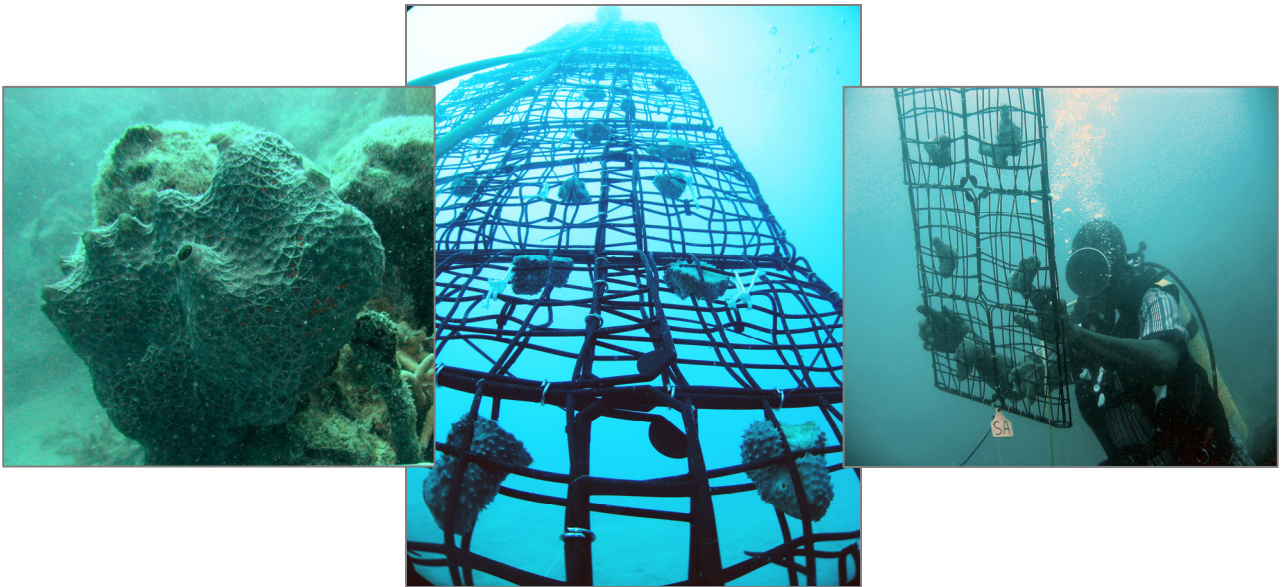


Ecological role and potential economic value of sponges to the Torres Strait

Annual Report 2009



Steve Whalan

Australian Institute of Marine Science



Australian Government

**Department of the Environment,
Water, Heritage and the Arts**

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August 2009

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Acronyms and Abbreviations

AIMS	Australian Institute of Marine Science
ANOVA	Analysis of variance
ARP	Annual Research Plan
cm	Centimetre(s)
CRC	Cooperative Research Centre
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts
m	Metre(s)
MANOVA	Multivariate analysis of variance
MTSRF	Marine and Tropical Sciences Research Facility
pers. obs.	Personal observation
RTRC	Reef and Rainforest Research Centre Limited
SE	Standard error
sec	Second(s) (time)
TSI	Torres Strait Islander(s)
TSRA	Torres Strait Regional Authority
vs.	Versus

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Summary

- Sponges are a key representative group throughout the coral reefs of Torres Strait. They play important functional roles in coral reef ecosystems and several species show commercial potential for use as biomaterials. Sponges that have specific skeletal (spongin) fibres are particularly targeted for use as bath sponges.
- Previously completed CRC Torres Strait and MTSRF research undertaken by AIMS and the Yorke Island Community Council established farming protocols to grow the bath sponge *Coscinoderma mathewsi*, a commonly found sponge surrounding Masig Island. The sustainability of a bath sponge industry was addressed by the current MTSRF funding which determines factors that contribute and maintain sponge populations in Torres Strait. This included assessments of abundance and distribution, size frequencies and larval recruitment.
- Two surveys were completed each year to assess abundance, distribution and size patterns of sponges at Masig Island. This has been ongoing since 2005. Sponge numbers in 2008 have remained consistent with abundance estimates from 2007 surveys. In 2008, there were inconsistent patterns between seasons with significant effects of site and depth in November but not May. This result, coupled with fluctuating numbers of sponges among previous surveys, could indicate recruitment pulses and mortality, but to confirm this, a change in the operational plan will be undertaken in 2009-2010 to include repeated surveys of permanent transects. This approach will more clearly identify population demographics for *C. mathewsi*.
- Size frequency trends for *C. mathewsi* were also consistent with previous surveys at Masig Island (e.g. Duckworth and Wolff 2008) the majority of sponges from both survey periods in 2008 fell within small to medium size classes (i.e. less than 20cm across the longest axis) with a small proportion being classed as large sponges (i.e. >20cm).
- Recruitment dynamics of sponges and other benthic sessile organisms to the Masig Island group were also elucidated as part of a larger, ongoing study associated with this project. Recruitment activity for six taxonomic groups was observed and results are consistent with previous survey findings; polychaetes dominated recruitment abundance while algae showed the highest percentage cover. Recruitment of *C. mathewsi* was less than one percent of the total species recruitment during 2008-2009 surveys.
- A series of experiments were undertaken from February to June 2009 to investigate if collection and handling strategies for sponge aquaculture could be optimised. Five treatments were investigated to establish effects on growth and survival of explants including, (1) exposure to air during handling, (2) handling (and associated incidental squeezing) during the transfer of explants to grow-out panels, (3) a transitional nursery stage prior to seeding into panels, (4) collecting from different size classes of donor sponges and (5) collecting from different regions of donor sponges. Operational strategies can be improved by incorporating a nursery stage and some exposure to air can be tolerated with no significant effect on explant survival.
- For all field work components Torres Strait Islanders have been actively engaged. Masig Island locals John Morris, Samson Lowatta and Gavin Mosby were employed as divers and boat operators during the 2008-2009 surveys and were instrumental in completing the objectives of this study

Introduction

Overall objective: Determine key population demographics for the sponge *Coscinoderma mathewsi* at Masig Island, Torres Strait, and establish a sustainable strategy for the aquaculture of this sponge.

Background

Sponges occupy all aquatic biotopes from the tropics to the poles with an estimated diversity of over 15,000 species (Hooper and Levi 1994). They are implicated in the functioning of reefal ecosystems, playing important ecological roles including reef bio-erosion and consolidation, infaunal habitat refuges and benthic-pelagic coupling (review Bell 2008). In addition, there are several species that are commercially important as biomaterials, including their use as bath sponges (Pronzato 1999).

Commercial bath sponges (Order: Dictyocertida) are characterised by a skeletal composition with high quality spongin which is targeted for both household and industrial applications. The supply of bath sponges has relied heavily on wild-harvest effort predominantly in the Mediterranean and Caribbean (Pronzato 1999). However, unregulated harvest effort, coupled with disease outbreaks, has placed enormous pressure on wild sponge populations in these regions with subsequent impacts on the supply of bath sponges (Pronzato 1999). The short fall in supply, originating from wild-harvest effort, provides an opportunity for the development of a bath sponge aquaculture industry, which will begin to meet the demand for bath sponges in a sustainable manner.

Coscinoderma mathewsi was identified during surveys of the Torres Strait in 2004. A market analysis of *C. mathewsi*, sourced from the Great Barrier Reef, revealed this sponge to comprise commercial grade spongin (Figure 1a-b). *Coscinoderma mathewsi* occurs throughout several islands of the eastern and central Torres Strait, but shows highest abundances in the vicinity of Masig Island (Duckworth *et al.* 2007b). The key priority of CRC Torres Strait Task 1.6 was to optimise the culture of *C. mathewsi*. The outcome of this project established that clonal propagules (explants) could be seeded and grown in pearl panels, achieving both high survival and growth, thereby suggesting bath sponge aquaculture in the Torres Strait would be a viable industry (Figure 1c).

[MTSRF Project 1.3.2](#) has built on the output of previous sponge aquaculture research to develop further the sustainability of a sponge aquaculture industry in Torres Strait. This has included specific foci on optimising the collection, handling and grow-out of sponge explants and key ecological indicators concerning population demographics of wild sponge populations. As such, this MTSRF project will be able to deliver:

- Abundance and size frequency information on *C. mathewsi* populations within the immediate vicinity of the proposed farming region;
- Information on the recruitment dynamics of sponges (and other sessile organisms);
- Data associated with the potential risks of translocated sponge recruits; and
- Optimal handling and collection methods that will contribute to increased survival and growth of cultured sponges.

Objectives

The specific objectives of this project are to:

- (a) Assess the distribution and abundance of *C. mathewsi* in Torres Strait, identifying elements of environmental risk (evidence of disease);
- (b) Determine connectivity between sponge populations and risks in translocation;
- (c) Determine patterns of sponge recruitment/ mortality and the environmental risk of seed stock harvest leading to development of a sustainable seed collection strategy; and
- (d) Develop optimal handling guidelines to improve sponge explant growth and survival.

Objectives (a) and (c) are ongoing with data collection occurring over the full length of the project. Objectives (b) completed in Year 1 (Duckworth *et al.* 2007a) and (d) in 2009.

Involvement of Torres Strait Islanders

The involvement of Torres Strait Islanders (TSI) has been integral to this project with an intensive focus on field and diving work at Masig Island. John Morris and Samson Lowatta from Masig Island were employed for diving and boating assistance during the 2008 and February 2009 field trips (Figure 1d-e). Given the value in skills development, linked to operational procedures of a commercial sponge farm for TSI, coupled with the savings for the Project Leader to minimise the expense associated with field trips to monitor the experiments, John and Samson were trained in methods to monitor sponge explant survival and growth unassisted (Objective d). Along with the assistance of Solomon Elia and Joey Billy, data was collected monthly from March until the June 2009 field trip where final measurements were undertaken with the assistance of the Project Leader.

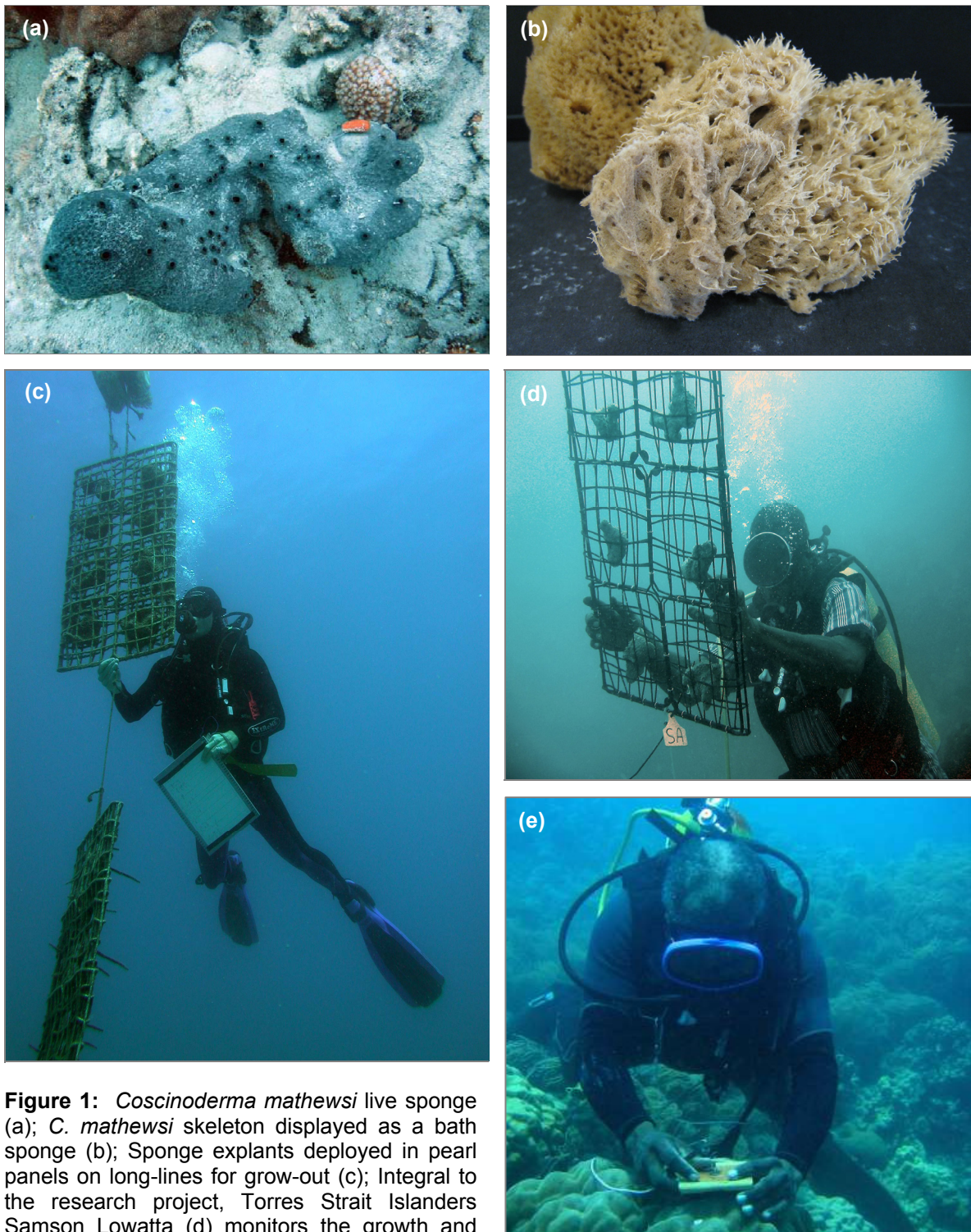


Figure 1: *Coscinoderma mathewsi* live sponge (a); *C. mathewsi* skeleton displayed as a bath sponge (b); Sponge explants deployed in pearl panels on long-lines for grow-out (c); Integral to the research project, Torres Strait Islanders Samson Lowatta (d) monitors the growth and survival of explants (Objective d), and John Morris (e) collects recruitment data (Objective c).

