

ARE THERE
MICROPLASTICS
IN OUR
WATERWAYS?

Microplastics Monitoring Manual









































'Are There Microplastics in Our Waterways? Microplastics Monitoring Manual.' Take 3 Ltd. Acknowledgements Dixon-Valk, R., Freeman, C., Marechal, A. and Wilson, S. (2018).

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- ◆ Tumbi Campus-Tuggerah Lakes Secondary
- ♦ Woy Woy Campus-Brisbane Waters Secondary
- ♦ Wyong High

**AUSMAP** is a new national citizen science program gathering data about microplastic in the aquatic environment; building on the pilot work of Take 3 and Macquarie University's 'What's in Our Waterways? Microplastic Citizen Science Project'. **AUSMAP** are developing activities for high schools and community groups, to obtain widespread reliable data on the presence of microplastics hotspots, such as how much is actually out there, where it is located and where is it coming from.

### Contents

Acknowledgements	 3
Introduction	 5
Microplastics	 7
Citizen Science	 8
What's in Our Coastal Waterways/Lagoons?	 8
About Take 3	 9
Microplastic & Marine Debris Monitoring Why monitor? Aim Scientific sampling tools Quadrant sampling Site selection Timing Sampling sizes	 10
Quality Assurance / Quality Control	 13
Design Decision Tree	 14
Part 1 – Site Description Part 2 – Marine Debris Survey Part 3 – Microplastic sampling Part 4 – Recording results Part 5 – Data analysis and further work	 15
Microplastic Photo-guide  Microplastics Categories (<5 mm)  Items commonly mistaken  for microplastics	 20
Microplastics Site Assessment	 22
Microplastic Data Collection	 24
Marine Debris (Macro) Data Sheets	 26
Take 3 Fact Sheet	 28
Sample Unit Earth and Environmental Science - Year 11	 30
Related Research and Links	 36
References	 37
Notes	 38

### Introduction

### **PLASTIC NOT SO FANTASTIC**

Ok. So here's a quick low down on plastic marine pollution. It comes from us. Every piece of plastic litter that blows away from us or that we leave on the ground can make its way to the ocean through our storm-water drains, creeks and rivers. Oceans are the lowest point in our landscape and are downhill from everywhere. And approximately 8 million tonnes of new plastic enters our oceans every year<sup>1</sup>.

In our oceans, plastic may persist for hundreds or even thousands of years. We don't really know how long plastic will stay around for because it is a relatively new material. Plastic is a word that originally meant 'pliable and easily shaped.' It only recently became a name for a category of materials.



Strandline Phuket 2018. Photo © Roberta Dixon-Valk.

### HISTORICAL PLASTIC

Plastic was originally developed in 1869 as a replacement for ivory in the popular billiard industry, however the development of conventional plastics revolutionised manufacturing. Manufacturing was no longer constrained by the availability of natural materials; humans could create new materials.

Since the 1960s, single-use disposable plastics have gained a firm foothold within our fast paced lifestyles driven in particular by the disposable society of developed countries, including Australia. These plastics are usually synthetic and are most commonly derived from petrochemicals – natural gas and petroleum. Due to their relatively low cost, ease of manufacture, versatility, durability and imperviousness to water, plastics are used in an enormous and expanding range of products, and have already displaced many traditional materials, such as wood, stone, horn/bone, leather, paper, metal, glass, and ceramic, in most of their former uses. Plastics are now ubiquitous in our everyday life.

### PLASTIC MARINE POLLUTION

In the ocean, plastic is responsible for the deaths of countless (literally millions) of innocent animals every year. Over 690 marine species are reported to have been impacted by plastic marine pollution, including dolphins, whales, seals, turtles, seabirds and fish² – few marine animals are immune to this lurking predator. It is estimated over 1 million seabirds and 100,000 marine mammals/reptiles die each year as a result of eating (ingesting) or becoming caught (entangled) in plastic³.

<sup>&</sup>lt;sup>1</sup> Jambeck, J. et al, 2015. Plastic waste inputs from land into the ocean. Science 13 Feb 2015: Vol. 347, Issue 6223, pp. 768-771.

<sup>&</sup>lt;sup>2</sup> Gall, S. C., & Thompson, R. C. (2015). The impact of debris on marine life. Marine Pollution Bulletin, 92(1), 170-179. doi:http://dx.doi.org/10.1016/j.marpolbul.2014.12.041

<sup>&</sup>lt;sup>3</sup> United Nations Educational, Scientific and Cultural Organisation (UNESCO) website:

http://www.unesco.org/new/en/natural-sciences/ioc-oceans/focus-areas/rio-20-ocean/blueprint-for-the-future-we-want/marine-pollution/facts-and-figures-on-marine-pollution/



Plastics found in Albatross Chick. Photo@ Chris Jordan.

Plastics in our ocean are also incredibly attractive to synthetic toxic chemicals washed down from the catchment into our oceans - such as pesticides, solvents, pharmaceuticals and industrial chemicals known as persistent organic pollutants (or POPs for short). These POPs don't like water (hydrophobic) and attach to floating plastic particles, making these plastics a particularly toxic lunch for any animal that ingests them!

Approximately 70% of the plastic entering our oceans sink (particularly the heavy stuff), however a lot of it ends up floating around in the world's ocean currents. The action of the waves and wind (mechanical degradation) and sun (photo degradation) breaks large pieces of plastic up into hundreds and thousands of tiny pieces of plastic. These small pieces of plastic may then be eaten by all sorts of marine animals, either directly or indirectly (bioaccumulation through the food chain)5.



Microplastics in strandline, Phuket 2018. Photo@ Roberta Dixon-Valk.

An ocean gyre is a large system of circulating ocean currents, formed by global wind patterns and forces created by the Earth's rotation. There are 5 major oceanic gyres around the globe and all of these concentrate plastics. The most well studied of these gyres in the North Pacific Sub-tropical Gyre affectionately known as the Great Pacific Garbage Patch. In this area, said to be potentially bigger than Australia, these small plastic particles are 40-60 times more abundant than plankton.

While there are strategies and policies in place to reduce the impact of this plastic pollution and to improve sustainable practices - including the development of a circular economy and biodegradable plastics – the fact is there is a continuing need to monitor plastics in the environment.

### SIZE MATTERS!

Plastics can be defined by their size as:

- Macroplastic (>25mm)
- Mesoplastic (5mm 25mm)
- Microplastic (1 µm\* 5mm)
- Nanoplastic (1 nm\*\* 1µm)
- \* Micrometer or micron (µm) = 10-6 of a meter (a millionth of a meter).

for human health. Environment International, https://doi.org/10.1016/j.



Microplastic fragments. Photo @ Maddison Carbery.

The smallest microplastic particle reportedly detected in the oceans at present is 1.6 micrometres in diameter. The smaller the plastic particle, the more available it becomes for consumption by a greater number and variety of marine wildlife. The term zooplankton is derived from the Greek word 'zoon' meaning 'animal', and 'planktos' meaning 'wanderer' or 'drifter'. Zooplankton includes some of the smallest animals in our oceans and are the basis of many oceanic ecosystems. All sorts of marine animals eat zooplankton – generally the larger the animal the more zooplankton they eat. And zooplankton are consuming plastic!6

### Microplastics

Microplastics come from a variety of sources, including plastic breakup, clothing, and industrial processes. Two classifications of microplastics currently exist:

1. Primary microplastics are plastic particles purposefully manufactured to be tiny, sometimes microscopic. They are used in facial cleansers and cosmetics ('micro-beads' replacing traditionally used natural ingredients, including ground almonds, oatmeal and pumice), in air blasting technology (to remove rust and paint), in medicine (as vectors for drugs) or in plastic manufacture ('nurdles' or resin pellets as the raw material of plastic).



