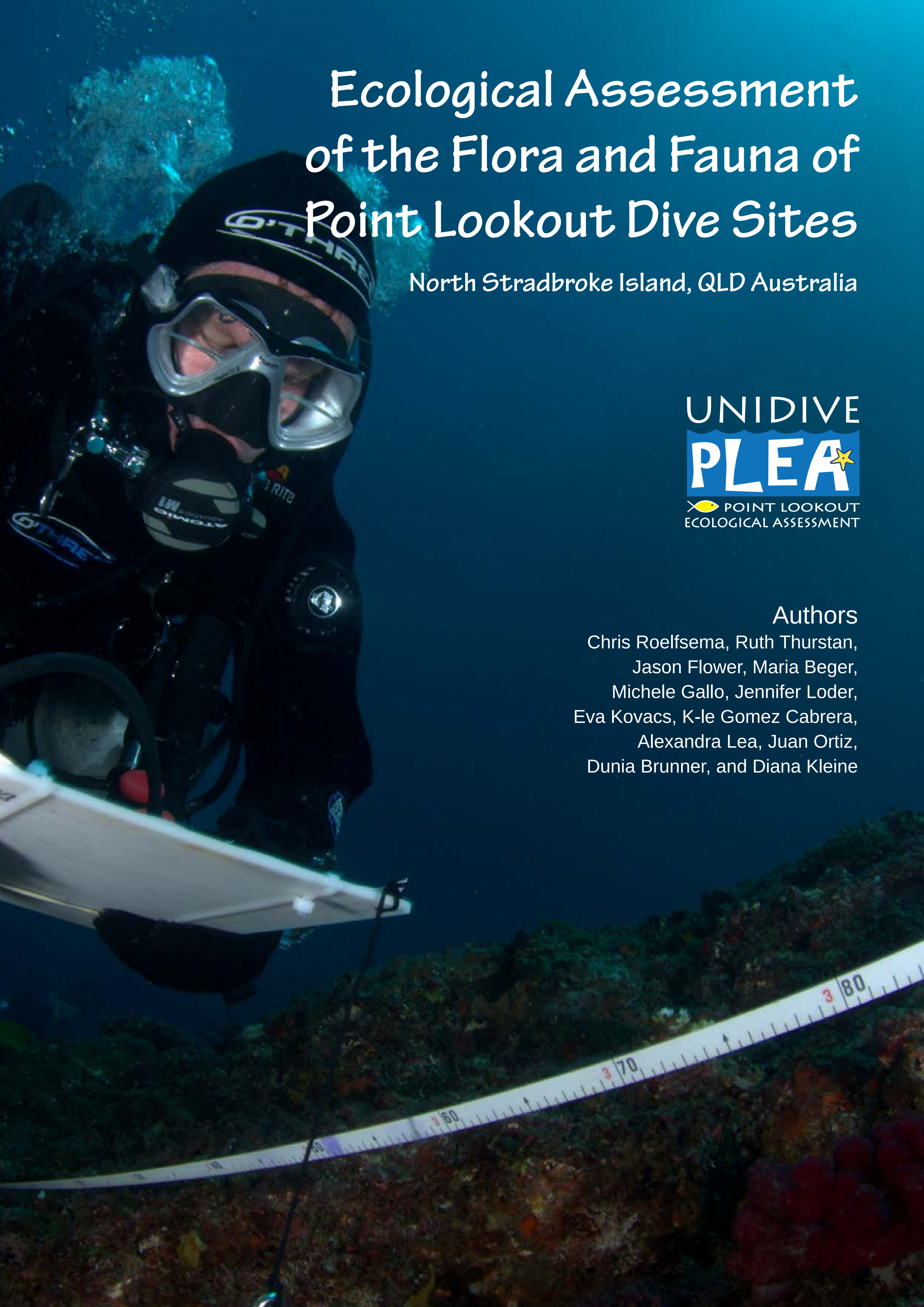
Ecological Assessment of the Flora and Fauna of Point Lookout Dive Sites

North Stradbroke Island, QLD Australia



UNIDIVE PLEA

POINT LOOKOUT ECOLOGICAL ASSESSMENT

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Ecological Assessment of the Flora and Fauna of Point Lookout Dive Sites, North Stradbroke Island, Queensland.

Final Report

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The views and interpretation expressed in this report are those of the authors and not necessarily those of contributing agencies and organisations.

I see a majestic gliding turtle
Like a bird of the ocean
Go past colourful stinging coral
The slimy fish like darts
Miniscule bubbles rising fast
That are like ocean toys
I hear colossal waves forming
A front flip splashing, shrill, bulking dolphin
Diving through the salt water, croaking calmly

A poem by Felix Pheasant 8 years old,

the youngest PLEA participant to join us during the survey weekends..

This Report will give him a chance to enjoy “Straddie” as much as the volunteers did.

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Acknowledgements

Congratulations to the volunteer divers, supporters and friends of the University of Queensland Underwater Club (UniDive) - **you did it!!** 535 safe dives, six weekends, 25 presentations, 614 oranges, 12000+ hours volunteered time, and one enormous data set! We have finished what we started, have made, and will continue to make a difference. While volunteering with likeminded, community orientated people, we produced this report, the beautiful “Straddie” photo book, with more to come: videos, brochures, maps, presentations, scientific papers and/or data sets.

We learned from each other about: people, diving, the reef, identification (fish, invertebrates, substrate, benthic, and impacts), mapping, data management, quality control, analysis, videography, photography, writing, and about managing a bunch of motivated divers all helping to conserve our beloved dive site “Straddie”. There we spent 375 hours underwater the remaining time was directed we spent our spare time ion various ways. Some of the favorites were: emailing, listening to presentations, homework, exams, buddy of a survey diver, cooking food, Facebook-ing, making permanent markers, nurturing survey gear, entering data, selling t-shirts, sorting photos, creating a video, storing photos, managing data, buying sausages, making a book, writing trip reports, etc, etc.

Special thanks to the volunteers who did more than the surveys: Trevor Barrenger (mapper Flat East), Liette Boisvert (Facebook), Ryan Booker (safety officer), Gavin Bott (videographer), Peran Bray (data management), Dunia Brunner (Coral Watch analysis), Jenni Calcraft (party organiser), Robert Cook (Tank Filler), Donna Easton (book and T Shirt sales), Michele Gallo (Statistics and Graphs for data analysis), Blair Jedras (permanent marker builder), Karen Johnson (food, beverages & oranges), Diana Kleine (graphic designer and patient lover of the project organiser), Julie Klint (food & beverages), Eva Kovacs (quality control and editing Dutch/English), Bruce McLean (finance), Melanie Oley (survey gear), Dee Passenger (publications), Josh Passenger (project support, transport and sausages), Michael Pheasant (Cartographer, mapper of Shag Rock and dive officer), Lachlan Pollard (DOTY, trip writer, assistant Mapper of Shag, accommodation, and “Straddie” author), Lee Raby (mapper Flat West), and Douglas Stetner (photographer and mapper Manta Bommie).

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Skipper extraordinaire, Ken Holzheimer, director of Point Lookout SCUBA Charter and Accommodations. We owe you a big thanks for all your support, and especially for bringing us back safely, great job! This is the third UniDive conservation project that you have helped with.

Additionally, huge thanks to all the friends and family that helped out during the survey weekends: Joanne Edkins, Andy Findlay, Zara Passenger, Lockie Passenger, Eric Peterson, Konrad Peterson, Magnus Peterson, Nina Pheasant, Felix Pheasant, little zooxanthellae, Djoy Roelfsema, and Anouk Roelfsema.

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The project could not have succeeded without the financial support of the Redland City Council and Sibelco Australia Mineral Sands Community Grants Programs. Transit Systems / Stradbroke Ferries provided transport of our cars for training and survey weekends and Point Lookout SCUBA Charter with discounted dives and accommodation. Lecture rooms, survey equipment, and hard/software was provided through the School of Geography, Planning and Environmental Management and Biophysical Remote Sensing Group. General support was provided University of Queensland through: Dr. Ian Tibbets from the Centre for Marine Science; Dr. Kilpatrick, from the Shark and Ray Research Group; Kevin Townsend at the Moreton Bay Research Station, Coral Watch for the coral health charts, and, Adin Hewat from UQ Sport for organising the appropriate liability insurance so we could undertake our project.

UniDive PLEA is thankful to: Manta Lodge and Scuba Centre for their ongoing support and help with retrieving the permanent markers; Queensland Cyber Infrastructure Foundation (QCIF); Reef Check Australia providing support with method development and survey gear; Village Meats of Toowong.

The comments provided by the reviewers Nicola Udy and Paul Maxwell were invaluable and ensured a solid report was generated.

Lastly UniDive PLEA would like to show their respect and thank the traditional owners for providing us access to the beautiful dive sites of "Straddie".

Long nights and many emails I am typing these finishing sentences. Sentences like "I learned so much", "I am proud to be part of it", "It's great to work on a common goal", "after PLEA my dives are different, there is much more to see" - are comments from volunteers during the last year which gave me a big kick. This project was for me, a challenge, and a logical follow up of what UniDive did in 2001 and 2003. It had to happen. I just needed a push to do it again and now it's finished. The push came from a need to start something positive and inspiration from giving those in the club who are keen a volunteer a willing chance to make a difference.

Thank you! Now, Let's get ready for the next project, I am in.

Chris Roelfsema
UniDive PLEA Project Organiser

"Everything is awesome when you are part of a team"

Core PLEA divers during training weekend in January and March 2014.

Executive Summary

Introduction

In 2014, UniDive (The University of Queensland Underwater Club) conducted an ecological assessment of the Point Lookout Dive sites for comparison with similar surveys conducted in 2001. UniDive was awarded funding by Redland City Council and Sibelco Community Funds to map and conduct biological surveys of Flat Rock, Shag Rock and Manta Ray Bommie. Involvement in the project was voluntary. Members of UniDive who were marine experts conducted training for other club members who had no, or limited, experience in identifying marine organisms and mapping habitats.

Since the 2001 detailed baseline study, no similar seasonal survey has been conducted. The 2014 data is particularly important given that numerous changes have taken place in relation to the management of, and potential impacts on, these reef sites. In 2009, Moreton Bay Marine Park was re-zoned, and Flat Rock was converted to a marine national park zone (Green zone) with no fishing or anchoring. In 2012, four permanent moorings were installed at Flat Rock. Additionally, the entire area was exposed to the potential effects of the 2011 and 2013 Queensland floods, including flood plumes which carried large quantities of sediment into Moreton Bay and surrounding waters. The population of South East Queensland has increased from 2.49 million in 2001 to 3.18 million in 2011 (BITRE, 2013). This rapidly expanding coastal population has increased the frequency and intensity of both commercial and recreational activities around Point Lookout dive sites (EPA 2008).

Queensland Parks and Wildlife Service has conducted opportunistic Reef Health Impact Surveys at Point Lookout reefs, and since 2009 Reef Check Australia has carried out annual reef health surveys. The Point Lookout Ecological Assessment (PLEA) survey project contributes an extensive, detailed dataset that has built upon these rapid reef assessment approaches and has included seasonal variation and detailed information about reef composition, inhabitants, impacts and geography.

Methodology used for the PLEA project was based on the 2001 survey protocols, Reef Check Australia protocols and Coral Watch methods. This hybrid methodology was used to monitor substrate and benthos, invertebrates, fish, and reef health impacts. Additional analyses were conducted with georeferenced photo transects. The PLEA marine surveys were conducted over six weekends in 2014 totalling 535 dives and 376 hours underwater. Two training weekends (February and March) were attended by 44 divers, whilst biological surveys were conducted on seasonal weekends (February, May, July and October). Three reefs were surveyed, with two semi-permanent transects at Flat Rock, two at Shag Rock, and one at Manta Ray Bommie. Each transect was sampled once every survey weekend.

Outcomes

Based on the 2001 and 2014 studies, the Point Lookout reefs support 53 species of algae, three species of seagrass, 122 species of invertebrates, including 43 species of hard coral and 316 species of fish. The diversity of species observed in the waters off North Stradbroke Island indicates a complex, productive community.

Macroalgae and small turf algae were the most abundant group of organisms growing on the reefs surveyed in both 2001 and 2014. Average macroalgae cover across all sites was 32.7% in 2014 and 28.9% in 2001, and turf algae 28.4% in 2014 and 18.4% in 2001. The most commonly observed macroalgae were *Lobophora, Laurencia and Asparagopsis*, which suggest a change from 2001 when the macroalgal community was predominately more homogenous {*Asparagopsis*). Cover of hard and soft corals averaged for all sites was 7.9% and 1.4% respectively in 2014, versus 8.5% and 5.7% in 2001 with Shag and Flat Rock East having the highest coral cover. The most common hard coral types were encrusting and branching corals. 30 out of the 35 substrate indicators were observed.

Invertebrates observed included sponges, ascidians, sea cucumbers, anemones, sea stars, feather stars, sea urchins, nudibranchs and worms. As in 2001, less diversity of invertebrates was found at Shag Rock compared to Flat Rock. However, long spined and collector urchins were more abundant at Shag Rock.

Twenty out of the 21 indicator fish families and 22 out of the 25 target fish species were observed at Manta Ray Bommie, Flat and Shag Rock. The surveys indicated no major differences in fish composition between Flat and Shag Rock and no differences within sites over the sampling period, although there was varied species dominance over the seasons. No differences in fish composition or abundance were found when 2014 numbers were compared to 2001. Many of the fish targeted for human consumption were not found in great abundance.

Indicators of ecosystem health as surveyed in 2001 and in 2014 suggest that the North Stradbroke Island reefs have stayed in generally good health. There was no increase or presence of nutrient indicator algae (e.g. *Ulva spp.*) suggesting no obvious nutrient enrichment. Nor was there any obvious residual impact from major floods based on observation of the algae species present. Visual evidence of coral stress, such as coral bleaching, was only recorded at low levels. In 2014 coral disease was observed in low levels at all sites except for Manta Ray Bommie (with higher abundance at Shag Rock locations). As this parameter was not surveyed in 2001, it cannot be determined whether the prevalence of coral disease has changed.

One notable observation from the study was an increase in the recorded abundance of physical coral damage from unknown causes across all 2014 PLEA survey sites, except Manta Ray Bommie (damage was documented in highest abundance at Flat Rock West and Shag Rock East). Coral scars (from coral-eating *Drupella* snails and other unknown causes) were the only impacts observed at all sites. Rubbish was recorded only in low abundance, but fishing line was recorded at Flat Rock sites (Green Zone).

The biological assessment of North Stradbroke Island dive sites in 2014 was the first detailed reef-level seasonal survey since 2001. The 2014 and 2001 surveys have both demonstrated the diversity and complexity of these rocky reef systems. The 2014 survey has recorded some impacts from humans through increased presence of rubbish, physical damage to corals and potentially, fishing pressure. As no detailed surveys were performed between 2001 and 2014, nothing can be concluded about reef health during this transitional period (decline and recovery, incline and degradation, or, stability). However, the 2014 assessment has confirmed the importance of conservation of the Point Lookout dive sites, and the need for continued support for conservation efforts from the community and marine park managers.

Recommendations for Management and Community

The results of the PLEA project and the lessons learnt implementing the surveys lead to the following recommendations aimed at improving the health and understanding of the Point Lookout reefs:

Continued and improved monitoring of the Point Lookout dive sites.

- Repeating the ecological assessment on an annual basis (e.g. Reef Check, QPWS Reef Health Impact Surveys) and every five years seasonally (e.g. PLEA project) would be beneficial for proper understanding and management for conservation. A regular monitoring programme would enable distinction of long term changes in the reef community from short term (e.g. seasonal) changes, and better enable diagnosis of stressors to the reef (e.g. water quality issues).
- Permanent transect markers would enable a significant improvement in the quality and reliability of survey result comparisons between years and seasons.

Reduction of Physical Damage to Corals

Several complementary options could be introduced to avoid anchor damage to corals:

- No anchoring at Shag Rock (as is currently the case for Flat Rock).
- Anchoring on sand so anchor and chain are not able to impact the reef.
- Providing fixed public or private moorings.
- Educating divers, snorkelers, fishers and skippers on how to reduce physical damage.

Community Engagement to Create Awareness of the Beauty of the Reefs

- Educating the community about the Moreton Bay reefs will help preserve these resources for the future.
- The community can help build an understanding of local reefs through citizen science.

Support conservation of the reefs by providing peer reviewed information.

Scientific publications, reports and datasets (such as those from the PLEA project) should be available for local authorities, to help support management decisions. Information may include products such as:

- Project documents, such as this report and the associated research methods manual
- Peer-reviewed scientific papers describing key findings of the research. (Two papers are planned for publication based on the results of the PLEA project.)
- Open access datasets that may be used for additional scientific research and management applications. (Survey data collected as part of this project are to be uploaded to an open access data repository).

A more complete description of these recommendations is available in Section 0: Recommendations for Management and Community.

1. Introduction

In 2014, UniDive (the University of Queensland dive club) conducted an ecological assessment of flora and fauna at the Point Lookout dive sites, located on North Stradbroke Island in southeast Queensland. These sites comprise a number of rocky outcrops and reef ecosystems that support and attract a diverse range of marine flora and fauna. The current assessment replicated surveys conducted in 2001-2003 by UniDive. This report will describe the results of the data collected by the volunteer members of UniDive at the Point Lookout dive sites, and where possible, compare the observations with those reported in 2001-2003.

In 2001-2003 UniDive conducted two major survey projects: the Point Lookout Baseline Monitoring Project Funded by Coastcare (McMahon et al 2002), and the Grey Nurse Shark Habitat Mapping Project funded by Threatened Species Network (Ford et al 2003). Since then, no benthic surveys have been performed at a level of detail comparable to these studies. Beginning in 2009, Reef Check Australia has conducted substrate, invert and impact surveys at Flat and Shag Rock, in addition to individual researchers that have conducted fish surveys over winter 2010 and summer 2011 (Pers. Com Maria Beger).

Since the 2001-2003 initial UniDive surveys, several changes have occurred that could have impacted the reefs. These include increased commercial and recreational activities not limited to SCUBA diving, specimen collection, aquarium collection, recreational and commercial fishing, and, coincident anchor damage. In 2009 Flat Rock was protected from extractive activities (i.e. all recreational and commercial fishing and collection activities) as well as vessel anchorage unless moored on the public moorings now in place. Existing aquarium collectors at the time of the rezoning of the marine park in 2009 were allowed to continue collecting until March 2013 under transitional arrangements. In addition to anthropogenic effects, large-scale natural disasters have also occurred, the 2011 Queensland flood being an example. Despite the potential for negative reef impacts, no surveys have taken place at a comparable scale to the 2001-2003 UniDive surveys.

The aim of the 2014 UniDive Point Lookout Ecological Assessment (PLEA) project was to:

Repeat the ecological assessment of flora and fauna at the Point Lookout dive sites, and, report on the current status and any changes when compared with the 2001 study.

The survey methods were based on past surveys and other research initiatives, to enable direct comparison. The results of these surveys will be communicated not only through this report, but by a coffee table photo book *"Straddie, Flora and Fauna of Point Lookout Dive Sites"*, videos and presentations to the wider community, and to government agencies.

Bio-geographically, the study sites are located in a marine transition zone encompassing both tropical and temperate species. These subtropical reefs and the communities they support, exist in close proximity to their environmental limits (e.g. temperature, salinity and aragonite saturation (Kleypas et al. 1999)). They are also subject to high rates and magnitudes of fluctuating environmental conditions (Guinotte et al. 2003). Temperature plays an important role in species composition, with seasonal differences in fish and mobile invertebrate communities due to the recruitment of tropical species in summer, and the subsequent die-off of some species in winter (Booth et al. 2007).

As environmental parameters change (through natural causes or human activities), the community structure of subtropical reefs such as those at Point Lookout is also likely to change. We may see subtropical endemics declining (e.g. the morwongs), more tropical species becoming established (we might start seeing coral trout near Stradbroke!) (Riegl and Piller 2003; Greenstein and Pandolfi 2008; Funk et al. 2012), and, temperate species disappearing (Wernberg et al. 2011; Smale and Wernberg 2013).

2. General Methods

2.1. Overview

UniDive conducted four survey weekends, one in each season. During the surveys, 24 divers assessed a total of five sites at the most commonly dived locations: Shag Rock, Manta Ray Bommie and Flat Rock. Each survey involved broad scale mapping using a towed GPS (compass, depth readings and georeferenced underwater photos) and transect surveys (3 x 20 m transects were assessed for substrate type, reef impacts, and, fish and invertebrate species distribution and abundance).

The following section provides an overview of the survey methods (for full details see *Thurstan, R., Flower, J., Beger, M., Dudgeon, C., Gomez, K., Ortiz, J., Kovacs, E., Loder, J., Saunders, M., Passenger, J., Kleine D. and Roelfsema, C (2014). Survey Methods Manual UniDive Point Lookout Ecological Assessment (PLEA). The University of Queensland Underwater Club, Brisbane, Australia).* Survey methods used were based on Reef Check Australia methodology and were consistent with the methodology used in the 2001 UniDive surveys to ensure data could be compared. Surveys were conducted under a marine parks permit.

2.1.1. Survey Sites and Timing

Three sites (Flat Rock, Shag Rock and Manta Ray Bommie; Figure 1) were surveyed for fish, invertebrates, impacts, and benthic composition along transect lines deployed at a depth of 10 m below chart datum. Two transects at each of Flat Rock and Shag Rock were surveyed for comparison with 2001-2002 survey findings. One new site at Manta Ray Bommie was also surveyed, providing baseline ecological data for this site. Surveys were conducted four times during the year at each site to ensure that seasonal changes in the marine flora and fauna were captured in the data (Table 1).

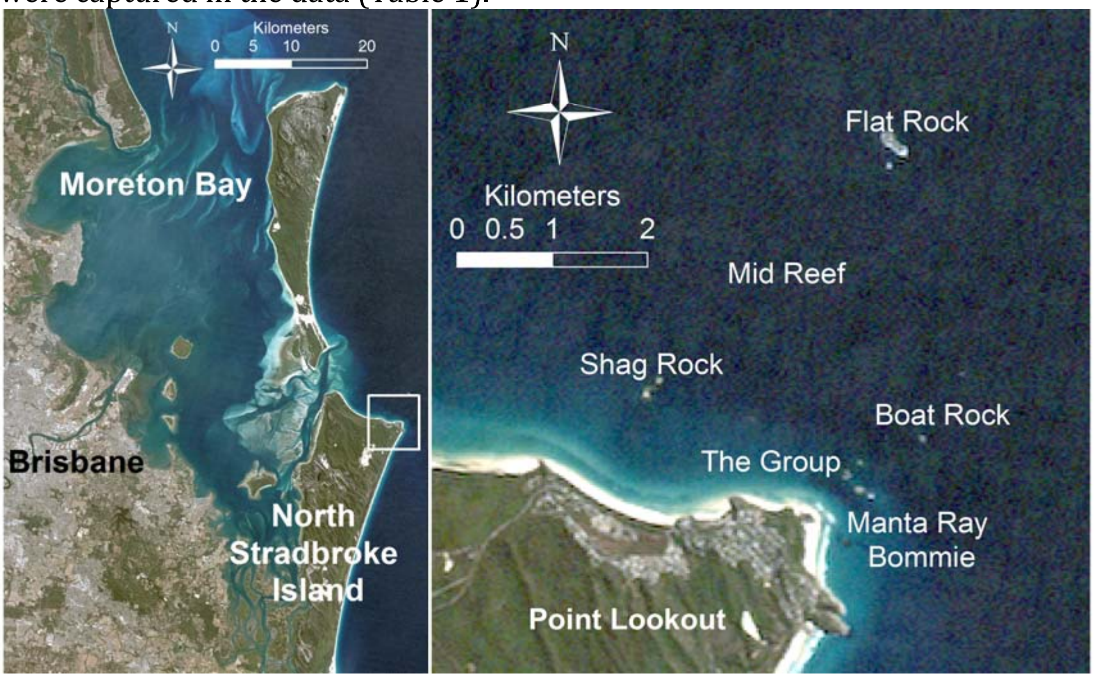


Figure 1: Point Lookout dive sites, North Stradbroke Island..The white box in the Moreton Bay Region (left panel) indicates the Point Lookout Dive sites at North Stradbroke Island. Approximate transect locations are indicated in yellow. Source image: Landsat Thematic Mapper 5, USGS.

Mapping of all sites was undertaken, with new site maps produced for Shag Rock and Manta Ray Bommie, and an update of the map produced in 2001 for Flat Rock.

Table 1: Seasonal survey dates for each transect location.

Site	Summer	Autumn	Winter	Spring
Flat Rock West (TFW)	22nd Feb. 2014	3rd May 2014	2nd Aug. 2014	25th Oct. 2014
Flat Rock East (TFE)	22nd Mar. 2014	3rd May 2014	2nd Aug. 2014	25th Oct. 2014
Shag Rock West (TSW)	22nd Feb. 2014	3rd May 2014	19th July 2014	25th Oct. 2014
Shag Rock East (TSE)	22nd Feb. 2014	3rd May 2014	19th July 2014	25th Oct. 2014
Manta Bommie (TM)	22nd Mar. 2014	4th May 2014	19th July 2014	30th Oct. 2014

At each survey location, semi-permanent markers were used to mark a 70 m transect, with markers deployed at 0 m, 25 m and 50 m. Within this 70 m length, three 20 m long transect lines were deployed and surveyed (Figure 2). Each 20 m transect followed the designated depth contour, separated from the next transect by a 5 m gap.

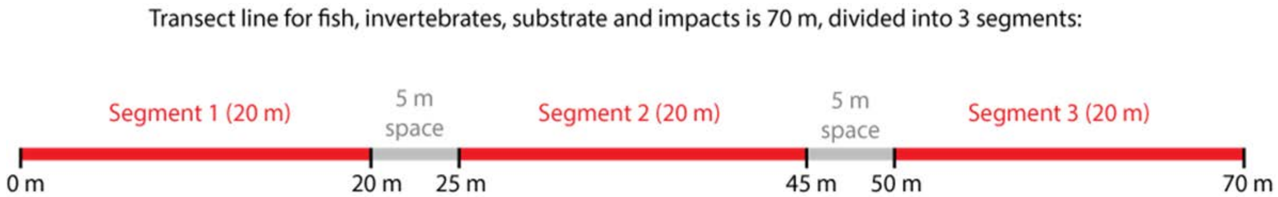


Figure 2: Placement of the transect lines.

For each survey, six pairs of divers undertook mapping and/or transect surveys to identify the species present and major features at each site. Fish, invertebrates, substrate and benthos were all surveyed. Photos and video of the transect and the site fauna were taken for later analysis and cataloguing of species.

2.1.2. Participants

UniDive is the University of Queensland Underwater Club. In 2014, UniDive was awarded Coastcare funding to conduct a baseline biological survey and also map the SCUBA dive sites of North Stradbroke Island. All participants in the program were volunteers, certified divers and members of UniDive. These volunteers encompassed marine experts, SCUBA instructors, mapping experts and people interested in learning about the marine environment. See Appendix A for a detailed list of the volunteers and their main task during the project.