Population demographics of *C. mathewsi*: Abundance, size and disease

Objective 1: Determine the distribution, abundance and size frequencies of *C. mathewsi* populations at Masig and Kodall Islands.

Introduction

Bath sponges have been sourced for centuries for use in a range of commercial and cosmetic uses (Pronzato 1999). Traditionally, the bath sponge market was supplied through the collection of wild sponges mostly from the Mediterranean and Caribbean. More recently, there has been an increasing interest in developing sustainable culture techniques to supply markets, thereby alleviating pressure on wild sponge populations. The ability of sponges to grow from fragments (explants) excised from donor wild sponges, and then seeded on a range of standard aquaculture infrastructure, makes them ideal candidates for aquaculture (Duckworth and Wolff 2007a). Harvesting from donor wild stock and subsequent culture of explants is a feasible method to obtain commercial quantities of sponge (Duckworth and Wolff 2007a). However, key data on abundance and distribution of the target species are fundamental to guiding decisions on both developing a sustainable industry and conserving wild sponge populations. Proceeding with a commercial venture without this information poses potential risks of localised extinction due to over-harvest at inappropriate spatial scales.

Determining distribution and abundance patterns for sessile invertebrates must account for biotic and abiotic processes that contribute to distribution patterns across a wide range of spatial and temporal scales. Research effort must examine the mobile larval phase (e.g. to examine availability of suitable settlement habitat – Whalan *et al.* 2008), and also post-settlement processes following recruitment as juveniles and adults (e.g. to examine predation and disturbance events – Maldonado and Uriz 1998). The interaction of these processes for both larval and adults stages is a contributing influence to the patchy distributions often seen in sponge populations (e.g. Barnes *et al.* 2006).

Other population demographic characters such as size frequencies can also show considerable patchiness in sponges, particularly over localised spatial scales (Duckworth and Wolff 2007b). Both physical and biological processes influence size structures of sponge populations and can have either detrimental or beneficial impacts on growth and therefore size structures. For example, strong water currents can deliver more food have a positive effect on growth for some species (Duckworth and Battershill 2003), but for other more fragile species strong currents can damage sponges and reduce growth (Trautman *et al.* 2000).

Determining key population demographic patterns for *C. mathewsi* has been a central focus of MTSRF Project 1.3.2 and has confirmed that throughout Torres Strait this species is most abundant in the Masig Island group. A continued effort has centered on establishing the spatial and temporal patterns of abundance, distribution and size frequencies at Masig Island since 2005 and the objective of this report is to provide updated information since the last reporting period in 2008 (i.e. from surveys undertaken in 2008-2009).

Methods

Methods for examining the abundance, distribution and size frequencies of target sponges have been undertaken in accordance to the methods outlined by Duckworth for previous surveys associated with Project 1.3.2. (Duckworth and Wolff 2008) and are reiterated briefly as follows:

Abundance and size frequencies between depths and microhabitats

Surveys were undertaken in November 2008. Because data collected by Duckworth during May 2008 was not included in the last annual report it is included and compared to the November 2008 data here. For these surveys, *Coscinoderma mathewsi* was surveyed at two depths (6 and 12m) at 6-10 sites, each site being separated by at least one kilometre at each location. For simplicity, the two depth ranges will be referred to as *shallow* (6m) and *deep* (12m) for the remainder of this report. Three 20x1m transects were used to record *C. mathewsi* abundances, in addition to estimates of reef profile, and composition of reef substrate (percentages of dead coral rubble, sand, and rock). Each transect was separated by at least twenty metres. To quantify size frequency patterns the longest axis of length for each sponge was recorded.

The change in the operational plan (MTSRF 2009) meant that abundance estimates for the June 2009 survey could not be used as a comparison to previous surveys. Data associated with permanent transects, established in June 2009, will be incorporated in the 2009 annual report.

Data analysis

To assess differences of sponge abundances between depths and among sites a two-way analysis of variance (ANOVA) was used. Where necessary data was log transformed to meet the assumptions of ANOVA. To examine size variation, sponges from each depth-survey were grouped into three size classes: small ≤ 10 cm, medium 11-20cm and large > 20 cm. Multivariate analysis of variance (MANOVA) was used to examine the influence of site and depth and their interaction on the four environmental factors (slope, percent rock, percent rubble and percent sand). Wilks' lambda statistic was used to compute F-ratios and data was then analysed further by ANOVA.

Study area and sampling strategy

Sponge abundance, size frequencies and distributions were undertaken within the Masig Island group, namely Masig and Kodall Islands. Both Masig and Kodall Islands are sand cays approximately ten metres above mean sea level, less than five square kilometres in size and surrounded by fringing coral reef.

Results

Abundance in 2008

There was no effect of site or depth on the mean number of *C. mathewsi* in May 2008, with 1.56 and 2.63 sponges occurring in shallow and deep sites respectively. In November 2008, mean sponge numbers differed between sites and also depth (3.56 sponges at deep sites in comparison to 1.84 sponges at shallow sites). Overall, sponge numbers were consistent between the two survey periods (May vs. November) (Figure 2). No sponges showed evidence of disease.

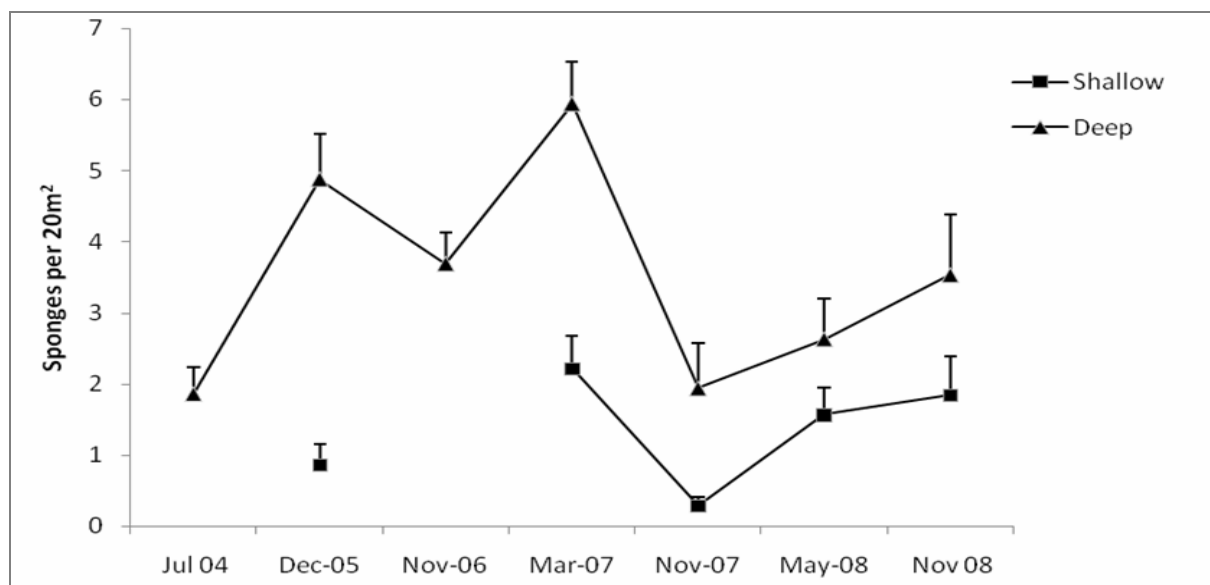


Figure 2: Summary of *C. mathewsi* mean abundances across different depths (± 1 SE) at Masig and Kodall Islands over time.

Benthic characteristics in 2008

Bottom composition characters were defined as reef-slope and type of benthic habitat (rubble, rock or sand) associated with transects. Bottom composition characters of rubble and reef slope were greater at deeper sites. For example, in May 2008 reef slope was 9° at six metres, compared to 31° at twelve metres, and mean rubble composition comprised 14% at six metres in comparison to 28% at twelve metres. A similar trend was observed for November. Consistent with previous years both the May and November 2008 surveys showed a significant interaction effect of depth and site on the bottom composition (MANOVA (Wilks lambda), $F_{27, 102} = 4.19$ $p < 0.05$).

Abundance across time at Masig Island

To date Project 1.3.2 has quantified temporal and spatial patterns associated with *C. mathewsi* at Masig Island since 2004. Numbers of *C. mathewsi* have shown significant fluctuations across time and this has been evident in data collected over 2004-2007; this trend of fluctuating abundances has been demonstrated at both deep and shallow sites and is clearly reported in previous annual reports (e.g. Duckworth and Wolff 2008). Reiterating this pattern, the abundance of *C. mathewsi* (deep) varied significantly across time ($F_{4, 60} = 4.04$; $P = 0.006$) with the mean number of sponges doubling between 2004 and 2006. From

2006 the number of sponges fell but had increased by the March 2007 surveys. From March to November 2007, mean abundance at deep sites decreased by two-thirds, showing similar levels of abundance similar to what was recorded in July 2004. Over the course of 2008-2009 surveys, numbers of sponges have increased (Figure 2).

Given the clear temporal fluctuations in numbers of sponges coupled with the change to the operational plan for surveys from June 2009 (MTSRF 2009), we consider that there is little value in making comparisons to previous years until we can confidently conclude if the fluctuations are real. Therefore, we have not undertaken a comparison of 2008/2009 surveys to previous years in this report. The change of the operational plan included replacing the randomised placement of transects to permanent transects. This will provide more conclusive information on whether the temporal abundance fluctuations are an artefact of the previous survey design, or a result of recruitment and mortality dynamics.

Size frequencies – November 2008

For both survey periods, there was no effect of depth on the mean size of sponges. In November 2008 the mean size of sponges was 12cm (range: 1-34cm), while in June 2009 the mean size of sponges was 11.72cm (range: 1-60cm). Consistent with previous surveys at Masig Island (Duckworth and Wolff 2008) the majority of sponges from both survey periods in 2008 were small to medium sized sponges (i.e. less than 20cm) with a small proportion being classed as large sponges (i.e. >20cm) (Figure 3).

