Cardno Ecology Lab

Shaping the Future

Marine and Freshwater Studies

Ex-HMAS Adelaide Artificial Reef

Reef Community Monitoring

Survey 2

Job Number: EL1112024

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Cover Image: Encrusting Growth on the Ex-HMAS Adelaide, February 2011. Photographer, Brendan Alderson (Cardno Ecology Lab).

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Executive Summary

Cardno (NSW/ACT) trading as Cardno Ecology Lab Pty Ltd was commissioned by the Department of Primary Industries – Catchments and Lands, to undertake the post-scuttling environmental monitoring for the Ex-HMAS Adelaide artificial reef and dive site.

A comprehensive environmental assessment has been undertaken for the project in accordance with state and federal environmental legislation. This included approval under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and obtaining an Artificial Reef (or Sea Dumping) Permit issued under the *Environment Protection (Sea Dumping) Act 1981* from the federal Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). A condition of the Permit is that the Department of Primary Industries – Catchments and Lands must implement the proposed Long Term Monitoring and Management Plan (LTMMP) prepared in March 2011.

This Progress Report outlines the methodology and findings of Reef Community Monitoring Survey 2 (**Table ES 1**), the second of eight reef community surveys required as part of the LTMMP. These surveys are carried out on a quarterly basis. The aims of the reef community survey as outlined in the LTMMP were to gain an understanding of:

- Types of flora and fauna assemblages present;
- Rate of development of fouling assemblages and how they change over time;
- Variation in the rates at which assemblages develop on different surfaces of the vessel; and
- Presence of introduced or pest species.

Field surveys were carried out on 14 and 16 February 2012. Survey methods involved using divers to take photoquadrats and under water video on different parts of the ship. Photoquadrats were analysed for percentage cover of encrusting biota using Coral Point Count with Excel extensions (CPCe) and compared with the baseline and Monitoring Survey 1. Underwater video footage was reviewed and also used to describe the encrusting reef community.

Analysis of photoquadrats taken from different parts of the ship showed that there had been an increase in the number of individual taxa or groups of taxa from 28 to 32 and several taxa not previously recorded (including red and brown algae, anemones and sponges) were observed in the current survey. Throughout the ship a matrix of barnacles, sediment and brown filamentous algae provided the greatest coveage followed by a matrix of serpulid tubes covered with trapped sediment and turfing brown algae. Large barnacles, sediment, brown filamentous algae and the brown macroalgae *Ecklonia radiata*, had the next greatest percentage cover. Analysis of spatial differences and comparison through time indicated that the assemblage recorded on the ship in February 2012 was significantly different to that in October 2011, although the effect of time was not consistent among parts on the ship.

Visual comparisons of fixed point photographs indicated that the encrusting assemblage appears to have increased in thickness on parts of the ship, particularly, ladders, railings and pylons associated with the vertical superstructure. In addition to the assemblage of bryozoans, sponges, serpulids and barnacles observed in Monitoring Survey 1, large ascidians covered in hydroids, anemones and mobile invertebrates (such as gastropod molluscs and crabs) were observed in the current survey. *Ecklonia radiata* had also grown substantially on parts of the ship since the previous survey.

Fish abundance and species richness observed around the Ex-HMAS Adelaide does not appear to have increased since the previous survey, although several new species including tarwhine (*Rhabosargus sarba*), girdled scalyfin (*Parma unifasciata*) and yellowtail kingfish (*Seriola lalandi*) were recorded, some of which are likely to be seasonally abundant at the time of survey. Several of the species observed were of recreational or commercial importance. The eastern blue groper (*Archoerodus viridis*) (observed in Monitoring Surveys 1 and 2) is protected under the NSW *Fisheries Management Act 1994*. No introduced marine pests were observed during the survey.

Table ES1: Summary of Reef Community Sampling Carried Out To-Date

Survey	Sampling Dates	Timeframe
Baseline	18 April and 30 May 2011	1 week post-scuttling
Monitoring Survey 1	11 and 13 October 2011	6 months post-scuttling
Monitoring Survey 2	14 and 16 February 2012 (Current survey was proposed for January 2011 but postponed due to inclement weather)	10 months post-scuttling

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Glossary

Artificial Reef	A structure or formation placed on the seabed for the purpose of increasing or concentrating populations of marine plants and animals or for the purpose of being used in human recreational activities.
CPCe	Coral Point Count with Excel Extensions. A software package used to analyse cover of encrusting organisms and corals.
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EP&A Act	Environmental Planning & Assessment Act 1979
LAT	Lowest Astronomical Tide
Epiphytic	Growing on the surface of.
LTMMP	Long Term Monitoring and Management Plan
Introduced Marine Pest	Introduced marine pests are species moved to an area outside their natural range, generally by human activities, and that threaten the environment, human health or economic values.
PCoA	Principle Coordinates Analyses
PERMANOVA	Permutational Analysis of Variance. A statistical routine run in Primer-E.
SIMPER	Similarity Percentage. A statistical routine run in Primer-E.

1 Introduction

1.1 Background and Aims

Cardno (NSW/ACT) trading as Cardno Ecology Lab Pty Ltd was commissioned by the Department of Primary Industries – Catchments and Lands to undertake the post-scuttling environmental monitoring for the Ex-HMAS Adelaide artificial reef and dive site.

The Ex-HMAS Adelaide was gifted from the Australian to the NSW Government for the specific purpose of scuttling the ship as an artificial reef off the Central Coast of NSW. A comprehensive environmental assessment was undertaken for the project in accordance with state and federal environmental legislation. This included approval under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and obtaining an Artificial Reef (or Sea Dumping) Permit issued under the *Environment Protection (Sea Dumping) Act 1981* from the federal Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC).

Sea Dumping Permits ensure that appropriate sites are selected, materials are suitable and appropriately prepared, that there are no significant adverse impacts on the marine environment and that the reef does not pose a danger to marine users. A condition of the Permit is that the Department of Primary Industries – Catchments and Lands must implement the proposed Long Term Monitoring and Management Plan (LTMMP) which was prepared in March 2011.

The LTMMP covers environmental and structural monitoring for the first five years post-scuttling and forms the basis for ongoing monitoring and maintenance over the operational life of the vessel as a dive site, which is estimated to be 40 years. The frequency of monitoring and the methodologies used will be reviewed periodically during the life of the Plan. The scope of work to be carried out by Cardno Ecology Lab is for a two year period post-scuttling, which follows on from initial baseline investigations carried out by Worley Parsons in April/May 2011. It includes the following environmental monitoring components:

- Reef communities;
- Sediment quality; and
- Bioaccumulation studies.

This Progress Report outlines the methodology and findings for the second of eight reef community surveys. These surveys are to be carried out on a quarterly basis.

The aims of the reef community monitoring survey, as outlined in the LTMMP, is to gain an understanding of:

- Types of flora and fauna assemblages present;
- Rate of development of fouling assemblages and how they change over time;
- Variation in the rates at which assemblages develop on different surfaces of the vessel; and
- Presence of introduced or pest species.

This progress report outlines the following:

- Description of sampling dates, times, weather conditions and tidal height;
- Description of the methods used including the position of the fixed transects and photoquadrats;
- Results including interpretation of video footage, fixed point photographs and CPCe analyses;
- Statistical analyses of photoquadrats over time and spatially;
- Identification of fish, threatened or protected species and any introduced or marine pest species observed during the survey;
- Discussion of findings; and
- Reports of any condition or occurrence that may influence results of the study.

1.2 Study Site and Vessel

The Ex-HMAS Adelaide artificial reef and dive site is located within Balbaring Bay, approximately 1.87 km offshore from Avoca Beach. The ship lies at a depth of approximately 32 m to 34 m of water at Lowest Astronomical Tide (LAT) and is embedded approximately 1 m into the flat, sandy, seabed. There is a minimum of 6 m of sand overlying bedrock. The vessel is orientated with the bow facing into the prevailing ESE swell

direction (**Figure 1**). Approximate depths to various levels on the ship from Lowest Astronomical Tide (LAT) are shown in **Figure 2**.

The ship is 138.1 m in length, with a beam of 14.3 m and an original displacement of 4,200 tonnes. The hull is made of steel and the superstructure of aluminium alloy. Heights are approximately 12 m to the main deck, 18 m to the bridge, 24 m to the top of the foremast (the mast closest to the bow), and 39 m to the top of the mainmast (NSW Government 2011).

Preparation for scuttling involved the removal of the main mast structures for safety and navigation reasons and stripping of machinery, hatches and any items that could pose a risk to divers or the environment. Potential contaminants such as fuels, oils, heavy metals, batteries and electrical items containing polychlorinated biphenols (PCBs) were removed. Diver access holes were cut into the sides of the hull, floors and ceilings to allow extra vertical access between decks and also to allow light to penetrate. Further holes were also made to allow air to escape during the scuttling process (NSW Government 2011).

The Ex-HMAS Adelaide was prepared to meet DSEWPaC standards which were specified during the months of preparation prior to scuttling. DSEWPaC had conducted a series of inspections to confirm that its detailed requirements were achieved. The original clean-up process included removing loose or flaking paint in accordance with DSEWPaC's requirements.

1.3 Previous Surveys

1.3.1 Baseline Survey

The Ex-HMAS Adelaide was scuttled on the 13 April 2011. A baseline investigation of reef communities was carried out between the 18 April and 30 May 2011 (Worley Parsons 2011), immediately post-scuttling. In accordance with the methodology outlined in the LTMMP, underwater video and still photography was taken along horizontal and vertical transects of the ship using divers. These were sampled as follows:

- Horizontal Hull = 6 transects in total (3 x 100 m transects along the starboard and port planes).
- Vertical Hull = 4 transects in total (2 x starboard (stern and bow), 2 x port (stern and bow)).
- Horizontal Deck = 6 transects in total (2 x 50 m transects at the bow, mid ship and stern).

Qualitative surveys of the superstructure were also undertaken.

As expected, marine growth on the vessel was minimal, consisting of green foliose algae and calcareous casings of serpulid polychaete worms, although these were thought to have colonised the lower part of the vessel's hull while docked for preparation prior to scuttling. A light covering of algae and bryozoans was noted on the horizontal (deck) surface of the vessel approximately two weeks post-scuttling, otherwise the superstructure was bare. Three species of juvenile fish including blennies (Blenniidae), goatfish (Mullidae) and bannerfish (Chaetodontidae) were recorded around the vessel although their abundance was not reported.

As for the current study, SCUBA divers were limited to working to a maximum depth of 30 m (as per Australian Standard AS 2815: Training and Certification of Occupational Divers) and as the lowest point of the vessel sits at approximately 33.9 m (LAT), samples could not be collected from the bottom section of the hull. Horizontal transects along the hull were within 1 m of each other and did not provide the vertical spread across the hull as intended. Furthermore, in adverse weather conditions, horizontal surveys of the hull proved difficult due to surges and time restrictions. An alternative design to that specified within the LTMMP was therefore recommended whereby six additional transects (50 m length) were taken on the deck of the ship which is at approximately 28 m LAT, and can therefore be sampled at all tides. In summary, the following recommendations were made for future monitoring surveys:

- Horizontal Hull transects be limited to a single 100 m transect along the horizontal plane on either side of the vessel; and
- Additional vertical transects be taken on either side of the super structure.

Adjustments to the sampling methodology from that outlined in the LTMMP were therefore made to subsequent monitoring surveys. Additional transects were added to the superstructure to provide a greater vertical range, while some of the deeper horizontal transects were not surveyed. The sampling design was modified to allow for more robust statistical analyses to be undertaken.

1.3.2 Monitoring Survey 1

Following the baseline survey, the first monitoring survey was carried out over a two-day period on 11 and 13 October 2011. Analysis of photoquadrats taken from different parts of the ship indicated that at approximately six months post-scuttling, spatial differences in community assemblages were evident. This was particularly apparent among transects sampled from the deck (horizontally orientated) and hull (vertically orientated) surfaces, which were significantly different from each other, mainly due to differences in abundance of serpulid and serpulid/barnacle matrices. Visual comparison of photoquadrats between the baseline and monitoring survey 1 showed that the majority of the ship's surface had changed from being virtually bare to completely covered in encrusting organisms including serpulid polychaetes, barnacles, ascidians, encrusting algae, bryozoans and hydroids.

Fish abundance and diversity observed around the Ex-HMAS Adelaide had also increased substantially. A total of three species; from three families were initially observed in the baseline survey. A total of 19 species from 16 families were observed during the first monitoring survey. The most common species of fish were eastern fortesque (*Centropogon australis*) and yellowtail scad (*Trachurus novaezelandiae*), but also observed were a mixture of resident reef-associated species and transient visitors which are typical of temperate natural reef habitats. No introduced marine pests or species that are protected under conservation legislation were observed during the first survey.

1.3.3 Summary of Sampling to Date

Table 1: Summary of Reef Community Sampling Carried Out To-Date

Survey	Sampling Dates	Timeframe
Baseline	18 April and 30 May 2011	1 week post-scuttling
Monitoring Survey 1	11 and 13 October 2011	6 months post-scuttling
Monitoring Survey 2	14 and 16 February 2012 14 and 16 February 2012 (Current survey was proposed for January 2011 but postponed due to inclement weather)	10 months post-scuttling

Boundary of Dive Site	Easting (MGA 94)	Northing (MGA 94)
A	356428.713	6296117.693
B	356538.438	6296341.142
C	356850.615	6296188.618
D	356742.410	6295963.310

Figure 1: Location of Ex-HMAS Adelaide Artificial Reef and Dive Site. The approximate location and orientation of the ship is indicated by the yellow line.

2 Study Methods

2.1 Field Methods

2.1.1 Photoquadrats

Line transects were demarcated along vertical and horizontal planes of the ship on the hull, superstructure and deck. These transects were based on those used for the previous monitoring survey. Cable ties used in the baseline survey to mark transects were located to ensure the same transects were sampled. Fluorescent pink flagging tape was also added to help locate the same transects in future surveys where needed. Within each line transect, replicate photoquadrats (50 x 50 cm) were taken to sample reef assemblages colonising different parts of the ship. In total, 82 photoquadrats and 16 line transects were sampled. These included:

Horizontal Hull

- x 2 transects in total: (1 x 100 m transects along the starboard and port planes).
- x 12 photoquadrats in total (x 6 photoquadrats along each side).

Vertical Hull

- x 4 transects in total: (portside stern x 1), (portside bow x 1), (starboard stern x 1), (starboard bow x 1),
- x 20 photoquadrats in total (x 5 photoquadrats along each vertical transect).

Vertical Superstructure

- x 4 transects in total: (portside stern x 1), (portside bow x 1), (starboard stern x 1), (starboard bow x 1),
- x 20 photoquadrats in total (x 5 photoquadrats along each vertical transect).

Deck

- x 6 transects in total (2 x 50 m transects at the bow, 2 x mid ship and 2 x stern).
- x 30 photoquadrats in total (x 5 per transect).

The approximate locations of all transects are indicated on **Figure 2**.

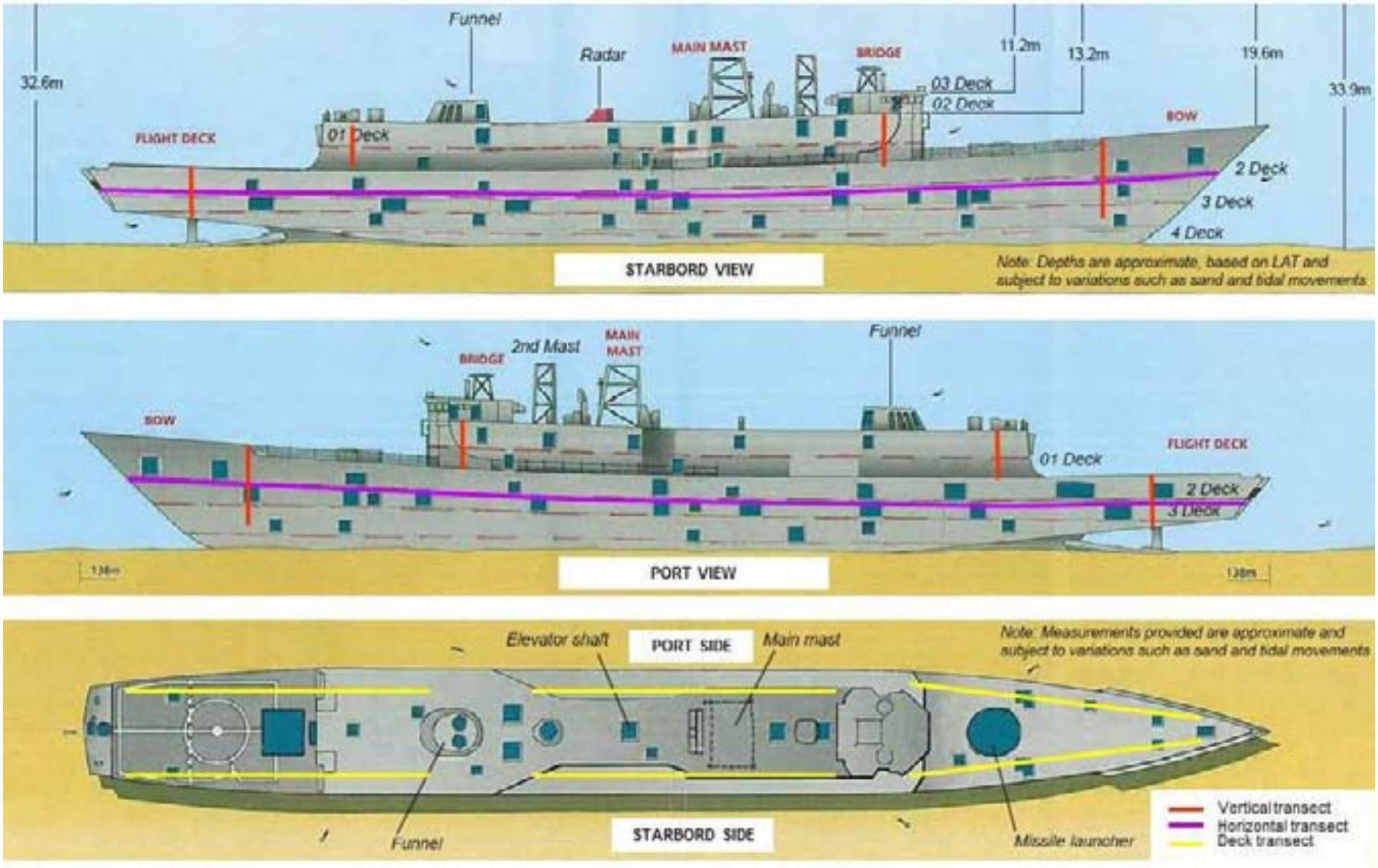

Figure 2: Plans of the Ex-HMAS Adelaide and Positions of the Reef Community Survey Sampling Transects.

Photoquadrats were acquired at regular intervals along each transect. For the vertical transects this was approximately every metre. For horizontal hull transects this was approximately every 6 m and for the deck and superstructure every 10 m (consistent with earlier surveys). Photographs were taken with a Canon G12 digital still camera which provides high quality (10MP) photographs. Photographs of individual taxa were taken to aid in identification and the interpretation the video transects and photoquadrats. Fish species encountered were also photographed where possible.

2.1.2 Fixed Point Photographs

Photographs were taken at 10 fixed point locations. This is to provide a qualitative record of changes to reef assemblages over time. These locations were marked with luminous flagging tape and locations noted to assist in identifying these points in future surveys. Notes were taken on the exact location, distance from the structure or reference point and depth at which the photographs were taken (**Appendix A**).

2.1.3 Video Transects

Video footage covered the same transects used for the photoquadrat survey. Divers used underwater scooters, enabling them to maintain a constant slow speed and depth while filming along the proposed transects. Video was taken on Canon G12 still cameras set to HD video mode or a Sony miniDV HD camcorder. The video footage was taken at approximately 1 – 2 m from the vessel and angled at approximately 45° towards the vessel. This allowed the benthic community to be seen clearly in the foreground of the footage, while also capturing fish swimming in the background.

