Sri Lanka Expedition 2018

University *of* Glasgow

Preliminary Report 17/09/2018

Expedition Leader

Celine Goslinga
21 Oakfield Avenue
Glasgow G12 8JF
2181724G@student.gla.ac.uk
07519449143

Contents

Acknowledgements

The team is incredibly grateful for the support received to set up and carry out this unforgettable expedition and carrying it out successfully. First and foremost, the team would like to express thanks to our academic advisor Dr Deborah McNeill, who has given us invaluable advice, perspective and encouragement from the very beginning and has continued to do so all the way throughout this project, even contributing her time and energy to accompany the team in the field to ensure research methods and data collection techniques were carried out to the highest standard. Debbie's engaging attitude towards marine science and education has been an inspiration to the whole team.

We would also like to thank our dissertation supervisors Dr David Bailey, Dr Donald Reid, Dr Adrian Bass, Dr Ashley Le Vin and Dr Anna McGregor for guiding us in forming research questions and helping us explore the possibilities of applicable research methods for an unfamiliar site of study as well as for lending out equipment to the expedition that was fundamental to our data collection.

We would also like to acknowledge the generosity of the funding bodies, namely The University of Glasgow Chancellor's Fund, The Glasgow Natural History Society, The Percy Sladen Memorial Trust, The Gilchrist Educational Trust, The University of Glasgow College of Social Sciences, The RSK Group and Rotary Club Nairn. We want to express a tremendous thanks for their financial contribution and that faith they have had in our endeavour. We also want to thank K-Dive and Dive Proof for supporting the expedition with a contribution to our diving equipment.

We want to thank the Exploration Society for their supportive community, their facilitation of team recruitment and the first aid training; the Exploration Society Council for reviewing our research proposals and risk assessment and providing vital feedback; and the leaders of the 2017 Sri Lanka expedition, Rosie Dowell, Lily Copping and Chloe Erskine for their courage to initiate this project, providing a groundwork for us to build on.

Furthermore, we would like to express thanks to all staff at Poseidon Diving Station in Nilaveli for their excellent service and cooperation, making our scientific diving both safe and enjoyable. They have gone above and beyond to suit our calendar, site selection and making us feel at home in Sri Lanka. In particular a great thanks to site manager Praveen Wijesuriya, who has been available day and night to assist not only with dive related matters but any obstacle that required the aid and expertise of a trustworthy local.

A special thanks to all of outreach partners and the friends we have made in Sri Lanka, in particular Dr Terney Pradeep Kumara, CEO and General Manager of the Marine Environment Protection Authority for his warm welcome into the marine conservation community of Sri Lanka, his enthusiasm to collaborate with the expedition and for going out of his way to assure research permission from the Department of Wildlife Conservation.

And finally we would like to thank all of our family and friends for encouraging us in every way they did, from attending our bakesale to donating to our sponsored beach clean. The encouragement was tremendously appreciate it and we want to recognise the expedition would not have been a success without your support. Thank you all!

The Team

The expedition was undertaken by an interdisciplinary team of 10 University of Glasgow students who share a passion for environmental conservation and research; Celine Goslinga (team leader, researcher), Esther Whitford (planning & permits coordinator, researcher), Jamie Crowther (travel coordinator, researcher), Andrew Middleton (grants coordinator, researcher), Maria Day-Wilson Player (trusts coordinator, researcher), Emelie Adenlöf (treasurer), Priyanka Chandi (outreach coordinator), Adriana Barnett Del Pozo (fundraising coordinator, dive officer), Jack Rawlinson (sponsorships coordinator, filmmaker) and Andrew Matthews (sponsorships coordinator, social media & blog). The team was strengthened by the staff of Poseidon Diving Station and by our academic advisor Dr Deborah McNeill who traveled out to Sri Lanka for ten days supporting the researchers during their pilot studies and finalising their methodologies.

Budget

Income

Personal Contribution and Fundraising	£850 x 10	£8500
Group Fundraising	(pub quiz, band night, bucket shaking, bake sales)	£1472
Additional Donations		£1255
Grants and Trusts	University of Glasgow Chancellors Fund	£2500
	Glasgow Natural History Society	£600
	Gilchrist Educational Trust	£1000
	Percy Sladen Memorial Trust	£1000
	UofG College of Social Sciences Employability Fund	£400
Honours Project Funding		£400
Sponsors	RSK Group	£1000
	Rotary Club Nairn	£250
Funds Remaining from 2017 Expedition		£452
TOTAL		**£18829**

Expenditures

Flights		£4425
Airport Transfers		£136
Accomodation	(Bunkyard + Pigeon Beach Residence)	£2525
Food & Water		£2840
Sim Cards		£41
First aid supplies		£106
Housekeeping Items	(soap, washing liquid)	£30

Transport within Sri Lanka	(bus/tuktuk rides to Trincomalee / plastics project	£264
Scientific Equipment	(transect lines, dive slates, rattles, tank bangers, GPS, water resistant casing, pvc poles, gloves, tubes, seive, jars, pipette, etc)	£162
Scientific Diving and Boating		£5,977
Entry to Pigeon Island		£413
Servicing Diving Equipment and Repairs		£153
Fundraising costs	(t-shirts, banner, donation buckets, printing costs)	£140
Tips to hosts in Sri Lanka		£191
ATM Fees in Sri Lanka		£179
Academic Advisor	(flights, accommodation, food, visa)	£787
TOTAL		**£18369**

Travel & Logistics

On the 4th of June 2018 the team flew with Emirates from Glasgow International Airport to Bandaranaike Airport (Colombo) with Emirates, having a layover at Dubai International Airport. The team spent two nights at the Bunkyard Hostel in Colombo to arrange visa extensions and purchase final equipment and sim cards. On the 7th of June the team took the pre-booked overnight bus to Nilaveli.

The first few days in Nilaveli were spent settling into the accomodation, meeting representatives of Blue Resources Trust and the Marine Environment Protection Authority (MEPA) and getting to know the marine life of the Trincomalee Bay area. After which some of the team finished their PADI Rescue Diver courses, whilst others scouted out locations and tested equipment for pilot studies. Initially six days were planned for undertaking pilot studies, but due to the tough field conditions of the data collection it took slightly longer than anticipated for all inexperienced divers to get comfortable and skilled with the complex scientific diving methodology (see appendix 1). Additionally the methodology of the microplastics project had to be adjusted entirely to accommodate the feasibility of collecting data in the extremely hot and dry weather conditions. Hence we eventually took nine days to complete our pilot studies.

