Southern Cross University
National Marine Science Centre

Underwater Volunteers NSW

A Standardised Protocol for Assessing Marine Debris in NSW Waters

Robert J. Edgar and Stephen D. A. Smith

CARING FOR OUR COUNTRY

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A standardised protocol for assessing marine debris

Introduction

Marine debris, also known as marine litter, marine garbage and ocean debris, can be defined as any manufactured or processed solid waste material that enters the marine environment from any source whether on land or at sea. Much of this debris is composed of persistent synthetic materials such as plastics, and thus is not biodegradable.

Globally, as much as 80% of marine debris entering the ocean each year is thought to come from land-based sources, with the remainder arising from shipping and other maritime sources. The increasing influx of people into coastal zones of NSW is magnifying the problem in adjacent marine ecosystems. Research indicates that 6.4 million tonnes of debris reach the world's oceans each year, and that ~ 8 million items enter the sea every day. Plastics consistently comprise 60 to 80% of total debris recorded. Levels and rates of debris input are increasing despite measures to control the problem.

Marine debris is not only an aesthetic problem that one encounters on beach rambles or scuba diving in coastal waters, but has become a serious threat to marine life. Debris has been identified as one of the Key Threatening Processes [1] to marine habitats and organisms in Australia, especially to threatened and/or endangered species. Impacts on marine organisms have received some attention, mostly related to entanglement by, and ingestion of, various plastics by larger organisms. Plastic in water appears as food to many varieties of marine life often resulting in fatal ingestion. Debris, especially plastic film and sheeting, can settle over sessile benthic organisms such as corals effectively smothering them and rendering them uninhabitable and unproductive. Estimates of marine life endangered by debris included most of the world's turtle species, 25 percent of marine mammal species, and more than 15 percent of seabird species. In Australia, 77 species of marine animal are known to have been affected by entanglement or ingestion of marine debris.

Project Objectives

Despite measures to prevent and reduce marine debris, evidence shows that the problem continues and will likely get worse. This indicates that current measures for preventing and reducing marine debris are inadequate. While a great deal has been learned about marine debris, there are still many gaps in the understanding of marine debris sources, abundance, fates, and impacts. These gaps in knowledge hinder the ability to prioritise mitigation efforts and to assess the effectiveness of measures that have been implemented.

[1] A threatening process is defined as a key threatening process if it threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community. A process can be listed as a key threatening process if it could:

- cause a native species or ecological community to become eligible for inclusion in a threatened list (other than the conservation dependent category); or
- cause an already listed threatened species or threatened ecological community to become more endangered; or
- adversely affect two or more listed threatened species or threatened ecological communities.

The protocol was developed to aid interested volunteer groups who have identified a marine debris problem in their local area and provide a mechanism for the collection of meaningful information on marine debris in a standardised manner. The protocol aims to scientifically quantify the composition of marine debris and also provide clues as to its sources.

To achieve consistency within each survey site, and between survey sites and regions, it is recommended that all groups participating are clear about why the information is being collected, what information is required and understand the methodologies proposed, before commencing a survey.

When surveys are repeated regularly they become a monitoring program. A monitoring program allows questions about change over time to be answered. However, to provide reliable information, surveys will need to be repeated using the same methods and recorded in the same way. This consistency will ensure that the results are comparable between survey sites and over time.

If survey sites are drawn from a random sample of coastal areas, data generated are suitable for scientifically valid analyses of trends in debris prevalence, across regions and through time. The data may also be suitable for assessing the effectiveness of targeted source reduction programs.

Marine Debris Removal Guidelines

Marine debris removal must take place in a controlled and safe manner. Safety of participants is the most important factor to consider during all marine debris removal activities and must not be compromised.

The process of removing the debris from the marine environment should be executed so as to cause minimum or no damage or disruption to the marine habitat/biota being assessed or 'cleaned'.

What Marine Debris should be removed?

Studies have shown that debris can alter the seafloor, by providing artificial habitat to demersal organisms. In particular, debris often becomes colonised, sometimes quite heavily, by encrusting invertebrates. Thus the potential function of marine debris as habitat should be a consideration in any plans for debris removal, since removal can cause damage and kill organisms.

The question as to whether to remove the debris or leave it may sometimes be a difficult judgment to make. Ultimately, this decision rests on the individual removing the debris to take it or leave it. However, there are a few things to consider.