Microplastics in mangrove sample. Photo@ Maddison Carbery.

**2.** Secondary microplastics are plastic fragments derived from the breaking up of larger plastic. Sources are varied and can include cigarette filters, hard plastic fragments, car and truck tyres, synthetic fibres/textiles (one load of laundry can contain more than 1,900 plastic microfibers ), ropes, paint and waste treatment.

High levels of microplastics have been detected in the environment. According to a recent international report, in many developed countries microplastics are more abundant than the more visible larger pieces of marine litter 7. This will increasingly become the trend in all countries as microplastics are the fate of all larger plastic items (just as nanoplastics are the subsequent fate of microplastics). The entire cycle and movement of microplastics in the environment is not yet known, but research is currently underway to investigate this issue. This is where you guys come in!

<sup>\*\*</sup> Nanometer (nm) = 10-9 of a meter (a billionth of a meter).

<sup>&</sup>lt;sup>4</sup> Hammer, J., et al. (2012). Plastics in the marine environment: the dark side of a modern gift. In Reviews of environmental contamination and toxicology (pp. 1-44). envint.2018.03.007. Springer New York doi:https://doi.org/10.1016/j.envint.2018.03.007

<sup>&</sup>lt;sup>5</sup> Carbery, M., O'Connor, W., & Thavamani, P. (2018). Trophic transfer of microplastics and mixed contaminants in the marine food web and implications

<sup>&</sup>lt;sup>6</sup> Desforges, J. P., Galbraith, M., & Ross, P. S. (2015). Ingestion of microplastics by zooplankton in the Northeast Pacific Ocean. Arch Environ Contam Toxicol, 69. doi:10.1007/s00244-015-0172-5

<sup>&</sup>lt;sup>7</sup> Browne, M., et al (2011). Accumulations of microplastic on shorelines worldwide: sources and sinks. Environmental Science & Technology Journal, September

### Citizen Science

We are asking you all to become citizen scientists! Citizen scientists are members of the general public who collect and analyse data relating to the natural world, typically as part of a collaborative project with professional scientists to help inform management and decision-making.

Four common features of citizen science are:

- **1.** Anyone can participate,
- **2.** Participants use the same protocol/methods so data can be combined and be of high quality,
- **3.** Data can help scientists come to real conclusions, and:
- **4.** A wide community of scientists and volunteers work together and share data to which the public, as well as scientists, have access.

The benefits of citizen science are that data can be collected more broadly – areas can be sampled more often (temporal) and in more areas (spatial) than would normally be possible by scientists alone. The resources normally required for similar large data collection efforts by trained scientists are usually prohibitive.



Microplastics in mangrove sample. Photo@ Maddison Carbery.

### What's in Our Coastal Waterways/Lagoons?

Coastal waterways are an integral part of the ecology, livelihood and the social/cultural fabric of Sydney and the Central Coast. Coastal lagoons, in particular, are fragile ecosystems and home to a wide variety of plants and animals, specially adapted to a specific mix of freshwater and saltwater conditions.

These coastal lagoons were historically important cultural sites for Aboriginal people, offering seasonal shelter, fish and wetland resources to the Gai-mariagal (Camaraigal) of Sydney and the Darkinjung of the Central Coast. They remain a popular recreational location for coastal dwellers like ourselves!



Cochrane Lagoon. Photo @ Amanda Marechal.

Microplastics are one modern and insidious threat to these lagoon systems as this pollutant, which is transported through urban waterways, can harm wildlife and impact upon aquatic habitats. Little is currently known about microplastic loads throughout the region and there is a general lack of community awareness/education on this issue.

The first steps in identifying the potential risks of microplastics are to determine how much is out there and where it may be accumulating. Therefore, Take 3 and Macquarie University's Litter Lab are piloting a microplastics assessment programme using citizen scientists to assist in addressing this issue.



Strandline Dee Why Lagoon Photo® Amanda Marechal.

This project will be piloted in the Northern Beaches and Central Coast Local Government Areas, where there are numerous coastal lagoons that are potentially natural sinks for microplastics. Surface sediment will be sampled in selected lagoons with microplastic survey kits to enable sampling for, and analysis of, microplastics. The type, size, colour and amount of microplastic will be quantified. The data gathered via this project will give scientists, government and the community an indication of what is entering our unique coastal lagoon systems.



Dee Why Lagoon Photo @ Amanda Marechal.



### Take 3

The 'Take 3' message is a simple one: Take 3 pieces of rubbish with you when you leave the beach, waterway or anywhere and you have made a difference!

Our mission is to significantly reduce global plastic pollution through education and participation and, importantly, initiate a conversation around each individual's plastic footprint.

As you have read, plastic marine pollution has a disastrous impact in our oceans – on our marine life and, ultimately, on us (should our seafood become increasingly contaminated). We can greatly reduce the amount of plastic marine pollution in our oceans by preventing it from getting there in the first place!

In 2011 the Taronga Conservation Society felt our message was so strong we were awarded the inaugural Taronga Conservation Society Green Grant. This has helped us to be here today. Now it is your turn!

Visit www.take3.org and share the online videos with your friends, class and family. You all know the 3R's (Reduce, Reuse, Recycle) but we have two more important ones: Refuse disposable plastic ('silly plastic' like bags, bottles, coffee cups, cutlery and straws) and Remove rubbish when you see it on the ground.

Just by taking these simple actions, imagine how many microplastics you have prevented from entering the waterway and potentially impacting on marine life.

Everyone can make a difference every day! Take up the Take 3 challenge at your home and school – what can you do to reduce your own plastic footprint?

Macro and microplastics in strandline, Phuket 2018. Photo @ Roberta Dixon-Valk.



### **METHODOLOGY - LET'S GET TECHNICAL!**

### Microplastic & Marine Debris Monitoring:

**DESIGN AND PROTOCOLS** 

### WHY MONITOR?

The accumulation of plastic pollution is a growing global problem with documented impacts to wildlife, habitats and food chains in all ecosystems - marine, freshwater and terrestrial. Due to their small size, microplastic particles are more likely to be biologically available and therefore cause environmental damage.



Seaweed and microplastic strandline Phuket. Photo @ Roberta Dixon-Valk.

Determining how much microplastic is out there, what type of plastic it is and where it is coming from is technical, costly and time consuming. Training the community as citizen scientists to sample for microplastics will assist in our understanding of the extent of the microplastics problem, in and around our coastal areas.

This section will broadly outline how to undertake a citizen science microplastic survey. The approach is based upon the European Strategic Directive design for sampling microplastics on beaches, as a surrogate (or substitute) for determining what is in our waters. The approach has been developed by world leading expert with many years' experience in quantifying microplastic loads. The method below will explain the flexible design options available and will detail the field sampling and analytical procedures.

### AIM

The aim is to develop a citizen science microplastic program that provides reliable microplastic data whilst educating and engaging communities. Individual school and community groups will be looking at how to measure and record the levels of microplastics (small!)

and macroplastic (big!) found in and around their local area, and examine whether there is a link between the amount of microplastic and macroplastic present on a beach (including where it might be coming from and what to do about it).