Having planned for reserve dive days this lead to no problem with the amount of field days the team needed to collect a sufficient data set for each research project. After pilots studies, from the 24th of June until the 23rd of July, the team commenced in data collection, managing 25 successful field work days and four days off which were spent resting, participating in a Mangroves restoration project in collaboration with the MEPA, and visiting Sri Lanka's UNESCO World Heritage sites Dambulla and Sigiriya.

The team resided at Pigeon Beach Residences, a guest house in Nilaveli neighbouring Poseidon Diving Station, who have facilitated us for the diving and boating aspects of our research projects. Breakfast was cooked for by the friendly staff of Pigeon Beach Residences, lunch was delivered by a local supplier and dinners were spent at a variety of eateries and low-cost restaurants a walking distance away.

Health and safety protocols were abided to at all times, such that no major incidents occured throughout the whole expedition, neither during fieldwork nor outside of it, with the exception of one accident were a team member accidentally stood on the tail of a dog at night and was bitten. Within two hours of the bite the team member was treated by staff of the District General Hospital Trincomalee, receiving appropriate rabies vaccines and doing well ever since. The incident has been officially reported to and dealt with by the University of Glasgow Crisis Team.

On the 24th of July the team traveled back by overnight bus to Colombo, where the expedition officially came to an end. One of the team members then flew home, whilst the others remained in Sri Lanka for an additional five days to travel around the South of the island on their own expenses, flying back to Glasgow on the 30th of July.

The experiences of the team, relating predominantly to the fieldwork carried out, but also extending to the outreach activities, excursions and impressions of the culture and ecology of Sri Lanka have been extensively captured both in writing on our blog (https://exposrilanka2018.wixsite.com/srilanka) , and in 'Photo of the Day' on our Instagram (https://www.instagram.com/uofgsrilanka/).

Research Projects

Assessing Herbivore, Piscivore and Invertivore Trophic Guild Structures in Relation to Different Sites and Habitat Types in the Trincomalee Bay Area, Sri Lanka

Jamie Crowther, supervised by Dr David Bailey, and Maria Day-Wilson Player, supervised by Dr Donald Reid

Introduction

Coral reef ecosystems are one of the most productive, biodiverse marine ecosystems in the world (Connell, 1978, Ray, 1988, Pelletier, 2011). However, globally coral reefs are in decline and reef fish assemblages are changing due to habitat degradation, climate change and overfishing (Bellwood et al., 2006, Caldwell et al., 2016). A variety of reef substrates and structures can be found off the shores of Nilaveli providing an important habitat for many species of reef fish. Fish assemblages are expected to vary among habitats due to the different requirements of each trophic group and its associated species (Friedlander and Parrish, 1998). The variation in availability and food type and the protection afforded by each reef habitat type will influence the structure of these assemblages (Friedlander and Parrish, 1998). The Indian Ocean has received less scientific attention in regard to fish assemblages than other parts of the world such as the Great Barrier Reef (Öhman, Rajasuriya and Ólafsson, 1997). This study will be building upon last year's expedition data baseline and help better understand the assemblages found in this under-studied part of the world.

The majority of reefs found off the shore of Nilaveli are coral and sandstone reefs and can be broken down into several distinct habitat types. Within coral reefs there are shallow reef flats, shallow patch reefs, deep flat reefs and Porites domes (Öhman, Rajasuriya and Ólafsson, 1997). Sandstone reefs can be structured or flat (Öhman, Rajasuriya and Ólafsson, 1997). Attention was paid to these reef habitat types whilst sampling different sites in relation to reef fish assemblages from the Herbivore, Piscivore and Invertivore trophic guilds (Öhman, Rajasuriya and Ólafsson, 1997).

The Piscivore trophic guild is comprised of fish that prey almost entirely on other fish hence they are carnivorous. Invertivores feed on invertebrates such as crustaceans and are an important link in food webs as crustaceans form a key link between primary production and consumers (Kramer et al., 2015). Fish residing within the herbivorous trophic guild are very important in coral reef ecosystems as they can play a large role in controlling the growth of macroalgae. In turn, this means that the presence or absence of these fish species can affect a reef systems resilience to trophic shifts (Bejarano and Golbuu, 2013). Human activity increasing nutrient availability in water sources is often seen as a cause of algal blooms. In addition to this, any damage to coral reefs, for example from coral bleaching, can lead to the transition of that habitat into an algal dominated one (Heenan and Williams, 2013). This reduces the biodiversity of the habitat. In some rare cases, herbivorous fish species have been able to return an algal habitat back to its coral state (Cheal et al., 2010). Herbivorous fish feed on various algal forms including fleshy macroalgae and algal turf. By controlling the levels of algae, it ensures that coral larvae have an opportunity to settle and grow. Different species can also be grouped according to their feeding strategy, from grazers to excavators. It is also important to note that herbivorous fish populations can differ greatly on different reef structures and within different reef habitats. The topology of the reef can also affect their assemblages (Heenan and Hoey, 2016). These fish species are under threat from fishing and ornamental aquarium collection. As such it is important to gain a better understanding of their distribution in different habitats to create better conservation management plans (Bejarano and Golbuu, 2013).

Methodology

A haphazard sampling technique was used to assess fish assemblages across a variety of sandstone and coral reef habitat types; 20m by 5m visual belt transect surveys were carried out. The four-man dive team (where diver A1 and A2 swam ahead carrying out the fish assemblages data collection and diver B1 and B2 swam behind doing the benthic project) descended using the anchor line as a guide. The non-divers on the boat recorded the water entry point at each site using a GPS. At the bottom, diver A1 selected a randomly generated bearing and number of fin kicks, leading the team to the beginning of the first transect. Diver B1 then attached the transect line to a non-coralline piece of substrate.

The transect line followed the direction of the initial bearing and a distance of 4 metres was swam before the fish dive team were alerted to begin the fish survey, in order to provide a fish calming period. Diver B1 followed behind unreeling the transect line. Diver A1 and A2 observed and recorded the abundance of fish that were within their assigned trophic guilds on their individually pre-prepared dive slates. Diver A1 only recorded species of fish which were members of the piscivore and invertivore trophic guilds. Diver A2 only recorded species of fish from the herbivore trophic guild. Diver B2 recorded and made notes on the habitat type. The entire dive team swam at a constant speed of 10 metres per minute ensuring consistent sampling effort across all transects and that each transect was completed within three minutes. When a distance of 18 metres had been covered, diver B1 alerted divers A1 and A2 by tapping their own tank with a tank banger. This signified that the transect had been completed and that visual surveying must stop. As divers A1 and A2 were swimming ahead, being alerted at 18 metres ensured that the transect line did not exceed 20 metres in length. At the end of the transect divers B1 and B2 swam back to the beginning of the transect to detach the real whilst diver A1 Selected a new random bearing and number of fin kicks. Once divers B1 and B2 had returned, the methodology was repeated.