2.1.3. Training and Quality Control,

Over the course of 25 educational lectures, more than 100 UniDive members learned about local reef ecology and survey protocols. Lecture topics included: coral and rocky reef ecology; survey methods; identification and biology of coral, algae, substrate, fish, and invertebrates; causes and assessment of impacts; database management; underwater photography and videography; mapping and buoyancy control. Practical training was assessed over two training weekends, putting knowledge to practice.

All divers (44) taking part in surveys were required to attend a series of lectures that provided training in survey methods. Competence in theory was assessed using an 130 question exam (pass mark 75% or higher). In-water survey training was also conducted to ensure divers were able to correctly identify the marine life and substrate to be surveyed and were competent to conduct surveys. A review session was organised before each survey weekend, and, on the eve of the first surveys of each survey weekend, the volunteers refreshed their memory by discussing survey categories with others whom would have the same survey task. Data sheets were used for surveys (see Appendix B: Data Sheets), which aided in quality control. The datasheets were checked for errors or inconsistencies both directly after dives and during the data processing stage. Results derived from the quality controlled data were presented after each survey weekend by UniDive members with a marine science background in their field, thus providing additional quality control.

2.2. Mapping

Mapping of the three sites was conducted to generate maps of the main features (e.g. major substrate types, gullies and ridges) and provide a reference for future ecological surveys and planning and zoning of the sites (e.g. installation of mooring buoys). Feature mapping was undertaken on each transect by two divers. This buddy pair conducted a roving survey of each site, to a maximum depth of 20m, and recorded characteristic features. Feature location was mapped by cross-referencing the time each feature was recorded or photographed, with GPS data recorded by a floating GPS towed by one of the two divers (Figure 3).

Figure 3: Conceptual diagram of the georeferenced photo transects.

For the five survey sites, images were taken at 2 m intervals along the transect tapes, 0.5 m above the substrate providing a 1 m^2 foot print. This diver towed a dry bag in which a standard GPS logged the track of the transect (Figure 3).

The collected images were analysed for benthic composition using Coral Point Count Excel (Kohler 2006) in which twenty-four random points were plotted on the photo and manually assigned one of the substrate classes assessed in the study (see details on classes in the substrate and benthos section). More detail is available in the georeferenced photo transect manual (Roelfsema et al 2009). All georeferenced photos that documented each of the reefs were plotted on top of the basic site map for each location to provide additional information for the mapping.

2.3. Fish Species and Families

Fish populations were assessed using a visual census along 3 x 20 m transects. Each transect was 5 m wide (2.5 m either side of the transect tape), 5 m high and 20 m in length (Figure 4). One diver counted target fish families while the other counted indicator species as highlighted on the data sheets (Appendix B: Data Sheets). Each 20 m transect was completed in 7-10 minutes.

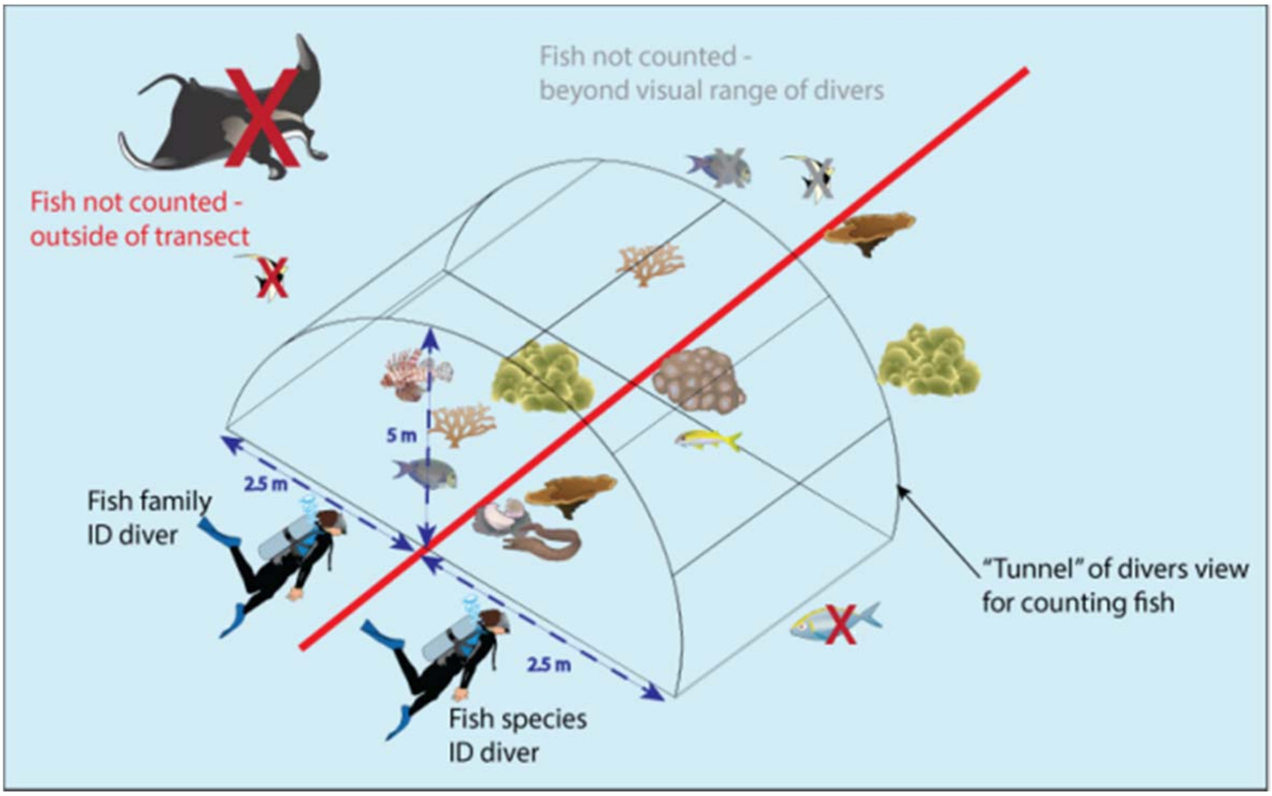
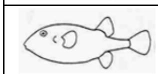
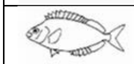
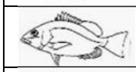
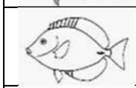
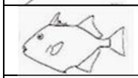
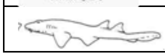


Figure 4: Diagrammatic representation of the fish survey transects showing the imaginary frame of the diver's view. Fish outside of the diver's view were only counted if they subsequently entered the view eg manta ray.

Fish families and species were chosen that are commonly targeted by recreational or commercial fishers, or targeted by aquarium collectors, and that were easily identified by their body shape (Table 2). Rare or otherwise unusual species were also recorded.

Table 2. Indicator fish families. Common family names occur in uppercase and the corresponding latin family names are in brackets. "Fished" indicates species within thefamily that are commonly fished for consumption. "Aquarium trade" indicates those families that are targeted by aquarium collectors globally (see Hodgson and Liebeler 2002).

	Family	Fished	Aquarium trade
	ANGELFISH (Pomacanthidae)		✓
	BUTTERFLY FISH (Chaetodontidae)		✓
	CARDINAL FISH (Apogonidae)		✓
	CODS/GROUPERS (Serranidae)	✓	✓
	DAMSEL FISH (Pomacentridae)		✓
	EMPERORS (Lethrinidae)	✓	
	GOAT FISH (Mullidae)		
	LEATHERJACKETS (Monocanthidae)		
	LION/STONE FISH (Scorpaenidae)		✓
	MORAYS (Muraenidae)		✓
	PARROTFISH (Scarridae)	✓	✓
	PIPEFISH/SEAHORSE (Sygnathidae)		✓
	PORCUPINE FISH (Diodontidae)		
	PUFFERFISH (Tetraodontidae)		
	RABBITFISH (Siganidae)	✓	
	SNAPPERS (Lutjanidae)	✓	
	SURGEONFISH (Acanthuridae)		✓
	SWEETLIPS (Haemulidae)	✓	
	STINGRAYS	✓	
	TRIGGER FISH (Balistidae)	✓	
	WRASSE (Labridae)	✓	✓
	WOBBEGONG	✓	✓

2.4. Invertebrates

Target invertebrate populations were assessed using visual census along 3 x 20 m transects. Each transect was 5 m wide (2.5 m either side of the transect tape) and 20 m in length. The diver surveying invertebrates conducted a 'U-shaped' search pattern, covering 2.5 m on either side of the transect tape (Figure 5). Each 20 m transect was completed in 7-10 minutes. See Appendix B: Data for datasheet.

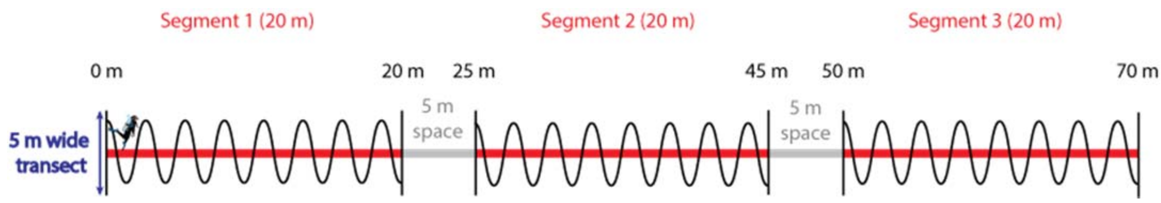


Figure 5: Diagrammatic representation of the invertebrate and reef impact survey transects. Divers swam a 5m wide transect in a U-shaped pattern along the transect tape.

2.5. Substrate and Benthos

Substrate surveys were conducted using the point sampling method, enabling percentage cover of substrate types and benthic organisms to be calculated. The survey method was based on the Reef Check Australia methods (Hill and Loder 2013) and was consistent with the methods used in 2001.The substrate or benthos under the transect line was identified at 0.5m intervals, with a 5m gap between each of the three 20m segments (Figure 6).

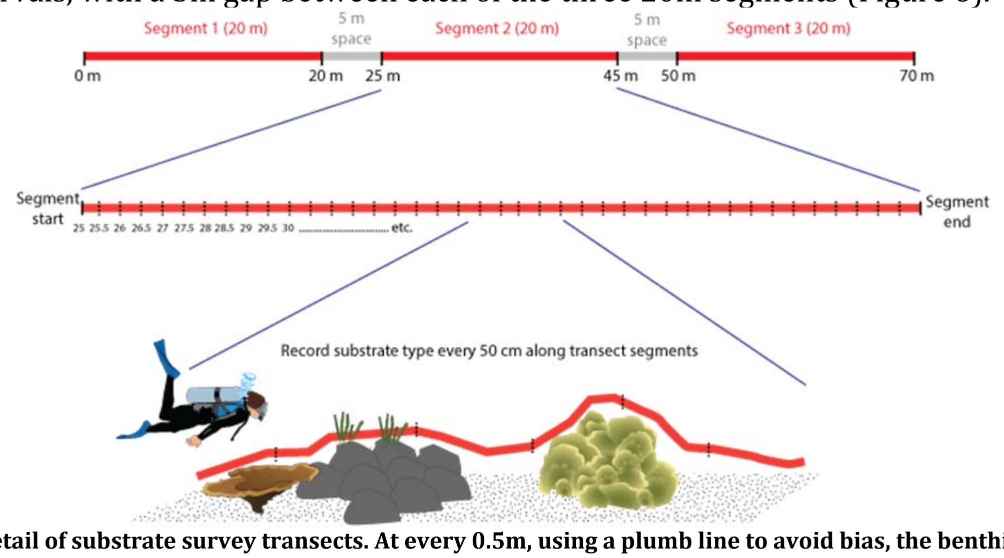


Figure 6: Detail of substrate survey transects. At every 0.5m, using a plumb line to avoid bias, the benthic category located directly beneath the transect tape was recorded.

Categories recorded included various growth forms of hard and soft coral, key species/growth forms of algae, other living organisms (i.e. sponges), recently killed coral, and, non-living substrate types (i.e. bare rock, sand, rubble, silt/clay). See Appendix B: Data for data sheet. The georeferenced photos taken along the transect (Section 2.2) provided an additional source for benthic assessment.

To compare the total coral cover between 2001 and 2014 a permutational general linear mixed model was conducted with YEAR as a fixed factor and SITE as an unreplicated random factor.

2.6. Reef Impacts

Target impacts were assessed using a visual census along the 3 x 20 m transects. Each transect was 5 m wide (2.5 m either side of the transect tape) and 20 m in length. The transect was surveyed via a 'U-shaped' search pattern, covering 2.5 m on either side of the transect tape (Figure 5). Each 20 m transect was completed in 7-10 minutes. See Appendix B: Data for datasheet.

To assess if the differences in impact between the sites were significant, a permutational general linear mixed model was conducted, with SITE as a fixed factor, SEASON as an un-replicated random factor, and TOTAL NUMBER OF IMPACTS standardized by CORAL COVER as the response variable.

Coral bleaching was assessed using coral health charts developed by CoralWatch (www.coralwatch.org). Divers selected individual coral colonies along the 3 x 20 m transects (to a maximum of 20 colonies). For each colony the diver used the coral health chart to record the darkest and lightest colour present, thus giving an approximate assessment of coral health including bleaching.

2.7. Species List

Flora and fauna species lists reported in 2001 and 2003 from previous volunteer projects were reassessed and updated. This was done by:

1) Identification of flora and fauna from photos and videos taken by divers at the dive sites during and outside the survey weekends.
2) Those volunteers with detailed knowledge of the local flora and fauna recorded any non-surveyed species.
3) Literature searches for marine flora and fauna identified at Point Lookout Reefs but not noted in the existing list.
4) Previous data sets collected by volunteers on the project such as that of fish species by Dr. Maria Berger.

The species list has been compiled in Appendix B and represents what has been observed at the Point Lookout Dive sites generally but not specifically during this study..

3. Results

3.1. Survey Considerations

Surveys were conducted over a total of 11 days from February to October 2014. Table 3 summarizes the environmental conditions documented during the survey dates. For the duration of the study, the water temperature at the bottom (SBT) ranged from 18 °C in July to 26 °C in February. Of note, the average visibility was ~14m, and, the highest waves were recorded in July (3.1 m). The survey dates were chosen as being representative of the four seasons, allowing the study of potential seasonality patterns.

Table 3: Environmental conditions during each of the survey weekends (Source: Bureau of Meteorology, Wave Rider Buoys, divers participating in the PLEA project).

Date	Dive	SST	SBT (10m)	Wind (9 am) (knots)	Wind direction (8am)	Wind (3 pm) (knots)	Wind direction (3 pm)	Visibility (m)	Cloud cover (9 am)	Cloud cover (3 pm)	Rain (mm)	Wave Height (m)
31/01/2014	Marker	NA	24	NA	NA	15-20	SE	25	NA	NA	0	1.4
1/02/2014	Training	NA	24	NA	NA	10-15	SE	20	NA	NA	0	1.4
1/02/2014	Training	NA	25	NA	NA	5-10	SE	20	NA	NA	0	1.4
22/02/2014	Survey	25	26	20	S	20	SSE	5	8	8	0.2	2.01
23/02/2014	Survey	25	26	27	SSE	23	SSE	5	7	4	0	2.72
8/03/2014	Marker	26	25	15	SE	NA	NA	20	3	NA	0	1.61
22/03/2014	Survey	26	25	0	CALM	7	ESE	10	5	1	0.5	1.68
29/03/2014	Training	28	26	NA	NA	0-5	NA	10	NA	NA	0	1.4
30/03/2014	Training	28	26	NA	NA	0-5	NA	10	NA	NA	0	1.4
3/05/2014	Survey	23	23	10-15	SE	10-15	SE	10	NA	NA	0	0.82
4/05/2014	Survey	22	22	10-15	SE	10-15	SE	12	NA	NA	0	0.62
19/07/2014	Survey	19	18	6	SW	5	E	15	0	0	0	2.95
20/07/2014	Survey	19	19	14	SSW	12	SW	15	4	5	0	3.1
2/08/2014	Survey	20	19	5	SW	11	SE	15	0	0	0	1.7
25/10/2014	Survey	NA	23	15-20	N	20-25	NE	15	NA	NA	NA	1.2
26/10/2014	Survey	NA	23	15-20	NE	20-25	NE	15	NA	NA	NA	1.8
30/10/2014	Survey	NA	23	10-15	SE	10-15	SE	15	0	0	0	1.2

3.2. Mapping

Georeferenced habitat maps (UTM-WGS84) were created for Shag Rock (Figure 7), and Manta Ray Bommie dive sites (Figure 8). The existing map of Flat Rock (Figure 9) was adjusted from the 2001 map based on additional surveys.

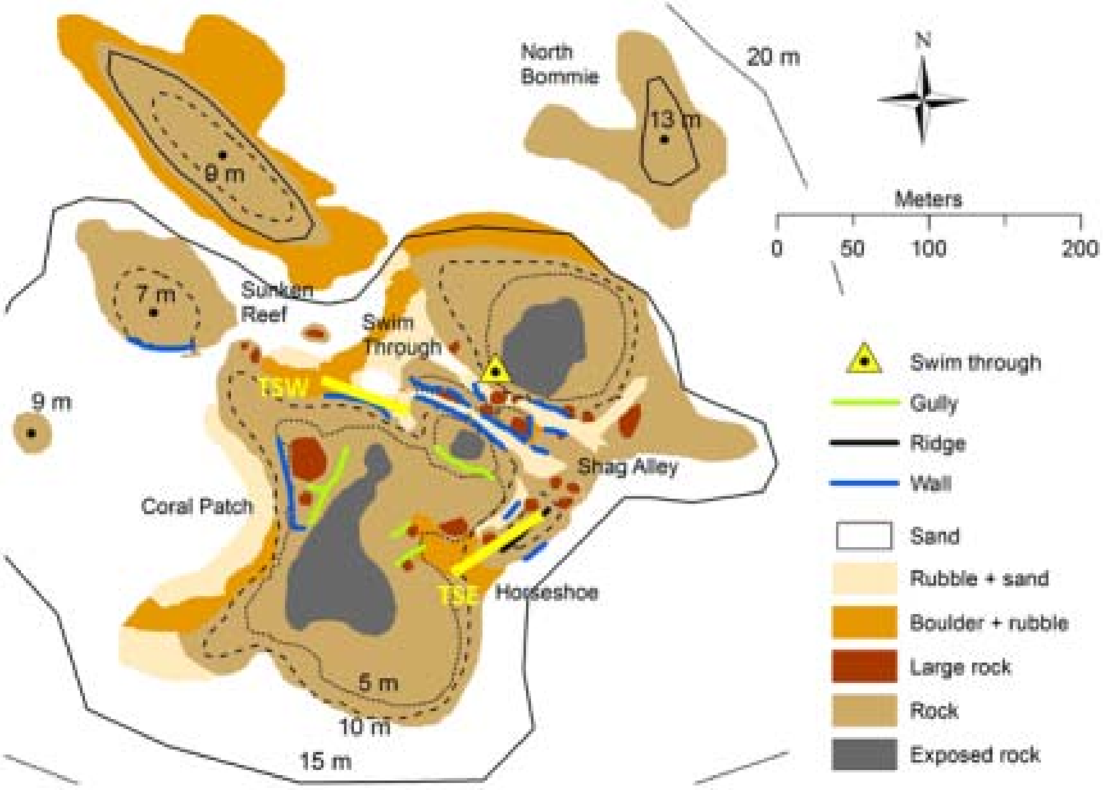


Figure 7: Prominent features at Shag Rock, North Stradbroke Island, Australia. The transect survey sites are indicated in yellow.

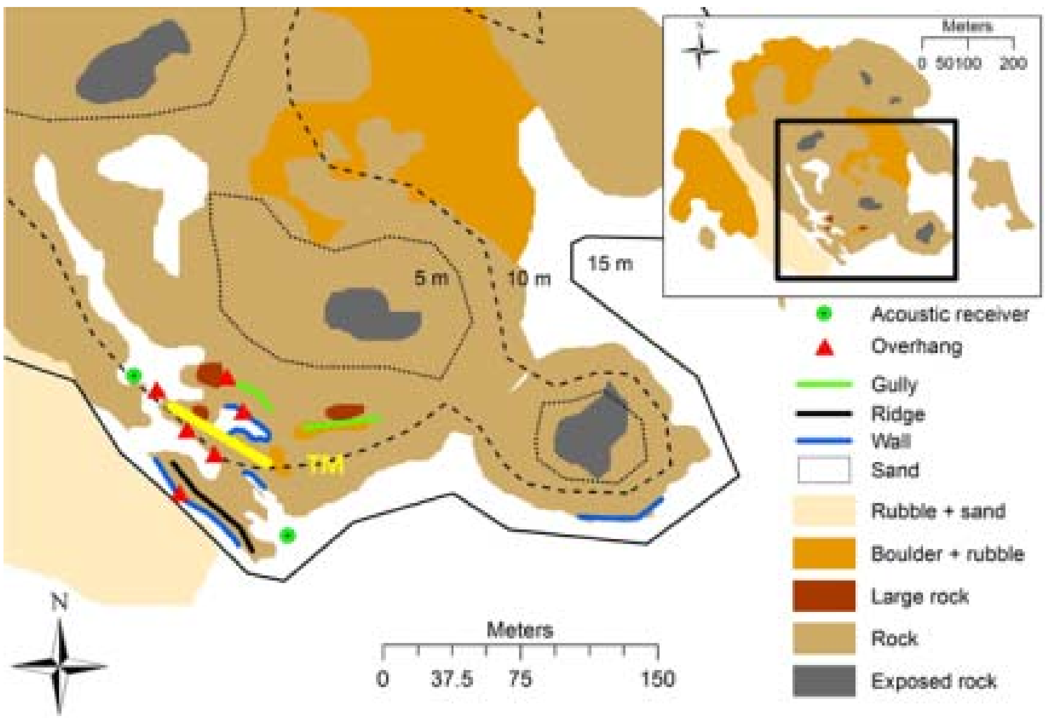


Figure 8: Prominent features at Manta Ray Bommie, North Stradbroke Island, Australia. The transect survey site is indicated in yellow.

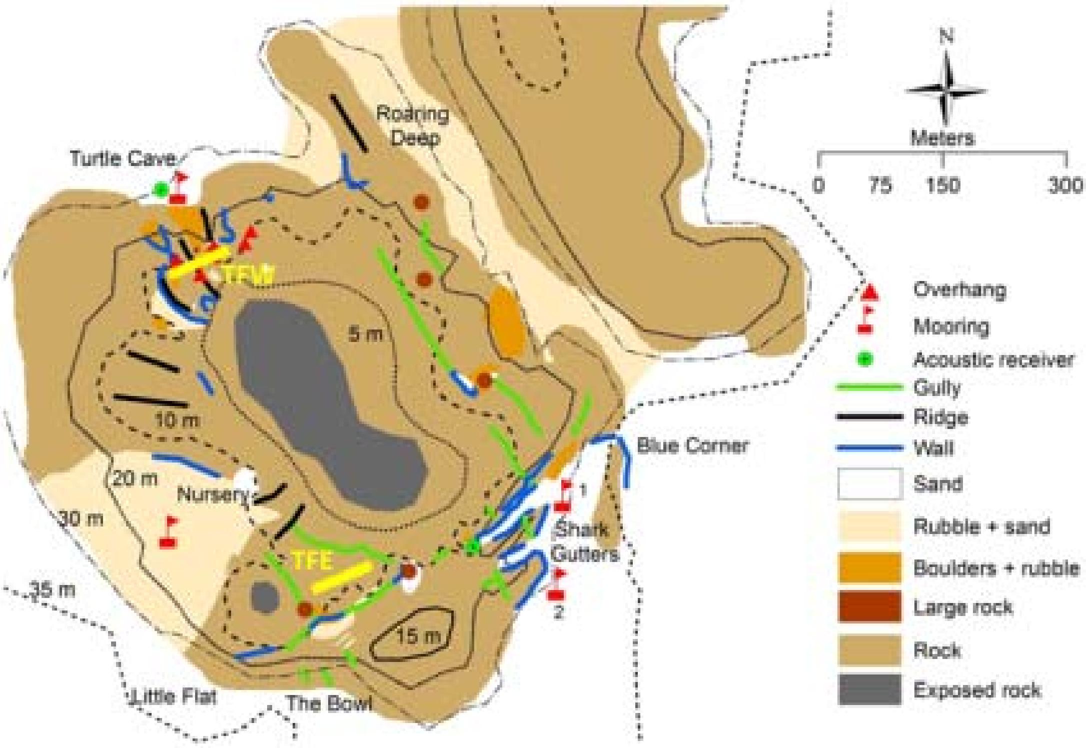


Figure 9: Updated map of prominent features at Flat Rock, North Stradbroke Island, Australia. The transect survey sites are indicated in yellow.

Refer to Appendix C for a detailed location of the transects, and to Appendix D for coordinates of the start and end points of the transects.

3.3. Fish

3.3.1. Fish families

For simplicity, the observed numbers of the key fish groups were averaged over the year for each of the survey sites and are displayed in Figure 10. Angelfish, butterflyfish, rabbitfish, surgeonfish and goatfish were common at all sites, although butterflyfish were observed in lower abundances at the nearshore sites (both Shag Rock sites and Manta Ray Bommie; Figure 10). Manta Ray Bommie had high abundance of groupers, and surgeonfish. Parrotfish, as a purely tropical group, also had low abundance, and were restricted to two species.

The rarest families were mega-fauna such as sharks and rays, predators such as emperors, snappers, and groupers, and cryptic fauna such as moray eels, lionfish and leatherjackets.

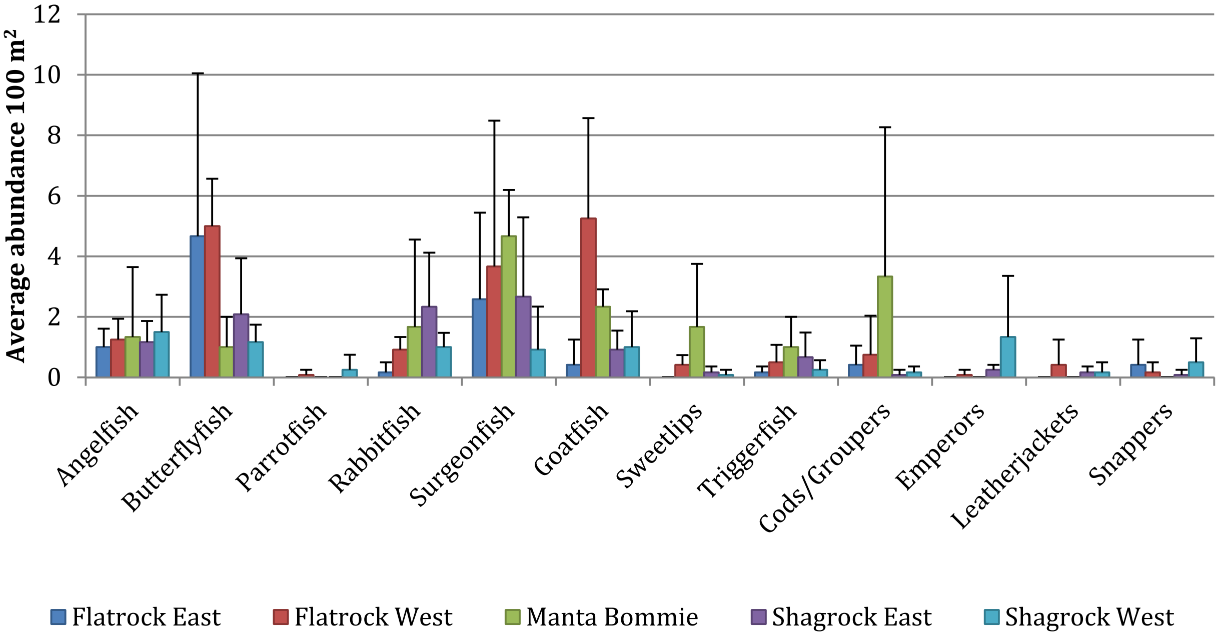


Figure 10: Average abundance of target fish families for the five sites surveyed excluding wrasses and damselfish (error bars indicate standard deviation).

