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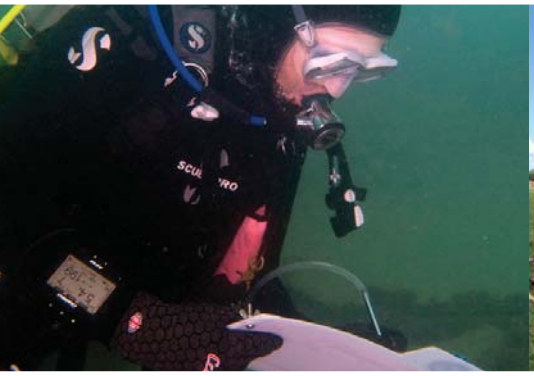

Subtidal marine debris in the Hunter-Central Rivers region of NSW

Results of surveys by underwater volunteers

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NSW GOVERNMENT Catchment Management Authority
Hunter-Central Rivers

Report prepared for the Hunter-Central Rivers Catchment Management Authority, July 2013

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Cover photos (l to r): A volunteer conducting surveys, Swansea Channel; GLUG members with debris collected from the Tuncurry Breakwall; Interaction between fishing line and soft coral, Pipeline, Nelson Bay.

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Introduction

Anthropogenic debris has been identified as a Key Threatening Processes to marine habitats and organisms in Australia (Department of the Environment & Heritage 2003), especially to threatened and/or endangered species. Recent reports list 77 species of Australian marine animal which have either been found entangled in, or have ingested, marine debris (Ceccarelli 2009). Global estimates suggest that from 170-270 species are affected (e.g. Derraik 2002). However, much of this research relates to the larger fauna such as birds, reptiles and mammals with many fewer records for invertebrates and other vertebrates (although examination of gut contents of fish is showing ingestion of microplastics is widespread (Boerger et al. 2010)).

One of the reasons for the relative lack of data on invertebrate taxa is that direct observation requires diving studies, which form a relatively small component of the literature on marine debris (e.g. Smith et al. 2008 and others). Another factor limiting the acquisition of accurate and broad-scale information on subtidal marine debris is the relative difficulty of gaining data. This issue can be substantially mitigated by the use of underwater volunteers using standardised methods to gain accurate, site-specific data on debris loads.

Underwater Volunteers NSW (UVNSW) was established in 2011 to: promote awareness of marine conservation issues through the diving community; establish groups of citizen scientists across the entire NSW coastline; and, increase the capacity of underwater volunteers through training in a range of marine survey techniques. To date, the primary focus has been on quantitative assessment of marine debris using standard protocols that were developed by marine scientists (Smith et al. 2006; Rule and Smith 2007) and have already led to successful acquisition of relevant data (e.g. Smith et al. 2006, 2008).

Since the implementation of the UVNSW program, a total of >150 sites, from Eden in the south to the Tweed River in the north, have been surveyed and cleaned by >300 volunteers from 11 underwater volunteer groups (UVGs). This report provides a summary of the data collected by 3 of the groups (Great Lakes Underwater Group (GLUG), Combined Hunter Underwater Group (CHUG), and Terrigal Underwater Group (TUG)), mostly through 2012/13 as part of a marine debris program funded through the Caring for our Country (CfoC) initiative and managed by the Hunter-Central Rivers Catchment Management Authority (HCRCMA) (but note that earlier data are also included to provide a complete overview).

Methods

Training

Prior to commencing field surveys, all volunteers undertook training to ensure they understood the context of the work and the need for standardised methods. Following this classroom-based component, field training occurred at suitable sites within the respective regions. Working with the training team, and volunteers who had already completed the training program, the trainees: completed supervised underwater surveys using the standardised protocol; examined and classified the debris recorded; filled in all requisite fields in the standardised data sheets. At least one member of each group was also instructed in the process for uploading the data into the dedicated online portal on the UVNSW web site (uvnsw.net.au). The training protocol is outlined in Edgar and Smith (2011).

Field work

Based on local knowledge, groups selected the most appropriate sites for conducting their surveys, restricted only by local conditions and the budget provided for the on-ground works. At each site, 4 transects, each measuring 25 x 5m (2.5m either side of 25-m tape), were deployed and all debris occurring within this area was recorded onto pre-printed data sheets. Where possible, debris items were removed: however, where items were habitat-forming, and their removal was likely to result in harm to marine biota (e.g. old bottles with resident fish – Fig. 1), they were recorded but left *in situ*. At most sites, an additional, 30-min search of the seafloor between the 4 transects was also conducted, with debris items similarly recorded and removed.