2.2 Analysis

2.2.1 Photoquadrats

Photographs were reviewed immediately after collection to ensure they were of suitable quality to meet the long term outcomes of the study. Where necessary, photographs were colour-corrected using Adobe Photoshop which helped filter out the green light and bring out natural colours.

Photoquadrats were analysed for percentage cover of encrusting biota (algae, bryozoans, sponges, sessile invertebrates, etc.) using Coral Point Count with Excel extensions (CPCe) (Kohler and Gill 2006). A 'virtual' photoquadrat scaled to 50 x 50 cm was digitally overlaid on each of the 82 frames (**Figure 3**). Within each photoquadrat, 100 points were placed on a 10 x 10 grid and the taxon, matrix or substratum under each point was identified visually. The total number of each was used as an estimate of percentage cover. Still photographs of different taxa were then compiled to prepare a project-specific Biota Identification Manual and project coral code file for use with CPCe. Identifications were made to the highest taxonomic level practical, although it should be recognised that at this early stage of colonisation, species level identification of many encrusting organisms such as sponges, bryozoans and ascidians was not feasible without further laboratory identification. In many instances, groups were described as an encrusting 'matrix' or were based on morphological characteristics such as colour or growth form. Examples of the matrix categories assigned included:

Serpulid matrix = serpulid tubes, sediment and fine brown filamentous algae;

Barnacle matrix = *Balanus* spp. sediment and fine brown filamentous algae;

Large barnacle matrix = large barnacles, sediment and brown filamentous algae;

Serpulid/barnacle matrix = Mixture of serpulid tubes and barnacles with a layer of encrusting red algae; and

QA/QC checks of CPCe files and identifications were made to minimise the potential for user bias in visual identification and to ensure the accuracy and repeatability of methods.

Analyses carried out included:

1. General findings;
2. Analysis of spatial variation in reef communities; and
3. Analyses of temporal variation in reef communities using a qualitative approach.

General Findings

General findings included a list of species, taxa or groups identified, a description of the groups identified and general trends in total percentage cover.

Spatial and Temporal Analyses

Variation in reef assemblages on different parts of the ship and over time were analysed using multivariate and univariate statistical techniques as appropriate. Due to the existing design of the sampling program (pre-determined by the LTMMP and the baseline survey) this was separated into different analyses. As data for the baseline survey was limited, no time comparisons were made between the baseline and Monitoring Survey 1. Time was added as a factor in the current analyses to investigate both spatial and temporal trends between Monitoring surveys 1 and 2. The four null hypotheses tested were:

1. No significant differences in reef assemblage structure between deep and shallow vertical transects or among times.

2. No significant differences in reef assemblage structure between port and starboard vertical transects or among times.

The design to test these hypotheses was as follows:

- Time (Survey 1/Survey 2): fixed, orthogonal;
- Depth (shallow/deep): fixed, orthogonal;
- Aspect (port/starboard): fixed, orthogonal;
- Transect: nested (depth x aspect), random.

This design compared vertical transects among the superstructure (i.e. port bow, port stern, starbord bow and starbord stern) and vertical hull at the same positions at two times.

3. No significant differences in reef assemblage structure between horizontally orientated (i.e. deck) surfaces and vertically orientated (hull) surfaces or among times.

The design to test these hypotheses was as follows:

- Time (Survey 1/Survey 2): fixed, orthogonal;
- Orientation (deck/hull): fixed, orthogonal;
- Aspect: (port/starboard): fixed, orthogonal.

This design compared transects from the deck (stern and mid, port and starbord) with the two horizontal transects along the ship's hull at two times.

4. No significant differences in reef assemblage structure among positions (deck surface only) or among times.

The design to test these hypotheses was as follows:

- Time (Survey 1/Survey 2): fixed, orthogonal;
- Position (bow, mid-ships, stern): fixed, orthogonal;
- Aspect (port/starboard): fixed, orthogonal.

This design compared all transects sampled along the deck surfaces of the ship at two times.

Statistical analysis of photoquadrat data was done using PERMANOVA+ (based on Bray-Curtis similarity matrices) in PRIMER v6. This is a permutational approach to analysis of variance (ANOVA) that is superior to traditional methods (Anderson *et al.* 2008) in that there is no assumption of normality in the data and designs can be unbalanced (e.g. different numbers of replicate samples at different places or times) if necessary. The approach yields exact tests for each level of an experimental design and is robust to differences among variances. As transformation of data to achieve normality was unnecessary, percentage data were not transformed. This also avoids problems with the transformation commonly applied to percentage data that have been recently identified (Warton and Hui 2011).

Multivariate data were represented graphically using Principles Coordinates Analysis (PCoA), a generalised form of Principal Components Analysis which complements the permutational ANOVA procedure (Anderson *et al*. 2008). Similarity Percentage Analysis (SIMPER) was used to identify those taxa, or groups of taxa contributing most to dissimilarities between assemblages.

Differences in the dispersion of data between surveys were examined using the PERMDISP routine in Permanova+. This routine is used to separate the effects of differences in dispersion of points within clusters from differences in the relative positions of the clusters (Anderson *et al.* 2008).

Where appropriate, further univariate analyses were done using PERMANOVA+ (based on Euclidian distance) to investigate the abundance of species or taxa contributing the most to the spatial variability of samples.

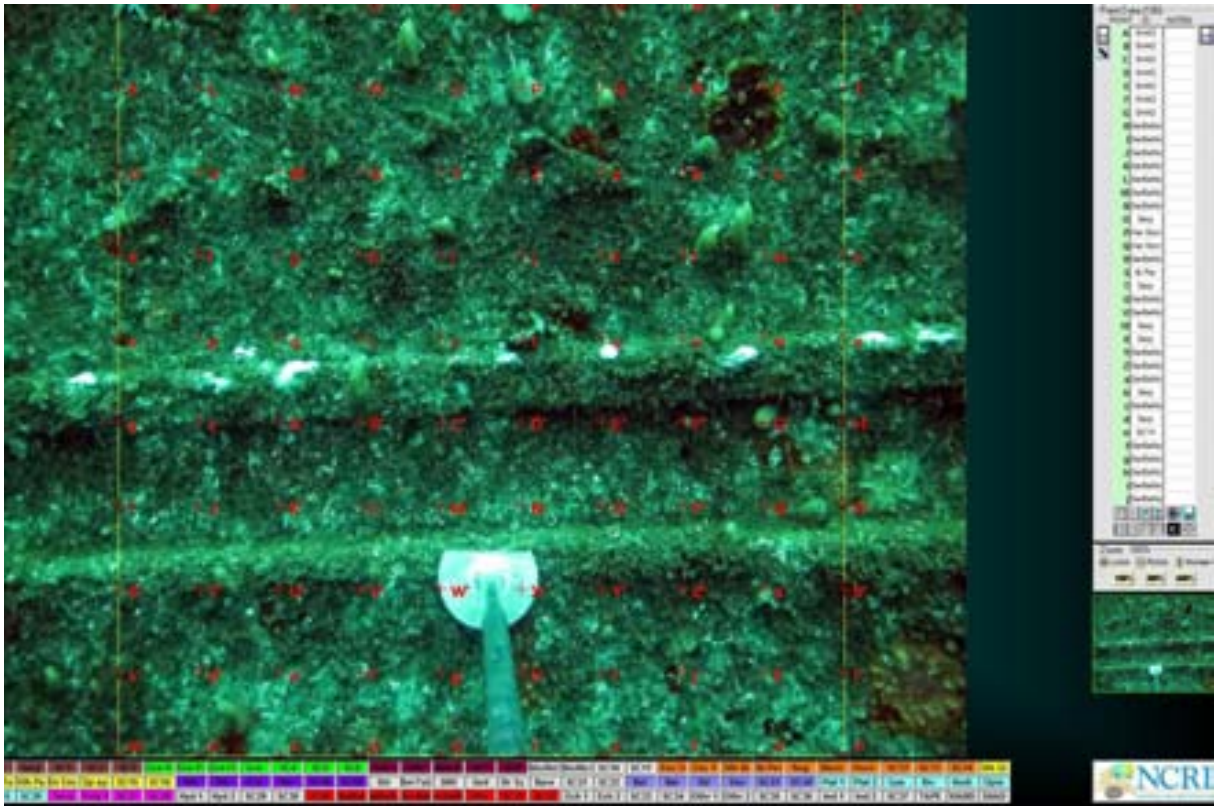

Figure 3: Screenshot of the CPCe Photoquadrat Analyses Frame with a Virtual 10 x 10 Grid Overlayed.

2.2.2 Fixed Point Photographs

Fixed point photographs were qualitatively evaluated and compared to photos taken in similar locations during the baseline survey. It is noted, however, that due to difficulty in finding many of the original fixed points, direct comparisons were not made. Direct comparisons at the exact fixed points will be used for comparison in future surveys.

2.2.3 Video Transects

Video footage was reviewed and used to describe the encrusting reef community colonising the hull, deck and superstructure. Categories included: sessile invertebrates, mobile invertebrates, aquatic vegetation and fish. Identifications were done to the highest taxonomic level practical.

Fish observed were identified and added to the master species list for all surveys to date. Notes were made on the abundance of fish observed but no quantitative assessment of the fish assemblage associated with the ship was made in this survey.

Species of particular interest, i.e. that were observed in abundance or that were possible pests/introduced species were identified for further investigation. In future reef community surveys specimens will be brought back to the laboratory for identification.

3 Results

3.1 Photoquadrats

3.1.1 General Findings

In total, 34 categories were identified from the 82 quadrats. These included various types of barnacles, serpulid polychaete worms, brown algae, encrusting bryozoans, solitary ascidians, sponges and anemones, among others. The most numerically dominant group throughout the survey was a matrix of barnacles, sediment and brown filamentous algae followed by a matrix of serpulid tubes covered with trapped sediment and turfing brown algae. Large barnacles, sediment, brown filamentous algae and the brown macroalgae *Ecklonia radiata*, had the next greatest percentage cover. Several species not previously recorded on the ship were observed in the current survey. These included an unidentified, iridescent, brown-lobed algae, a brightly coloured filamentous brown algae, the anemone *Anthothoe albocincta,* a white papillate sponge and a thin branching red algae. Some species of bryozoan, sponges and bivalve that were present in the previous survey were not recorded in the current survey. A summary of all taxa and groups of taxa identified in the analyses of photoquadrats for the current survey is given in **Appendix B**. Comparisons of photoquadrats among the baseline, Monitoring Survey 1 and Monitoring Survey 2 are presented in **Plates 1 – 16**.

3.1.2 Spatial and Temporal Variation in Reef Communities

Overall, the assemblage observed at Survey 1 was significantly different to that at Survey 2 (**Appendix C**) although there were some similarities in spatial patterns evident in the PCoA (**Figure 4**). PCoA separated samples for all transects along two axes which explained approximately 55 % of the total variation. Approximately 41 % of the total variation among species assemblages appeared to be due to differences among the deck and horizontally orientated surfaces with vertically orientated surfaces, regardless of depth, aspect (i.e. port or starboard) or time. PERMDISP did not, however, indicate a statistical difference in dispersion among surveys indicating that the overall variation among samples has not increased.

Orientation

PERMANOVA indicated that species assemblages on the hull and deck surfaces varied through time, but that differences were not consistent among transects (**Appendix C**). Pair-wise tests indicated that this was due to differences between the deck and hull surfaces occurring within Surveys 1 and 2 as well as between Surveys (**Appendix D**). This is illustrated in the corresponding PCoA (**Figure 5**). SIMPER analyses indicated that the difference between the deck and the hull in Survey 1 was due to an overall greater percentage cover of barnacles on the hull and not the deck of the ship (**Appendix E**). Significant differences between the hull and deck within Survey 2 were due to the presence of ascidians (*Herdmania momus*) and turfing brown algae on the hull but not on the deck of the ship. Assemblages on the deck surfaces appeared to have developed from one dominated by serpulid matrix in Survey 1, to a more diverse assemblage of serpulids, turfing brown algae, barnacles and the macroalgae *Ecklonia radiata in* Survey 2. Similarly the assemblage present on the hull in Survey 1 appeared to have developed into a more diverse assemblage that included ascidians and turfing brown algae in addition to serpulids. PERMDISP indicated that dispersion between survey times was not significantly different in relation to orientation (i.e. the variability between survey times was similar)(**Appendix F**).

Depth and Aspect

Neither time nor position (depth/aspect) on its own caused significant differences within to assemblages. However, there was a significant interaction between time and position (**Appendix C**), which indicates that the effect of time on assemblages was dependent on whether assemblages were located at the bow, midship or stern. Pair-wise tests indicated that it was the deep portside stern transect, the deep starboard side stern transect and the shallow starboard stern transects which differed significantly between the two surveys (**Appendix D**). This is graphically illustrated in the PCoA (**Figure 6**) which shows separation of these groups between times.

Differences in the deep starboard stern and deep port stern were due to an increase in percentage cover of large barnacles, sediment and brown filamentous algae matrix from Survey 1 to Survey 2. Differences in the shallow starbord stern in Surveys 1 and 2 were due to a decrease in percent cover of the serpulid, barnacle and

encrusting algal matrix over time (**Appendix E**). PERMDISP indicated that dispersion between survey times was not significantly different in relation to depth and aspect (i.e. the variability between survey times was similar)(**Appendix F**).

Deck Position (Bow, Midships, Stern)

PERMANOVA indicated that species assemblages on deck surfaces varied through time, but that this was dependent on the deck position (**Appendix C**). At the time of the first survey, assemblages at the bow, midship and stern appeared to be similar. At the time of Survey 2, however, assemblages at the midship appeared to be different from that at the bow and stern of the ship. This is evident in the PCoA (**Figure 7**) which illustrates the similarities among positions in the first survey compared with the separation of groups in the second survey. Pair-wise tests showed significant differences between Survey 1 and Survey 2 at the bow, stern and midship and also differences among positions within Survey 2 (**Appendix D**). Temporal differences were generally due to increased sedimentation and growth of turfing brown algae and barnacles over the serpulid matrix which previously covered the deck surface and growth of *Ecklonia radiata* (and to a lesser extent red branching algae), particularly at the midship. Within Survey 2, significant differences among positions were due to a greater percentage cover of serpulid matrix and *Ecklonia radiata* at the midship compared with that at the bow and stern (**Appendix E**). The species assemblage observed at the time of Survey 2 was generally more variable than at Survey 1 as indicated by the significant PERMDISP test (**Appendix F**).

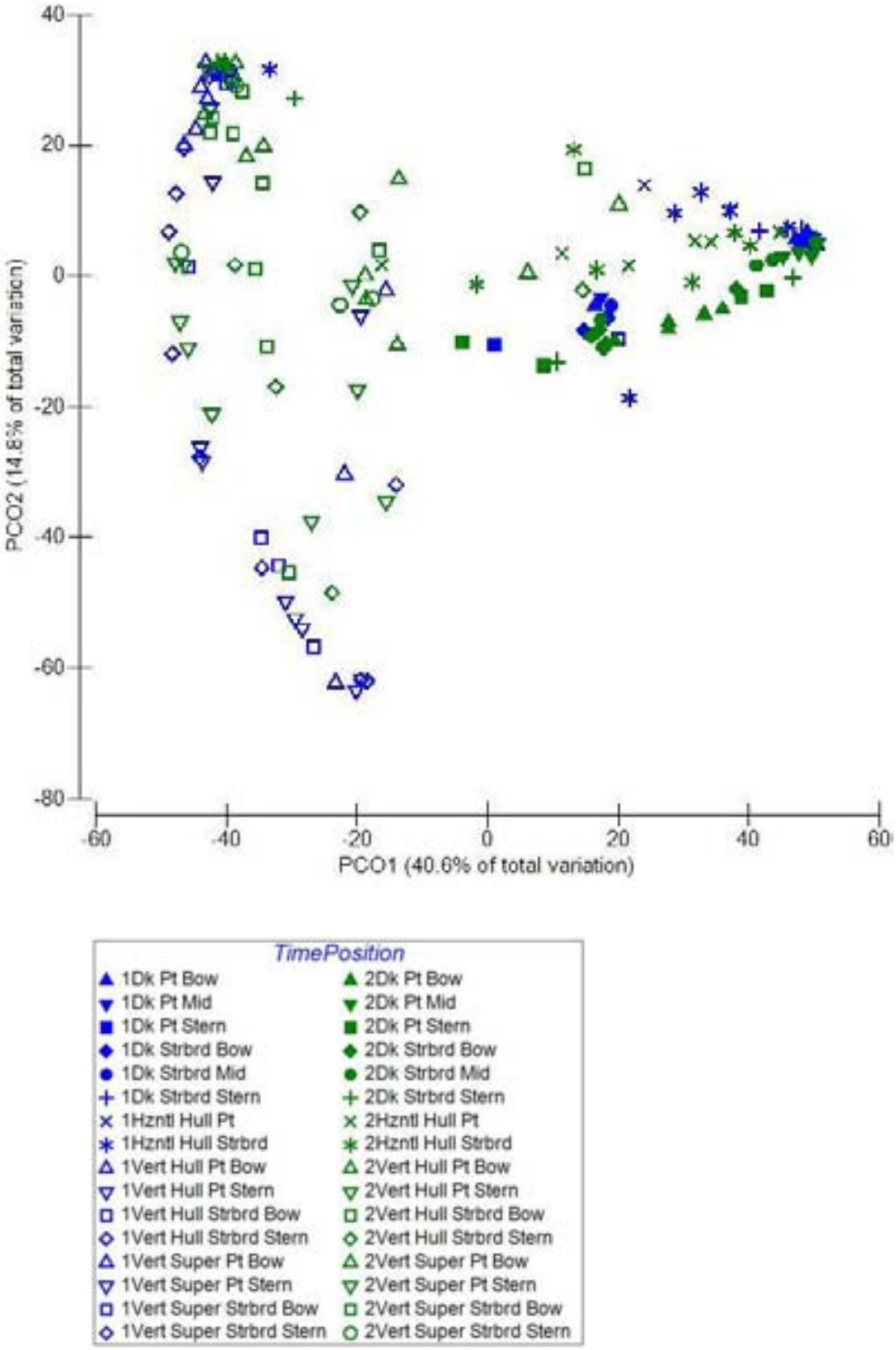

Figure 4: Principal Coordinates Analyses (PCoA) of Percent Cover of Encrusting Assemblages from Transects Taken at all Positions on the Ex-HMAS Adelaide for Surveys 1 and 2.