Overall, wrasses and damselfish had the highest total abundance at all sites (annual combined site average of 85.9 x 10^2 for damsels and 9.9 x 10^2 for wrasses). These two families were omitted from Figure 10 as their high abundances obscured trends in other groups, but are shown in Figure 11. Figure 11 and Appendix E demonstrate that damselfish are more abundant than wrasses, but both families are more than ten times more abundant than other groups (Figure 10 and Figure 11).

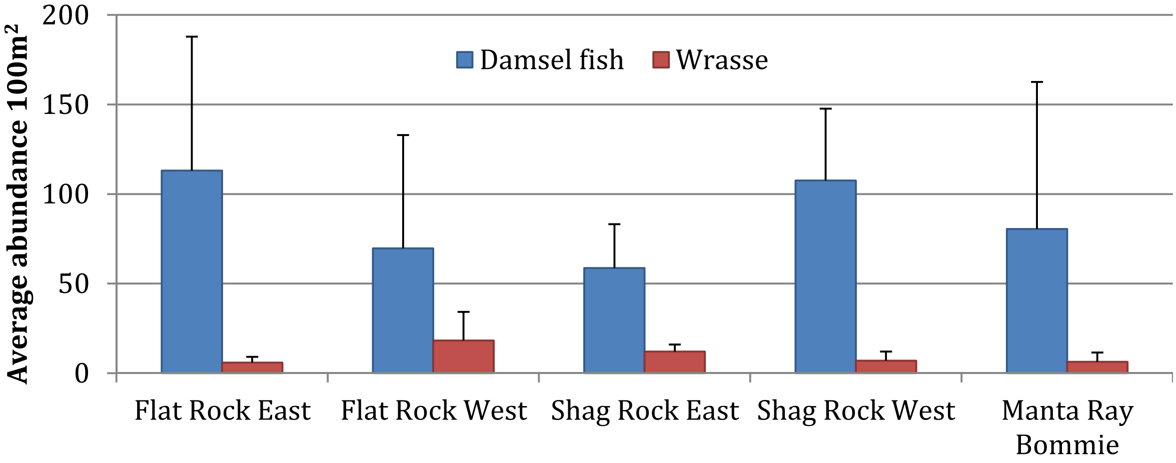


Figure 11: Average abundance of damselfish and wrasse families for the five sites surveyed. (error bars indicate standard deviation)

Seasonal patterns

Surveys conducted at different times of year revealed important trends in functional groups. Herbivorous families (Figure 12) were observed primarily in summer and autumn. Predatory families were generally not abundant and seasonal variations were not apparent. In regards to the tropical and subtropical corallivores and omnivores, angelfish showed no seasonal variation, but butterfly fish were more abundant in autumn at exposed sites, and more abundant in winter at the near-shore sites. Of the invertivore group, only goatfish were prevalent. Goatfish abundance peaked in autumn and winter (at Flat Rock West). See Appendix E for more detailed information on the Fish families.

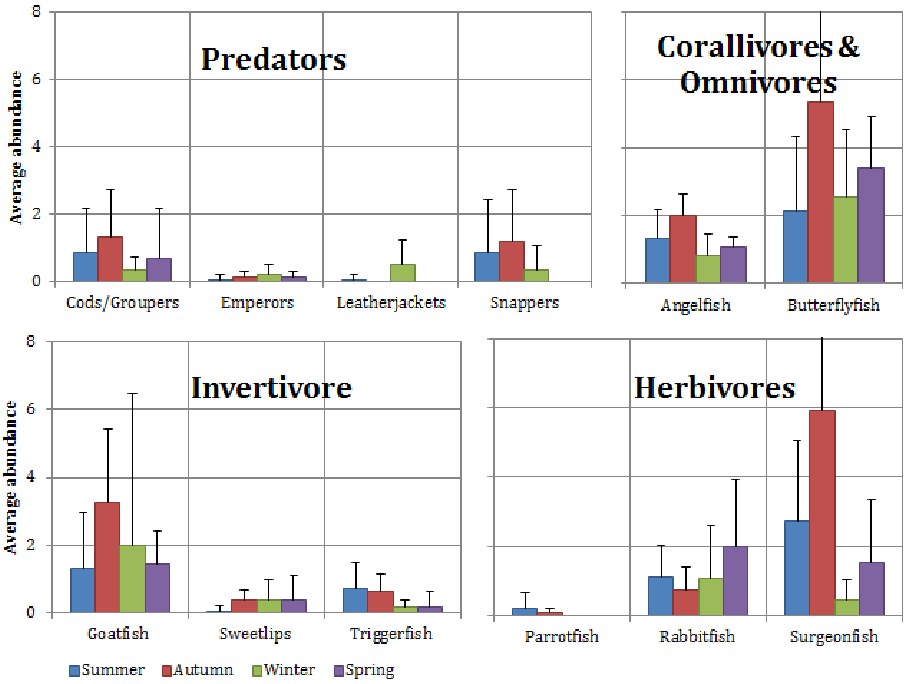


Figure 12: Seasonal abundance of predators, tropical and subtropical corallivores and omnivores, invertivores and herbivores. (error bars indicate standard deviation)

3.3.2. Fish Species

A set of target fish species were selected as surrogates to indicate the overall fish assemblage. Factors considered were the function of fishes on the reef (e.g. herbivory, corallivory), tropical, and subtropical zoogeographic affiliation, and ease of identification by volunteer divers. The species surveyed in 2001 were also included to enable temporal comparisons. Seasonal surveys show that the fish community changes throughout the year, as outlined.

Blue damselfish were one of the target fish species recorded, however, due to their high abundance, they have been treated as an isolated group so as not to hide trends in other species. The average abundance of blue damselfish at all sites is shown in Figure 13, and is more than 15 times greater than for other species surveyed.

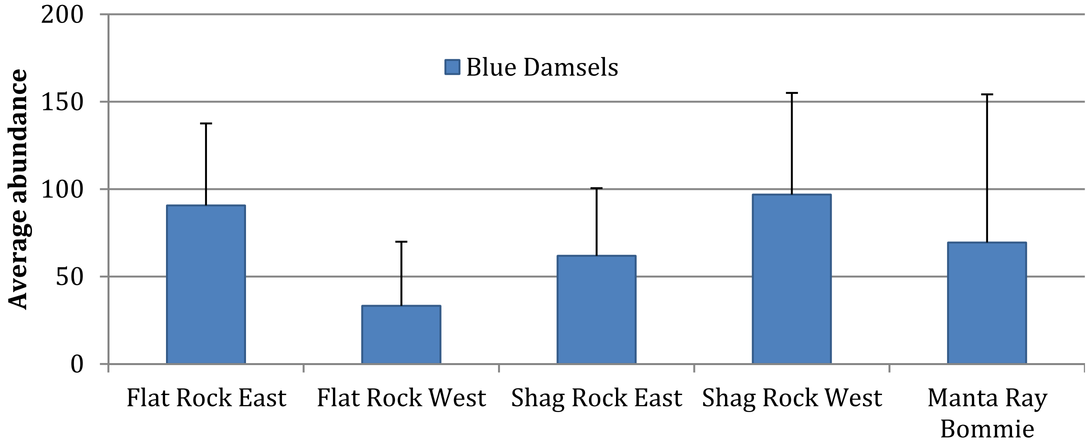


Figure 13: Average abundance of blue damsels at each of the five sites surveyed. (error bars indicate standard deviation)

Subtropical species

Subtropical species are generally present year round (Figure 14). Big scaled scalyfin, coral sea Gregory and Guenthers were the most prevalent.

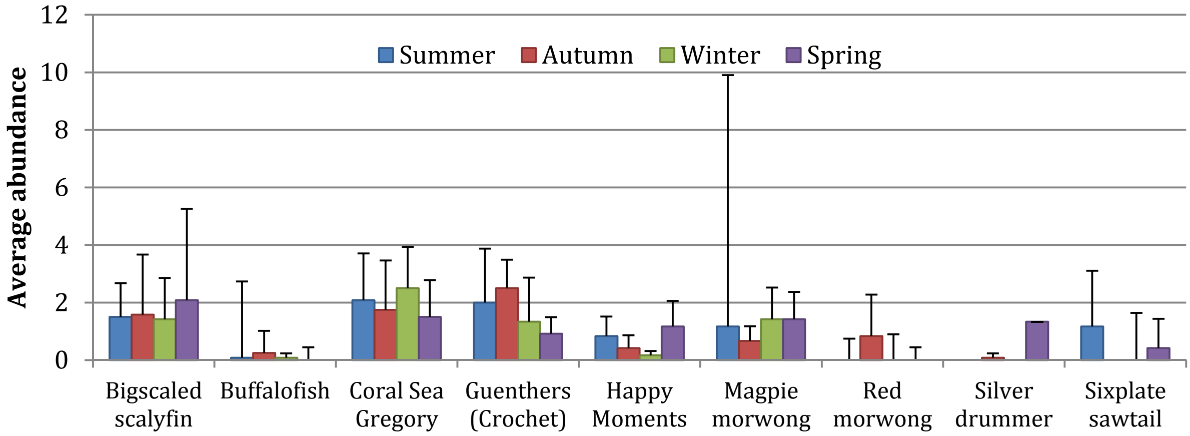


Figure 14: Seasonal abundance of subtropical fish species. (error bars indicate standard deviation)

Tropical species

Most of the tropical species surveyed were more abundant in summer and autumn than winter and spring (Figure 15). Second to blue damsels (Figure 13), wrasses were observed to be the most abundant indicator species each season.

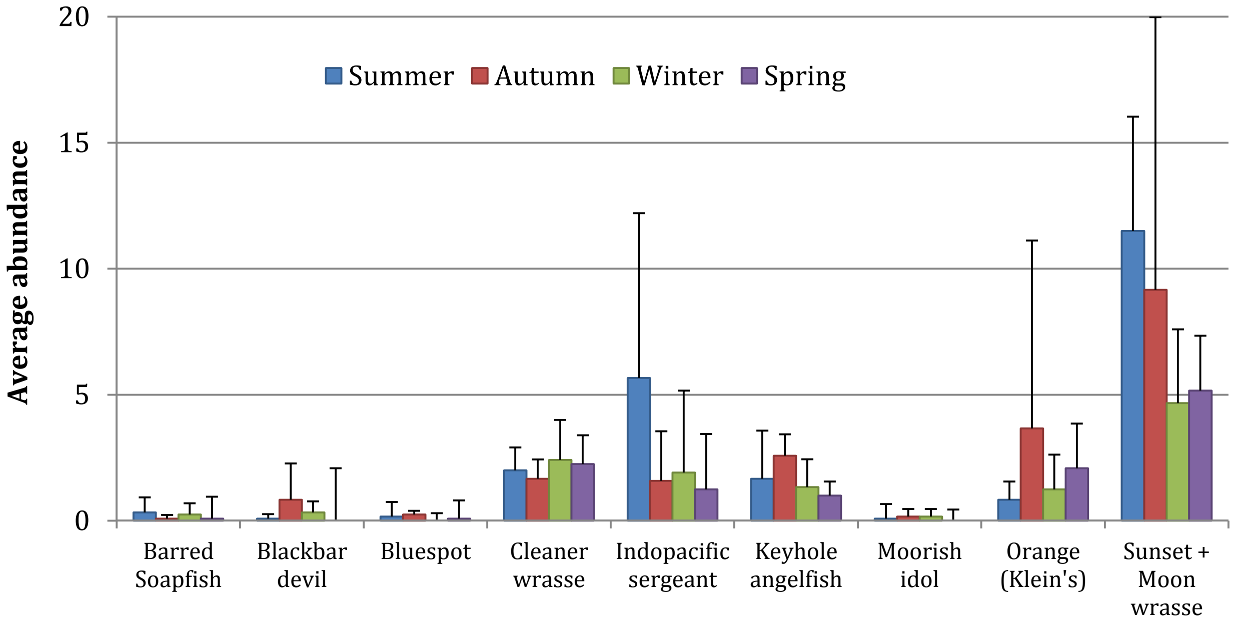


Figure 15: Seasonal abundance of tropical fish species. (error bars indicate standard deviation)

Additional Indicator Species

Several fish species selected for indicators did not have a specific tropical or subtropical range and showed no seasonal variation (not shown). However, these species demonstrated site-based preferences (Figure 16). Triggerfish were rare at Shag Rock, whilst Boxfish were only observed at the coastal sites. See Appendix F for more detailed information on the Fish Species.

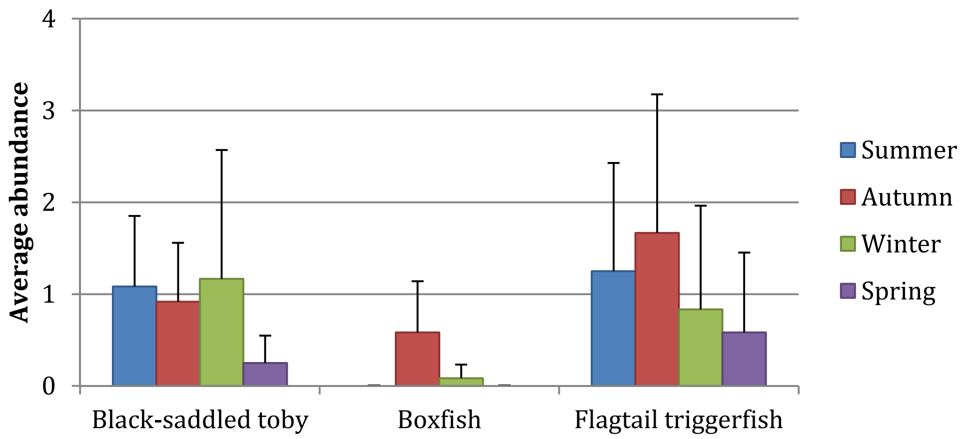


Figure 16: Site-specific abundance of additional indicator fish species surveyed. (error bars indicate standard deviation)

3.4. Invertebrates

Diadema, or long spine sea urchins were the most abundant invertebrate at both Shag Rock sites (

Figure *17*). The average observed number of collector urchins at Shag Rock West was higher than at any other site, whilst Manta Ray Bommie had the highest abundance of pencil urchins.

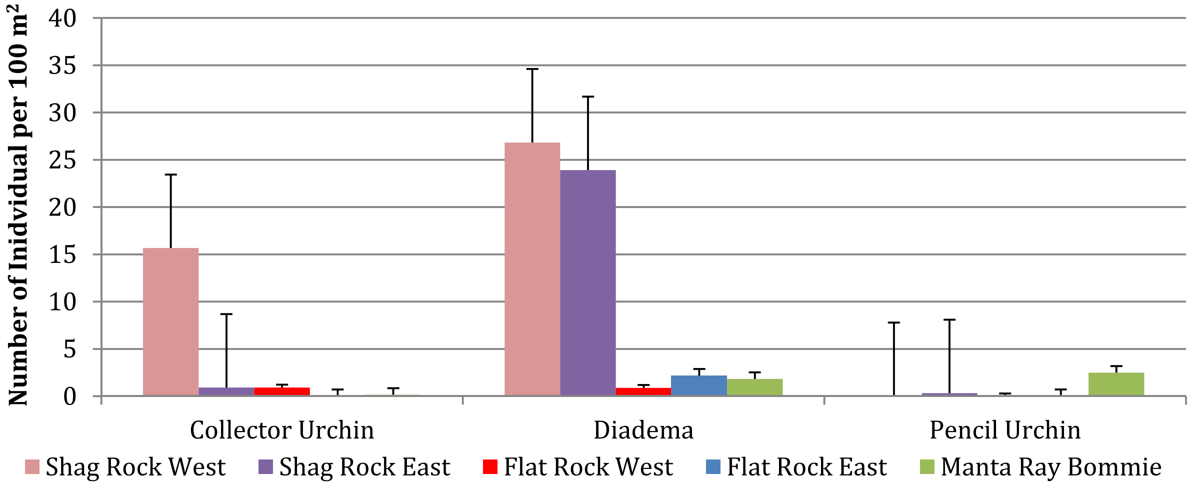


Figure 17: Average abundance of indicator urchins for all sites. (error bars indicate standard deviation)

With the exception of anemones (with or without fish) and banded coral shrimp, Flat Rock sites had a low abundance of indicator invertebrates, compared to Shag Rock sites (Figure 18). Anemones with or without fish were the dominant invertebrate observed at both Shag Rock sites, Flat Rock West and Manta Ray Bommie. More anemones were found without anemone fish than with fish, at all sites.

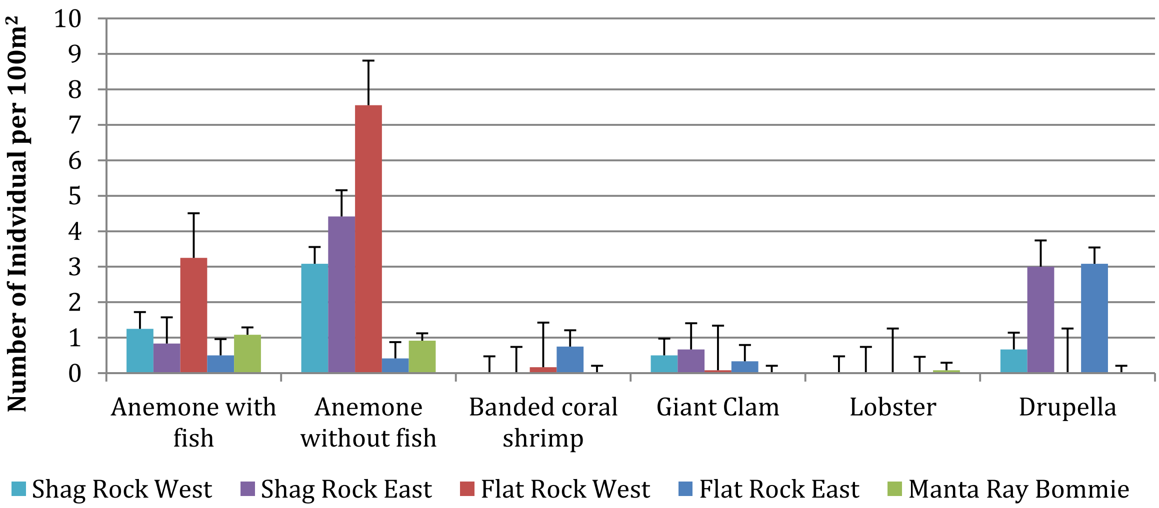


Figure 18: Average number of indicator invertebrates for all sites. (error bars indicate standard deviation)

Drupella snails were found in greatest numbers at Shag Rock East and Flat Rock East. Lobster sightings were low at all sites.

3.5. Substrate and Benthos

Substrate and benthic data collected using the photo analysis method showed that macro algae (e.g., *Lobophora*, *Asparagopsis* and *Laurencia*) and turf algae accounted for the highest percentage cover (>50%) of the substrate types at all sites throughout the year (

Figure *19*). Of the macro algae recorded, *Asparagopsis* was most abundant at Flat Rock East and *Laurencia* at Manta Ray Bommie. All sites had a high cover of *Lobophora*.

Coral cover varied between the sites. The highest coral cover occurred at Flat Rock East, averaging 22.8% across all surveys, and mainly consisting of encrusting (11.1%) and branching type hard corals (7.7 %), as well as soft coral (0.9%). Shag Rock East had the second highest coral cover (14.4%), with the majority of corals being of the branching or foliose variety (5.7 %), encrusting (2.3%) in addition to 2.4% soft coral cover. Manta Ray Bommie had the lowest average coral cover (less 1%). Encrusting coral cover was only observed in significant quantities at Flat Rock East, and was rarely observed at the other sites.

No major seasonal differences in substrate and benthic cover were observed, although there was some variability in all categories. These trends are also apparent when the benthic cover is averaged for each site, disregarding seasonality (
Figure *20*).

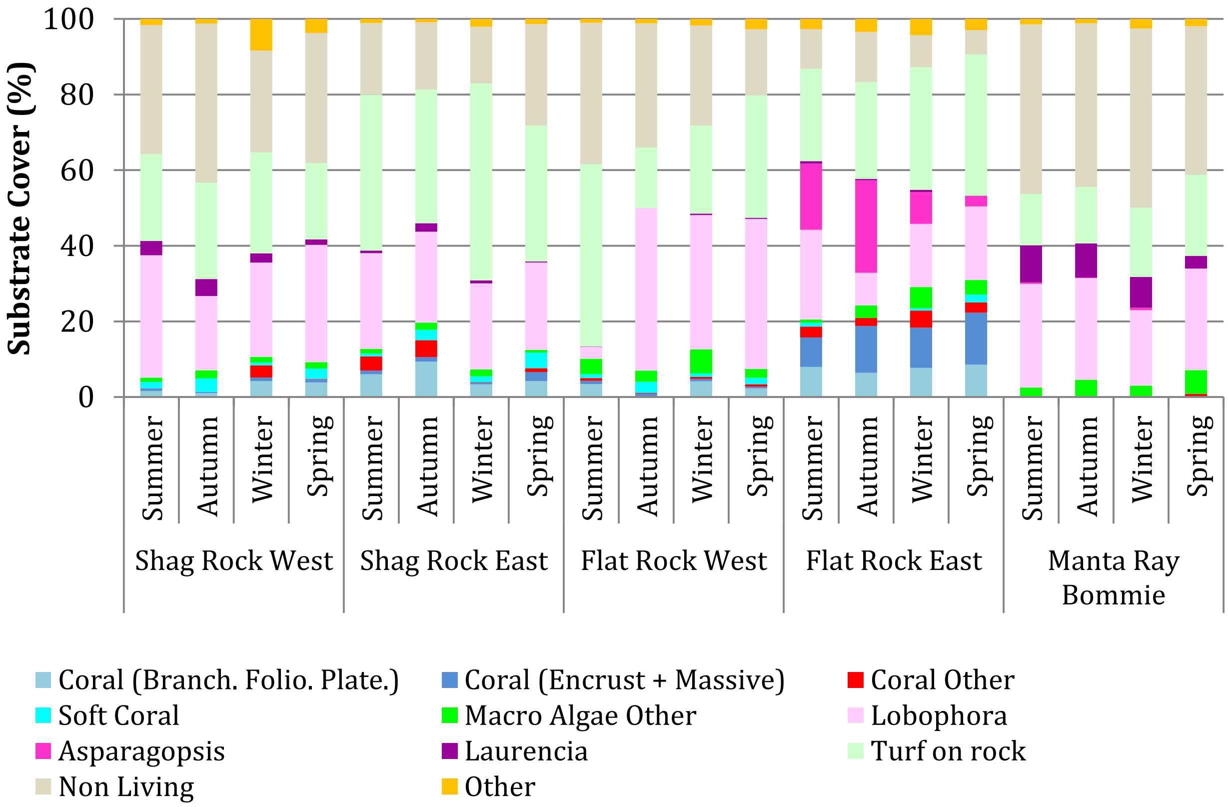


Figure 19: Summary of substrate type for each season derived from analysis of benthic photos.

Figure 20: Summary of substrate type averaged over the four seasons derived from photo analyses.

In addition to photo transects, substrate and benthic cover data was collected using point intercept surveys carried out by divers *in situ*. Photo analysis results versus diver surveyed substrate data showed similar overall trends (Appendix G), however the photo transect data was more consistent. Results from both surveys are shown in Appendix G. Photo transects are more consistent over the seasons, for each site, but, the diver based data identifies variations in individual substrate categories.

3.6. Impacts

3.6.1. Reef Health Impacts – Individual Sites

Figure 21 demonstrates the reef health impact per site, normalized for the coral cover (percentage of substrate cover) present at that site. Normalising impact abundance with coral cover acknowledges that many reef impacts specifically affect corals, and as such, the ratio of coral cover to impact abundance should be considered when interpreting reef impact data. Both Shag Rock sites had significant numbers of observed impacts (*Figure 21*; Table 4). Additionally, Shag Rock West had a significantly higher number of impacts than Flat Rock West, and similarly, Shag Rock East recorded a significantly greater number of impacts than Flat Rock East (*Figure 21*; Table 4). At the two Shag Rock locations, the highest average abundance of physical coral damage (unknown causes) and coral disease were observed. Physical coral damage can be caused by natural causes such as storms, or anthropogenic factors such as boat anchoring, divers, snorkelers and fishing.

The site with the lowest recorded reef impacts and the only site where coral damage was not recorded was Manta Ray Bommie (Figure 21), however, this site has the lowest coral cover (

Figure *19*,
Figure *20*). Low levels of rubbish were recorded at Flat Rock East, Flat Rock West whilst the highest was observed at Manta Ray Bommie. Coral scars (from *Drupella* snails and unknown causes), coral disease, physical damage and rubbish were recorded consistently at both Shag Rock, and, both Flat Rock locations. Coral bleaching was not included in this section but has been addressed in the coral health survey.