Each dive day included a maximum of two dives with three transects being carried out per dive, totalling six transects per dive day. Each dive represented one dive site with three transects within that habitat type. No dive exceeded a period of 45 minutes. The transects at each dive site were carried out at a depth of no greater than 15 metres. Additionally, we were restricted by the dive company’s boat schedule, because of this the data collected represents a snapshot into fish communities within these time frames and locations.

The week prior to the start of data collection was dedicated to familiarizing ourselves with the area in which we were diving, standardising our swimming speeds and becoming accustomed to the appearance of 5 metres under water. Our habitat types were also studied and a clear definition of each habitat type or sub habitat type was described.

Before arriving in Sri Lanka all dive team members learnt how to visually identify all species encountered in the 2017 expedition and those mentioned in the Öhman, Rajasuriya and Ólafsson study from 1997. In addition, these identification skills were fine-tuned during the pilot week. After this pilot week, the relevant species encountered on our practice identification dives were written onto our dive slates. Ensuring quick tallies could be made while carrying out the visual belt transects.

Preliminary Results

A total of 140 successful transects were carried out across 14 different sites in the Trincomalee Bay area. The majority of habitats encountered were sandstone reefs, with the main variation being between structured and flat forms. The data collected will be analysed on our return to Glasgow.

Investigating the Distinctions in Benthic Coverage Amongst Reef Habitats of Different Substrate Types in the Trincomalee Bay area, Sri Lanka

Celine Goslinga, supervised by Dr Adrian Bass

Introduction

The Trincomalee Bay area is known for its lively and productive marine ecosystems; its 'rocky seabed supports extensive reef habitats' (Rajasuriya, 2005) which, in this region, are commonly patchy, bouldery reef structures with a sandstone or rocky substrate. Reefs founded on a coral substrate occur too, mostly off the coast of Nilaveli (a small village 13 km North of Trincomalee), such as in the marine protected area (MPA) of Pigeon Island.

Corals can be defined as foundation species of reefs for they have been shown to create complexity by allowing increased habitat scale and dimensions while also providing reef heterogeneity (Bruno and Valdivia, 2016). Hence, if corals are damaged or destroyed, such as they were in the Trincomalee Bay area after the Indian Ocean Tsunami in 2004, this results in the eventual habitat degradation of its reef ecosystem (Bruno and Valdivia, 2016). Rajasuriya (2005) found that often the reefs orientated in an exposed position toward the open ocean - as opposed to being situated more sheltered in a lagoon - suffered the most extensive damage from the Tsunami. Particularly, when these reefs were abundantly inhabited with fragile coral species such as foliose Montipore and branching Acropora (Rajasuriya, 2005). In the cases where such fragile corals or dead coral or rubble formed the underlying substrate of a reef, the destructive impact of the Tsunami was also relatively greater, because such substrates are unstable and hence prone to wreckage (Rajasuriya, 2005).

As a result of 'heavy resource exploitation, use of destructive fishing methods and lack of management' (Rajasuriya, 2005), reef habitats in Trincomalee and along the whole of the Sri Lankan coast, have been degrading for the past three decades at a distressing rate (Dharmaretnam, 2004). As important as it is to understand the reef habitats in order to improve the management of marine resources, such endeavors have been obstructed considerably by political conflict in the region up until 2009.

The University of Glasgow expedition team collected a baseline dataset on reefs in the Trincomalee Bay area in summer 2017 that revealed the varying substrate types of multiple reefs as well as tested methodologies to quantifying benthic coverage. Having returned in June and July of 2018, I can now build on this dataset and deepen the insight into the relationship between benthic coverage and habitat types in the marine environment of Trincomalee.

Aims and Hypothesis

The aim of this project was to measure and evaluate the distinctions in benthic coverage amongst reef habitats of different substrate types (i.e. sandstone, coral, rock reefs) in the Trincomalee Bay area. It was expected that benthic coverage will vary amongst reef habitats of different substrate types. Additionally, I will investigate whether patterns in benthic coverage, and the relation between it and reef substrate type, can be distinguished amongst sites:

1. That are oriented differently toward the Indian Ocean (i.e. the extent to which a reef is sheltered from or exposed to the open ocean).
2. That are located different distances from the urban area of Trincomalee and the Marine Protected Area (MPA) of Pigeon Island.
3. Of which the Tsunami-induced damage has been labeled differently by Rajasuriya (2005) (i.e. ‘extreme’, ‘high’, ‘low to medium’, or ’ ‘no damage’).

Methodology

This research project was carried out by 2 divers, diver ‘B1’ and ‘B2’, collaborating in a buddy pair with the two divers of the fish assemblages project, Divers ‘A1’ and ‘A2’. The four divers closely stuck closely together during every dive, such that data collected in each separate research project can be linked together by geographical location and form a cohesive data set.

During each dive, the four divers descented to a depth of 3 to 15 meters. Upon reaching the ocean floor by the anchor line, the haphazard sampling technique (described above) was undertaken to remove selection bias from identifying the starting point of the first transect. Upon reaching this point, Diver B1 tied the end of a measure tape reel to a non-coraline feature (i.e. a rock or a piece of dead coral) of the benthos. Then, the four divers swam 20 meters at a speed of 10 meters per minute, in a predetermined random bearing. Divers A1 and A2 will swam in front collecting their data in a visual survey, followed by Diver B1 reeling out the transect reel, keeping track of time and possible depth fluctuations during the 20 meter transect. Closely behind Diver B1 swam Diver B2, taking a series of five images of the same frame of benthic coverage at 4 meter intervals along the transect line, using a FujiFilm XP 120, a GoPro Hero 3 or a GoPro Hero 4. Depth of each photo was recorded by photographing the screen of the dive computer before each series of three images. A 75 cm pvc pole was used as a means of indication that the images was taken at a set depth above the benthos. Care was taken so that the pvc pipe did not damage coral, by either placing it on a rocks, sand or dead coral or, if that is not an option, hoovering it at max. 5 cm above the coraline, in which case the photo will be taken at 70cm distance from the benthos. The transect tape was kept along the left side of each image taken.