Microplastics fragments in strandline, Phuket 2018. Photo@ Roberta Dixon-Valk

The following simple questions are posed to help frame the study:

- How much microplastic and macroplastic are on the most recent tideline/strandline (a line of washed-up seaweed or other debris marking a previous high water level along a shore).
- Are there differences within a beach or tideline/ strandline? (for longer beaches/shorelines)
- What types of microplastic and macroplastic are present?
- Is there a predominance of certain colours (if easily identifiable), types and sizes?
- Where might the microplastic/debris have come from?
- Do the microplastic loads (quantity) and types (hard, film, foam, etc) change over time or between places? (Extension guestion)
- What impacts may the plastics have on local fauna? (Extension question)
- What actions can be taken to reduce these pollution issues and protect the local waterways? (Extension question)



Lagoon rubbish. Photo @ Amanda Marechal.

### SCIENTIFIC SAMPLING TOOLS

Transects and quadrats are two scientific sampling tools that allow us to quantify the relative abundance of microplastics and macroplastics in an area. To track changes over time, it is important to be able to measure changes in abundance in a consistent manner. These techniques will give citizen scientists the necessary data to ask their own ecological questions and make comparisons among sites.

For the purpose of this study, a belt transect is the area or 'strip' between two transect lines, which allows citizen scientists to record all macrolitter found along the belt.



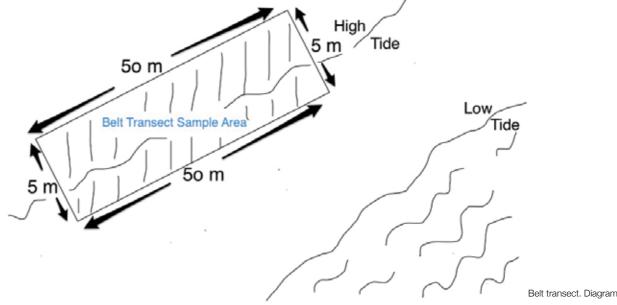
Transect. Photo@ Scott Wilson.

### **QUADRAT SAMPLING**

A quadrat is a known square area that is marked using a pre-made square of PVC plastic, or stakes and string. Quadrats can range in size (25cm x 25cm to 1m x 1m), depending on the area being sampled - the type of shoreline, the size of the sediment, etc. Once processed, all microplastics within the quadrat are identified and counted. This process is generally repeated many times in different places along the shoreline to get an accurate overall representation of microplastic abundance at that particular site.



Randomly placed quadrant. Photo@ Scott Wilson.



Belt transect. Diagram © Debbie Venter

### SITE SELECTION

The site, that is the beach or shoreline, should ideally be representative of the given region of interest. Not all sites may be suitable. Factors such as accessibility, substrate type (e.g. sandy, rocky, heavily vegetated, muddy), beach length and previous clean-up activities, should be taken into consideration.

The following are suggested criteria for site selection:

- Total shoreline length is a minimum of 100m (so that a minimum of 3 transects and 5 quadrats can be sampled).
- Low to moderate sloping shores (4 15° or 15 – 45°) should be targeted (as per the European Union (EU) Standard). Avoid very shallow (long intertidal area where debris is spread out) or steep slopes (where debris may not accumulate).
- Only sample soft sediment intertidal or flow influenced banks and shorelines (sands, silts, muds) that have no or little vegetation cover (mangrove, saltmarsh & riverine sites may be an exception).
- Avoid areas where structures (natural or anthropogenic) may block flows to the shore. For example, do not sample near reefs, break-walls and jetties.
- Access to the site is year-round.
- Ideally, the site should not be subject to other major litter collection activities. If mechanical cleaning occurs, sampling should be conducted at the longest period after the cleaning.
- Consider targeting sites that are reflective of local litter sources and/or provide background levels (e.g. oceanic sources). For instance, locate sites both near to and far from stormwater outlets, shoreline access points and river/creek discharges.
- Choose sites that are suitable for repeat sampling over time. Locate and record with GPS readings and key physical markers (e.g. permanent landscape features).

Transect. Photo © Scott Wilson.

### TIMING

- To determine trends over time, a minimum of four samples per year for a site would be ideal. However, this may not be possible so at least select a period where the same site can be visited at about the same time each year.
- To compare between different sites, sampling should be undertaken within the shortest possible period (e.g. within the same month) to enable accurate site comparisons within a region. This helps to eliminate differences in the data due to site specific factors such as weather, foot traffic etc
- Sampling on the day should consider time of high tide, with the best time occurring at least an hour after the peak high tide. Also, consider timing the sampling around the highest spring tide of the month, where relevant, to enable the greatest deposition rates on the strandline. Be careful of rogue waves!
- Other events like rainfall, storms and flooding are hard to predict. Any recent event that is likely to influence deposition or removal of materials should be noted.

### SAMPLING SIZES MACROPLASTIC:

- The unit of measure for macroplastics is a count within a belt transect.
- For macroplastic, all human generated or modified items down to 5mm should be collected and removed
- Record the number of items only. Weight and volume can be problematic due to moisture levels or compression of items, respectively.



Belt transect. Photo@ Christine Freeman

### MICROPLASTIC:

- The unit of measure for microplastics is a count within the sediment samples from a quadrat.
- For microplastic sampling, ideally a minimum of 5 quadrats per site is required for the larger size fractions (1-5mm).
- For information on the smaller size fraction (<1mm), at least 5 samples of 250ml of sediment from the top 2 cm should be taken and placed in individually labelled envelopes/bags and sent to Dr Thava Palanisami (thava.palanisami@newcastle.edu.au) at the University of Newcastle for further analysis.within a belt transect.
- For macroplastic, all human generated or modified items down to 5mm should be collected and removed.
- Record the number of items only. Weight and volume can be problematic due to moisture levels or compression of items, respectively.



Sampling. Photo @ Amanda Marechal.

### Quality Assurance /Quality Control

To ensure reliable data is collected and analysed, consistent high quality training is essential. Specific training programmes will enable educators and project team leaders to deliver the program to students and the community in a robust way.

- To verify the macroplastic loads, one transect per site should be re-surveyed by a trainer or educator. This will involve checking the transect after it has been surveyed.
- To verify the larger microplastic loads (1-5mm), two of the bagged bulk samples collected per site could also be re-checked for the larger size fractions.
- Ideally, the difference between the citizen science analysed data and the verified data should be marginal (<10%).</li>

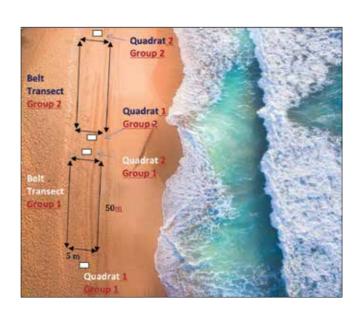
### **Example Sampling Layout**



Figure 1a: Example of a transect layout on a small beach (colours represent different transects). NB: Far ends of beach not sampled due to potential influence of rocky headland or creek outflow on spatial dispersion of macro and microplastic debris. (Image © Scott Wilson).



Figure 1b: Example of sampling zones on a long beach. Within each zone a minimum of three transects are sampled (see Fig. 1a) (Image © Scott Wilson).