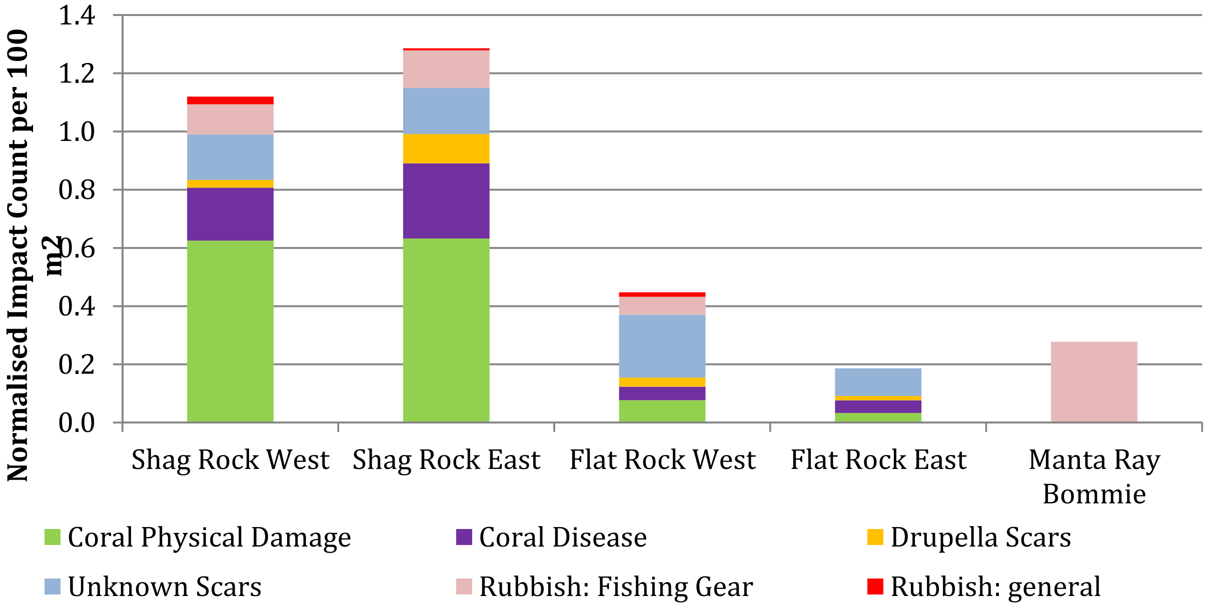


Figure 21: Normalised cumulative abundance of reef health impacts weighted by coral cover per site across 2014 surveys.

Table 4: Post-hoc multiple comparison of reef impacts per site, per season. Sites were statistically significant (Pseudo F = 5.2309, p = 0.018).* values represent statistical significance, ** represent marginal significance.

	Shag Rock West	Shag Rock East	Flat Rock West	Flat Rock East	Manta Ray Bommie
Shag Rock West					
Shag Rock East	0.704				
Flat Rock West	0.040*	0.069**			
Flat Rock East	0.051**	0.060*	0.060*		
Manta Ray Bommie	0.251	0.329	0.594	0.243	

3.6.2. Reef Health Impacts - Seasonality

Seasonally, Shag Rock sites consistently had the highest abundance of reef impacts (Figure 22). Manta Ray Bommie had the lowest abundance of reef impacts (one instance of discarded fishing line), but also the lowest coral cover (

Figure *19*,
Figure *20*). The observed trends suggest that there are no major seasonal variations with respect to the type of reef impacts recorded.

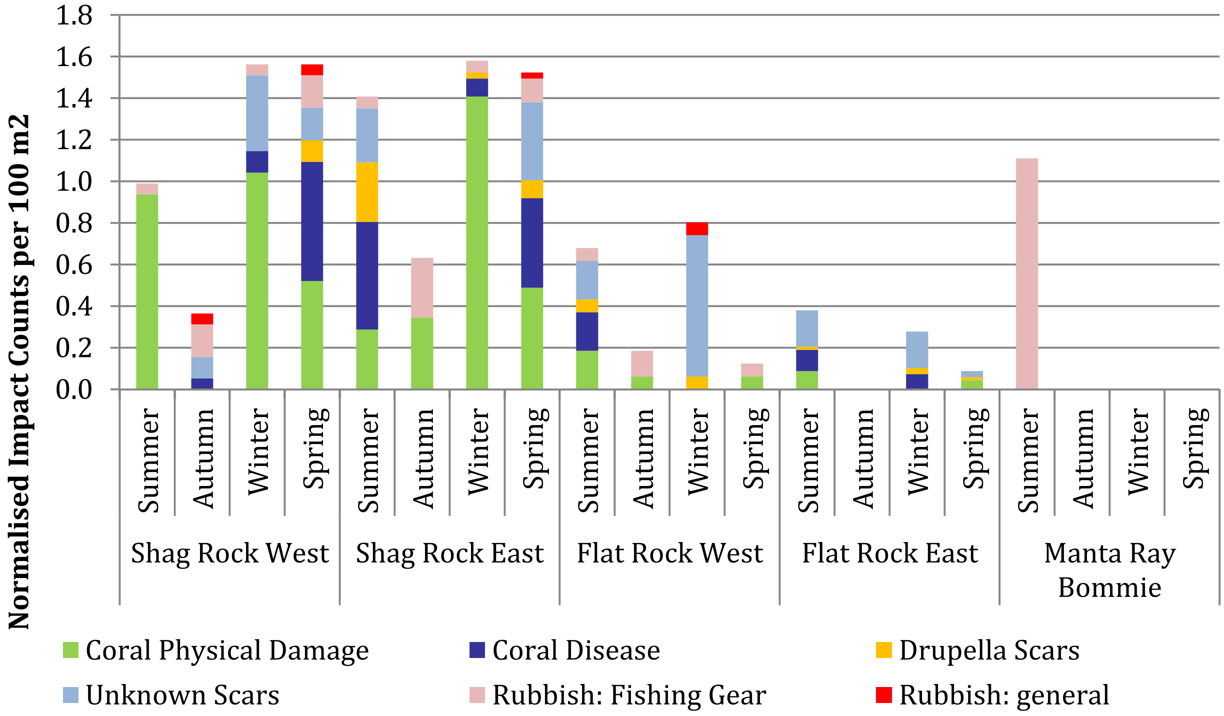


Figure 22: Average abundance of reef health impacts per 100m² normalised for coral cover for each survey site by season.

3.6.3. Coral Health (bleaching)

For the period of observation, the recorded coral health was relatively stable with no obvious bleaching (Figure 23), with a score of 6 considered healthy. Overall, the lightest scores were observed in summer, when the water temperature was the highest (Table 3). As data were consistent and similar for the five survey transects, they were amalgamated to create an average for the Point Lookout dive site region. Seasonal averages for each dive site are shown in Appendix H. Figure 23 shows that the average score ranges from 3.5 in summer to 4 in winter. The error bars represent the range of the average darkest to average lightest scores that were recorded.

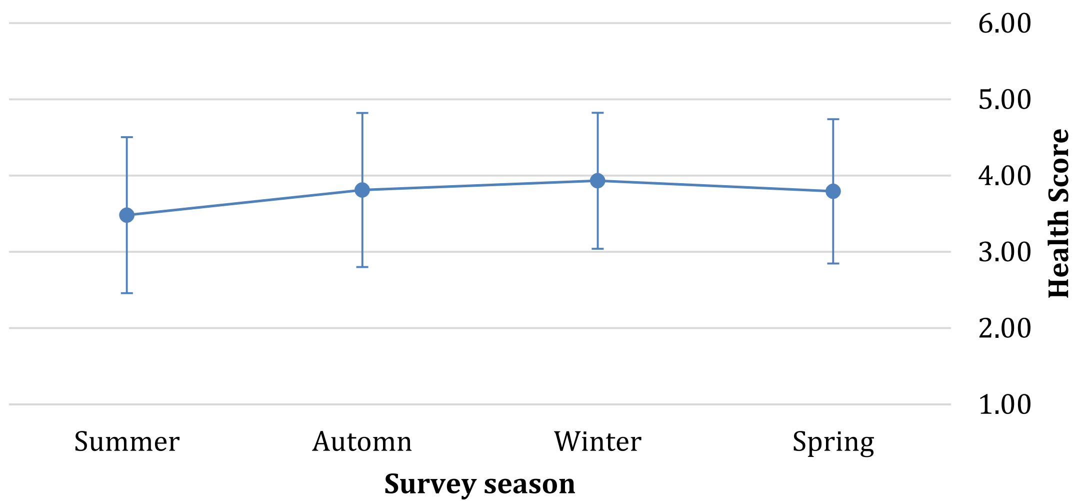


Figure 23: Average coral health observed for each season.

3.7. A Comparison of 2001 to 2014 Ecological Data

Manta Ray Bommie was omitted from the change analysis, as this site was not surveyed in 2001.

3.7.1. Invertebrates

The abundance of most of the categories of invertebrates was lower in 2014 compared to 2001 (Figure 24). *Diadema* was more abundant at Shag Rock in 2001 compared to 2014. Collector urchins and giant clams were found in higher abundance in 2014 compared to 2001, with collector urchins being most prevalent at Shag Rock West. .

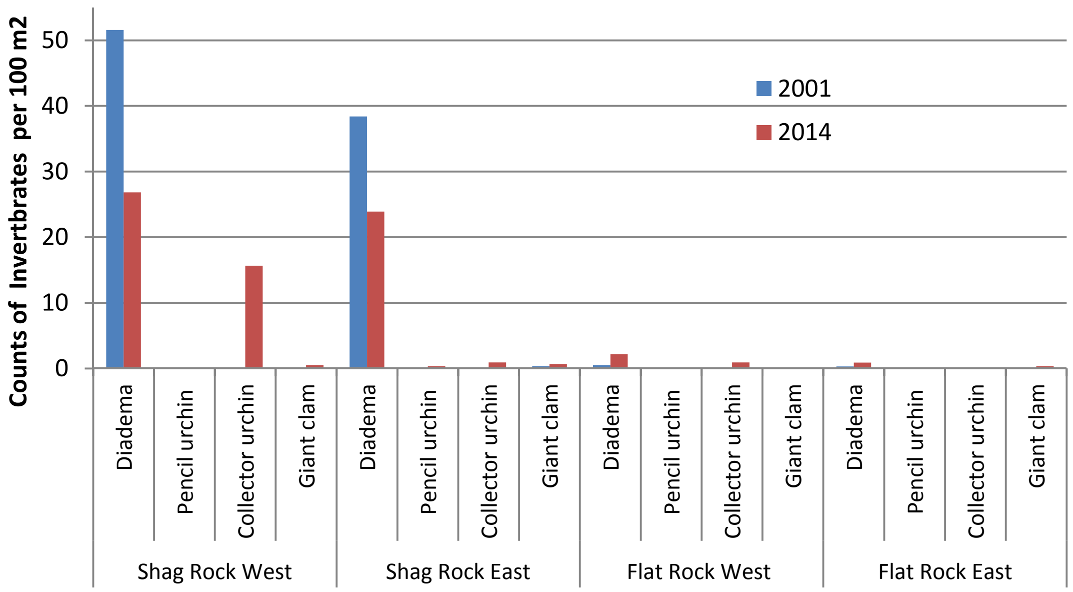


Figure 24: Comparison of the abundance of indicator urchins from 2001 to 2014 for the Point Lookout region.

3.7.2. Fish

Families

Both Flat Rock sites showed lower butterflyfish abundance in 2014 compared to 2001.Most fish groups showed directly opposing patterns between Flat Rock East and West, i.e. sheltered versus exposed sites (Figure 25). The exposed site had more goatfishes, triggerfishes and parrotfishes in 2001 than in 2014. The sheltered site had more surgeon fishes, and more parrot fishes in 2001 compared to 2014. The abundance of angelfishes, goatfishes, and triggerfish decreased between 2001 and 2014 at Shag Rock West, but remained relatively similar at both Flat Rock sites. In contrast, the abundance of herbivores such as rabbitfishes and surgeonfishes increased at both Shag Rock sites between 2001 and 2014.

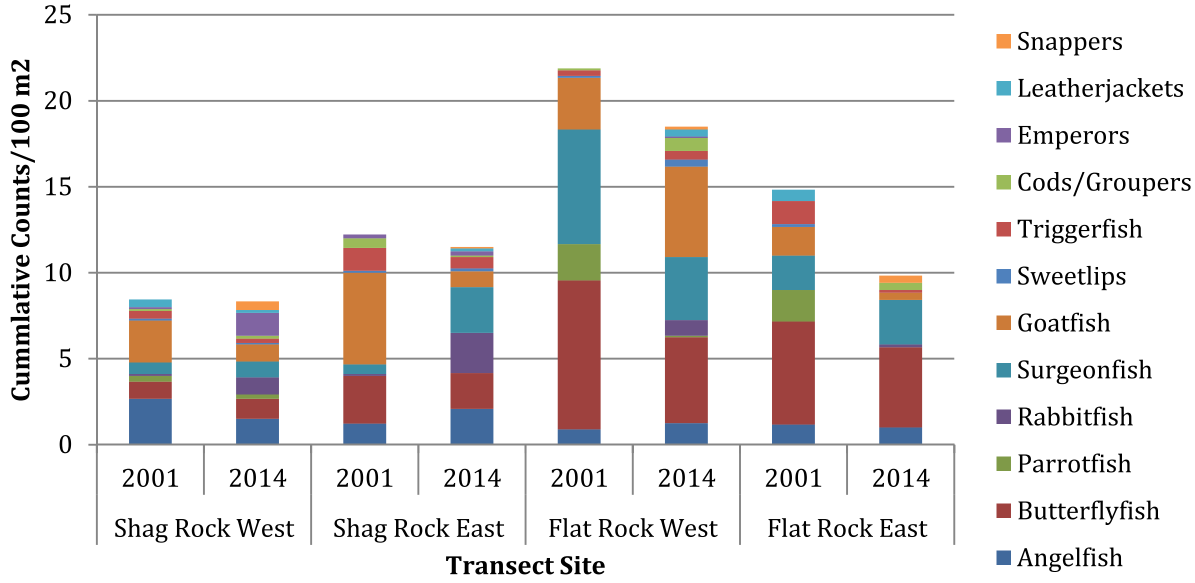


Figure 25: Mean abundance of target fish families for 2001 and 2014 for each of Shag Rock West, Shag Rock East, Flat Rock West and Flat Rock East dive sites.

Species

Target species were only compared where they were surveyed in both 2001 and 2014 (Figure *26*). Flat Rock West had the highest total abundance of target species in both 2001 and 2014. Most sites demonstrated higher abundance of target species in 2014, except for Flat Rock East, which remained constant. The number of target species found at each site has increased since 2001, also with a greater diversity of species seen in 2014 (refer to Appendix B the species list).

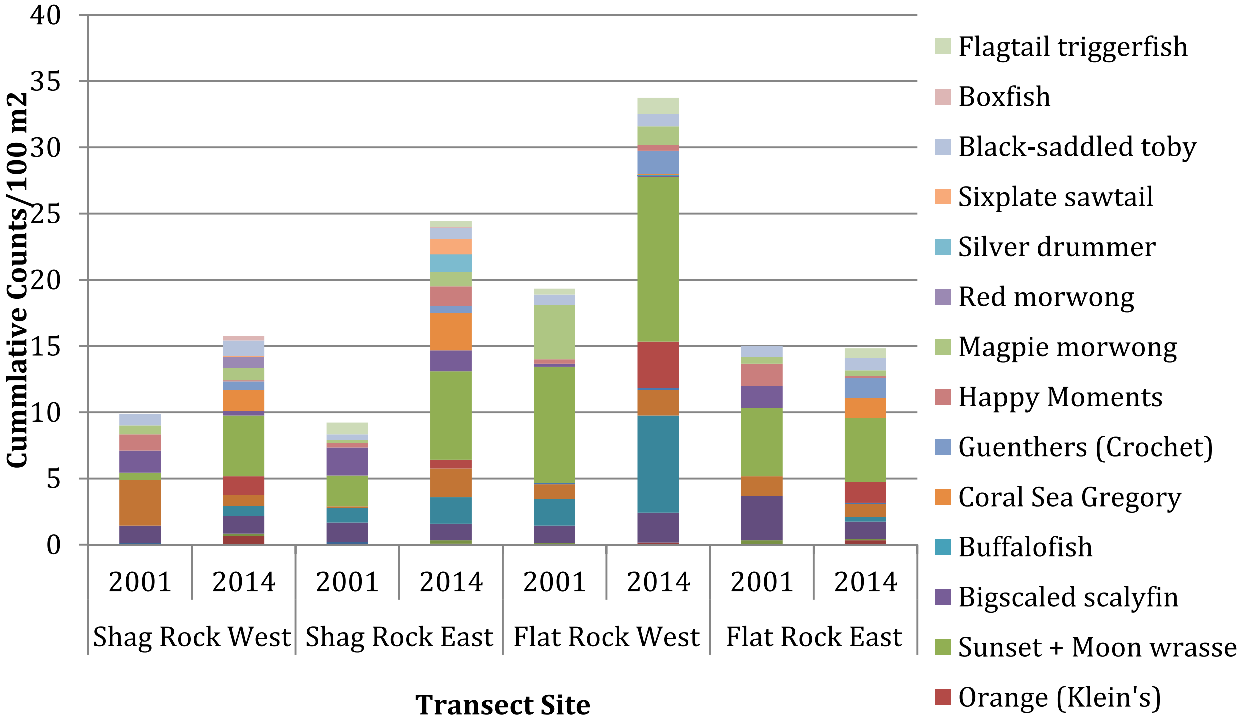


Figure 26: Mean abundance of target fish species for 2001 and 2014 for each of Shag Rock West, Shag Rock East, Flat Rock West and Flat Rock East dive sites.

3.7.3. Substrate

Comparisons were made between the major substrate types per site mapped in 2001 and 2014 (Figure 27), or, as an annual average for the Point Lookout region (Figure 28).

Per site (Figure 27), coral cover increased slightly from 2001 to 2014 at Flat Rock East (16% to 19%), remained constant at Shag Rock West (6%), but declined at Shag Rock East (18% to 9%) and Flat Rock West (17% to 5%). Soft coral cover was slightly lower at all sites in 2014 than 2001. All sites showed an increase in the percentage cover of turf algae from 2001 to 2014. *Lobophora* was observed at higher levels during 2014 surveys at all sites. Lower average cover of the "other" category (e.g. ascidians, anemones, corallimorphs, etc.) was observed at both Shag Rock sites in 2014.

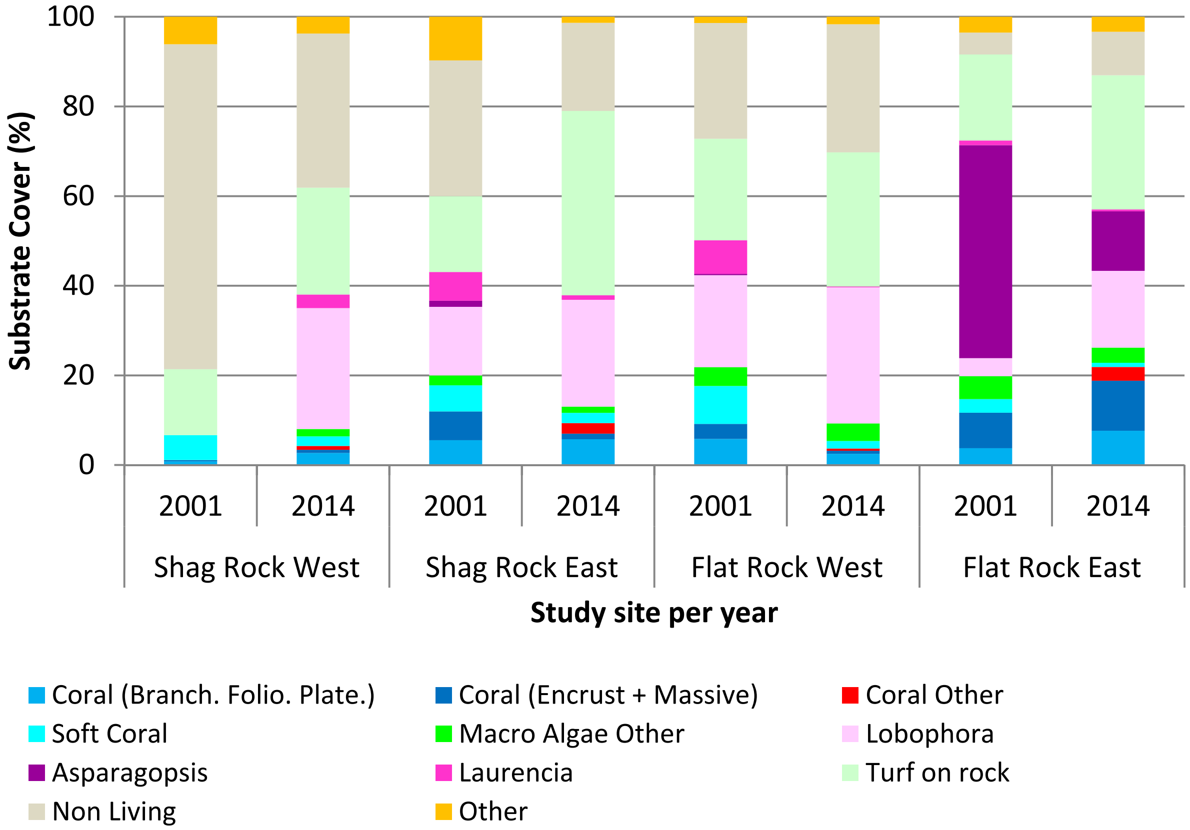


Figure 27: Substrate composition for 2001 and 2014 for each site.

Grouping the five transects together to represent Point Lookout dive sites as a whole, there was no substantial variation in benthic cover types from 2001 to 2014 (Figure 28). Notably, no significant difference in total hard coral cover was observed between 2001 and 2014 (Pseudo F = 0.143, p = 0.708). There were variations in composition of non-living, turf and macro algae cover from 2001 to 2014, but much of this would be accounted for by bare rock versus algae covered rock. The cover of the "other" substrate category decreased slightly in 2014.

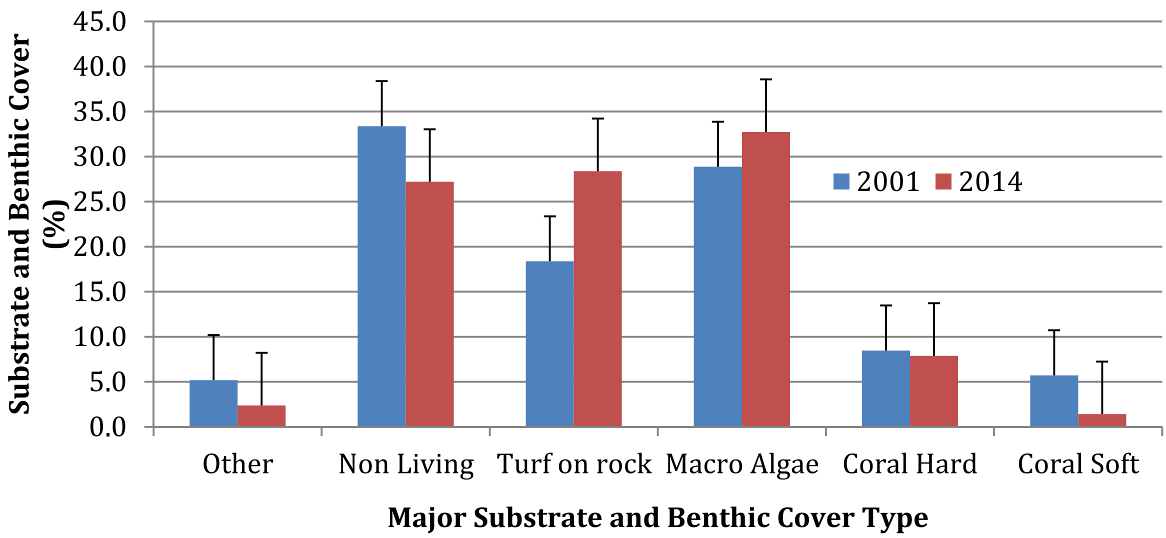


Figure 28: Substrate composition for the Point Lookout Region, calculated as an annual average for 2001 and 2014. (error bars indicate standard deviation)

3.7.4. Reef Health Impacts

Three reef health impact categories (unknown coral damage, fishing gear and general rubbish) were monitored in both 2001 and 2014, allowing comparison between the survey years (Figure 29). Reef health impacts per site were normalized for the coral cover (percentage of substrate cover) present at that site.

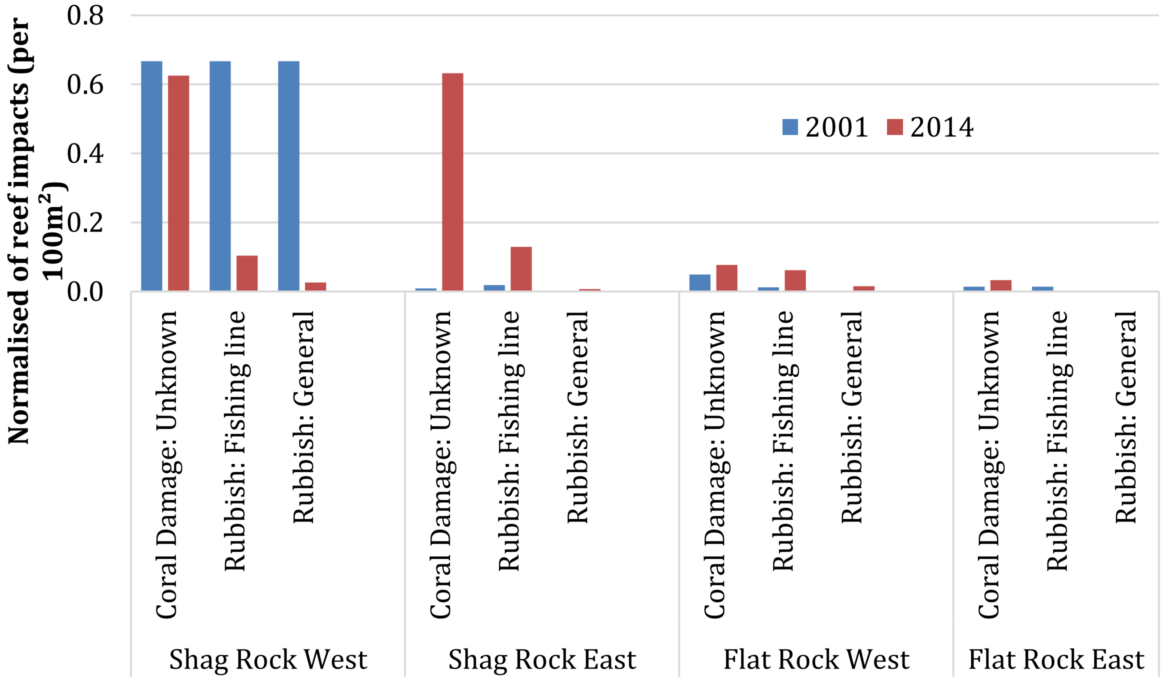


Figure 29: Comparison of the normalised average abundance of reef health impact categories that were recorded in both 2001 and 2014 studies.

Coral damage from unknown causes was recorded more on 2014 surveys. Flat Rock East showed overall low impacts for both 2001 and 2014. Flat Rock West and Shag Rock East surveys recorded high abundance of coral damage in 2014, and increased abundance of fishing line. Shag Rock West showed similar results for 2001 and 2014, with a decrease in coral damage and in general rubbish.

4. Discussion

The rocky reefs at Point Lookout represent an important transitional area where temperate, tropical and sub-tropical species co-exist (Perry & Larcombe 2003). This region is exhibiting rapid population growth and coastal development, with corresponding impact upon its marine environments. It is also likely to be impacted in the future by species shifts due to climate change (Pandolfi et al 2006). Despite the recognised importance of this region for biodiversity and its unique species assemblages (e.g.Harrison, et al 1998), monitoring of these habitats is currently limited (Reef Check 2010). The PLEA survey project has contributed effort to the documentation and monitoring of the Point Lookout dive sites.