Upon completion of each transect Divers A1 and A2 took the transect reel whilst Divers B1 and B2 swam back to the starting point of the transect to collect its tail. Diver B2 noted down the substrate type and the diving conditions (such as currents and surges) whilst Diver B1 took care that the transect line was not getting tangled up. Simultaneously, on the other end of the Transect line, Diver A1 selected a new random bearing and Diver A2 carefully reeled in the transect reel, noting down the visibility underwater by checking at what point along reeling in the tape Divers B1 and B2 would become visible to them.

During each dive, 3 or 4 of such transects were carried out, depending on feasibility to accomplish this with the time limitation of 45 minutes per dive. Care was taken to not conduct transects that cross over the same bit of reef (see Appendix 1. Dive Protocol).

Preliminary Results

Fifteen reefs were surveyed for this research project. At thirteen reefs, twelve transects were carried out and at the other two reefs (which were much smaller and prone to over sampling), six transects were carried out, adding up to a data set of 840 photo quadrats, spanning the Trincomalee Bay area, both inside and outside of the Marine Protected Area of Pigeon Island (see appendix 2. Dive Sites Map).

The photo quadrats collected in each transect will be analysed using Coral Point Count with excel extensions V2.01 (CPCe) software to determine benthic coverage, percentage coral cover and the lowest identifiable taxonomic group of each coral, but as of yet (17/09/2018) there are no preliminary results yet.

Differences in Ecological Soundscapes within the Trincomalee Bay area, Sri Lanka

Andrew Middleton, Supervised by Dr Anna McGregor

Introduction

Acoustic measurements are becoming more encouraged for the use of monitoring underwater ecosystems usually due to their ability to monitor species that range in size from millimetres to meters and the area over which it can be achieved (Trenkel 2011). These acoustic measurements are now being applied to the monitoring of endangered habitats such as coral reefs with acoustic results positively correlating with characteristics of the substratum and fish diversity (Bertucci 2016).

Sound is important to marine animals and is used in a variety of ways from communication, navigation or to forge for food with a growing number of studies into sounds influence on development and behaviour. (Merchant 2015). Coral reefs can be noisy environments due to the high density of animals such as shrimp, urchins, vocal fish, crabs or other organisms (Bertucci 2015). Many organisms in their larval stage use this noise along with visual and chemical cues to orient to a suitable habitat on the reef to settle (Vermeij 2010).

Soundscapes are becoming a fundamental part of ecology (Slabbekoorn 2008) with their non-intrusive measurements and their valuable data that stretches across different attributes of the ocean such as habitat selection and trophic interactions (Hughes 2014). With high levels of sound and acoustic complexity correlating with species diversity (Harris 2016).

Although acoustics have been used to measure, studies so far appear to have only been snapshots with no long-term measurement comparisons being made (Barth 2015). hopefully the acoustic data gathered would be of use to further expeditions who could build on the results gathered.

This experiment will measure the overall acoustic environment of different habitats within the bay and compare their soundscapes. Habitats with different relative contributions of biophony (sound created by biological organisms usually the most complex), geophony (sound created by the environment such as wind or running water), and anthrophony (sound created by human made objects or activities) (Farina 2014) have been linked to differences in habitat quality. In addition, because this technique is relatively fast to use, it could be used on large scales.

Aims & Hypothesis

- To compare the soundscape of different habitats within the Trincomalee area of Sri Lanka.
- To analyse anthropogenic sounds/activities effects on biotic sounds.
- We hypothesise that the habitats with more coral cover and fish species will have higher biotic sound & be more diverse also that anthropogenic sound will negatively affect biotic sounds.

Methodology

The areas to be surveyed will be different coral reef areas around the Trincomalee Bay of Sri Lanka. This will be to vary the species of fish, cover of the coral and amount of anthropogenic activity.

The range of the hydrophone was calculated by having a diver swim away from the hydrophone underwater sounding a horn the distance at which the horn could no longer be heard was then recorded. This distance was used to avoid the overlapping of sites. Care was taken to position the hydrophone at the same distance from the seabed at each site by having a diver duck dive down and check the distance. Information on the substrate and coral cover of the area will be provided by divers working on the benthic coverage research project, simultaneously in at a given site. A recording next to the anchor was also taken so the sound of the anchor will be easily identifiable in the results.

A hydrophone (sensitivity -165dB re: 1 V/uPa) was dropped down and 3 readings will be taken for 5 minutes each. Recordings where taken on arrival at the site and during the divers surface interval. Five minutes was given to allow the fish and invertebrates to settle before any recordings where taken. This restricted data collected to certain times. Comparisons between recordings were measured at different frequency bands, such as (20 Hz to 2 kHz) as a low frequency band and 2 kHz to 10 kHz for a high frequency band by splitting the recording into the different bands on audacity. This was done to focus on the predominant sounds in each of the bands with the low frequency being the band at which most fish species vocalise (Lobel, P.S. 2010) and the high frequency band being mainly dominated by the sounds of snapping shrimp (Hildebrand, J.A. 2009). This is being visualized using acoustic software such as Audacity. These waves and sounds will then be compared to online sound banks such as DOSITS, identified and sorted into biophony, geophony or anthrophony. The acoustic complexity index (ACI) of the different areas is being calculated and compared as a measure of diversity.

GPS coordinates were taken to make sure repeats are done at the same site. At each site, weather conditions were recorded by personal judgement and put into categories Calm, Mild, Choppy, Fierce, time of day was also recorded. Any passing boats or divers in close proximity were also noted and the time they arrived/passed by.

Preliminary results

There are no preliminary results yet but twelve readings each were taken at fourteen different sites (see appendix 2. Dive Sites Map). Three of which were inside the Marine Protected Area of Pigeon Island. There was variation in weather and anthropogenic sounds at many of the sites.

Investigating the Impact of Oceanography and Beach Usage on the Distribution and Abundance of Marine Plastics on the East Coast of Sri Lanka.

Esther Whitford, supervised by Dr Ashley Le Vin

Introduction

Marine litter, especially marine plastics, have become a worldwide problem, having been found in every ocean ecosystem (Niaounakis, 2017).They can have both environmental and economic impacts. Marine plastics get into the ocean through many different methods. They can enter through inadequate disposal on land, run-off from urban areas, through marine industries like fishing or from plastic production directly (Hirai et al, 2011). The plastics have been placed into two categories: macroplastics and microplastics. Macroplastics include anything bigger than 5mm and microplastics are anything less than 5mm (Gauquie et al, 2015).