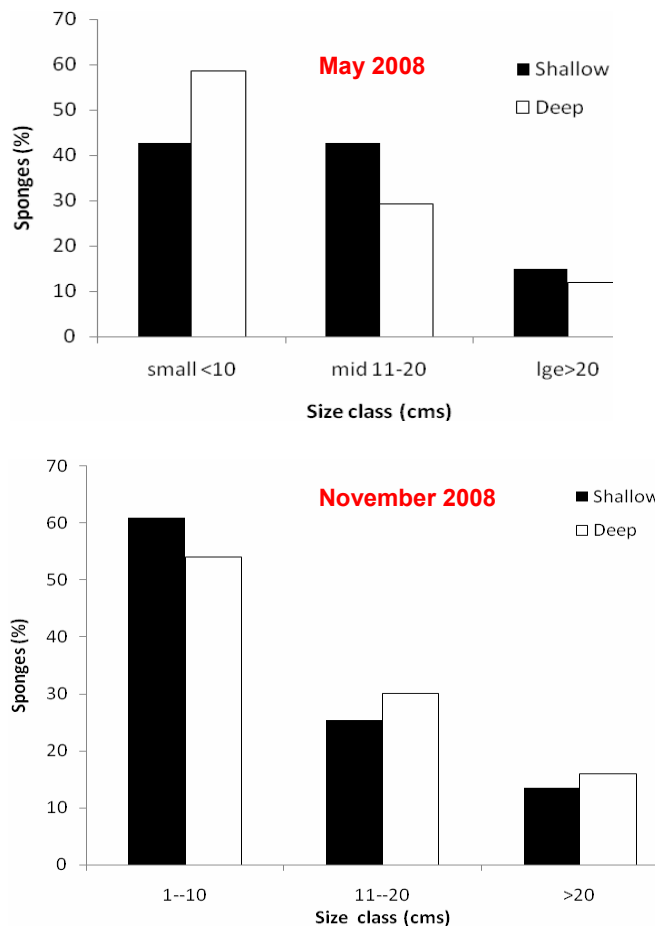


Figure 3: Size frequencies of *C. mathewsi* recorded in May and November 2008.

Discussion

Abundance patterns for *C. mathewsi* are consistent with the general trend displayed in previous surveys reported for this project. Specifically, more sponges occur at deeper sites and the majority of sponges fall within a size class where the longest axis of length is below twenty centimetres. This pattern also supports the findings associated with broader surveys undertaken for this sponge throughout the Torres Strait (Duckworth *et al.* 2007a; Duckworth and Wolff 2007a).

Processes influencing abundances of sessile organisms, such as sponges, can be complex acting on both larval and adult stages (Morgan 2001). Although sponges are sessile organisms as adults they have a mobile larval phase with most species' producing larvae that disperse over limited spatial scales (Whalan *et al.* 2005) before locating a suitable site to metamorphose into a sponge. Once metamorphosis occurs, the sponge is unable to escape any adverse habitat/environmental influences sometimes resulting in mortality. Therefore, limited larval dispersal capabilities, stochastic larval recruitment, coupled with post-settlement mortality due to unfavourable habitats (e.g. increased competition from coral or algae, excessive wave exposure, incidental grazing from herbivores), may all contribute to abundance patterns (Wilkinson and Evans 1989; Maldonado and Young 1996; Bell 2008). There are clear hydrodynamic differences between deep and shallow sites at Masig Island (Duckworth *et al.* 2007a) in addition to reef profiles, with more complex slopes at deep sites; both of these factors are likely to contribute to sponge distribution patterns. The substrate available for recruitment may also be critical for larval recruitment (e.g. Pawlik 1992 – the presence of open space represented by rock or rubble may be influential) and the effect of depth on substrate compositions determined in this study may explain the differences in sponge numbers between depths. Deeper sites may provide different scales of competition and available space for larval recruitment than shallow sites (i.e. free from high-light dependant species such as algae and some corals). While several habitat related features have been examined, during the life of this project, further work needs to be undertaken to better understand the factors that contribute to depth related abundance patterns for *C. mathewsi*, including larval settlement and post settlement pressure (e.g. competition, predation and incidental grazing).

The size frequency data for *C. mathewsi*, when taken over the entire survey period of this project (2004-present), remains relatively consistent with most sponges being less than twenty centimetres. The large fluctuations seen in the temporal abundance data over the same period suggest that recruitment pulses and mortality events have taken place, however this is not reflected in the size frequency structure (see Duckworth and Wolff 2008). Whilst the previous surveys have provided an excellent foundation of sponge abundance and distribution, the change in the operational plan (identified in MTSRF 2009) to include permanent transects will provide a more conclusive assessment of recruitment pulses, mortality and overall population demographics.

Recruitment dynamics of sessile invertebrates

Objective 3: Quantify recruitment and mortality dynamics for sponges (and other sessile marine invertebrates).

Introduction

Population demographics for sessile marine invertebrates are shaped by a myriad of interacting processes that include biotic and abiotic influences (Morgan 2001). Moreover, for sessile invertebrates, which display a bi-partite life cycle, the mobile larval phase also has significant implications for population demographics. The complexity of these processes can contribute to remarkable variability in population abundances and distributions within species (e.g. Barnes *et al.* 2006), both on temporal and spatial scales and with particular regard to larval recruitment. Moreover, intra-specific variation in larval recruitment can influence the composition and diversity of benthic communities (Smith and Witman 1999), and can help explain community dynamics both temporally and spatially.

While traditional survey techniques (e.g. transects) that rely on quantifying patterns of sessile invertebrate distributions have often highlighted their patchy nature (e.g. sponges – Barnes *et al.* 2006), population genetic data also corroborate the highly variable nature of larval dispersal and recruitment. For example, several coral species show high levels of endogenous recruitment but also wide-scale dispersal that spans the Great Barrier Reef (Ayre and Hughes 2000). Similar patterns are also demonstrated for dictyoceratid sponges (e.g. Whalan *et al.* 2008). Despite the difficulty in quantifying patterns of recruitment in sessile marine invertebrates, the importance of developing our understanding of the role these processes play in structuring populations cannot be underestimated. This is particularly relevant for commercially targeted marine resources where our understanding of processes that maintain populations are pivotal to how we manage harvest activities, both temporally and spatially, and ultimately how the resource can be conserved (yields optimised) into the future. With specific reference to this study, the sustainable management of commercial species in Torres Strait, such as *C. mathewsi*, will rely on robust recruitment data. The objective of this study is to quantify the recruitment of both sponges and other sessile organisms to reefs in the Masig Island group.

Methods

This study forms part of an ongoing data collection series (2006-) and the methodology is reported in previous annual reports (e.g. Duckworth and Wolff 2008). The methods and study sites in this study are consistent with previous reports, but are briefly reiterated here.

Study site and plate development

The study was conducted at Masig and Marsden Islands (central Torres Strait). Both islands comprise sand cays with fringing coral reefs, the reef profile typically comprising a reef slope descending at an angle ranging from 20-60° from six metres terminating at a sand bottom at fifteen metres. Approximately five kilometres of open water reaching thirty metres in depth and with a bottom composition of mud and sand, separates the two islands (Harris 1988).

To quantify recruitment patterns of sessile marine invertebrates, settlement plates were deployed at three locations on the northern side of each island, each location separated by two hundred metres. Each location was divided into three sites separated by twenty metres, with each site having two depth categories: shallow (6m) and deep (12m). Five settlement plates were deployed at each depth using the direct attachment method of Mundy (2000).

Briefly, 11x11cm terracotta tiles were anchored one centimetre above the reef to provide settlement surfaces on both sides of each plate. Tiles were placed one metre apart.

In accordance with data collections from previous years, to allow temporal (i.e. seasonal) patterns to be assessed, plates were deployed at the start of summer (i.e. November) and the start of winter (i.e. May). Plates were left for six-month periods to allow comparisons over summer and winter. In summary, this study ran for approximately three years from November 2006 to June 2009. Each season, 180 plates were deployed at Marsden and Masig equating to thirty plates per location. Each plate was used once. At the end of each season, the top and underside of each plate were photographed *in situ* and a new plate was then deployed.

Photographic analysis

Photos of each tile were undertaken following the exact protocol in previous years.

“An underwater close-up frame was constructed to photograph settlement tiles at a fixed distance and to record site and tile information on its frame. As the aspect ratio of the digital images allowed for the recording of extra information on each image, due to the tiles being square, a four-digit code wheel was built into one side of the frame. The framer was adapted to accommodate either an Olympus C-7070 or Canon IXUS 850IS camera in underwater housings. Both these cameras have identical lenses and sensor-resolution, hence images produced are comparable in quality and view. The recruitment of sessile organisms to central Torres Strait was determined for both abundance and percent cover. To determine the abundance of each taxon, an overhead transparency marked with a square was overlaid on a PC-screen. All images of tiles were displayed by Microsoft Windows XP Picture and Fax Viewer™ and enlarged by clicking the zoom-in button sufficient times to identify each organism. To measure surface area occupied by each taxon a 40 point grid was overlaid on the PC-screen image. For both abundance and percent cover, the square or grid was reduced by a 1cm margin to eliminate any potential edge effects” (Duckworth and Wolff 2008).

Data analysis

Tile recruitment data for both abundance and percent cover for each season was analysed separately for each taxonomic group using ANOVA. Following Duckworth's experimental design for previous surveys in this project (e.g. Duckworth and Wolff 2008), season, island and depth were fixed factors, while location (island) and site (location(island)) were nested factors. Data for all species in each taxonomic group was pooled, and if necessary log or arcsine transformed to meet assumptions of ANOVA.

Translocation of recruitment tiles

A separate experiment was undertaken in 2008 to assess the effect of habitat on sponge recruit performance. Tiles with recruits were collected in May 2008, photographed and then re-deployed as follows: One treatment included deploying tiles from natal sites at Masig and translocating them to Marsden and one treatment included deploying tiles from natal sites at Marsden and translocating them to Masig Island. Controls for each were included at each island. Tiles were then photographed in November 2008. The number of sponge recruits from all tiles was recorded from the photos and analysed using repeated measures ANOVA.

Results

Recruitment – all groups

Seven broad taxonomic groups recruited to experimental tiles placed around Masig Island group over two seasons and at two depths during 2008/2009 (Figure 4). Tiles were placed at fixed depths and for ease of discussion these are referred to as shallow (6m) and deep (12m). Notably, both sessile invertebrate and algal recruits recruited to the bottom surface of tiles with no evidence of successful recruitment to the top surface of tiles. Identification to species or genus level was not established for many of the recruits. This exercise will require taxonomic expertise and will be undertaken in due course.

With the exception of sponge recruitment, numbers of recruits for all taxonomic groups showed similarities between the two sampling periods (corresponding to summer and winter). Polychaetes dominated tiles with the mean number of this group being four-fold higher than any other taxa (Figure 4). In contrast however, polychaetes occupy the least surface area of tile ($2.74 \pm 0.29\%$) in comparison to other groups which have several species with encrusting, prostrate morphologies such as algae ($24.65 \pm 1.94\%$) and sponges ($20.74 \pm 1.5\%$) (Figure 5). Very low numbers of cnidarians were recorded for summer recruitment (0.5 ± 0.1) and none were observed for winter surveys and as such have not been included in the formal statistical analyses.

Overall, when taxonomic groups are analysed separately there were significant interactive effects of location, season and depth for all taxa. These are discussed more comprehensively for each group.

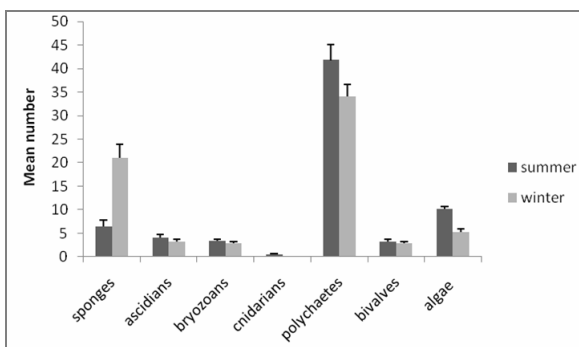


Figure 4: Mean number of recruits (± 1 SE) to settlement tiles at Masig and Marsden Islands over two seasons in 2008-2009 for sessile invertebrates and algae.

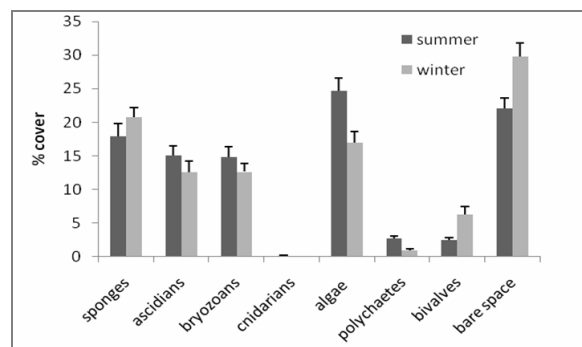


Figure 5: Mean percentage cover of recruits (± 1 SE) occupying settlement tiles at Masig and Marsden Islands over two seasons in 2008-2009 for sessile invertebrates and algae.