4.1. Interpretation of Findings

All sites exhibited a diversity of fish families and species, with the highest abundance exhibited by the damsel and wrasse families. Variation was observed both seasonally and temporally: sub-tropical fish groups were observed more commonly in colder seasons, and tropical groups such as parrotfish were comparatively rare. Importantly however, the recorded observations of predatory fish may be low due to the fact that surveys were done during the day while some predatory fish hunt at night. Comparisons of 2001 versus 2014 fish family abundances help to highlight potential changes that may be the result of adverse or positive impacts on fish communities. For example, offshore sites at Flat Rock had lower numbers of butterflyfish in 2014 compared to 2001, which may indicate a reduction of coral abundance, since some butterflyfishes are obligate coral feeders. However, whilst it is possible that changes have occurred that have modified the fish community, it is also plausible that these records represent stochasticity or inter-annual variability.

Invertebrate abundance was also different between sites, which may reflect the differences among substrate cover and the subsequent availability of suitable habitat. Flat Rock sites had a low abundance of all indicator invertebrates compared to Shag Rock sites, which may reflect the more sheltered nature of Shag Rock, or its' topography (i.e., more crevices). Less exposed sites may have more 3-dimensional habitat such as branching, foliose and plate corals, which provide more habitat for invertebrates. A higher number of anemones were found without fish than with, at all sites. This may be due to the collection of anemone fish for the aquarium trade (at some sites), or the dominance of smaller anemones seen.

Some of the invertebrate indicators were not recorded during the surveys. These included *Trochus* and *Triton* shells, and, the sea cucumbers, however, these species are mostly indicative for tropical waters. Other shells or sea cucumbers were observed that are more characteristic of subtropical reef environments, for example *Holothuria difficillis* and *Chicoreu ramosue.* These are recorded in the species list in Appendix B. The total number of giant clams found in 2014 was greater than in 2001, which may be an indicator that these invertebrates are becoming more common around South East Queensland with changing water temperatures. However, this is impossible to confirm without more data or analysis.

The sites also exhibited very different benthic characteristics, both within and among sites. For example, Flat Rock East exhibited high levels of coral cover compared to other sites, especially encrusting coral, reflecting the more exposed nature to waves and wind of this site. Manta Ray Bommie exhibited the lowest level of coral cover and the highest abundance of non-living material. *In-situ* diver observations exhibited more variability between seasons than photo transects (Appendix G). Whilst it is difficult to directly compare the two methods, the more consistent results from the photo transect (which were analysed by one person) suggests that the differences observed from the *in-situ* observations are, at least in part, due to different divers undertaking substrate identification throughout the year. Whilst changes in coral cover were also observed over time, it is difficult to know at this stage whether these are a function of environmental change or due to sampling error.

The greatest amount of physical damage occurred at the Shag Rock sites, and of this, the most commonly recorded category of damage was 'other', for which the cause is not known but could be caused by anchor, diver or storms. Since the 2001 surveys, Flat Rock has been designated as a marine national park zone precluding anchoring, and, the area was closed to fishing under the Fisheries Act for GNS 2012. However, some fishing lines were recorded at Flat Rock in 2014. Lower levels of rubbish were recorded at Shag Rock West and Manta Ray Bommie in 2014. Compared to 2001, coral damage was significantly higher in 2014 at Shag Rock sites. This could reflect higher levels of diver activity, or higher fishing activity (and subsequently more boat-related damage). However, it is difficult to distinguish human-related versus storm-related damage without more frequent survey activity.

Caution must be taken when drawing conclusions as to the health of the reefs between the 2001 and 2014 surveys. As there is no detailed information available for this time, there are a number of potential scenarios. Recorded coral cover was similar for 2001 and 2014, however, what happened in between is unknown. Various trajectories could have taken place (Figure 30). Regular detailed monitoring would provide the necessary information to link processes with observations for conservation and management.

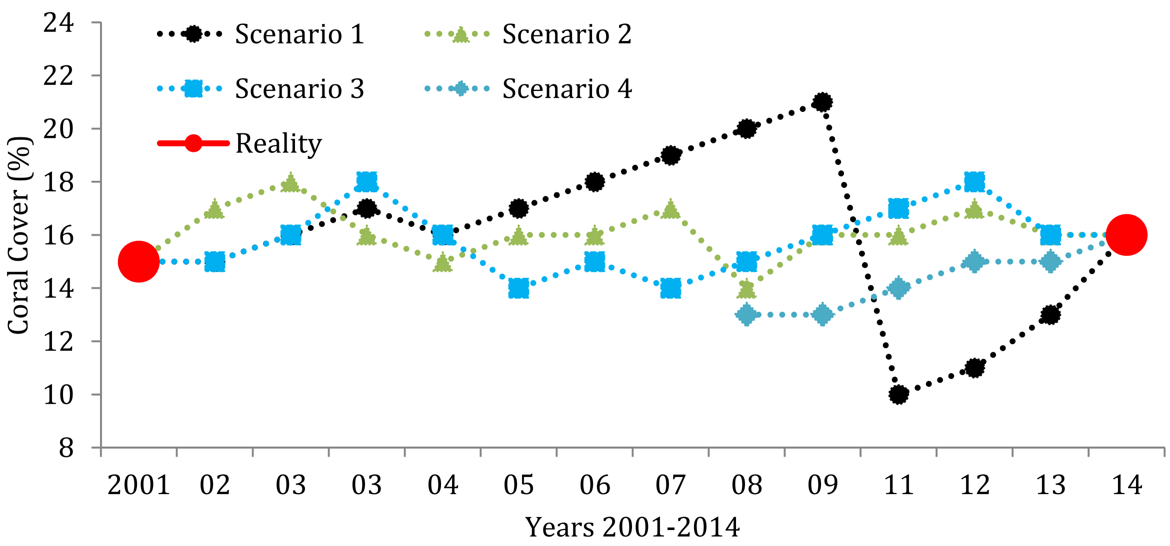


Figure 30: Coral cover for 2001 and 2014 with possible scenarios as to what the coral cover could have been for the years in between.

4.2. Project and Data Limitations

The PLEA surveys were carried out by a group of 44 trained volunteer divers (Appendix A). Whilst a high number of volunteers was imperative for project engagement, there was some variation in the results due to data that could not be explained through seasonality (e.g. Hard Coral cover). Likely this variation arises from data being collected by different divers on different surveys. To reduce this variation however, divers were trained to a high standard (Pass mark 75 % on written identification exams) and core divers were appointed consistent survey activities from season to season where feasible.

The substrate survey was a point survey where people used a lead plumb line to eliminate bias. However, each seasonal survey repeat would have slightly different line placing resulting in the plumb line touching a different location which would explain some variation in the results. Some differences were also evident on comparison of field-based substrate data and photo transect data. Photo transect based substrate survey allowed for rapid data collection in the field, yet, the analysis of the photos required much more time. However, this method provided a higher level of consistency as the photo analysis was done by one person, and questionable analyses could be reassessed.

Surveys were carried out seasonally over a 12 month period and all seasonal surveys were completed in a single weekend where possible (see Appendix I). The environmental conditions (e.g. wind, swell, tides, and temperature.) during the surveys varied due to normal weather patterns, which would influence the flora and fauna present. The results will therefore be affected by these factors, and hence, ongoing seasonal surveys are valuable to provide better knowledge of what is present or absent at different times of the year. Whilst we aimed to complete all surveys for a season during one weekend, sometimes this was not possible due to weather conditions and the team had to return at a later date (usually the following weekend or as soon as possible). Due to potential variation in conditions such as visibility and currents on the different weekends, variability, especially for the fish survey, would have been inherent and contribute to potential intra-season differences.

During the planning phase of the surveys, the categories of substrate, invertebrates, fish and reef health impacts were chosen to be comparable to the 2001 Coastcare project which was the main comparison. However, the protocols were also adopted to fit in with Reef Check Australia and Coral Watch methods, so some cross comparison was possible. On completion of the surveys, during the data comparison, the categories used were similar, but the methodology used to collect the data was different enough that it was difficult to compare some categories. This imposed a limit on the amount of data that could be compared between the 2001 and 2014 studies. Consistent methodology will be a consideration for future surveys to enable more efficient comparison and allow change detection.

During the surveys it was clear that there was some movement in the semi-permanent markers. Further, an aim was to have the transects in the same locations as in 2001. The 2014 transects were located based on sketches and expert knowledge of those that had been involved in the 2001 surveys. This information was insufficient to guarantee 2014 transect placement in identical locations as to 2001. Hence, it is proposed for future and ongoing surveys, that more permanent markers (e.g. steel bars) be installed to enable ongoing comparison with future surveys.

5. Recommendations for Management and Community

5.1. Continued and improved monitoring of the Point Lookout dive sites.

Repeating the ecological assessment on an annual basis (e.g. Reef Check) and every five years seasonally (e.g. PLEA project) would be beneficial for proper understanding and management for conservation. The results of this survey show that some changes have taken place, but with only two years of data it is difficult to say how or why these changes are taking place. Regular monitoring of these reefs would improve our understanding of ecological changes and enable us to better understand if they are natural variations or caused by external factors such as fishing, pollution or physical damage. The Reef Check initiative to voluntarily survey the reefs annually every winter since 2009 is of great importance as the data can be used to support management decisions. Repeating the same detailed survey as presented here in five years' time would be beneficial, as seasonal changes in the reef can also be understood.

Permanent transect markers would enable a significant improvement in the quality and reliability of survey result comparisons between years and seasons. The 2014 surveys demonstrated that it was difficult to identify the same transect segments on seasonal revisits. This was only achievable by using the same skilled diver(s) to mark out the transect line every survey. As these surveys should not rely on the experience of only a small group of divers to relocate the transect locations, it would be beneficial to install permanent transect markers (e.g. steel pegs in the rocks). These would mark the beginning and end points of each of the transects, as opposed to using the concrete blocks that were used, and, then removed at the end of this project.

5.2. Reducing Physical Damage to Corals

Several complementary options could be introduced to avoid anchor and mooring line damage to corals:

No anchoring at Shag Rock. Although not dropping anchor is a change in boat diving procedures and not always suitable for all diver experience levels or weather conditions, it will directly reduce damage caused by anchoring. Boat operators could instead drop a shot line with a small surface marker buoy, dive flag and weight, that divers or snorkelers could use to navigate back to when finishing the dive. Other boats not used for diving, would have to drift with the current, and avoid the rocks. Additional costs due to fuel usage for boat dive operators should be shared with the users (e.g. divers), and it requires divers and operators work together in helping reduce damage. Fishers whom like to stay on top of the fishing habitat could consider equipping their boat with an additional electric engine to keep the boat on the site.

Anchoring on sand so anchor and chain are not able to impact the reef. Alternatively anchoring could be permitted in non-coral areas (e.g. sand) at such a distance from the rock substrate that the anchor and chain will not damage coral. This would require that divers or snorkelers navigate to the site of interest, potentially requiring additional briefing. The briefing would include how to navigate from the anchor to the main dive site, and could include the dive site maps generated from this project. For fishers this approach would not be as suitable since they prefer to anchor on top of the fish habitat.

Providing fixed moorings. Currently no public or private moorings are present at Shag Rock, and high levels of physical damage to corals were observed at all transects at this location. Various options are available to install and maintain moorings at these sites which may help reduce damage to corals. These include: 1) direct funding by the users (e.g. divers, dive shop owners, interested organisations), 2) through an organisation of users (e.g. Mooring Trust), 3) via an industry partner (e.g. diving, mining, tourism), 4) provision of assistance from government agencies (e.g. Marine Parks), or, 5) direct funding by Marine Parks. Appendix J outlines suggested approaches that could be followed up by the community or management agencies to enable this to happen.

Educating divers, spear fishers, snorkelers, fishers and vessel skippers in how to reduce physical damage. Divers should be encouraged, or ideally required, to follow a code of conduct that highlights the need for good buoyancy control to avoid touching the bottom, and, the streamlining of dive gear to avoid entanglement in corals. Snorkelers should be encouraged not to touch or get close to the bottom, reducing their impact. At sites where fishing is allowed, fishers should avoid fishing near or close to the bottom to avoid line entanglement and/or loss of fishing gear and associated damage to corals.

5.3. Community Engagement to Create Awareness of the Importance of the Reefs

Educating the community about the Moreton Bay reefs will help preserve these resources for the future. A survey of the South East Queensland community in June 2010 indicated that a quarter of people surveyed were not aware that there were reefs in the waters of South East Queensland. Half of respondents were aware that there were reefs but had not visited them (Reef Check Australia 2010). Increasing awareness about the importance of these habitats and how personal actions can support their protection will be critical to help in the conservation of these ecosystems for the future. The production of the PLEA photo book *"Straddie, Marine Flora and Fauna of North Stradbroke Island Dive Sites"* and video will assist in increasing community awareness about the existence of the reefs around South East Queensland and showcase the value, beauty and diversity of these reefs.

The community can help build an understanding of Moreton Bay reefs through citizen science. The broader community can get involved in numerous citizen science initiatives to support increased understanding of Moreton Bay Reefs:

- Reef Check Australia (http://www.reefcheckaustralia.org/)
- Coral Watch (http://www.coralwatch.org/)
- Grey Nurse Shark Watch (http://www.reefcheckaustralia.org/grey-nurse-shark-watch.html)
- Project Manta (https://www.facebook.com/ProjectMANTA)
- Spot the Leopard Shark (http://www.uq.edu.au/whale/spot-the-leopard-shark)

5.4. Support conservation of the reefs by providing peer reviewed information.

The scientific community, non-governmental organisations, management authorities, local area councils and interested citizen can use the findings of this research and future research projects to help support management decisions and guide further monitoring of the reefs. The results and data from this project will be made publicly available, and include:

Project Documents

- Thurstan, R., Flower, J., Beger, M., Dudgeon, C., Gomez, K., Ortiz, J., Kovacs, E., Loder, J., Saunders, M., Passenger, J., Kleine D. and Roelfsema, C *(2014). Survey Methods Manual UniDive Point Lookout Ecological Assessment (PLEA).* The University of Queensland Underwater Club, Brisbane, Australia.

  Manual was based on methods used in surveys in 2001 and 2003, and the Reef Check and Coral Watch Protocols.

- Roelfsema C., R. Thurstan, J. Flower, M. Beger, M. Gallo, J. Loder, E. Kovacs, K. Gomez Cabrera, A. Lea, J. Ortiz, D. Brunner, and D. Kleine (2014). *Ecological Assessment of the Flora and Fauna of Point Lookout Dive Sites, North Stradbroke Island, Queensland.*, Unidive, The University of Queensland Underwater Club, Brisbane, Australia.

  Each document was reviewed by two coastal region managers, both having ten plus years' experience with monitoring and managing the coastal regions and national parks in South East Queensland.

Peer Reviewed Scientific Papers

- Roelfsema C., R. Thurstan, J. Flower, M. Beger, M. Gallo, J. Loder, E. Kovacs, K. Gomez Cabrera, A. Lea, J. Ortiz, D. Brunner, and D. Kleine (manuscript in preparation). *Flora and Fauna of North Stradbroke Island Dive Site for 2001 and 2014: A Citizen Science Based Comparison.* Journal of Ecosystem and Ecography

- Thurstan, R., C. Roelfsema, J. Flower, M. Beger, M. Gallo, J. Loder, E. Kovacs, K. Gomez Cabrera, A. Lea, J. Ortiz, D. Brunner, and D. Kleine (manuscript in preparation). *Can we trust citizen science? An examination of the consistency of survey results among volunteer divers.* PLOS One

Peer Reviewed Data Set

- Roelfsema C., E. Kovacs, P. Bray, M. Gallo, R. Thurstan, J. Flower, M. Beger, J. Loder, K. Gomez Cabrera, A. Lea, J. Ortiz, D. Brunner, and D. Kleine (in preparation). *Fish, Invertebrate, Substrate, and Impact Data Set collected in 2014 as part of the Ecological Assessment of the Dive Sites at North Stradbroke Island Dive , Queensland. UniDive PLEA Project,* Pangea or Coastal Data Portal

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7. Appendices

Appendix A: Participants List

Name	Cert	Survey Job	Training	Organisation	Science	Methods	Book	Report	Video
Aaron Aeberli	ADV	Buddy							
Alexandra Lea	DM	Fish	x		x		x	x	
Alyssa Ryan	ADV	Buddy							
Andy Findlay	N/A	Support		x					
Beth Kita	RES	Substrate, inverts							
Bruce McClean	DM	Inverts		Finance					
Chris Roelfsema	INS	Mapping		Organisation	x			x	
Christine Dudgeon	SCI	fish	x		x			x	
Craig Bolland	ADV	Buddy							
David Warren	RES	Buddy					x		
Dee Passenger	DM	Inverts					x		
Diana Kleine	INS	Fish							
Donna Easton	RES	Inverts		Sales					
Douglas Stetner	INS	Photo, Video, mapping		Photo			x		x
Dunia Brunner	ADV	Substrate						x	
Eva Kovacs	RES	Fish, Inverts	x	Quality control	x	x	x	x	
Gavin Bott	DM	Video		Video					x
James Sadler	ADV	Buddy							
Jason Flower	INS	Methods	x		x	x		x	
Jennifer Loder	DM	Impacts	x		x	x	x	x	x
Jenni Calcraft	RES	Coral Health							
Josh Passenger	DM	Impacts	x	transport					
Juan Carlos	SCI	Impacts	x		x	x		x	
Julie Klint	RES	Fish		Food					
Justin Mariner	DM	Buddy					x		x
Karen Johnson	ADV	Fish, coral health		Food			x		
K-Le Gomez	SCI	Trainig, Inverts	x		x	x	x		
Lachlan Pollard	DM	Mapping		Accomodation			x		x
Lee Raby	INS	Mapping							
Liette Boisvert	ADV	Coral Health		Facebook					
Maria Beger	SCI	Trainer, Fish	x		x	x	x	x	
Mark Stenhouse	DM	Substrate							
Megan Saunders	SCI	Inverts	x		x				
Melanie Oey	RES	Mapping, Coral Health,		Facebook, survey gear					
Michael Pheasant	DM	Mapping		Dive officer, data		x	x	x	
Michele Gallo	RES	Video, impacts			x	x	x	x	
Olivier Cheneval	INS	Substrate, impacts					x		
Peran Bray	RES	Inverts, impacts, mapping	x	Data Management					
Robert Cook	DM	Buddy							
Roxane Borruat	RES	Coral Health							
Ruth Thurstan	DM	Fish	x		x	x	x	x	
Ryan Booker	INS	Mapping, video, photo	x	Safety					x
Sarah Buckley	RES	Buddy							
Stefano Freguia	DM	Substrate, inverts							x
Trevor Barrenger	DM	Mapping		Food					

Appendix B: Data Sheets

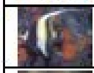
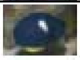
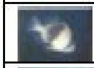
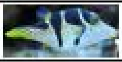
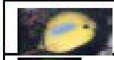
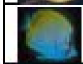
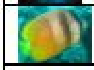
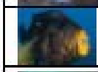
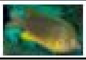
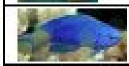
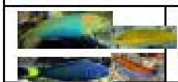
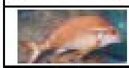
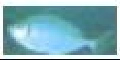
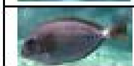
UNIDIVE PLEA - FISH FAMILY

Name:	**Time in:**	**Time out:**	UNIDIVE PLEA POINT LOOKOUT ECOLOGICAL ASSESSMENT
Buddy Name:	**Air in:**	**Air out:**	
Team:	**Date:**		
Survey site:	**Transect number:**		

Indicator Family		Segment 1 (0-20 m)	Segment 2 (25-45 m)	Segment 3 (50-70 m)
	ANGELFISH			
	BUTTERFLY FISH			
	CODS/GROUPERS			
	DAMSEL FISH			
	EMPERORS			
	GOAT FISH			
	LEATHERJACKETS			
	LION/STONE FISH			
	MORAYS			
	PARROTFISH			
	PORCUPINE FISH			
	PUFFERFISH			
	RABBITFISH			
	SNAPPERS			
	SURGEONFISH			
	SWEETLIPS			
	STINGRAYS			
	TRIGGER FISH			
	WRASSE			
	WOBBEGONG			
	Leopard shark			
	Bamboo shark			
	Grey nurse shark			
		Time:	**Time:**	**Time:**
		Air:	**Air:**	**Air:**

UNIDIVE PLEA – FISH SPECIES

Name:	Time in:	Time out:	UNIDIVE PLEA POINT LOOKOUT ECOLOGICAL ASSESSMENT
Buddy Name:	Air in:	Air out:	
Team:	Date:		
Survey site:	Transect number:		

Indicator Species		Segment 1 (0-20 m)	Segment 2(25-45 m)	Segment 3 (50-70 m)
	*Moorish Idol*			
	*Keyhole Angelfish*			
	*Barred Soapfish*			
	*Flagtail Triggerfish*			
	*Black-saddled Toby*			
Butterflyfishes				
	*Bluespot*			
	*Guenthers (Crochet)*			
	*Orange (Klein's)*			
Damselfishes				
	Bigscaled Scalyfin			
	*Indopacific Sergeant*			
	Buffalofish			
	Coral Sea Gregory			
	*Blue damsels*			
	Black bar devil			
Wrasses and morwongs				
	Sunset + Moon wrasse			
	*Cleaner Wrasse*			
	*Red Morwong*			
	*Magpie Morwong*			
Silvery large fishes in groups				
	*Happy Moments Rabbitfish*			
	*Sixplate Sawtail*			
	*Silver drummer*			
Rarities: frogfish/ boxfish/ seahorse/ barracuda				
		Time:	Time:	Time:
		Air:	Air:	Air:

UNIDIVE PLEA – Substrate

Name:	**Time in:**	**Time out:**	
Buddy Name:	**Air in:**	**Air out:**	
Team:	**Date:**		
Survey site:	**Transect number:**		

Living

MA: Algae *(+ r if on rubble)*


CA: Encrusting


TA: Turf (furry mat)

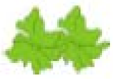

AS: Asparagopsis (purple feathers)

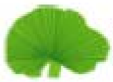

LB: Lobophora (brown lined petals)


PA: Padina (white pencil shaving)


LA: Laurencia (many branches)

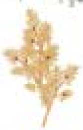

HA: Halimeda (tough green)


UV: Ulva (sea lettuce)


FL: Filamentous (fine green strands)


CR: Caulerpa rasemosa (bunc nh of grapes)


CT: Caulerpa taxifolia (green feather)


SG: Sargassum (large brown with grapes)


TU: Turbinaria (large brown with trumpets)


LY: Lyngbya (Hairy black fibres)

Coral *(+ b if bleached)*		***Other living***
HC: Coral Other-Unknown	**SC:** Soft Coral Other - Unknown	**SP:** Sponge
HM: Massive	**SCL:** Leathery	**OT:** Other
HE: Encrusting	**SCO:** Ornate	**CY:** Cyanobacteria
HBR: Branching	**SCZ:** Zoanthids	**RKC:** Recently killed coral
HF: Foliose		**KCY: RKC + CY**
HP: Plate		**KTA: RKC + Turf**

Non-Living

SI: Silt/clay	**RB:** Rubble	**RC:** Bare Rock	**SD:** Sand

DATA

Segment 1				**Segment 2**				**Segment 3**			
0 – 20m				25 – 45m				50 – 70m			
0.0		10.0		25.0		35.0		50.0		60.0	
0.5		10.5		25.5		35.5		50.5		60.5	
1.0		11.0		26.0		36.0		51.0		61.0	
1.5		11.5		26.5		36.5		51.5		61.5	
2.0		12.0		27.0		37.0		52.0		62.0	
2.5		12.5		27.5		37.5		52.5		62.5	
3.0		13.0		28.0		38.0		53.0		63.0	
3.5		13.5		28.5		38.5		53.5		63.5	
4.0		14.0		29.0		39.0		54.0		64.0	
4.5		14.5		29.5		39.5		54.5		64.5	
5.0		15.0		30.0		40.0		55.0		65.0	
5.5		15.5		30.5		40.5		55.5		65.5	
6.0		16.0		31.0		41.0		56.0		66.0	
6.5		16.5		31.5		41.5		56.5		66.5	
7.0		17.0		32.0		42.0		57.0		67.0	
7.5		17.5		32.5		42.5		57.5		67.5	
8.0		18.0		33.0		43.0		58.0		68.0	
8.5		18.5		33.5		43.5		58.5		68.5	
9.0		19.0		34.0		44.0		59.0		69.0	
9.5		19.5		34.5		44.5		59.5		69.5	
Time				**Time**				**Time**			
Air				**Air**				**Air**			

Remarks:

UNIDIVE PLEA - INVERTEBRATES

Name:	Time in:	Time out:
Buddy:	Air in:	Air out:
Team:	Date:	
Survey site:	Transect number:	

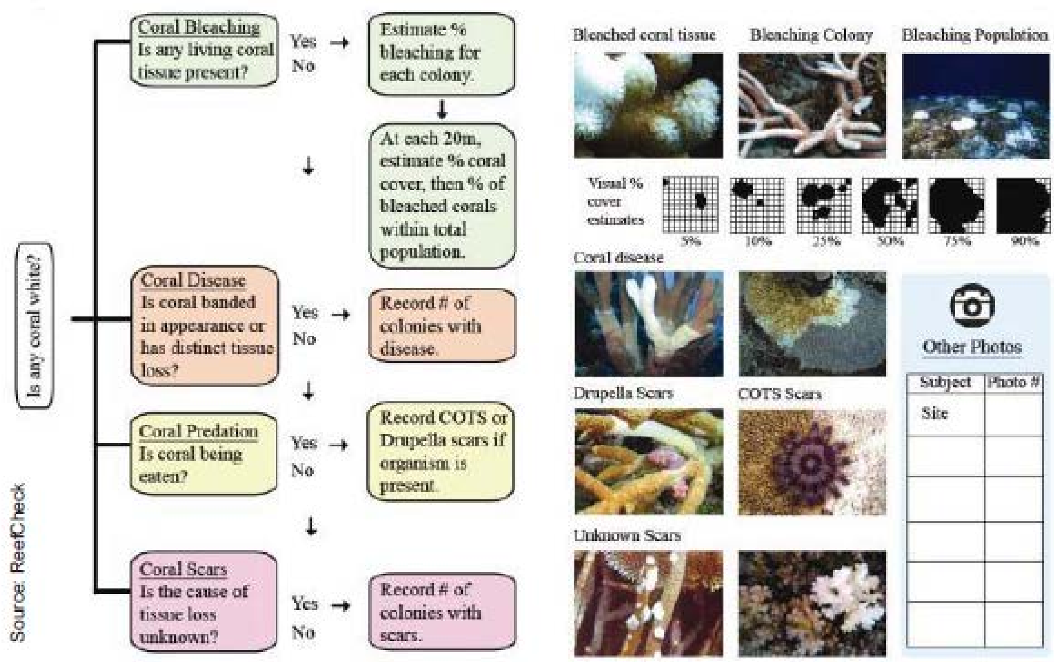
			Segment 1 (0-20m)	Segment 2 (25-45m)	Segment 3 (50-70m)	photo NO.
Anemone	With Fish					
	Without Fish					
Banded Coral Shrimp						
COTS	≤ 5cm					
	6-15cm					
	16-25cm					
	> 25cm					
Giant Clams	≤ 10cm					
	10-20cm					
	20-30cm					
	30-40cm					
	40-50cm					
	> 50cm					
Lobster (spiny & slippery)						
Shells	Drupella					
	Triton					
	Trochus Shell					
Sea Cucumbers	Pinkfish					
	Prickly Greenfish					
	Prickly Redfish					
Sea Urchins	Collector					
	Diadema					
	Pencil					
Source: ReefCheck			TIME	TIME	TIME	
			AIR	AIR	AIR	

UNIDIVE PLEA - IMPACTS

Name:	Time in:	Time out:
Buddy:	Air in:	Air out:
Team:	Date:	
Survey site:	Transect number:	

		Segment 1 (0-20m)	Segment 2 (25-45m)	Segment 3 (50-70m)	photo NO.
bleaching	Estimate % impact for EACH bleached colony				
	Estimate % total coral population				
damage	Coral damage: Boat / anchor				
	Coral damage: other				
	Coral disease				
coral scars	Crown of Thorns scars				
	Drupella scars				
	Unknown / other scars				
trash	Fishing line				
	Trash: Fish nets				
	Trash: General				
	Rare animals				
		TIME	TIME	TIME	
		AIR	AIR	AIR	

Record 3 dominant algae: 1. 2. 3.