**Figure 1c:** Detailed example layout of belt transects for macro litter collection and quadrats for microplastic collection for two groups (Image © Scott Wilson).

13

### Design Decision Tree

The design of the program is somewhat flexible with some individual site features accounted for. The decision tree below (Figure 2) provides a visual guide that helps guide the user through the selection process.

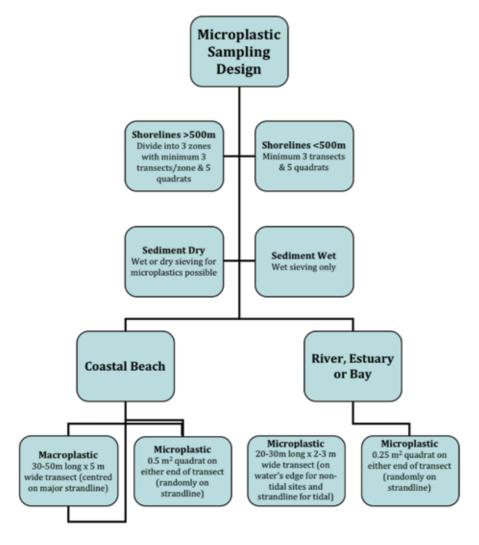


Figure 2: Decision tree to assist with sample design selection (Diagram @ Scott Wilson).

Example fie	ld sampling equipment re	equired (per group)
1 x 50 m tape	1 x folding metre ruler	2 x sorting tray
4 x stakes (plastic)	1 x jar of hypersaline solution (1.3g/l)	3 x data sheets (Site description sheet, Tangaroa Blue marine debris data sheet, Microplastic data sheet)
1 x 0.5m (.25m2 or equivalent) quadrat	1 x 250ml measuring cup	Microplastic photo guide
1 x sieve set (1mm and 5mm)	5 x envelopes or paper bags	Compass and Clinometer App
2 x trowels	1 x large collection bag	
2 x forceps	4 x small bags	
1 x spatula	4 x small sample jars	
1 x water jug or small bucket	1 x permanent marker pen	

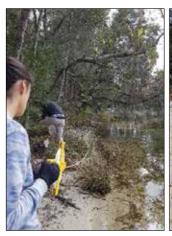
### Sampling Procedures

### **PART 1 - SITE DESCRIPTION**

- 1. Record the following details on the Microplastics Site Assesment sheet (pg. 22-23):
  - a. General information location, date, time, group name.
  - **b.** Site characteristics-
  - i. shore type (e.g. sandy beach, mangrove, river foreshore),
  - ii. shore or reach length,
  - iii. aspect (record using compass facing toward water),
  - iv. slope (record using clinometer app) can be Little None (0-3%), Gentle (4-9%), Moderate (10-15%), Steep (16-30%), Extremely Steep (31-60%), Excessively Steep (>60%),
  - $\textbf{v.}\ \text{presence}$  of stormwater outlets, river or tributary, offshore reef etc.
  - **c.** Weather conditions (wind speed, wind direction, rain), wave height or river flow, recent significant weather events (can all be collected from Beauro of Meteorology (BOM) site).
  - **d.** Other factors recently cleaned, number of bins, pathways/entranceways, education signs, number of people on beach/shoreline (e.g. 0-10, 11-50, 51 -200, >200).
- 2. Take site photographs from key points. Record GPS location of these photo-monitoring points.

### **PART 2 - MARINE DEBRIS SURVEY**

- 1. Work in groups of 4-6. You will be allocated a zone and/or number (e.g. North 1). Groups can be split between different areas of the shoreline but allocation and coding should be decided prior to the day.
- 2. Mark out a belt transect (e.g. 50m\* x 5 m\*\*) parallel to the shore centred on major strandline or shoreline\*\*. Have at least a 5m gap between transects. Use stakes to mark position and record GPS location for start and finish of each transect. This allows the same site to be revisited over time.
  - \* Depends on shore length. Transect length can be adjusted (e.g. 20 m for short river stretches) for the site and time availability (see Figure 2 for choices). However, maintaining consistency in the transect length for ongoing sampling at that site is imperative.
  - \*\* Depends on location (e.g. riverine and lagoon sites will have narrow transect width see Figure 2)
- 3. Using the Tangaroa Blue marine debris data sheet (pg. 26-27), label the data sheet with site, date, start time, transect number, number of collectors. Use pencil to scribe.
- **4.** Walk up and back along the transect slowly in emu file and collect all human generated debris on the beach surface within the transect.
- **5.** Do not dig in the sand or turn over seaweed unless retrieving a debris item partly visible. Be careful of dangerous objects (e.g. glass, syringes). Any large items too big to fit in the collection bag should be noted on the data sheet (e.g. 2 x timber, 5m and 3m long).





Marking out the transect. Photo © Scott Wilson.



Transect macro collection. Photo © Scott Wilson.

### **PART 3 - MICROPLASTIC SAMPLING**

- 1. Place a 0.5 x 0.5 m quadrat\* on an obvious strandline\*\* (hightide) area outside of marine debris transect. Make sure to avoid highly disturbed areas. Press down on the quadrat edges so that the complete frame is flush with the surface.
  - \* Quadrat size can be adjusted (e.g.0.25 x 0.25 m) for the site, sediment size and time availability. However, maintaining consistency of quadrat size for ongoing sampling at that site is imperative.

    \*\* Depends on location
- **2.** Remove any large obvious non-plastic items (e.g. sticks, seaweed, pumice).
- **3.** Make sure the two sieves are aligned on top of one another with the larger meshed one (5mm) on top.
- **4.** Excavate the top 2cm of sediment (depth of PVC pipe used in the quadrat). Transfer the sediment from the quadrat to the sieves using the trowel. This should be done in 2-3 scoops at a time to avoid overloading sieve.
- 5. If sediment is dry the sieving can be done without water. Agitate the sieve gently back and forth in semi-circular fashion. If the sediment is damp, then water is required to facilitate sieving. Use either the water jug or small bucket to pour water over the sediment and through the sieve or take to the water's edge and sieve in water (like panning for gold!). However, do not submerge the sieve under water as potential samples may float away.
- 6. When sediment is removed from the top sieve pass this to group members to search for any obvious plastics. The first sieve will collect only macro-litter (>5mm) so this should be recorded under the 'other observations' column on the Microplastics Data Sheet.
- **7.** Tip contents of the first sieve on to tray for easier sorting and place any plastics found in a labelled jar (site name, location no., plastic size, date).
- **8.** Continue sieving the second sieve (1mm) until all sediment is removed. Transfer contents to second tray and search for plastics.
- **9.** Repeat steps 4 8 until all the sediment is excavated to the correct depth.
- 10. If item is unknown or difficult to identify as plastic then place, using forceps, into the hypersaline solution. The hypersaline solution is denser than normal seawater, 1.3g/l, so will float most plastics. If it floats then it should be placed into a labelled jar as 'possible plastic'. However fouled plastics (plastics that have been floating in the water for a long time which now have algae/animals growing on them) may sink in hypersaline solution so any suspicious items should be investigated further.



Quadrat randomly placed. Photo © Scott Wilson.



Sieving. Photo @ Amanda Marechal.



Sieve sample. Photo@ Scott Wilson.