Sponges

Abundance: At least eleven species of sponges recruited to the underside of tiles, including several with encrusting morphologies (*Clathria* sp. and three other unidentified encrusting species), *Iotrochota* sp., *Callyspongia* spp., *Dysidea* spp., *Hyrtilis erecta*, *Nara nematifera* and *Leucetta* sp. Overall, sponge recruitment per 100cm² tile surface at Masig Island sites was 7.61 (±1.78) at deep sites and 5.24 (±1.45) at shallow sites during the winter compared to 6.64 (±2.19) (deep) and 2.93 (±0.47) (shallow) at Marsden during the same time period (Figure 6). Sponge recruitment in summer at Masig Island was 16.23 (±3.33) at deep sites and 20.82 (±7.35) at shallow sites compared to 29.47 (±6.13) (deep) and 17.58 (±4.7) (shallow) at Marsden Island. There was a significant interactive effect of location and depth in addition to a significant main effect of season on sponge recruitment with more sponges recruiting during summer (ANOVA: $F_{4, 359} = 6.99, p < 0.05$).

Percent cover: Encrusting species dominated tiles in terms of coverage with *Clathria* sp. occupying up to 35% of the tile surface (mean – winter recruitment) and with a combined coverage for other encrusting species being 28% of the total tile surface (mean – winter recruitment). There was a significant main effect of island (Figure 6; ANOVA: $F_{1, 359} = 6.48, p < 0.05$) on the extent of percent cover for sponges.

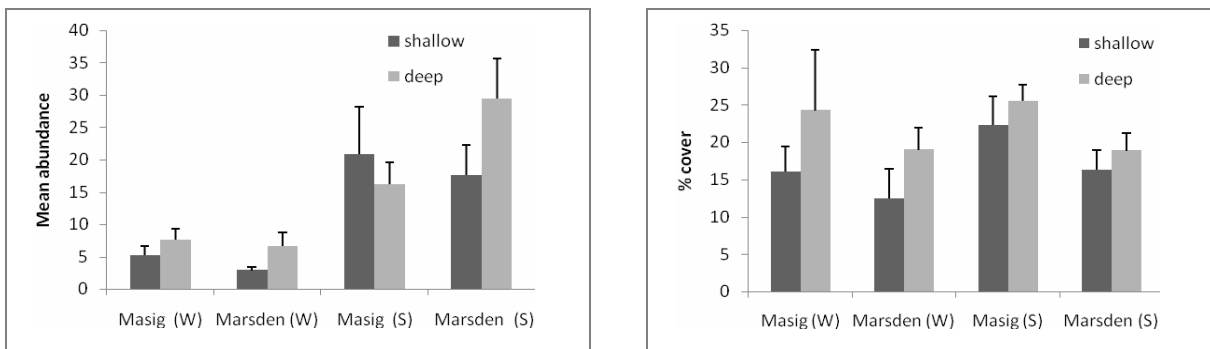


Figure 6: Mean number of sponge recruits (±1 SE) left, to settlement tiles at Masig and Marsden Islands over two seasons in 2008-2009 and mean percentage cover sponge recruits (±1 SE) to settlement tiles (right) [W = winter, S = summer].

Ascidians

Abundance: At least seven species of ascidians recruited to the underside of tiles, including *Didemnum* spp. *Botryllus* spp. and *Clavelina* spp. and a further species identified from the Styelidae family. Other species were unidentified at this time. Overall, ascidian recruitment 100cm² at Masig Island sites was 3.91 (± 1.37) at deep sites and 5.56 (± 1.99) at shallow sites during the winter compared to 2.58 (± 1.04) (deep) and 4.18 (± 1.23) (shallow) at Marsden during the same time period (Figure 7). Ascidian recruitment in summer at Masig Island was 2.07 (± 0.33) at deep sites and 4.84 (± 2.02) at shallow sites compared to 2.51 (± 0.64) (deep) and 3.44 (± 0.74) (shallow) at Marsden Island. There were significant interactive effects of season and site (Figure 7; ANOVA: $F_{12, 359} = 1.85$ $p < 0.05$), in addition to significant interactions of depth and location (ANOVA: $F_{4, 359} = 3.88$ $p < 0.05$) on ascidian recruit abundance.

Percent cover: Didemnid species dominated percent cover for ascidians with a mean coverage of 52% in winter and 25% in summer per 100cm² tile. Styelid and Botrylid species showed less dominance with mean percent covers being 13% and 6% (winter) and 5% and 4.5% (summer) respectively. There was a significant interaction effect of depth and location on ascidian percentage cover (Figure 7; ANOVA: $F_{4, 359} = 3.02$ $p < 0.05$). In addition, there was also a significant main effect of season with higher coverage observed in winter (ANOVA: $F_{1, 359} = 7.71$, $p < 0.05$).

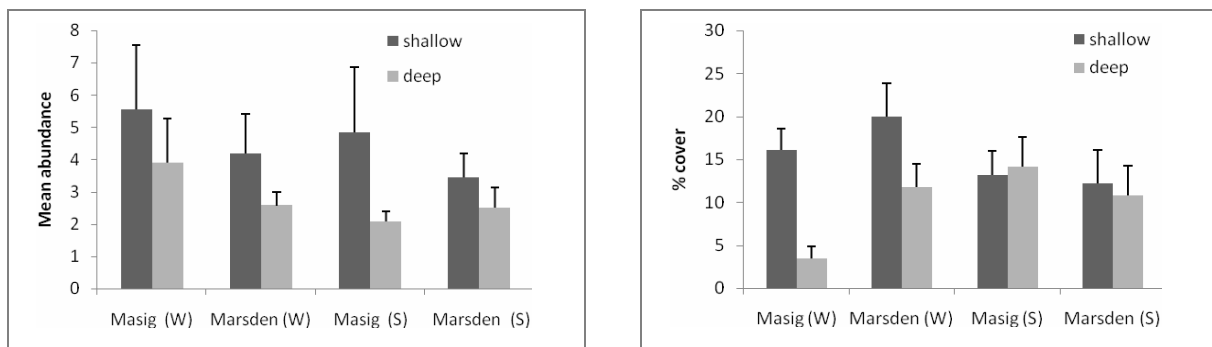


Figure 7: Mean number of ascidian recruits to settlement tiles at Masig and Marsden Islands over two seasons in 2008-2009 (± 1 SE) (left), and mean percentage cover ascidian recruits (± 1 SE) to settlement tiles (right) [W = winter, S = summer].

Bryozoans

Abundance: At least six species of bryozoans recruited to the underside of tiles. Species identification was completed on colony morphology and colour and still requires formal taxonomic confirmation. Bryozoan recruitment was dominated in both seasons by an encrusting white species (total numbers equivalent to 84.4% in winter and 79.3% in summer) and a grey erect branching species (11.5% in winter and 8.4% in summer). Overall, bryozoan recruitment 100cm^{-2} at Masig Island sites was 3.1 (± 0.51) at deep sites and 3.62 (± 0.74) at shallow sites during the winter compared to 4.28 (± 0.91) (deep) and 3.25 (± 0.24) (shallow) at Marsden during the same period (Figure 8). Bryozoan recruitment in summer at Masig Island was 3.31 (± 0.56) at deep sites and 2.5 (± 0.45) at shallow sites compared to 2.68 (± 0.52) (deep) and 3.31 (± 0.54) (shallow) at Marsden Island. There was a significant interactive effect of season and depth explaining differences across seasons and locations (ANOVA: $F_{12, 359} = 1.96$ $p = 0.03$).

Percentage cover: Bryozoans showed variability in space occupied on the settlement tiles with a significant interaction of depth, site and season (Figure 8; ANOVA: $F_{12, 359} = 1.82$ $p < 0.05$).

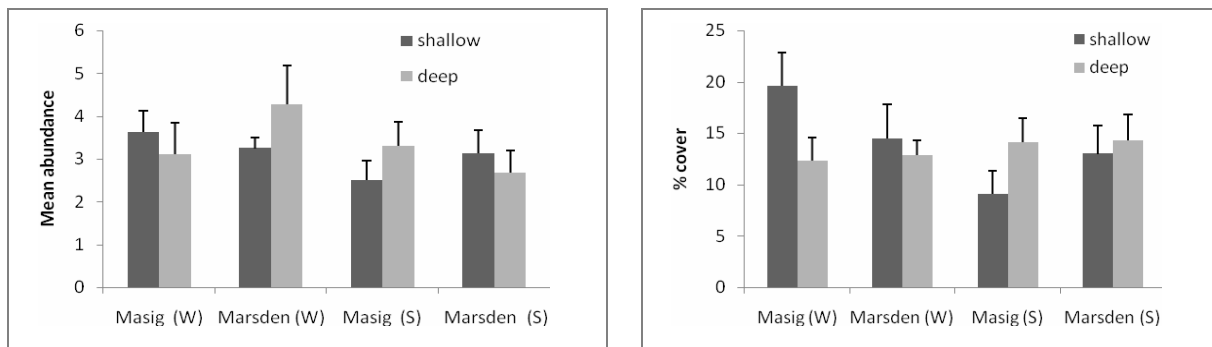


Figure 8: Mean number of bryozoan recruits to settlement tiles at Masig and Marsden Islands over two seasons in 2008-2009 (± 1 SE) (left), and mean percentage cover bryozoan recruits (± 1 SE) to settlement tiles (right) [W = winter, S = summer].

Polychaetes

Abundance: Two genera of polychaetes recruited to the underside of tiles (*Metalaeospira* spp. and *Galeotaria* spp.), both of which form calcareous tubes. Overall, polychaete recruitment 100cm^{-2} at Masig Island sites was 46.29 (± 5.91) at deep sites and 40.93 (± 7.94) at shallow sites during the winter compared to 39.47 (± 2.82) (deep) and 43.49 (± 8.9) (shallow) at Marsden during the same period (Figure 9). Polychaete recruitment in summer at Masig Island was 29.4 (± 5.4) at deep sites and 36.6 (± 4.45) at shallow sites compared to 30.67 (± 5.1) (deep) and 40.2 (± 5.14) (shallow) at Marsden Island (Figure 9). There was a significant interactive effect of site and depth explaining the spatial variation among islands (Figure 9; ANOVA $F_{12, 359} = 2.052$; $p = 0.02$). A significant interaction effect of season and island also accounting for spatial and temporal recruitment differences (ANOVA: $F_{12, 359} = 2.052$; $p = 0.02$).

Percent cover: Although polychaetes recruited in higher numbers to tiles, the percent cover for this group was the lowest in comparison to all other taxa (with the exception of cnidarians). For example, the highest mean coverage of tiles by of polychaetes was 3.11 ($\pm 0.91\%$) at Masig Island (deep) during winter and the lowest was 0.56 ($\pm 0.21\%$) during summer also at Masig Island deep sites. Percent cover was consistent across all factors with the exception of a significant main effect of season, percent cover being higher in winter.

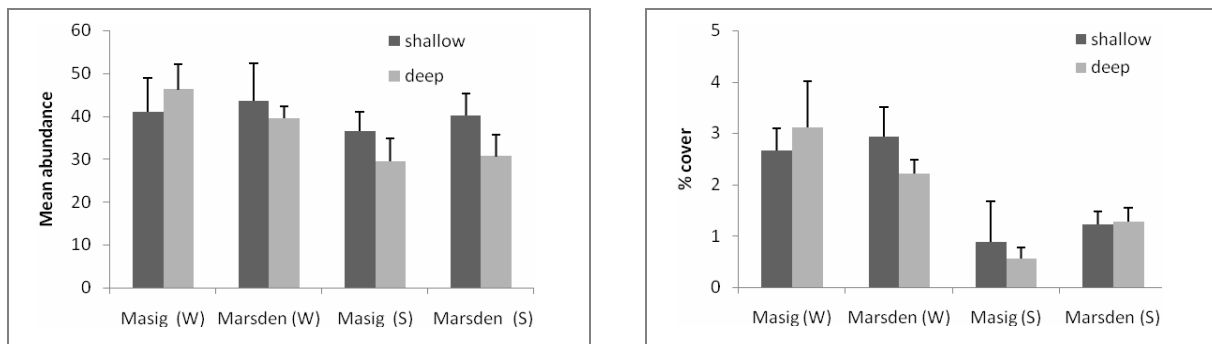


Figure 9: Mean number of polychaete recruits (± 1 SE) left, to settlement tiles at Masig and Marsden Islands over two seasons in 2008-2009 and mean percentage cover polychaete recruits (± 1 SE) to settlement tiles (right) [W = winter, S = summer].