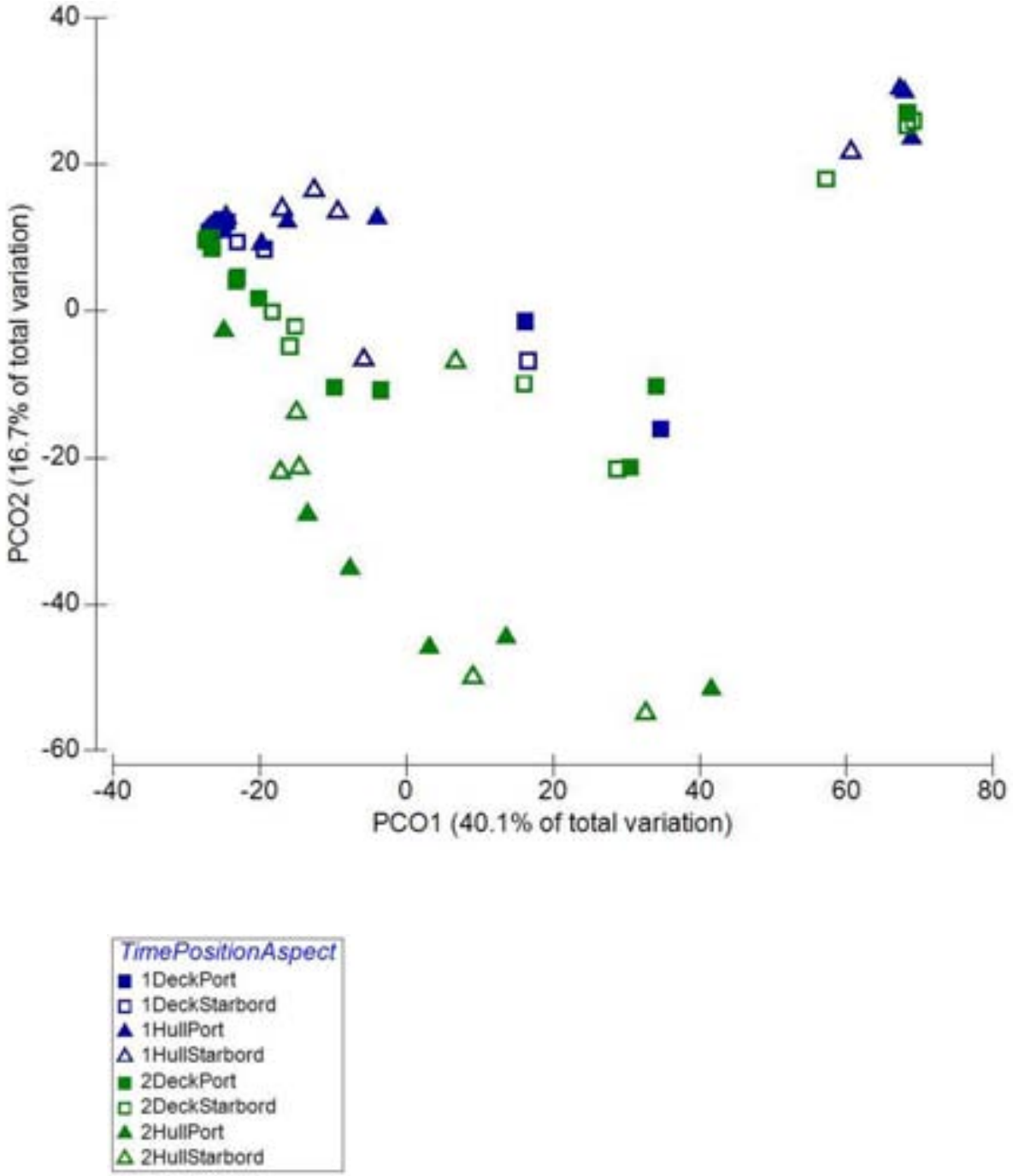

Figure 5: Principal Coordinates Analyses (PCoA) of Percent Cover of Encrusting Assemblages from Transects Taken on Hull and Deck Surfaces of the Ex-HMAS Adelaide for Surveys 1 and 2.

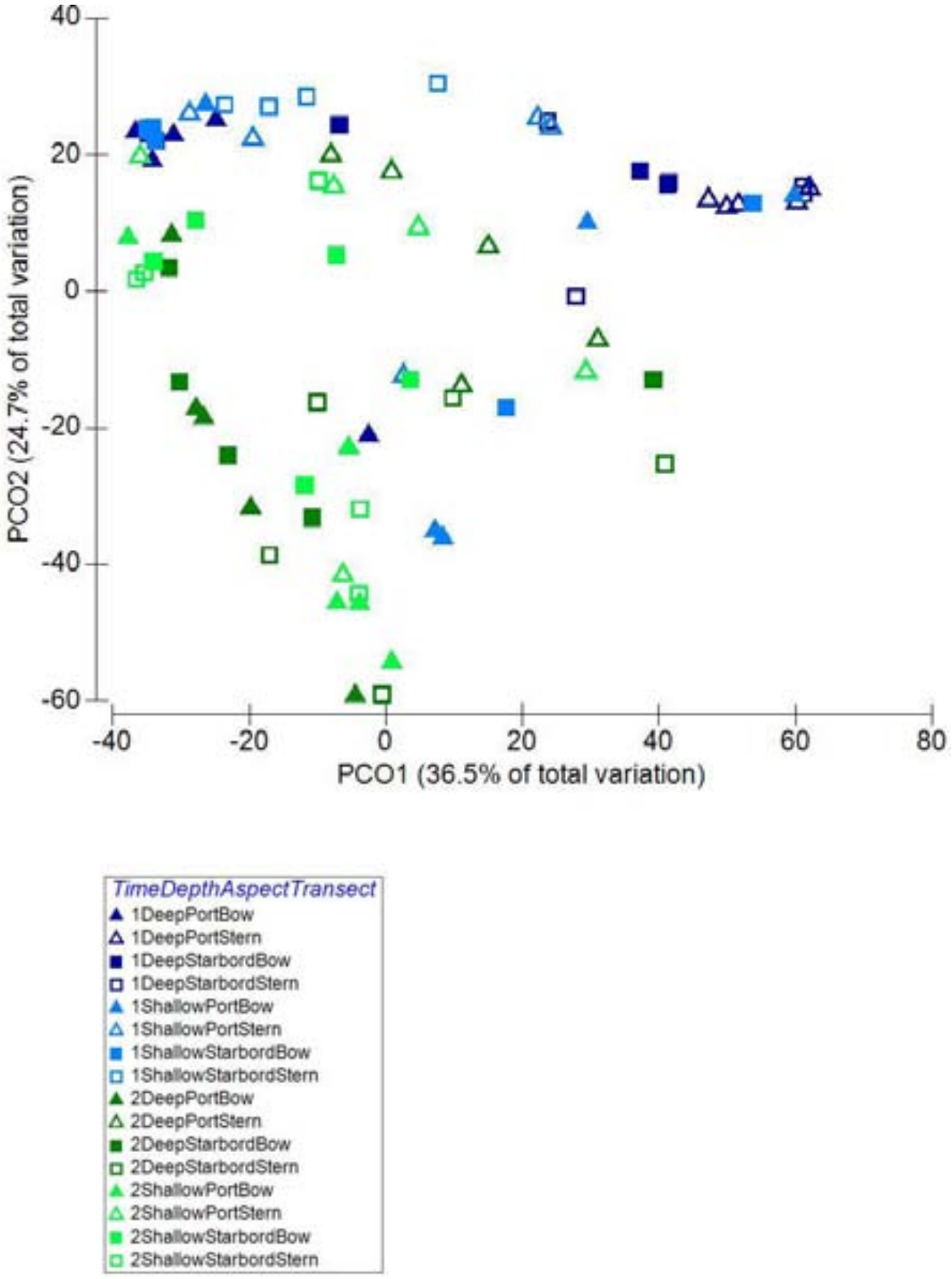

Figure 6: Principal Coordinates Analyses (PCoA) of Percent Cover of Encrusting Assemblages from Transects at Different Depths and Aspect on the Ex-HMAS Adelaide for Surveys 1 and 2.

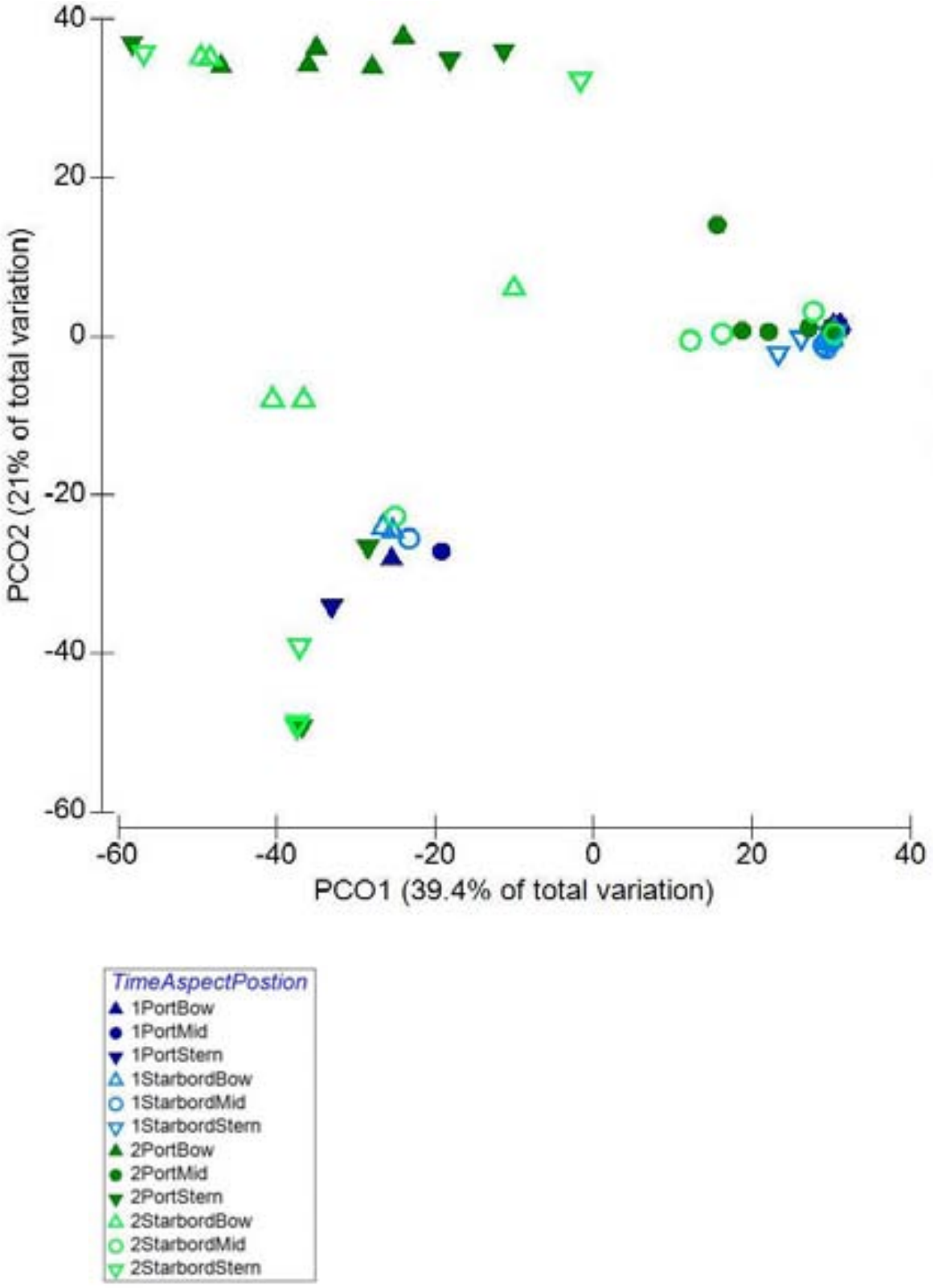

Figure 7: Principal Coordinates Analyses (PCoA) of Percent Cover of Encrusting Assemblages from Transects Taken at Different Positions on the Deck Ex-HMAS Adelaide for Surveys 1 and 2.

3.2 Fixed Photographs

Photographs taken from fixed locations are presented in **Appendix A.** All surfaces were covered with an encrusting layer of early colonisers as identified in the photoquadrat analyses which appears to have increased in thickness on parts of the ship, particularly, ladders, railings and pylons associated with the vertical superstructure (e.g. fixed photos 1, 3, 4, 5, 9 and 10). In addition to the encrusting assemblage of bryozoans, sponges, serpulids and barnacles observed in survey 1, large ascidians covered in hydroids, anemones and mobile invertebrates such as gastropod molluscs and crabs were recorded in the current survey. *Ecklonia radiata* had grown substantially on parts of the ship since the previous survey.

Fish, including fortescue (*Centropogon australis*) and silver sweep (*Scorpis lineolata*) were clearly seen in several frames although mado (*Atypicthys strigatus*) were conspicuously abundant at the time of survey (e.g. frame 4).

3.3 Video Transects

The results of observations made from video transects are summarised in **Table 2** below. A list of all fish observed during previous surveys and the current monitoring survey (Survey 2) are listed in **Table 3**. Species of recreational, commercial or conservation value are indicated.

Table 2: Summary of Observations of Attached Encrusting and Fish Assemblages Observed from Video Footage of the Ex-HMAS Adelaide in February 2012 (Survey 2).

Position	Description of Assemblage
Deck Port Bow	Previously recorded serpulid matrix is now covered by a fine layer of filamentous brown algae and sediment. Newly settled branching red algae can be seen. An anemone (*Anthothoe albocincta*) and yellow sponge previously not recorded were observed growing attached to the serpulid matrix.
Deck Port Mid	Where there was previously a serpulid matrix is now covered by a fine layer of filamentous brown algae and sediment. More pronounced growth of Kelp fronds (*Ecklonia radiata*), branching red algae and an unidentified iridescent brown-lobed algae. Patches of a bright white encrusting substance (observed in previous survey) was also present.
Deck Port Stern	Predominantly serpulid matrix with some areas of barnacles and sandy sediment settled on the surface. Occasional fronds of filamentous or branching red algae.
Deck Starbord Bow	Where there was previously a serpulid matrix is now covered by a fine layer of filamentous brown algae and sediment. Early growth of branching red algae can be seen. Occasional ascidians (*Herdmania momus*), distinct white papillate sponges and encrusting yellow and orange bryozoans were also observed.
Deck Starbord Mid	Kelp fronds (*Ecklonia radiata*), branching red algae and an unidentified iridescent brown lobed algae have colonised the serpulid matrix. Patches of a bright white encrusting substance were again present.
Deck Starbord Stern	The deck assemblage has developed from a thick crust of serpulid matrix to include barnacle growth and has been covered by a fine layer of sandy sediment.
Horizontal Hull Port and starbord	The species assemblage from the previous survey included a serpulid matrix with occasional ascidians, orange bryozoans and encrusting red algae. The area of ascidians (predominantly consisting of *Herdmania momus*) has increased substantially, covering a large proportion of the total surface area of the photoquadrats analysed. There is a notable layer filamentous algae covered with fine sediment.
Vertical Hull Port Bow and Stern	There has been a distinct shift in the encrusting species assemblage from a serpulid matrix to one dominated by ascidians. Fine algae and sediment forms a thin layer attached to the ascidians.

Vertical Hull Surfaces	The cover of ascidians has increased substantially since the previous survey. Species recorded in the previous survey including bryozoans, serpulids and barnacles were also present.
Vertical Superstructure Surfaces	The cover of ascidians has increased substantially since the previous survey. Species recorded in the previous survey including bryozoans, serpulids and Large barnacles were also abundant. Orange sponge, ecrusting bryozoans and filamentous algae appears to have colonised and pink coralline algae formed a layer over part of the large barnacle matrix. Anemones, mobile macroinvertebrates (crabs and gastropod molluscs) and kelp was also observed attached to railings, ladders and pylons.

Table 3: Species of Fish Observed in Association with the Ex-HMAS Adelaide Artificial Reef between April/May 2011 and February 2012. (*) = recreationally important species, (+) = commercially important species, (#) = species of conservation significance.

Family	Species Name	Common Name	Baseline Survey (April/May 2011)	Survey 1 (October 2011)	Survey 2 (February 2012)
Aulopidae	*Aulopus purpurrissatus*	Sergeant baker		●	●
Scorpaenidae	*Centropogon australis*	Eastern fortesque		●	●
Scorpaenidae	*Scorpaena cardinalis*	Red rock cod		●	●
Dinolestidae	*Dinolestes leweni*	Longfin pike		●	
Carangidae	*Trachurus novaezelandiae*	Yellowtail scad+		●	
Carangidae	*Seriola lalandi*	Yellowtail kingfish			●
Sparidae	*Pagrus auratus*	Snapper (juv)*+		●	●
Sparidae	*Rhabdosargus sarba*	Tarwhine			●
Mullidae	*Parupeneus spilurus*	Blackspot goatfish	●		
Chaetodontidae	*Hemiochus* sp.	Bannerfish	●	●	
Scorpididae	*Scorpis lineolata*	Silver sweep*		●	●
Microcanthidae	*Atypicthys strigatus*	Mado		●	●
Microcanthidae	*Microcanthus strigatus*	Stripey		●	●
Cheilodactylidae	*Nemadactylus douglasii*	Blue morwong*		●	●
Cheilodactylidae	*Cheilodactylus fuscus*	Red morwong		●	●
Latridiidae	*Latridopsis forsteri*	Bastard trumpeter		●	●
Pomacentridae	*Parma microlepis*	White ear		●	
Pomacentridae	*Parma unifasciata*	Girdled scalyfin			●
Labridae	*Achoerodus viridis*	Eastern blue groper#		●	●
Blenniidae	*Petroscirtes lupus*	Sabretooth blenny	●		
Monacanthidae	*Nelusetta ayraudi*	Chinaman leather jacket*+		●	●
Tetraodonitdae	*Dicotlichthys punctulatus*	Three-bar porcupinefish		●	

4 Discussion

4.1 Encrusting Biota

The colonisation of the Ex-HMAS Adelaide, 10 months post- scuttling, has been substantial and the early colonising assemblage that has formed is consistent with observations on similar artificial structures on the east coast of Australia and abroad.

Overall there has been an increase from Monitoring Survey 1 to Monitoring Survey 2 in the number of individual taxa or groups of taxa (excluding abiotic groups) from 28 to 32 and several taxa not previously recorded were observed in the current survey. An increase to diversity within the first year of scuttling is consistent to what was observed for the Ex-HMAS Brisbane (Queensland) and the Ex-HMAS Swan (Western Australia)(Queensland EPA 2007, Morrison 2001). This would be expected as encrusting organisms create new and more heterogeneous habitat available for different species to occupy. Notwithstanding this, certain taxa recorded in the previous survey were not recorded in the current survey (for example, some bryozoans and sponges). There are several reasons as to why this may have occurred including:

- Overgrowth (from other organisms, hence certain taxa could not be seen in photoquadrats);
- Competition with other taxa (for food/attachment surface);
- Succession; or
- Because they occur in low abundance and were not recorded in photoquadrats.

The greatest coverage throughout the ships surface was a matrix of barnacles, sediment and brown filamentous algae followed by a matrix of serpulid tubes covered with trapped sediment and turfing brown algae. As indicated from the previous survey, these early colonising matrices are likely to provide habitat for small invertebrates such as polychaetes, amphipod crustaceans and bivalves. There was a general increase in the cover of barnacles rather than serpulids which were more common in the previous survey.

Analysis of photoquadrats taken from different parts of the ship indicated that species assemblages varied through time, but that these differences were not necessarily consistent among transects. It is likely that there are several bio-physical factors which are driving spatial and temporal differences in species assemblages. In both surveys, transects on the deck (horizontally orientated) were generally different from the hull (vertically orientated). In the current survey this was due to the development of macroalgae (*Ecklonia radiata*), and the appearance of a new unidentified iridescent brown algae and a red branching algae, however, *Ecklonia radiata* was observed on the mid deck only. The growth of *Ecklonia* on this part of the deck and not elsewhere, may be due to subtle depth differences and associated light penetration or because of local currents and chance sporophyte settlement. Other red branching algae appears to have colonised on different parts of the deck.

A greater amount of sedimentation was generally observed on the deck surfaces in the current survey which may (among other things) contribute to differences in assemblages between vertical and horizontal surfaces (e.g. Glasby 2000 in Walker *et al.* 2007).

A distinct change in the overall species assemblage between surveys is the proliferation of the ascidian *Herdmania momus* in Monitoring Survey 2, which has mainly been on the vertical surfaces of the ship (although it was recorded on horizontal surfaces in lower abundance). This species is the most common ascidian observed subtidally in southern Australia and can occur from 1 – 100 m depth (Edgar 2000). It is possible that (similar to findings on other scuttled vessels) this species tends to proliferate on more shaded portions of the ship.

4.2 Fish and Mobile Macroinvertebrates

Ten months after being scuttled in April 2011, fish abundance and species richness observed around the Ex-HMAS Adelaide have increased substantially. Only three species; (blackspot goatfish, (*Parupeneus spilurus;* bannerfish, *Hemiochus* sp. and sabretooth blenny, *Petroscirtes lupus*) from three families, were initially observed in the baseline survey. In contrast, a total of 19 species from 16 families were observed during Monitoring Survey 1 and 15 species from 11 families were observed in the current survey. This is probably a function of the time available for species to recruit to the ship, but is also likely to be related to an increased amount of food becoming available as a consequence of the development of the reef assemblage.

