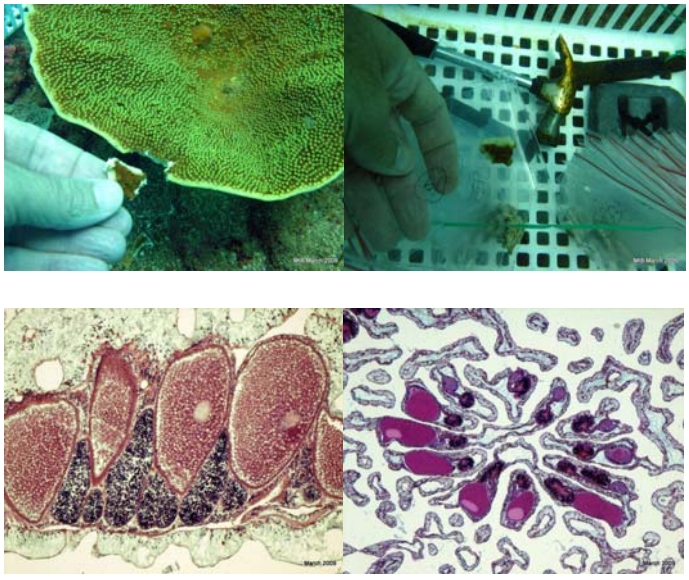
Port Hedland Outer Harbour Development



CORAL SPAWNING AUTUMN SURVEYS 2009

- Revision 0
- WV03716-MV-RP-0034
- 2 September 2009

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Limitation Statement

The sole purpose of this report and the associated services performed by Sinclair Knight Merz (SKM) is to provide details of the methods and results of coral spawning status surveys, in accordance with the scope of services set out in the contract between SKM and FAST JV ('the Client'). That scope of services was defined by the request of the Client.

SKM derived the data in this report primarily from the coral spawning assessments carried out during April and May 2009. The passage of time, manifestation of latent conditions or impacts of future events may require further exploration of the study area and subsequent data analysis, and re-evaluation of the findings, observations and conclusions expressed in this report.

In preparing this report, SKM has relied upon and presumed accurate, certain information (or absence thereof) relative to the Outer Harbour Development, as provided by the Client. Except as otherwise stated in the report, SKM has not attempted to verify the accuracy or completeness of any such information.

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List of Acronyms

Acronym	Full title
AIMS	Australian Institute of Marine Science
BPP	Benthic Primary Producer
BPPH	Benthic Primary Producer Habitat
COR	Cornelisse Shoal
COX	Coxon Shoal
CTH	Cape Thouin
EPA	Environmental Protection Authority
GBR	Great Barrier Reef
LTI	Little Turtle Island
MIB	Minilya Bank
SKM	Sinclair Knight Merz
TSS	Total Suspended Solids
WIS	Weerdee Reef

Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
Revision A	04/06/09	J. Hanley R Burgess	T Probst	09/06/09	First draft for client review
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1. Project Definition

BHP Billiton Iron Ore proposes to expand their iron ore operations in the Pilbara by developing a new port. This proposed development is known as the Port Hedland Outer Harbour Development (Outer Harbour Development). The proposed Outer Harbour Development is located on the coast near Port Hedland in the Pilbara region of Western Australia.

The Outer Harbour Development will involve the construction of infrastructure (jetty and wharves) and dredging, to allow ship access to the infrastructure for loading of iron ore. In the vicinity of the proposed development are areas of benthic primary producer habitat (BPPH), which are defined by EPA Guidance Statement No. 29 (EPA 2004) as areas supporting or capable of supporting benthic primary producers (BPP). Currently, SKM is assisting BHP Billiton Iron Ore to achieve environmental approval for the project.

The environmental approval process requires an assessment of the impacts from dredging on BPPH. Based on the zone of impact, estimated by preliminary numerical modelling of the sediment plume in March 2008, six BPPH sites were selected for deployment of water quality loggers and coral monitoring transects (**Figure 1.1** and **Table 1.1**). These sites are regularly monitored, with the aim of collecting at least 12 months of baseline data prior to dredging activities in order to document and distinguish natural variability from potential dredging impacts during the project implementation.

Dredging and dredge spoil disposal activities have the potential to lead to direct loss of BPPH, both through removal and indirect loss through sedimentation and through shading by turbidity plumes. In addition, the extent and timing of coral spawning in subtidal areas adjacent to port Hedland will be examined.

This additional data will provide assistance in predicting impacts of dredging and satisfy potential Ministerial requirements for the regulatory approval process. In addition, undertaking such monitoring during the pre-dredging phase will enable improved predictions of the timing, extent and duration of coral spawning in the study area. This information will provide BHP Billiton Iron Ore with a more accurate estimate of potential dredge downtime as dredging is typically not permitted by the regulatory authorities during events defined as significant coral mass spawning period.

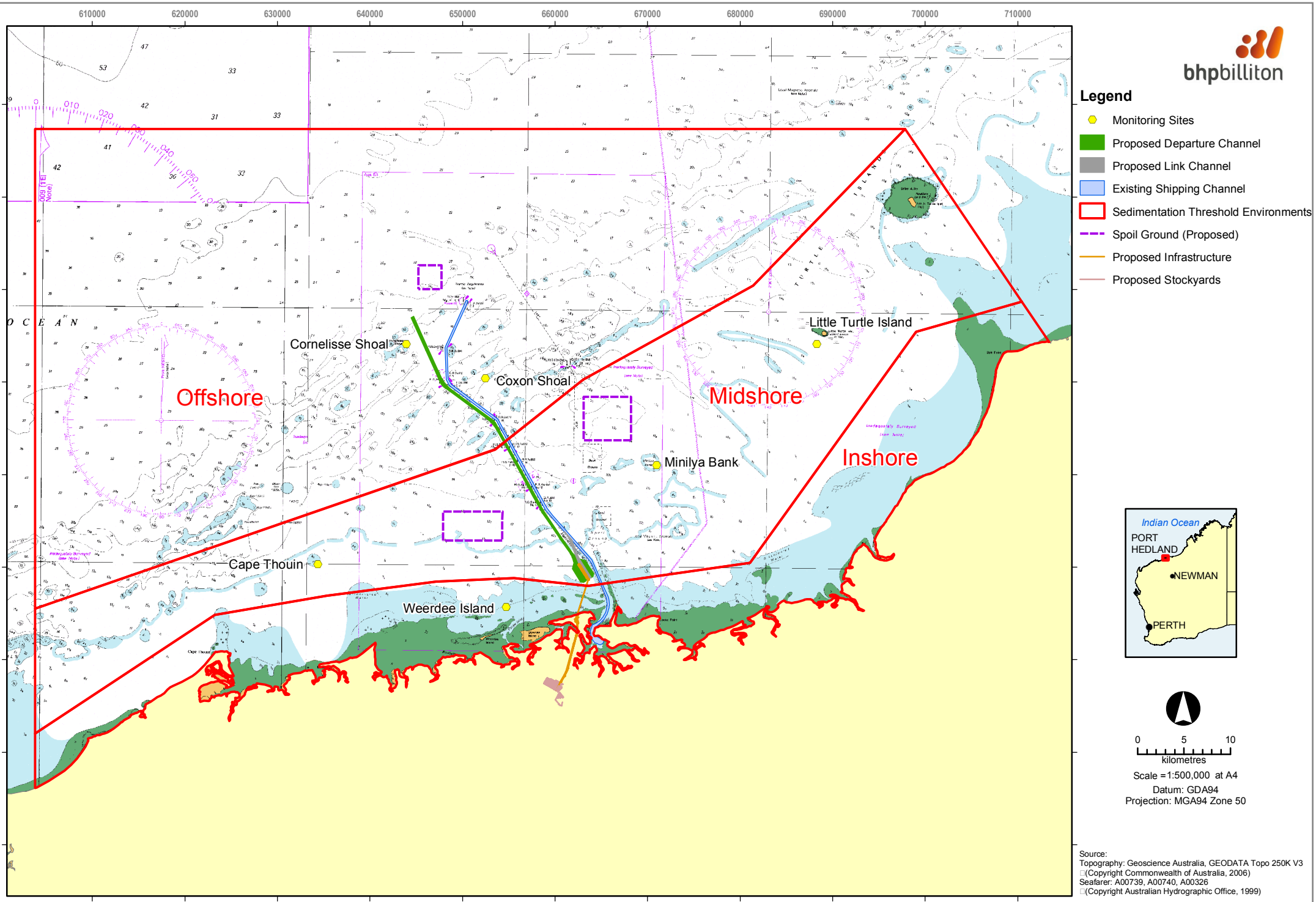

Figure 1-1 Locations of the three environments and monitoring sites offshore from Port Hedland

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- **Table 1.1 Coral monitoring sites offshore from Port Hedland**

Site Name	Code	Environment	Approx. distance from the mainland (km)	Approx. mid tidal water depth (m)	Latitude	Longitude
Weerdee Reef	WIS	Inshore	3	5	20° 17.414' S	118° 28.893' E
Cape Thouin	CTH	Midshore	10	6	20° 14.995' S	118° 17.194' E
Minilya Bank	MIB	Midshore	16	9	20° 09.002' S	118° 38.157' E
Little Turtle Island	LTI	Midshore	19	7	20° 01.081' S	118° 47.991' E
Cornelisse Shoal	COR	Offshore	33	12	20° 02.040' S	118° 22.560' E
Coxon Shoal	COX	Offshore	28	12	20° 03.998' S	118° 27.485' E

1.1. Scope of Works

1.1.1. Purpose

This coral spawning study report will provide:

- background information relating to coral spawning in the Pilbara;
- methods of the investigation;
- analysis of results;
- discussion on any items of significance, implications to the project; and
- conclusions.

In addition, this report provides advice on whether the targeted corals are likely to spawn outside the selected spawning periods.

1.1.2. Methodology

The basic methodology used in this document includes the following steps:

- identification of the areas/sites likely to be at risk from elevated turbidity (the existing six monitoring sites will be used);
- identification of the dominant and sub-dominant coral species in the survey area;
- sampling of at least 20 corals for each dominant and sub-dominant species and examining the corals either visually or using histology; and
- in the event of a predicted mass spawning, further assessment to determine whether the event is complete.

2. Introduction

Synchronous spawning or 'mass spawning' of coral colonies was first reported on the Great Barrier Reef (Babcock *et al.* 1986). 'Mass spawning' in corals is the ejection of reproductive propagules (larvae, eggs or sperm) by a large number of coral species on consecutive nights during one period of the year. Studies of coral spawning on inshore regions of north western coastline of Western Australia identified the main 'mass spawning' period to occur 6 to 8 days after the full moon in the autumn months of March and April (Stoddart & Gilmour 2005; Baird *et al.* in prep). Recent research suggests that additional spawning for *Acropora* spp. may occur on reefs in Northern Western Australia during spring (Rosser & Gilmour 2008).

