This article appeared in a journal published by Elsevier. The attached copy is furnished to the author for internal non-commercial research and education use, including for instruction at the authors institution and sharing with colleagues.

Other uses, including reproduction and distribution, or selling or licensing copies, or posting to personal, institutional or third party websites are prohibited.

In most cases authors are permitted to post their version of the article (e.g. in Word or Tex form) to their personal website or institutional repository. Authors requiring further information regarding Elsevier’s archiving and manuscript policies are encouraged to visit:

http://www.elsevier.com/copyright
Linking social drivers of marine debris with actual marine debris on beaches

Chris Slavin, Anna Grage, Marnie L. Campbell *  

School of Applied and Medical Science, Central Queensland University, Bryan Jordan Drive, Gladstone, Queensland 4680, Australia
National Centre for Marine Conservation and Resource Sustainability, University of Tasmania, Locked Bag 1370, Newnham, Tasmania 7250, Australia

A R T I C L E   I N F O

Keywords:  
Litter  
Pollution  
Littering behaviour  
Marine debris source  
Urbanisation  
Fishing gear pollution

A B S T R A C T

The drivers (social) and pressures (physical) of marine debris have typically been examined separately. We redress this by using social and beach surveys at nine Tasmanian beaches, across three coastlines and within three categories of urbanisation, to examine whether people acknowledge that their actions contribute to the issue of marine debris, and whether these social drivers are reflected in the amount of marine debris detected on beaches. A large proportion (75%) of survey participants do not litter at beaches; with age, gender, income and residency influencing littering behaviour. Thus, participants recognise that littering at beaches is a problem. This social trend was reflected in the small amounts of debris that were detected. Furthermore, the amount of debris was not statistically influenced by the degree of beach urbanisation, the coastline sampled, or the proximity to beach access points. By linking social and physical aspects of this issue, management outcomes can be improved.

© 2012 Elsevier Ltd. All rights reserved.

1. Introduction

Littering pervades our life, causes environmental degradation, and is recognised as an anti-social behaviour (e.g., Baltes and Hayward, 1976; Reich and Robertson, 1979; Cialdini and Baumann, 1981; Cialdini, 2003). In a marine context (including beaches), persistent anthropogenic litter that is within the marine environment or washed ashore is referred to as marine debris. The marine debris problem is extensive with isolated and unpopulated islands and coastlines accumulating as much debris as urbanised or populated coasts and islands (e.g., Benton, 1995; Gregory and Ryan, 1997; Barnes, 2002; Barnes and Fraser, 2003; McDermid and McMullen, 2004; Barnes et al., 2009; Santos et al., 2009). Large ‘islands’ of floating debris, associated with oceanic gyres and oceanic convergence, have also formed in the Atlantic, Pacific and Indian oceans (Moore et al., 2001; Morishige et al., 2007; Martinez et al., 2009; Kershaw et al., 2011). Of these, five were plastic accumulates (Kershaw et al., 2011; 5 Gyres Institute, 2012). The majority of marine debris consists of plastics (e.g., Whiting, 1998; Derraik, 2002; Cunningham and Wilson, 2003; Oigman-Pszczol and Creed, 2007), which are buoyant; accumulate toxins; and are persistent (a long half-life).

In Australia, littering and its consequences for the marine environment are managed with the help of tools such as awareness campaigns aimed at changing behaviour (e.g., Keep Australia Beautiful (KAB, 2011)) and legislation responding to both domestic (e.g., Environment Protection and Biodiversity Conservation Act 1999 (Cth), Section 138 Listing of Key Threatening Processes) and international concerns (e.g., International Convention for the Prevention of Pollution from Ships 1973/78 (‘MARPOL’) and the associated Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (Cth), Part IIIC Prevention of pollution by garbage).

The factors that influence littering and littering behaviour are well studied (Baltes and Hayward, 1976; Santos et al., 2005; Arafat et al., 2007; Khatib, 2009; Bator et al., 2011), as are the biological/physical (e.g., Laist, 1987; Ribic et al., 1992; Frost and Cullen, 1997; Barnes, 2002; Barnes and Fraser, 2003; Aiyana and Molcard, 2003; Derraik, 2002; Ivar do Sul and Costa, 2007; Moore, 2008; Kershaw et al., 2011) and social (e.g., Bell and Leeworthy, 1990; Kirkley and McConnell, 1997; Nash, 2001; Sheavly and Register, 2007; Thompson et al., 2011) impacts. Whilst the creation of marine debris is fundamentally linked to people’s littering behaviour, it would appear that few marine debris studies have considered these linkages.