- Is the item truly marine debris? If yes, the debris does not belong in the marine ecosystem.

- Is the marine debris currently threatening the health of the marine ecosystem? If yes, it must be removed to prevent harm to the marine ecosystem.
- Will the marine debris threaten the marine ecosystem in the future if not removed? If yes, it must be removed to prevent future harm. A good example of this is a rubber tyre that has some marine organisms growing on it. The future damage from the decomposing rubber and the tyre bumping into coral from surge motions will have a negative effect on the marine ecosystem and the tire should be removed.
- Can the removal of the debris item be completed without compromising the safety of the diver? If yes, the debris should be removed
- Are the aesthetics of the marine debris unpleasing to me as a diver? If yes, the debris should be removed.

Protocol

Pre-dive data recording

Upon arrival at the site to be surveyed the site name, date, compass bearing from start of transect and latitude and longitude of the site should be recorded on the standard recording sheet (Appendix 1). Date should be recorded in the form dd/mm/yyyy. Latitude and longitude should be recorded in decimal format, i.e. $00^{o}.0000^{o}$. Names of the members comprising the 'buddy pair' also need to be recorded.

Field methods

Establishing the transects

Four transects are established, in random positions, upon a reef. How you achieve this will depend on a number of factors that include: the type of site; the size of the habitat patch; whether you are completing a shore dive or boat dive; and other logistical constraints. The following provide some examples of how sites can be set up.

Diving from a boat. Transects are deployed from a random point in the middle of the reef, at radial intervals of 90^{o}. Thus, viewed from above, transects radiate out from a central point forming a 'cross' (Fig. 1).

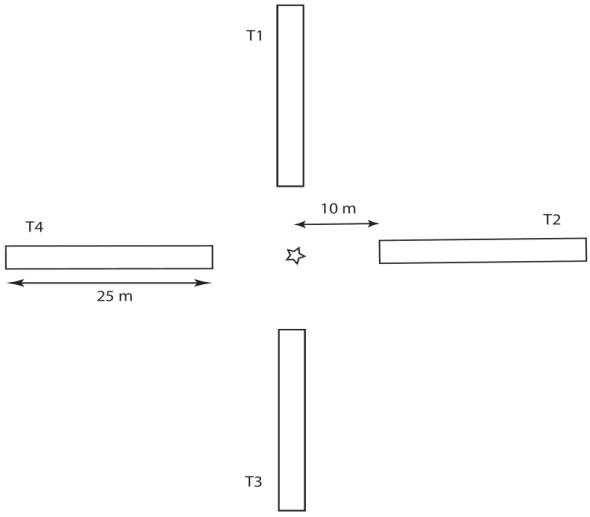

Figure 1. Orientation of transects on a reef

Because it is advantageous for transects to be laid on continuous habitat (this minimises biases), on some smaller reefs, or on fragmented reefs, this pattern cannot always be achieved (i.e. the transects would intersect large areas of sand or run off the edges of the reef). In such cases, transects may be allocated across the available reef habitat (Fig. 2).

In all cases, transects are deployed so that they are spaced by at least 10 m (including at the centre of the cross). Once the assessment of debris within the bounds of the transects has been completed the areas in between transects are searched (see below).

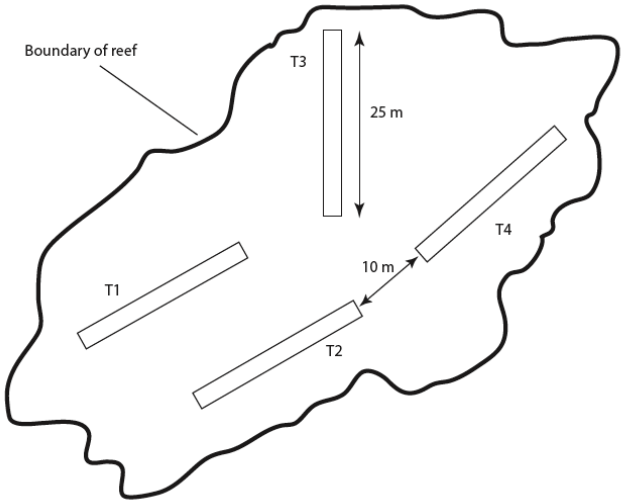

Figure 2. Orientation of transects on a small reef.