Extensive surveys of the benthic habitat offshore of Port Hedland were undertaken between December 2007 and May 2008 (SKM 2009). These surveys indicate that the benthic habitat offshore from Port Hedland is characterised by extensive plains of sand/silt/rubble substratum and ridge lines of hard pavement often covered in a layer of sand/silt. Offshore ridge lines support occasional patches of sparse biota, including hard corals, macroalgae, sponges and soft corals. Hard corals, in particular corals from the *Turbinaria* genera, represented the most dominant BPP growing along these ridgelines.

The precedent set by Ministerial conditions and previous dredging campaigns in the region to assess the capabilities and timing of a coral community's likelihood of spawning firstly requires the identification of representative monitoring sites followed by an initial survey of the coral population at these sites to quantify the dominant and sub-dominant coral species composition. There may not be one clear dominant species common to all monitoring sites, so a range of different dominant and sub-dominant coral species may need to be chosen at each of the sites to reflect this. The dominant species at each site is described as that species which represents or occupies at least 20% of the coral biomass at that site. The sub-dominant species is the next most abundant species after the dominant species.

Assessing a coral colonies spawning status can be carried out in three ways:

1) *In situ* observations of the evidence of gametes in a coral colony by 'snapping' off a small part of the coral and examining the broken section of the piece for eggs as follows:
   - if there are no eggs the colony is deemed to have spawned recently or will not spawn in the next three or more months;
   - if there are white small eggs then the coral is likely to spawn in the next three months; or
   - if there are large pink eggs then the coral is likely to spawn in the following full moon.

   This method is particularly uselful for coral species where the size of the eggs is sufficient to be clearly visible to the naked eye, and there is scope for the diver to 'snap' off a bit of the coral. It is primarily used in *Acropora* spp. spawning assessments.

2) The second method is particularly appropriate for coral species with smaller eggs (such as *Porites* spp. and some *Turbinaria* spp.), which at any stage of development are often not visible to the naked eye. It involves collection of a small sample from the target coral and examination under a microscope to determine whether there are eggs present and whether the size and/or colour of the eggs indicates an imminent spawning event.
3) The third method requires the collection of a small piece of the coral for subsequent processing at a laboratory for more detailed histological analysis under a high powered microscope. This process determines the exact stage of egg and sperm development to pinpoint more accurately the timing of spawning.

In this project, the third method was chosen in an attempt to accurately predict the time of spawning of the dominant and sub-dominant coral species during the autumn of 2009 at the six monitoring sites offshore from Port Hedland. Results from this survey will be used to inform decisions about the scope and scale of future spawning assessments during the dredging phase of the Outer Harbour Development.

The focus of the impact of the dredging and spoil disposal activities on coral spawning should centre on the key question: 'Will the potential loss of gametes due to elevated total suspended solids (TSS) levels in the predicted zone of potential impact during the coral spawning adversely affect the ecology of the entire ecosystem offshore from Port Hedland?'.

3. Methods

3.1. Dominant Coral Genus and Species

The dominant and sub-dominant coral genera at each site were identified using a survey technique that utilises methods developed by scientists at the Australian Institute of Marine Science (AIMS) (Abdo *et al.* 2004). The basis of the survey technique involved taking 100 underwater photographs of the sea floor at random intervals across the entire coral monitoring site. Each photograph was taken from directly above the substrate at a distance of 35 cm. Each photograph was then analysed using software (AVTAS – AIMS Video Transect Analysis System) developed at AIMS, which superimposes five points onto that photograph in a fixed pattern. The coral genera that occurred under each point were entered into a database and the absolute percentage cover and proportional percentage cover of various coral genera at each site was then ascertained. Once the dominant and sub-dominant genera were ascertained, a representative species from each category was selected for coral spawning assessments.

3.2. Collection and Processing of Coral Samples

Sampling periods were planned around the full moon in the autumn months of March and April 2009 which coincide with the predicted mass spawning events (**Table 3.1**). From each of the six monitoring sites 20 samples from the dominant coral species and 10 samples of the sub-dominant coral species were randomly collected from coral colonies each site.

Table 3.1 Spawning, full moon and the sampling dates in Autumn 2009

Full Moon 2009	Spawning window 2009	Survey dates 2009
11 March	17–21 March	1–7 March
9 April	15–19 April	1–5 April

Small pieces (3 cm x 3 cm) of the target coral species (dominant and sub-dominant) at each site were cut from the extremities of the coral colony (**Figure 3.1**). The extreme outer edge of the excised piece was removed because the coral polyps in this area contain a substantial percentage of new growth which is unlikely to contain gonads at this stage (Wallace 1985). The sample was placed into a sample bag for subsequent histological processing and analysis as follows.

The samples from each site were fixed in 10% neutral formalin for at least 24 hours prior to decalcification in 10% formic acid. The tissue was processed through graded ethanol, chloroform and paraffin wax and each sample was bisected and embedded in both transverse and vertical orientation in the same wax block. The blocks were sectioned at 6 µm thickness and mounted on slides. Slides were stained using Mayer's haematoxylin and counterstained with Youngs eosin-erythrosine. The stages of gonad maturity in each histological section were classified using criteria cited in Baird *et al.* (in prep) and summarised in **Table 3.2**.

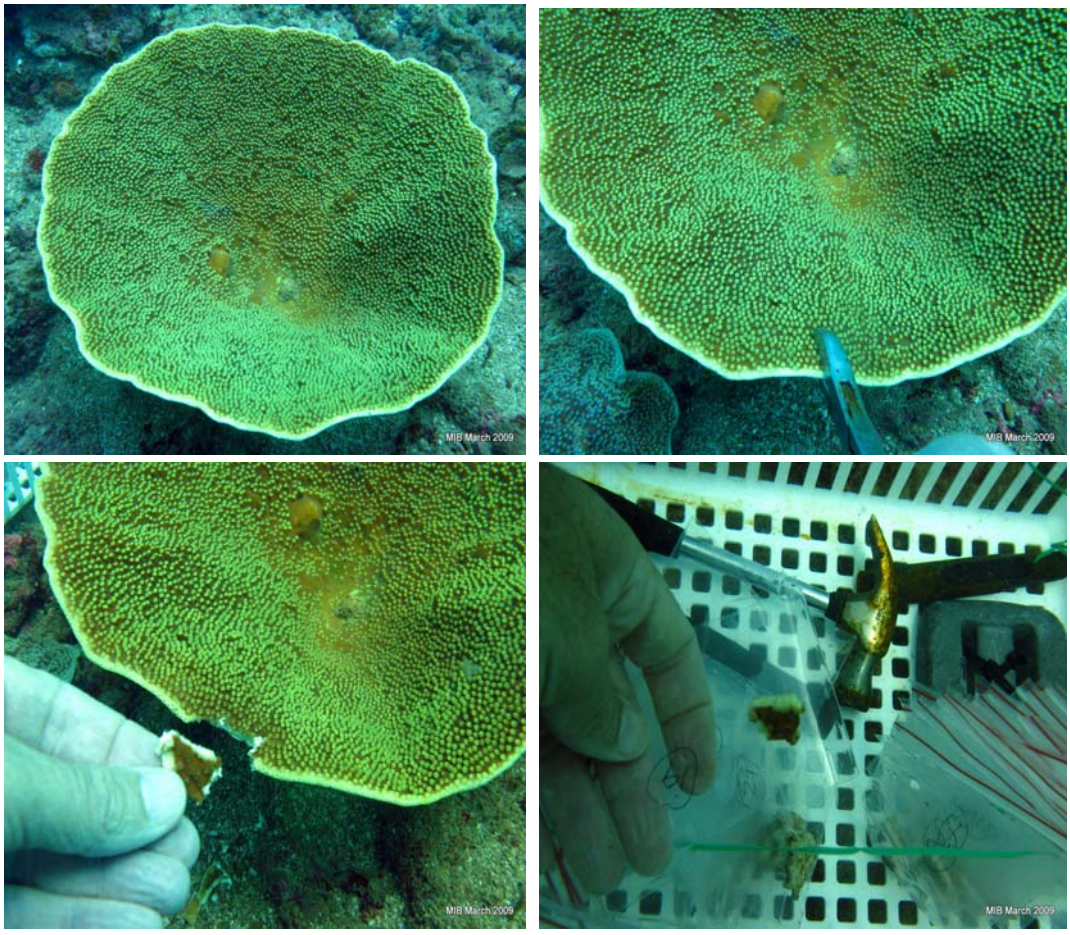


Figure 3.1 Collecting a coral sample from a colony of *Turbinaria mesenterina*

- **Table 3.2 Gamete identification characteristics of the four stages of oogenesis and spermatogenesis in *Turbinaria***

Stage	*Turbinaria* female gametes	Size(µm)	*Turbinaria* male gametes
I	Enlarged interstitial cells in the mesoglea of mesenteries nucleus make up the bulk of the oocyte. Oocytes well spaced and surrounded by cytoplasm mesoglea.	0–60	Small clusters of interstitial cells near or entering the mesoglea. Stain deep blue.
II	Accumulation of blue staining yolk around nuclei which remains in the centre of the oocyte. Still lots of cytoplasm surrounding oocytes.	60–100	Clusters of spermatocytes with distinct spermary boundary; large nuclei. Nuclei arranged peripherally.
III	Finely granular yolk staining pink. Nucleus migrates to periphery of nucleus. Still some cytoplasm between oocytes.	100–300	Spermatocytes are smaller with smaller nuclei and the number of cells within spermary is larger. Conspicuous peripheral arrangement of spermatocytes.
IV	Oocytes stain dark pink; oocytes crowded, nucleus at periphery. Clear lipid globules obvious under high power.	>300	Spermatozoa with tails.

Source: Baird et al. (in Prep.)

4. Results

4.1. Dominant Coral Genus and Species

The dominant coral genus and representative species sampled for coral spawning assessments are summarised in **Table 4.1**. Over 50% of all corals growing at five of the six monitoring sites were corals from the hard coral genus *Turbinaria* (**Figure 4.1**). The most dominant species within this genus was *Turbinaria mesenterina* and 20 samples in total were taken from this species for histological processing and analysis from the five sites. At the COR monitoring site the cover of hard corals was sparse (<15%, refer to **Figure 4.2**) and the dominant genus was *Acropora* from a range of species (**Figure 4.3b** and **Figure 4.3c**)**,** with no one species dominating. Twenty samples from this genus were taken for histological processing and analysis.