Bivalves

Abundance: At least two species, from two genera, of sessile bivalves recruited to the underside of tiles. Identification to species level was not completed due to the small size of bivalves and formal identification still needs to be confirmed, however tentative identification indicates species to be from the genera *Pindacta* and *Pteria*. Overall, bivalve recruitment 100cm^{-2} at Masig Island sites was 5.35 (± 1.28) at deep sites and 1.51 (± 0.51) at shallow sites during the winter compared to 3.48 (± 0.79) (deep) and 1.91 (0.4) (shallow) at Marsden during the same time period (Figure 10). Bivalve recruitment in summer at Masig Island was 2.43 (± 0.49) at deep sites and 1.96 (± 0.45) at shallow sites compared to 4.33 (± 0.7) (deep) and 2.79 (± 0.45) (shallow) at Marsden Island. There was a significant interactive effect of location and depth (ANOVA: $F_{4, 359} = 3.73$, $p < 0.05$) in addition to a significant main effect of season (ANOVA: $F_{1, 359} = 5.07$, $p < 0.05$) explaining recruitment variability at spatial scales of locations within islands and between summer and winter recruitment abundance.

Percent cover: There were significant interactive effects of season and depth (Figure 10; ANOVA: $F_{1, 359} = 8.71$, $p < 0.05$) in addition to interactions of depth and location (ANOVA: $F_{4, 359} = 3.33$, $p < 0.05$) on bivalve percent cover.

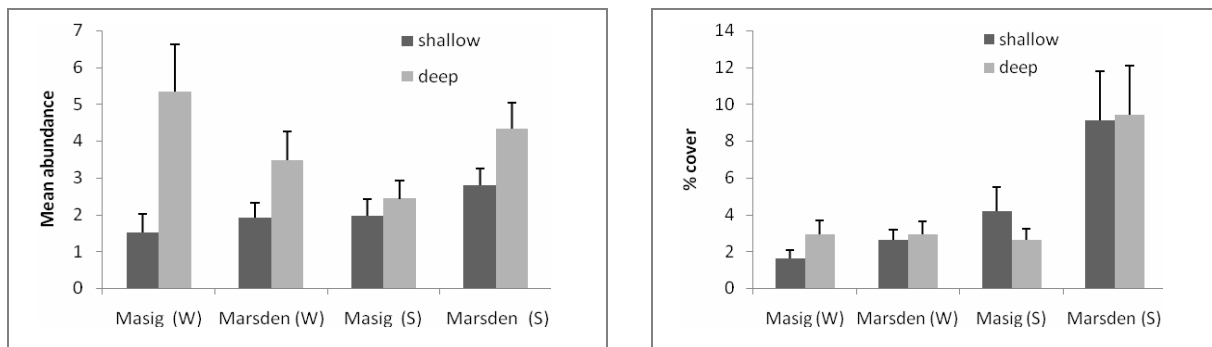


Figure 10: Mean number of bivalve recruits (± 1 SE) left, to settlement tiles at Masig and Marsden Islands over two seasons in 2008-2009 and mean percentage cover bivalve recruits (± 1 SE) to settlement tiles (right) [W = winter, S = summer].

Algae

Abundance: At least five different groups of algae recruited to the underside of tiles. Identification was completed on algal morphology (encrusting or filamentous) and basic taxonomic grouping (red, green, brown), but still requires formal taxonomic confirmation. As such, filamentous and encrusting green and red algae were found in addition to brown algae. Overall, algal recruitment 100cm^{-2} at Masig island sites was 9.19 (± 1.11) at deep sites and 8.48 (± 1.19) at shallow sites during the winter compared to 10.44 (± 1.09) (deep) and 11.64 (± 1.28) (shallow) at Marsden during the same time (Figure 11). Algal recruitment in summer at Masig Island was 2.84 (± 0.77) at deep sites and 4.56 (± 0.75) at shallow sites compared to 4.91 (± 0.14) (deep) and 8.86 (± 1.65) (shallow) at Marsden Island. There was a significant interactive effect of site and depth (ANOVA: $F_{12, 359} = 1.99$, $p < 0.05$) in addition to a significant main effect of season (ANOVA: $F_{1, 359} = 110.49$, $p < 0.05$) explaining recruitment differences between summer and winter and at spatial scales among locations within the island groups.

Percent cover: Space occupied by algae on the settlement tiles varied significantly in accordance with interactions of site and depth (Figure 11; ANOVA: $F_{12, 359} = 2.21$, $p < 0.05$) and also season and island. For example, algae occupied more space on tiles at Marsden during the winter in comparison to Masig in summer (ANOVA: $F_{1, 359} = 8.11$; $p < 0.05$).

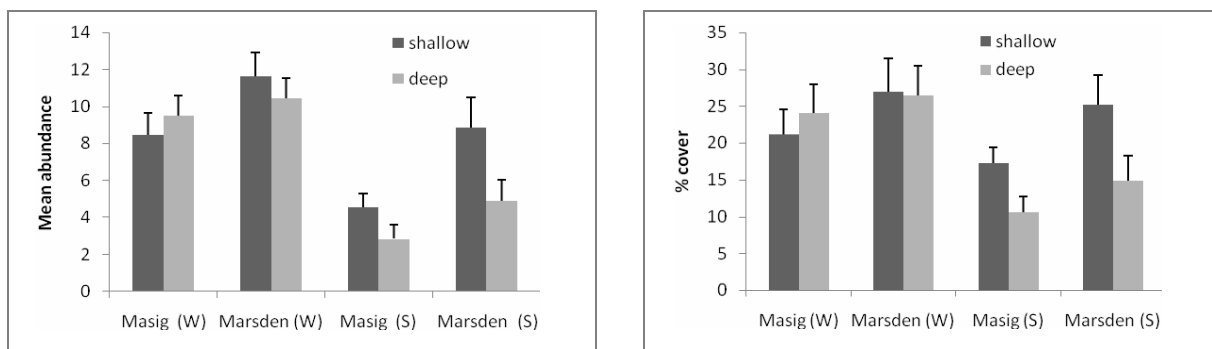


Figure 11: Mean number of algal recruits (± 1 SE) left, to settlement tiles at Masig and Marsden Islands over two seasons in 2008-2009 and mean percentage cover algal recruits (± 1 SE) to settlement tiles (right) [W = winter, S = summer].

Translocation of sponge recruits

There was no significant effect of translocation on numbers of sponge recruits translocated between the two islands in comparison to control treatments that were not translocated, over the period of this experiment (May to November 2008).

Discussion

Recruitment patterns for many marine organisms exhibit considerable variation over spatial (Ayre and Hughes 2000) and temporal scales (Johnson and Black 1984), corroborated by the patchy distributions observed for numerous sessile invertebrates (e.g. Barnes *et al.* 2006 Bannister *et al.* 2007). A complex suite of processes including variability in levels of adult reproductive output (e.g. Whalan *et al.* 2007), and pre and post larval settlement selection processes (Morgan 2001; Whalan *et al.* 2008) contribute to fluctuating recruitment trends. The overall findings in this study are consistent with other studies that have identified spatial variability in recruitment patterns for sessile marine invertebrates (e.g. Barnes *et al.* 2006; Bannister *et al.* 2007). Notably, that recruitment of sessile invertebrates at Masig and Marsden Island showed complex patterns as discerned by significant interactive effects across a range of spatial (e.g. depth, site, location and island) and temporal scales (i.e. season).

Although the groups of taxa recruiting to Masig and Marsden Island reefs are consistent among the three years of this MTSRF-funded project the variability exhibited at both temporal and spatial scales among each year of survey make generalised conclusions difficult. For example, ascidian recruitment showed consistent levels of recruitment regardless of season and location during the 2007-2008 surveys (Duckworth and Wolff 2008) while the present study showed that interactive effects of location, season and depth, are responsible for different levels of recruitment. Whilst the last three years of surveys have collected valuable baseline data on recruitment patterns, further information is required before more conclusive interpretations can be drawn regarding temporal and spatial patterns of sessile invertebrate recruitment at Masig and Marsden Island. For example, recruitment for a number of groups varied between seasons. For some sessile invertebrates reproduction occurs according to discrete seasons and reproductive outputs (usually summer, e.g. Whalan *et al.* 2007) so this finding is not unexpected. The findings of year round recruitment however, suggest a continuous reproductive effort, although the collection of winter recruitment tiles (i.e. tiles deployed in May/June and collected in November) may also contain results of recruitment as late as November. An understanding of reproductive ecology including timing of seasonality and reproductive output are central in developing our understanding of population maintenance and this information would be valuable in partly explaining recruitment patterns of sessile invertebrates in Torres Strait.

One overwhelming and uniform finding among the three years of surveys is that recruitment has not been successful to the light exposed (topside) surface of tiles suggesting that larval settlement to top surfaces are either not occurring or are being disturbed by post-settlement processes, including incidental grazing (Maldonado and Uriz 1998). Settlement to the underside of tiles may therefore be un-representative of total settlement; it was expected that coral recruits would play a role in the recruitment dynamics, so this proposal is clearly supported with the low numbers of corals recruiting to tiles, many of which rely on access to light. Sponge larvae can also have specific cues for settlement to light (Whalan *et al.* 2008). The presence of adult *C. mathewsi* in light exposed, coral rubble habitats (see [Population demographics](#), this report) suggest that this sponge would be more likely to recruit to light exposed surfaces rather than the underneath of tiles. The low numbers of *C. mathewsi* recruits may therefore be a reflection of larvae settling to the topside surfaces but failing to recruit to populations, succumbing to mortality through processes such as incidental grazing. Given the diversity and density of the settlement community and the observation that settlers may seldom become recruits or established adults, particularly on upper surfaces, suggests that the process of successful recruitment is a rare event. If this is the case then there is a likelihood that the reef biodiversity is vulnerable to disturbance events and the observed community may well have been established over a long period.

While there are no data detailing the larval ecology of *C. mathewsi* (e.g. larval behaviour, competency, settlement cues), for some sponges successful settlement is mediated by a range of behaviours linked to both specific chemical and physical cues (Whalan *et al.* 2008). The discrete habitat associated with the experimental design (tiles) may be insufficient for larval settlement of *C. mathewsi*. Although terracotta tiles have proved successful for coral and other invertebrate settlement studies, the specificity of larval settlement cues for other invertebrates such as *C. mathewsi* may have prevented realistic estimates of recruitment in this study. *Coscinoderma mathewsi* has a strong association with light exposed, dead coral rubble habitats (pers. obs.). Settlement assays coupled with permanent quadrats to quantify *C. mathewsi* recruitment planned in 2009-2010 will provide further information on recruitment dynamics for *C. mathewsi*

Finally, the translocation of tiles with sponge recruits between Marsden and Masig Islands showed no effect on post-settlement survival. Given the presence of species that recruit to the tiles are common to both habitats this is not entirely surprising. The abundance of *C. mathewsi* recruits to tiles has generally been low (<1%) in comparison to dominating forms (e.g. encrusting species) so drawing conclusions on the effects of island habitat for this species are difficult with the data associated with the present study. There are clearly differences in abundances of *C. mathewsi* adults between these two islands, and it would be valuable to include translocations of adults (e.g. explants) as well as recruits of *C. mathewsi*, with adequate replication, to assess this question further.

Effects of handling and collection of explants on growth and survival

Introduction

Sponge aquaculture currently relies on growing out clonal fragments from wild donor sponges. The production of explants for grow-out involves cutting and exposing the surface of sponges, which in turn involves a recovery stage before the sponge explants can grow (Louden *et al.* 2007). The recovery of sponges following damage from cutting can be rapid with several species, including the sponge *Coscinoderma mathewsi*, establishing a protective collagen layer over the cut surface within 24 hours (Louden *et al.* 2007). Indeed, full cellular integrity of the pinacoderm (i.e. outer skin of the sponge) and aquiferous systems for these species were established within six weeks after cutting. While there is a continuing body of work establishing optimal ways to successfully farm sponges (Duckworth and Wolff 2007a), the growth and survival of sponge explants within a culture environment is clearly determined by the health of those explants at the time of seeding (Duckworth and Wolff 2007a).

The objective of this study is to build on the existing data generated for Project 1.3.2. The specific aim is to establish the effects of collection and handling of sponges (explants) on both growth and survival. The outcomes of this research will add to the existing outcomes and milestones of this project and increase our understanding of practices that optimise the collection and handling of sponges prior to grow-out.

Key questions addressed:

Q. How much does the exposure of explants to air influence survival and growth?

A. Collection of explants can result in some exposure to air, often during the transfer of explants to the grow-out panel framework. While the time of exposure can be restricted to relatively short time frames (i.e. seconds to minutes) we know little of the effect on survival or growth from this exposure. Although some species that inhabit intertidal regions experience periodic exposures to air (e.g. *Phyllospongia lamellose*), *C. mathewsi* is a subtidal species and the effects of subjecting these sponges to “out of water conditions” (air, sunlight, temperature) are unknown. Experiments will be undertaken to compare survival and growth of explants treated with a range of air-exposure regimes, to those not exposed.