Appendix B: Species List

FLOWERING PLANTS

SCIENTIFIC NAME
Halophila ovalis (Dugong Grass)
Halophila spinulosa
Halodule uninervis

ALGAE

Chlorophyta
Acetabularia sp.
Boergesenua forbesii
Boergesenua sp
Bometella nitida
Boodlea composita
Boodlea sp.
Bryopsis indica
Bryopsis sp.
Caulerpa brachypus
Caulerpa lentillifera
Caulerpa nummularia
Caulerpa peltata
Caulerpa racemosa
Caulerpa taxifolia
Chlorodesmis fastigiata Turtle Weed
Codium sp.
Dictyosphaeria sp.
Enteromorpha sp.
Halimeda discoidea
Neomeris van-bosseae
Ulva lactuca Sea lettuce
Valonia sp.
Ventricaria sp.

Phaeophyta
Colpomenia sinuosa
Colpomenia sp.
Dictyopteris sp
Dictyota sp.
Dilophus marginatus
Hormophysa triquetra
Hydroclathrus clathratus
Lobophora variegata
Padina sp.
Sargassum sp.
Stypopodium sp.
Zonaria sp.

Rhodophyta
Acanthophora sp.
Amansia sp.
Asparagopsis taxiformis Iodine Weed
Champia sp.
Dictyomenia sp.
Euchema sp.
Gelidiella sp.
Gelidium sp.
Gracilaria sp.
Griffithsia sp.
Halymenia sp.
Hypnea sp.
Laurencia sp.
Peysonnelia sp.
Sarconema sp.

REPTILES
Caretta caretta Loggerhead Turtle
Chelonia mydas Green Turtle
Eretmochelys imbricata Hawksbill Turtle

MAMMALS
Megaptera novaenglia Humpback (heard)
Tursiops truncatus Bottlenose Dolphin
Dugong dugon Dugong
Orcinus orca Killer whale

INVERTEBRATES

CNIDARIA (Hard corals)

Acanthastrea bowerbanki Encrusting
Acanthastrea echinata Encrusting to massive
Acanthastrea lordhowensis Massive
Acropora cytherea Plate
Acropora digitifera Digitate
Acropora divaricata Digitate to plate
Acropora gemmifera Digitate
Acropora glauca Plate
Acropora latistella Plate
Acropora sarmentosa Digitate to plate
Acropora solitaryensis Plate
Acropora subulata Digitate
Cyphastrea serailia Massive
Favia speciosa Massive
Favia stelligera Collumnar
Favites spp. Hard
Goniastrea australiensis Encrusting to submassive
Hydnophora exesa Encrusting to submassive
Lobophyllia corymbosa Massive
Montastrea curta Massive
Montipora caliculata Massive
Montipora peltiformis Submassive to plate
Oulophyllia bennettae Massive
Oxypora lacera Encrusting to foliose
Pavona varians Encrusting to foliose
Platygyra daedalea Encrusting to massive
Pocillopora verrucosa Branching
Pocillopora aliciae Branching
Pocillopora damicornis Branching
Psammocora contigua Collumnar
Seriatopora hystrix Branching
Stylophora pistillata Branching
Tubastrea faulkneri Orange Tube
Turbinaria frondens Foliose
Turbinaria meseterina oliose
Turbinaria peltataF oliose

CNIDARIA (Soft)

Dendronephthya sp. Prickly Red Tree
Sarcophyton sp. Leather soft
Xenia sp. Soft
Cladiella sp. Spotted soft

Other Cnidaria

Macrorhyncia phillipina White stinging Sea
Castostylus mosaicus Blue blubber
Discosoma sp. limorp
Entacmaea quadricolor Bulb-tentacle
Macrorhynchia phoenicea Sea fir
Palythoa caesia Sandy zooanthid
Physalia physalis Bluebottle
Tubipora musica Organpipe

PORIFERA (Sponges)

Acanthella costata Orange Ribbed
Niphates sp. Brown Furry Vase
Pseudaxinella australis Furry red
Spirastrella vagabunda Roaming burrowing
Cliona sp. Burrowing
Callispongia sp. Blue

ARTHROPODA (Crustaceans/Barnacles)

Calcinus gaimardii Gaimard's Hermit
Dardanus lagopodes Swift-Footed Hermit
Dardanus megistos Spotted Hermit
Gonodactylaceus falcatus Yellow-spot Smashing Mantis
Neopetrolisthes maculatus Dotted Anemone Crab
Panulirus versicolor Painted Spiny Lobster
Periclimenes brevicarpalis Pacific Clown Anemone Shrimp
Periclimenes soror Starfish Shrimp
Rhynchocinetes brucei Bruce's Hinge-Beak Prawn
Stenopus hispidus Banded Shrimp
Thenus sp. Moreton Bay Bug
Thor amboinensis Bold-Spotted Anemone Shrimp
Trapezia septata Honeycob Crab
Parribacus antarticus Slipper lobsters

MOLLUSCA

Aplysia dactylomela Black-ringed Sea Hare
Ceratosoma trilobatum Three Horned Nudibrach
Chromodoris aurepurpurea Purple-edge nudibranch
Chromodoris kuiteri Kuiter's Nudibranch
Conus capitaneus Captain's Cone
Conus textile Textile Cone
Cuthona sibogae Siboga Aeloid
Cypraea captuserpentis Serpent's-Head Cowrie
Cypraea tigris Tiger Cowrie
Eupryma tasmonica Cuttlefish
Exobranchus sanguineus Spanish Dancer
Flabellina rubrolineata Red-Lined Aeolid
Glaucus atlanticus Sea Lizard
Glossodoris atromarginata Black-Edged Nudibranch
Hypselodoris maculosa Purple-Speckled Nudibranch
Hypselodoris obscura Obscure Nudibanch
Jorunna funebris Funeral Pyre Nudibranch
Octopus cyanea Day Octopus
Ovula ovum Egg Cowrie
Phyllidia ocellata Eyed Phyllidia
Phyllidia varicosa Varicose Phyllidea
Pteraeolidia ianthina Blue Dragon
Sepia apama Giant Cuttlefish
Sepioteuthis lessoniana Tiger Squid
Trisidos tortuosa Propeller Ark (dead)

ECHINODERMATA(Starfish/ Seacucumbers/ Feathersta

Acanthaster planci Crown of Thorns Starfish
Asthenosoma periculosum Stinging Sea Urchin
Astrobrachion constrictum Grasping Brittlestar
Calcita novaeguineae Cushion Star
Cenolia sp. Black Featherstar
Comanthena nobilis Noble (Yellow) Featherstar
Diadema savignyi Long-Spined Black Urchin
Echinaster luzonicus Luzon Seastar
Echinostrephus aciculatus Burrowing Sea Urchin
Echiometra mathaei White-Tipped Urchin
Fromia indica Indian Seastar
Gomophia mamillifera Ornamented Seastar
Holothuria nobilis Teatfish
Leiaster coriaceus Tanned Seastar
Linckia laevigata Blue Seastar
SeastarDana's Brittlestar
Oxycomanthus bennetti Bennett's Featherstar (Black and yellow featherstar)
Pentagonaster dubeni Vermillion Seastar
Prionocidaris callista Beautiful Sea Urchin
Tamaria sp. Seastar
Temnopleurus alexandri Alexander's Sea Urchin

CTENOPHORA
Beroe sp. Comb Jelly

TUNICATE
Clavelines australis(Seasquirt)
Sea-squirt
Polycarpa papillata(Seasquirt)
Polycarpa procera(Seasquirt)

ANNELIDA
Spirobranchus sp. Christmas tree worm
Filograna implexa Fan worm
Sabellastarte indica Fan Worm

Platyhelminthes
Pseudoceros gloriosus Glorious flatworm
Pseudoceros sp. Flatworm

FISHES

Pomacanthidae (Angelfish)

Centropyge bicolor (Bicolour Angelfish)
Centropyge flavissima (Lemon angelfish)
Centropyge tibicen (Keyhole angelfish)
Centropyge vrolikii (Pearlscale angelfish)
Chaetodontoplus meredithi (Yellowfind angelfish)
Pomacanthus semicirculatus (Semicircle angelfish)

Ephippidae (Batfish)

Platax pinnatus (Pinnate spadefish)
*Platax teira (*Common tall-fin batfish)

Chaetodontidae (Butterflyfish)

Chaetodon aureofasciatus (Golden butterfly)
Chaetodon auriga (Threadfin butterfly)
Chaetodon citrinellus (Citron butterfly)
Chaetodon flavirostris (Dusky butterfly)
Chaetodon guentheri (Guenthers Butterfly)
Chaetodon kleinii (Klein's butterfly)
Chaetodon pelewensis (Sunset butterfly)
Chaetodon plebeius (Bluespot butterfly)
Chaetodon rainfordi (Rainford's butterfly)
Chaetodon speculum (Mirror butterfly)
Chaetodon trifascialis (Chevroned butterfly)
Chaetodon unimaculatus (Teardrop butterfly)
Chaetodon vagabundus (Vagabond butterfly)
Chlemon rostratus (Beaked)
Forcipiger flavissimus (Long nose butterfly)
Forcipiger longirostrus (Very long nose butterfly)
Heniochus acuminatus (Longfin banner)
Heniochus monoceros (Masked banner)

Pomacentridae (Damselfish)

Abudefduf bengalensis (Bengal sergeant)
Abudefduf septemfasciatus (Sevenbar sergeant)
Abudefduf sexfasciatus (Scissor-tailed sergeant)
Abudefduf vaigensis (Indopacific sergeant)
Abudefduf whitleyi (Whitleys sergeant)
Amphiprion akindynos (Barrier Reef anemonefish)
Chromis atripectoralis
Chromis hypsilepis (Brown puller)
Chromis lepidogenys
Chromis margaritifier (Bicolor chromis)
Chromis nitida (Yellow-black puller)
Chromis opercularis
Chromis vanderbilti (Vanderbilt's puller)
Chromis viridis (Blue-green puller)
Chromis weberi
Chromis xanthochira
Chrysiptera flavipinnis
Chrysiptera rex
Chrysiptera unimaculata
Dascyllus aruanus
Dascyllus reticulatus (Reticulated damsel)
Dascyllus trimaculatus
Neoglypthidodon nigroris (Yellowfin damsel)
Neopomacentrus azysron (Yellowtail demoiselle)
Parma oligolepis (Big scale parma)
Parma polylepis (Buffalofish)
Parma unifasciata (Girdled scalyfin)
Plectroglyphidodon dickii (Dick's damsel)
Plectroglyphidodon johnstonianus
Plectroglyphidodon leucozonus
Pomacentrus amboinensis
Pomacentrus australis
Pomacentrus bankanensis (Speckled damsel)
Pomacentrus coelestis (Neon damsel)
Pomacentrus imitator
Pomacentrus mollucensis
Pomacentrus nagasakiensis
Pomacentrus pavo
Pomacentrus wardi (Wards damsel)
Stegastes gascoynei

Apogonidae (Cardinalfish)

Apogon angustatus (Striped cardinalfish)
Apogon aureus (Ring-tail cardinalfish)
Apogon cavitiensis (Cavite cardinalfish)
Apogon cyanosoma (Yellow striped cardinalfish)
Apogon limenus (Sydney cardinalfish)

Serranidae (Cods/Groupers/Anthiases)

Cephalopholis urodeta (Flagtail rockcod)
Diploprion bifasciatum (Two-banded soapfish)
Epinephelus coioides (Estuary cod)
Epinephelus cyanopodus (Purple rockcod)
Epinephelus fasciatus (Black-tipped rockcod)
Pseudoanthias bicolor (Bicolor anthias)
Pseudoanthias huchti (Red-cheeked anthias)
Pseudanthias squamipinnis

Pseudochromidae (Dottybacks)

Labracinus lineatus (Lined dottyback)

Lethrinus nebulosus (Spangled emperor)

Lutjanidae (Snappers)

Lutjanus fulviflamma (Black-spot snapper)

Lutjanus kasmira (Blue-striped seaperch)

Lutjanus quinequelineatus (Five-line snapper)

Lutjanus sebae (Red emperor)

Haemulidae (Sweetlips)

Plectorhinchus flavomaculatus (Gold-spotted sweetlip)

Plectorhinchus gibbosus (Brown sweetlip)

Plectorhinchus picus (Magpie sweetlip)

Plectorhinchus unicolor

Siganidae (Rabbitfish)

Siganus argenteus (Forktail rabbitfish)

Siganus fuscescens (Happy moments)

Siganus vulpinus (Foxface)

Mullidae (Goatfish)

Mulloidichthys vanicolensis

Parupeneus cyclostomus (Yellow saddle goatfish)

Parupeneus multifasciatus (Banded goatfish)

Parupeneus pleurostigma (Sidespot goatfish)

Parupeneus spilurus (Black-spot goatfish)

Upeneus tragula (Bar-tailed goatfish)

Tetradontidae (Pufferfish)

Arothron hispidus (Stars & stripes toadfish)

Arothron meleagris (Guineafowl puffer)

Arothron nigropunctatus (Blackspotted puffer)

Arothron reticularis

Arothron stellatus

Canthigaster benetti (Bennett's puffer)

Canthigaster axiologus (Crowned puffer)

Canthigaster valentini (Black-saddled toby)

Diodontidae (Porcupinefish)

Cyclichthys jacauliferus (Long-spined porcupinefish)

Dicolichthys punctulatus (Threebar porcupinefish)

Diodon holocanthus (Fine-spotted porcupinfish)

Diodon hystrix (Black-spotted porcupinefish)

Diodon liturosus (Blotched porcupinefish)

Ostraciidae (Trunkfish/Boxfish)

Ostracion cubicus (Yellow boxfish)

Ostracion meleagris (Black spotted boxfish)

Tetrosomus concatenates (Turretfish)

Monocanthidae (Leatherjacket)

Cantherhines pardalis (Wire-net filefish)

Cantheschenia grandisquamis (Large-scale)

Monacanthus chinensis (Fan-bellied leatherjacket)

Oxymonacanthus longirostris (Long-nose filefish)

Paraluteres priorurus (Mimic filefish)

Pervagor alternans (Yellow-eyed leatherjacket)

Pervagor janthinosoma

Balistidae (Triggerfish)

Balistapus undulatus (Orange striped)

Balistoides conspicillum (Clown)

Melichthys vidua

Sufflamen chrysopterum (Flagtail)

Sufflamen fraenatum

Scaridae (Parrotfish)

Scarus ghobban (Blue-barred parrotfish)

Scarus niger (Black parrotfish)

Labridae (Wrasse)

Anampses caeruleopunctatus (Diamond wrasse)

Anampses geographicus (Geographic Wrasse)

Anampses femininus (Blue-tail wrasse)

Anampses neoguinaicus (Black-backed wrasse)

Bodianus axillaris (hogfish)

Bodianus mesothorax (Black-belt hogfish)

Bodianus perditio (Gold-spot pigfish)

Cheilinus trilobatus

Choerodon cephalotes (Grass tuskfish)

Choerodon graphicus

Choerodon fasciatus (Harlequin tuskfish)

Choerodon graphicus (Graphical tuskfish)

Choerodon schoenleinii (Black-spot tuskfish)

Choerodon venustus (Venus tuskfish)

Coris aygula (Bulbhead coris)

Coris batuensis (Batu coris)

Coris dorsomacula (Pale-barred coris)
Coris gaimard (Gaimard wrasse)
Cirrhilabrus punctatus (Dotted wrasse)
Diproctacanthus xanthurus (Yellowtail tubelip)
Gomphosus varius (Bird wrasse)
Halichoeres chrysus (Canary wrasse)
Halichoeres hortulanus (Checkerboard wrasse)
Halichoeres nigrescens
Hologymnosus annulatus (Ring wrasse)
Hologymnosus doliatus (Pastel ring wrasse)
Labroides dimidiatus (Cleaner wrasse)
Leptojulis cyanopleura
Macropharyngodon choati (Choats Wrasse)
Macropharyngodon meleagris (Blackspotted wrasse)
Macropharyngodon negrosensis
Novaculichthys taeniourus (Reindeer wrasse)
Oxycheilinus bimaculatus
Pseudolabrus guentheri
Pteragogus cryptus
Stethojulis bandanensis (Bluelined, red-spot wrasse)
Stethojulis interrupta (Cut-ribbon wrasse)
Suezichthys arquatus
Thalassoma hardwicke (Sixbar wrasse)
Thalassoma jansenii (Jansen's wrasse)
Thalassoma lunare (Moon wrasse)
Thalassoma lutescens (Sunset wrasse)

Blennidae (Blennies)

Plagiotremus rhinorhynchos
Plagiotremus tapeinosoma (Mimic blenny)

Scorpaenidae (Lion/Stonefish)

Dendrochirus zebra (Zebra lionfish)
Pterois volitans (Common lionfish or turkeyfish)
Synanceia horrida (Estaurine stonefish)

Cirrhitidae (Hawkfish)

Cirrhitichthys aprinus (Blotched, threadfin hawkfish)
Cirrhitichthys falco (hawkfish)
Cirrhitichthys oxycephalus
Paracirrhites arcatus (Ring-eyed hawkfish)
Paracirrhites forsteri

Acanthuridae (Surgeonfish)

Acanthurus albipectoralis (Whitefin surgeon)
Acanthurus auranticavus (Orange-socket surgeon)
Acanthurus dussumieri (Blue-tailed surgeon)
Acanthurus mata
Acanthurus nigrofuscus
Acanthurus nigroris
Acanthurus olivaceus (Orange-blotch surgeon)
Acanthurus xanthopterus (Yellowfin surgeon)
Ctenochaetus striatus (Lined bristletooth)
Naso brachycentron
Naso hexacanthus
Naso lituratus (Orangespine unicorn)
Naso unicornis (Blue-spine unicorn)
Paracanthurus hepatus (Blue tang)
Prionurus microlepidotus (Sixplate sawtail)
Zebrasoma scopas (Twotone tang)

Muraenidae (Moray Eels)

Echidna nebulosa (Starry)
Gymnothorax eurostus (White-speckeled)
Gymnothorax pseudothrysoidea (Highfin or Coastal)
Gymnotorax favagineus (Black-blotched)
Gymnotorax javanicus (Giant)
Gymnotorax undulatus (Undulate)
Siderea thyrsoidea (White-eyed)

Gobiidae (Gobies)

Amblyeleotris fasciata (Banded shrimpgoby)
Cryptocentrus maudae (Maude's shrimpgoby)
Gobiodon citrinus (Poison goby)
Valenciennea strigata (Golden-head sleeper goby)

Pinguipedidae (Grubfish)

Parapercis clathrata (Latticed sandperch)
Parapercis cylindrica (Sharp-nose grubfish)
Parapercis millepunctata (Black dotted sand perch)
Parapercis stricticeps (White-streaked grubfish)

Cheilodactylidae (Morwongs)

Cheilodactylus fuscus (Red morwong)
Cheilodactylus vestitus (Magpie morwong)

NEMIPTERIDAE (Spinecheeks)

Scolopsis bilineatus (Twoline spinecheek)
Scolopsis monogramma (Barred spinecheek)
Pentapodus paradiseus (Paradise whiptail)

Carangidae (TREVALLIES)

Alectis ciliaris (Treadfin trevally)

Carangoides ferdau (Blue trevally)

Pseudocaranx dentex (White trevally)

Seriola lalandi (Yellowtail kingfish)

Trachinotus blochii (Subnose dart)

Trachurus novaezelandiae (Southern yellowtail scad)

Caesionidae (Fusiliers)

Caesio caerulaurea (Blue and gold fusilier)

Caesio lunaris (Lunar fusilier)

Paracaesio xanthurus (Southern fusilier)

Pterocaesio digramma (Blacktipped or Yellow-lined fusilier)

Pterocaesio marri (Marr's fusilier)

Sphyraenidae (Barracudas)

Sphyraena flavicauda (Yellowtail barracuda)

Sphyraena obtustata (Striped sea pike)

Microdesmidae (Dartfish)

Ptereleotris evides (Two-tone dartfish)

Pempherididae (Bullseye)

Pempheris affinis (Black-tipped bullseye)

Pempheris analis (Bronze bullseye)

Pempheris compressa (Small-scale bullseye)

Holocentridae (Squirrelfish & Soldierfish)

Myripristis kuntee (Pearly or epaulette soldierfish)

Myripristis murdjan (Crimson soldierfish)

Sargocentron diadema (Crown soldierfish)

Sargocentron rubrum (Redcoat squirrelfish)

Aulostomidae (Trumpetfish/ Cornetfishes)

Aulostomus chinensis (Trumpetfish)

Fistulariidae (Flutefish)

Fistularia commersonii (Flutemouth)

Monodactylidae (Silver Batfish)

Monodactylus argenteus (Diamondfish or Butterbream or Silver batfish)

Schuettea scalaripinnis (Eastern pomfret)

Elasmobranchii (Sharks & Rays)
Rays/ Numbfish

Aetobatus narinari (Eagle)

Neotrygon kuhlii (Bluespotted sting)

Himantura uarnak (Coachwhip)

Hypnos monopterygium (Numbfish or Electric)

Manta alfredi (Manta)

Pastinachus sephen (Cowtail sting)

Rhynochobatus djddersis (White-spotted shovelnose

Trygonoptera testacea (Common sting)

Sharks

Carcharhinus brachyurus (Bronze whaler)

Carcharias Taurus (Grey nurse shark)

Carcharodon carcharias (White pointer shark)

Chiloscyllium punctatum(Brown-banded catshark/ Bambooshark)

Galeocerdo cuvier (Tiger shark)

Orectobulus maculatus (Spotted wobbegong)

Orectobulus ornatus (Banded wobbegong)

Rhincodon typus (Whale shark)

Sphyrna sp. (Hammerhead shark)

Stegostoma fasciatum (Leopard shark)

Other Fish

Atypichthys strigatus (Australian mado)

Aeoliscus strigatus (shrimpfish)

Aulopus purpurissatus (Sergeant baker)

Batrachomoeus dubius (Eastern frogfish)

Cleidopus gloriamaris (Pineapplefish)

Dactyloptena orientalis (Flying gunard)

Echeneis naucrates (Common suckerfish)

Enoplosus armatus (Old wife)

Equetus lanceolatus (Jacknife-fish)

Heteropriacanthus cruentatus (Duskyfin red bullseye)

Kyphosus cinerascens (Highfin rudderfish)

Microcanthus strigatus (Stripey)

Pagrus auratus (Snapper)

Platycephalus endrachtensis (Bar-tailed flathead)

Plotosus lineatus (Striped catfish)

Priacanthus hamrur (Moontail bullseye)

Rhabdosargus sarba (Goldlined seabream)

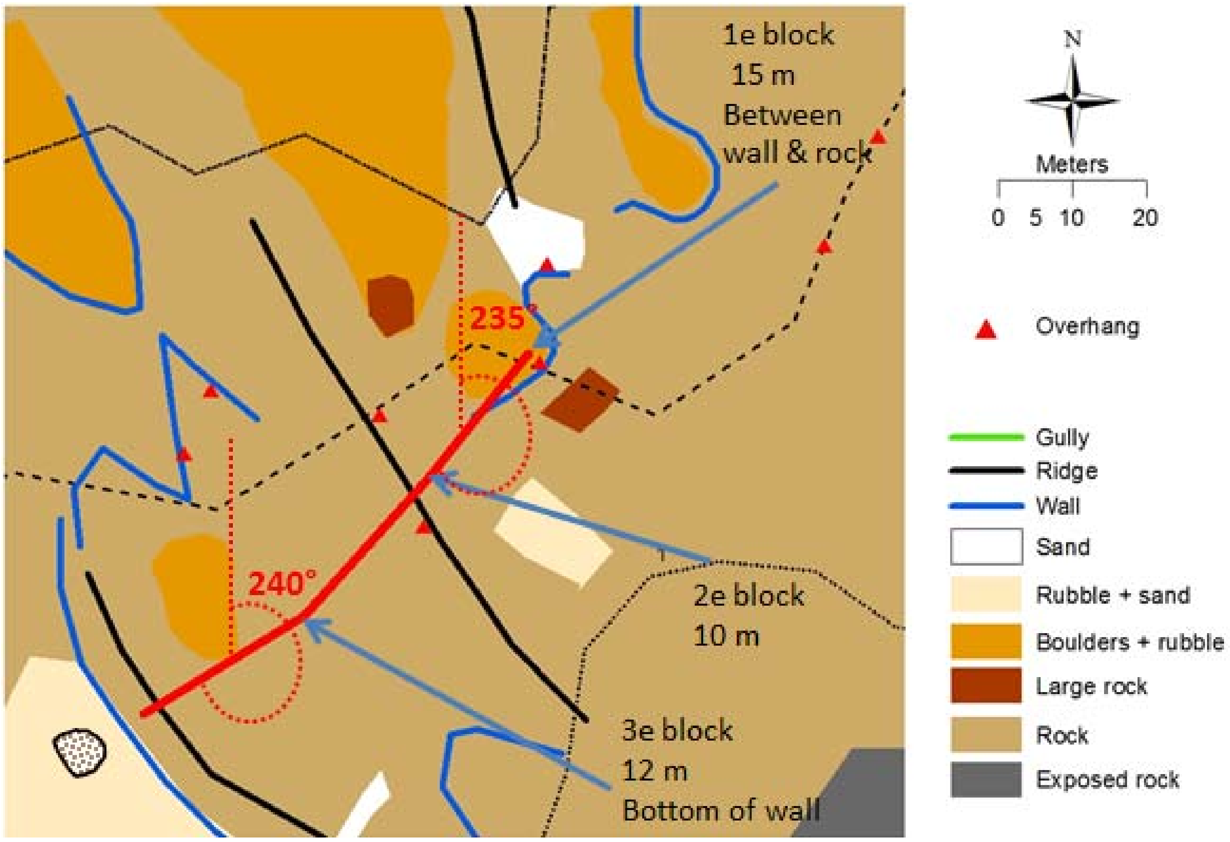
Scorpis lineolata (Silver sweep)