To further this aspect, we’ve undertaken research to first investigate if the local population acknowledge that their actions contribute to the marine debris issue and then quantified (determine the types of sources) marine debris in an island setting, to see if the populations self-admitted practices reflect the marine debris issue that we see at beaches. Tasmania was selected as our study location because of its “green” reputation (Chang and Kristiansen, 2006) with unique flora and fauna (e.g., Vanormelingen et al., 2008), as well as the opportunity to access beaches that are both relatively pristine and in close proximity to populated areas than when compared to mainland Australian locations. Although we’ve used Tasmania as a case study, the implications of re-emphasising
the linkage between both natural and social science to investigate
the marine debris issue has ramifications for all regions.

2. Materials and methods

We undertook the study in two discrete parts, with outcomes
being synthesised across both aspects: (1) we implemented ques-
tionnaire (social) surveys to determine the social drivers of marine
debris in Tasmania; and (2) we undertook beach surveys to deter-
mine marine debris types and sources. Both social and beach sur-
veys occurred at the same nine beaches spread across western,
northern and eastern Tasmania, with social surveys extending into
the population catchment area of each beach. The beaches and
their catchment were categorised into three groups: high urbanisa-
tion; recreational; and low urbanisation (Fig. 1). They were also
categorised by location (west, north and east coast).

Definitions of catchment urbanisation can vary, thus we defined
our three beach urbanisation categories as follows:

- Highly urbanised beaches were defined as beach localities in
close proximity to large (>450 individuals) urban population
centres for that region. Data for town population sizes was
obtained from the Australian Bureau of Statistics 2006 census
(Australian Bureau of Statistics, 2011). These beaches had low
visitation by tourists on an annual basis (Tourism Tasmania
Corporate, 2011). The beaches sampled were Ocean beach (west
coast), Bell Buoy beach (north coast), and Coles Bay (east coast);
- beaches that represented the middle degree of urbanisation
were categorised as those that had catchments similar to the
highly urbanised areas but the beaches were recreational in
usage. Recreational beaches were defined largely by the number
of tourists (Tourism Tasmania Corporate, 2011) that visited the
area on an annual basis for that region. Sample locations were
Murrawah (west coast), Stanley beach (north coast), and Bin-
along Bay (east coast); and
- low urbanised beaches were defined as a site that was located
away from a major population centre (population number
<450 individuals; Australian Bureau of Statistics, 2011), with
low population sizes in surrounding towns. Sampling occurred
at Trial Harbour (west coast), Boobyalla beach (north coast),
and the Gardens (east coast).

2.1. Social surveys

A questionnaire (survey instrument) was developed to evaluate
whether the Tasmanian public perceive that their actions contrib-
ute to the marine debris problem. This aspect was particularly
important as one of the first steps to combating a problem is for
the people causing the problem to recognise the problem and to
acknowledge that they could be contributing to it.

Questionnaires were conducted in eight Tasmanian towns that
were within the immediate catchment of each beach that was sam-
ploed (Strahan; Trail Harbour; Marrawah; Smithton; Stanley; Laun-
ceston; St. Helens; and Coles Bay; Fig. 1). Sampling occurred over
an eight week period that targeted the austral spring and summer
period. Sampling of each location was randomised, but coupled
with beach surveys to ensure that debris collected was associated
with respondents opinions at that point in time (to overcome tem-
poral bias). The sampling period took advantage of increased tour-
ists and people at locations and in public places during the warmer
months.

Data was collected on site across weekdays and weekends using
intercept surveys of adults over the age of 18. A combined skip
interval, sample point sampling method was employed, with the

Fig. 1. Beach and social survey locations in Tasmania.
next available person that walked past the sampling point at each location being asked to participate in the survey. The survey sampling frame was focussed at local users of the beaches and the catchment region.