Q. Does the inclusion of a transitional nursery stage, following collection from donor sponges, increase survival and growth of explants?

A. The initial collection of sponges requires cutting off sections from donor sponges resulting in exposed tissue sections. The potential for cell-loss through the exposed surface is increased with the transfer into mesh panels, which requires some ‘squeezing’ to fit them into the mesh panels. We therefore propose to include a nursery/recovery phase where explants are placed into recovery trays, following removal from donor sponges, to heal and replace lost tissue surfaces prior to being placed into mesh panels for grow out. Growth and survival of these sponges will be compared to sponges that are directly placed into mesh panels at the time of collection from donor sponges.

Q. Determine if explant growth is enhanced by collecting from specific size classes of donor sponges. That is, do explants from smaller sponges grow quicker than those from larger sponges?

A. Growth is mediated by investment into key life history traits, including reproduction. Based on this premise do smaller, sexually immature sponges, that are not yet contributing to the bio-energetically investment of reproduction, exhibit faster growth rates, and if so does this transfer to clonal explants. Growth and survival of explants sourced from different size classes of donor sponges will be compared to address this question.

Q. Quantify the growth rates of explants taken from different regions of donor sponges (e.g. basal vs. dorsal profiles).

A. The recovery rate of a damaged sponge is influenced by its efficiency to regenerate compromised cellular and skeletal architecture. The upper surface of a sponge often houses essential inhalant and exhalant canals that facilitate water (i.e. food and oxygen) exchange. Therefore, do explants with intact aquiferous systems survive or grow better than explants, originating from middle and basal regions of the sponge, that have less well established cellular and skeletal architecture? Growth and survival of explants taken from different regions of donor sponges will be compared.

Q. Establish the effect of squeezing (i.e. the loss of sponge cells) on growth and survival.

A. The production of explants results in exposed sections of sponges, which can lead to significant loss of sponge cells and increased risks of mortality. This is exacerbated with the handling of sponges particularly during the process of placing them into grow out panels, which requires some 'squeezing'. The design of the mesh panels require the explant to be lodged so a tight fit is established to prevent the explant rolling around and incurring tissue damage. We therefore propose to examine the effect of cell loss (through handling) in a range of 'squeezing' treatments on survival and growth of sponge explants.

Materials and methods

General collection methods

Explants were sourced from several donor sponges surrounding Masig Island, collecting approximately one-third of donor sponge to make explants (the donor remains attached to the reef, heals and regrows). Explants were cultured following methods modified from Duckworth and Wolff (2007a). Briefly, explants were measured and randomly placed into eight-pocket PVC mesh panels (Australian netmakers), commonly used to farm pearl oysters. Each panel had four explants, forming subsamples with each experimental treatment, which was replicated four times. Each panel was attached to a riser (rope) line, which was fixed to the bottom and held upright with a sub-surface buoy, so that each panel was established between nine and twelve metres. For the "nursery" and handling experiments, explants were also loosely placed into plastic mesh oyster baskets (TTP plastics-aquatray) which were also fixed horizontally to the bottom. Oyster baskets are purpose-made plastic mesh (25mm mesh) rectangular crates (93cm x 91cm x 10cm) with nine internal partitions and enclosed with a mesh lid (Figure 12). To quantify growth during the experimental period, explants were measured along the greatest axis of length, width and depth at the experiment deployment (February 2009), monthly for the duration of the experiments, and then at the end of the experiment in June 2009. Explant survival was also recorded. For simplicity, analyses of results relied on incremental growth from the beginning and final measurements. Data was analysed using one-way Analysis of Variance (ANOVA)

except for the nursery experiments, which was analysed using t-tests. Data for the survival of explants in the handling experiments did not meet the assumption of homoscedasticity and was analysed using the non-parametric test of Kruskal-Wallis.

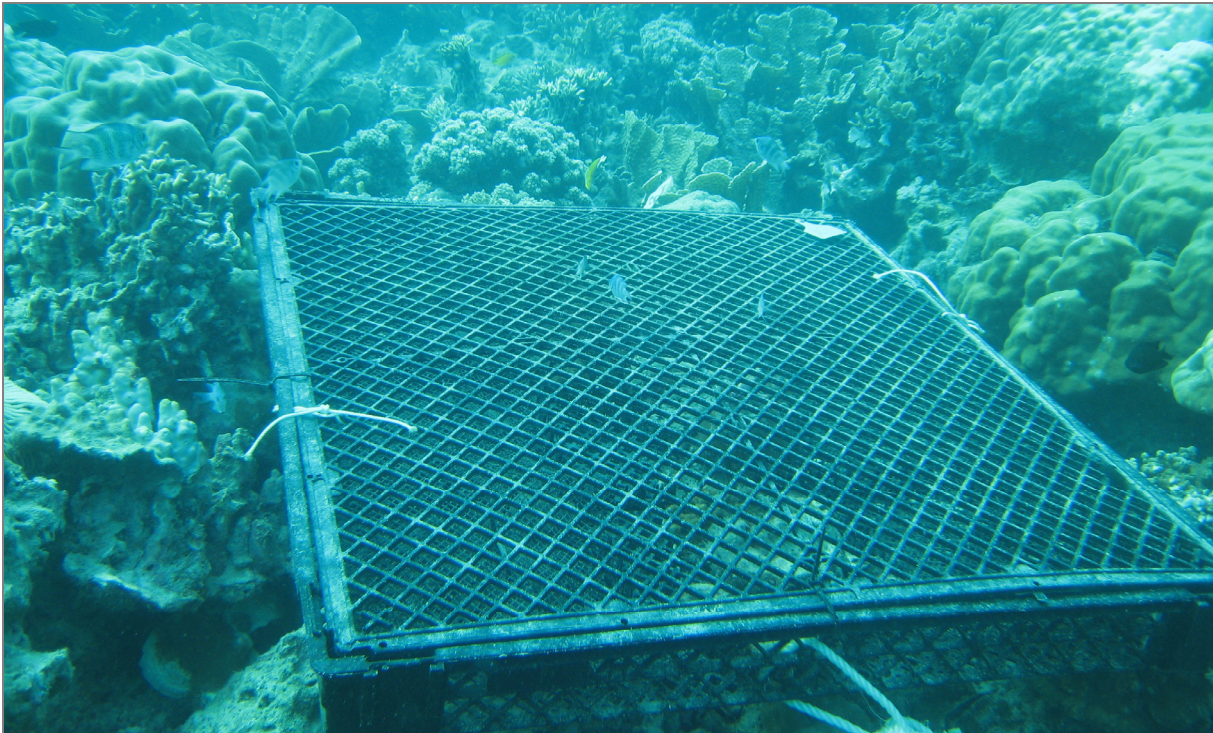


Figure 12: Photo showing an oyster basket used in the squeezing of sponges (handling / nursery experiments).

Specific methods for individual experimental treatments

Exposure of explants to air: To quantify the effects of exposing explants to air, as may be expected during the seeding process, we exposed explants to three different exposures: 10 seconds, 30 seconds and 2 minutes. Following collection, explants were suspended in a mesh catch bag at approximately two metres under the dive boat. Explants were removed and placed into a large plastic tub filled with seawater ensuring that no explants were exposed to air. Explants were then individually exposed to ambient conditions (air, sunlight and temperature) for each of the experimental exposures within the experiment and subsequently returned to the catch bag pending seeding into the culture panels. Exposure of explants took place during the early afternoon, on a clear, sunny day. A control treatment included explants undergoing all the handling described excluding any exposure to air.

Collecting from different size classes of donor sponge: At Masig Island *Coscinoderma mathewsi* exhibits a size range of 1-60cm (Duckworth and Wolff 2008). Accordingly, we targeted three different size class to determine if the size of donor sponges influenced subsequent explant growth, under the premise that small individuals were immature and medium to larger sponges were mature individuals and more likely to invest energy into reproduction at the expense of growth. The size classes of donor sponges were determined by the length of the greatest axial dimension and were arbitrarily defined as: small <10cm, medium 11-15cm and large >20cm. Explants were made *in situ* and placed into the plastic mesh panels following the general methods outlined previously.

Collecting from the top or base of donor sponges: To test the effect on growth and survival of explants originating from different regions of donor sponge we collected explants from the top half of donor sponges and others from the basal portion of donor sponges. As a control we also collected explants that were not divided, but comprised both top and bottom portions. Explants were made *in situ* and placed into the plastic mesh panels following the general methods outlined previously.

The effect of handling and placing explants into panel: To determine whether explants placed directly into mesh panels, following cutting into explants, were subjected to extra “squeeze effects”, two treatments were compared. First, explants were placed into panels and then removed to mimic the pressure of being seeded into panels. These were then placed into oyster baskets and gently held in place with a loose covering of plastic to prevent them from rolling around and incurring incidental tissue damage. A second treatment included placing explants directly into oyster baskets (following cutting into explants); these explants therefore were not exposed to the squeezing effect associated with seeding directly into the pearl panels.

The effects of a transitional nursery stage: To determine if growth and survival are enhanced if explants are placed into a transitional nursery to allow recovery of the cut surface, explants were placed into a nursery for one month. The nursery comprised an oyster basket (Figure 12) as outlined in the general methods. *Coscinoderma mathewsi* explants establish a new pinacoderm and aquiferous system approximately one month after explanting (Louden *at al.* 2007). Therefore, after one month of recovery in the nursery, explants were removed, and seeded onto mesh panels for the remainder of the experiment. Growth and survival over the experimental period was compared to explants seeded onto mesh panels at the beginning of the experiment.

Results

Effects of exposure of explants to air on growth and survival

There was no significant effect of exposure to air on explant growth regardless of exposure period (i.e. 10 seconds, 30 seconds or 2 minutes) when compared to explant controls not exposed to air (Figure 13(a)-(c); ANOVA, $F_{3,10} = 1.69$ $p > 0.05$). The mean size of explants increased for the 30-second and 2-minute treatments, including controls, but for the 10-second treatment the mean size of explants decreased from $98.7 (\pm 36.2\text{cm}^3)$ in February to $55.4 (\pm 11.6\text{cm}^3)$ in June. Mean survival of explants ranged from 43 ($\pm 24\%$) to 75 ($\pm 25\%$) for controls, but overall there was also no significant effect of air exposure on the survival of explants (Figure 14; ANOVA $F_{3,1} = 0.87$, $p > 0.05$).

Effects of donor sponge size classes on growth and survival

Explants collected from different sized donor sponges did not exhibit different growth profiles with explants collected from small donor sponges (<10cm) showing consistent growth rates to those collected from either medium (11-15cm) or larger (>20cm) donor sponges (Figure 15, ANOVA $F_{2,9} = 2.46$, $p > 0.05$). The mean size of explants sourced from all size classes of donor sponges decreased over the experimental period with small, medium and large samples showing a mean decrease of 31.4%, 41.8% and 54.9% respectively. Survival of sponges was also consistent regardless of the size of donor sponge the explant was sourced from (Figure 16, ANOVA $F_{2,1} = 0.91$, $p > 0.05$).