Diving from shore**.** When diving from shore, the design described above may be difficult to implement. For this reason, two alternatives are often used. The first allows for transects to be run end-to-end along the depth profile to be surveyed (i.e. parallel to shore). Once, again a gap of at least 10 m is allocated between transects. This type of design has been very successful, for example, in surveying marine debris along a breakwall. A second option, which is particularly useful where the slope of the sea floor is shallow, is to descend to your chosen depth and then run transects perpendicular to shore.

In some cases, where specific questions are being asked about the distribution of debris, additional considerations will need to be made in determining the arrangement of the transects.

Assessing debris load

Debris, defined as any processed item (i.e. including processed wood), is documented and removed (if not providing habitat) in a corridor 2.5 m either side of a tape-measure spanning 25 m laid across the substrate (Fig. 3), thus defining an area of 125 m^2 to be surveyed. At each site a total of 500 m^2 is assessed for marine debris, i.e. 4 transects are assessed. Items are counted and classified into broad categories. In order to provide a more complete picture of debris load, additional, roaming searches are conducted for a further 30 minutes at each site. Debris can be patchily distributed and is often concentrated in specific

areas by the combined effects of benthic topography and water movement, and not necessarily within transects. The roaming survey allows for a more complete picture of debris load at a site.

Transects should be conducted by buddy pairs swimming side-by-side along either side of the tape measure. It is important to thoroughly search the substrate for debris. This will necessitate swimming slowly and checking under overhangs and in cracks and crevices. Divers should regularly look back in the direction they have swum from to gain a different search perspective. While divers should always practice good buoyancy control to minimize impact on marine organisms, being too far above the substratum will limit the ability to detect debris.

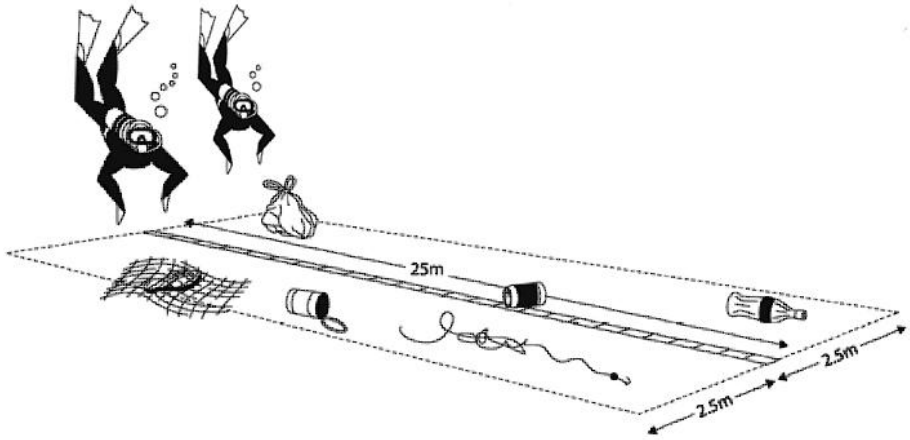

Figure 3. Detail of a transect.

Any debris and rubbish encountered is removed (if not providing habitat) from the substrate, 'bagged up' and returned to shore. **Note**: Larger pieces of debris may become habitat for marine biota – these should be noted but left *in situ*. If a camera is available, larger items should be photographed. Photographs should also be taken of any impacts on biota (e.g. abrasions, mortality) and noted on the standard recording sheet.

The designated leader of the buddy pair should ensure that all data entry is completed (and legible) before the data sheets are submitted.

Marine Debris Removal Procedures.

- When working around nets constantly observe the movement of the net in the surge to avoid entanglement of yourself or gear in the nets and other debris.
- Have a sharp knife available to remove any entanglements.
- When cutting, for example, monofilament, cut in a direction away from you, your dive partner, and your gear.
- Secure your knife when it is not being used.
- Work with a 'buddy' and keep them in view it all times.
- Frequently communicate with your dive partner.
- Cancel the activity and surface if there is excessive risk to you and/or your dive partner.