Species not previously recorded in earlier surveys included tarwhine (*Rhabosargus sarba*), girdled scalyfin (*Parma unifasciata*) and yellowtail kingfish (*Seriola lalandi*). Kingfish are generally more common in coastal waters off NSW around December to May. Eastern fortesque (*Centropogon australis*), were present in large numbers in close association with the ships surface in the previous survey but appeared to be less abundant in the current survey. This may be due to predation from larger fish, competition for food and habitat from new species or seasonal fluctuations in abundance as they tend to be more common in the reproductive season (spring time) which may account for the large numbers observed in the previous October (Survey 1). Mado (*Atypicthys strigatus*) were observed in large schools and are commonly found in association with natural rocky reef habitat. Fish were generally observed around the superstructure at shallower depths.

Fish observed in the present study are commonly found on natural rocky reefs in the greater Sydney region. This is consistent with other studies which show that over time, fish assemblages colonising artificial reefs may become similar in species composition to neighbouring natural reefs (Clynick *et al*. 2008, Santos and Monteiro 2007, Relini *et al*. 2002.

5 Acknowledgements

This report was written by Kate Reeds and reviewed by Marcus Lincoln Smith. Field Work was done by Marcus Lincoln Smith, Yesmin Chikani, Craig Blount, David Cummings, Brenden Alderson and Kane Organ. Cardno Ecology Lab thanks Terrigal Dive for assistance in provision of diving equipment and vessel hire.

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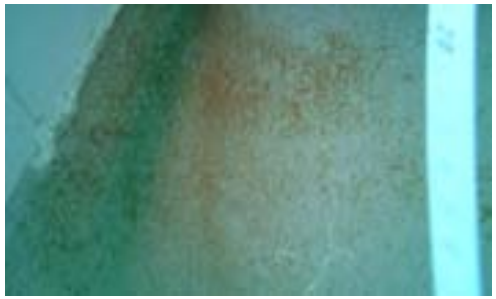
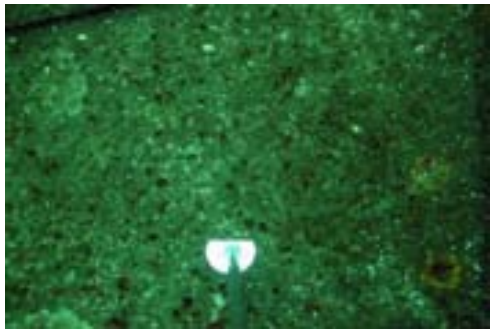
7 Plates

Deck, Port Bow

Baseline Survey (April/May 2011)



Monitoring Survey 1 (October 2011)



Monitoring Survey 2 (February 2012)

Plate 1: Deck port bow

Deck, Port Mid

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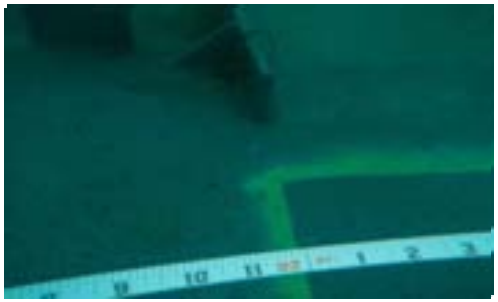

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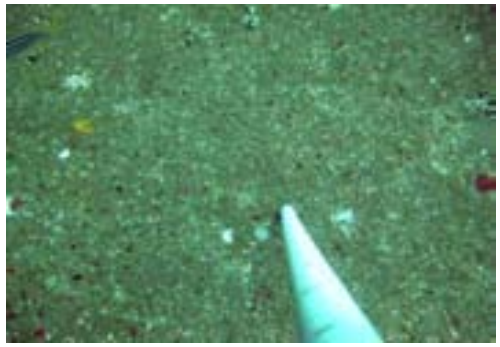

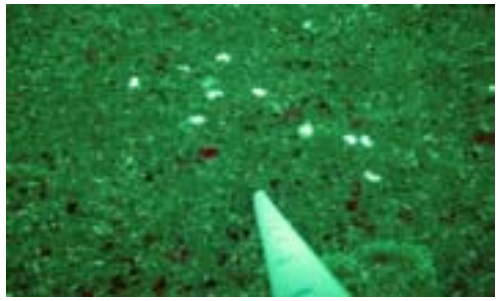

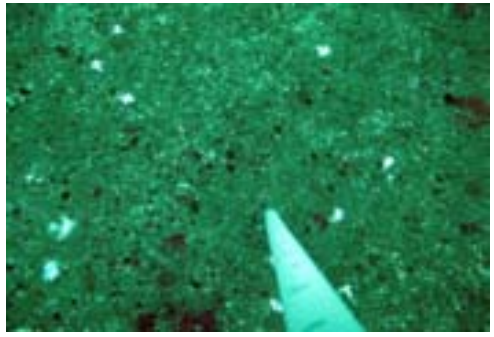

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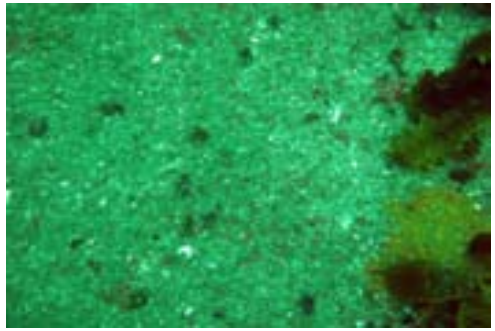
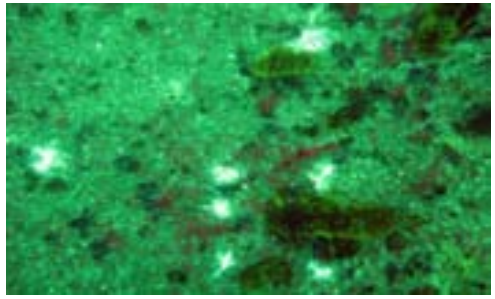




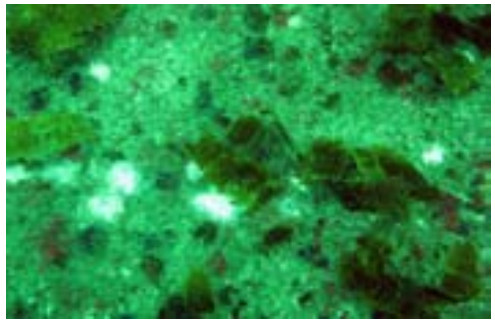
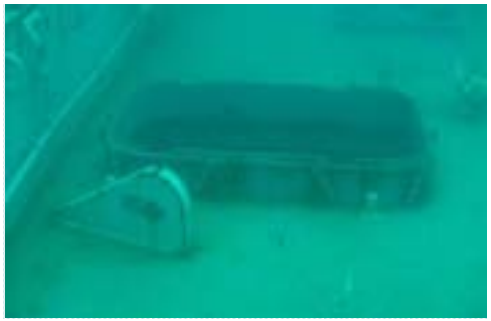


Plate 2: Deck Port Mid

Deck, Port , Stern

Baseline Survey (April/May 2011)



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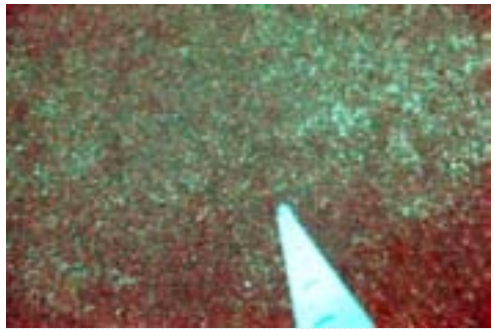

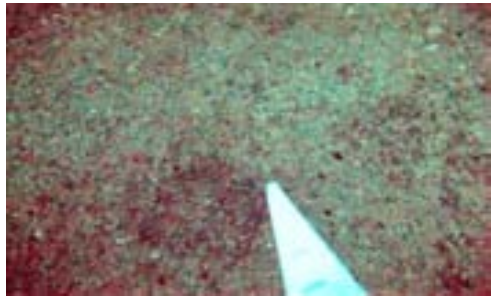

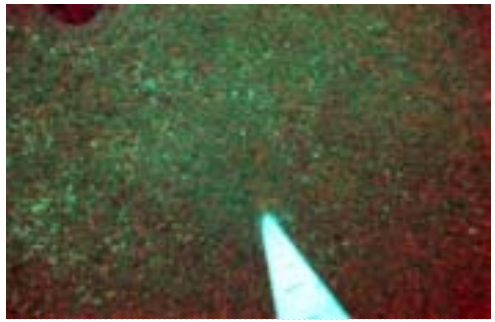

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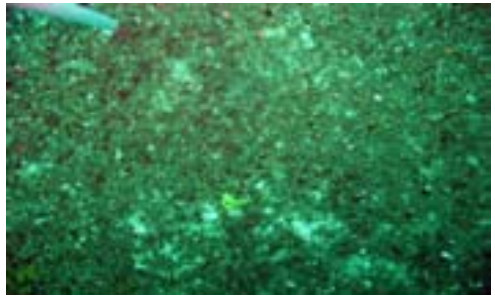

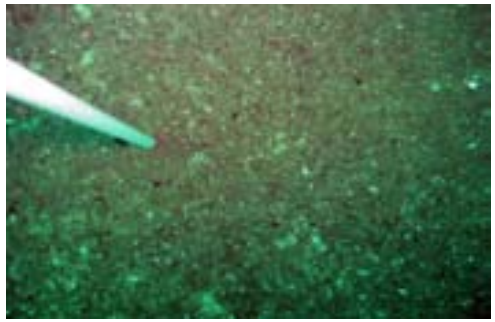

Plate 3: Deck Port Stern

Deck, Starbord, Bow

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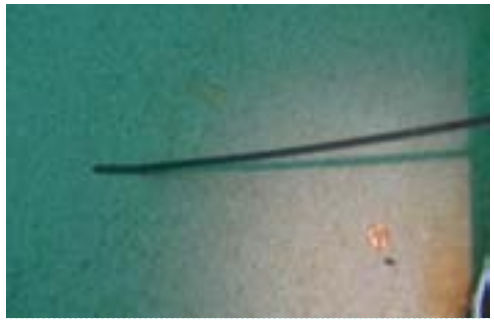

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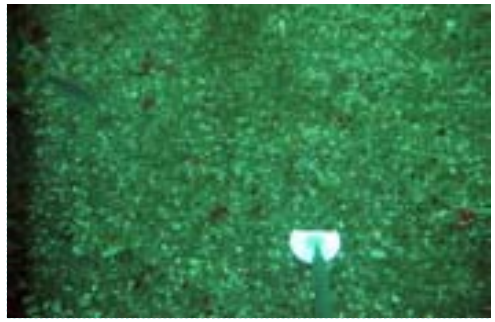

Monitoring Survey 2 (February 2012)

Plate 4: Deck Starbord Bow

Deck, Starbord, Mid

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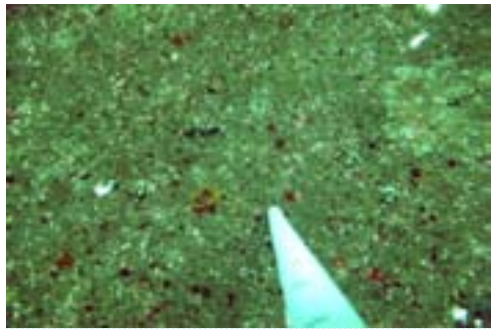
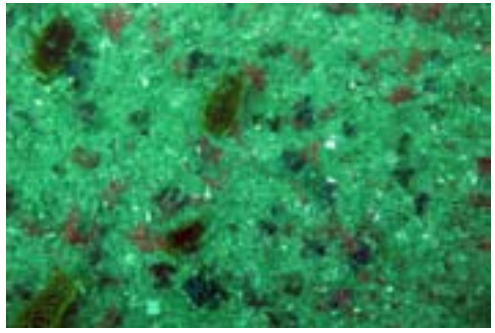
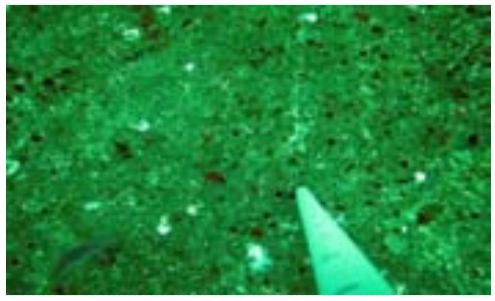
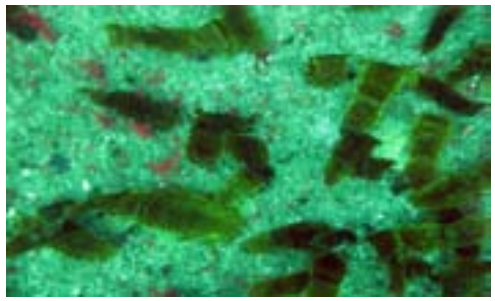
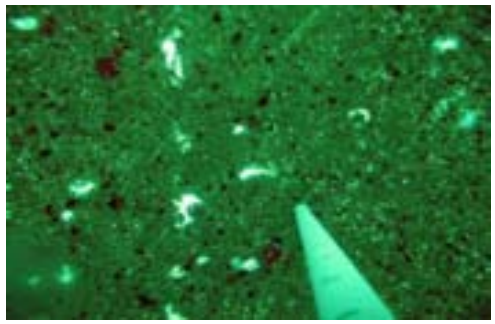
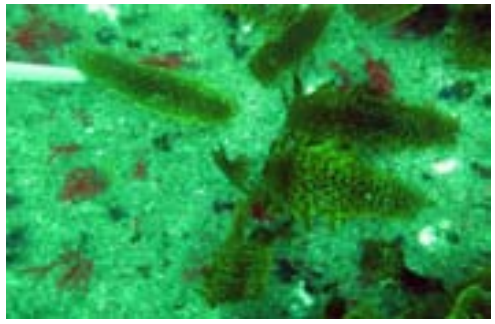
		
		
		

Plate 5: Deck Starbord Mid

Deck, Starbord, Stern

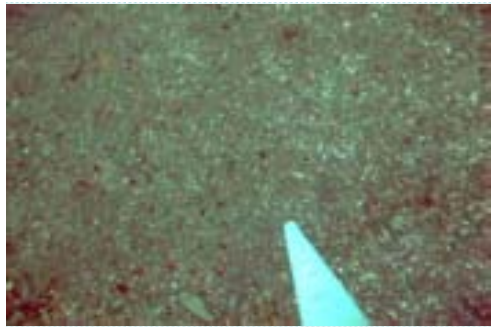
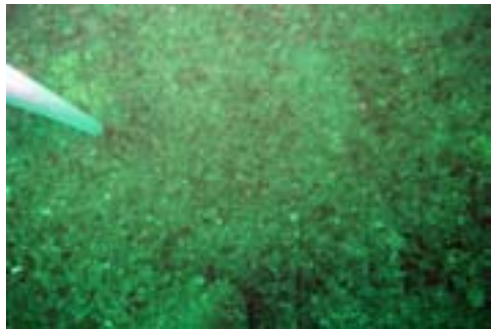
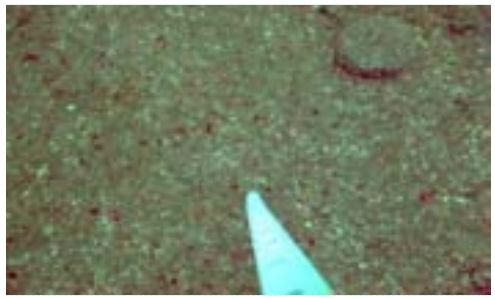
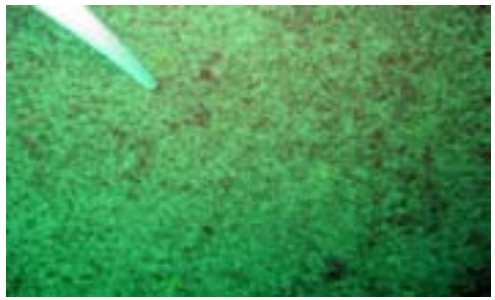
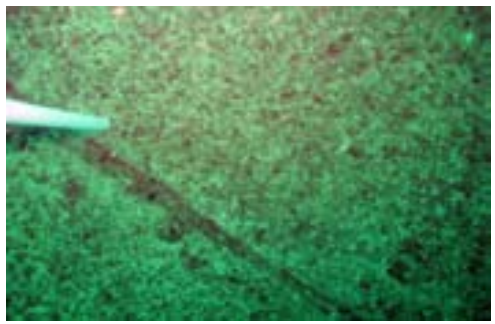
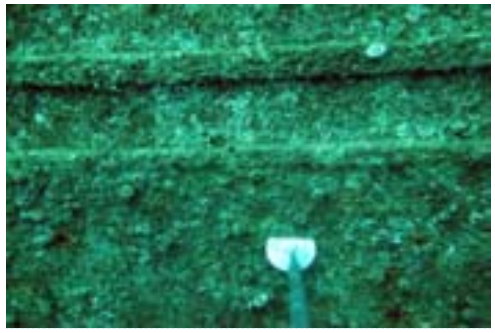
Baseline Survey (April/May 2011)	Monitoring Survey 1 (October 2011)	Monitoring Survey 2 (February 2012)
		
		
		

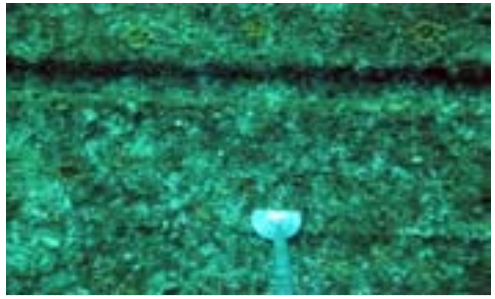
Plate 6: Deck Starbord Stern

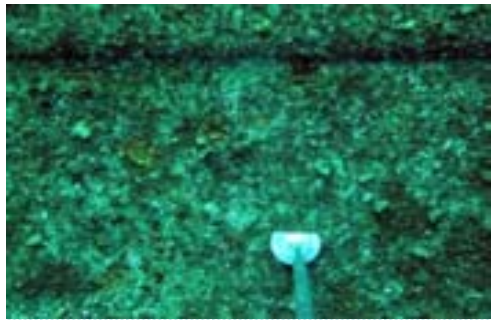
Horizontal Hull Port

Baseline Survey (April/May 2011)

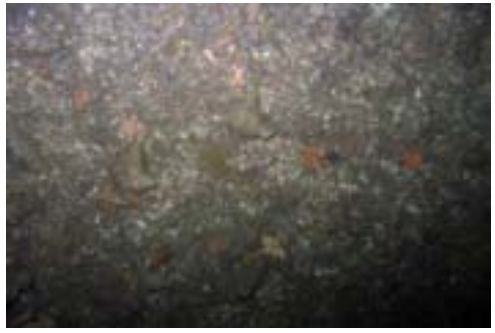
Monitoring Survey 1 (October 2011)







Monitoring Survey 2 (February 2012)



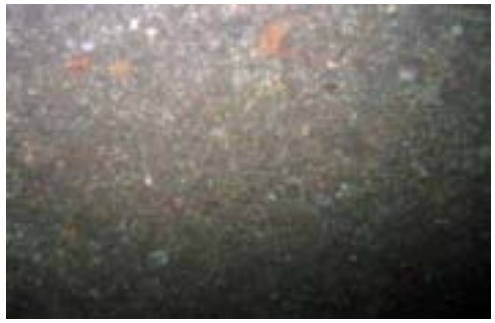
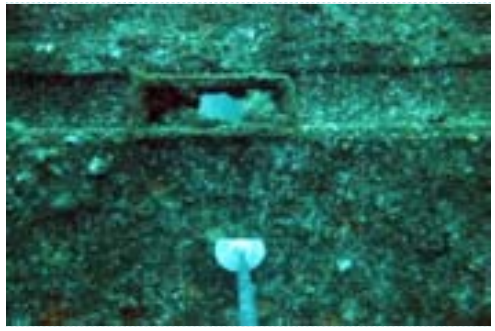