Data upload and analysis

At least one member from each group either uploaded data directly onto the UVNSW database through the online portal, or submitted spreadsheets to the project team for data entry. Quality Assurance/Quality Control procedures are built into the data entry protocols promoting high confidence in the resulting data set. For the purposes of this report, which

covers only some of the data from surveys across the entire state, data analysis comprised simple summaries of debris loads in transects, primarily by usage category, across sites surveyed in the Hunter-Central Rivers region. While most surveys were conducted as part of the CfoC-funded program (between June 2012 and May 2013), earlier data are included in the summaries.

Fig. 1. Brown sabre-toothed blennies (*Petroscirtes lupus*) are common occupants of discarded bottles. Wherever possible, care was taken to ensure that items occupied by marine life were left *in situ* (Photo: Steve Smith).

Results

The 3 UVGs in the Hunter-Central Rivers region have performed a total of 60 surveys of 42 sites, recording a total of 1241 items of marine debris. A brief summary of the data is provided for each group, below.

Great Lakes Underwater Group

GLUG performed a total of 31 surveys at 22 different sites between May 2010 and April 2013 (Table 1) (note that some of this work was funded under a separate successful funding application through CfoC). The sites ranged from Snapper Rock in the north, to Little Seal Rocks in the south. Debris loads were mostly quite low with a total of 175 items recorded: 78 of the 120 transects contained no detectable debris.

The most prevalent items were fishing-related and this usage category accounted for 45.1% of the total debris (Table 2A and 2B). The other dominant debris category was “industrial” (24.0%) which primarily comprised bricks. From past experience, when bricks are found in offshore sites, they have primarily originated from fishing traps in which they are used as weights.

Combined Hunter Underwater Group

GLUG performed a total of 19 surveys at 12 different sites from November 2011 to May 2013 (Table 3) with the Pipeline surveyed 6 times (this site is often used for training CHUG members). The sites ranged from Providence Beach in the north, to The Haven, Terrigal in the south. The CHUG sites recorded the highest debris loads over the survey period (total of 959 items), with the “dirtiest” site consistently being Pipeline at Nelson Bay, despite the fact that this area is often targeted for clean-up activities. Only 25 of the 76 transects contained no detectable debris.

The most prevalent items were fishing-related (37.5%) closely followed by “other” (29.9%) and “food and drink” (24.6%) categories (Tables 2A and 2B). The high proportion for the “other” category was primarily a result of small fragments of plastic (total of 185 across all sites), and glass bottles (143) were a primary contributor to the “food and drink” category.

Table 1. List of sites and dates of surveys conducted by GLUG.

Site	Date Surveyed (mm/dd/yyyy)	Latitude	Longitude
The Pinnacle	04/25/2012	-32.22850	152.60200
	03/10/2012	-32.22850	152.60200
Latitude Reef	04/25/2012	-32.20410	152.57000
	10/03/2012		
	04/06/2013		
Big Seal Rock	05/12/2012	-32.46380	152.55300
	01/11/2013		
	04/28/2013		
Bulls Paddock	08/05/2012	-32.31730	152.53100
Baitgrounds	11/24/2012	-32.17780	152.52300
Elizabeth Beach	10/20/2012	-32.32760	152.54200
Snapper Rock	10/20/2012	-32.02760	152.60300
	04/13/2013		
Redhead Ridge	10/20/2012	-32.05600	152.55700
Graveyards	08/05/2012	-32.27080	152.53400
	03/23/2013		
The Colours	09/02/2012	-32.20560	152.56300
One Mile Gutters	09/02/2012	-32.18370	152.54100
Inner Edith	01/11/2013	-32.47210	152.50200
The Barge	11/24/2012	-32.15380	152.53900
	06/04/2013		
No 1 Point	05/08/2010	-32.43000	152.54000
	08/05/2010		
Inner Baitgrounds	01/24/2013	-32.17610	152.52300
Tuncurry Breakwall	02/16/2013	-32.17610	152.50200
Sawtooth Rocks	03/14/2013	-32.17380	152.50400
Status Rock	03/14/2013	-32.42830	152.53600
Haydens Rock	03/21/2013	-32.17530	152.51900
Seagull Point	03/23/2013	-32.32520	152.54600
Little Seal Rock	04/11/2013	-32.47360	152.54700
Redhead Gutters	04/13/2013	-32.05640	152.55700

Table 2A. Breakdown of the number of debris by usage category for each of the 3 underwater volunteer groups.

Usage category	CHUG	GLUG	TUG	Total
Apparel	8	2	0	10
Boating	8	18	10	36
Clothing	5	0	1	6
Diving	2	0	8	10
Domestic	20	1	13	34
Fishing	360	79	21	460
Food or drink	236	23	12	271
Industrial	16	42	6	64
Metal	2	0	9	11
Other	287	7	24	318
Packaging	6	1	2	9
Plastic	4	0	0	4
Scientific	0	1	0	1
Transport	5	1	1	7
Grand Total	**959**	**175**	**107**	**1241**

Table 2B. Breakdown of the percentage of debris items by usage category for each of the 3 underwater volunteer groups.