- When you or your dive partner has 50 bar of air remaining in your scuba cylinder both divers must begin a slow ascent and perform a 3-minute safety stop at 5 metres. Plan your dive in this context, for example, plan to have 50 bar remaining after the transect line has been retrieved, rather than starting to retrieve the line when you have 50 bar remaining.
- If working in coral dominated habitat minimise direct contact with coral.
- Be careful not to break off coral when untangling debris from this taxa, for example, do not pull on monofilament. Pulling can harm the coral more than the presence of the monofilament.
- Cut nets or monofilament in sections if it is severely entangled.
- Cut in sections to avoid further entanglement on the reef.
- Be careful of hooks. Cut them off and place in a rigid container.

After the dive

A designated survey leader is responsible for the collection of all standard data sheets and debris resulting from a survey and for ensuring that they are passed onto the group member responsible for data collation and data entry. **Note**: Not all volunteers are necessarily SCUBA divers and taking on data collation and data entry responsibilities provides them with the opportunity to participate in group activities. All data sheets should be retained in a centralised location.

Designated volunteers have responsibility for entering the data on the standard recording sheets into a marine debris on-line database on the Underwater Volunteers of NSW website.

Equipment Required

The equipment needed for the field and laboratory components of the assessment of marine debris is listed in the table, below.

Field Equipment		Laboratory Equipment
• Tape measures (4 x 30 m) (one for each transect*)	• Knife or scissors	• Camera
• Plastic bags/carry bag (one for each transect and an extra one for the roaming surveys)	• Compass	
• Slate	• Pencil	
• Standard data sheet on waterproof 'paper'** (see Appendix 1)	• Underwater camera (not essential but desirable)	

* Only 2 tape measures are required if you have 2 buddy pairs and each pair conducts 2 transects.

** Underwater paper can be purchased from Xerox distributors. Order: *Premium Never Tear 95 micron Polyester. A4 Part No. 003R98056*

The slate is not a slate in the true sense of the term in that it not designed to 'write' upon, but rather, it acts as a clipboard. Before you take your slate into the water there are a few things you can do to make it easier to use, and to ensure that you don't lose any of its parts! There are a number of variations to just how a slate can be constructed. The image below shows one example.

It is constructed of polycarbonate and uses stainless steel bolts and wing nuts to make a 'clamp' at the top edge of the slate. The clamp is designed to hold the underwater 'paper' upon which records are made in place, along with a piece of taunt shock cord located towards the bottom of the slate. Importantly there is a compass bolted to the slate. This is particularly useful for following compass bearings that may delineate a roving transect. Silicon tubing allows a pencil to be tethered to the slate - this is a better arrangement than using twine as the silicon tubing and pencil tend to have neutral buoyancy and are less likely to become entangled on consoles or benthos. If required an additional hole can be drilled in the top corner of the slate and a clip attached – the clip can then be attached to a D-ring on a buoyancy vest thus leaving the hands free. If there is little current slates can be left on the substrate whilst an observer uses their hands for other purposes.

Applications and Modifications

As indicated above, the arrangement of transects can be modified depending upon the question being asked, or in other words, the aims of a project. For example, if the aim is to quantify the debris load on a particular reef then the use of the protocol as outlined above is all that is required. The data will allow an examination of the number of items collected, the density of debris (i.e. the quantity for a given area) and the prevalence of different categories of debris.

The question being asked might be: 'Are the use of boat moorings and debris loads directly related'? In this instance the basic protocol is used but the siteing of the transects is designed in such a way as to elucidate this question. See Appendix 2 for a Case Study conducted by the Solitary Islands Underwater Research Group: ***Impacts of Marine Debris in the Solitary Islands***

Standard Recording Sheets

There are a number of data fields to complete on the data sheet. Where necessary, these are explained below.

The survey data template (see Appendix 1) consists of 2 pages which are essentially mirror images of one another with the exception that page 1 has a number of items pre-filled under the column titled '*Debris Type'.* The remaining blank rows in this column provide for divers to add other debris items encountered during the conduct of the transect.

The pages should be photocopied onto 2 separate 'plastic' underwater sheets. Once attached (one behind the other) to a slate you flip between them to record the data. If Pages 1 and 2 are photocopied back-to-back on the one piece of underwater paper it becomes difficult to record the data, as when you flip the underwater paper over you don't have a hard surface, i.e. the slate, to rest the paper on.

Furthermore, Page 1 should be photocopied on both sides of a sheet of underwater paper; the same for Page 2, thus enabling a buddy pair to conduct 2 surveys per dive if they have the time.