2.1. Survey questions

The survey was written to assess people's behaviour about littering, and their beliefs in whether their actions have an impact on the marine environment. Surveys maintained respondent's confidentiality and took approximately 10–15 min to complete. The surveys collected data on four main focal points: demographics, beach dislikes, behaviours at beaches, parks and home. A further description of the survey is provided in Supplementary Appendix A.

2.2. Beach surveys

2.2.1. Sampling sites

Beach surveys investigated three questions that created points of contention within the general marine debris literature:

1. Does the degree of urbanisation within a beach catchment influence the prevalence of marine debris types on Tasmanian beaches?
2. Is Tasmanian marine debris more commonly derived from land or ocean-based sources? and
3. Is marine debris more prevalent close to beach access points?

All beaches were sampled on spring tides, at low tide to maximise the exposure of the beaches to tidal waters and any potential floating debris. To assess research question 3, each beach was divided into two zones: Zone (1) entry access point to the beach; and Zone (2) non-entry access point on the beach. In both zones, three belt transects (Zone 1: 3 m × 50 m, covering a total surface area of 600 m² and Zone 2: 3 m × 100 m, with a total surface area of 1200 m²) were used to demarcate the sampling area. The placement of belt transects was stratified.

In Zone 1 at all sampled beaches, transects were placed 25 m either side of the entry access point, parallel to the shoreline at the high tide mark (indicated by the beach wrackline). Transect one was placed 5 m below the high tide mark. Transect two was placed at the high tide mark and transect three was placed 5 m above the high tide mark.

Zone 2 locations were determined randomly. Due to natural features at the sampling locations, many of the beaches were relatively small, which prevented the creation of two Zone 2 areas at either side of the access area (Zone 1). To accommodate this, we adjusted our sampling by implementing a 3-rule set that guided and stratified the sampling design. The rule set established that: (1) at a minimum, Zone 2 must be 26 m from the end of Zone 1; and (2) at a maximum, Zone 2 could start 400 m from the end of Zone 1; and (3) if one direction is impossible to sample (i.e., against a rocky headland) then Zone 2 must be placed in the other available direction, with the distance from the entry zone being randomly selected.

2.2.2. Beach sampling methods

To quantify and assess research questions 1, 2, 3 all macro-sized marine debris (5 mm to 2–3 cm) was collected from within each belt transect, following Ribic et al. (1992) size classification for debris items: macro-debris (5 mm to 2–3 cm) being collected, mega-debris (>1 m) being photographed, and meso- (<5 mm) and micro-debris (powdered) not being collected. Marine debris was categorised into types (glass, metal, paper and wood, fabric, rubber, hard plastic, sheet plastic/fibre, medical, and rope) to help identify the debris source. To aid with identification of fishing associated debris, classification guides such as “The Net Kit”, produced by the World Wildlife Fund (Hamilton et al., 2002), and UNEP/FAO and UNESCO technical papers (UNEP – United Nations Environment Program, 2005; Macfadyen and Cappell, 2009) were used. Debris items were classified as ‘unknown source’ when they could not be categorised into a type. Land or ocean source could not be inferred for ‘unknown source’ items.

2.3. Statistical analysis

The social survey data was analysed using chi-square ($\chi^2$) tests of independence. These analyses focussed on whether survey participants acknowledged that marine debris is a major problem and whether they believe that their actions contribute to this problem. A two way analysis of variance (ANOVA), with a 5% level of significance ($\alpha = 0.05$), was used to examine the beach survey data, to determine differences in debris composition (type, based on weight and count) and to determine trends with degree of urbanisation and coastal locations (west, north, east). Both Microsoft Excel and SPSS statistical software were used to undertake the statistical analyses.

3. Results

3.1. Social surveys

A total of 253 people were asked to participate in the survey, of which 173 people participated (68% response rate). A quarter of respondents (25%) readily admitted to littering at the beach, with the majority of participants (75%) stating that they either took their litter home with them or that they used waste receptacles at the beach. A demographic analysis indicated that there were a number of factors that influenced littering behaviours.