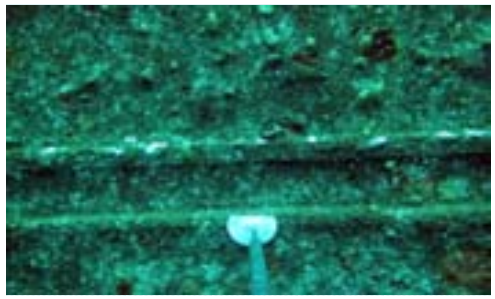
Plate 7: Horizontal Hull Port

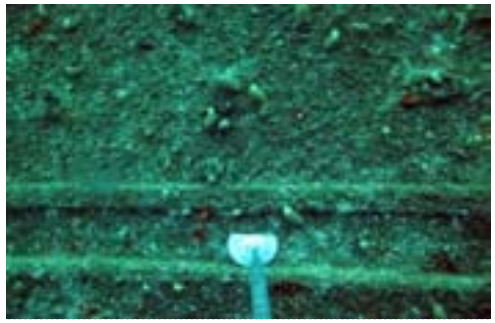
Horizontal Hull Starbord

Baseline Survey (April/May 2011)

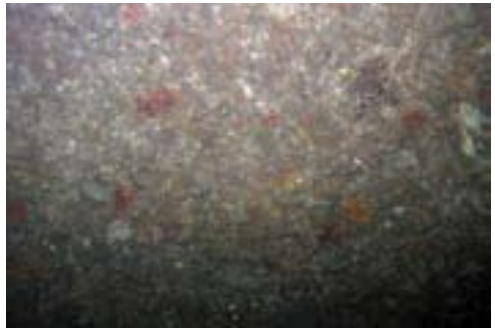
Monitoring Survey 1 (October 2011)







Monitoring Survey 2 (February 2012)



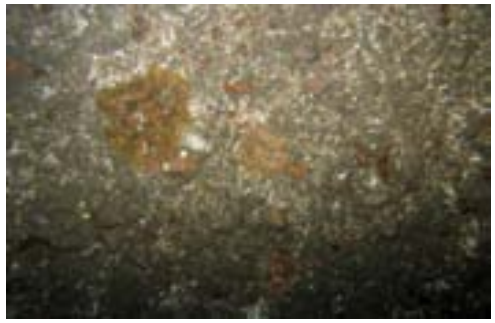
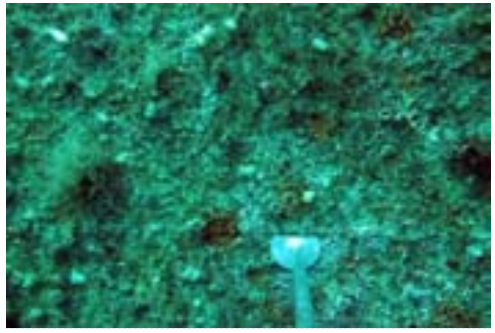


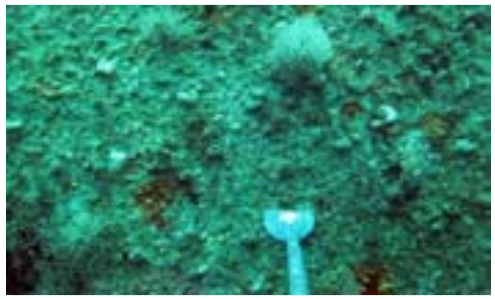
Plate 8: Horizontal Hull Starbord

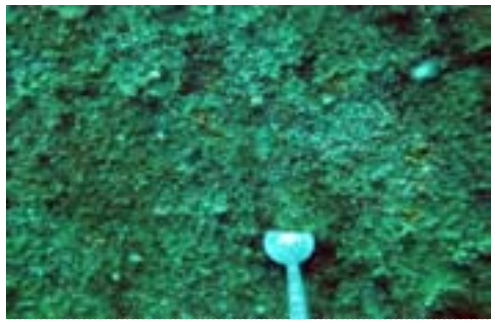
Vertical Hull Port Bow

Baseline Survey (April/May 2011)

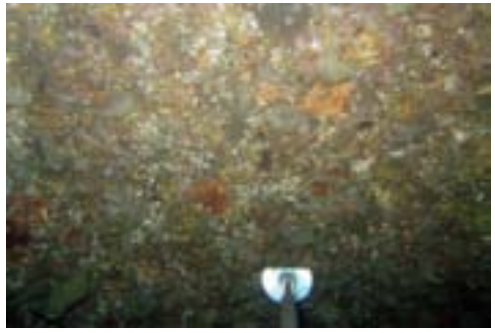
Monitoring Survey 1 (October 2011)

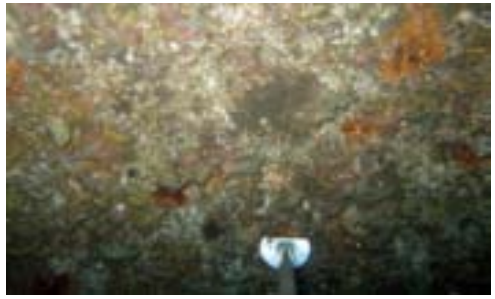






Monitoring Survey 2 (February 2012)





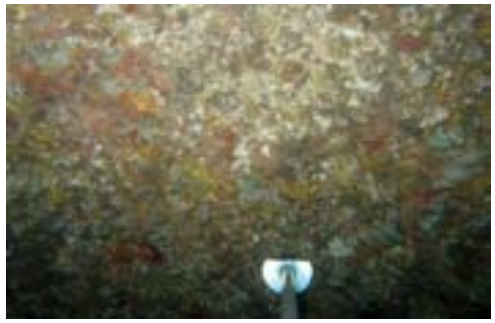
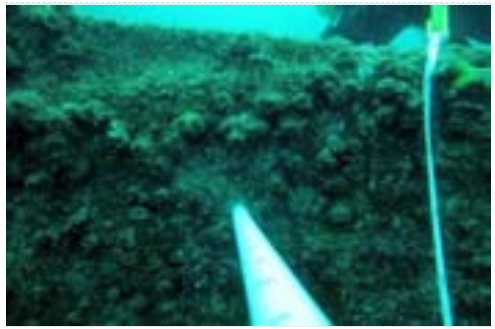


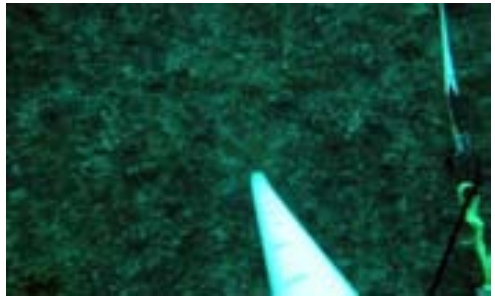
Plate 9: Vertical Hull Port Bow

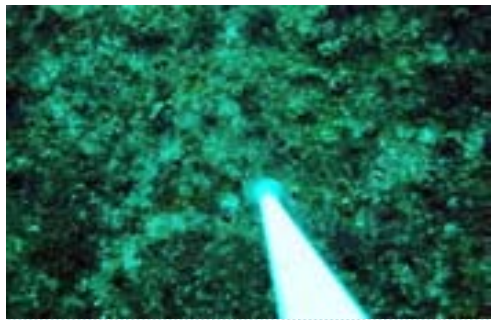
Vertical Hull Port Stern

Baseline Survey (April/May 2011)

Monitoring Survey 1 (October 2011)







Monitoring Survey 2 (February 2012)

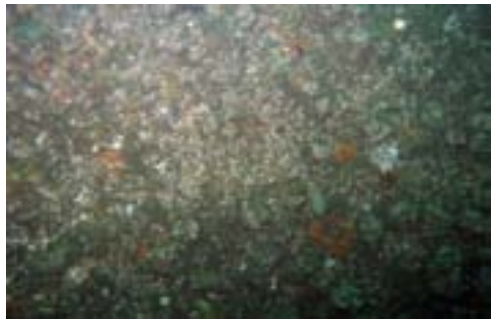
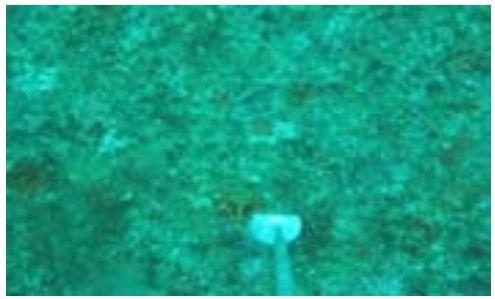


Plate 10: Vertical Hull Port Stern

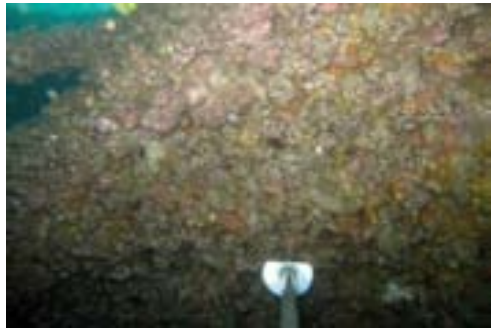
Vertical Hull Starbord Bow

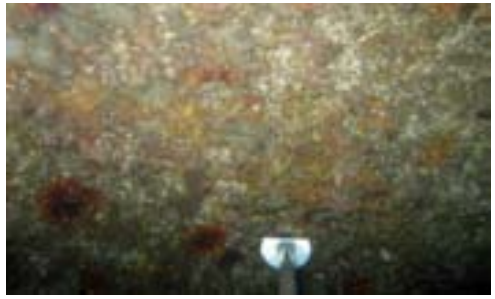
Baseline Survey (April/May 2011)

Monitoring Survey 1 (October 2011)



Monitoring Survey 2 (February 2012)





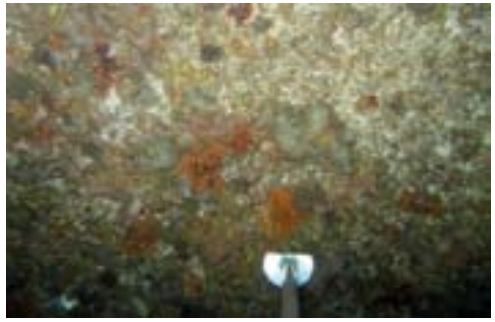


Plate 11: Vertical Hull Starbord Bow

Vertical Hull Starbord Stern

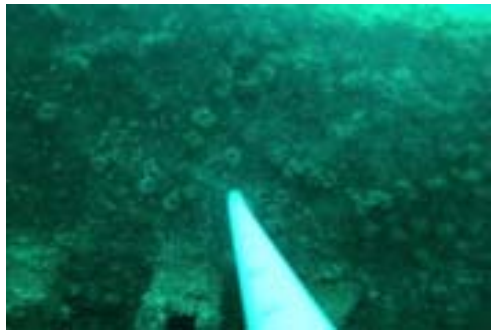
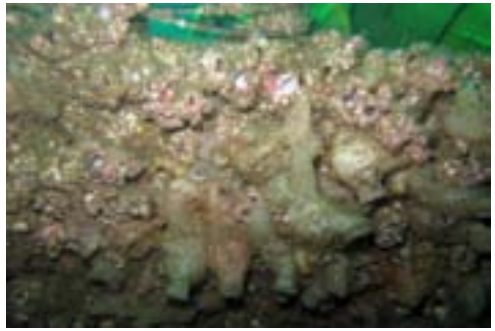
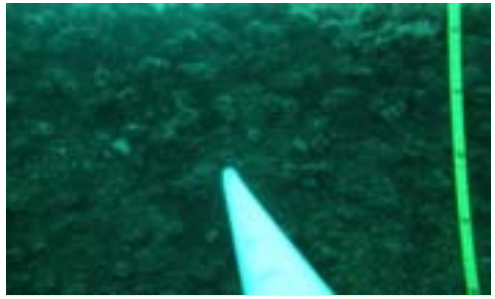
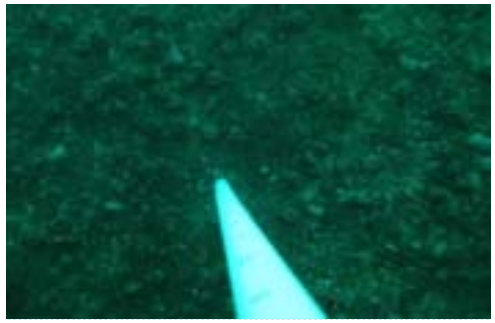
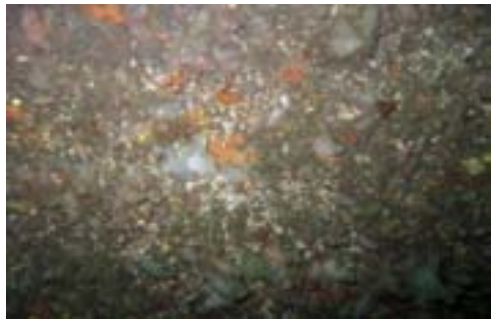
Baseline Survey (April/May 2011)	Monitoring Survey 1 (October 2011)	Monitoring Survey 2 (February 2012)
		
		
		

Plate 12: Vertical Hull Starbord Stern

Vertical Superstructure Port Bow

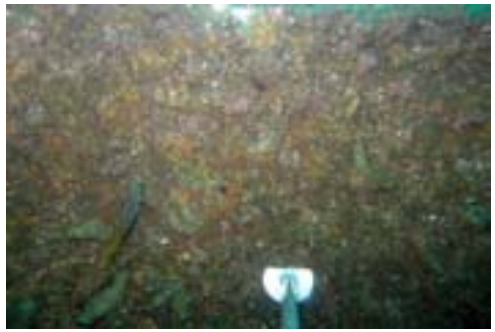
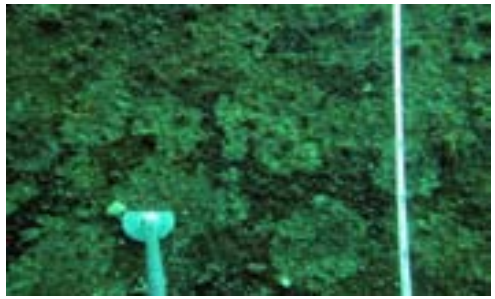
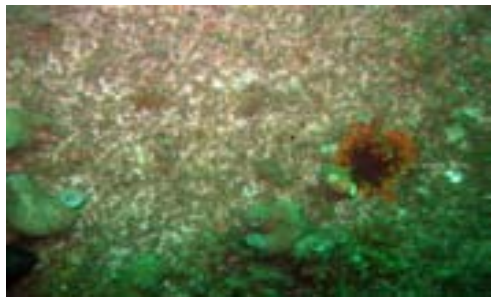
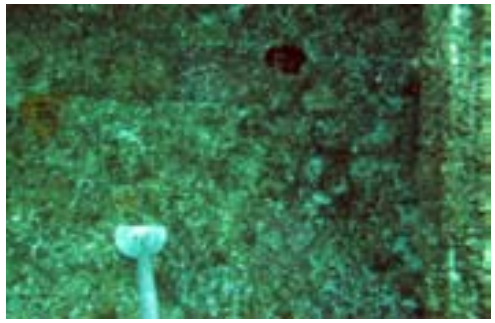
Baseline Survey (April/May 2011)	Monitoring Survey 1 (October 2011)	Monitoring Survey 2 (February 2012)
Not Sampled		
Not Sampled		
Not Sampled		

Plate 13: Vertical Superstructure Port Bow

Vertical Superstructure Port Stern

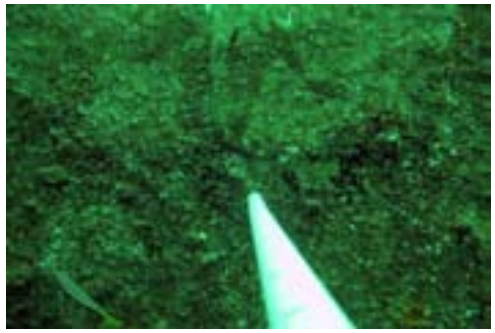
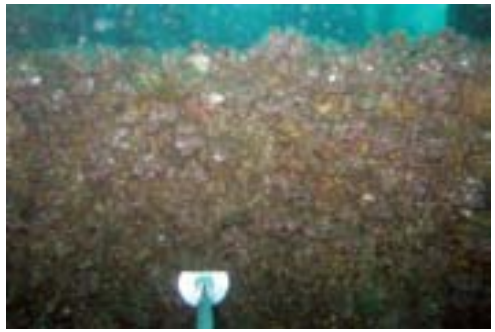
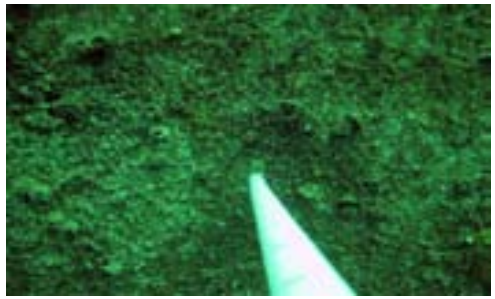
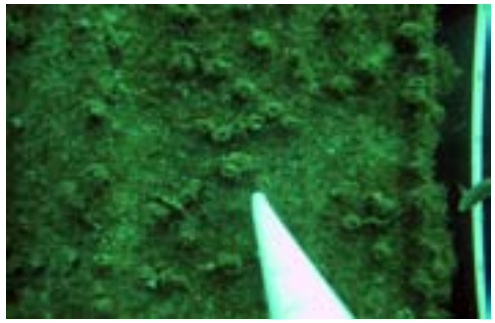
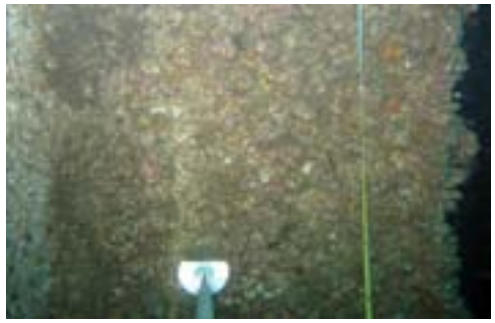
Baseline Survey (April/May 2011)	Monitoring Survey 1 (October 2011)	Monitoring Survey 2 (February 2012)
Not Sampled		
Not Sampled		
Not Sampled		

Plate 14: Vertical Superstructure Port Stern

Vertical Superstructure Starboard Bow

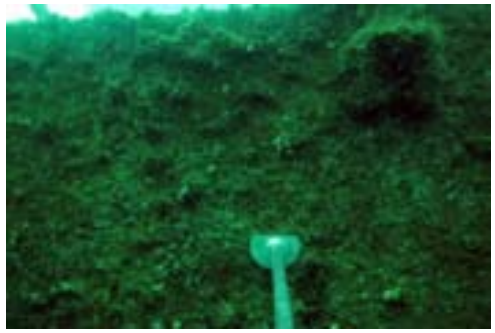
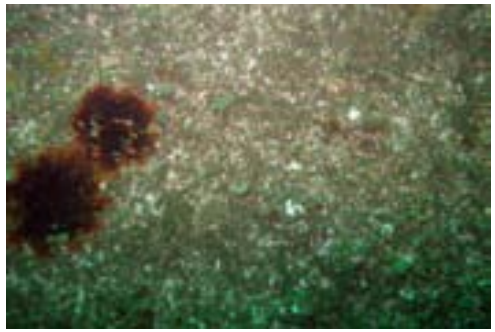
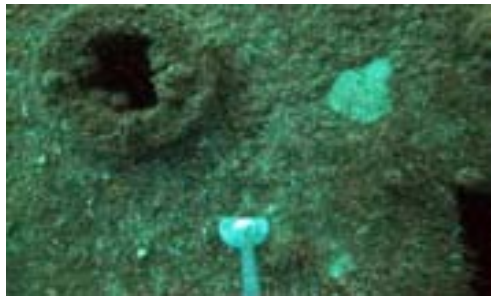
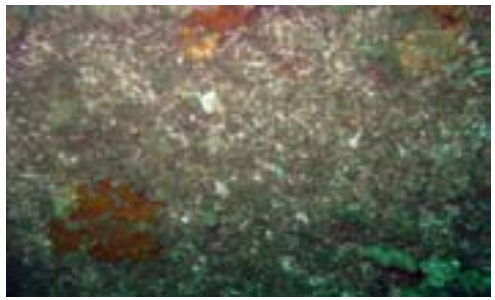
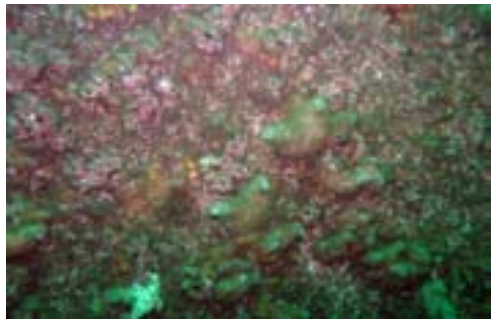
Baseline Survey (April/May 2011)	Monitoring Survey 1 (October 2011)	Monitoring Survey 2 (February 2012)
Not Sampled		
Not Sampled		
Not Sampled		