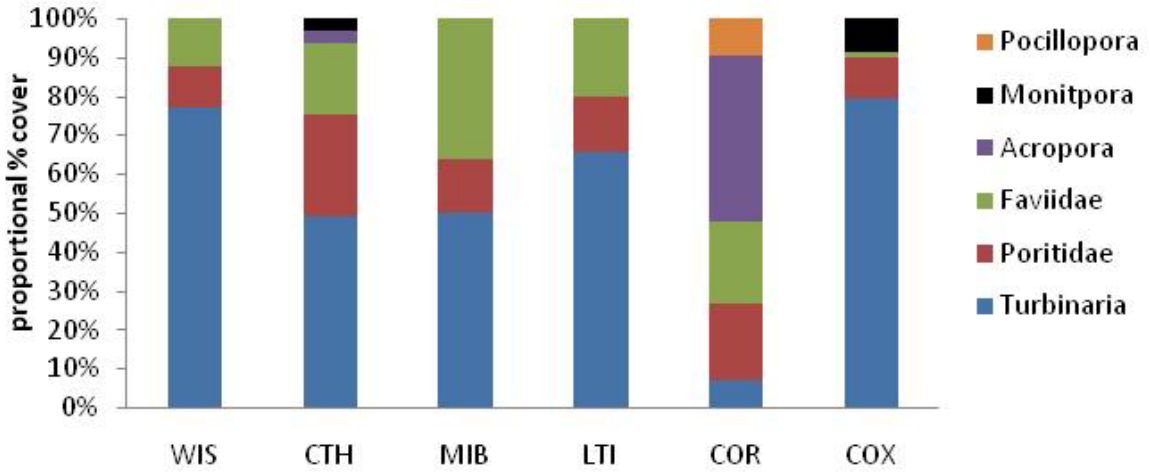
- **Table 4.1 Dominant coral genus and representative species used for coral spawning assessments**

Site	Dominant Genus	Species used
Weerdee Reef	*Turbinaria*	*Turbinaria mesenterina*
Cape Thouin	*Turbinaria*	*Turbinaria mesenterina*
Minilya Bank	*Turbinaria*	*Turbinaria mesenterina*
Little Turtle Island	*Turbinaria*	*Turbinaria mesenterina*
Cornelisse Shoal	*Acropora*	A range of *Acropora spp.*
Coxon Shoal	*Turbinaria*	*Turbinaria mesenterina*

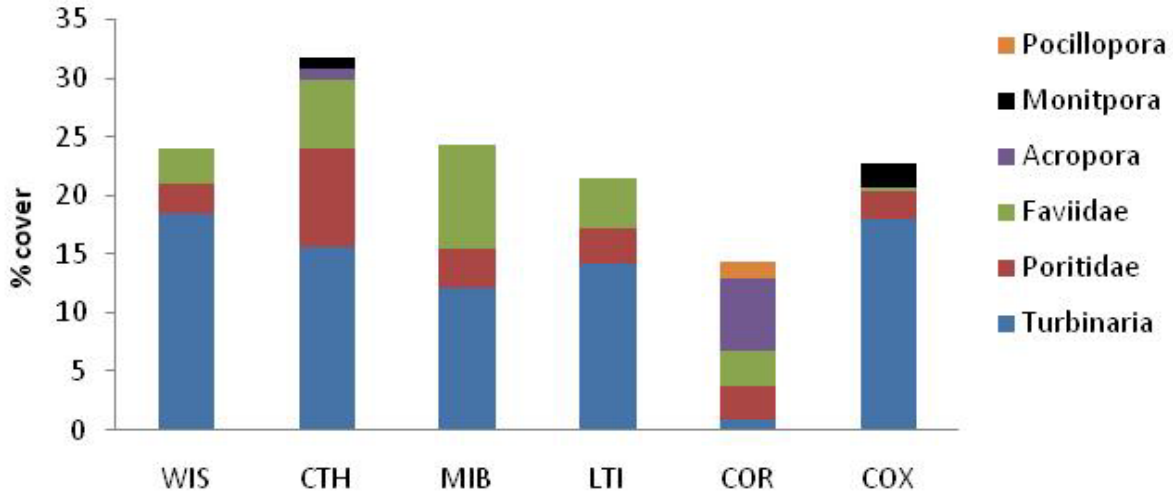
The sub-dominant genera at five of the six monitoring sites were corals from the Faviidae family and in particular the species *Favites pentagona* (**Figure 4.3a**). Ten samples of this species were collected for further analysis of their spawning status from each of the five sites. At the COX monitoring site, the sub-dominant coral was *Montipora undata* (**Figure 4.3c**) and ten samples from these colonies were sampled for analysis.

A total of 120 samples of the dominant species and 60 of the sub-dominant species were collected from the six monitoring sites during each spawning assessment survey.

Corals from the Poritidae family were not chosen as a candidate for spawning assessment for the following reasons. There were several genera represented from Poritidae including *Goniopora* and *Porites* and the absolute and relative cover of these two genera indicated no dominance by either genus. In addition, within each of these genera there was no one dominant species represented.

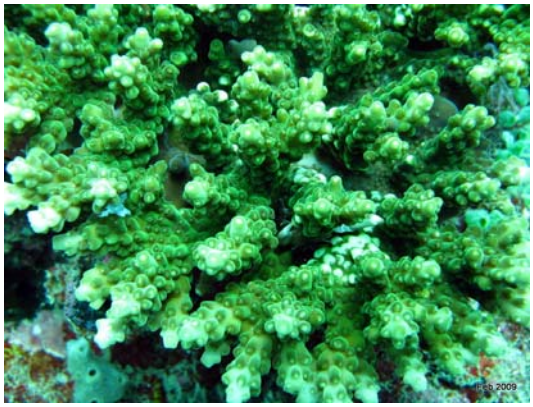


- **Figure 4.1 The proportional percentage cover of the dominant coral taxa at the six monitoring sites**



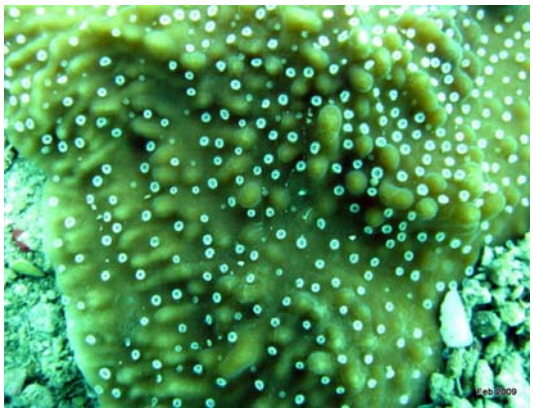
- **Figure 4.2 The absolute percentage cover of the dominant coral taxa at the six monitoring sites**

(a) *Favites pentagona*



(b) *Acropora* sp. 1

(c) *Acropora* sp. 2



(d) *Montipora undata*

- **Figure 4.3 Photographs of the coral genera and species targeted for coral spawning assessments at the six monitoring sites**

4.2. Assessing the Reproductive Stages of Coral Colonies

The reproductive stage of each coral colony sample from *Turbinaria mesenterina, Favites pentagona, Montipora undata* and *Acropora* were assessed based on criteria outlined in Baird *et al.* (in prep). Stage 1 and 2 represents the beginning of the process of gametogenesis, and oocytes (eggs) or spermatocytes (sperm) at this stage are very small usually in the range of 0–100 µm. Stage 3 and 4 represent the final two stages of gamete development and both oocytes and spermatocytes are well developed and generally range in size from 100–300 µm and are visible under a low powered microscope. Results of the analysis to determine the stage of development for the oocytes or spermatocytes in each of the 180 coral colony samples from each survey trip in autumn 2009 are presented in **Appendix A**.

Figure 4.5 shows a summary of the recorded stages of gamete development for *Turbinaria mesenterina.* Many *Turbinaria mesenterina* samples had combinations of reproductive stages present. If two stages of gamete development in a single colony are observed; such as stage 3 and stage 4, or stage 1 and stage 4, these are represented on the graphs in **Figure 4.5** as 34 and 14 on the x axis.

During the March 2009 surveys the most dominant reproductive stages observed in *Turbinaria mesenterina* were the stage 3 and 4 combination as well as the stage 4 (**Figure 4.5**). Most sites recorded similar percentages of stage 3/4 and stage 4 gametes. At CTH there were considerably more stage 3/4 gametes than stage 4 gametes only.

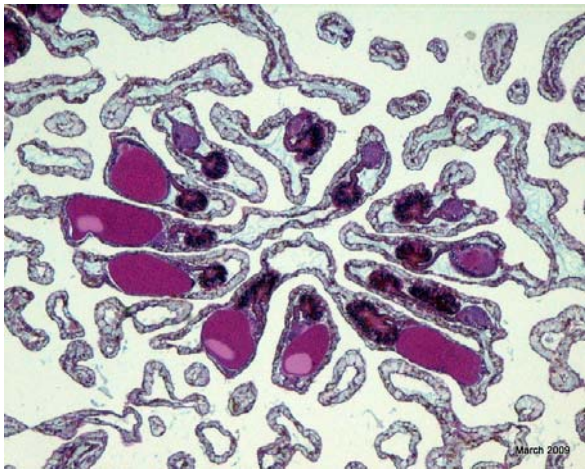
In the April surveys, the presence of stage 4 in both male and female gametes in the *Turbinaria mesenterina* samples appeared to represent residual ova and sperm after a fairly recent spawning event. In most samples there was evidence of re-organisation of the gonad and the appearance of gametes at stage 1. The remaining stage 4 gametes that co-exist with the stage 1 gametes (stage 1/4) would potentially have been released during the following spawning window in mid April. There was evidence of a breakdown in the structure of some stage 4 gametes indicating they may not be released but reabsorbed.

Given that the colonies that contain any stage 4 eggs or stage 4 sperm will most likely spawn in the near future, the number and percentages of colonies spawning after the full moon in March and April are represented in **Table 4.2.**

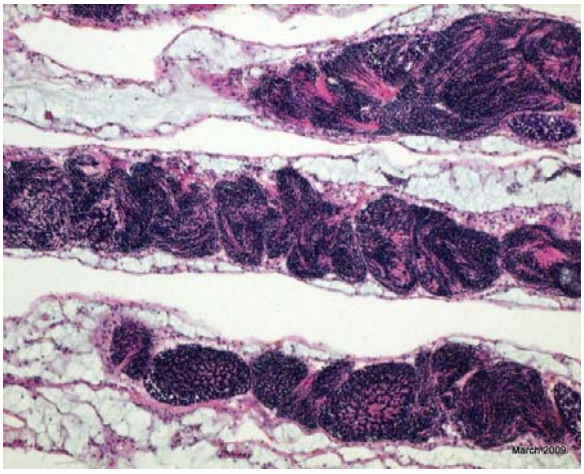
- **Table 4.2 The number and percentage of *Turbinaria mesenterina* colonies potentially spawning after the March and April full moons**

Site	Dominant Genus	Species used	number of colonies spawning in March (Stage I/IV, 3/4 and 4)	number of colonies spawning in April (Stage I/IV, 3/4 and 4)
Weerdee Reef	*Turbinaria*	*Turbinaria mesenterina*	17 (85%)	18 (90%)
Cape Thouin	*Turbinaria*	*Turbinaria mesenterina*	16 (80%)	14 (70%)
Minilya Bank	*Turbinaria*	*Turbinaria mesenterina*	17 (85%)	14 (70%)
Little Turtle Island	*Turbinaria*	*Turbinaria mesenterina*	18 (90%)	15 (75%)
Cornelisse Shoal	*Acropora*	A range of *Acropora spp.*	0 (0%)	0 (0%)
Coxon Shoal	*Turbinaria*	*Turbinaria mesenterina*	18 (90%)	14 (70%)

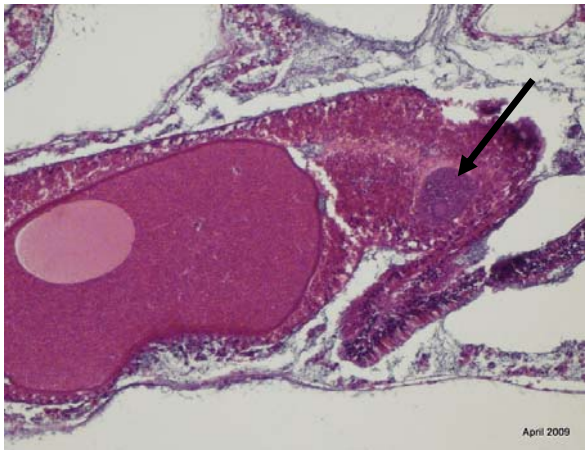
Stage 1 gametes in the females are reasonably easy to spot under a microscope (**Figure 4.4c**), but the male stage 1 gametes are considerably more cryptic. It is likely that the high percentage of stage 4 spermatocytes observed was a composite with an unknown proportion of stage 1 spermatocytes also present (**Figure 4.5**).