Microplastics have the potential to be highly damaging to the environment. Due to their small size, they have a high dispersal rate. Their size also means that they are often mistaken for small plankton, allowing them to enter the food chain and spread through the different trophic levels. They also absorb toxic chemicals from the environment that, when combined with plastics, can have negative effects on the organisms that ingest them (Andrady, 2011).

The movement and distribution of microplastics is thought to be strongly impacted by ocean currents as well as other factors like aspect and slope of the beach, wind and tides (Zhang, 2017). Some studies, like one done in Brazil in 2009 by Santos et al, have also suggested that coastal currents can spread plastics from populated areas onto relatively remote beaches. As well as having major environmental issues, this could affect local tourism and affect the country’s economy (Santos et al, 2009).

The east coast of Sri Lanka, specifically around the Trincomalee area, has a wide range of uses and is of high economic importance. Some beaches are predominantly used for tourism, while others are used for the local fishing industry, which produces around 23,780 Mt of fish per year (NARA, 2016). There is also a lot of boat traffic offshore, due to the shipping lanes that run down the east coast and the fact that Trincomalee harbour is one of the largest natural harbours in the world. The importance of the marine ecosystem on the local community is why understanding how plastics can be distributed, both on and between different beaches, could be key for local conservation and governmental agencies.

The aim of this project was to compare how oceanography influences microplastic abundance on beaches and between beaches along the north east coast of Sri Lanka. It was also to assess how microplastic type, abundance or distribution differs between different beach types, focusing on beach usage.

Methodology

Microplastic samples were taken from three beaches. The first beach was the semi-populated tourist beach of Nilaveli (8° 41' 9.3696'' N, 81° 11' 55.4604'' E). The second was a busy fishing beach in the city of Trincomalee (8° 34' 38.7768'' N, 81° 14' 10.2768'' E). The last beach was the remote Shell Beach, just south of Trincomalee (8°30’52.7”N, 81°18’43.0”E). Using a random number generator, 12 random coordinates were chosen from each beach. At each coordinate, aspect was measured using a compass, standing perpendicular to the ocean. Slope was measured using a homemade clinometer. Time was also noted at each location to allow the time to low tide to be assessed.

Microplastic samples were taken from each location at a depth of 5cm. When the samples were analysed, a blind sampling technique was used to reduce sampling bias. To analyse each sample, a concentrated saline solution was created. 50g of sediment sample was added to 300ml saline solution and shaken for two minutes before being left for two hours, allowing the sample to settle. The solution was then filtered through three different sieves: 1.18mm, 600mm and 250mm, with care taken to only pour the liquid through the sieves and not the sediment. Using a wash bottle, two extractions were done to reduce the likelihood of plastic being left on the side of the bottle. The sieves were also washed to make sure no smaller plastics had been caught in the larger sieve when they should have been in the smaller size classification.

Using a x20 microscope and a UV light, each petri dish was methodically assessed for microplastics. Any microplastics found were removed using tweezers to prevent double counting. Microplastics found were recorded by size of sieve, colour and type, either fragment or fibre.

Preliminary Results

In total, 36 samples were collected, with twelve randomly chosen from each beach. The samples were all processed in Sri Lanka and the data collected is currently (17/09/2018) being analysed back in Glasgow.

Public Engagement

The expedition has been a most valuable opportunity for the team to represent the University of Glasgow and strengthen its ties with foreign public engagement institutions. The team has set up an official research collaboration with the Marine Environment Protection Authority of the Sri Lankan Government, through the kind support of Dr Terney Pradeep Kumara, CEO and General Manager, who has helped us with receiving research permits from the Department of Wildlife Conservation.

We have also strengthen our ties with the staff of Poseidon Diving Station, whom have played a great role in introducing the team to Sri Lankan Culture. Furthermore we have explored the opportunities with the marine research consultancy Blue Resources Trust and the Ocean University, by meeting up with representatives and discussing our intentions, searching for areas of overlap. A strong potential was found for future expeditions to build on our mutual passion for marine conservation and interest in the ecology of Sri Lanka's coral reef habitats.

The team has also engaged in enthusing the local youth about marine biology and conservation through participation in a mangroves restoration project with the Anar Balika Girls School as well as frequent visits to the Nilaveli Kaileshwara College. And teaching pupils age ….. about the marine environment of Sri Lanka in engaging English classes. A valuable and unforgettable experience to both the pupils and the team, which we highly encourage future expeditions to carry on.

References

Andrady, A.L., 2011. Microplastics in the marine environment. Marine Pollution Bulletin. 62(8). Pp. 1596-1605. DOI: https://doi-org.ezproxy.lib.gla.ac.uk/10.1016/j.marpolbul.2011.05.030

Barth, P. et al. 2015. “From the ocean to a reef habitat: how do the larvae of coral reef fishes find their way home”. Vie et milieu - Life and environment, 95(2), 91–10
Farina, A., 2014. Soundscape ecology: principles, patterns, methods and applications. Dordrecht: Springer Netherlands.

Bertucci, F., Parmentier, E., Berten, L., Brooker, R.M. & Lecchini, D. 2015. Temporal and Spatial Comparisons of Underwater Sound Signatures of Different Reef Habitats in Moorea Island, French Polynesia. PLoS One, vol. 10, no. 9

Bertucci, F., Parmentier, E., Lecellier, G., Hawkins, A.D. & Lecchini, D. 2016. “Acoustic indices provide information on the status of coral reefs: an example from Moorea Island in the South Pacific”. Scientific reports, vol. 6, pp. 33326

Bejarno, S., Golbuu, Y., Sapolu, T. and Mumby, P.J., 2013. Ecological risk and the exploitation of herbivorous reef fish across Micronesia. Marine Ecology Progress Series, 482, pp. 197-215.

Bruno, J. F., Valdivia, A. 2016. Coral reef degradation is not correlated with local human population density. Scientific Reports, 6.

Cheal, A.J., MacNeil, M.A., Cripps, E., Emslie, M.J., Jonker, M., Schaffelke, B. and Sweatman, H., 2010. Coral-macroalgal phase shifts or reef resilience: links with diversity and functional roles of herbivorous fishes on the Great Barrier Reef. Coral reefs. 29(4), pp. 1005-1015.

Connell, J. H., 1978. Diversity in tropical rain forest and coral reefs. High diversity of trees and corals is maintained only in a non-equilibrium state. Science. 199, pp. 1302-1310.

