundação Universidade Federal do Rio Grande, 78.

Pianowski, F., Silva, K.G., Fillmann, G., 1997. Resíduos sólidos e esférulas plásticas nas praias do Rio Grande do Sul (Brasil). Proceedings of the XI Semana Nacional de Oceanografia, 547–549.

Portz, L.C., Ivar do Sul, J.A., Filgueras, A.S., Ihara, P.M., Matthiensen, A., Fillmann, G., 2005. Determinação da toxicidade do conteúdo de sinalizadores luminosos (lightsticks) ao tanaidáceo *Kalliapseudes schubartii* em sedimento estuarino. Proceedings of the Congresso da Sociedade de Química e Toxicologia Ambiental (SETAC), Santigo, Chile.

Santos, I.R., 2005. Naves flutuantes de plástico. Ciência Hoje 37, 64–65.

Santos, I.R., 2006a. Tubarões de coleira. Ciência Hoje 38, 54–55.

Santos, I.R., 2006b. Plásticos na dieta da vida marinha. Ciência Hoje 39, 50–51.

Santos, I.R., Friedrich, A.C., Mariano, C., Absalonsen, L., Duarte, E., 2001. Os problemas causados pelo lixo marinho sob o ponto de vista dos usuários da Praia do Cassino (RS). Revista Eletrônica do Mestrado em Educação Ambiental special edition, pp. 251–266 (www.sf.dfis.furg.br/remea).

Santos, I.R., Friedrich, A.C., Duarte, E., 2003a. Percepções sobre o lixo na praia do Cassino, RS, Brasil. Mundo & Vida 4, 11–17.

Santos, I.R., Friedrich, A.C., Wallner-Kersanach, M., Fillmann, G., Shiller, R.V., Costa, R., 2003b. Geração de resíduos sólidos pelos usuários da praia do Cassino, RS, Brasil. Revista de Gestão Integrada para Países de Língua Portuguesa 3, 12–14.

Santos, A.N., Nascimento, L., Bittencourt, A.C.S.P., Dominguez, J.M.L., 2005. Poluição das praias do litoral do sul do estado da Bahia por lixo e resíduos de petróleo. In: Proceedings of the X ABEQUA.

Santos, I.R., Friedrich, A.C., Barretto, F.P., 2005a. Overseas garbage pollution on northeast Brazilian beaches. Marine Pollution Bulletin 50, 778–786.

Santos, I.R., Friedrich, A.C., Wallner, M., Fillmann, G., 2005b. Influence of socio-economic characteristics of beach users on litter generation. Ocean & Coastal Management 48, 742–752.

Sazima, I., Gadig, O.B.F., Namora, R.C., Motta, F.S., 2002. Plastic debris collars on juvenile carcharhinid sharks (*Rhizoprionodon lalandii*) in southwest Atlantic. Marine Pollution Bulletin 44, 1147–1149.

Secchi, E.R., Zarzur, S., 1999. Plastic debris ingested by a Blainville's beaked whale, *Mesoplodon densirostris*, washed ashore in Brazil. Aquatic Mammals 25, 21–24.

Silva, J.S., Leal, M.M.V., Araújo, M.C.B., Barbosa, S.C.T., Costa, M., in press-a. Plastic litter on the strandline – implications of the beach morphology for its accumulation. Waste Management and Research, in press.

Silva, J.S., Barbosa, S.C.T., Leal, M.M.V., Costa, M., in press-b. Flag items as a tool for monitoring solid wastes from users on urban beaches. Journal of Coastal Research.

Silva-Iñiguez, L., Fischer, D.W., 2003. Quantification and classification of marine litter on the municipal beach of Ensenada, Baja California, Mexico. Marine Pollution Bulletin 46, 132–138.

Singh, J.G., Xavier, B., 1997. Land-based sources of Marine Debris and contamination of the coastal areas of the Caribbean Islands of St. Lucia, Dominica, and the British Virgin Islands. In: Coe, J.M., Rogers, D.B. (Eds.), Marine Debris: Sources, Impacts and Solutions. Springer, New York, pp. 371–380.

Soares, A.M., Costa, M.F., Silva, J.S., Araújo, M.B.C., 2007. Contaminação da linha-do-deixa da praia da Boa Viagem (Recife-PE) por

resíduos sólidos no verão de 2005: uma nova metodologia de avaliação. In: Proceedings of the XII Colacmar. Florianópolis, Brazil.

Thiel, M., Hinojosa, I., Vasquez, N., Macaya, E., 2003. Floating marine debris in coastal waters of the SE-Pacific (Chile). Marine Pollution Bulletin 46, 224–231.

UNEP, 2005. Marine Litter, an analytical overview.

UNESCO, 1994. Marine debris: solid waste management action plan for the Wider Caribbean. IOC Technical Series 41, 20 pp.

Wade, B.A., 1997. The challenges of ship-generated garbage in the Caribbean. In: Coe, J.M., Rogers, D.B. (Eds.), Marine Debris: Sources, Impacts and Solutions. Springer, New York, pp. 229–238.

Wade, B.A., Morrison, B., Jones, M.A.J., 1991. A study of beach litter in Jamaica. Caribbean Journal of Science 27, 190–197.

Wetzel, L., Fillmann, G., Niencheski, L.F.H., 2004. Litter contamination on the Brazilian southern coast: processes and management perspectives. International Journal of Environment and Pollution 21, 153–164.

Widmer, W.M., Soriano-Sierra, E.J., Hennemann, M., Carrero, G., 2004. Patterns of marine debris on sandy beaches on the Island of Santa Catarina, South Brazil. In: Proceedings of II Simpósio Brasileiro de Oceanografia, São Paulo, SP, Brasil.

Zarzur, S.A., 1995. Alimentação e ingestão de plásticos nos Procellariiformes (albatrozes e petréis) encontrados na Praia do Cassino. Monograph, Fundação Universidade Federal do Rio Grande, 39.

Zarzur, S.A., Vooren, C.M., 1995. Ingestão de plásticos nos Procellariiformes (Albatrozes e Petréis) do sul do Brasil. In: Proceedings of the VI Congresso Latino-Americano de Ciências do Mar, Mar del Plata, 208.