Usage category	CHUG	GLUG	TUG	Total
Apparel	0.8%	1.1%	0.0%	0.8%
Boating	0.8%	10.3%	9.3%	2.9%
Clothing	0.5%	0.0%	0.9%	0.5%
Diving	0.2%	0.0%	7.5%	0.8%
Domestic	2.1%	0.6%	12.1%	2.7%
Fishing	37.5%	45.1%	19.6%	37.1%
Food or drink	24.6%	13.1%	11.2%	21.8%
Industrial	1.7%	24.0%	5.6%	5.2%
Metal	0.2%	0.0%	8.4%	0.9%
Other	29.9%	4.0%	22.4%	25.6%
Packaging	0.6%	0.6%	1.9%	0.7%
Plastic	0.4%	0.0%	0.0%	0.3%
Scientific	0.0%	0.6%	0.0%	0.1%
Transport	0.5%	0.6%	0.9%	0.6%
	100%	**100%**	**100%**	**100%**

Table 3. List of sites and dates of surveys conducted by CHUG.

Site	Date Surveyed (mm/dd/yyyy	Latitude	Longitude
Boat Harbour	04/14/2012	-32.78830	152.11300
Boondlebah Island	04/06/2013	-32.70830	152.22600
Cabbage Tree Island	11/17/2012	-32.68890	152.22200
Coal Shaft Bay	05/26/2013	-32.62020	152.31200
Fingal Island	04/06/2013	-32.74670	152.18800
Governor's Wharf	05/11/2013	-32.74060	152.19500
Lucy's Breakwall	04/01/2012	-33.08850	151.66000
Pipeline, Port Stephens	11/26/2011	-32.71800	152.14200
	11/27/2011		
	04/28/2012		
	07/07/2012		
	11/03/2012		
	01/12/2013		
Providence Beach	05/26/2013	-32.61280	152.31400
Shoal Bay Jetty	08/05/2012	-32.71970	152.17600
Terrigal Haven	05/27/2012	-33.44700	151.45000
	10/06/2012		
Swansea Bridge	05/06/2012	-33.08660	151.64000
	10/27/2012		

Terrigal Underwater Group (TUG)

TUG conducted a total of 10 surveys at 8 sites (all in 2013), with 3 surveys on the HMAS Adelaide (Table 4). The sites ranged from Terrigal in the north, to Avoca in the south. The TUG sites recorded a total of 107 debris items with the highest loads occurring at The Haven, Terrigal (total = 35 items, average = 8.75 per transect). Twelve of the 32 transects contained no detectable debris, including all transects conducted at Avoca Reef North.

The most prevalent items were “other” (22.4%) and fishing-related (19.6%) with “domestic” and “food and drink” categories combined accounting for a further 23.3% (Tables 2A and 2B).

Table 4. List of sites and dates of surveys conducted by TUG.

Site	Date Surveyed (mm/dd/yyyy)	Latitude	Longitude
Avoca Reef North	04/14/2013	-33.47280	151.45600
Avoca Reef South	04/14/2013	-33.47000	151.46000
ex HMAS Adelaide 1	04/28/2013	-33.46480	151.45800
	05/14/2013	-33.46480	151.45800
ex HMAS Adelaide Site 2	04/28/2013	-33.46450	151.45700
Terrigal Haven	05/05/2013	-33.44700	151.45000
	05/05/2013	-33.44670	151.48500
Terrigal Reef 1	10/03/2013	-33.46560	151.45700
Terrigal Reef 2	10/03/2013	-33.46530	151.45700

Comparison across sites

As can be seen from the listing of sites by rank order of debris load (highest to lowest – Table 5), estuarine sites were by far the dirtiest. Indeed, the only offshore reef site found to support a mean debris density of >10 items per transect (125m^2) was The Haven, Terrigal. All surveys at the Pipeline returned mean loads of >10 items per transect with the highest single transect value being 218 items. With only a few exceptions, reef sites general had mean debris loads of <5 items, with no debris found on any transect at Big Seals, Inner Edith, Inner Baitgrounds, Elizabeth Beach (all in the GLUG area), Redhead Ridge (CHUG area), and Avoca Reef North (TUG).

Table 5. List of site surveys (some sites sampled multiple times) on which average debris load per transect (125m^2) was >10 (Standard Error in brackets).