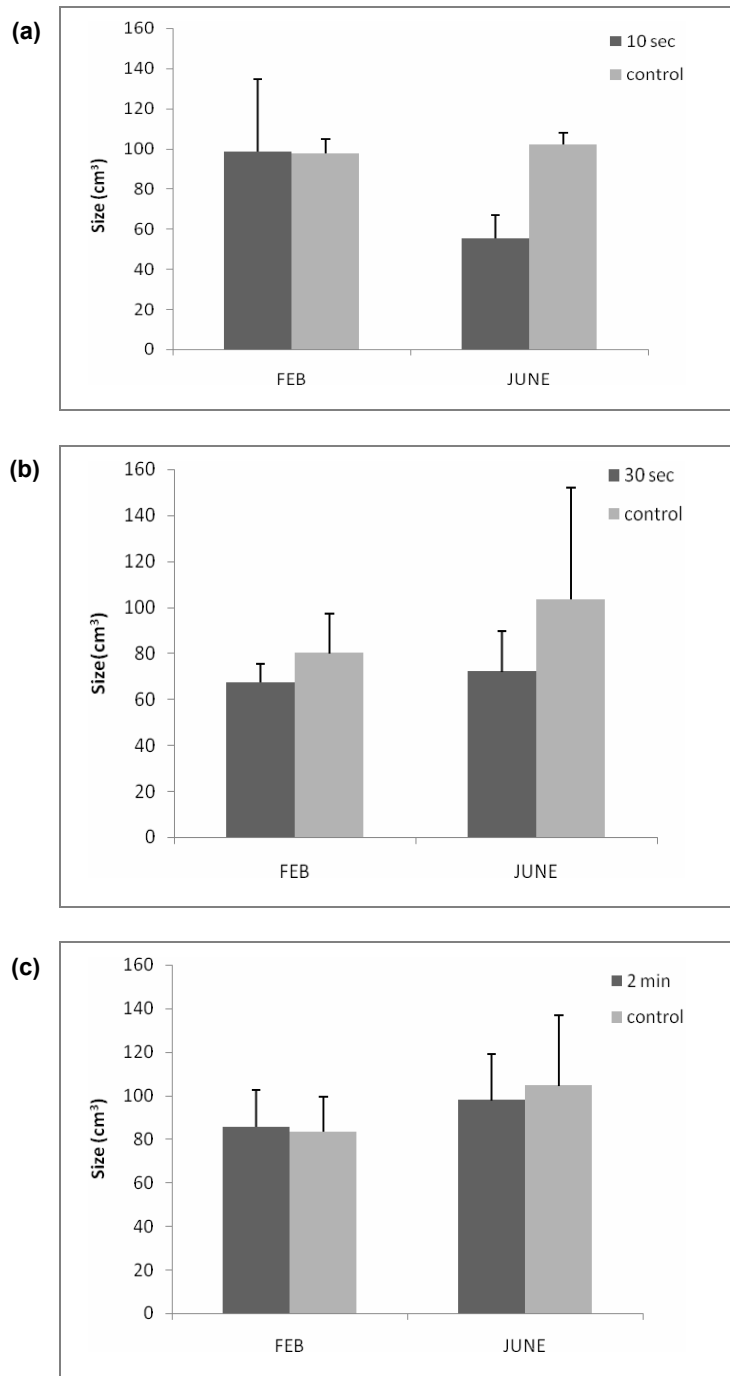


Figure 13(a)-(c): Mean sponge explant size (volume) (± 1 SE) following three different exposure times following three different exposure times to air. Controls include explants not exposed to air.

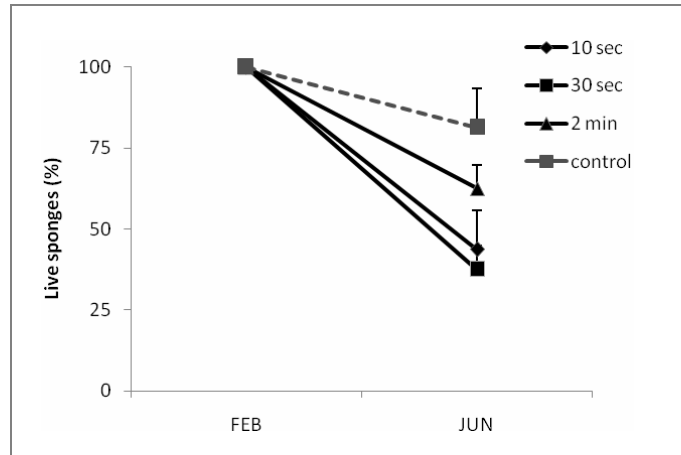


Figure 14: Mean survival (± 1 SE) of sponge explants following different exposure times to air.

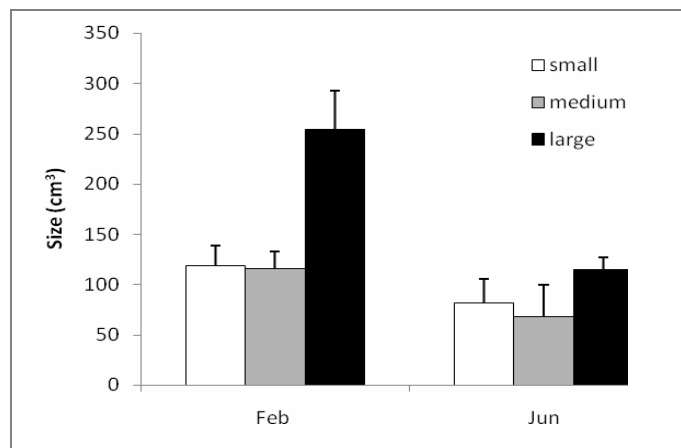


Figure 15: Mean size (± 1 SE) of explants prepared from different size classes of donor sponges. Size classes are based on explants taken from donor sponges – small <10cm, medium >10cm-<15cm and large >20cm.

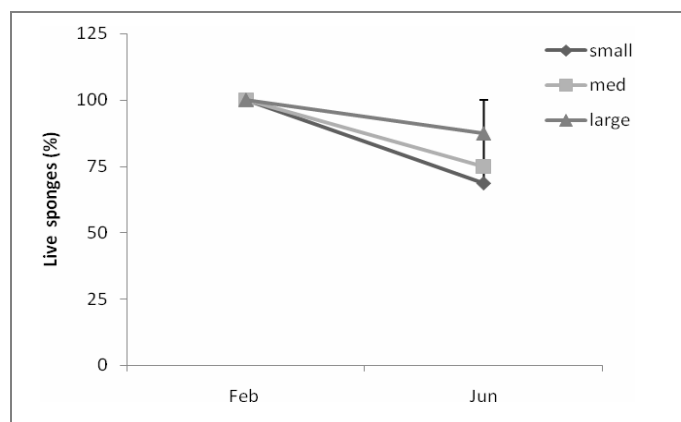


Figure 16: Mean survival (± 1 SE) of explants prepared from different size classes of donor sponges. Size classes are based on explants taken from donor sponges – small <10cm, medium >10cm-<15cm and large >20cm.

Effects of collecting from the top or base of donor sponges on growth and survival

Both explants sourced from top and basal donor sponge regions exhibited a mean reduction in size, explants from top regions decreasing by 13.5% while basal sourced explants shrank by 16.8%. In contrast, controls, comprising both top and basal regions, showed a mean increase of 4.6%. Overall, there was no significant effect on growth in relation to where the explant was collected with growth profiles being consistent for either top, basal or controls (top/basal) sourced explants (Figure 17; ANOVA: $F_{2,8} = 0.58, P > 0.05$). Mean survival of explants was consistent among all treatments and ranged from 58 ($\pm 8.3\%$) in controls (top and basal) to 75 ($\pm 8.3\%$) in top and 75 ($\pm 8.8\%$) in bottom sourced explants (Figure 18; ANOVA: $F = 1.72, p > 0.05$).

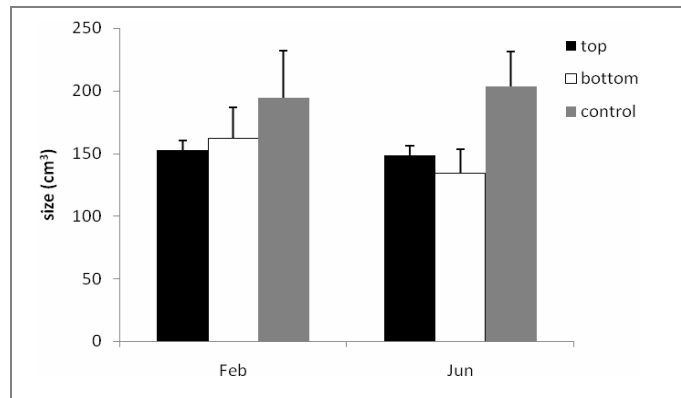


Figure 17: Mean sizes (± 1 SE) of explants seeded from different regions of donor sponges. Controls are a cross section of donor sponge displaying both top and basal sections.

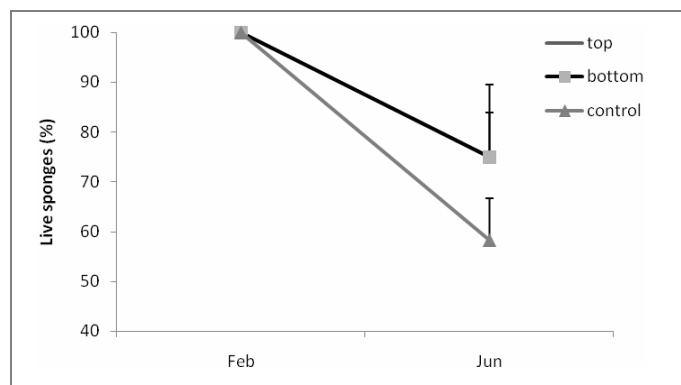


Figure 18: Mean survival of explants seeded from different regions of donor sponge. Note trend line for top region obscured as a result of having the same values as bottom regions.

Effects of handling and placing explants into panels on growth and survival

Both the mean size of handled and non-handled explants increased (39.3% and 20.7% respectively.) The handling of sponges, via the action of placing newly cut explants directly into panels however, did not significantly influence growth (Figure 19; ANOVA: $F_{2,9} = 0.99$, $p > 0.05$) or survival (Figure 20; ANOVA: $F_{2,9} = 0.81$, $p > 0.05$).

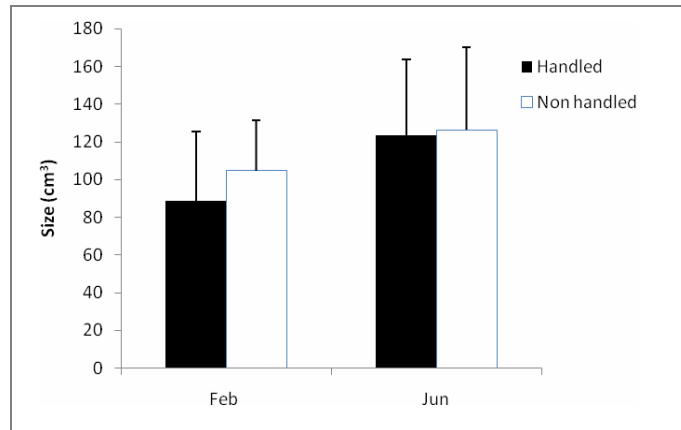


Figure 19: Mean sizes (± 1 SE) of explants subjected to handling via the placement directly into mesh panels following explanting compared to explants allowed to recover from explanting prior to placement into mesh panels.

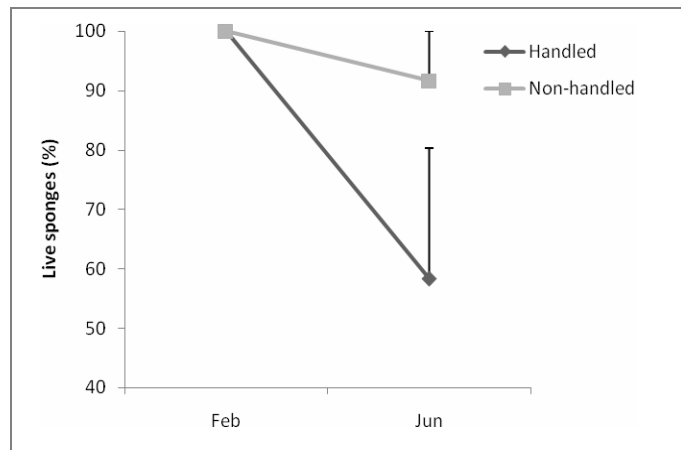


Figure 20: Mean survival (± 1 SE) of explants subjected to handling via the placement directly into mesh panels following explanting compared to explants allowed to recover from explanting prior to placement into mesh panels.

Effects of a transitional nursery stage on growth and survival

Consistent with other experiments in this study explants decreased in size for both handled (54.5%) and non handled (10.5%) sponges, but growth rates between treatments was significant with nursery treatments performing better than non-nursery treatments (Figure 21; t-test, $df = 6$, $p > 0.05$). There was no effect of a transitional nursery stage on survival (Figure 22; t-test, $df = 1$, $p = 0.059$), although the significance level is very close to the arbitrary rejection alpha level of 0.05. The mean survival of nursery explants was 87.5 ($\pm 7.2\%$) compared to 50 ($\pm 14.4\%$) for explants not subjected to a nursery period.