Plate 15: Vertical Superstructure Starboard Bow

Vertical Superstructure Starboard Stern

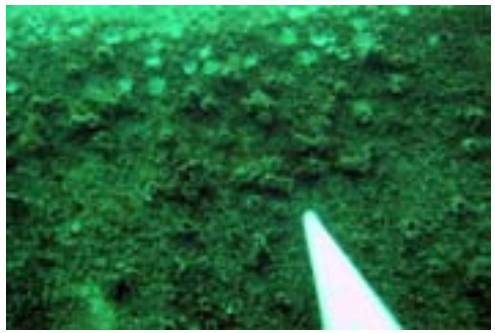
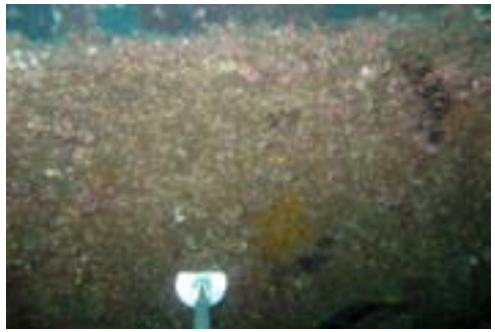
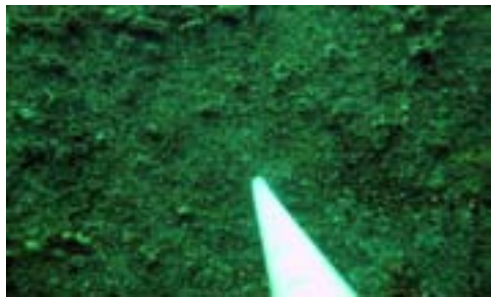
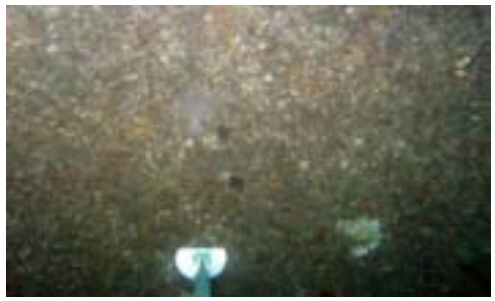
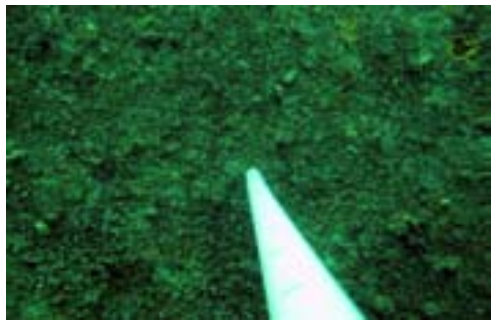
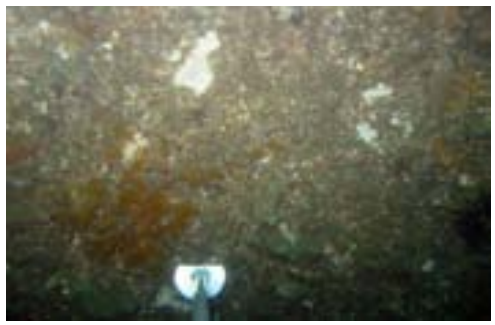
Baseline Survey (April/May 2011)	Monitoring Survey 1 (October 2011)	Monitoring Survey 2 (February 2012)
Not Sampled		
Not Sampled		
Not Sampled		

Plate 16: Vertical Superstructure Starboard Stern

8 Appendices

Appendix A: Fixed Photograph Locations.
Appendix B: Mean Percentage Cover (± Standard Error) of Reef Communities.
Appendix C: PERMANOVA of Reef Assemblages.
Appendix D: Pair-wise t-tests.
Appendix E: SIMPER Analyses
Appendix F: PERMDISP Analyses

Appendix A: Fixed Photo Locations and Descriptions

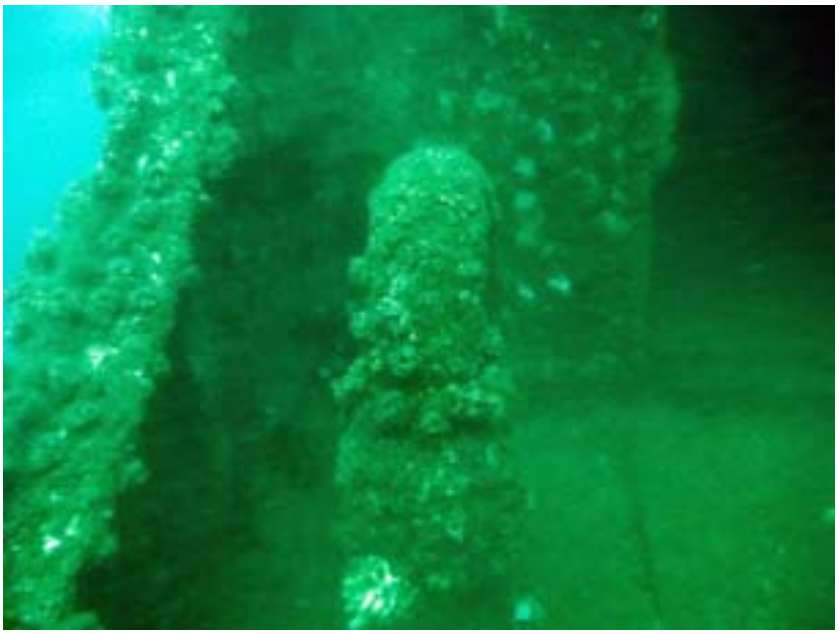
Fixed Photo: 1

Location: Flight deck port side between the hanger and hull. Photo taken standing 2 m towards the stern from the pipe.

Depth: Approximately 27 m

Survey 1

Survey 2



Appendix A: (Continued).

Fixed Photo: 2

Location: Back of the flight deck, starbord side. Photo taken swimming 2 m off and above the deck.

Depth: Approximately 27 m

Survey 1

Survey 2

Appendix A: (Continued).

Fixed Photo: 3

Location: Middle of the stern end of the top deck. Photo taken standing 2 m towards the bow from the pillar.

Depth: Approximately 23 m

Survey 1

Survey 2

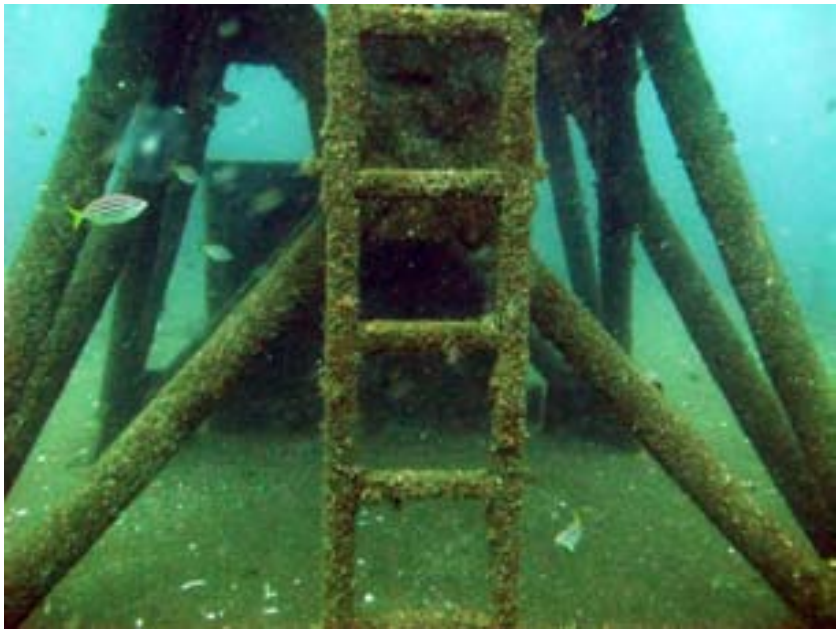
Appendix A: (Continued).

Fixed Photo: 4

Location: Middle of the the top deck. Photo taken standing 2 m towards the stern from the main mast.

Depth: Approximately 23 m

Survey 1



Survey 2

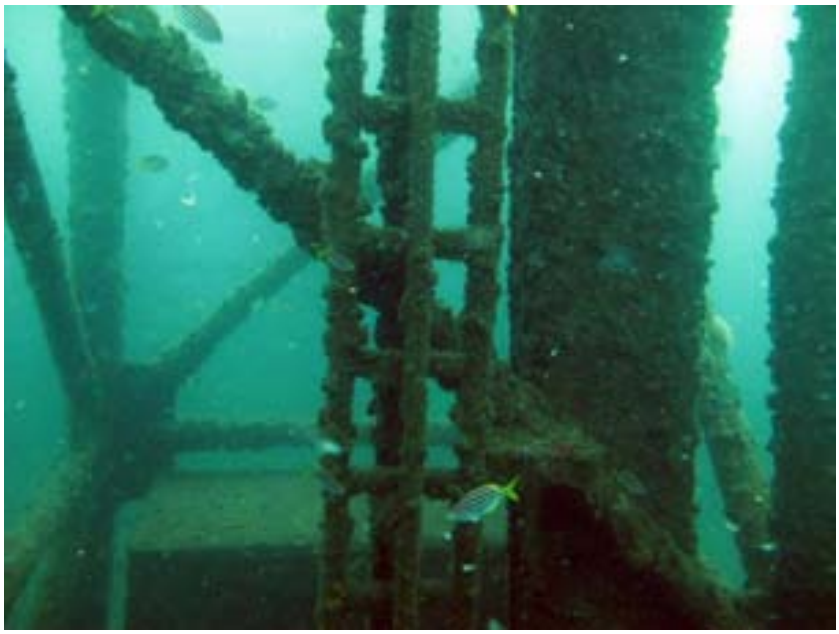
Appendix A: (Continued).

Fixed Photo: 5

Location: Front of the main mast. Photo taken standing on top of the bridge facing the main mast.

Depth: Approximately 18 m

Survey 1



Survey 2

Appendix A: (Continued).

Fixed Photo: 6

Location: Port bollard between the bow and mid-ship on the front deck. Photo taken standing 2 m towards bridge facing the bow.

Depth: Approximately 26 m

Survey 1

Survey 2

Appendix A: (Continued).

Fixed Photo: 7

Location: Starbord vent on the bow deck. Photo was taken standing 2 m towards the centre of the deck.

Depth: Approximately 25 m.

Survey 1

Survey 2

Appendix A: (Continued).

Fixed Photo: 8

Location: Inside of bow. Photo was taken standing behind the cut out in the deck.

Depth: Approximately 25 m.

Survey 1

Survey 2

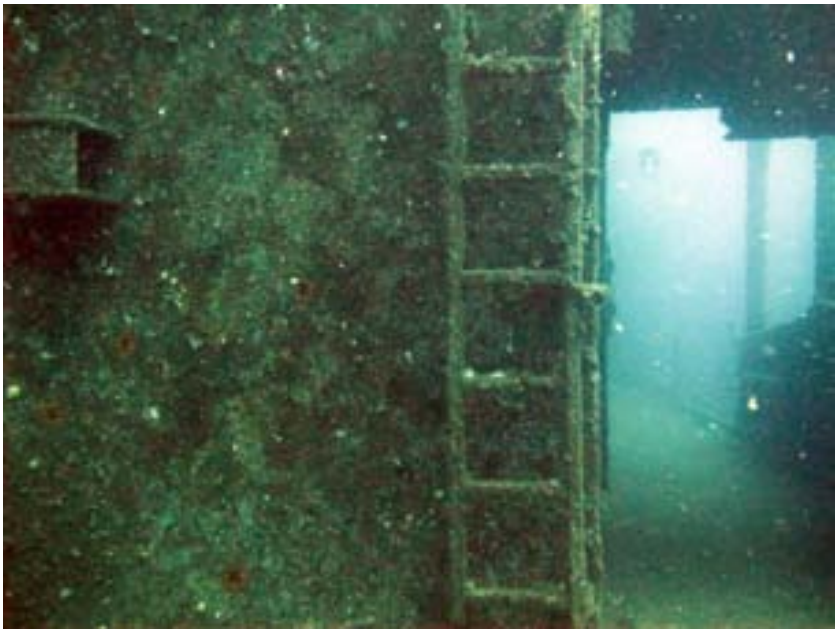
Appendix A: (Continued).

Fixed Photo: 9

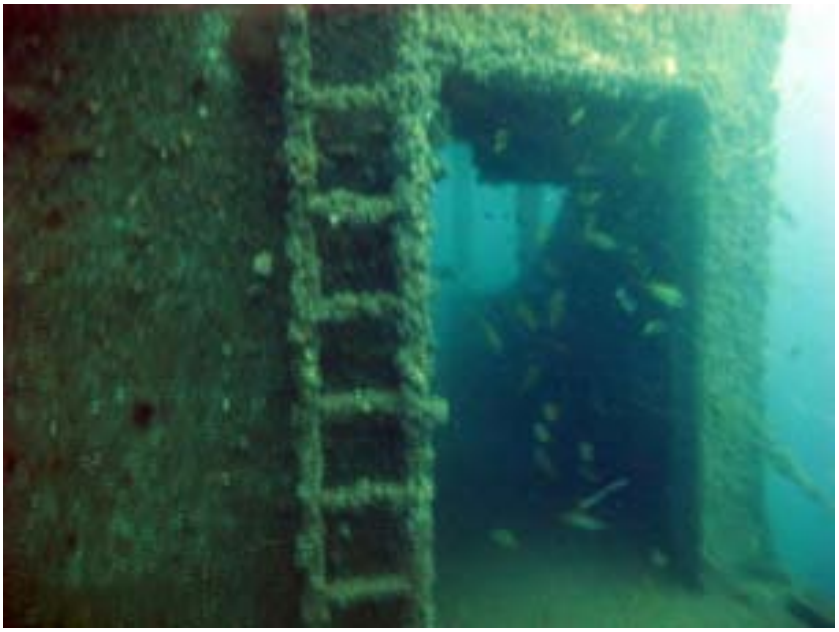
Location: Wall below the bridge on the starboard side. Photo was taken standing on the front deck 2 m in front of the ladder.

Depth: Approximately 26 m.

Survey 1



Survey 2



Appendix A: (Continued).

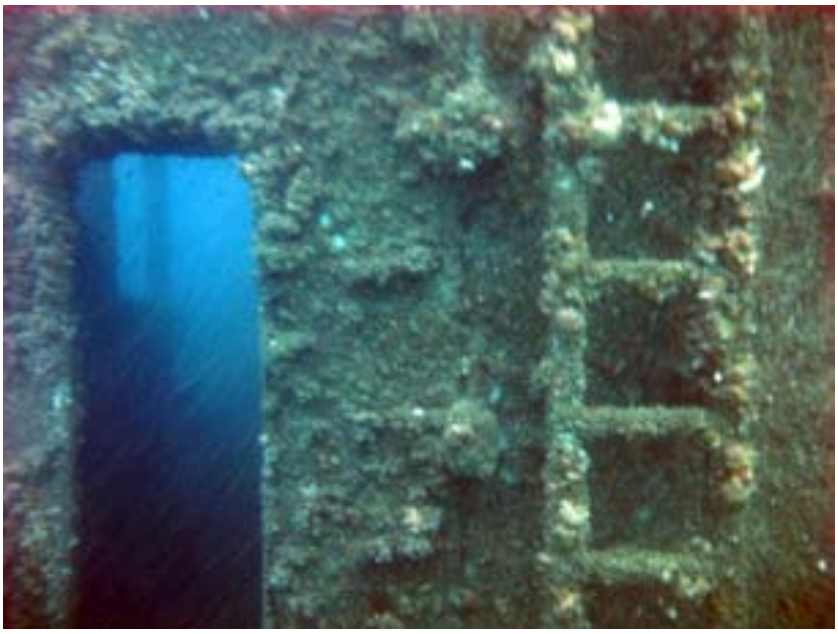
Fixed Photo: 10

Location: Wall below the bridge on the port side. Photo was taken standing on the front deck 2 m in front of the ladder.

Depth: Approximately 26 m.

Survey 1

Survey



Appendix B: Mean percentage cover (± standard error) of reef communities for each transect analysed during survey 2.

	Deck Port Bow		Deck Port Mid		Deck Port Stern	
Categories	Mean	S.E.	Mean	S.E.	Mean	S.E.
PHAEOPHYTA						
Ecklonia radiata	0.00	0.00	14.04	5.43	0.00	0.00
Lobed Brown Algae	0.20	0.20	2.60	1.12	0.00	0.00
Turfing Brown Algae	0.00	0.00	0.00	0.00	0.00	0.00
Orange Filamentous	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL PHAEOPHYTA	0.20	0.20	16.64	6.55	0.00	0.00
RHODOPHYTA						
Encrusting Red Algae	0.00	0.00	0.00	0.00	0.00	0.00
Red Branching Algae	7.87	3.00	7.01	2.55	0.20	0.20
Red Thin Branching	0.20	0.20	0.00	0.00	0.60	0.60
TOTAL RHODOPHYTA	8.07	3.20	7.01	2.55	0.80	0.80
BRYOZOA						
Biflustra Perfragilis	0.00	0.00	0.00	0.00	0.00	0.00
Encrusting Orange Bryozoan	0.40	0.25	0.00	0.00	0.00	0.00
Encrusting Yellow Bryozoan	0.00	0.00	0.00	0.00	0.00	0.00
Membranipora membranacea	0.00	0.00	0.00	0.00	0.00	0.00
Triphyllozoan sp.	0.00	0.00	0.00	0.00	0.00	0.00
White Branching Bryozoan	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL BRYOZOA	0.40	0.25	0.00	0.00	0.00	0.00
PORIFERA						
Orange Encrusting Sponge	0.00	0.00	0.40	0.24	0.00	0.00
Yellow Encrusting Sponge	0.82	0.50	0.21	0.21	0.20	0.20
White Encrusting Sponge	0.20	0.20	0.20	0.20	0.00	0.00
White Globular Sponge	0.00	0.00	0.00	0.00	0.00	0.00
White Papillate Sponge	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL SPONGE	1.02	0.70	0.81	0.65	0.20	0.20
ASCIDIA						
Herdmania momus	0.20	0.20	0.00	0.00	0.00	0.00
White Encrusting Solitary Ascidian	0.00	0.00	0.00	0.00	0.00	0.00
White Tubular Solitary Ascidian	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL ASCIDIA	0.20	0.20	0.00	0.00	0.00	0.00
ABIOTIC						
Bare Ships Surface	0.00	0.00	0.00	0.00	0.00	0.00
Sand	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL ABIOTIC	0.00	0.00	0.00	0.00	0.00	0.00
CRUSTACEA						
Balanus trigonus	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL CRUSTACEA	0.00	0.00	0.00	0.00	0.00	0.00
POLYCHAETA						
Serpulid Polychaete	1.41	0.51	0.00	0.00	1.02	0.79
TOTAL POLYCHAETA	1.41	0.51	0.00	0.00	1.02	0.79
CNIDARIA						
Hydroid 1	0.00	0.00	0.00	0.00	0.00	0.00
Anthothoe albocincta	0.41	0.41	0.00	0.00	0.00	0.00
TOTAL CNIDARIA	0.41	0.41	0.00	0.00	0.00	0.00
MATRIX (MAT)						
Barnacle,sediment,brown fil	0.00	0.00	0.00	0.00	0.00	0.00
Large Barnacle,Sediment,brown fil	0.00	0.00	0.00	0.00	0.00	0.00
Serpulid, Barnacle and Encrusting Algae Matrix	0.00	0.00	0.00	0.00	39.59	24.25
Serpulid Matrix	23.98	3.49	69.71	5.39	17.54	10.01

Turfing Brown, Sediment and Serpulid Matrix	64.31	2.79	2.80	2.56	40.84	18.04
TOTAL MATRIX	88.29	6.28	72.51	7.95	97.98	52.30
FISH MOBILE (FSH)						
Fish in Frame	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL FISH	0.00	0.00	0.00	0.00	0.00	0.00
INDETERMINATE						
Unknown White Material	0.00	0.00	3.03	1.15	0.00	0.00
TOTAL INDETERMINATE	0.00	0.00	3.03	1.15	0.00	0.00
TAPE, WAND, SHADOW						
Shadow	0.80	0.49	0.60	0.60	0.00	0.00
Tape Measure in Frame	0.00	0.00	0.00	0.00	0.00	0.00
Camera Pole in Frame	0.00	0.00	0.00	0.00	1.00	0.45
TOTAL TAPE, WAND, SHADOW	0.80	0.49	0.60	0.60	1.00	0.45

Appendix B: (Continued).