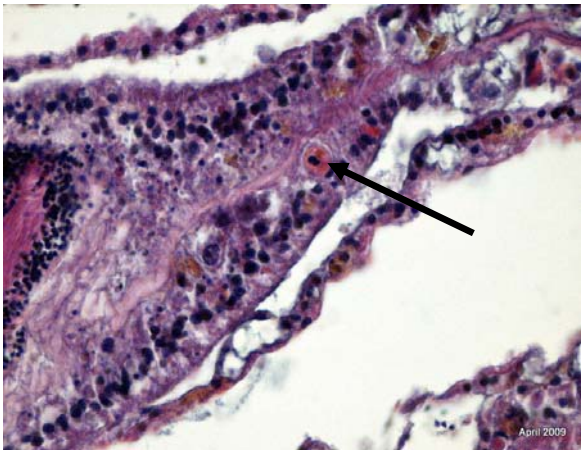
(a) Stage 4 female oocytes (pink)



(b) Stage 3 and 4 spermatocytes

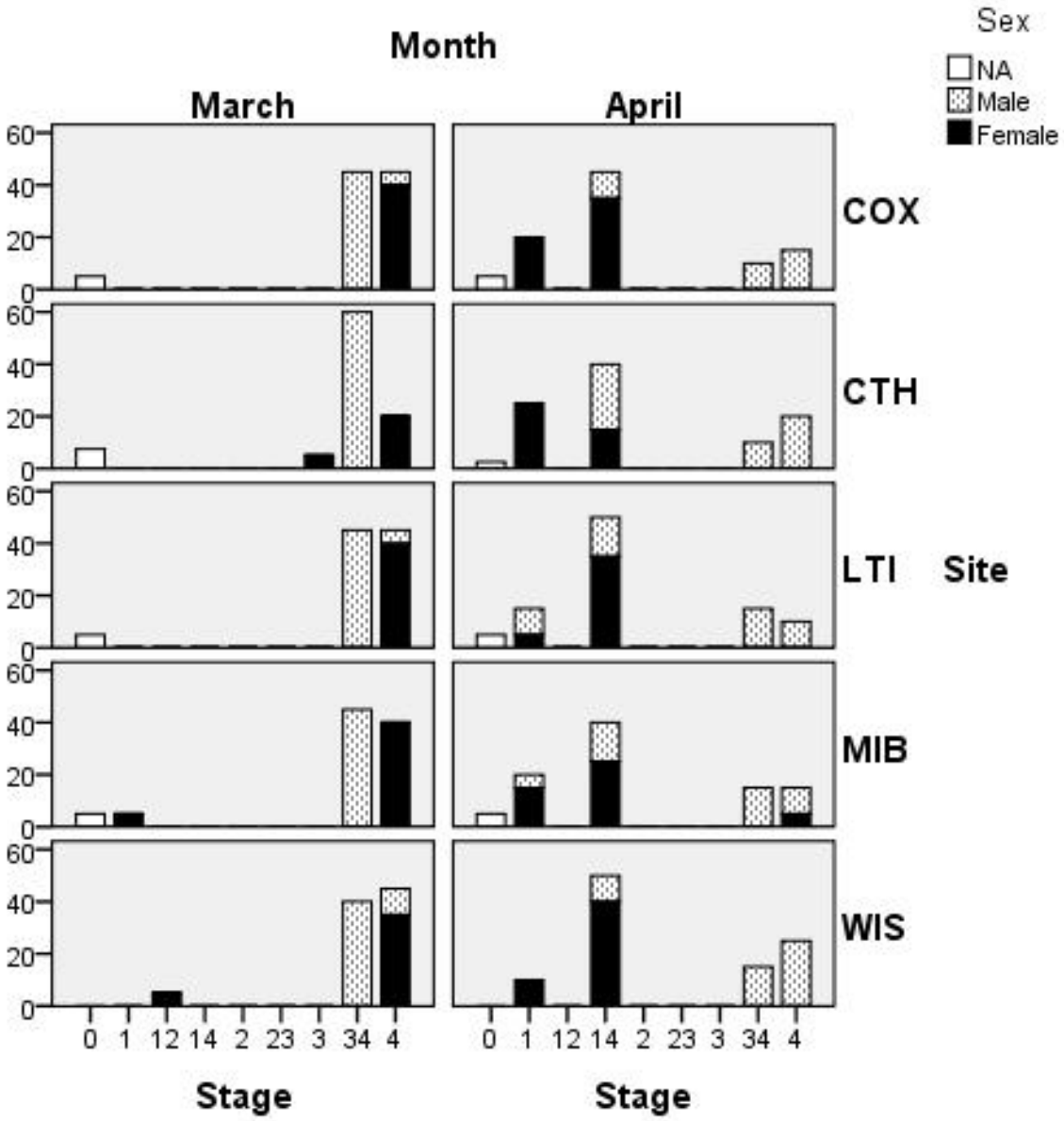


(c) Stage 4 oocytes with a large pale pink nucleus and stage 1 oocytes (arrow)



(d) Stage 4 and Stage 1 (arrow) spermatocytes

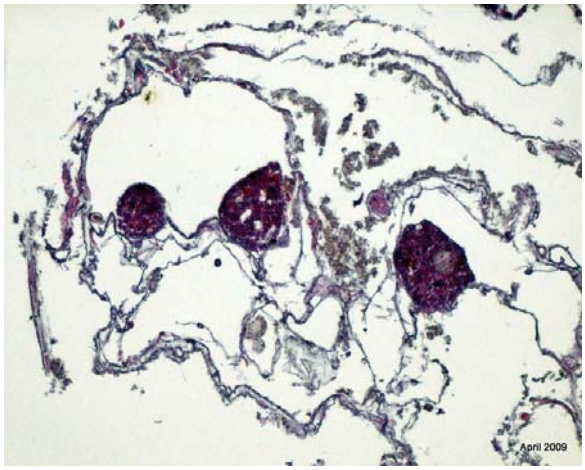
- **Figure 4.4 Micrographs of histological sections of *Turbinaria mesenterina* samples collected from sites during March**



- **Figure 4.5 The percentage of *Turbinaria mesenterina* colonies collected during the two sampling periods showing each stage (and combinations) of gamete development**

4.2.1. *Favites pentagona* Spawning Patterns

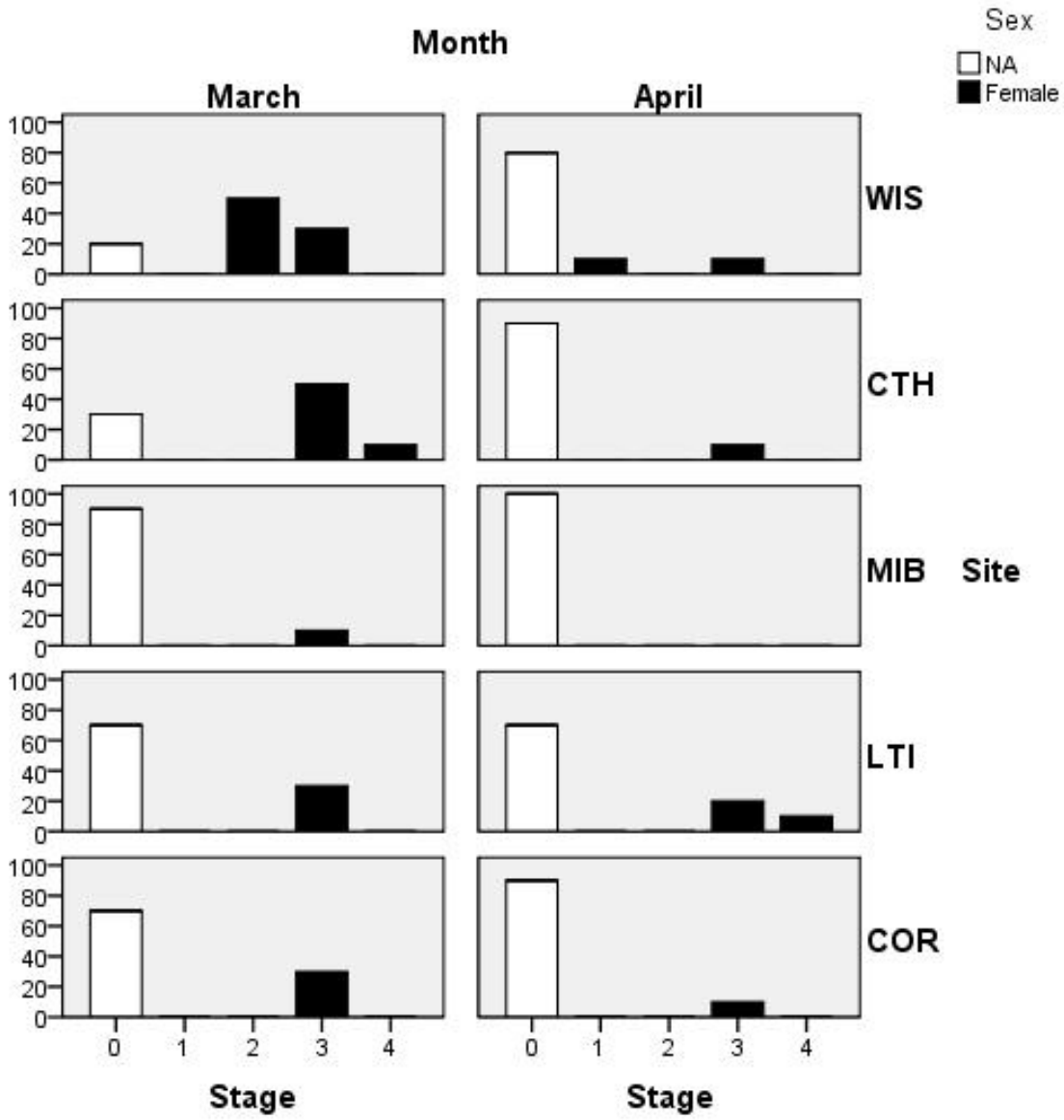
Corals from the Faviidae family are primarily mass spawning hermaphrodites which mean each individual colony contains both male and female gametes (**Figure 4.6**). Ten samples were collected from each of the five monitoring sites where *Favites pentagona* was found. Results of analysis of *Favites pentagona* suggested that some individuals were spawning after the full moons in March and April (as indicated by the presence of stage 3 and 4 eggs), but overall most samples of this species at most sites contained no evidence of gametes (**Figure 4.7**). At two of the monitoring sites (WIS and CTH) there was stronger evidence of spawning occurring after the March full moon with over 50% of colonies containing stage 3 and stage 4 eggs during early March and then having very few mature gametes during the April surveys. Pooling the results from all sites to examine the broad patterns of spawning for these sub-dominant species indicated that most of the spawning occurred during the autumn period (**Figure 4.8**). Over 25% of colonies sampled did not contain any evidence of gametes in the March surveys which may suggest that some colonies of this species may spawn during periods outside of autumn.