Freidlander, A. and Parrish, J., 1998. Habitat characteristics affecting fish assemblages on a Hawaiian coral reef. Journal of Experimental Marine Biology and Ecology. 224(1), pp.1-30.

Guaquie, J., Devriese, L., Robbens, J. and De Witte, B., 2015. A Qualitative screening and quantitative measurement of organic contaminants on different types of marine plastic debris. Chemosphere. 138. Pp. 348-356. DOI: https://doi-org.ezproxy.lib.gla.ac.uk/10.1016/j.chemosphere.2015.06.029

Harris, S.A., Shears, N.T., Radford, C.A. & Reynolds, J. 2016, "Ecoacoustic indices as proxies for biodiversity on temperate reefs", Methods in Ecology and Evolution, vol. 7, no. 6, pp. 713-724

Heenan, A. and Williams, I.D., 2013. Monitoring herbivorous fishes as indicators of coral reef resilience in American Samoa. PloS One. 8(11), p.e.79604.

Heenan, A., Hoey, A.S. and Williams, I.D., 2016. Natural Bounds on herbivorous coral reef fishes. In. Proc. R. Soc. B(Vol. 283, No. 1842, p.20161716. The Royal Society.

Hirai, H., Takada, H., Ogata, Y., Yamashita, R., Mizukawa, K., Saha, M., Kwan, C., Moore, C., Gray, H., Laursen, D., Zettler, E.R., Farrington, J.W., Reddy, C.M., Peacock, E.E. and Ward, M.W., 2011. Organic Micropollutants in Marine Plastic Debris from the Open Ocean and Remote and Urban Beaches. Marine Pollution Bulletin. 62(8). Pp. 1683-1692. DOI: https://doi.org/10.1016/j.marpolbul.2011.06.004

Hughes, A.R., Mann, D.A. & Kimbro, D.L. 2014. “Predatory fish sounds can alter crab foraging behaviour and influence bivalve abundance”. Proceedings. Biological sciences / The Royal Society, vol. 281, no. 178

Kramer, M., Bellwood, O., Fulton, C. and Bellwood, D. 2015. Refining the invertivore: diversity and specialisation in fish predation on coral reef crustaceans. Marine Biology. 162(9), pp. 1779-1786.

Lobel, P. S., Kaatz, I. M. & Rice, A. N. 2010. Acoustical behaviour of coral reef fishes. Reproduction and Sexuality in Marine Fishes: Patterns and Processes, pp .307–386 Hildebrand, J.A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series, vol. 395, pp. 5-20

Merchant, N.D., Fristrup, K.M., Johnson, M.P., Tyack, P.L., Witt, M.J., Blondel, P., Parks, S.E. & Hodgson, D. 2015, "Measuring acoustic habitats", Methods in Ecology and Evolution, vol. 6, no. 3, pp. 257-265.

National Aquatic Resources Research and Development Agency (NARA), 2016. Fisheries Industry Outlook -2016. Socio-economic and Marketing Research Division, NARA. http://www.nara.ac.lk/wp-content/uploads/2017/09/2016-Fisheries-Outlook-2018.01.18-new.pdf

Niaounakis, M., 2017. Management of Marine Plastic Debris: Prevention, Recycling and Waste Management [e-book]. Oxford: Williams Andrew, Elsevier Inc. Available at: http://www.sciencedirect.com.ezproxy.lib.gla.ac.uk/science/book/9780323443548 [Accessed 16 November 2017].

Öhman, M.C., Rajasuriya, A. and Ólafsson, E., 1997. Reef fish assemblages in north-western Sri Lanka: distribution patterns and influences of fishing practices. Environmental Biology of Fishes, 49(1), pp.45-61.

Rajasuriya, A., 2005. The Status of Coral Reefs in Sri Lanka in the Aftermath. Coral Reef Degradation in the Indian Ocean, p.83. Rajasuriya, A.R.J.A.N., Perera, N.I.S.H.A.N. and Fernando, M.A.L.I.K., 2005. Status of coral reefs in Trincomalee, Sri Lanka. Coral reef degradation in the Indian Ocean (CORDIO): status report, pp.97-103.

Santos, I.R., Friedrich, A.C. and Ivar do Sul, J.A., 2009. Marine debris contamination along underdeveloped tropical beaches from northeast Brazil. Environmental Monitoring and Assessment. 148(1-4). Pp. 455-462. DOI: https://doi-org.ezproxy.lib.gla.ac.uk/10.1007/s10661-008-0175-z

Slabbekoorn, H. & Bouton, N. 2008. "Soundscape orientation: a new field in need of sound investigation". Animal Behaviour, vol. 76, no. 4

Trenkel, V.M., Ressler, P.H., Jech, M., Giannoulaki, M. & Taylor, C. 2011. "Underwater acoustics for ecosystem-based management: state of the science and proposals for ecosystem indicators". Marine Ecology Progress Series, vol. 442, pp. 285-301.

Vermeij, M.J.A., Marhaver, K.L., Huijbers, C.M., Nagelkerken, I. & Simpson, S.D. 2010. "Coral larvae move toward reef sounds". PLoS One, vol. 5, no. 5

Zhang, H., 2017. Transport of microplastics in coastal seas. Estuarine, Coastal and Shelf Science. 199. Pp. 74-86. DOI: https://doi.org/10.1016/j.ecss.2017.09.032

Appendix 1. Sri Lanka Expedition 2018 Dive Protocol

Night before

1) Dive site for next day is selected and discussed with Praveen; this includes rough navigational map of site.
2) Data entry; dive slates cleaned.
3) List of random bearings and reciprocal bearings and random fin kicks added to dive slate.
4) Camera batteries charged including spares.
5) Camera SD cards backed-up and formatted.
6) Soak equipment.

On Dive Day

On land

1) 'Are you fit to dive?' Be honest with yourself and the group, deciding this early in the day makes it easier to keep things smooth.
2) Everyone set up diving gear (BCD and reg onto tank).
3) Pick up own weights.
4) Ensure correct fins/mask are in the group box.
5) Personal wetsuit.
6) Personal sunscreen and water.
7) Research equipment inventory taken (IKEA bag):
   - 4 dive computers
   - 2 Casio watches
   - 2 tank bangers
   - 1 wand
   - 1 rattle
   - 6 slates
   - 2 dsmb's and 2 reels attached
   - 2 knifes
   - 1 compass
   - 1 transect line (with elastic bands that are fit)
   - 1 dry bag with First Aid Kit and spare parts
   - 2 Fuji Film cameras
   - Gloves if reel person wants them
   - Hydrophone and GPS.
   - 1x mobile phone with Local emergency services number including DAN.