Age, income and residency all had a statistically significant influence on littering behaviour (age: $\chi^2_6 = 27.747$, $p = 0.000$; income: $\chi^2_6 = 6.851$, $p = 0.033$; residency: $\chi^2_6 = 14.718$, $p = 0.000$; Fig. 2a, c and e, respectively). In general, younger respondents, and respondents with less income admitted to littering behaviour more frequently than older age groups, and respondents in higher income categories. Tasmanian based residents admitted to littering more than frequently than people who did not reside in Tasmania (Fig. 2a, c and e).

Similarly, age and income statistically influenced participants guilt (positive correlation) associated with littering behaviour (age: $\chi^2_6 = 6.788$, $p = 0.034$; income: $\chi^2_6 = 11.822$, $p = 0.003$; Fig. 2b and d, respectively). However, there was no statistically significant difference between whether a participant was from Tasmania or was a non-Tasmanian and their guilt associated with littering behaviour (Fig. 2f).

Older respondents were statistically more likely to clean up their dog(s) waste when visiting the beach ($\chi^2_6 = 18.731$, $p = 0.001$; Fig. 3a). A respondents residency status statistically influenced their level of guilt regarding whether they clean up their dog waste ($\chi^2_6 = 10.269$, $p = 0.006$; Fig. 3b), with Tasmanians feeling no guilt about leaving their dog’s waste at the beach.

Gender also appeared to influence a number of littering behaviours. Although not statistically robust, males and females tend to visit the beach at a similar frequency (32% males, 28% females), with slightly more females (32%) walking their pets at the beach than males (30%) (Fig. 4). When at the beach, females are statistically more likely to feel guilt if they don’t collect other people’s litter ($\chi^2_6 = 10.348$, $p = 0.001$) and they are also statistically more willing to collect their own dog’s waste at the beach ($\chi^2_6 = 9.258$, $p = 0.26$).

3.2. Beach surveys

Just over 1000 ($n = 1010$) items of marine debris were collected, with an aggregated weight of 15.23 kg for the nine beaches. On
average this represented 113 items or 1.69 kg of debris per beach. Table 1 summarises the number of items and weight of total debris collected from each beach. At the scale of the beach, data was pooled to the level of the beach as no significant differences existed between belt transects.

At the scale of Tasmania, the types of debris items were varied, with the majority of items being plastic and hard plastic, with glass and paper/wood being the most common by weight (Fig. 5). Contrary to some of the literature (e.g., O’Callaghan, 1993; Herfort, 1997; Kusui and Noda, 2003), there were no statistically significant trends for debris type (weight and count) by degree of beach urbanisation (weight: \(F_{[2]} = 1.838, p = 0.195\); count: \(F_{[2]} = 1.319, p = 0.298\)). Similarly, the coastline that a beach was located upon (i.e., north, west or east) had no statistically significant influence on the debris type (weight: \(F_{[2]} = 1.838, p = 0.195\); count: \(F_{[2]} = 1.319, p = 0.298\)). Hence, debris type was uniformly distributed across low urbanisation, recreation, and highly urbanised beaches and coastlines.

The proportion of debris differed superficially by source (land or ocean based) when considering the number of items versus the weight of items, but these trends weren’t statistically different. In general, the weight of debris was relatively evenly spread across land (35%), unknown (35%), and ocean sources. Yet, the number of items was slightly skewed to unknown sources (60%), land (31%), and ocean (9%). If we remove unknown sources, then 77.5% of litter had a land origin, with 22.5% of debris being sourced from the marine environment. Thus, land-sourced litter was the most common by weight and number of items. Statistically, the source of marine debris showed no evident trends across degree of beach urbanisation (weight: \(F_{[2]} = 1.913, p = 0.261\); count: \(F_{[2]} = 1.364, p = 0.353\)). There were no trends between source across the coastlines (weight: \(F_{[2]} = 0.795, p = 0.466\); count: \(F_{[2]} = 0.776, p = 0.519\)).

We further delineated ocean sourced debris into commercial fishing, recreational fishing, and shipping related debris (Fig. 6) to investigate if there were any evident trends. By weight (kg/m²), shipping related debris was the highest proportion (61%), followed by commercial fishing debris (29%) and recreational fishing debris (10%). In comparison debris assessed by number of items (number/m²) showed that commercial fishing dominated (90%), followed equally by shipping related and recreational fishing.
debris (5% each). Commercial fishing items tended to be light weight and hence dominated the number of items but not the weights.