Location/Site
Record the name of the location. In some instances it may include a named reef/island and also a dive 'site' on that reef, e.g. Split Solitary Island – Turtle Cove. If there is only one location/site record the name under location.

Date of Survey
Self-explanatory. Record as 00/00/0000.

Average Depth
Many dive computers will calculate the exact average depth, but make sure it accurately represents the depth where you spent the most time surveying.

Transect Number
Record if debris was collected from T1, T2, T3 or T4.

Habitat Affected
The habitat types most commonly affected will be dependent on the geographic area in which the survey was conducted. For example, corals seem to be most affected by fishing line around the Solitary Islands offshore from Coffs Harbour.

Compass bearing
The compass bearing from beginning of the transect is recorded. For example, it may be the bearing is related to the mooring or anchor line that a boat is attached to. This information will allow volunteers to repeat the transect over time, e.g. at 6 monthly intervals.

GPS Coordinates
Latitude and longitude should be recorded in decimal format, i.e. 00.0000^{o}.

Debris Type

The list below gives an indication of *some* of the individual debris items that may be encountered when conducting debris surveys. The list is not exhaustive - other items may include snorkels, fins, masks, spear guns, carry bags, batteries and antennae.

Note the inclusion of a category called "***no debris found***" - it signifies a 'clean' patch of substratum. It is just as important to enter data for transects with no debris as it is for those with substantial debris loads.

Debris Item	Material Category	Usage Category
Aluminium can	Metal	Food and drink
Aluminium can - partial	Metal	Food and drink
Brick	Other	Industrial
Cable tie	Plastic	Industrial
Clothing	Cloth	Clothing
Dive clip	Metal	Diving
Dive weight	Metal	Diving
Fibreglass fragment	Other	Other
Fish trap	Metal	Fishing
Fishing hook	Metal	Fishing
Fishing knife	Metal	Fishing
Fishing lure (non-plastic)	Metal	Fishing
Fishing lure (soft plastic)	Plastic	Fishing
Fishing rod	Fibreglass	Fishing
Fishing trace (wire)	Metal	Fishing
Food wrappers	Plastic	Packaging
Glass bottle	Glass	Food and drink
Glass bottle - fragment	Glass	Food and drink
Lead sinker	Metal	Fishing
Monofilament	Plastic	Fishing
Monofilament and hook	Mixed	Fishing
Monofilament and sinker	Mixed	Fishing
Monofilament, hook, sinker, swivel	Mixed	Fishing
No debris found		
Other metal	Metal	Other
Other plastic	Plastic	Other
Plastic bag	Plastic	Packaging
Plastic bottle	Plastic	Food and drink
Plastic pipe	Plastic	Industrial
Rope	Plastic	Boating
Rubber (fragment)	Rubber	General
Shoe	Mixed	Clothing
Shopping trolley	Metal	Other
Steel can	Metal	Food and drink
Steel can - partial	Metal	Food and drink
Tile (building)	Other	Industrial
Twine/string	Other	General
Tyre	Rubber	Transport
Wire - electrical	Mixed	Industrial
Wood (processed)	Wood	Industrial

Tally

Keep a running tally of the number of items of each debris type.

Debris Type	Tally	Habitat Damaged (Y/N)	Debris Removed (Y/N)	Notes
Monofilament	𝍸 //			
Mono & Hook	///			
Mono & Swivel	𝍸 ////			
Mono & Sinker	//			
Mono, Hook & Sinker				

Notes:

The notes section can be used to record a variety of observations. Examples include:

- Record the taxa entangled in marine debris and any obvious signs of damage to benthic organisms.
- Is monofilament incorporated into the habitat matrix, e.g. monofilament line can be overgrown by sponges and corals.
- A comment on the magnitude of lost fishing gear relative to the sizes of organisms affected could be recorded. Small taxa may be more prone to damage that larger ones.

References

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Page 1 **Subtidal Reef Debris Survey Data Sheet**

Site: **Date:** **Average Depth:**

Transect Number: **Habitat:** **Compass Bearing:**

Latitude: **Longitude:** **Buddy Pair Names:**

Debris Type: **Record debris type in this column. Note: If a bottle/jar record whether glass or plastic**

Debris Type	Tally	Habitat Damaged (Y/N)	Debris Removed (Y/N)	Notes
Monofilament				
Mono & Hook				
Mono & Swivel				
Mono & Sinker				
Mono, Hook & Sinker				
Mono, Swivel & Sinker				
Lure (hard plastic)				
Lure (soft plastic)				
Lure (metal)				
Sinker				
Plastic Bag (bait bag)				
Plastic Bag (other)				
Plastic (piece)				

In 'Notes' record whether the debris was collected on a 'Roaming' survey. Record size or length where appropriate.