Sieves in water. Photo@ Amanda Marechal

11. The sieve or tray can be further scoured in the field using plug-in microscopes, magnifying glasses or smartphone apps (e.g. cozy magnifier). Use the photo-guide to help identify microplastics from other common items. A sub-sample (a quantifiable fraction such as 1/2, 1/3, 1/4 or 1/10 of the sample depending on its size) should be collected for detailed examination in the lab, as fine items (e.g. microfibres) can be easily missed if only sorting by eye. Record these findings (and fraction of the sample) under the 'other observations' column.



Microplastics in mangrove sample. Photo @ Maddison Carbery.

- **12**. Record any microplastics found on the Microplastics Data sheet (pg. 24) noting:
  - colour.
  - approximate size class (1 mm ranges),
  - type (foam plastic fragment, hard plastic fragment, bead, pellet, fibre, sheet plastic fragment) and
  - number of particles.



Beach collected microplastics. Photo@ Maddison Carbery.

13. If further in-depth analysis is required or weather prevents sorting in the field, contents of the tray/sieve can transferred to sample bags, labelled and returned to the 'lab' for analysis. A sub-sample (a quantifiable fraction such as 1/2, 1/3, 1/4 or 1/10 of the sample depending on its size) should undergo a more detailed examination, as fine items e.g. microfibres can be easily missed if only sorting by eye. Record these findings (and fraction of the sample) under the 'other observations' column.

- **14.** If time permits complete a second quadrat (ideally, 5 quadrats needed for entire shore on any given sample day).
- 15. Collect one 250ml sample randomly from the strandline (top 2cm) using the measuring cup, sieve contents using 5mm sieve and place in labelled envelope (including time, date, location/GPS coordinates, organisation/school, contacts, etc). This should be sent to Dr Thava Palanisami (thava. palanisami@newcastle.edu.au) at The University of Newcastle for further analysis.



### **PART 4 - RECORDING RESULTS**

- Data for macroplastics and microplastics should be recorded on the appropriate data sheets found in this Manual. Data for each site will need to be pooled before being uploaded.
- 2. Once compiled, data should be emailed to: info@take3.org scott.p.wilson@mq.edu.au and info@ausmap.org Data will be shared with the AUSMAP program.
- **3.** Data should then be entered into the Tangaroa Blue website

### www.tangaroablue.org/database.html

- 4. To access the database, you must first 'I ACCEPT THE OPEN ACCESS POLICY FOR THE AMDI DATABASE', (http://amdi.tangaroablue.org) which allows data sharing.
- **5.** Follow the prompts to submit data. In order to do this, you will have to register and then sign in.
- 6. Once logged in, identify the location of your data collection point/s and the detail of the data collection, e.g. date, time, organisation/school number of people, etc. Under 'Contact Details' and 'Organisation, school or agency', please identify Take 3 along with your own organisation/school/agency so that we will be able to identify data collected as part of this program and generate a report.
- 7. The items collected will then be listed under the appropriate category. All items collected in the macro (or marine debris) clean up will be recorded under their specific item category.
- 8. All microplastic identified will be recorded under the 'Microplastic Surveys and Ratings'. Select 'Microplastic Survey' under the Item drop-down menu.
- Select the 'What's in Our Waterways Take 3' tab under 'Survey Project' and identify the relevant parameters of your survey, e.g. quadrat, sample, etc.
- 10. Add data.

18

- 11. Submit the form.
- 12. After the data has been accepted (which may take a couple of days), you will then be able to access your data and generate a report on the macroplastics. To access your data and generate a report on the microplastics, you will need to contact Tangaroa Blue at info@tangaroablue.org.

### PART 5 - DATA ANALYSIS & FURTHER WORK

- All group data (both marine debris and microplastics) can be used to determine site metrics.
- **2.** Data totals or means can be derived for the measures.
- **3.** A per metre m2 value for marine debris and a per cm3 for the microplastics can be obtained by calculating the total numbers by either the total area or volume sampled.
- **4.** A comparison can be made between sites or over time using T-tests or other advanced statistics.
- **5.** Inference on the sources of the plastics can be made based on the types and amounts of items found
- **6.** More data collected over time can lead to a greater understanding of potential sources.



Blue plastic in sieve. Photo@ Amanda Marechal.



Red plastic in sieve. Photo @ Amanda Marechal.



Microfibre. Photo @ Amanda Marechal.

### Notes for Sampling Procedures


## Microplastic Photo-Guide WHAT DO THEY LOOK LIKE? FIBER PELLET FOAM FRAGMENT

### **MICROPLASTICS CATEGORIES (<5 MM)**



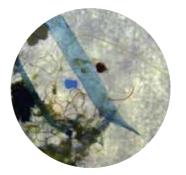
Resin Pellets
(also known as nurdles)



**Fibres** (consistent width and colour along length)



Foam beads and fragments



Sheet plastic fragments (blue)



Hard plastic fragments (usually with distinct edges)



**Microbeads** (from cosmetics and detergents)

### ITEMS COMMONLY MISTAKEN FOR MICROPLASTICS



Organic fibres
(usually variable width with cellular structure). Blue synthetic fibre also present



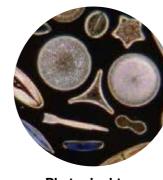
**Shell and rock fragments.**Floating in water is a simple way to differentiate.



**Fish lens and bone structures.**May float but will bubble in hydrogen peroxide



**Miscellaneous organic debris**Breaks up easily.



**Phytoplankton.**Structures visible under microscope.



Seaweed and marine micro-crustaceans
Cells visible under microscope. Look closely,
six hard plastic fragments also present.

### MICROPLASTICS SITE ASSESSMENT

Site Name		
Date	Time	
Surveyors		
Location (e.g. North Zone)	GPS	
Rainfall in last 24hrs (None, minor, moderate, heavy)	Temperature	
Wind Speed (e.g. zero, slight, moderate, strong, gale)	Wind direction	

	Shoreline/ Water Features		
Beach length (Km)		Tide	
Aspect		Shore slope (gentle, moderate, steep)	
Natural features (e.g. offshore reef, embayment, prominent headlands, mangroves, meandering stream)		Average wave height (or river flow)	
Mean channel width (rivers)		Water depth (rivers)	

Dune/Riparian Cover (adjacent to sample location)				
No. trees > 3 m		No. shrubs		
Ground cover % (including pneumatophores)		Canopy cover %		
Width of dune/riparian zone (m)		Height of dune/shore (max.)		

	Human Influences
No. of storm water outlets/other inputs (rivers/creeks)	
No. and proximity to pollution traps	
No. of bins in surrounding area	
Proportion of impermeable surfaces in surrounding area	
No. of formal entrance/exit points	
No. people observed in area	

	Human Influences
No. of storm water outlets/other inputs (rivers/creeks)	
No. and proximity to pollution traps	
No. of bins in surrounding area	
Proportion of impermeable surfaces in surrounding area	
No. of formal entrance/exit points	
No. people observed in area	

No. people observed in area	
Include all relevent features a g	Planform Sketch
include all relevant leatures e.g.:	stormwater drains, pollution traps, bins, entrance points, pathways, litter accumulation

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Date:		Name of recorder:		Tea	Team members/Group no.:	
Site name and description:	lion:					
GPS location:		Region:		Que	Quadrat No.:	
Colour (including clear & opaque)	Plastic Type (hard fragments, pellets, films, foams, fibres, beads)	Size (<1mm, 1-2 mm, 2-3mm, 4-5mm, >5mm)	Shape (cylindrical, rounded, angular, irregular)	Amount	Comments on plastic condition (fresh, weathered, grooved, fracturing)	Other observations (including animals, etc)



### MARINE DEBRIS (MACRO) DATA SHEETS



26

### **Data Collection Sheet**

AUSTRALIAN MARINE DEBRIS INITIATIVE

Tangaroa Blue Foundation
PO Box 1176 Margaret River WA 6285 www.tangaroablue.org



Name of Cleanup Location	on (Beach)					
Cleanup Locality						Locality Postcode
Nearest Town	rest Town Nearest Road or Landma			mark		
Date	Start time	rt time Finish time			Number of People	
Contact Name	Phone or		email			
Organisation/School (if a	applicable)					
Total Filled Bags	Total Weig	Total Weight Kg		Length o	of Beach Cleaned (m)	
Average Width of Beach	of Beach (m) Type of Adjoining land			ning land		
Diagraphic items not listed below in the additional items section or on an attached sheet						

Please enter items not listed below in the additional items section or on an attached sheet.