Beach zones (access points versus non-access points to the beach) had no influence on the number of items or weight of items located at each beach (weight: $F_{[2]} = 0.542, p = 0.648$; count: $F_{[2]} = 3.363, p = 0.229$). Comparing beach zones against degree of urbanisation also showed no statistically significant trends in debris abundance (weight: $F_{[2]} = 0.951, p = 0.512$; count: $F_{[2]} = 5.753, p = 0.148$). Thus, beach zone had no influence on the amount of debris at the beaches sampled.

4. Discussion

If we are to solve the issue of marine debris then we need to examine the linkages between actual marine debris and the social drivers of the debris within a locality. To this end, this research used northern Tasmania beaches as a case study to examine the linkages between actual marine debris and the social drivers of marine debris in that region. An a priori assumption of this study was that that survey participants would not acknowledge that marine debris was a pressing issue and hence their actions would reflect littering behaviours. However, the majority of participants (75%) stated that they did not litter while they were at the beach. These behaviours infer that participants within the study acknowledge that littering and marine debris is a problem and attempt to avoid littering at beach locations.

The recognition of marine debris as a threat to marine and coastal environments has been illustrated in other studies (e.g., Jedrezejczak, 2004; Scott and Parsons, 2005; Fletcher et al., 2009). From this finding, it could be reasoned, that the people that participated in the survey are aware that their actions contribute to the issue of marine debris; something that is also reflected in the beach litter survey results.

The beach litter surveys detected a small amount of debris at each beach (Table 1), which in comparison was significantly less than that recorded for the KAB beach collections (Fig. 7). The massive discrepancy in amounts detected in KAB surveys and the current study might be explained by KAB surveys being people and patriotism driven; collections of litter occur on Australia day (national public holiday), with highly polluted beaches being targeted for clean-up efforts. Sampling design could also explain the difference. We used a stratified, random sampling design, whereas KAB collections do not follow specific sampling methods or designs. To decrease the likelihood of inadvertent interference in our sample collections, we sampled beaches that had no active cleaning campaigns by local community groups, individuals, and shire councils (Slavin, 2011); however some of these activities may have occurred without our knowledge.

A high proportion of the number of litter items were land sourced (77.5% of identified litter). Previous studies suggest that land-sourced debris is more prevalent (up to 80%) than ocean-sourced litter (Gregory, 1991; UNESCO – United Nations Educational and Cultural Organisation, 1994; Nollkaemper, 1994; Andrady, 2011). Land-sourced litter on beaches is not just derived by human visitations at beaches, but is also associated with council and industrial waste sites, sewage and stormwater outfalls, and via river systems from upland sources (Wilber, 1987; Pruter, 1987; Karua, 1992; Williams and Simmons, 1997; Santos et al., 2005; Corcoran et al., 2009). Andrady (2011) notes that about 18% of the marine plastic debris detected in the ocean (not beaches) is derived from fishing. We detected a medium proportion of ocean sourced debris (22.5%), with fishing items (both recreational and commercial) dominating (90%) the numbers of items.

We note that the true trends between land and ocean sources were potentially obscured by the amounts of ‘unknown’ source debris. A large proportion of unknown source debris occurs because the debris material is often found as small fragments (due to plastic degradation and weathering; Andrady, 2011), which prevented accurate identification. To help overcome this issue beaches would need to be surveyed at a frequency that would collect debris shortly after it arrives on beaches and before further weathering.

![Fig. 3. Proportion of survey participants that collect their dog’s waste, for appropriate disposal, when visiting a beach. Light grey denotes “always”, dark grey denotes “sometimes”, and black denotes “never”.

![Fig. 4. By gender: (a) beach visitation rates; and (b) prevalence of dog walking activity at the Tasmanian beaches surveyed. Where light grey denotes that you do not visit the beach or walk your dog at the beach, and dark grey denotes the opposite, that you do visit the beach and do walk your dog at the beach.](image-url)
and degradation of the debris occurs. However as Andrady (2011) review illustrates, in many instances this may not be possible as microplastics are created (via a weathering process) while being transported by ocean currents.