Just before getting on boat

1) Help with own equipment to boat, keep walking back and forth until everything is on the boat, don't hang around, help out.
2) Ensure all weight belts are on board.
3) Check IKEA bag (with inventory) is also on board.

4) Spare tanks and Oxygen tank is on board.

On boat arrived at dive site

1) Hydrophone in water and check for appropriate depth and habitat.
2) Pre-dive briefing including; conditions, hand signals, lost buddy protocol (1min search then surface), max depth and length, judgement of boat traffic and ascent mode, behaviour in water (all discussion on boat- none in water and regs/snorkel in mouth on surface), task allocation, buddy pairs and rough description of dive site- show map*.
3. Dive Briefing (SEEDS):

   - Safety (name of dive site; max depth 15 m, max length of dive 45 minutes, start ascend with safety stop at 38 minutes, always use DSMB; judge weather conditions, surge, currents, visibility; protocol if diver gets lost is to search for 1 minute, then ascend and ring alarm/start searching party)
   - Exercise (revise methodology and what role everyone is taking on)
   - Equipment (what equipment belongs to every role, see below)
   - Discipline (Abide safety rules, look out for each other, stick close if vis is bad, don't mess around)
   - Signals (revise all hand signals, particularly methods related signals)

3) Gear up.
4) Buddy checks- BWARF (BCD, Weights, Air, Releases, Final Checks) - final checks include equipment checks for individual dive roles:

   - Fish diver 1) slate, tank banger, computer, watch and Compass
   - Fish diver 2) slate, tank banger, computer and watch
   - Reel diver: Reel, rattle/horn, computer
   - Camera diver: 2x camera, computer, rattle/wand/horn
   - 1x Knife and 1x DSMB and 1x spare 'communications' slate per buddy pair.

In water

1) Reg or snorkel always in mouth at surface + NO discussion (all should have been carried out before hand on the boat).
2) Descend on the anchor line.
3) At 2m do bubble check. Includes: tank valve, 1st stage, 2nd stage, octopus, depth gauge and BCD inflator. Champagne bubbles are ok, if anything more serious (very rapid bubbles from first stage, or massive bubbles from any of them) then everyone should ascend and diver with leak get it sorted on the boat as quickly as possible while the rest of the team hold onto anchor line being wary of boat in swell.
4) Assuming bubble check ok or leak sorted continue descent along anchor line, keeping contact with buddy and watch for equalization problems.

On Bottom of anchor line, start of dive

1) Signal ok to everyone.
2) Compass person takes first bearing on list and checks suitability 1) not sandy bottom (70% habitat rule) 2) no big rocks or depth rises.

3) Carry out random fin kicks (start at top of the list of fin kicks) to first transect starting point, fish team in front, reel and camera diver side by side following behind.
4) Signify transect starting point if suitable and fish team move out of the way for reel attachment- attach reel in direction of the transect being careful of harmful organisms (Crown of Thorns, Stone Fish, Lion Fish, Cone Shells, Crabs/Lobsters).
5) If starting point is not suitable, use next random bearing on list and fin kicks if next random starting point is not suitable then repeat until suitable site located.
6) If as you are doing fin kicks you see that you are approaching sand or boulder finish fin kicks and use step outlined above.

Once Suitable Site has been reached

7) Compass Diver signifies transect starting point and fish team move out of the way for reel attachment- attach reel in direction of the transect being careful of harmful organisms (Crown of Thorns, Stone Fish, Lion Fish, Cone Shells, Crabs, Lobsters).
8) Fish people line up to the side of the reel person on bearing of transect not encroaching on first four metres of transect (fish relaxation session).
9) Swim the first four metres getting into arm length apart position and dive slates ready.
10) Reel person tugs on the fins of one of the fish divers after reaching four metres signifying start of visual transect.
11) Surveyors should record fish within 2m in front and should not be any higher than 2m above the sea floor.
12) Fish diver signifies start of visual transect recording to other fish diver and stopwatches started.
13) Carry out visual transect – ensuring to follow bearing as accurately as possible being mindful of depth contours, aggressive triggerfish, habitat limitations including: sandy bottom, large boulders/ rock walls. in case of large boulder / rock wall, always turn left.
14) Diver with reel needs to stay 2m behind fish team.
15) Camera diver follows right behind reel diver, taking photo quadrats of benthos at 8m, 12m, 16m, 20m, 24m at 75 cm distance from ocean floor, using pvc pipe to indicate this.
16) Order of photos taken by camera diver

  A. 1 photo of their own fingers at the start of each transect signifying which number it is on (1, 2, 3)
  B. 1 photo of dive computer (for depth) per quadrat
  C. 3 photos of benthos (all at 75 cm) from directly above ground at each of the five points (4 m intervals) along the transect line
  D. no random 'fun' photos of surroundings or other divers

17) At 22m diver with reel will signify end of transect by rattling. Hence transect will be 24m in length including the 4m fish calming period.
18) One of the fish team will be passed the reel and the camera/reel buddy pair swims back along the transect to detach it from the substrate. They tug shortly on the line to signify the fish buddy pair can reel in the line. Camera/reel buddy paid will then return to the fish team, holding the transect line to avoid separation.
19) After all are united at the end of the first transect with the tape reel, divers signify to ask each other for their air, all respond, start ascend (with 3 minutes safety stop) if any of the divers is on 60 bar. If all are ok on air, continue dive.

Next Transect

20) New bearing and fin kicks selected from slate. Bearing should be checked for suitability: extensive sand flat/trigger fish.
21) Repeat transect steps above (aim for 3 transects per dive).
22) If accompanied by divemaster from Poseidon Diving (who knows the geography of the reef) then return to anchor line and carry out 3min/5m safety stop. Ensuring to ascend holding onto the anchor line.
23) If anchor line is too far away (40 mins into the dive), sense of direction under water has been lost and/or not accompanied by a Poseidon DM: inflate BOTH DSMB's and then carry out 3min/5m safety stop. Upon ascent ensure the two buddy pairs are tightly grouped together and directly below the inflated DSMB(s).