Site and date (mm/dd/yyyy)	Mean (SE)
Pipeline (11/26/2011)	66.0 (51.30)
Pipeline (4/28/2012)	24.3 (7.36)
Pipeline (1/12/2013)	23.8 (1.70)
Pipeline (7/07/2012)	22.5 (5.36)
Tuncurry Breakwall (2/16/2013)	22.5 (31.8)
Swansea Bridge (5/06/2012)	17.0 (1.83)
Terrigal Haven (5/27/2012)	13.5 (6.89)
Pipeline (11/27/2011)	13.3 (2.50)
Swansea Bridge (10/27/2012)	13.3 (2.84)
Pipeline (11/03/2012)	12.3 (3.28)
Shoal Bay Jetty (8/05/2012)	10.5 (1.55)

Discussion

In many respects, the data from the Hunter-Central Rivers region reflect what is already known about the type and distribution of marine debris in the coastal waters of NSW. However, these observations strengthen the inference made from just a few locations in the past (e.g. Smith et al. 2008; Smith 2010). Thus, benthic debris is dominated by fishing-related items, and especially monofilament fishing line, and safe, accessible sites, such as breakwalls and jetties in estuaries, are the dirtiest locations. Although not specifically addressed here, the tendency for areas with higher population densities to be dirtier is also evident within this dataset, and particularly in the full data from the statewide UVNSW program (unpublished data).

It is highly likely that the number of fishing-related items is under-represented in the data, as only items directly related to fishing activities were allocated to that category. For example, bricks found at reef sites are most likely to be remnants of fishing traps: the project team has regularly encountered traps in various stages of deterioration with bricks placed in the corners as weights. In addition, at some popular fishing sites, it is highly likely that other items (such as clothing, food and drink items) result from fishing-related activities.

One of the most disturbing results from these surveys is that a site with very high conservation value (Pipeline – Poulos et al. 2013) consistently recorded the highest debris load. *In situ* observation further indicates that fishing activity at this site is having a direct impact on an important, geographically restricted, habitat-forming species (the soft coral *Dendronephthya australis*). This impact is due to entanglement by fishing line (Fig. 2) as well as the direct effects of anchor damage (one of the project team has even been struck by an anchor whilst diving in the soft corals at the Pipeline!). Not only is *D. australis* geographically restricted, but it also contributes strongly to the biodiversity of the Port Stephens-Great Lakes Marine Park (Smith et al. 2010; Poulos et al. 2013).

Fig. 2. Interaction between fishing line (braided in this case) and the soft coral *Dendronephthya australis* at the Pipeline, Nelson Bay (Photo: Steve Smith).

In reflecting on the contribution of the citizen scientists participating in the 2012/13 research effort, it is clear that investment in the training of underwater volunteers, with subsequent facilitation of on-ground works, represents a very cost-effective use of public money. There are many positive outcomes:

1. The work has generated more data on marine debris and its interactions with marine organisms and habitats, thus directly helping to address knowledge gaps about a Key Threatening Process (Rule et al. 2007; Smith et al. 2010). The results also provide a clear focus for directed effort to mitigate the effects of marine debris at key sites, and thus provide obvious objectives for resource managers. For example, in this case, a key management challenge is to reduce benthic debris loads at the Pipeline and establish mechanisms to reduce the impact of fishing-line entanglement on soft corals. Solutions for the former may be as simple as improved debris management systems in the direct vicinity (e.g. i) more garbage bins; ii) more suitable garbage bins from which it is difficult for garbage to escape; iii) more frequent collection of garbage; iv) specific litter patrols at periods of high use). Solutions for the latter would be to introduce fishing closures at key sites or to develop and implement better guidelines for sensitive fishing practices in these fragile habitats.

2. Many underwater volunteers have improved their knowledge of research approaches in marine habitats and have directly contributed to the sustainability of their local marine ecosystems. Both of these were identified as important reasons why divers chose to become involved with voluntary underwater research groups across the state (reviewed in Dalton and Smith 2009).
3. The activities performed by the groups and by the project team have led to broad-scale community education through various mechanisms which include: word-of-mouth; direct observation and interaction during survey work; and media releases that have received strong uptake across the range of forms (print, radio, TV, online).

In conclusion, the 2012/213 program in the Hunter-Central Rivers region has provided important insight into the issue of marine debris at a regional scale and has built the capacity of underwater volunteers to both quantify the scale of the problem and conduct targeted clean-up activities. The value of these activities should not be underestimated in terms of their promotion of sustainable marine and estuarine ecosystems throughout the region. The data suggest that further activities should target the dirtier habitats – estuaries and embayments – as this is where debris loads are consistently at their highest. However, it is imperative that data resulting from the surveys are used to inform management practices to mitigate the problem, especially where it is having a demonstrable effect on the health of the ecosystem. This will not only require additional work to identify the primary factors determining the distribution of marine debris, but also close collaboration amongst a range of agencies and, importantly, commitment from all stakeholders to implement mitigation measures once these have been identified.

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