Our research of littering behaviours at other regions (parks, suburbs) also detected that, just like at the beaches sampled, the rates of active littering by people was low (Slavin, 2011; Slavin et al., unpublished results). However, it is acknowledged that further research on this aspect could assist in focusing management practises.

Studies of beach littering have found that people’s actions do contribute to the issue of marine debris and people are capable of attributing the litter on the beach to their actions (e.g., Santos et al., 2005). Beach litter is not liked, with it playing a major role when people select a suitable beach for recreation (Nelson, 1998; Table 1

<table>
<thead>
<tr>
<th>Beach</th>
<th>Coastline</th>
<th>Degree of urbanisation</th>
<th>Weight (kg/m²)</th>
<th>Count (items/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean Beach</td>
<td>West</td>
<td>High</td>
<td>0.008414</td>
<td>0.023</td>
</tr>
<tr>
<td>Bell Buoy Beach</td>
<td>North</td>
<td>High</td>
<td>0.003433</td>
<td>0.112</td>
</tr>
<tr>
<td>Coles Bay</td>
<td>East</td>
<td>High</td>
<td>0.001116</td>
<td>0.074</td>
</tr>
<tr>
<td>Murrawah</td>
<td>West</td>
<td>Recreational</td>
<td>0.000004</td>
<td>0.038</td>
</tr>
<tr>
<td>Stanley</td>
<td>North</td>
<td>Recreational</td>
<td>0.000012</td>
<td>2.034</td>
</tr>
<tr>
<td>Binalong Bay</td>
<td>East</td>
<td>Recreational</td>
<td>0.000094</td>
<td>0.019</td>
</tr>
<tr>
<td>Trial Harbour</td>
<td>West</td>
<td>Low</td>
<td>0.000793</td>
<td>0.023</td>
</tr>
<tr>
<td>Boobyalla Beach</td>
<td>North</td>
<td>Low</td>
<td>0.001177</td>
<td>0.016</td>
</tr>
<tr>
<td>The Gardens</td>
<td>East</td>
<td>Low</td>
<td>0.000472</td>
<td>0.210</td>
</tr>
</tbody>
</table>

Fig. 5. The proportion of marine debris detected during sampling, pooled across all nine beach sites to represent a measure of marine debris for all locations. Where light grey denotes the number of items, and dark grey denotes the weight of items (kg/m²).

Fig. 6. Proportion of debris items detected from ocean-sources, where light grey denotes the number of items, and dark grey denotes the weight (kg/m²).

Fig. 7. Keep Australia Beautiful temporal (2005–2010) beach litter trends in all Australian States and Territories measured in items/m² over the following time periods: (a) number of items (number/m²); and (b) weight of items (kg/m²).
Santos et al., 2005; Tudor and Williams, 2008; Slavin, 2011). There is strong evidence that people are more likely to litter in places where litter is already present (Heberlein, 1971; Geller et al., 1980; Cialdini et al., 1991; Al-Khatib, 2009). This behaviour is strongly linked to an individual’s social norms that indicate to an individual that if the environment around them is unclean then it is acceptable to litter (Cialdini et al., 1990; Sibley and Liu, 2003).

This concept supports our results, where there were relatively small amounts of debris on the sampled Tasmanian beaches with the majority (75%) of participants stating that they did not litter when they were at the beach. This may suggest that the participants that were questioned may have a strong social norm to keep the coastal environment free from litter and debris (Cialdini et al., 1990; Sibley and Liu, 2003). Furthermore, combining the research results, the previous research on anticipated social behaviour, and the apparent state of an environment, the nexus supports approaches taken within management strategies that focus on targeted campaigns and cleaning for areas of high use.

There were a number of demographic factors (e.g., age, gender, income, residency) that appeared to have influenced littering behaviour. Being aware of these influences will aid environmental managers to target education programs and management actions. We observed that younger people tend to litter more and also feel less guilt about doing so. This trend of age related increases in littering is supported in the literature (Robinson, 1976; Cialdini et al., 1990; Reams et al., 1996) and may be related to younger people having weaker social norms in relation to the environment and littering behaviour (Krauss et al., 1978; Arafat et al., 2007; Bator et al., 2011). Older generations have been brought up with less affluence and consequently have stronger social norms regarding recycling measures and littering (Krauss et al., 1978). Younger people may also be desensitised to litter the campaigns that have been in the media for many years and may believe that littering is not their problem but rather believes a belief that regulators need to control and respond to littering (Arafat et al., 2007).

