



# Using citizen science data to assess the difference in marine debris loads on reefs in Queensland, Australia

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## ABSTRACT

The prevalence of marine debris in global oceans is negatively impacting the marine environment. In Australia, marine debris has been an increasing concern for sensitive marine environments, such as coral reefs. Citizen science can contribute data to explore patterns of subtidal marine debris loads. This study uses data from Reef Check Australia to describe patterns of debris abundance on reef tourism sites in two Queensland regions, the Great Barrier Reef (GBR) and Southeast Queensland (SEQ). Debris was categorized into three groups, fishing line, fishing net, and general rubbish. Overall, debris abundance across reefs was relatively low (average 0.5–3.3 items per survey (400 m<sup>2</sup>)), but not absent on remote reefs surveyed in the GBR region. Highest debris loads were recorded in SEQ near cities and high use areas. These results indicate the presence of marine debris on remote and urban reefs, and the applicability of using citizen science to monitor debris abundance.

## 1. Introduction

In recent years, the growing prevalence of marine debris in world oceans is gaining attention as a critical issue in marine conservation (Currie et al., 2017; Darmon et al., 2017; Eriksen et al., 2014; Hardesty et al., 2017; Lavers and Bond, 2017). In particular, there is an increasing volume of literature from across the world indicating impacts to marine wildlife through either the entanglement of fishing debris or ingestion of plastic, suggesting that the problem is more ubiquitous than previously thought (Courten-Jones et al., 2017; Denuncio et al., 2017; Law, 2017; Worm et al., 2017). Debris is even being recognized as a threat in more remote areas without human populations, for example, large amounts (53.1 to 4492 pieces per m<sup>2</sup>) of plastic debris were found on Henderson Island, a remote island in the South Pacific (Lavers and Bond, 2017). Despite the extent and magnitude of the problem, there is still very little knowledge about the abundance of marine debris in sub-tidal marine environments, how it gets there, how it moves, and the degree to which it may threaten marine wildlife and their habitats (Ryan, 2015).

In Australia, the impact of debris on local marine ecosystems has been an increasing concern for marine scientists, conservationists and governing agencies (Derraik, 2002; Gall and Thompson, 2015; Vince and Hardesty, 2017; Willis et al., 2017). Due to the increasing records of debris impacts on marine wildlife, the Australian government

identified marine debris as a “key threatening process” in coastal Australian waters (Smith and Edgar, 2014; Willis et al., 2017). In 2009, the Australian government prepared a ‘Threat Abatement Plan for the Impacts of Marine Debris on Vertebrate Marine Life’ to further recognize the threat of marine pollution on marine wildlife and co-ordinate abatement strategies. In addition, scientists and conservation agencies have started to provide alternatives for fishing debris, such as the use of TAngler bins and initiating ‘Sealing the loop’ programs around public fishing spaces (Pearson et al., 2014). Despite this nationwide plan and increased political attention, the sale and disposal of single use plastics and the volume of marine litter is expected to grow (Jambeck et al., 2015). Furthermore, while marine debris on shorelines are well quantified, there is still relatively little information on debris loads within the sub-tidal waters of Australia. A further understanding of the abundance of debris, debris type, and accumulation is needed to provide a robust platform for legislation or incentives to mitigate marine debris.

Survey data from beach-based clean ups indicates that Queensland beaches can accumulate between 439 and 2806 plastic items per km per year (Clark and Johnston, 2016). These items include a variety of plastic products from fishing debris to everyday household items (Taylor and Smith, 2009) and they could come from a variety of marine and/or land-based sources (Critchell et al., 2015). This load of plastic items accumulating on beaches could have strong implications for the

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potential impact of sensitive marine habitats, such as the ecological and social values of important natural and cultural heritage areas such as the Great Barrier Reef World Heritage Area (Derraik, 2002).

In addition, it is likely that most of the impacts to marine species arises from debris within the water column or in benthic habitats, but unlike beach clean ups, it is exceptionally hard to quantify either the existing load of debris in marine habitats, or the volume of inputs into the marine system. Therefore, there is relatively little publically available information about the level of debris in subtidal Queensland coastal waters. Essentially, because quantifying patterns or abundances of debris in subtidal benthic habitats is more difficult, and less cost effective, to achieve and therefore debris loads are not well documented. Obtaining an estimate of the level of debris in benthic habitats is essential if we are to further understand how marine debris interacts and potentially alters the state and value of marine species and habitats.

Volunteer organizations and citizen science groups are able to implement replicable and cost-effective monitoring across broad areas (Jambeck and Johnsen, 2015; Dickinson et al., 2010; van der Velde et al., 2017), and have been successful in monitoring ecosystem health (Done et al., 2017; Marshall et al., 2012), tracking wildlife (Jaime et al., 2012; Marshall and Pierce, 2012), and providing information on invasive species (López-Gómez et al., 2014). In Australia, subtidal marine debris have been recorded by citizen science groups such as Tangaroa Blue Foundation, PADI Project Aware, and the New South Wales Underwater Marine Debris database. However, these volunteer diving programs often visit known debris prone areas, and thus their data does not provide means of quantifying overall patterns of subtidal debris abundance.