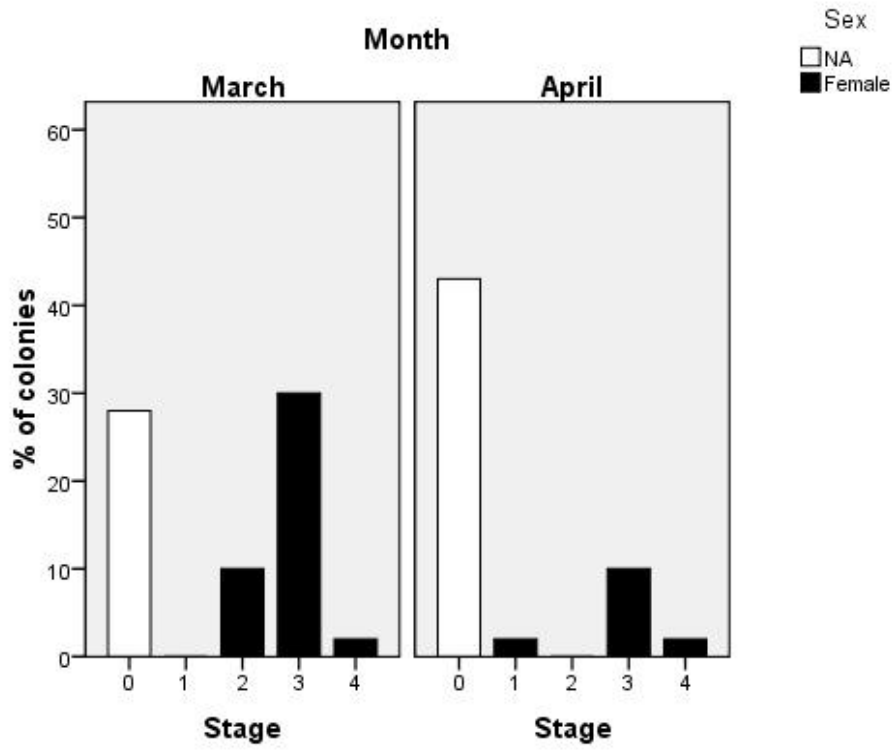
(a) Stage 1 oocytes

(b) Stage 3 oocytes (pink) and stage 3 spermatocytes (black)

- **Figure 4.6 Micrograph of histological sections of *Favites pentagona* collected from sites during March and April 2009**



- **Figure 4.7 The percentage of *Favites pentagona* colonies collected during the two sampling periods showing each stage of gamete development**

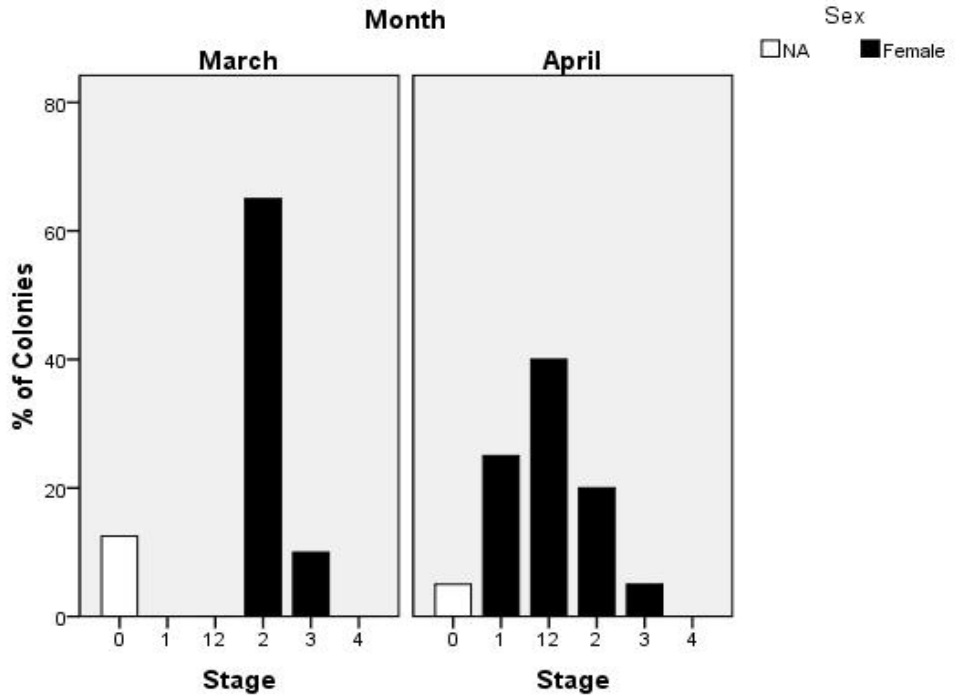


- **Figure 4.8 The overall percentage of *Favites pentagona* colonies collected during the two sampling periods showing each stage of gamete development**

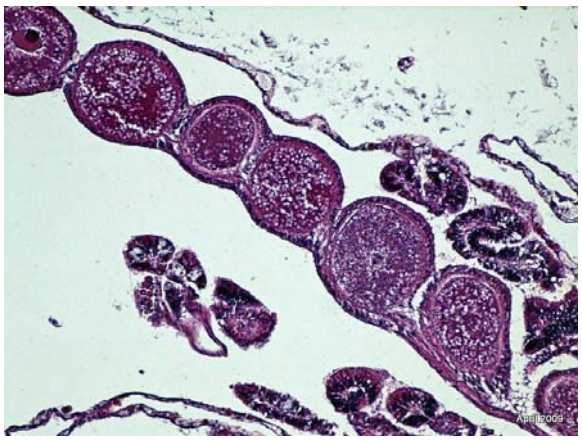
4.2.2. *Acropora* and *Montipora* Spawning

Coral colonies from the genus *Acropora* participate in mass spawning and individuals may contain both male and female gametes. During both surveys, there was no evidence of mature stage 4 eggs in colonies of *Acropora*, which would be released during the March or April spawning periods (**Figure 4.9**). Less than 10% of *Acropora* colonies contained stage 3 gametes during both surveys (**Figure 4.9**, **Figure 4.10b**). Most *Acropora* colonies sampled contained stage 1, stage 2 or combinations of these two stages (**Figure 4.10a**) which means colonies of *Acropora* are likely to spawn later in the year once the gonads reach stage 4 maturity.

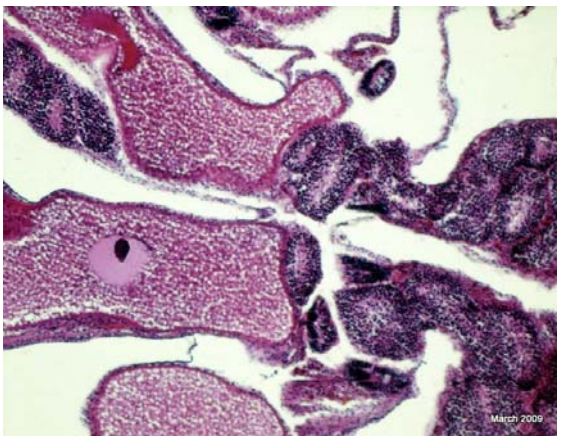
Coral colonies from the genus *Montipora* participate in mass spawning and individuals may contain male and female gametes. Only at the COX monitoring site were encrusting *Montipora* found in abundance, and only one colony contained gametes of any stage (**Appendix 1**). In April, no gametes of any reproductive stage were found in the samples collected. This indicated a spawning period outside the autumn period, potentially in late spring or summer.



- **Figure 4.9 The percentage of *Acropora* colonies collected during the two sampling periods showing each stage (and combinations) of gamete development**



(a) stage 1 and 2 oocytes



(b) stage 3 oocytes (pink left) and stage 3 spermatocytes (dark right)

- **Figure 4.10 Micrographs of histological sections of *Acropora* samples**

5. Discussion

The results of surveys to determine the dominant and sub-dominant coral species occurring at the six monitoring sites indicated the most dominant corals at five of the six sites were from the genus *Turbinaria* and the sub-dominant species at five of the six sites was from the genus *Favites*. Branching *Acropora* and encrusting *Montipora* spp. corals were found in small numbers only at the offshore ridgelines in deeper water (>12 m) at COR and COX respectively. Only one or two colonies of each of these two genera were found growing at the other four monitoring sites located in shallower coastal waters.

The results of the autumn spawning surveys indicated no real period that could be defined as a 'mass spawning' of *Turbinaria.* There is evidence of mature eggs and sperm being produced before and after the March and April 2009 full moons with a potential for the stage 4 gametes to be held until the following full moon in May 2009. This genus is predicted to have a 13 to 14 month reproductive cycle (Willis 1987) on the Great Barrier Reef. Based on the appearance of early stage 1 eggs and sperm during the April 2009 surveys, this may indicate maturity and spawning could occur again in the following March, April or May 2010. Alternatively the appearance of stage 1 eggs and sperm may indicate spawning will occur before the following autumn. Studies of the timing of spawning in *Turbinaria* in the Pilbara also concluded that corals from this genera are not typical 'mass spawners' and have multiple spawning events from November to April (Baird *et al.* in prep). The spawning of *Favites pentagona* appears to occur primarily in the autumn months. There was some evidence of spawning outside of this period by a quarter of the individuals examined. The results of this study present a difficult situation for accurately predicting a spawning window for both dominant and sub-dominant species. There may be no 'mass spawning' occurring after any particular full moon during the year.

The corals growing on inshore and midshore ridges are more likely to be potentially impacted upon by the dredging activities associated with the Outer Harbour Development. Therefore the timing of spawning for the two genera, *Turbinaria* and *Favites* should be the main focus of any efforts to quantify the potential effects of dredging related activities on gamete fertilisation and larval survival. Recent studies into the effect of suspended solids (grain size <63µm) on fertilisation and larval development in *Acropora millepora* concluded that suspended sediment levels of >50 mg/L inhibited fertilisation but had little effect on larval development (Humphrey *et al.* 2008). The grain sizes of dredged suspended sediments in the Outer Harbour Development are likely to a range of sizes. A more applicable study in to the effects of suspended solids on fertilisation and larval development that incorporated a larger range of grain sizes from 50–200 µm found that a concentration suspended sediments of >50mg/L is required to inhibit fertilisation but had little effect on the larval development (Gilmour 1999).