Country of origin and barcode information from intact labels can be entered in the tally and note section against the particular item or on a separate sheet. A secondary data sheet is also available to record this and other information.

Cigarette butts & filters Cigarette lighters Pens, markers & other plastic stationary Straws, confection sticks, cups, plates & cu Toothbrushes, brushes & combs, hair ties of Toys, party poppers, ribbons, clips & similar Bleach & cleaner bottles Lids & tops, pump spray, flow restrictor & similar Personal care & pharmaceutical packaging Plastic bags supermarket, garbage, dog por Plastic containers non food (oil, sealant, che Plastic drink bottles (water, juice, milk, soft) Plastic packaging food (wrap, packets, come Plastic wrap non food (bubble wrap etc) Strapping band scraps Strapping band whole (record as single item Bait & tackle bags & packaging Bait containers & lids, bait savers Commercial fishing remnants (float, pot, come commercial fishing items (lures, floats, row Rope & net scraps less than 1 metre Rope (estimated length in metres) Plastic bits & pieces hard & solid Plastic film remnants (bits of plastic bag, we Remnants burnt plastic	etc r similar o, ice emical) c drink) sainers)	
Pens, markers & other plastic stationary Straws, confection sticks, cups, plates & cu Toothbrushes, brushes & combs, hair ties of Toys, party poppers, ribbons, clips & similar Bleach & cleaner bottles Lids & tops, pump spray, flow restrictor & selection of the	etc r similar o, ice emical) c drink) sainers)	
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Plastic bits & pieces hard & solid Plastic film remnants (bits of plastic bag, w Remnants burnt plastic		
Plastic film remnants (bits of plastic bag, we Remnants burnt plastic		
Remnants burnt plastic	rap etc)	
Foamed Plastic (Polystyrene) Items	Total	Tally and Note
Foam buoys		
Foam cups, food packs & trays		
Foam insulation & packaging (whole and rem	ıants)	
Other Materials	Total	Tally and Note
Oil globules & tar-balls		
Sanitary (tissues, nappies, condoms, cotton b		+
Shoes leather & fabric	ıds)	



### **Data Collection Sheet**

AUSTRALIAN
MARINE DERRIS INITIATIVE

A A A A

Tangaroa Blue Foundation
PO Box 1176 Margaret River WA 6285 www.tangaroablue.org

Glass & Ceramic Items	Total	Tally and Note
Fluorescent light tubes and bulbs		
Glass beer stubbies & pre-mixed alcohol bottles		
Glass jars & sauce bottles		
Glass or ceramic broken		
Glass wine, spirit and similar bottles		
Cloth Items	Total	Tally and Note
Binding, thread, string & cord natural		
Cloth, clothing, hats & towels		
Metal Items	Total	Tally and Note
Aerosol cans		<i>.</i>
Aluminium cans		
Foil wrappers, packets, bladders & alfoil		
Metal bottle caps, lids & pull tabs		
Metal fishing items (sinkers, lures, hooks, traps, pots)		
Tins under 4 litres (food, drink tins and similar)		
Paper & Cardboard Items	Total	Tally and Note
Newspaper, magazines & brochures		į
Paper & cardboard packaging		
Tetra packs & drink cartons		
Rubber Items	Total	Tally and Note
Rubber balloons, balls & toys, elastic straps & bands	10000	, and 1000
Rubber footwear & thongs		
Rubber remnants		
Wood Items	Total	Tally and Note
Brooms, brushes & paint brushes	- Total	runy and reste
Processed timber, pallets & other wood		
Wooden confection sticks, pencils, matches etc		
Additional Items	Total	Notes
, tautional resins	Total	110103
	<del>                                     </del>	
Additional Information	(Circle)	Comments
Did you observe any plastic resin pellets?	YN	
Did you observe any dead/injured animals or birds?  Did you observe any highly unusual beach conditions?	Y N	

V07-2013

### Take 3 Facts

### **HOW DOES PLASTIC GET INTO OUR OCEANS?**

- Approximately 80% of marine debris enters the oceans from a land-based source.
- Rubbish is blown by the wind; washed down storm water drains; enters creeks and rivers; pollutes lakes; can be moved by wildlife (e.g. birds) and eventually finds its way into the oceans.
- Approximately 20% of marine debris comes from ocean-based activities e.g. shipping, fishing, recreation, resource extraction and accidents.
- In NSW, approximately one third of marine debris can be traced back to the beverage industry (including cups, lids, bottles, containers, straws).

### PLASTIC POLLUTION

- 80-90% of marine debris is plastic, hence many prefer the term 'plastic pollution'.
- Plastic is made from fossil fuels. Oil and gas derivatives are synthesized with the addition of many toxic chemicals to create different types of plastic.
- An estimated 8 million tonnes of new plastic enters our oceans each year. The Japanese tsunami on 11 March 2011 released over 5 million tonnes of debris into the North Pacific Ocean.

### **PLASTIC IN OUR OCEANS**

- Over 70% of marine debris sinks (many plastics are more dense than water).
- Debris that floats can be carried vast distances by the wind, currents and tides, and has been reported to transport non-native species
- Debris that floats can be carried vast distances by the wind, currents and tides.
- Plastic doesn't biodegrade. Its complex molecular structure means no known natural organisms (e.g. microbes) can digest it in nature
- Plastic breaks up, not down. In the ocean plastic goes through processes of environmental degradation.

  Photodegradation from sunlight causes many plastics to become brittle and fragment easily. Physical forces (waves, boats) can also break plastic apart.

### **OCEAN CURRENTS AND GYRES**

- Debris gathers in rotating currents known as an eddy and can accumulate in massive systems of currents known as gyres.
- There are five major oceanic gyres. They occur in the largest bodies of ocean (i.e. North Pacific Sub-tropical Gyre, South Pacific Gyre, North Atlantic / South Atlantic Gyre and Indian Ocean Gyre).
- Hawaii sits in the midst of the North Pacific Sub-tropical Gyre, aka the Great Pacific Garbage Patch, and suffers from huge levels of pollution on some windward facing beaches.