	Deck Starbord Bow		Deck Starbord Mid		Deck Starbord Stern	
Categories	Mean	S.E.	Mean	S.E.	Mean	S.E.
PHAEOPHYTA						
Ecklonia radiata	0.60	0.40	20.28	8.19	0.00	0.00
Lobed Brown Algae	0.00	0.00	2.41	0.93	0.00	0.00
Turfing Brown Algae	0.00	0.00	0.00	0.00	0.00	0.00
Orange Filamentous	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL PHAEOPHYTA	0.60	0.40	22.69	9.13	0.00	0.00
RHODOPHYTA						
Encrusting Red Algae	0.00	0.00	0.00	0.00	0.00	0.00
Red Branching Algae	2.40	1.50	5.61	1.44	0.00	0.00
Red Thin Branching	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL RHODOPHYTA	2.40	1.50	5.61	1.44	0.00	0.00
BRYOZOA						
Biflustra Perfragilis	0.00	0.00	0.00	0.00	0.00	0.00
Encrusting Orange Bryozoan	0.00	0.00	0.00	0.00	0.00	0.00
Encrusting Yellow Bryozoan	0.00	0.00	0.00	0.00	0.00	0.00
Membranipora membranacea	0.00	0.00	0.00	0.00	0.20	0.20
Triphyllozoan sp.	0.00	0.00	0.00	0.00	0.00	0.00
White Branching Bryozoan	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL BRYOZOA	0.00	0.00	0.00	0.00	0.20	0.20
PORIFERA						
Orange Encrusting Sponge	0.80	0.80	1.20	0.73	0.00	0.00
Yellow Encrusting Sponge	0.40	0.40	0.00	0.00	0.00	0.00
White Encrusting Sponge	0.00	0.00	0.20	0.20	0.00	0.00
White Globular Sponge	0.00	0.00	0.20	0.20	0.00	0.00
White Papillate Sponge	0.60	0.40	0.00	0.00	0.41	0.41
TOTAL SPONGE	1.80	1.60	1.60	1.13	0.41	0.41
ASCIDIA						
Herdmania momus	0.60	0.40	0.00	0.00	0.00	0.00
White Encrusting Solitary Ascidian	0.00	0.00	0.00	0.00	0.00	0.00
White Tubular Solitary Ascidian	0.00	0.00	0.20	0.20	0.00	0.00
TOTAL ASCIDIA	0.60	0.40	0.20	0.20	0.00	0.00
ABIOTIC						
Bare Ships Surface	0.00	0.00	0.00	0.00	0.00	0.00
Sand	0.00	0.00	0.00	0.00	6.87	6.62
TOTAL ABIOTIC	0.00	0.00	0.00	0.00	6.87	6.62
CRUSTACEA						
Balanus trigonus	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL CRUSTACEA	0.00	0.00	0.00	0.00	0.00	0.00
POLYCHAETA						
Serpulid Polychaete	0.00	0.00	0.20	0.20	0.00	0.00
TOTAL POLYCHAETA	0.00	0.00	0.20	0.20	0.00	0.00
CNIDARIA						
Hydroid 1	0.00	0.00	0.00	0.00	0.00	0.00
Anthothoe albocincta	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL CNIDARIA	0.00	0.00	0.00	0.00	0.00	0.00
MATRIX (MAT)						
Barnacle,sediment,brown fil	0.00	0.00	0.00	0.00	0.00	0.00
Large Barnacle,Sediment,brown fil	0.00	0.00	0.00	0.00	0.00	0.00
Serpulid, Barnacle and Encrusting Algae Matrix	0.00	0.00	0.00	0.00	50.50	21.96
Serpulid Matrix	13.40	3.59	68.89	8.54	14.15	10.41
Turfing Brown, Sediment and Serpulid Matrix	81.20	3.26	0.20	0.20	27.86	18.22
TOTAL MATRIX	94.60	6.85	69.09	8.74	92.52	50.58

FISH MOBILE (FSH)						
Fish in Frame	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL FISH	0.00	0.00	0.00	0.00	0.00	0.00
INDETERMINATE						
Unknown White Material	0.00	0.00	0.60	0.40	0.00	0.00
TOTAL INDETERMINATE	0.00	0.00	0.60	0.40	0.00	0.00
TAPE, WAND, SHADOW						
Shadow	0.00	0.00	0.00	0.00	0.00	0.00
Tape Measure in Frame	0.00	0.00	0.00	0.00	0.00	0.00
Camera Pole in Frame	0.00	0.00	0.20	0.20	1.40	0.24
TOTAL TAPE, WAND, SHADOW	0.00	0.00	0.20	0.20	1.40	0.24

Appendix B: (Continued).

	Horizontal Hull Port		Horizontal Hull Starbord		Vertical Hull Port Bow	
Categories	Mean	S.E.	Mean	S.E.	Mean	S.E.
PHAEOPHYTA						
Ecklonia radiata	0.00	0.00	0.00	0.00	0.00	0.00
Lobed Brown Algae	0.00	0.00	0.00	0.00	0.00	0.00
Turfing Brown Algae	25.44	5.86	27.23	6.82	2.67	1.73
Orange Filamentous	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL PHAEOPHYTA	25.44	5.86	27.23	6.82	2.67	1.73
RHODOPHYTA						
Encrusting Red Algae	0.17	0.17	0.00	0.00	0.00	0.00
Red Branching Algae	0.00	0.00	0.00	0.00	0.00	0.00
Red Thin Branching	0.00	0.00	0.00	0.00	0.21	0.21
TOTAL RHODOPHYTA	0.17	0.17	0.00	0.00	0.21	0.21
BRYOZOA						
Biflustra Perfragilis	1.01	0.69	2.34	0.80	1.48	0.73
Encrusting Orange Bryozoan	2.50	0.85	2.00	0.36	2.29	1.06
Encrusting Yellow Bryozoan	2.17	0.79	0.67	0.42	0.20	0.20
Membranipora membranacea	0.00	0.00	0.00	0.00	0.00	0.00
Triphyllozoan sp.	0.00	0.00	0.00	0.00	0.00	0.00
White Branching Bryozoan	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL BRYOZOA	5.68	2.33	5.01	1.59	3.97	2.00
PORIFERA						
Orange Encrusting Sponge	0.00	0.00	0.00	0.00	0.00	0.00
Yellow Encrusting Sponge	0.00	0.00	0.00	0.00	0.00	0.00
White Encrusting Sponge	0.00	0.00	0.17	0.17	0.00	0.00
White Globular Sponge	0.00	0.00	0.33	0.33	0.00	0.00
White Papillate Sponge	0.00	0.00	0.17	0.17	0.00	0.00
TOTAL SPONGE	0.00	0.00	0.67	0.67	0.00	0.00
ASCIDIA						
Herdmania momus	21.25	2.95	16.85	5.57	48.26	4.07
White Encrusting Solitary Ascidian	0.00	0.00	0.00	0.00	0.00	0.00
White Tubular Solitary Ascidian	0.00	0.00	0.00	0.00	0.41	0.25
TOTAL ASCIDIA	21.25	2.95	16.85	5.57	48.67	4.33
ABIOTIC						
Bare Ships Surface	0.17	0.17	0.00	0.00	0.00	0.00
Sand	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL ABIOTIC	0.17	0.17	0.00	0.00	0.00	0.00
CRUSTACEA						
Balanus trigonus	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL CRUSTACEA	0.00	0.00	0.00	0.00	0.00	0.00
POLYCHAETA						
Serpulid Polychaete	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL POLYCHAETA	0.00	0.00	0.00	0.00	0.00	0.00
CNIDARIA						
Hydroid 1	0.00	0.00	0.00	0.00	1.88	0.69
Anthothoe albocincta	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL CNIDARIA	0.00	0.00	0.00	0.00	1.88	0.69
MATRIX (MAT)						
Barnacle,sediment,brown fil	0.00	0.00	0.00	0.00	0.00	0.00
Large Barnacle,Sediment,brown fil	0.00	0.00	0.83	0.83	0.00	0.00
Serpulid, Barnacle and Encrusting Algae Matrix	3.00	2.05	4.42	4.22	34.13	7.21
Serpulid Matrix	44.29	8.50	45.00	5.07	8.47	4.61
Turfing Brown, Sediment and Serpulid Matrix	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL MATRIX	47.29	10.55	50.25	10.12	42.61	11.82

FISH MOBILE (FSH)						
Fish in Frame	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL FISH	0.00	0.00	0.00	0.00	0.00	0.00
INDETERMINATE						
Unknown White Material	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL INDETERMINATE	0.00	0.00	0.00	0.00	0.00	0.00
TAPE, WAND, SHADOW						
Shadow	0.33	0.21	0.33	0.33	2.20	0.86
Tape Measure in Frame	0.00	0.00	0.00	0.00	0.00	0.00
Camera Pole in Frame	0.00	0.00	0.00	0.00	1.40	0.24
TOTAL TAPE, WAND, SHADOW	0.33	0.21	0.33	0.33	3.60	1.11

Appendix B: (Continued).

	Vertical Hull Port Stern		Vertical Hull Starbord Bow		Vertical Hull Starbord Stern	
Categories	Mean	S.E.	Mean	S.E.	Mean	S.E.
PHAEOPHYTA						
Ecklonia radiata	0.00	0.00	0.00	0.00	0.00	0.00
Lobed Brown Algae	0.00	0.00	0.00	0.00	0.00	0.00
Turfing Brown Algae	4.07	1.56	1.85	0.38	17.40	4.66
Orange Filamentous	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL PHAEOPHYTA	4.07	1.56	1.85	0.38	17.40	4.66
RHODOPHYTA						
Encrusting Red Algae	0.40	0.25	0.61	0.41	0.20	0.20
Red Branching Algae	0.00	0.00	0.00	0.00	0.00	0.00
Red Thin Branching	0.00	0.00	0.41	0.25	0.00	0.00
TOTAL RHODOPHYTA	0.40	0.25	1.02	0.66	0.20	0.20
BRYOZOA						
Biflustra Perfragilis	0.44	0.27	2.87	0.76	0.40	0.24
Encrusting Orange Bryozoan	1.04	0.32	2.25	0.88	1.80	0.97
Encrusting Yellow Bryozoan	1.36	0.94	0.61	0.25	0.20	0.20
Membranipora membranacea	0.00	0.00	0.00	0.00	0.00	0.00
Triphyllozoan sp.	0.00	0.00	0.00	0.00	0.00	0.00
White Branching Bryozoan	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL BRYOZOA	2.84	1.53	5.74	1.88	2.40	1.41
PORIFERA						
Orange Encrusting Sponge	0.00	0.00	0.41	0.41	0.20	0.20
Yellow Encrusting Sponge	0.00	0.00	0.00	0.00	0.00	0.00
White Encrusting Sponge	0.00	0.00	0.00	0.00	0.00	0.00
White Globular Sponge	0.00	0.00	0.00	0.00	0.21	0.21
White Papillate Sponge	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL SPONGE	0.00	0.00	0.41	0.41	0.41	0.41
ASCIDIA						
Herdmania momus	8.46	1.02	45.45	7.43	36.88	4.42
White Encrusting Solitary Ascidian	0.20	0.20	0.00	0.00	0.00	0.00
White Tubular Solitary Ascidian	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL ASCIDIA	8.66	1.22	45.45	7.43	36.88	4.42
ABIOTIC						
Bare Ships Surface	0.00	0.00	0.00	0.00	0.00	0.00
Sand	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL ABIOTIC	0.00	0.00	0.00	0.00	0.00	0.00
CRUSTACEA						
Balanus trigonus	0.60	0.60	0.00	0.00	0.00	0.00
TOTAL CRUSTACEA	0.60	0.60	0.00	0.00	0.00	0.00
POLYCHAETA						
Serpulid Polychaete	0.00	0.00	0.00	0.00	0.20	0.20
TOTAL POLYCHAETA	0.00	0.00	0.00	0.00	0.20	0.20
CNIDARIA						
Hydroid 1	5.65	3.97	1.64	0.52	0.00	0.00
Anthothoe albocincta	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL CNIDARIA	5.65	3.97	1.64	0.52	0.00	0.00
MATRIX (MAT)						
Barnacle,sediment,brown fil	0.00	0.00	0.00	0.00	0.00	0.00
Large Barnacle,Sediment,brown fil	37.00	7.09	11.75	11.75	18.20	8.96
Serpulid, Barnacle and Encrusting Algae Matrix	40.78	9.77	30.89	7.82	17.11	7.14
Serpulid Matrix	0.00	0.00	1.04	1.04	7.20	4.68
Turfing Brown, Sediment and Serpulid Matrix	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL MATRIX	77.78	16.86	43.69	20.62	42.51	20.79

FISH MOBILE (FSH)						
Fish in Frame	0.00	0.00	0.21	0.21	0.00	0.00
TOTAL FISH	0.00	0.00	0.21	0.21	0.00	0.00
INDETERMINATE						
Unknown White Material	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL INDETERMINATE	0.00	0.00	0.00	0.00	0.00	0.00
TAPE, WAND, SHADOW						
Shadow	3.60	3.11	2.20	0.58	2.60	1.78
Tape Measure in Frame	0.00	0.00	0.00	0.00	0.00	0.00
Camera Pole in Frame	0.00	0.00	0.40	0.24	0.00	0.00
TOTAL TAPE, WAND, SHADOW	3.60	3.11	2.60	0.83	2.60	1.78

Appendix B: (Continued).

	Vertical Super Port Bow		Vertical Super Port Stern		Vertical Super Starbord Bow	
Categories	Mean	S.E.	Mean	S.E.	Mean	S.E.
PHAEOPHYTA						
Ecklonia radiata	0.61	0.61	0.00	0.00	0.00	0.00
Lobed Brown Algae	0.00	0.00	0.00	0.00	0.00	0.00
Turfing Brown Algae	6.47	2.94	8.00	2.22	13.80	4.18
Orange Filamentous	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL PHAEOPHYTA	7.08	3.55	8.00	2.22	13.80	4.18
RHODOPHYTA						
Encrusting Red Algae	0.00	0.00	0.20	0.20	3.00	1.82
Red Branching Algae	0.00	0.00	0.00	0.00	0.00	0.00
Red Thin Branching	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL RHODOPHYTA	0.00	0.00	0.20	0.20	3.00	1.82
BRYOZOA						
Biflustra Perfragilis	1.81	1.12	0.00	0.00	2.60	1.78
Encrusting Orange Bryozoan	2.62	1.96	0.61	0.25	1.80	0.97
Encrusting Yellow Bryozoan	0.00	0.00	0.00	0.00	0.00	0.00
Membranipora membranacea	0.00	0.00	0.20	0.20	0.00	0.00
Triphyllozoan sp.	0.00	0.00	0.00	0.00	0.20	0.20
White Branching Bryozoan	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL BRYOZOA	4.43	3.08	0.81	0.45	4.60	2.95
PORIFERA						
Orange Encrusting Sponge	0.20	0.20	0.20	0.20	1.60	0.68
Yellow Encrusting Sponge	0.00	0.00	0.00	0.00	0.00	0.00
White Encrusting Sponge	0.00	0.00	0.00	0.00	0.00	0.00
White Globular Sponge	0.00	0.00	0.00	0.00	0.20	0.20
White Papillate Sponge	0.00	0.00	0.00	0.00	0.20	0.20
TOTAL SPONGE	0.20	0.20	0.20	0.20	2.00	1.08
ASCIDIA						
Herdmania momus	19.76	8.15	5.01	2.28	10.60	5.64
White Encrusting Solitary Ascidian	0.40	0.25	0.00	0.00	1.60	0.68
White Tubular Solitary Ascidian	0.00	0.00	0.00	0.00	0.20	0.20
TOTAL ASCIDIA	20.17	8.40	5.01	2.28	12.40	6.51
ABIOTIC						
Bare Ships Surface	0.00	0.00	2.05	1.60	0.00	0.00
Sand	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL ABIOTIC	0.00	0.00	2.05	1.60	0.00	0.00
CRUSTACEA						
Balanus trigonus	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL CRUSTACEA	0.00	0.00	0.00	0.00	0.00	0.00
POLYCHAETA						
Serpulid Polychaete	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL POLYCHAETA	0.00	0.00	0.00	0.00	0.00	0.00
CNIDARIA						
Hydroid 1	0.00	0.00	0.00	0.00	0.00	0.00
Anthothoe albocincta	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL CNIDARIA	0.00	0.00	0.00	0.00	0.00	0.00
MATRIX (MAT)						
Barnacle,sediment,brown fil	8.98	8.98	13.13	13.13	0.00	0.00
Large Barnacle,Sediment,brown fil	6.00	6.00	17.10	7.37	10.00	5.07
Serpulid, Barnacle and Encrusting Algae Matrix	43.06	17.07	53.28	15.47	42.40	7.69
Serpulid Matrix	10.09	9.13	0.00	0.00	11.60	8.15
Turfing Brown, Sediment and Serpulid Matrix	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL MATRIX	68.13	41.18	83.51	35.97	64.00	20.91

FISH MOBILE (FSH)						
Fish in Frame	0.00	0.00	0.21	0.21	0.00	0.00
TOTAL FISH	0.00	0.00	0.21	0.21	0.00	0.00
INDETERMINATE						
Unknown White Material	0.00	0.00	0.00	0.00	0.20	0.20
TOTAL INDETERMINATE	0.00	0.00	0.00	0.00	0.20	0.20
TAPE, WAND, SHADOW						
Shadow	0.00	0.00	3.80	3.56	0.00	0.00
Tape Measure in Frame	0.00	0.00	0.20	0.20	0.00	0.00
Camera Pole in Frame	0.60	0.40	1.00	0.00	0.00	0.00
TOTAL TAPE, WAND, SHADOW	0.60	0.40	5.00	3.76	0.00	0.00

Appendix B: (Continued).