Both of these studies used *Acropora* to test the effects of suspended sediment on fertilisation and larval survival. Gilmour *et al.* (2006) examined the water quality environment in the Pilbara region and identified a range of potential water quality stressors such as increases in sedimentation and

suspended solids. The susceptibility of a range of adult coral taxa to these stressors was characterised into three categories; high, medium and low. The dominant adult coral taxa occurring in the Port Hedland area is *Turbinaria* which is described by Gilmour *et al.* (2006) as having low susceptibility to increases in sedimentation and suspended solids. Other genera in the Port Hedland region such as corals from the Faviidae and Poritidae family and *Acropora* (branching) were described as having medium susceptibility to major changes in the sedimentation and suspended solids. It is likely that gametes and larvae of the adult genera *Turbinaria* predominately found in the Port Hedland region are also more resilient than the larvae and gametes of adult *Acropora* to elevated sediments and suspended solids.

Spawning generally takes place during neap tides in the early evening to promote gamete mixing (fertilisation) and to potentially 'satiate' predators (Babcock *et al*. 1986). In addition the viability of gametes once released is limited to several hours (Oliver & Babcock 1992) which indicates that fertilisation is optimal immediately or within a matter of hours after the release of gametes into the water column. Fertilisation is therefore most likely to occur in close proximity to the coral communities releasing the gametes during neap tides. The plume from dredging and spoil disposal during the neap tides is significantly reduced due to the lack of tidal movement, indicating the area of effect on coral gametes would also be reduced. Thus, gametes released from coral colonies several kilometres away from the dredging and spoil ground activities are very unlikely to be affected by the dredge and spoil related activities.

The results collected from the spring spawning surveys to identify significant spawning periods and the modelling of plumes created by dredging and spoil activities during these periods can be used to develop meaningful management responses.

6. Conclusions

A summary of the conclusions and recommendations arising from the autumn coral spawning surveys is presented below:

- The most abundant dominant (*Turbinaria*) and sub-dominant genera (*Favites*) of corals found at the six monitoring sites showed signs of spawning after the full moons March and April.
- Coral from the *Acropora* and *Montipora* genera are primarily found at offshore locations and in very low abundance and are not located in the areas potentially impacted by the Outer Harbour Development.
- The spawning surveys should be repeated during the spring/summer months in 2009 to determine the potential spawning windows in that period for the dominant and sub-dominant species.
- Based on the results collected from the spring spawning surveys to identify the spawning periods, and further investigations into the extent of the plume created by dredging and spoil activities during these periods, meaningful management responses can be developed.

7. References

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Appendix A Sampling Data

CORAL SAMPLES MARCH 2009											
Site	Date	Depth	Species		No.	ST	Ova	Stage	Sperm	Stage	Information
WIS	5/03/2009	5m	T1	Turbinaria spp	1		Y	IV			3150001
WIS	5/03/2009	5m	T2	Turbinaria spp	1		Y	I & II			3150002
WIS	5/03/2009	5m	T3	Turbinaria spp	1				Y	IV	3150003, 3150004
WIS	5/03/2009	5m	T4	Turbinaria spp	1		Y	IV			3150005
WIS	5/03/2009	5m	T5	Turbinaria spp	1				Y	III & IV	mostly IV. 3150006, 3150007
WIS	5/03/2009	5m	T6	Turbinaria spp	1				Y	III & IV	3150008, 3150009,3150010
WIS	5/03/2009	5m	T7	Turbinaria spp	1						no gametes identified
WIS	5/03/2009	5m	T8	Turbinaria spp	1				Y	III & IV	3150011, 3150012
WIS	5/03/2009	5m	T9	Turbinaria spp	1				Y	III & IV	3150013, 3150014
WIS	5/03/2009	5m	T10	Turbinaria spp	1		Y	IV			3150015
WIS	5/03/2009	5m	T11	Turbinaria spp	1						no gametes identified
WIS	5/03/2009	5m	T12	Turbinaria spp	1				Y	IV	3150016
WIS	5/03/2009	5m	T13	Turbinaria spp	1		Y	IV			3150017
WIS	5/03/2009	5m	T14	Turbinaria spp	1				Y	III & IV	3150018
WIS	5/03/2009	5m	T15	Turbinaria spp	1				Y	III & IV	3150019
WIS	5/03/2009	5m	T16	Turbinaria spp	1		Y	IV			3150020
WIS	5/03/2009	5m	T17	Turbinaria spp	1		Y	IV			3150021
WIS	5/03/2009	5m	T18	Turbinaria spp	1				Y	III & IV	3150022
WIS	5/03/2009	5m	T19	Turbinaria spp	1				Y	III & IV	3150023
WIS	5/03/2009	5m	T20	Turbinaria spp	1		Y	IV			3150024
WIS	5/03/2009	5m	O01	Gon/Fav spp	1		Y	III	Y	II	3150025, 3150026
WIS	5/03/2009	5m	O02	Gon/Fav spp	1		Y	II			3150027
WIS	5/03/2009	5m	O03	Gon/Fav spp	1		Y	II			3150028, 3150029, 3150030
WIS	5/03/2009	5m	O04	Gon/Fav spp	1		Y	III	Y	III	3150031, 3150032
WIS	5/03/2009	5m	O05	Gon/Fav spp	1						no gametes identified
WIS	5/03/2009	5m	O06	Gon/Fav spp	1		Y	II&III	Y	II	3150033, 3150034, 3150035
WIS	5/03/2009	5m	O07	Gon/Fav spp	1		Y	II	Y	II	3150036, 3150037, 3150038

CORAL SAMPLES MARCH 2009											
Site	Date	Depth	Species		No.	ST	Ova	Stage	Sperm	Stage	Information
WIS	5/03/2009	5m	O08	Gon/Fav spp	1		Y	II			3150039
WIS	5/03/2009	5m	O09	Gon/Fav spp	1		Y	II	Y	II	3150040
WIS	5/03/2009	5m	O10	Gon/Fav spp	1	30					no gametes found
CTH	5/03/2009	9m	T1	Turbinaria spp	1				Y	III&IV	3150041, 3150042
CTH	5/03/2009	9m	T2	Turbinaria spp	1						no gametes identified
CTH	5/03/2009	9m	T3	Turbinaria spp	1						no gametes identified
CTH	5/03/2009	9m	T4	Turbinaria spp	1				Y	III&IV	3150043, 3150044
CTH	5/03/2009	9m	T5	Turbinaria spp	1						no gametes identified
CTH	5/03/2009	9m	T6	Turbinaria spp	1				Y	III&IV	3150045, 3150046
CTH	5/03/2009	9m	T7	Turbinaria spp	1				Y	III&IV	3150047
CTH	5/03/2009	9m	T8	Turbinaria spp	1		Y	III			single ova identified - granular 3150048
CTH	5/03/2009	9m	T9	Turbinaria spp	1				Y	III&IV	3150049
CTH	5/03/2009	9m	T10	Turbinaria spp	1		Y	IV			
CTH	5/03/2009	9m	T11	Turbinaria spp	1		Y	IV			3150050
CTH	5/03/2009	9m	T12	Turbinaria spp	1				Y	III&IV	3150051
CTH	5/03/2009	9m	T13	Turbinaria spp	1				Y	III&IV	3150052
CTH	5/03/2009	9m	T14	Turbinaria spp	1		Y	IV			
CTH	5/03/2009	9m	T15	Turbinaria spp	1				Y	III&IV	3150053
CTH	5/03/2009	9m	T16	Turbinaria spp	1				Y	III&IV	3150054
CTH	5/03/2009	9m	T17	Turbinaria spp	1				Y	III&IV	3150055
CTH	5/03/2009	9m	T18	Turbinaria spp	1		Y	IV			3150056
CTH	5/03/2009	9m	T19	Turbinaria spp	1				Y	III&IV	3150057
CTH	5/03/2009	9m	T20	Turbinaria spp	1				Y	III&IV	3150058, 3150059, 3150060
CTH	5/03/2009	9m	O01	Gon/Fav spp	1						no gametes identified
CTH	5/03/2009	9m	O02	Gon/Fav spp	1		Y	III	Y	III	3150061, 3150062
CTH	5/03/2009	9m	O03	Gon/Fav spp	1		Y	II&III			3150063
CTH	5/03/2009	9m	O04	Gon/Fav spp	1		Y	III	Y	III	3150064, 3150065,3150066
CTH	5/03/2009	9m	O05	Gon/Fav spp	1		Y	III	Y	III	
CTH	5/03/2009	9m	O06	Gon/Fav spp	1		Y				one ova, stage not determinable

CORAL SAMPLES MARCH 2009											
Site	Date	Depth	Species		No.	ST	Ova	Stage	Sperm	Stage	Information
CTH	5/03/2009	9m	O07	Gon/Fav spp	1						no gametes identified
CTH	5/03/2009	9m	O08	Gon/Fav spp	1		Y	III & IV	Y	III	3150067
CTH	5/03/2009	9m	O09	Gon/Fav spp	1		Y	III?	Y?	III?	3150068
CTH	5/03/2009	9m	O10	Gon/Fav spp	1						no gametes identified
CTH	5/03/2009	9m	A1	Acropora spp		30					
MIB	6/03/2009	10.8m	T1	Turbinaria spp	1				Y	III & IV	3150069
MIB	6/03/2009	10.8m	T2	Turbinaria spp	1		Y	IV			3150070
MIB	6/03/2009	10.8m	T3	Turbinaria spp	1						no gametes identified
MIB	6/03/2009	10.8m	T4	Turbinaria spp	1				Y	III & IV	3150071
MIB	6/03/2009	10.8m	T5	Turbinaria spp	1						no gametes identified - fish egg between polyps
MIB	6/03/2009	10.8m	T6	Turbinaria spp	1		Y	IV			3150072
MIB	6/03/2009	10.8m	T7	Turbinaria spp	1		Y	IV			3150073
MIB	6/03/2009	10.8m	T8	Turbinaria spp	1		Y	IV			
MIB	6/03/2009	10.8m	T9	Turbinaria spp	1				Y	III & IV	
MIB	6/03/2009	10.8m	T10	Turbinaria spp	1		Y	IV			3150074
MIB	6/03/2009	10.8m	T11	Turbinaria spp	1		Y	IV			
MIB	6/03/2009	10.8m	T12	Turbinaria spp	1				Y	III & IV	3150075
MIB	6/03/2009	10.8m	T13	Turbinaria spp	1		Y	IV			3150076
MIB	6/03/2009	10.8m	T14	Turbinaria spp	1		Y	I			3150077
MIB	6/03/2009	10.8m	T15	Turbinaria spp	1				Y	III & IV	3150078, 3150079
MIB	6/03/2009	10.8m	T16	Turbinaria spp	1				Y	III & IV	3150080
MIB	6/03/2009	10.8m	T17	Turbinaria spp	1				Y	III & IV	3150081, 3150082
MIB	6/03/2009	10.8m	T18	Turbinaria spp	1				Y	III & IV	
MIB	6/03/2009	10.8m	T19	Turbinaria spp	1				Y	III & IV	3150083, 3150084
MIB	6/03/2009	10.8m	T20	Turbinaria spp	1		Y	IV			
MIB	6/03/2009	10.8m	O01	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O02	Gon/Fav spp	1		Y	III	Y	III	3150085, 3150086
MIB	6/03/2009	10.8m	O03	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O04	Gon/Fav spp	1						no gametes identified