### #TAKE3FORTHESEA

### HOW MUCH PLASTIC IS IN OUR OCEANS AND ON OUR BEACHES?

- In Australian waters, CSIRO found anything from a few thousand to more than 4,000 pieces of plastic per square kilometre.
- Approximately 13,000 pieces of plastic can be found in each square kilometre of the world's oceans. This figure can be up to 500,000 pieces inside the Gyres.
- French scientists found up to 42,000 pieces of plastic per square km in Antarctic waters.
- The CSIRO recently completed a study of marine debris around the Australian coastline and determined an estimated 150 million pieces litter the Australian coast. This is 6 pieces of rubbish for every person in Australia

### **ANIMAL IMPACTS**

- It is estimated over 1 million seabirds die every year from ingesting or becoming entangled in marine debris. The CSIRO gauge 90% of seabirds are presently impacted by plastic but predict that figure will increase to 99% by 2050.
- It is estimated over 100, 000 marine creatures die every year from marine debris including whales, turtles, dolphins, seals, penguins and sharks.
- Countless fish and small marine organisms are affected by marine debris every year

### OTHER IMPACTS OF PLASTIC IN OUR OCEANS

- A new report from the World Economic Forum concluded that by 2050 there will be more plastic in our oceans than fish.
- When in the ocean, pieces of plastic pollution can attract other pollutants present in the water. These pollutants adsorb onto plastic like a sponge and can result in concentrations of pollutants up to one million times higher than in the surrounding sea water.
- When ingested, plastic debris can transfer these toxic chemicals to animal tissue and impact development and reproduction.
- Marine debris can allow for the transport of invasive species across vast distances, creating threats to sensitive species and communities.
- Marine debris is a dangerous and very expensive problem for shipping and fishing. Derelict fishing gear (e.g. abandoned fishing nets called ghost-nets) can block propellers and water intakes.

### SILLY PLASTIC USE

- Plastic isn't stable. Chemicals can leach from plastic into food and drinks and then into the human body. Use glass to store food and drinks!
- Over 1 billion disposable coffee cups are used in Australia every year. Coffee cups have a plastic lining and are non-recyclable. Use a reusable coffee mug!
- Australians use over 6 billion disposable plastic bags every year. That's 16 million every day or 2 million every 3 hours. Take your own bags shopping!
- One third of marine debris can be traced back to the beverage industry (including cups, lids, bottles, containers, straws).
- Australians use over 13 billion beverage containers every year. Less than 40% are never recycled meaning over 8 billion are wasted. Choose glass bottles instead!
- Watch out for 'green wash'! 'Biodegradable plastic bags' are still plastic with a variety of chemical additives they are still bad for the environment. Biopolymers are plastics made from plant or animal based sources that may truly biodegrade under natural conditions.

# SAMPLE UNIT – EARTH AND ENVIRONMENTAL SCIENCE - YEAR 11

# Sample for implementation from Year 11 from 2018

## **Module 4: Human Impacts**

Duration: 10 hours including a 5 hour Depth Study

### **Content Focus**

Humans use the Earth's resources to maintain life and provide infrastructure. However, natural resources are not infinite. Renewable resources such as water, soil plants and animals can be managed sustainably using scientific knowledge. Incomplete information or failure to consider the impact of resources use may cause environmental damage. Scientific knowledge enables efficient use of resources and also the rehabilitation of damaged ecosystems. Healthy ecosystems provide renewable resources, purify air and water, regulate climate and provide cultural services.

### **Module Focus**

## Working Scientifically

In this module, students focus on developing questions and hypotheses when planning and conducting investigations about human impacts on the Earth. Students should be provided with opportunities to engage with all Working Scientifically skills throughout the course.

### **OUTCOMES**

A student:

- conducts investigations to collect valid and reliable primary and secondary data and information EES11/12-3
- selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media EES11/12-4 analyses and evaluates primary and secondary data and information EES11/12-5 describes human impact on the Earth in relation to hydrological processes, geological processes and biological changes

### RESOURCES

- TAKE 3 Microplastics resource booklet
- TAKE 3 Microplastics power point

### Formal assessment

Field study: Students engage in a field study of their local catchment with a focus on the effect microplastics on waterways.

## **Depth Study for assessment**

Students choose one area of interest from the field study that interests them and develop an inquiry question. They must include a practical investigation and research in their investigation. Students report their findings in 5 minute oral presentation.

### INQUIRY QUESTIONS

- 1. How can water be managed for use by humans and ecosystems?
- How can humans impact on water quality' 8
- How do microplastics effect waterways and local ecosystems. က

## Working Scientifically Skills

## **Targeted Working Scientifically skills**

## Questioning and Predicting - ESS11/12-1

A student develops and evaluates questions and hypotheses for scientific investigation

- develop and evaluate inquiry questions and hypotheses to identify a concept that can be investigated scientifically, involving primary and secondary data (ACSES001, ACSES061, ACSES096)
- modify questions and hypotheses to reflect new evidence

## Planning Investigations - ESS11/12-2

secondary data and information Students:

A student designs and evaluates investigations in order to obtain primary and

- assess risks, consider ethical issues and select appropriate materials and technologies when designing and planning an investigation (ACSES031,
- justify and evaluate the use of variables and experimental controls to ensure that a valid procedure is developed that allows for the reliable collection of data (ACSES002)
  - evaluate and modify an investigation in response to new evidence

## Conducting Investigations - ESS11/12-3

A student conducts investigations to collect valid and reliable primary and secondary data and information

### Students:

- employ and evaluate safe work practices and manage risks (ACSES031)
  - use appropriate technologies to ensure and evaluate accuracy
- select and extract information from a wide range of reliable secondary sources and acknowledge them using an accepted referencing style

## Processing Data and Information - ESS11/12-4

A student selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media

### Students:

them using a range of formats, digital technologies and appropriate media (ACSES004, ACSES007, ACSES064, ACSES101) select qualitative and quantitative data and information and represent

- apply quantitative processes where appropriate
- evaluate and improve the quality of data

## Problem Solving - ESS11/12-6

A student solves scientific problems using primary and secondary data, critical thinking skills and scientific processes

### Students:

- use modelling (including mathematical examples) to explain phenomena, make predictions and solve problems using evidence from primary and secondary sources (ACSES006, ACSES010)
  - use scientific evidence and critical thinking skills to solve problems

assess the relevance, accuracy, validity and reliability of primary and secondary data and suggest improvements to investigations (ACSES005)

assess error, uncertainty and limitations in data (ACSES004, ACSES005,

ACSES033, ACSES099)

· derive trends, patterns and relationships in data and information

Students:

A student conducts investigations to collect valid and reliable primary and secondary data and information

Analysing Data and Information - ESS11/12-5

## Communicating - ESS11/12-7

A student communicates scientific understanding using suitable language and terminology for a specific audience or purpose

### Students:

- select and use suitable forms of digital, visual, written and/or oral forms of communication
- select and apply appropriate scientific notations, nomenclature and scientific language to communicate in a variety of contexts (ACSES008, ACSES036, ACSES067, ACSES102)
- construct evidence-based arguments and engage in peer feedback to evaluate an argument or conclusion (ACSES034,