Appendix 1

Page 2 **Subtidal Reef Debris Survey Data Sheet**

Site: **Date:** **Average Depth:**

Transect Number: **Habitat:** **Compass Bearing:**

Latitude: **Longitude:** **Buddy Pair Names:**

Debris Type: **Record debris type in this column. Note: If a bottle/jar record whether glass or plastic**

Debris Type	Tally	Habitat Damaged (Y/N)	Debris Removed (Y/N)	Notes

In 'Notes' record whether the debris was collected on a 'Roaming' survey. Record size or length where appropriate.

Appendix 2

An interesting case study is provided by the work of the Solitary Islands Underwater Research Group (SURG) that had the aim of determining whether marine park users are complying with the regulations governing the types of activities that can be undertaken within a sanctuary zones in the Solitary Islands Marine Park (where all fishing activities are prohibited).

As there was considerable observational evidence that fishing activities continue to occur in sanctuary zones, SURG completed a study to quantify this through assessing debris load. Surveys were conducted in the sanctuary zones at each of the main islands as illustrated in Figure 4 for North West Solitary Island (NWSI). At NWSI, four sites were established, each one centered on an established mooring. A 'site' includes transects associated with a mooring and a control site (≥50 m from the mooring). All sites are located within a sanctuary zone.

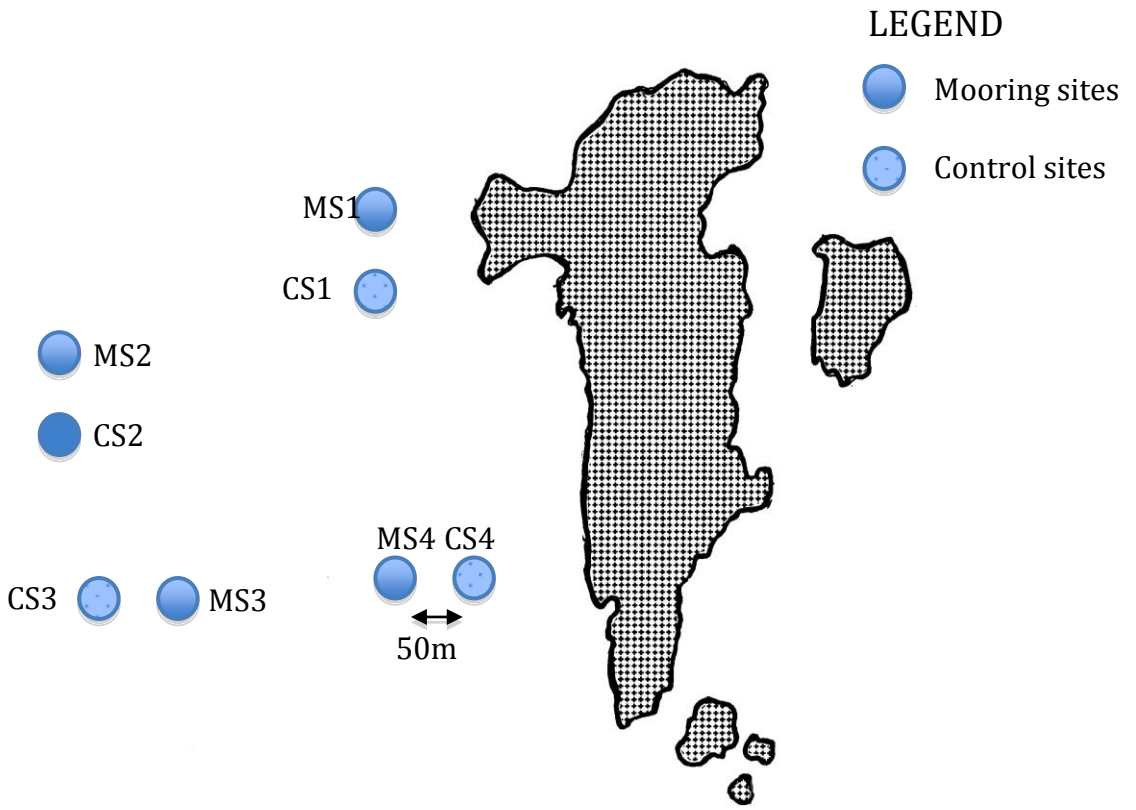

Figure 4: Example of North West Solitary Island debris survey design. Each site consists of one Mooring site and one Control site. The Control site is situated at a minimum distance of 50 m from an adjacent mooring.