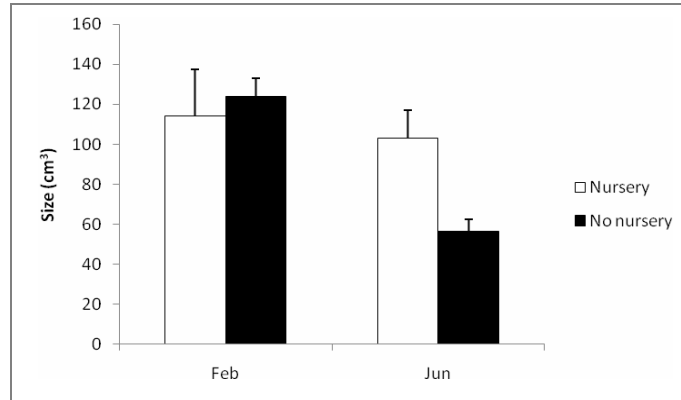


Figure 21: Mean sizes (± 1 SE) of explants subjected to a transitional nursery period enabling recovery of explanting period before seeding onto mesh panels compared to explants without a nursery stage.

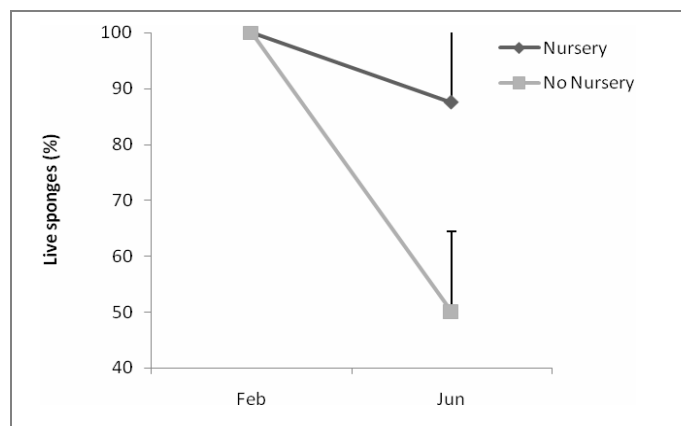


Figure 22: Mean survival (± 1 SE) of explants subjected to a transitional nursery period enabling recovery of explanting period before seeding onto mesh panels compared to explants without a nursery stage.

Discussion

Five separate experiments were conducted over a four-month period to establish the impacts of handling and collection procedures on explant growth and survival. Sponge farming has traditionally relied on collecting sections from donor sponges and then seeding them onto various farming structures, ranging from threading explants onto rope lines or placing them into other structures such as baskets or plastic mesh panels (e.g. Duckworth and Wolff 2007a). Regardless of the culture method employed to grow sponges, the creation of clonal fragments results in a proportion of the explants surface being cut and exposed as it is excised from the donor sponge. The ability of sponges to recover from this process, with full cellular integrity occurring within four to six weeks, demonstrates that this process is not detrimental to survival and highly suitable as a farming collection procedure (Louden *et al.* 2007). This is further evidenced with the high survivorship and growth observed from many experimental trials for sponge aquaculture (e.g. Duckworth and Wolff 2007a; Louden *et al.* 2007). Nevertheless, the overall health and growth potential for explants is reliant on minimising the stress of collection and in this vein protocols that optimise growth and survival are paramount to the farming success.

Exposing sponges to air provided some unexpected results in that exposures up to two minutes did not lead to significant growth or survival in comparison to explants not exposed. Given the subtidal habit of *C. mathewsi* (Duckworth and Wolff 2008) the exposure of explants to air for up to two minutes was expected to result in high mortalities due to challenges of exposure to sunlight (UV), air and increased temperatures. Environmental stress, particularly temperature, can play a significant and detrimental role in sponge health and survival (e.g. Webster *et al.* 2008). It is noted that there is considerable variation surrounding the mean values for growth and survival for both treatments and controls so some caution is warranted. This finding has economic implications due to the amount of work that can be undertaken on the deck of a boat rather than on SCUBA. Moreover, it provides an important operational advantage where handling of sponges on deck during the seeding process will allow short exposures of explants to air that might be experienced during the transfer of sponges between collection buckets and panels.

The finding that a nursery stage results in higher growth rates also provides an important advantage to optimising collection and handling plans. *Coscinoderma mathewsi* can establish a protective collagen layer over the cut surface and a new pinacoderm in as little as three days (Louden *et al.* 2007). Therefore, providing a nursery stage removes the adverse pressure placed on explant recovery within the confined grow-out panel and enhances the recovery. Following recovery, the subsequent transfer of explants to grow-out panels facilitates growth and survival.

In terms of collecting efficiencies, neither the size of the donor sponge nor the region from the donor sponge from which the explant was collected appears to influence growth or survival over the period of this study. It is important to note that decreased growth of explants observed in this study may be a reflection of the short term over which the study was conducted. Previous studies assessing growth of *C. mathewsi* explants have been conducted over twelve months showing 90% survival and 126% growth (Louden *et al.* 2007). The reduced growth in this four month study potentially being, in part, a reflection of the recovery at the expense of growth. As a result, further monitoring of growth associated with these experiments would be valuable in drawing more conclusive explanations.

Sponge assets and ecosystem health

Coscinoderma mathewsi is found throughout the central and eastern Torres Strait but is most abundant on reefs in the vicinity of Masig Island with sponges achieving larger sizes at this group (Duckworth *et al.* 2007b).

To date Project 1.3.2 has quantified temporal and spatial patterns associated with sponges (*Coscinoderma mathewsi*) at Masig Island. As a result of our population surveys it is clear that fluctuations in numbers of *C. mathewsi* exist between certain time periods, with notable reductions in numbers for November 2007. Patchy distribution patterns are well documented for sponges but to confirm if these fluctuations in *C. mathewsi* numbers are peculiar to the survey design or are indeed directed by real events (e.g. larval recruitment pulses and mortality) we have undertaken a different approach for future surveys (i.e. commencing in the June 2009 field trip). Specifically, we have replaced the random approach of assessing sponge abundance/distribution patterns to include monitoring of fixed transects for abundance estimates (Objective a) with these transects including fixed quadrats to provide estimates of recruitment of sponges (Objective c) thereby replacing the deployment of settlement tiles. We consider this change to the operational plan will build on existing data and provide greater interpretative power in the overall assessment of the population demography. Nevertheless, abundance estimates for *C. mathewsi* reinforce previous conclusions associated with this project that Torres Strait has adequate numbers of bath sponges to support a base stock for sponge farming, provided sustainable harvesting protocols are adopted. In addition, there was no evidence of disease or compromised health (tissue necrosis) in sponges surveyed in 2008/2009.

Recruitment of marine invertebrates to the settlement tiles show comparable diversity and recruit abundance to previous survey periods.

Field work conducted

AIMS personnel undertook three field trips during the 2008/2009 financial year. All work was undertaken at Masig Kodall and Marsden Islands (Table 1). Each trip was carried out with extensive cooperation of local Masig Islanders, including the charter of vessels and paid employment of personnel from Masig Island. John Morris and Samson Lowatta were employed for diving and boating assistance during the 2008 and 2009 field trips, while Gavin Mosby was hired as a coxswain during the June 2009 trip. In addition, given the value in skills development, linked to operational procedures of a commercial sponge farm for Torres Strait Islanders (TSI), coupled with the savings for the Project Leader to minimise the expense associated with field trips to monitor the experiments, John and Samson were trained in methods to monitor sponge explant survival and growth unassisted (handling experiments – Objective d). Along with the assistance of a third TSI, data was collected monthly from March until the June 2009 field trip where final measurements were undertaken with the Project Leader.

As with previous trips, the link with these key personnel has been instrumental in promoting the transfer of knowledge and experience between the project, Torres Strait Islanders and local communities. All personnel were fully employed for their contributions with a wage that was negotiated as fair for all parties including, AIMS and TSRA.

Table 1: Summary of fieldwork undertaken in 2008/2009.

Date	MTSRF objective undertaken
November 2008	(a), (c)
February 2009	(d)
1-15 June 2009	(a),(c),(d)

Communication activities

Extension of all aspects of this research to the Masig Island and the wider Torres Strait communities has been a key priority of this project. During 2008/2009, considerable effort has been implemented to involve community members in the project. Prior to all field trips, our visits proposed activities, and background to the project were advertised through posters which were delivered to the TSRA and presented to the Masig community via their local community notice board. Both the delivery of posters and interaction with community members has been an integral component of communication of this project to the Masig community.

Close relationships have also been forged with the TSRA advising of progress of all field trips in relation to research plans and also interactions with the local community. Information was also supplied to TSRA of the ongoing work for this project for inclusion in a local TSRA newsletter in July 2009. This focused on community participation of Masig Islanders, TSRA and also interaction with Tagai College at Thursday Island. The latest results were also presented at the 2009 MTSRF Annual Conference. The recruitment study is on-going but will be prepared for submission to a peer-reviewed science journal when the data collection and full analyses is completed.

Advice was also provided on diving procedures to the proponents of the commercial arm of the Masig Island sponge farm, Kailag Enterprises Pty Ltd. AIMS furnished a copy of their operational dive protocols to Mr Chris Robertson, Kailag's Project Manager of the sponge farm, to be used as base for Kailag sponge divers.

Planned activities for 2009/2010

To date Project 1.3.2 has quantified temporal and spatial patterns associated with sponges (*Coscinoderma mathewsi*) at Masig Island. This has delivered data over three years and provides a fundamental platform to develop our understanding of key population demographic parameters. However, as a result of our population surveys it is clear that fluctuations in numbers of *C. mathewsi* exist between certain time periods, with notable reductions in numbers for November 2007. Patchy distribution patterns are well documented for sponges but to confirm if these fluctuations in *C. mathewsi* numbers are peculiar to the survey design or are indeed directed by real events (e.g. larval recruitment pulses and mortality) we have undertaken a different approach for future surveys (i.e. commencing in the June 2009 field trip).

Specifically, we have replaced the random approach of assessing sponge abundance / distribution patterns to include monitoring of fixed transects for abundance estimates (Objective a) with these transects including fixed quadrats to provide estimates of recruitment of sponges (Objective c) thereby replacing the deployment of settlement tiles.

We consider this change to the operational plan will build on existing data and provide greater interpretative power in the overall assessment of the population demography. Moreover, it will provide data on fluctuations in sponge populations associated with mortality (e.g. natural disturbance events, disease, senescence) and recruitment. This change in approach will complement and add a new dimension to Objectives (a) and (c).

Importantly, it is considered essential in completing our assessment of C. mathewsi population demography. Transects were established in June 2009 and will be surveyed in November 2009 and April 2010 with a field trip time of four weeks, comprising two weeks per trip in November and April.

We further recommend that information generated to date from the recruitment tile surveys (Objective c) will be greatly enhanced if some simple experiments were carried out to establish pre-settlement behaviours of *C. mathewsi* larvae. Knowledge of planktonic durations greatly facilitates information on larval dispersal capabilities and therefore connectivity, one of the objectives (Objective b) of this project. It will also provide information on settlement cues implicated in larval metamorphosis (i.e. do larvae require specific substrates to settle?) and therefore recruitment to the population.

This approach requires laboratory-based aquarium facilities that will allow experimental manipulations of larval assays under controlled conditions (i.e. filtered (25 µm) flow-through sea water with regulation of photoperiod and temperature.

The small size of larvae (less than 0.5mm in length) also requires access to labs with microscopes to establish and monitor larval experiments. The facilities at Masig Island are therefore unsuitable as a base for conducting this research. Experiments for this component will be undertaken at the research aquarium facilities based at Orpheus Island Research Station, operated by James Cook University, during **December 2009**. Given *C. mathewsi* occurs both at Orpheus Island and Masig Island, information on larval behaviours should be relevant regardless of where the experiments take place. To establish if spawning cycles are consistent between Orpheus and Masig sponge populations we will train (employ) Torres Strait Islanders (during the November 2009 field trip) to assess the spawning cycles of *C. mathewsi* at Masig during the same period the larval work is being undertaken at Orpheus. Overall, this additional information will build on the existing data associated with connectivity (Objective c) by addressing issues central to population connectivity of sessile

organisms as the larval phase is the only phase that can disperse and when combined with knowledge of hydrodynamics is largely responsible for defining geographical boundaries. Although Objective (c) has identified rudimentary population genetic data and connectivity for *C. mathewsi*, the small sample sizes limits interpretation of the information on genetic structure of *C. mathewsi* (as identified in the Duckworth and Wolff 2008) and data on larval dispersal capabilities will augment our interpretation of the genetic data. In addition, an overall understanding of larval settlement behaviour will provide the first step necessary to underpin future exploration of hatchery production of seed sponges, thereby increasing the sustainable management of this resource.

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