	Vertical Super Starbord Stern	
Categories	Mean	S.E.
PHAEOPHYTA		
Ecklonia radiata	0.00	0.00
Lobed Brown Algae	0.00	0.00
Turfing Brown Algae	9.30	3.55
Orange Filamentous	1.62	1.62
TOTAL PHAEOPHYTA	10.92	5.17
RHODOPHYTA		
Encrusting Red Algae	1.27	0.61
Red Branching Algae	0.20	0.20
Red Thin Branching	0.64	0.26
TOTAL RHODOPHYTA	2.11	1.08
BRYOZOA		
Biflustra Perfragilis	1.83	1.13
Encrusting Orange Bryozoan	1.88	0.50
Encrusting Yellow Bryozoan	0.20	0.20
Membranipora membranacea	0.00	0.00
Triphyllozoan sp.	0.00	0.00
White Branching Bryozoan	0.20	0.20
TOTAL BRYOZOA	4.11	2.04
PORIFERA		
Orange Encrusting Sponge	0.20	0.20
Yellow Encrusting Sponge	0.00	0.00
White Encrusting Sponge	0.00	0.00
White Globular Sponge	0.00	0.00
White Papillate Sponge	0.40	0.40
TOTAL SPONGE	0.61	0.61
ASCIDIA		
Herdmania momus	7.77	2.80
White Encrusting Solitary Ascidian	0.20	0.20
White Tubular Solitary Ascidian	0.61	0.61
TOTAL ASCIDIA	8.58	3.61
ABIOTIC		
Bare Ships Surface	0.40	0.40
Sand	0.00	0.00
TOTAL ABIOTIC	0.40	0.40
CRUSTACEA		
Balanus trigonus	0.00	0.00
TOTAL CRUSTACEA	0.00	0.00
POLYCHAETA		
Serpulid Polychaete	0.00	0.00
TOTAL POLYCHAETA	0.00	0.00
CNIDARIA		
Hydroid 1	0.23	0.23
Anthothoe albocincta	0.00	0.00
TOTAL CNIDARIA	0.23	0.23
MATRIX (MAT)		
Barnacle,sediment,brown fil	0.00	0.00
Large Barnacle,Sediment,brown fil	4.95	4.46
Serpulid, Barnacle and Encrusting Algae Matrix	66.80	4.26
Serpulid Matrix	0.61	0.40
Turfing Brown, Sediment and Serpulid Matrix	0.00	0.00
TOTAL MATRIX	72.36	9.13

FISH MOBILE (FSH)		
Fish in Frame	0.68	0.68
TOTAL FISH	0.68	0.68
INDETERMINATE		
Unknown White Material	0.00	0.00
TOTAL INDETERMINATE	0.00	0.00
TAPE, WAND, SHADOW		
Shadow	2.40	2.16
Tape Measure in Frame	0.00	0.00
Camera Pole in Frame	1.20	0.20
TOTAL TAPE, WAND, SHADOW	3.60	2.36

Appendix C: Permutational Analysis of Variance of Percent Cover of Reef Assemblages Sampled in Reef Monitoring Surveys 1 and 2. *P*-values highlighted in bold are significant. RED = Redundant term. A term becomes redundant if a lower order interaction including that term is significant. Res = Residual. This term is a measure of the variation in the data not explained by the variation attributed to the main factors in the experimental model (i.e. Time, Orientation etc. and their associated interactions).

1. All Positions over Time

Source	df	SS	MS	F	*P*
Time	1	36088	36088	11.535	**0.0001**
Residual	162	5.0684E5	3128.7		
Total	163	5.4293E5			

2. Orientation (Deck/Hull) and Time

Source	df	SS	MS	F	*P*
Time	1	13491	13491	6.9008	RED
Orientation	1	13610	13610	6.9615	RED
Aspect	1	1420.8	1420.8	0.72672	0.594
Time x Orientation	1	14670	14670	7.5037	**0.0001**
Time x Aspect	1	3126.3	3126.3	1.5991	0.1433
Orientation x Aspect	1	1941.2	1941.2	0.99292	0.39
Time x Position x Aspect	1	943.84	943.84	0.48277	0.8206
Residual	56	1.0948E5	1955		
Total	63	1.5779E5			

3. Depth, Aspect and Time

Source	df	SS	MS	F	*P*
Time	1	28772	28772	9.2594	RED
Depth	1	6850.4	6850.4	0.88224	0.4399
Aspect	1	1757.1	1757.1	0.22629	0.9364
Time x Depth	1	3382.6	3382.6	1.0886	0.3838
Time x Aspect	1	880.26	880.26	0.28329	0.9159
Time x Aspect	1	880.26	880.26	0.28329	0.9159
Depth x Aspect	1	3918.5	3918.5	0.50465	0.6826
Transect (Depth x Aspect)	4	31059	7764.8	4.8196	**0.0001**
Time x Depth x Aspect	1	1546.6	1546.6	0.49775	0.7433
Time x Transect (Depth x Aspect)	4	12429	3107.3	1.9287	**0.0141**
Res	64	1.0311E5	1611.1		
Total	79	1.937E5			

Continued.

Appendix C: Continued.

4. Deck Position (Bow, Mid, Stern) and Time

Source	df	SS	MS	F	*P*
Time	1	24629	24629	15.381	0.0001
Position	2	21195	10597	6.6181	0.0001
Aspect	1	1918.6	1918.6	1.1982	0.2895
Time x Position	2	14579	7289.4	4.5522	0.0001
Time x Aspect	1	2399.6	2399.6	1.4986	0.173
Position x Aspect	2	3888.3	1944.1	1.2141	0.2614
Time x Position x Aspect	2	2548.8	1274.4	0.79586	0.614
Residual	48	76861	1601.3		
Total	59	1.4802E5			

Appendix D: Pairwise tests of reef assemblages of fish for significant term TimexPosition. Significant results in bold.

Orientation

Term 'TixPo' for pairs of levels of factor 'Position'

Within level '1' of factor 'Time'

Groups	t	P(perm)	Unique perms
Deck, Hull	2.2938	**0.0009**	9939

Within level '2' of factor 'Time'

Groups	t	P(perm)	Unique perms
Deck, Hull	2.785	**0.0001**	9936

Term 'TixPo' for pairs of levels of factor 'Time'

Within level 'Deck' of factor 'Position'

Groups	t	P(perm)	Unique perms
1, 2	2.2938	**0.0009**	9939

Within level 'Hull' of factor 'Position'

Groups	t	P(perm)	Unique perms
1, 2	3.2509	**0.0001**	9947

Depth/Aspect

Term 'TixTr(DexAs)' for pairs of levels of factor 'Time'

Within level 'Deep' of factor 'Depth'
Within level 'Port' of factor 'Aspect'
Within level 'Bow' of factor 'Transect'

Groups	t	P(perm)	Unique perms
1, 2	2.4078	**0.0173**	126

Within level 'Deep' of factor 'Depth'
Within level 'Port' of factor 'Aspect'
Within level 'Stern' of factor 'Transect'

Groups	t	P(perm)	Unique perms
1, 2	3.1298	**0.0076**	126

Continued

Appendix D:Continued

Depth/Aspect

Term 'TixTr(DexAs)' for pairs of levels of factor 'Time'

Within level 'Deep' of factor 'Depth'
Within level 'Starbord' of factor 'Aspect'
Within level 'Bow' of factor 'Transect'

Groups	t	P(perm)	Unique perms
1, 2	1.8496	**0.0723**	126

Within level 'Deep' of factor 'Depth'
Within level 'Starbord' of factor 'Aspect'
Within level 'Stern' of factor 'Transect'

Groups	t	P(perm)	Unique perms
1, 2	2.8808	**0.0088**	126

Within level 'Shallow' of factor 'Depth'
Within level 'Port' of factor 'Aspect'
Within level 'Bow' of factor 'Transect'

Groups	t	P(perm)	Unique perms
1, 2	1.5181	**0.0251**	125

Within level 'Shallow' of factor 'Depth'
Within level 'Port' of factor 'Aspect'
Within level 'Stern' of factor 'Transect'

Groups	t	P(perm)	Unique perms
1, 2	1.1705	0.2681	126

Within level 'Shallow' of factor 'Depth'
Within level 'Starbord' of factor 'Aspect'
Within level 'Bow' of factor 'Transect'

Groups	t	P(perm)	Unique perms
1, 2	1.1984	0.1955	126

Continued

Appendix D:Continued

Depth/Aspect

Term 'TixTr(DexAs)' for pairs of levels of factor 'Time'

Within level 'Shallow' of factor 'Depth'
Within level 'Starbord' of factor 'Aspect'
Within level 'Stern' of factor 'Transect'

Groups	t	P(perm)	Unique perms
1, 2	2.058	**0.0087**	126

Depth/Aspect

Term 'TixTr(DexAs)' for pairs of levels of factor 'Transect'

Within level '1' of factor 'Time'
Within level 'Deep' of factor 'Depth'
Within level 'Port' of factor 'Aspect'

Groups	t	P(perm)	Unique perms
Bow, Stern	5.1037	**0.0073**	126

Within level '1' of factor 'Time'
Within level 'Deep' of factor 'Depth'
Within level 'Starbord' of factor 'Aspect'

Groups	t	P(perm)	Unique perms
Bow, Stern	1.9147	0.0621	126

Within level '1' of factor 'Time'
Within level 'Shallow' of factor 'Depth'
Within level 'Port' of factor 'Aspect'

Groups	t	P(perm)	Unique perms
Bow, Stern	1.2844	0.1996	126

Within level '1' of factor 'Time'
Within level 'Shallow' of factor 'Depth'
Within level 'Starbord' of factor 'Aspect'

Groups	t	P(perm)	Unique perms
Bow, Stern	0.77253	0.5998	126

Continued

Appendix D:Continued

Depth/Aspect

Term 'TixTr(DexAs)' for pairs of levels of factor 'Transect'

Within level '2' of factor 'Time'
Within level 'Deep' of factor 'Depth'
Within level 'Port' of factor 'Aspect'

Groups	t	P(perm)	Unique perms
Bow, Stern	2.5102	**0.0071**	126

Within level '2' of factor 'Time'
Within level 'Deep' of factor 'Depth'
Within level 'Starbord' of factor 'Aspect'

Groups	t	P(perm)	Unique perms
Bow, Stern	1.4838	0.1097	126

Within level '2' of factor 'Time'
Within level 'Shallow' of factor 'Depth'
Within level 'Port' of factor 'Aspect'

Groups	t	P(perm)	Unique perms
Bow, Stern	1.1197	0.2873	126

Within level '2' of factor 'Time'
Within level 'Shallow' of factor 'Depth'
Within level 'Starbord' of factor 'Aspect'

Groups	t	P(perm)	Unique perms
Bow, Stern	1.0982	0.3215	126

Continued

Appendix D:Continued

Position on Deck

Term 'TixPo' for pairs of levels of factor 'Time'

Within level 'Bow' of factor 'Postion'

Groups	t	P(perm)	Unique perms
1, 2	3.6623	**0.0001**	9946

Within level 'Mid' of factor 'Postion'

Groups	t	P(perm)	Unique perms
1, 2	2.1208	**0.003**	9952

Within level 'Stern' of factor 'Postion'

Groups	t	P(perm)	Unique perms
1, 2	2.5886	**0.0005**	9947

Term 'TixPo' for pairs of levels of factor 'Postion'

Within level '1' of factor 'Time'

Groups	t	P(perm)	Unique perms
Bow, Mid	1.1316	0.3092	9932
Bow, Stern	1.2443	0.2517	9941
Mid, Stern	1.3651	0.0986	9959

Within level '2' of factor 'Time'

Groups	t	P(perm)	Unique perms
Bow, Mid	4.5683	0.0001	9957
Bow, Stern	1.9875	0.0167	9933
Mid, Stern	3.0371	0.0002	9933

Appendix E : Results of SIMPER analyses of reef assemblages of fish sampled in The Ex-Hmas Adelaide Articial Reef Community Sampling event 2. Cut off for percentage contribution is 90 %.

Orientation

Groups 1Deck & 1Hull

Average similarity: 59.00%

Taxon	Av. Abund	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Serpulid matrix	69.6	45.39	25.02	1.19	42.41	42.41
Serpulid barnacle and encrusting algae matrix	0.11	33.71	19.47	0.87	32.99	75.41
Serpulid polychaete	3.39	6.09	2.89	0.93	4.91	80.31
Encrusting red algae	3.7	0.88	2.15	0.62	3.65	83.96
Membranipora membranacea	0.23	1.92	1.12	0.87	1.9	85.87
Large barnacle,sediment,brown fil	0	1.61	1.1	0.32	1.86	87.73
Ecklonia radiata	1.86	0	1.03	0.68	1.75	89.48
Spongia sp.	1.08	1.22	1.02	0.84	1.73	91.21

Groups 1Deck & 2Deck

Average dissimilarity = 66.47%

Taxon	Av. Abund	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Serpulid matrix	69.60	39.04	28.61	1.26	43.05	43.05
Serpulid barnacle and encrusting algae matrix	0.11	17.57	10.45	0.48	15.72	58.77
Turfing brown, sediment and serpulid matrix	0.00	17.97	10.37	0.55	15.6	74.37
Ecklonia radiata	1.86	8.58	5.38	0.71	8.09	82.46
Red branching algae	0.00	3.26	2.12	0.62	3.18	85.65
Encrusting red algae	3.70	0	2.01	0.5	3.03	88.68
Serpulid polychaete	3.39	0.35	2	1.02	3	91.68

Groups 1Hull & 2Hull

Average dissimilarity = 69.06%

Taxon	Av. Abund	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Serpulid matrix	45.39	39.4	18.43	1.54	26.68	26.68
Serpulid barnacle and encrusting algae matrix	33.71	3.71	17.21	0.94	24.93	51.61
Turfing brown algae	0.1	23.33	12.55	1.47	18.18	69.79
Herdmania momus	0.86	18.3	9.09	1.59	13.17	82.95
Serpulid polychaete	6.09	0	3.25	1.06	4.71	87.67
Encrusting orange broyozoan	0	2.29	1.21	1.61	1.76	89.42
Large barnacle,sediment,brown fil	1.61	0.42	1.13	0.4	1.63	91.05

Continued

Appendix E:Continued

Groups 1Deck & 2Hull

Average dissimilarity = 74.93%

Taxon	Av. Abund	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Serpulid matrix	39.04	39.4	18.38	1.29	24.52	24.52
Turfing brown algae	0	23.33	13.44	1.32	17.93	42.46
Serpulid barnacle and encrusting algae matrix	17.57	3.71	10.57	0.59	14.1	56.56
Herdmania momus	0	18.3	10.07	1.51	13.43	69.99
Turfing brown, sediment and serpulid matrix	17.97	0	9.46	0.58	12.62	82.62
Ecklonia radiata	8.58	0	4.62	0.66	6.16	88.78
Red branching algae	3.26	0	1.85	0.73	2.47	91.24

Depth/Aspect

Groups 1DeepPortBow & 1DeepPortStern

Average similarity = 89.23%

Taxon	Av. Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Large barnacle,sediment,brown fil	2.46	89.6	48.14	4	53.96	53.96
Serpulid barnacle and encrusting algae matrix	69.75	7.01	31.77	2.16	35.61	89.56
Hydroid 1	3.73	0	2.14	1.11	2.4	91.96

Groups 1DeepPortStern & 2DeepPortStern

Average similarity = 64.26%

Taxon	Av. Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Large barnacle,sediment,brown fil	89.6	26.3	34.54	2.63	59.98	59.98
Serpulid barnacle and encrusting algae matrix	7.01	30.1	13.49	1.49	20.99	80.97
Hydroid 1	0	5.73	3.82	0.64	5.94	86.91
Turfing brown algae	0	4.09	2.33	1.27	3.63	90.54

Groups 1DeepStarbordStern & 2DeepPortStern

Average similarity =62.85%

Taxon	Av. Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Large barnacle,sediment,brown fil	66.8	26.3	30.37	1.9	48.32	48.32
Serpulid barnacle and encrusting algae matrix	10.95	30.1	16.75	1.38	26.65	74.97
Hydroid 1	2.16	5.73	4.75	0.64	7.56	82.52
Turfing brown algae	0	4.09	2.78	1.07	4.43	86.95
Balanus sp. 1	2.38	0	2.07	0.81	3.29	90.24

Continued

Appendix E:Continued

Depth/Aspect

Groups 2DeepPortBow & 2DeepPortStern

Average similarity = 67.16%

Taxon	Av. Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Herdmania momus	39.28	3.16	21.78	1.77	32.43	32.43
Large barnacle,sediment,brown fil	0	26.3	15.49	2.33	23.07	55.5
Serpulid barnacle and encrusting algae matrix	34.29	30.1	14.19	1.13	21.13	76.64
Serpulid matrix	8.49	0	5.01	0.87	7.47	84.1
Hydroid 1	2.01	5.73	3.97	0.68	5.91	90.01

Groups 1ShallowStarbordStern & 2ShallowStarbordStern

Average similarity = 54.00%

Taxon	Av. Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Serpulid barnacle and encrusting algae matrix	72.02	39.81	23.19	1.11	42.94	42.94
Large barnacle,sediment,brown fil	18.27	5.04	9.95	1.18	61.37	18.43
Turfing brown algae	0	9.5	5.1	1.49	70.81	9.44
Herdmania momus	0.35	8.26	4.93	1.18	1.18	9.13

Position on Deck

Groups 1Bow & 2Bow

Average similarity = 78.28%

Taxon	Av. Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Serpulid matrix	66.26	18.69	33.24	1.71	42.46	42.46
Turfing brown, sediment and serpulid matrix	0	51.16	32.5	1.75	41.52	83.97
Red branching algae	0	4.26	3.3	0.78	4.22	88.2
Serpulid polychaete	3.15	0.75	2.39	0.65	3.06	91.26

Groups 1Mid & 2Mid

Average similarity = 43.27%

Taxon	Av. Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Serpulid matrix	70.22	62.1	19.96	0.97	46.12	46.12
Ecklonia radiata	3.72	17.16	8.54	1.11	19.73	65.85
Red branching algae	0	6.42	3.95	1.28	9.12	74.97
Serpulid polychaete	4.34	0.1	2.64	1.62	6.09	81.07
Lobed brown algae	0	2.56	1.61	1.01	3.71	84.78
Red encrusting bryozoan	1.79	0	1.23	0.78	2.84	87.63
Spongia sp.	2.16	0	1.21	0.84	2.79	90.42

Continued

Appendix E:Continued

Position on Deck

Groups 1Stern & 2Stern

Average similarity = 86.48%

Taxon	Av. Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Serpulid matrix	68.98	15.99	35.2	1.63	40.7	40.7
Serpulid barnacle and encrusting algae matrix	0.22	35.15	21.96	0.76	25.39	66.09
Turfing brown, sediment and serpulid matrix	0	34.44	20.51	0.85	23.72	89.81
Encrusting red algae	6.61	0	3.61	0.68	4.18	93.99

Groups 2Bow & 2Stern

Average similarity = 68.10%

Taxon	Av. Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Turfing brown, sediment and serpulid matrix	51.16	34.44	26.72	1.28	39.23	39.23
Serpulid barnacle and encrusting algae matrix	0	35.15	20.69	0.77	30.39	69.62
Serpulid matrix	18.69	15.99	12.86	1.24	18.88	88.51
Red branching algae	4.26	0.1	2.94	0.7	4.32	92.82

Groups 2Mid & 2Stern

Average similarity = 84.20%

Taxon	Av. Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Serpulid matrix	62.1	15.99	27.93	1.55	33.17	33.17
Serpulid barnacle and encrusting algae matrix	0	35.15	18.57	0.78	22.05	55.22
Turfing brown, sediment and serpulid matrix	1.5	34.44	18.15	0.93	21.56	76.78
Ecklonia radiata	17.16	0	9.68	1.15	11.5	88.28
Red branching algae	6.42	0.1	3.87	1.09	4.59	92.87

Appendix F : Distance based test for homogeneity of multivariate dispersion between survey times 1 and 2. Significant results in bold

All Sites	
Group factor	P(perm)
Time	0.938

Orientation	
Group factor	P(perm)
Time	0.094

Depth/Aspect	
Group factor	P(perm)
Time	0.319

Position on Deck	
Group factor	P(perm)
Time	**0.021**