Synodus dermatogenys (Two-spot lizardfish)

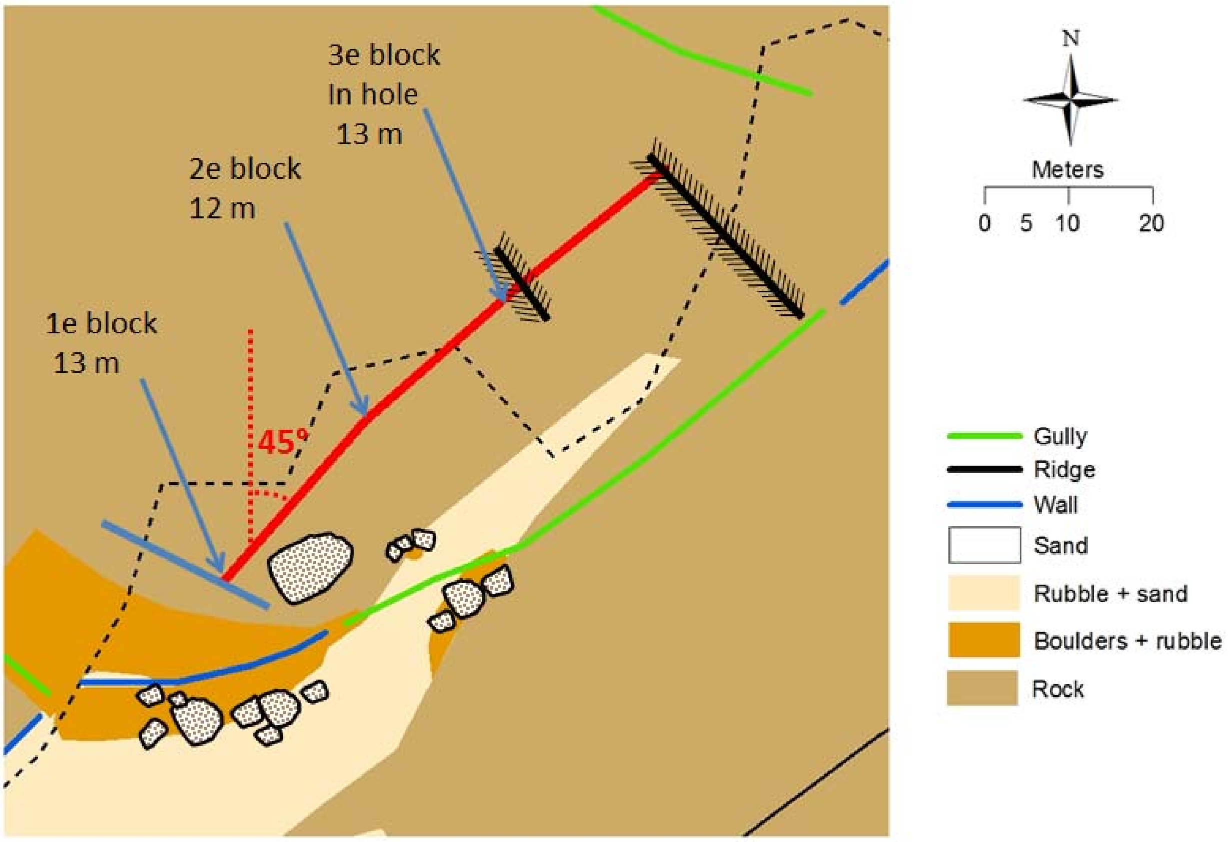
Zanclus cornutus (Morish idol)

Appendix C: Transect Locations

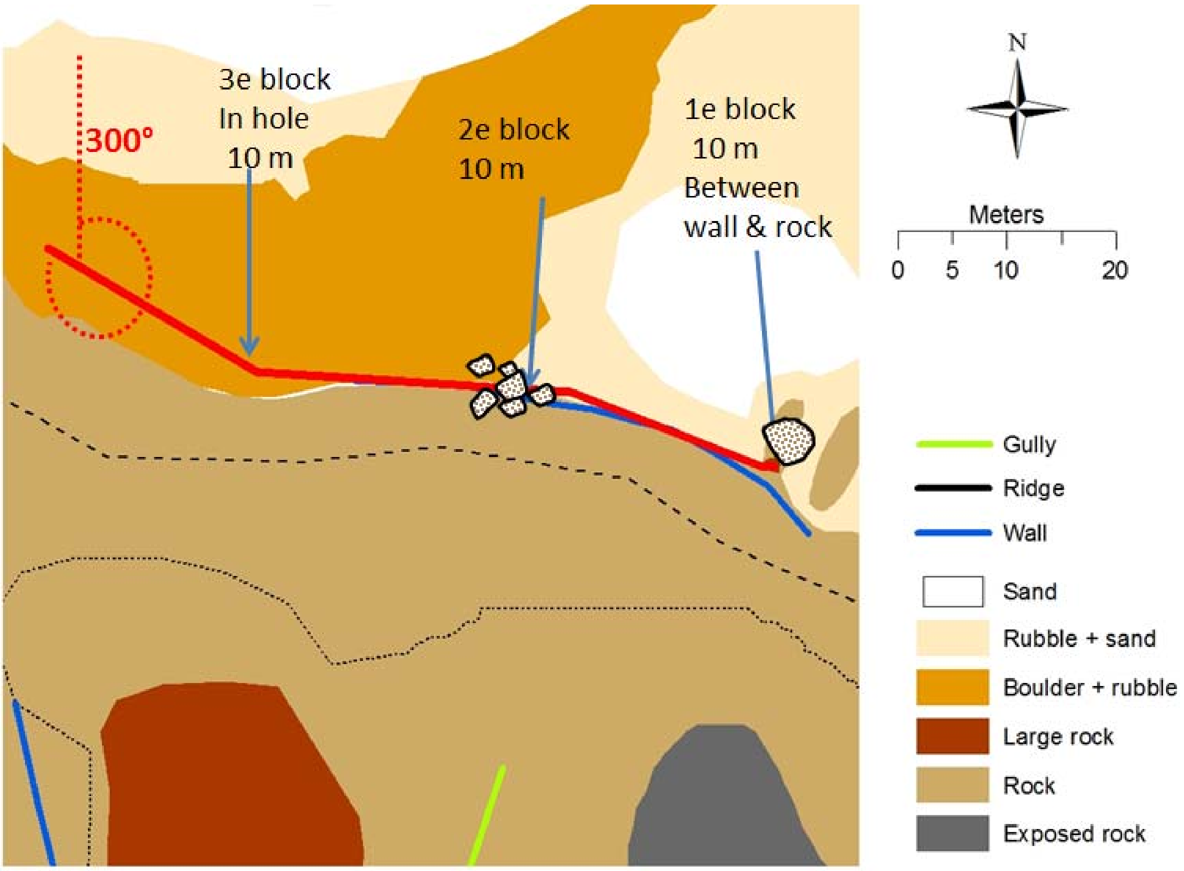
Flat Rock West



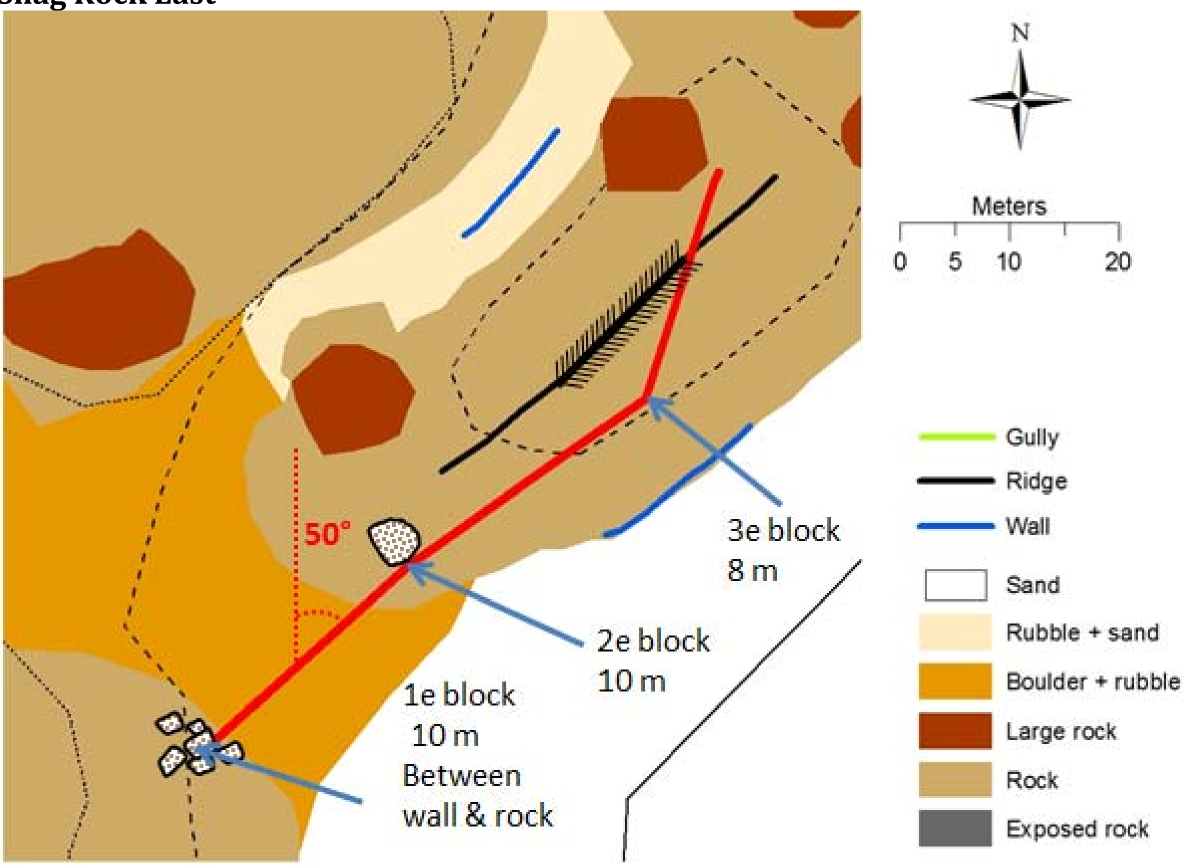
Flat Rock East



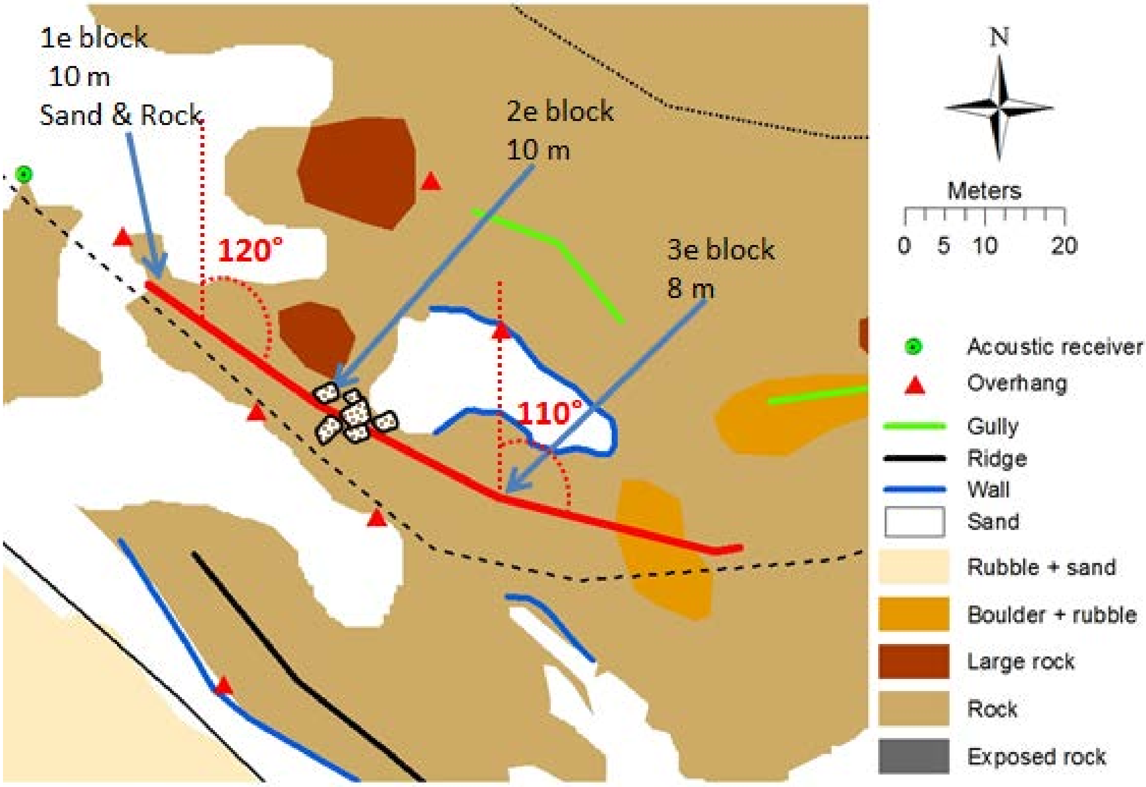
Shag Rock West



Shag Rock East



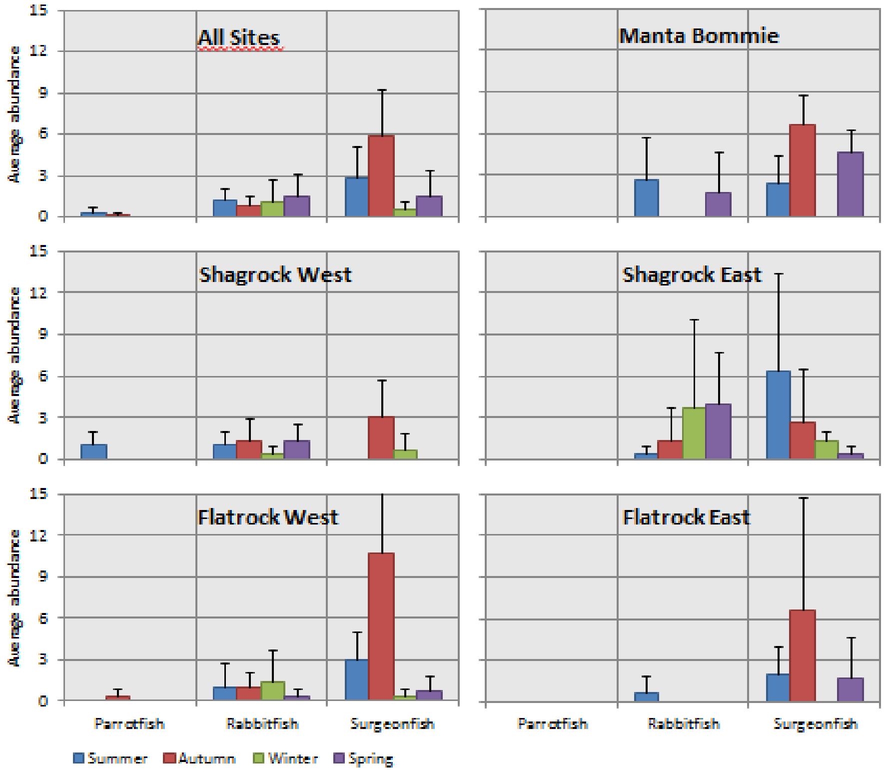
Manta Ray Bommie

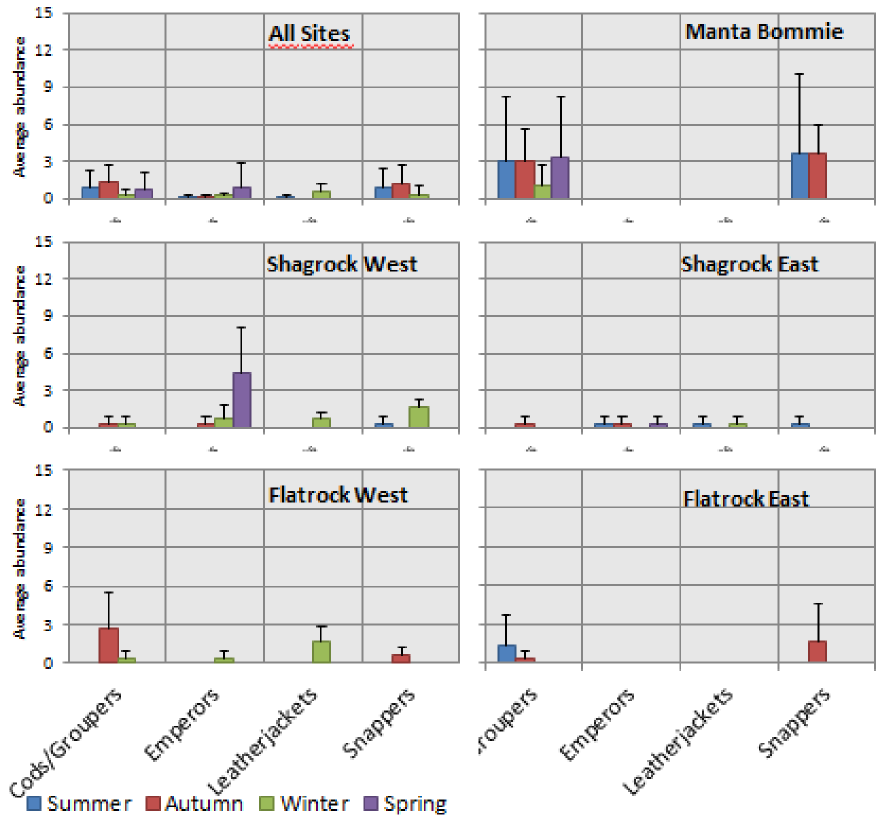


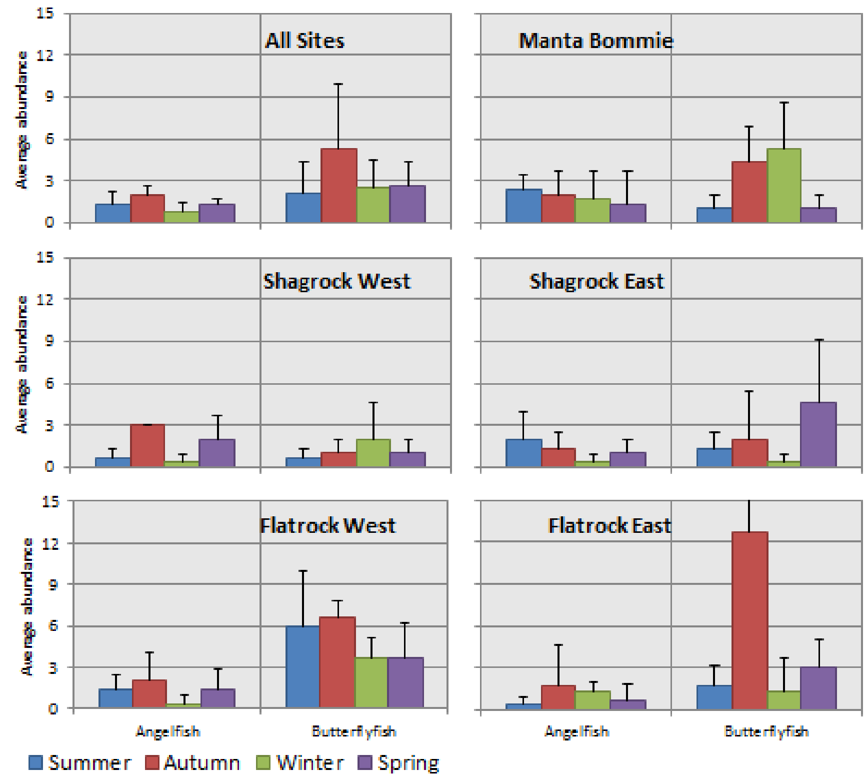
Appendix D: Transect Coordinates

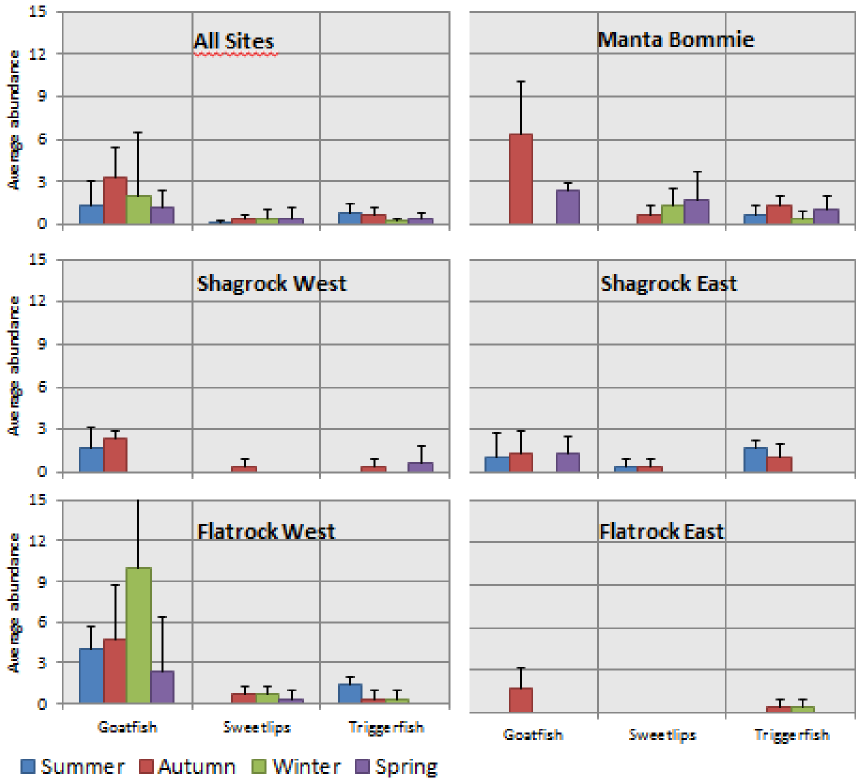
Transect Name	Point_Type	EastWGS854	NorthWGS84
Shag Rock West	Start	551987	6967660
Shag Rock West	End	551920	6967680
Shag Rock East	Start	552041	6967540
Shag Rock East	End	552091	6967590
Flat Rock West	End	554395	6970310
Flat Rock West	Start	554447	6970360
Flat Rock East	End	554648	6969980
Flat Rock East	Start	554595	6969940
Manta Ray Bommie	End	554162	6966480
Manta Ray Bommie	Start	554087	6966510