ACSES036)		
Topic: Human Impacts – Water Management		
Inquiry question: How can water be managed for use by humans and ecosystems?	y humans and ecosystems?	
Content	Teaching, learning and assessment	Resources
• represent the distribution of the Earth's water, including the amount available to plants and animals (ACSES060)	use secondary resources, eg. video Show Me The Water (Earths Water) https://pmm.nasa.gov/education/videos/show-me-water  • National Water Account 2016 • Water Use on Central Coast https://www.wyong.nsw.gov.au/my-property/water/water-supply-system/central-coast-water-story • Dam Levels and water distribution —. /Central-Coast-Water-Supply-Brochure.pdf.aspx • http://www.blueplanet.nsw.edu.au/home/.aspx	Earths Water  https://water.usgs.gov/edu/earthwherewater.html  National Water Account  https://www.youtube.com/watch?v=DqVM6YaTz0k
Students:  • investigate the treatment and potential reuse of different types of water, including but not	Investigate Water Reuse  Recycled Waste Water /Dual Reticulation — Case Study Baliina	Dual Reticulation http://www.ballinawater.com.au/general-information/ urban-water-cycle/recycled-water-overview.html

Desalinisation Process  https://www.youtube.com/ watch?v=aysj7696b0A&feature=youtu.be  Kurnell Desal Plant  http://www.sydneydesal.com.au/  https://www.wyong.nsw.gov.au/ getmedia/55b57940-92bc-4f78-ad20- 340f0c3e120a/WaterPlan_2050_adopted.aspx  Groundwater  http://www.watersciencelab.com.au/assets/ station-7-groundwater.pdf	https://www.wyong.nsw.gov.au/my-property/ water/water-supply-system/water-quality/annual- drinking-water-quality-report Water Quality Test Procedure for student field work http://www.nswwaterwatch.org.au/resources	Coastal Lagoons Process Study http://www.gosford.nsw.gov.au/environment-and- waste/environmental-management-and-planning/ estuaries/coastal-lagoons-management-planning
<ul> <li>Stormwater re use – see water plant 22050</li> <li>Sewerage https://www.wyong.nsw.gov.au/my-property/water/sewer-system</li> <li>Other water supply options for the Central Coast</li> <li>Desalinisation – Sydney –Kurnell Plant</li> <li>Groundwater</li> </ul>	<ul> <li>Water Quality – Monitoring Drinking Water Quality on the Central Coast</li> <li>Monitoring Water Quality In Estuaries and rivers – water watch</li> </ul>	<ul> <li>Back ground to Coastal Lagoons / ICOLLS /Central Coast http://www.gosford.nsw.gov.au/environment-and-waste/environmental-management-and-planning/estuaries/coastal-lagoons-management-planning</li> <li>Impacts to estuaries e.g Tuggerah Lake http://www.loveourlivinglakes.com.au/learn/impacts-to-our-living-lakes/</li> <li>Back ground to Microplastics – See Resource from Take 3</li> <li>Microplastics Filed Work Methodology – See Take 3 Resource</li> </ul>
limited to: (ACSES058)  • industrial wastewater  • sewage  • stormwater	• Describe ways in which human activity can influence the availability and quality of water both directly (eg overextraction or indirectly (eg algal bloom) (ACSES080)	<b>Students:</b> conduct a practical investigation to discover microplastics in lagoon entrances on the Central Coast



### Related Research and Links

### **LOCAL GOVERNMENT**

### Central Coast Council Coastal Lagoons

http://www.gosford.nsw.gov.au/environment-and-waste/environmental-management-and-planning/estuaries/coastal-lagoons-management-planning

### Northern Beaches Coastal Lagoons

https://www.northernbeaches.nsw.gov.au/environment/coast-and-waterways/coastal-lagoons

### **MEDIA**

http://www.abc.net.au/news/2018-02-09/marine-plastics-killing-arctic-creatures/9417270

https://www.theguardian.com/environment/2018/apr/16/plastic-is-literally-everywhere-the-epidemic-attacking-australias-oceans

### **OTHER**

### A Rocha International: The Microplastics Toolbox

http://www.arocha.org/wp-content/uploads/2018/01/Microplastic-sampling-protocol.pdf

### **RESEARCH & REVIEWS**

Annual Review of Marine Science: Plastics in the Marine Environment: Plastics in the Marine Environment https://www.annualreviews.org/doi/full/10.1146/annurev-marine-010816-060409

Browne, M., Crump, P., Niven, S.J., Teuten, E., Tonkin, A., Galloway, T. and Thompson, R. (2011). Accumulations of microplastic on shorelines worldwide: sources and sinks. In Environmental Science & Technology, September 2011.

https://pubs.acs.org/doi/abs/10.1021/es201811s

Convention on Biological Diversity. CBD Technical Series No. 67: Impacts of Marlne Debrls on Blodlversity - Current Status and Potential Solutions

https://www.cbd.int/doc/publications/cbd-ts-67-en.pdf

### Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP)

http://www.gesamp.org/work/groups/40

http://www.gesamp.org/publications/reports-and-studies-no-90

http://www.gesamp.org/publications/microplastics-in-the-marine-environment-part-2

http://www.gesamp.org/site/assets/files/1720/24472\_gesamp\_leaflet\_pq.pdf

http://www.gesamp.org/publications/pollution-in-the-open-oceans-review

Lachmann, F.A. (2016). Marine Plastic Debris – Flows, Mitigation Measures and Environmental Evaluation. Master's Thesis within the Environmental Science Programme

https://bioenv.gu.se/digitalAssets/1580/1580037\_florina-lachmann.pdf

Law, K. (2016). World Economic Forum: How much plastic is there in the ocean?

https://www.weforum.org/agenda/2016/01/how-much-plastic-is-there-in-the-ocean/

Marine litter - trash that kills (2003)

http://wedocs.unep.org/handle/20.500.11822/9691

Scientific and Technical Advisory Panel (2011). Marine Debris as a Global Environmental Problem - Introducing a solutions based framework focused on plastic.

http://www.stapgef.org/sites/default/files/stap/wp-content/uploads/2013/05/Marine-Debris.pdf

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Browne, M., Crump, P., Niven, S.J., Teuten, E., Tonkin, A., Galloway, T. and Thompson, R. (2011). Accumulations of microplastic on shorelines worldwide: sources and sinks. In Environmental Science & Technology, September 2011.

https://pubs.acs.org/doi/abs/10.1021/es201811s

Carbery, M., O'Connor, W., & Thavamani, P. (2018). Trophic transfer of microplastics and mixed contaminants in the marine food web and implications for human health. Environment International.

https://doi.org/10.1016/j.envint.2018.03.007. doi:https://doi.org/10.1016/j.envint.2018.03.007

Desforges, J. P., Galbraith, M., & Ross, P. S. (2015). Ingestion of microplastics by zooplankton in the Northeast Pacific Ocean. Arch Environ Contam Toxicol, 69.

doi:10.1007/s00244-015-0172-5

Gall, S. C., & Thompson, R. C. (2015). The impact of debris on marine life. Marine Pollution Bulletin, 92(1), 170-179.

doi:http://dx.doi.org/10.1016/j. marpolbul.2014.12.041

Hammer, J., Kraak, M. H., & Parsons, J. R. (2012). Plastics in the marine environment: the dark side of a modern gift. In Reviews of environmental contamination and toxicology (pp. 1-44). Springer New York

Jambeck, J., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., and Naray, R. (2015). Plastic waste inputs from land into the ocean. Science 13 Feb 2015: Vol. 347, Issue 6223, pp. 768-771.

http://science.sciencemag.org/content/347/6223/768

### United Nations Educational, Scientific and Cultural Organisation (UNESCO)

website: http://www.unesco.org/new/en/natural-sciences/ioc-oceans/focus-areas/rio-20-ocean/blueprint-for-the-future-we-want/marine-pollution/facts-and-figures-on-marine-pollution/