Transect suitability/cancellation protocol

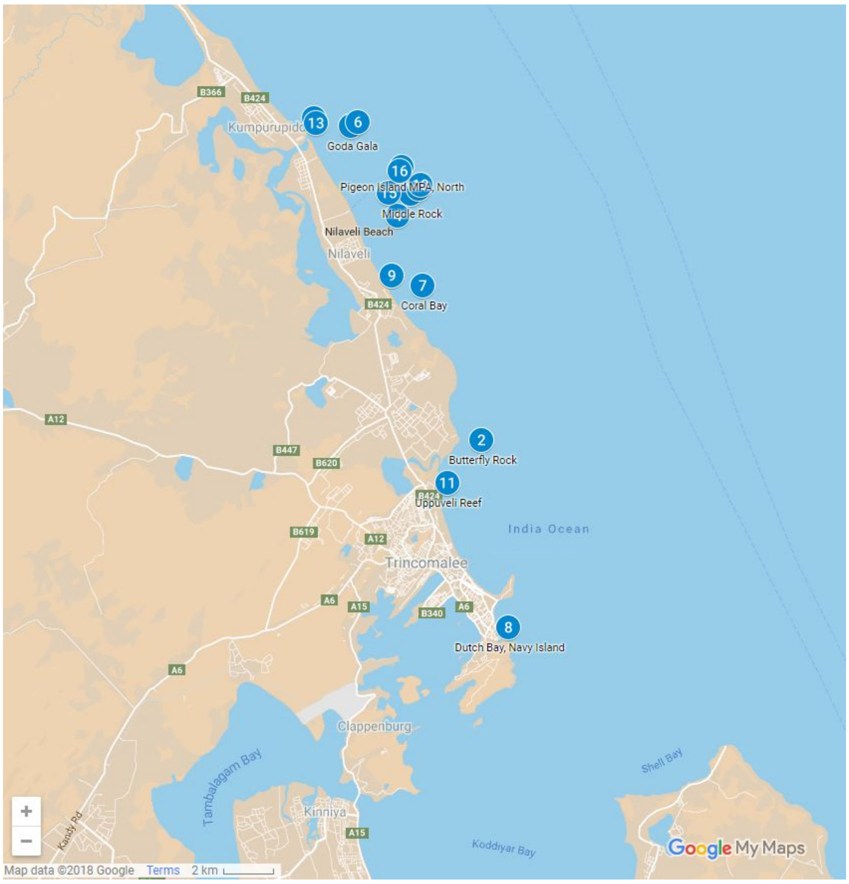
1) If more than 30% of transect is sand. (70% of transect should include the habitat type being sampled)
2) No transect should be shallower than 5m.
3) If while carrying out a transect the person taking substrate photos cannot see the fish team ahead the transect and the dive should be cancelled, as this signifies very bad visibility.
4) Sign for transect cancellation is crossing the arms forming an X.

Bearing protocol

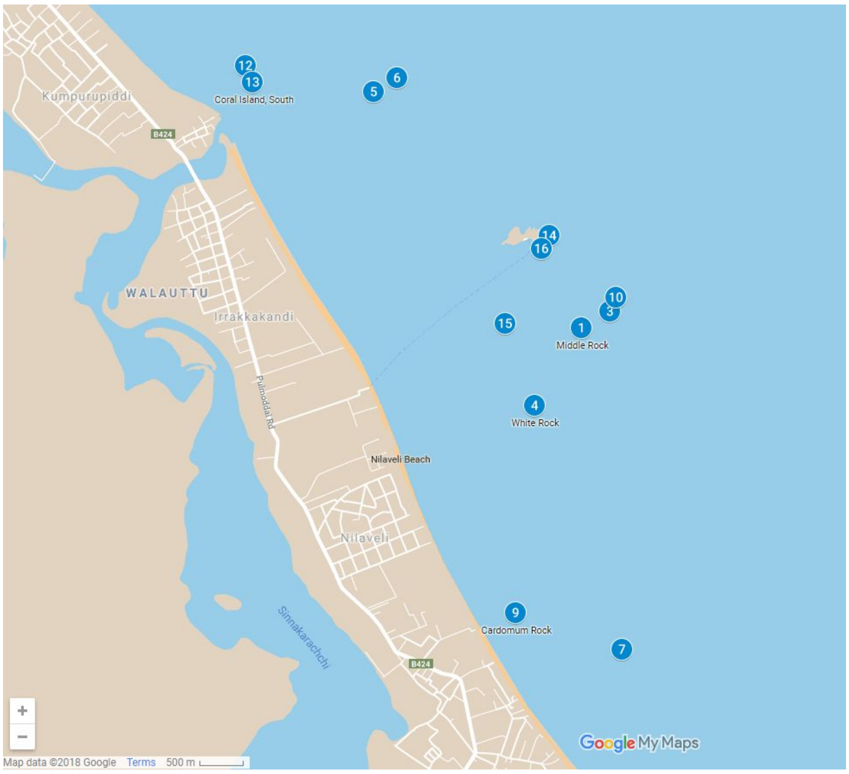
1) First bearing and fin kicks are selected at the bottom of the anchor line.
2) Bearing should be checked for suitability: A) extensive sand flats B) trigger fish C) Extreme rock formations D) Depths < 5m.
3) If not suitable select new bearing and carry out fin kicks.
4) If while carrying out the fin kicks to the random starting point you encounter extensive areas of sand finish the fin kicks and select new bearing and fin kicks. Continue this step until a suitable transect attachment point is found.
5) If while carrying out transect habitat ends (and goes into sandy bottom), follow along the contour of the habitat ensuring the diver on the right has 2.5m aside of them.
6) While carrying out transect, it is OK to stick to the same bearing and have slight depth changes when small rocks/obstacles (remember many reefs are patchy) occur on your transect or during fin kicks as well as gentle slopes.
7) If the rocks cause a large depth change (such that you have to change the position of your body upward or downward) then don't stick to the bearing but go around them (ALWAYS TO THE LEFT) and try to re-join the transect bearing once obstacle has been passed. In this case, don't swim up or down.
8) If transect has to be cancelled mid-way through, swim back to the transect attachment point and select a new bearing and carry out the transect along this new bearing.

Appendix 2. Maps of Dive Sites

The Trincomalee Bay area



The Coastline of Nilaveli



Sri Lanka Dive Sites

1. Middle Rock
2. Butterfly Rock
3. Knife Rock
4. White Rock
5. Goda Gala
6. Mada Gala
7. Coral Bay
8. Dutch Bay, Navy Island
9. Cardomum Rock
10. Deep Knife Rock
11. Uppuveli Reef
12. Coral Island, North
13. Coral Island, South
14. Pigeon Island MPA, North
15. Pigeon Island MPA, Lionfish Rock
16. Pigeon Island MPA, South