CORAL SAMPLES MARCH 2009											
Site	Date	Depth	Species		No.	ST	Ova	Stage	Sperm	Stage	Information
MIB	6/03/2009	10.8m	O05	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O06	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O07	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O08	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O09	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O10	Gon/Fav spp	1	30					no gametes identified
LTI	6/03/2009	11.3m	T1	Turbinaria spp	1				Y	III & IV	3150087, 3150088
LTI	6/03/2009	11.3m	T2	Turbinaria spp	1				Y	III & IV	
LTI	6/03/2009	11.3m	T3	Turbinaria spp	1				Y	III & IV	3150089
LTI	6/03/2009	11.3m	T4	Turbinaria spp	1		Y	IV			3150090
LTI	6/03/2009	11.3m	T5	Turbinaria spp	1				Y	III & IV	3150091
LTI	6/03/2009	11.3m	T6	Turbinaria spp	1		Y	IV			
LTI	6/03/2009	11.3m	T7	Turbinaria spp	1				Y	III & IV	
LTI	6/03/2009	11.3m	T8	Turbinaria spp	1				Y	III & IV	3150092, 3150093
LTI	6/03/2009	11.3m	T9	Turbinaria spp	1				Y	IV	3150094
LTI	6/03/2009	11.3m	T10	Turbinaria spp	1				Y	III & IV	
LTI	6/03/2009	11.3m	T11	Turbinaria spp	1				Y	III & IV	3150095
LTI	6/03/2009	11.3m	T12	Turbinaria spp	1						no gametes identified
LTI	6/03/2009	11.3m	T13	Turbinaria spp	1		Y	IV			
LTI	6/03/2009	11.3m	T14	Turbinaria spp	1						no gametes identified
LTI	6/03/2009	11.3m	T15	Turbinaria spp	1		Y	IV			3150096, 3150097
LTI	6/03/2009	11.3m	T16	Turbinaria spp	1		Y	IV			
LTI	6/03/2009	11.3m	T17	Turbinaria spp	1		Y	IV			3150098, 3150099
LTI	6/03/2009	11.3m	T18	Turbinaria spp	1		Y	IV			
LTI	6/03/2009	11.3m	T19	Turbinaria spp	1				Y	III & IV	
LTI	6/03/2009	11.3m	T20	Turbinaria spp	1		Y	IV			3150100
LTI	6/03/2009	11.3m	O01	Gon/Fav spp	1				Y	III	3150101, 3150102
LTI	6/03/2009	11.3m	O02	Gon/Fav spp	1						no gametes identified
LTI	6/03/2009	11.3m	O03	Gon/Fav spp	1						no gametes identified

CORAL SAMPLES MARCH 2009											
Site	Date	Depth	Species		No.	ST	Ova	Stage	Sperm	Stage	Information
LTI	6/03/2009	11.3m	O04	Gon/Fav spp	1						no gametes identified
LTI	6/03/2009	11.3m	O05	Gon/Fav spp	1						no gametes identified
LTI	6/03/2009	11.3m	O06	Gon/Fav spp	1						no gametes identified
LTI	6/03/2009	11.3m	O07	Gon/Fav spp	1						no gametes identified
LTI	6/03/2009	11.3m	O08	Gon/Fav spp	1		Y	III	Y	III	3150103
LTI	6/03/2009	11.3m	O09	Gon/Fav spp	1		Y	III	Y	III	3150104, 3150105, 3150106
LTI	6/03/2009	11.3m	O10	Gon/Fav spp	1						no gametes identified
LTI	6/03/2009	11.3m	M1	Montipora spp	1						no gametes identified
LTI	6/03/2009	11.3m	M2	Montipora spp	1						no gametes identified, 3150107
LTI	6/03/2009	11.3m	WS1	WS/Turb spp	1	33	Y	IV			3150108, 3150109
COX	6/03/2009	15.0m	T1	Turbinaria spp	1		Y	IV			3150110, 3150111, 315012
COX	6/03/2009	15.0m	T2	Turbinaria spp	1		Y	IV			
COX	6/03/2009	15.0m	T3	Turbinaria spp	1						no gametes identified
COX	6/03/2009	15.0m	T4	Turbinaria spp	1				Y	III & IV	3150113
COX	6/03/2009	15.0m	T5	Turbinaria spp	1		Y	IV			3150114
COX	6/03/2009	15.0m	T6	Turbinaria spp	1				Y	III & IV	3150115
COX	6/03/2009	15.0m	T7	Turbinaria spp	1				Y	III & IV	3150116
COX	6/03/2009	15.0m	T8	Turbinaria spp	1				Y	III & IV	3150117
COX	6/03/2009	15.0m	T9	Turbinaria spp	1		Y	IV			
COX	6/03/2009	15.0m	T10	Turbinaria spp	1				Y	III & IV	
COX	6/03/2009	15.0m	T11	Turbinaria spp	1		Y	IV			
COX	6/03/2009	15.0m	T12	Turbinaria spp	1				Y	IV	
COX	6/03/2009	15.0m	T13	Turbinaria spp	1				Y	III & IV	3150118
COX	6/03/2009	15.0m	T14	Turbinaria spp	1		Y	IV			
COX	6/03/2009	15.0m	T15	Turbinaria spp	1				Y	III & IV	3150119, 3150120
COX	6/03/2009	15.0m	T16	Turbinaria spp	1		Y	IV			3150121
COX	6/03/2009	15.0m	T17	Turbinaria spp	1				Y	III & IV	
COX	6/03/2009	15.0m	T18	Turbinaria spp	1		Y	IV			3150122
COX	6/03/2009	15.0m	T19	Turbinaria spp	1				Y	III & IV	

CORAL SAMPLES MARCH 2009											
Site	Date	Depth	Species		No.	ST	Ova	Stage	Sperm	Stage	Information
COX	6/03/2009	15.0m	T20	Turbinaria spp	1						no gametes identified
COX	6/03/2009	15.0m	O01	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O02	Montipora spp	1						no gametes identified, 3150123
COX	6/03/2009	15.0m	O03	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O04	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O05	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O06	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O07	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O08	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O09	Montipora spp	1		Y	III?			one only ova identified, 3150124
COX	6/03/2009	15.0m	O10	Montipora spp	1		Y	III	Y	II	3150125
COX	6/03/2009	15.0m	O11/G1	Gon/Fav spp	1	31					no gametes identified
COR	6/03/2009	12.5m	O01	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O02	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O03	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O04	Gon/Fav spp	1		Y	III?	Y	II&III	no nucleus for ova in section,3150126
COR	6/03/2009	12.5m	O05	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O06	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O07	Gon/Fav spp	1		Y	III	Y	III	3150127, 3150128
COR	6/03/2009	12.5m	O08	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O09	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O10	Gon/Fav spp	1		Y	III	Y	III	3150129
COR	6/03/2009	12.5m	A1	Acropora spp	1		Y	II			3150130
COR	6/03/2009	12.5m	A2	Acropora spp	1		Y	II			3150131
COR	6/03/2009	12.5m	A3	Acropora spp	1		Y	II			3150132
COR	6/03/2009	12.5m	A4	Acropora spp	1						no gametes identified
COR	6/03/2009	12.5m	A5	Acropora spp	1						no gametes identified
COR	6/03/2009	12.5m	A6	Acropora spp	1		Y	III	Y	III	3150133, 3150134, 3150135
COR	6/03/2009	12.5m	A7	Acropora spp	1		Y	II			3150136

CORAL SAMPLES MARCH 2009											
Site	**Date**	**Depth**	**Species**		**No.**	**ST**	**Ova**	**Stage**	**Sperm**	**Stage**	**Information**
COR	6/03/2009	12.5m	A8	Acropora spp	1		Y	II			
COR	6/03/2009	12.5m	A9	Acropora spp	1		Y	II			
COR	6/03/2009	12.5m	A10	Acropora spp	1		Y	II			3150137
COR	6/03/2009	12.5m	A11	Acropora spp	1						no gametes identified
COR	6/03/2009	12.5m	A12	Acropora spp	1		Y	II			
COR	6/03/2009	12.5m	A13	Acropora spp	1						no gametes identified
COR	6/03/2009	12.5m	A14	Acropora spp	1		Y	II			3150138
COR	6/03/2009	12.5m	A15	Acropora spp	1		Y	II			
COR	6/03/2009	12.5m	A16	Acropora spp	1		Y	II			
COR	6/03/2009	12.5m	A17	Acropora spp	1		Y	II			
COR	6/03/2009	12.5m	A18	Acropora spp	1		Y	III	Y	III	3150139, 3150140, 3150141, 3150142
COR	6/03/2009	12.5m	A19	Acropora spp	1		Y	II			
COR	6/03/2009	12.5m	A20	Acropora spp	1	30					no gametes identified
				Total	184	184					

CORAL SAMPLES APRIL 2009											
Site	Coll Date	Depth	Speci	Species	No.	ST	Ova	Stage	Sperm	Stage	Information
WIS	5/03/2009	5m	T1	Turbinaria spp	1				Y	IV	post spawn P5080150 - P5080154
WIS	5/03/2009	5m	T2	Turbinaria spp	1		Y	IV & I			P5080155 - P5080158
WIS	5/03/2009	5m	T3	Turbinaria spp	1				Y	III &IV	P5080159 - P5080161
WIS	5/03/2009	5m	T4	Turbinaria spp	1		Y	IV & I			P5080162 - P5080169
WIS	5/03/2009	5m	T5	Turbinaria spp	1				Y	III &IV	P5080170 - P5080171
WIS	5/03/2009	5m	T6	Turbinaria spp	1		Y	IV & I			P5080172 - P5080177
WIS	5/03/2009	5m	T7	Turbinaria spp	1		Y	IV & I			P5080178 - P5080181
WIS	5/03/2009	5m	T8	Turbinaria spp	1				Y	IV & I	P5080182 - P5080185
WIS	5/03/2009	5m	T9	Turbinaria spp	1		Y	I			P5080186 - P5080189
WIS	5/03/2009	5m	T10	Turbinaria spp	1				Y	III &IV	P5080190
WIS	5/03/2009	5m	T11	Turbinaria spp	1		Y	IV & I			P5080191 - P5080192
WIS	5/03/2009	5m	T12	Turbinaria spp	1				Y	IV	P5080193
WIS	5/03/2009	5m	T13	Turbinaria spp	1				Y	IV	P5080194 - P5080195
WIS	5/03/2009	5m	T14	Turbinaria spp	1		Y	IV & I			P5080196 - P5080197
WIS	5/03/2009	5m	T15	Turbinaria spp	1		Y	IV & I			P5080198 - P5080199
WIS	5/03/2009	5m	T16	Turbinaria spp	1		Y	IV & I			P5080200 - P5080201
WIS	5/03/2009	5m	T17	Turbinaria spp	1				Y	IV & I	P5080202 & P5080438
WIS	5/03/2009	5m	T18	Turbinaria spp	1				Y	IV	P5080203
WIS	5/03/2009	5m	T19	Turbinaria spp	1				Y	IV	P5080204
WIS	5/03/2009	5m	T20	Turbinaria spp	1		Y	I			P5080205 - P5080208
WIS	5/03/2009	5m	O01	Gon/Fav spp	1		Y	I			P5080209
WIS	5/03/2009	5m	O02	Gon/Fav spp	1						no gametes identified
WIS	5/03/2009	5m	O03	Gon/Fav spp	1						no gametes identified