Appendix E: Fish Families

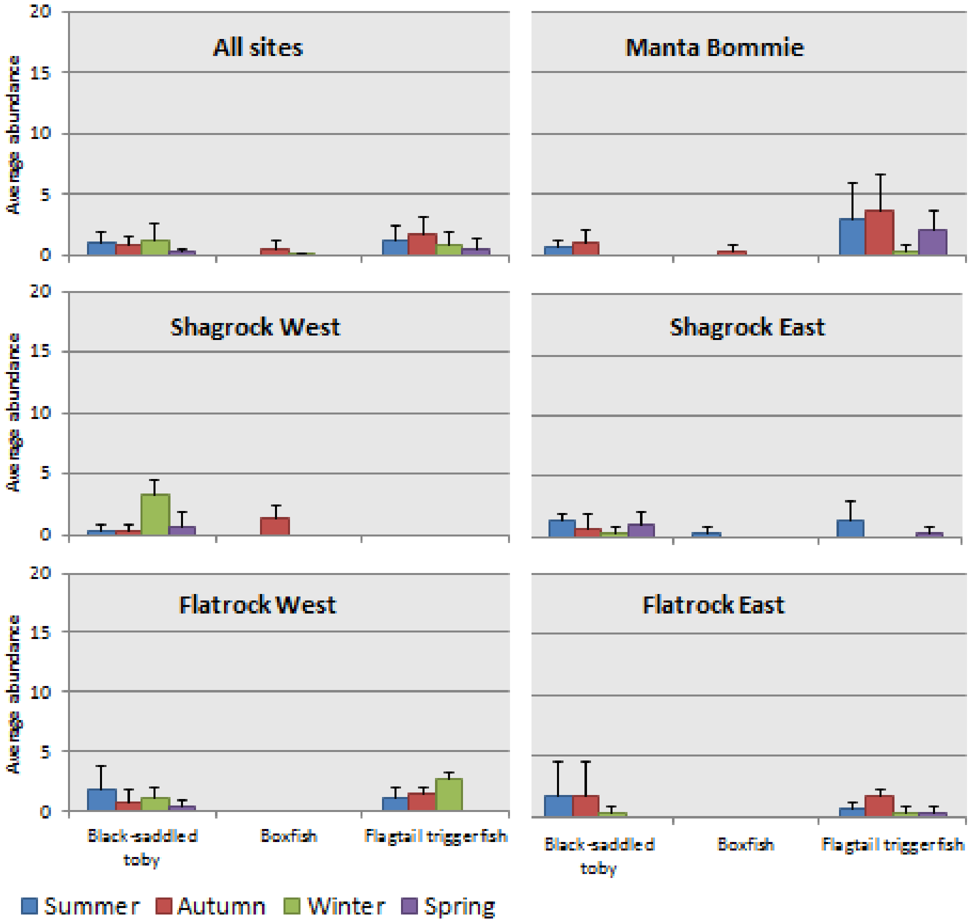


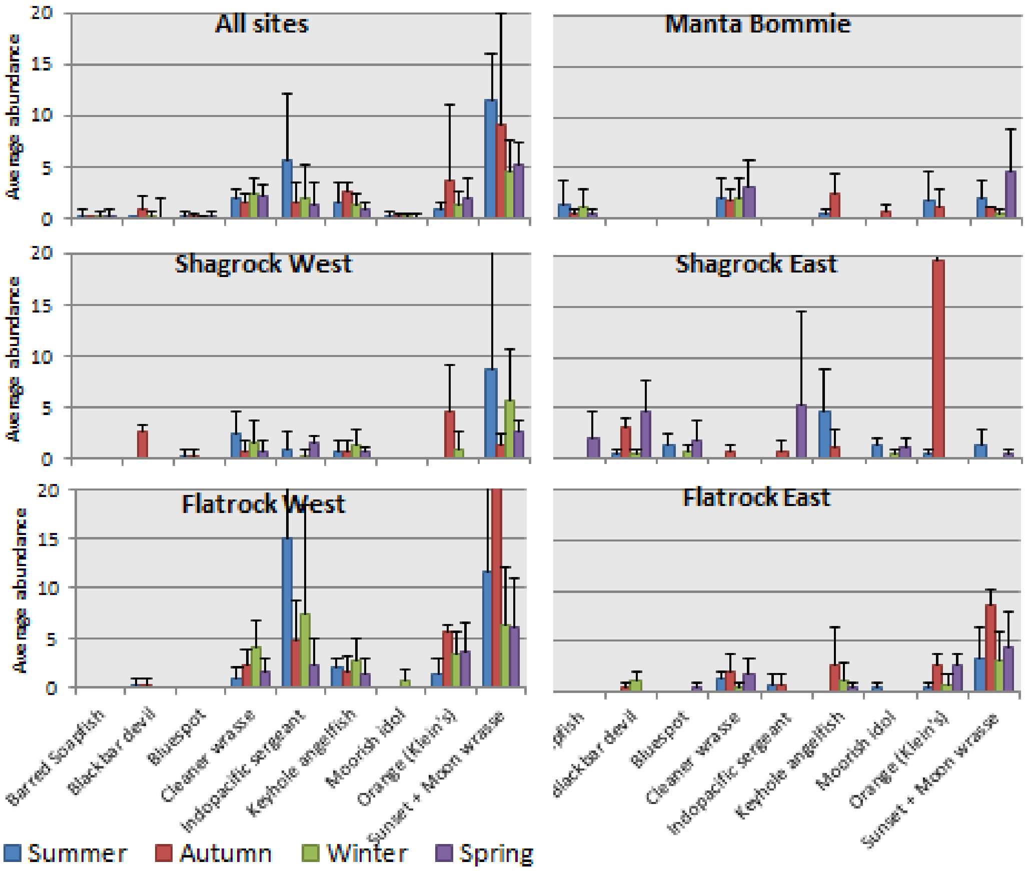


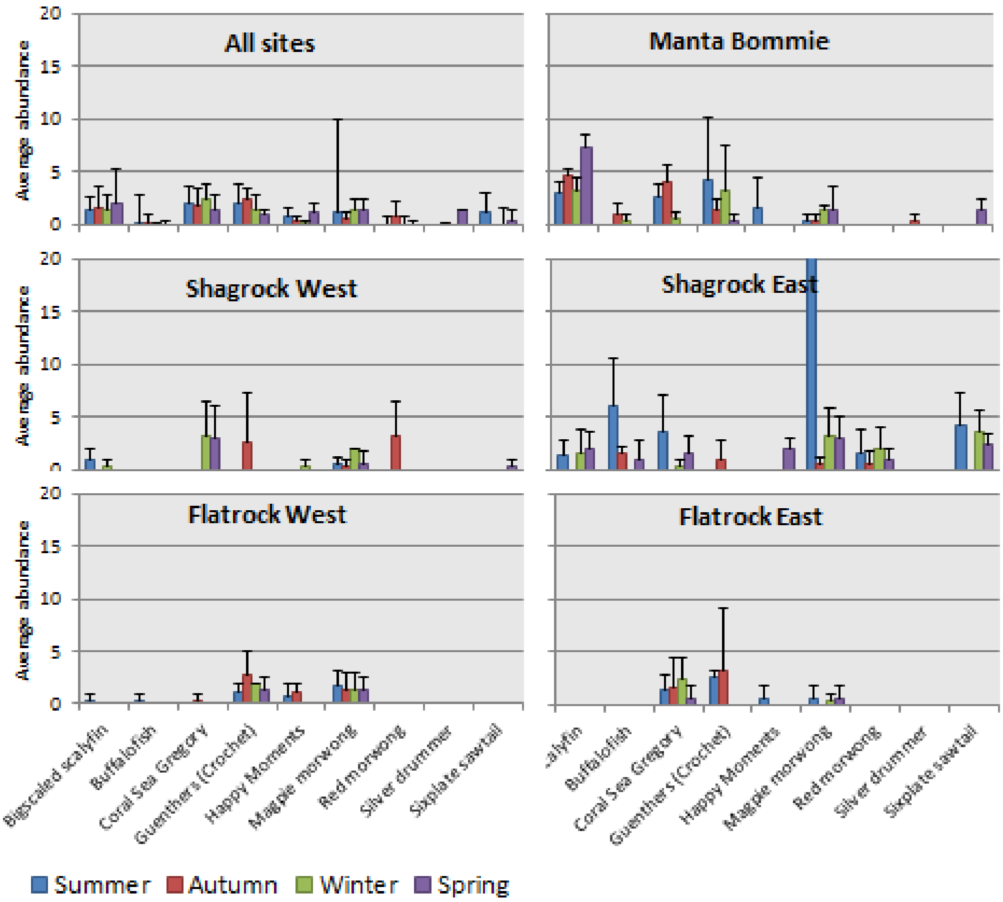

All Sites
Manta Bommie
Shagrock West
Shagrock East
Flatrock West
Flatrock East
Average abundance
0
3
6
9
12
15
Angelfish
Butterflyfish
Summer
Autumn
Winter
Spring


All Sites
Manta Bommie
Shagrock West
Shagrock East
Flatrock West
Flatrock East
Average abundance
0
3
6
9
12
15
Goatfish
Sweetlips
Triggerfish
Summer
Autumn
Winter
Spring

Appendix F: Fish Species

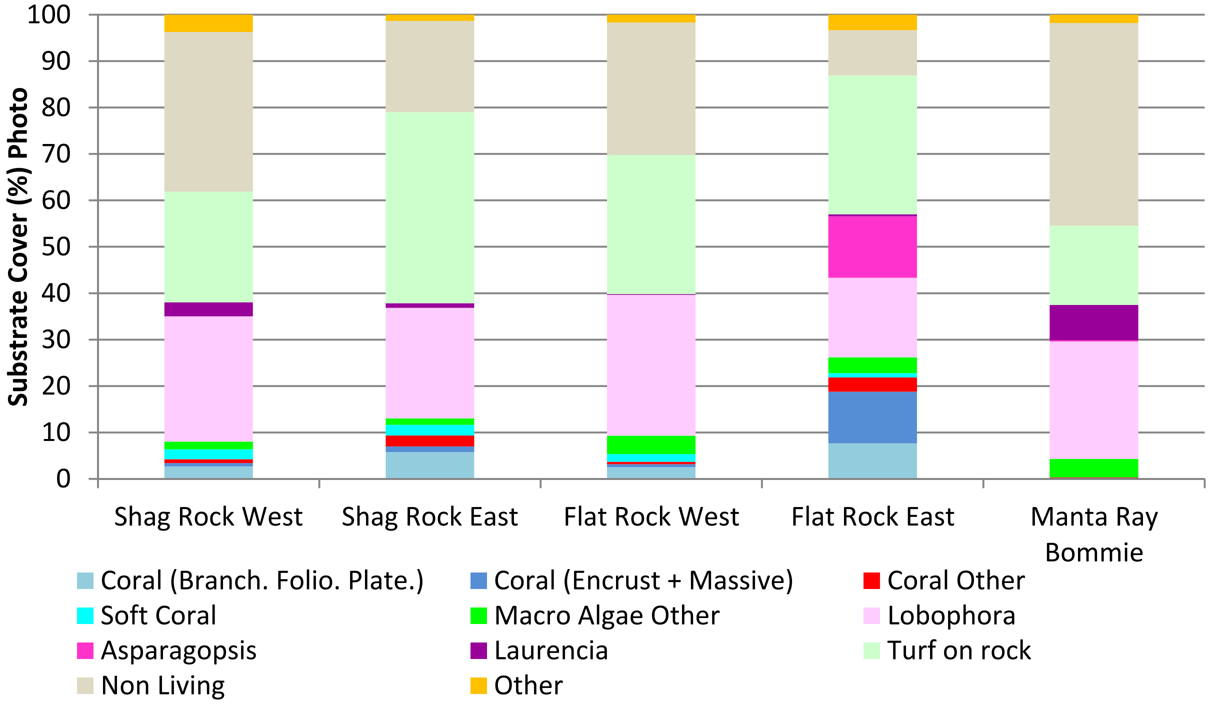



All sites
Manta Bommie
Shagrock West
Shagrock East
Flatrock West
Flatrock East
Average abundance
Barred Soapfish
Blackbar devil
Bluespot
Cleaner wrasse
Indopacific sergeant
Keyhole angelfish
Moorish idol
Orange (Klein's)
Sunset + Moon wrasse
Summer
Autumn
Winter
Spring

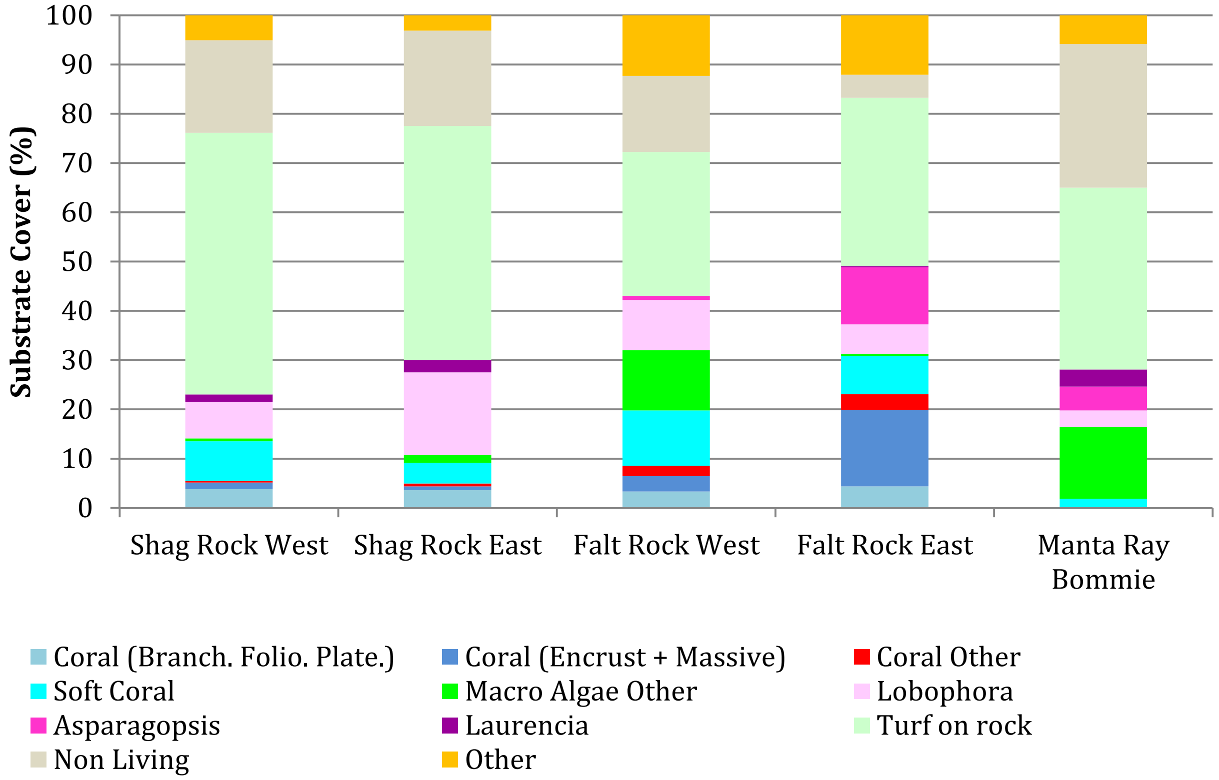

All sites
Manta Bommie
Shagrock West
Shagrock East
Flatrock West
Flatrock East
Average abundance
Bigscaled scalyfin
Buffalofish
Coral Sea Gregory
Guenthers (Crochet)
Happy Moments
Magpie morwong
Red morwong
Silver drummer
Sixplate sawtail
Summer
Autumn
Winter
Spring

Appendix G: Substrate Cover

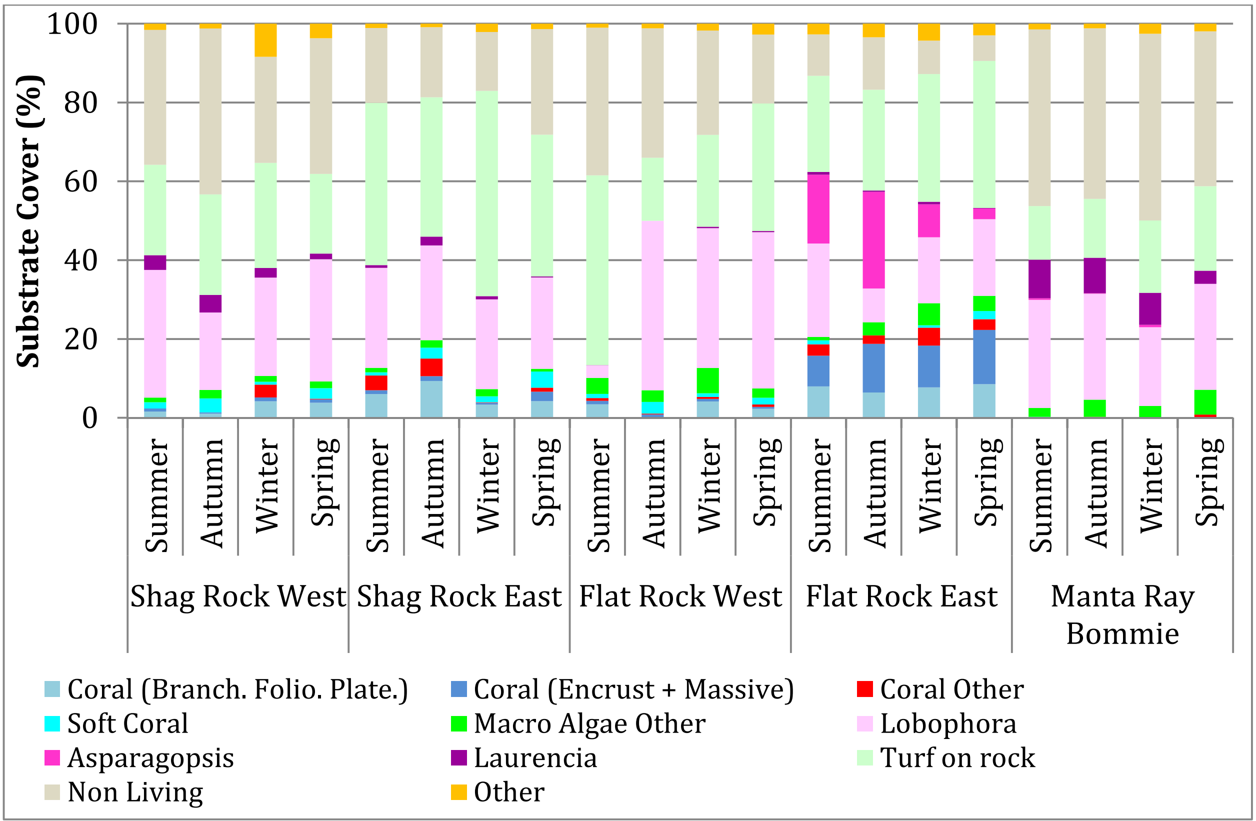
H 1: Transect photo analysis averaged per site



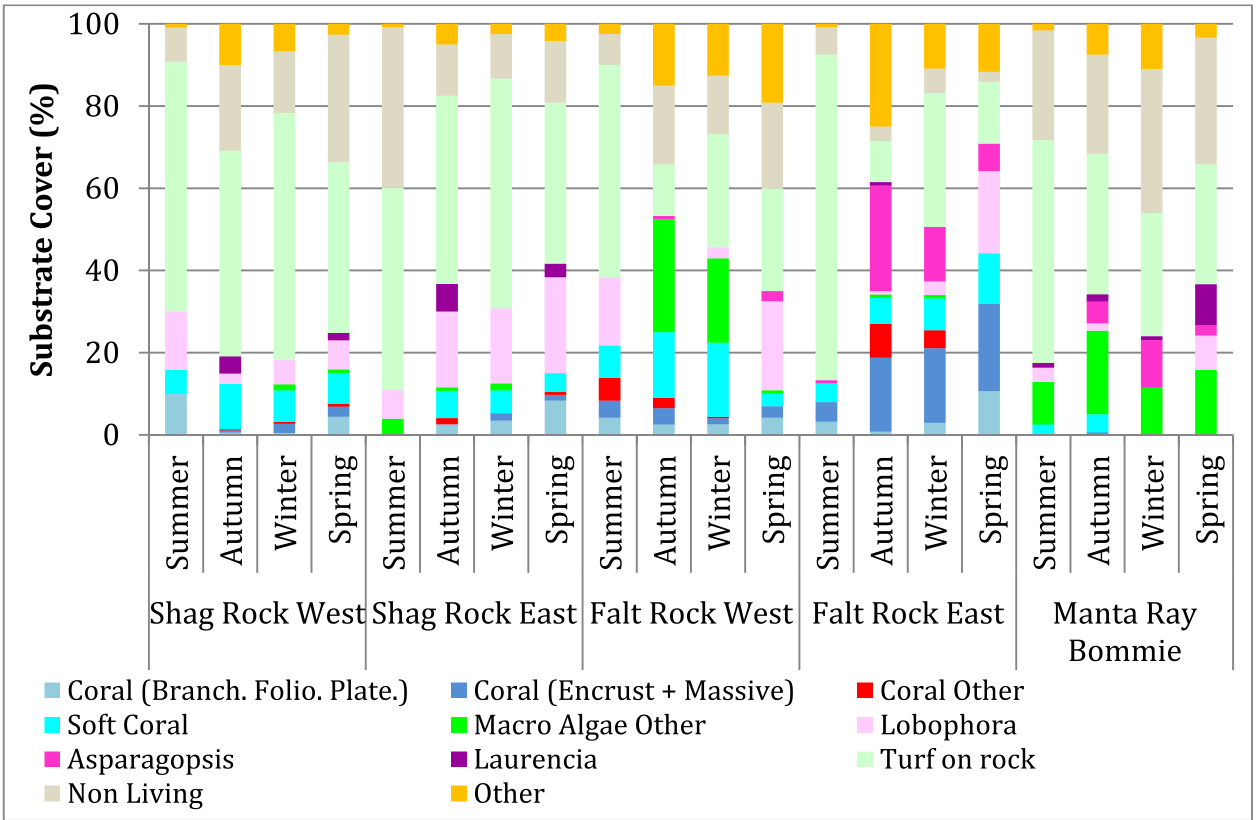
H 2: Diver-recorded transect data averaged per site.



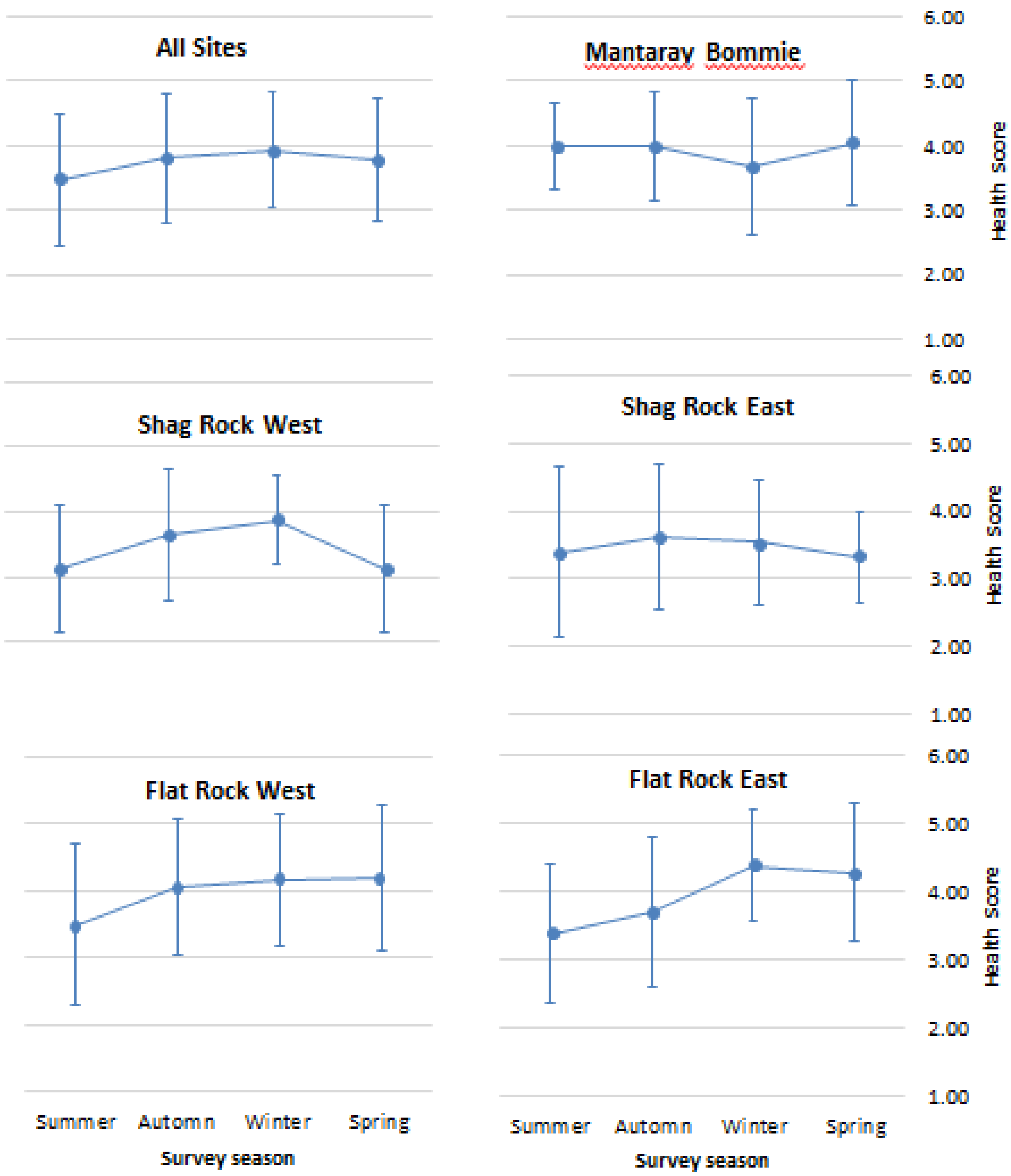
H 3: Transect photo analysis averaged per season for each site



H 4: Diver-recorded transect data averaged per season for each site.



Appendix H: Coral Health Chart Scores averaged for each season per site.



Appendix I: Dive Statistics

Dates	Number of Divers	SUM of Dives	SUM of Time (hrs.)	Dive location	Type of Dive
31/01/2014	10	21	9.3	Shag & Flat Rock	Place markers
1/02/2014 Weekend	26	97	75.3	Shag Rock	Training
22/02/2014 Weekend	23	59	41.1	Flat Rock West, Shag Rock	Survey Summer
8/03/2014	2	2	1.3	Manta Bommie	Place markers
22/03/2014	8	16	11.7	Flat Rock East and Manta Ray	Survey Summer
29/03/2014 Weekend	23	94	69.1	Shag Rock, Manta Bommie	Training
3/05/2014 Weekend	21	76	57.8	Flat and Shag Rock, Manta Bommie	Survey Autumn
19/07/2014 Weekend	23	67	44.2	Shag Rock, Manta Bommie, Flat Rock West	Survey Winter
2/08/2014	12	24	17.2	Flat Rock East and Manta Ray	Survey Winter
26/09/2014	8	8	5.3	Shag Rock West	Totally Wild
25/10/2014 Weekend	24	48	33.5	Flat and Shag Rock	Survey Spring
30/10/2014	10	23	10.1	Flat and Shag Rock, Manta Bommie	Transect + Marker recovery
Grand Total	**44**	**535**	**375.6**		

Appendix J: Mooring Options

Placing a private mooring at the Point Lookout reefs requires a marine park permit (from Queensland Parks and Wildlife Service- QPWS) and a buoy mooring authority (from Maritime Safety Queensland - MSQ). QPWS approval will depend on justification that the mooring, its installation and operation will cause the least damage to substrate when compared to alternatives. MSQ approval will depend on the mooring's location not causing a navigation hazard. Both mooring applications should be lodged together. Given its location, it would be beneficial to have a registered professional engineer or naval architect certify that the design is fit for purpose.

The Marine Park permit if approved,will require the permit holder to have public liability insurance of $20 million.

There are three mooring options to consider: 1. Private, 2. Public but privately funded, and, 3. Public.

Mooring Type	**Private**	**Public (Privately Funded)**	**Public**
Owner (liable)	Trust, joint dive shops, one dive shop, or dive club etc.	QPWS,	QPWS
Funding	Whoever is interested and wants to use the mooring	Money is donated privately sufficient to fund at least three years maintenance and installation	QLD Government
Maintenance (responsibility of owner)	Given its environmentally sensitive location, the marine park permit may specify who, (e.g. someone who belongs to the Board of Professional Engineers (RPEQ)) can carry out and/or certify the maintenance	Every three months, by appropriate service provider	Every three months, by appropriate service provider
Liability Insurance (Paid by owner)	$20 million	$20 million	$20 million
Mooring type: (refer to below)	Any class as approved by MSQ.	C class mooring	C class mooring
Users:	Only those with approval from the mooring owner; mooring is marked as limited access	Any user	Any user

Mooring Class	Colour Band	Max Wind Strength	Monohull Maximum Length	Multihull Maximum Length
Tender (T)	Brown	24 knots	6 metres	6 metres
Class A	Yellow	24 knots	10 metres	9 metres
Class B	Orange	34 knots	20 metres	18 metres
Class C	Blue	34 knots	25 metres	22 metres
Class D	Red	34 knots	35 metres	30 metres

From a safety point of view, it is advised that mooring points for common dive boats (e.g. 12-14 diver RIBS) are located in shallow waters. The moorings at Flat Rock do not promote safe diving profiles, and require divers to take unnecessary risk. Here, the moorings are located with buoys connected via a rope to mooring blocks which are located at a depth of 18-30 m from which divers explore the area surrounding it. Common dive protocol is that divers return to the boat. To do this at Flat Rock a diver is required to locate the mooring, in deep water, then return to the surface. As a result divers need to drop at the end of the dive to deeper water to find the mooring line and then conduct a safety stop. Alternatively, they do a mid-water ascent in shallower water where performance of a safety stop is often in current and swell. As such, divers will drift away from the dive site, requiring deployment of a surface marker buoy so the boat may then retrieve them from the water.
650 dives were safely conducted, during the project under various conditions. All divers: predominantly had at least 100 logged dives; were rescue diver qualified or higher; sat an exam that included dive safety; read risk assessments; noted air and time during each dive on their data sheets; were reminded in briefings of the importance of safety versus collecting good data; and, briefed on common emergency protocols, such as safety stops on ascent.

During the project volunteer divers were exposed to unnecessary reverse profiles or mid water assents when conducting surveys at Flat rock. This is also an occurrence for recreational divers at these dive sites. Reverse profiles during a dive are considered an unsafe dive practice under most common diving agencies (e.g. PADI, SSI, NAUI, BSAC……). Therefore, it is recommended that moorings be installed in shallower water.

This study was possible by the support and assistance of the following contributing agencies and organisations:

Redland City Council
Sibelco Australia
Point Lookout Scuba
UniDive
Transit Systems
The University of Queensland Australia
Biophysical Remote Sensing Group
CoralWatch
Reef Check Australia
Grey Nurse Shark
qcif
Manta Lodge & Scuba Centre Stradbroke Island