Four parallel transects were established in each survey location (4 control and 4 mooring) (Figs. 5 and 6) and divers performed their assessments as per the standard protocol. As 2 buddy pairs were working each set of 4 transects (completing 2 each), each pair also conducted one 15-minute roaming survey (total of 30 minutes). Data was recorded on pre-printed data sheets (see Appendix 2) and subsequent assessments provided an indication of compliance in the sanctuary zone and the role of moorings in concentrating activities generating marine debris.

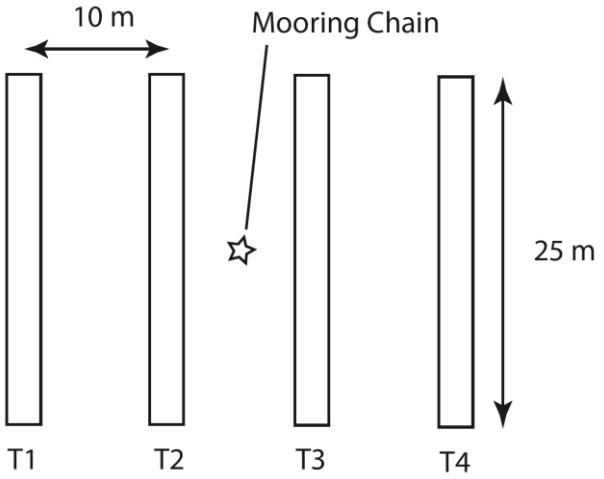

Figure 5: Orientation of 4 x 25m transects centred on the mooring chain attached to the substrate.

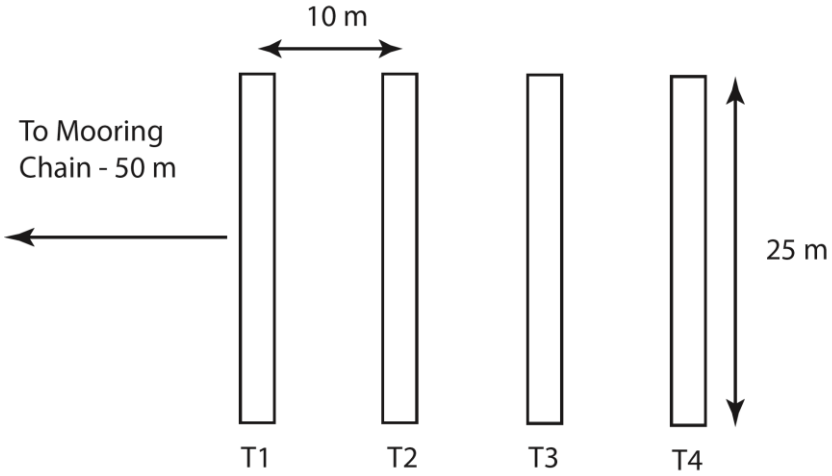

Figure 6. Orientation of belt transects at a Control site.

Mooring and Control Sites Survey Data Sheet

Location: **Site Name:**
Date:

Observer Names: **Mooring Site (cross box)** ☐ **Control Site** ☐

Latitude **Longitude**

Please use separate rows for every occurrence of debris. For fishing related debris use the following codes:

Codes:	Description	Codes:	Description
F	Fishing line only	**FLH**	Fishing line, lead, hook
FH	Fishing line and hook	**H**	Hook
FL	Fishing line and lead	**OF**	Other fishing gear
L	Lead		

Affected habitats include: Hard corals Soft corals Anemones
Kelp Barrens Boulders
Bare Rock Gravel

Depth (m)			
Code	**Habitat Affected**	**Code**	**Habitat Affected**
Transect No.		Transect No.	
e.g. MH	Hard coral	e.g. MHL	Kelp
Roaming Survey			
Notes			