Within the literature, females are reported to care more for the natural environment than males (Mohai, 1992; Zelezny et al., 2000); are less likely to litter than males (Meeker, 1997; Torgler et al., 2008; Al-Khatib et al., 2009); and are more likely to collect litter when in a group setting (Perry et al., 2010). This finding is consistent with our research. It’s hypothesised in the literature that females care more about the environment than males due to their nurturing behaviours and their roles as ‘mothers’ (Flynn et al., 1984; Davidson and Freudenburg, 1996; Zelezny et al., 2000). It has been discussed that as caregivers and nurturers, females have a greater concern for the health and safety of life and therefore have stronger social norms for a cleaner environment for children and others (Davidson and Freudenburg, 1996; Hunter et al., 2004; Torgler et al., 2008). In this study, we did not investigate the social norms surrounding why females behaved differently than males and we suggest that this may be a future research direction to improve educational messages about littering behaviour.

In the US, Spain and Brazil cigarette butts have been shown to be the main source of marine debris on beaches (Moore and Allen, 2000; Martinez-Ribes et al., 2007; Oigman-Pszczol and Creed, 2007). This trend was not evident in our study, with hard plastics dominating (Fig. 5) and only 1 cigarette butt being collected from all of the sampled beaches (Slavin, 2011; Slavin et al., unpublished results). By region, the majority of cigarette consumption occurs in Australia and Asia (57%; Shafey et al., 2009).

For Australia alone, smoking rates are moderate (Shafey et al., 2009), with prevalence trends dropping over the past 60 years to just <20% for females and about 23% for males (Australian Bureau of Statistics, 2009; Quit, 2008). Within Tasmania, smoking rates are slightly higher than the Australia rate, at 24% (Australian Bureau of Statistics, 2007), which was relatively represented in our sampling. Thus, there is some confidence in stating that our low detection rates of cigarettes on beaches might be related to the low beach visitation rates by smokers in Tasmania (Slavin, 2011).

Based on the outcomes of our research we posed the following question: does the Tasmanian region have a low marine debris problem because of the existing management regime including legislation and campaigns, or is it that Tasmanians (and visitors) are altruistic about the environment and littering? It could be inferred that past and current management practises have been effective, but without a longitudinal study this type of inference is difficult to substantiate. What can be substantiated, however, is that the results from the beach and the social perception surveys indicate that at the present there is no apparent significant management or policy related issue with regards to marine debris, because the amounts of marine debris at the sampled beaches were relatively low.

Declines in the quantity of marine debris have been recorded along some shorelines in countries such as New Zealand and eastern Canada (Gregory, 2009), yet KAB beach debris survey data (2005–2010) for Australia (KAB, 2011) indicates that declines are not occurring on Australian beaches when considering the number of items recorded ($r^2 = 0.1789$; Fig. 7a), although decreases are occurring in weight of debris ($r^2 = 0.4736$; Fig. 7b). Further complicating this issue is that KAB data lacks information about the probable source of debris. Again, within these studies no perception analyses have been run in parallel and hence declines in actual marine debris on beaches may be a result of anti-littering campaigns that have influenced people’s behaviours, or a reflection in more stringent legislation (that has also potentially influenced behaviours).

In conclusion, the results of the social perception survey support the results of the beach survey, as most survey participants stated that they did not litter and there were no statistically significant trends between debris types, debris source, coastline or degree of beach urbanisation. It appears that people visiting the beaches in northern Tasmania have strong social norms regarding coastal environments. The social linkages in our research provide a mechanism to improve how anti-littering education can be tailored to better target potential litters based on the demographic influences exerted upon them.

Acknowledgements

We would like to thank and acknowledge the participants in the questionnaire surveys and the volunteers that helped collect marine debris. Ethics approval was obtained (project number H11417) from the University of Tasmania Human Research Ethics Committee (Tasmania) Network prior to any survey work being conducted. This work was partially funded by Grants to CS from Alcorso, NRM North, and CQUniversity.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.marpolbul.2012.05.018.

References