Reef Check Australia (RCA) is a non-profit, citizen science organization that has been monitoring reef health on Queensland reefs using a globally-standardized protocol since 2001. Specifically, RCA conducts regular surveys of long-term monitoring sites to provide a robust baseline dataset that can document changes in reef condition over time (Done et al., 2017), and contributes to the knowledge of reef scale health and condition assessments (GBRMPA, 2014). During RCA reef surveys, volunteer divers record data on coral reef habitat, wildlife and condition. As part of the surveys they also record information on subtidal debris, providing an opportunity to quantify marine debris loads across regularly monitored reefs.

To provide insights of patterns of benthic debris, we use RCA's long term reef survey dataset to examine large scale patterns of marine debris occurring on Queensland sub-tidal reefs. With this dataset, we aim to describe state-wide patterns of debris abundance located at RCA monitoring sites. In addition, since Queensland reefs are intrinsically separated geographically, we compare patterns of debris types among the two main surveyed regions: Southeast Queensland (SEQ) and the Great Barrier Reef (GBR). Due differences in nearby population density, and ease of access, we predict that there will be more sub-tidal debris within SEQ reefs. In addition, we predict there will be differences in overall debris type between the two regions, suggesting different targeted management strategies for the relevant area's managing agencies.

## 2. Methods

### 2.1. Reef Check surveys

RCA conducts annual standardized coral reef health surveys, using point intercept transects to measure substrate composition and belt surveys for reef impacts, and share information with stakeholders (Hodgson, 1999). In Queensland, surveys were conducted in two regions: the Great Barrier Reef (GBR) and Southeast Queensland (SEQ) (Fig. 1). The GBR sites have been surveyed regularly since 2001, and range from Heron Island in the south to Osprey Reef in the Coral Sea. SEQ surveys began in 2007 and occur on reefs from Fraser Island south to the Gold Coast. GBR and SEQ survey sites include both coastal and off-shore reefs.

Most reef surveys were conducted within a five month survey period that occurred from February to June in the GBR, and August to December in SEQ. There is a concerted effort taken to conduct surveys at each location within the same month each year to minimize seasonal variation. However, because RCA relies on the availability of trained volunteers and dive operators offering their services in-kind or at a reduced cost, there can be variation in survey timing. Other constraints, such as unfavorable weather or budget limitations, also restrict the ability to reach certain sites each year, or at the same time every year. Therefore, sites that were newly implemented or not surveyed more than two times were not included in this analysis.

Reef Check surveys were conducted on SCUBA or snorkel and carried out using measurement tapes to mark four, 20 m transects, with 5 m between each replicate transect (Hill and Loder, 2013). Sites were located with GPS coordinates, and detailed maps that were regularly updated to relocate sites. Transects were placed in the same area each year, following the natural outline of the reef, and avoiding non reef building substrate, such as sand. Reef health surveys were made up of four parts, substrate percent cover, and abundance of reef impacts (such as bleaching, disease, and scaring), invertebrates, and fish. Debris was recorded as a part of the reef impact survey, where one to two divers performed a five meter belt within each 20 m transect (2.5 m on either side of the transect line) (Fig. 2), recording any debris item present within the belt area. These surveys are repeated once a year, unless interrupted by unforeseen circumstances, such as poor weather or if site was no longer accessible.

### 2.2. Debris categorization and quantification

Within RCA impact surveys, debris items were categorized into; fishing line, fishing net, and general rubbish (any debris that does not fall within the previous categories). This included any visible items in any size range. Since the debris surveys were part of a larger site survey, the debris items were counted but not weighed or measured. Instead, once the items were observed they were recorded in one of the three categories, and if a camera was available, a picture was taken for documentation and further identification. Photographs were later cross-referenced to survey data, to provide more information on debris type. If safe for the surveyors, debris items were removed from the site, whenever possible. However, sometimes the debris items such as fishing line were tangled with reef structure, and attempting to remove them could cause damage.

Due to low debris densities, the four twenty meter replicate transects were treated as a single eighty meter transect rather than as replicates (Fig. 2). Therefore, the total debris items were summed across all transects to obtain debris abundance per survey area (400 m<sup>2</sup>). The total debris abundance per survey was then averaged over multiple surveys. Any site visited three or more times between 2001 and 2016 was included in the analysis.

### 2.3. Statistical analysis

The average debris abundance per survey area (400 m<sup>2</sup>) was analyzed in ArcGIS (ESRI) to determine patterns of debris along the Queensland coast. To test the difference of the mean debris abundance and type between the two regions (SEQ and GBR) a non-parametric Man-Whitney-U test was performed in SPSS.

## 3. Results

Across a 15 year time span, a total of 79 locations were surveyed along the Queensland coast, ranging from Osprey Reef to the Gold Coast. This included 54 sites within the GBR, and 24 within SEQ (Supplementary Table 1). Within the two regions, a total of 622 surveys were conducted from 2001 to 2016 (n = 437 in GBR, and n = 185 in SEQ) (Fig. 1). Overall, debris was present in 32% of the surveys

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