CORAL SAMPLES APRIL 2009											
Site	Coll Date	Depth	Speci	Species	No.	ST	Ova	Stage	Sperm	Stage	Information
WIS	5/03/2009	5m	O04	Gon/Fav spp	1						no gametes identified
WIS	5/03/2009	5m	O05	Gon/Fav spp	1						no gametes identified
WIS	5/03/2009	5m	O06	Gon/Fav spp	1		Y	III	Y	III	P5080210
WIS	5/03/2009	5m	O07	Gon/Fav spp	1						no gametes identified
WIS	5/03/2009	5m	O08	Gon/Fav spp	1						no gametes identified
WIS	5/03/2009	5m	O09	Gon/Fav spp	1						no gametes identified
WIS	5/03/2009	5m	O10	Gon/Fav spp	1						no gametes identified
CTH	5/03/2009	9m	T1	Turbinaria spp	1				Y	III &IV & I	P5080211 - P5080213
CTH	5/03/2009	9m	T2	Turbinaria spp	1		Y	I			P5080214 - P5080216
CTH	5/03/2009	9m	T3	Turbinaria spp	1				Y	IV & I	P5080217
CTH	5/03/2009	9m	T4	Turbinaria spp	1		Y	I			P5080218
CTH	5/03/2009	9m	T5	Turbinaria spp	1		Y	I			P5080219
CTH	5/03/2009	9m	T6	Turbinaria spp	1				Y	III & IV	P5080220
CTH	5/03/2009	9m	T7	Turbinaria spp	1				Y	III & IV	P5080221
CTH	5/03/2009	9m	T8	Turbinaria spp	1				Y	IV	P5080222
CTH	5/03/2009	9m	T9	Turbinaria spp	1		Y	IV & I			P5080223 - P5080224
CTH	5/03/2009	9m	T10	Turbinaria spp	1		Y	I			P5080225
CTH	5/03/2009	9m	T11	Turbinaria spp	1				Y	IV & I	P5080226 - P5080230
CTH	5/03/2009	9m	T12	Turbinaria spp	1				Y	IV & I	P5080231 - P5080233
CTH	5/03/2009	9m	T13	Turbinaria spp	1		Y	IV & I			P5080234 - P5080237
CTH	5/03/2009	9m	T14	Turbinaria spp	1		Y	I			P5080238 - P5080239
CTH	5/03/2009	9m	T15	Turbinaria spp	1				Y	IV	P5080240
CTH	5/03/2009	9m	T16	Turbinaria spp	1				Y	IV	P5080241
CTH	5/03/2009	9m	T17	Turbinaria spp	1				Y	IV	P5080242

CORAL SAMPLES APRIL 2009											
Site	Coll Date	Depth	Speci	Species	No.	ST	Ova	Stage	Sperm	Stage	Information
CTH	5/03/2009	9m	T18	Turbinaria spp	1				Y	IV & I	P5080243 - P5080244
CTH	5/03/2009	9m	T19	Turbinaria spp	1		Y	IV & I			P5080245 - P5080246
CTH	5/03/2009	9m	T20	Turbinaria spp	1						no gametes identified
CTH	5/03/2009	9m	O01	Gon/Fav spp	1						no gametes identified
CTH	5/03/2009	9m	O02	Gon/Fav spp	1						no gametes identified
CTH	5/03/2009	9m	O03	Gon/Fav spp	1						no gametes identified
CTH	5/03/2009	9m	O04	Gon/Fav spp	1						no gametes identified
CTH	5/03/2009	9m	O05	Gon/Fav spp	1						no gametes identified
CTH	5/03/2009	9m	O06	Gon/Fav spp	1		Y	III	Y	III	P5080247 - P5080250
CTH	5/03/2009	9m	O07	Gon/Fav spp	1						no gametes identified
CTH	5/03/2009	9m	O08	Gon/Fav spp	1						no gametes identified
CTH	5/03/2009	9m	O09	Gon/Fav spp	1						no gametes identified
CTH	5/03/2009	9m	O10	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	T1	Turbinaria spp	1		Y	IV			P5080251 - P5080252
MIB	6/03/2009	10.8m	T2	Turbinaria spp	1		Y	IV & I			P5080253 - P5080257
MIB	6/03/2009	10.8m	T3	Turbinaria spp	1				Y	IV & I	P5080258 - P5080260
MIB	6/03/2009	10.8m	T4	Turbinaria spp	1				Y	IV & I	P5080261 - P5080264
MIB	6/03/2009	10.8m	T5	Turbinaria spp	1				Y	IV & I	P5080265 - P5080266
MIB	6/03/2009	10.8m	T6	Turbinaria spp	1				Y	III & IV	P5080267
MIB	6/03/2009	10.8m	T7	Turbinaria spp	1						no gametes identified
MIB	6/03/2009	10.8m	T8	Turbinaria spp	1				Y	III & IV	P5080268
MIB	6/03/2009	10.8m	T9	Turbinaria spp	1				Y	III & IV	P5080269- P5080270
MIB	6/03/2009	10.8m	T10	Turbinaria spp	1				Y	IV	P5080271
MIB	6/03/2009	10.8m	T11	Turbinaria spp	1		Y	I			P5080272 & P5080428, P5080429

CORAL SAMPLES APRIL 2009											
Site	Coll Date	Depth	Speci	Species	No.	ST	Ova	Stage	Sperm	Stage	Information
MIB	6/03/2009	10.8m	T12	Turbinaria spp	1						no gametes identified
MIB	6/03/2009	10.8m	T13	Turbinaria spp	1				Y	IV	P5080273
MIB	6/03/2009	10.8m	T14	Turbinaria spp	1		Y	IV & I			P5080274 - P5080277
MIB	6/03/2009	10.8m	T15	Turbinaria spp	1		Y	I			P5080278 & P5080430, P5080431
MIB	6/03/2009	10.8m	T16	Turbinaria spp	1		Y	IV & I			P5080279 - P5080280
MIB	6/03/2009	10.8m	T17	Turbinaria spp	1				Y	I	P5080281
MIB	6/03/2009	10.8m	T18	Turbinaria spp	1		Y	IV & I			P5080282 - P5080285
MIB	6/03/2009	10.8m	T19	Turbinaria spp	1		Y	I			P5080286 - P5080287
MIB	6/03/2009	10.8m	T20	Turbinaria spp	1		Y	IV & I			P5080288 - P5080290
MIB	6/03/2009	10.8m	O01	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O02	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O03	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O04	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O05	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O06	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O07	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O08	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O09	Gon/Fav spp	1						no gametes identified
MIB	6/03/2009	10.8m	O10	Gon/Fav spp	1						no gametes identified
LTI	6/03/2009	11.3m	T1	Turbinaria spp	1		Y	IV & I			P5080291- P5080292
LTI	6/03/2009	11.3m	T2	Turbinaria spp	1				Y	IV	P5080293
LTI	6/03/2009	11.3m	T3	Turbinaria spp	1		Y	I			P5080432- P5080433
LTI	6/03/2009	11.3m	T4	Turbinaria spp	1		Y	IV & I			P5080294- P5080295
LTI	6/03/2009	11.3m	T5	Turbinaria spp	1						no gametes identified - recut

CORAL SAMPLES APRIL 2009											
Site	Coll Date	Depth	Speci	Species	No.	ST	Ova	Stage	Sperm	Stage	Information
LTI	6/03/2009	11.3m	T6	Turbinaria spp	1				Y	I	P5080296
LTI	6/03/2009	11.3m	T7	Turbinaria spp	1		Y	IV & I			P5080297- P5080298
LTI	6/03/2009	11.3m	T8	Turbinaria spp	1				Y	I	P5080299 & P5080437
LTI	6/03/2009	11.3m	T9	Turbinaria spp	1		Y	IV & I			P5080300 - P5080301
LTI	6/03/2009	11.3m	T10	Turbinaria spp	1				Y	III & IV & I	P5080302 - P5080303
LTI	6/03/2009	11.3m	T11	Turbinaria spp	1				Y	IV & I	P5080304 - P5080306
LTI	6/03/2009	11.3m	T12	Turbinaria spp	1						no gametes identified
LTI	6/03/2009	11.3m	T13	Turbinaria spp	1				Y	IV & I	P5080307 - P5080308
LTI	6/03/2009	11.3m	T14	Turbinaria spp	1				Y	IV & I	P5080309 - P5080310
LTI	6/03/2009	11.3m	T15	Turbinaria spp	1				Y	III & IV	P5080311 - P5080312
LTI	6/03/2009	11.3m	T16	Turbinaria spp	1				Y	IV	P5080313
LTI	6/03/2009	11.3m	T17	Turbinaria spp	1				Y	III & IV	P5080314 - P5080315
LTI	6/03/2009	11.3m	T18	Turbinaria spp	1		Y	IV & I			P5080316 - P5080321
LTI	6/03/2009	11.3m	T19	Turbinaria spp	1		Y	IV & I			P5080322 - P5080325
LTI	6/03/2009	11.3m	T20	Turbinaria spp	1		Y	IV & I			P5080326 - P5080328
LTI	6/03/2009	11.3m	O01	Gon/Fav spp	1						no gametes identified
LTI	6/03/2009	11.3m	O02	Gon/Fav spp	1		Y	III	Y	III	P5080329 - P5080331
LTI	6/03/2009	11.3m	O03	Gon/Fav spp	1						no gametes identified
LTI	6/03/2009	11.3m	O04	Gon/Fav spp	1		Y	III	Y	III	P5080333 - P5080334
LTI	6/03/2009	11.3m	O05	Gon/Fav spp	1						no gametes identified
LTI	6/03/2009	11.3m	O06	Gon/Fav spp	1						no gametes identified
LTI	6/03/2009	11.3m	O07	Gon/Fav spp	1						no gametes identified
LTI	6/03/2009	11.3m	O08	Gon/Fav spp	1		Y	IV	Y	IV	P5080335 - P5080337
LTI	6/03/2009	11.3m	O09	Gon/Fav spp	1						no gametes identified

CORAL SAMPLES APRIL 2009											
Site	Coll Date	Depth	Speci	Species	No.	ST	Ova	Stage	Sperm	Stage	Information
LTI	6/03/2009	11.3m	O10	Gon/Fav spp	1						no gametes identified
COX	6/03/2009	15.0m	T1	Turbinaria spp	1		Y	I			P5080338 - P5080341
COX	6/03/2009	15.0m	T2	Turbinaria spp	1				Y	IV & I	P5080342 - P5080344
COX	6/03/2009	15.0m	T3	Turbinaria spp	1						no gametes identified - recut
COX	6/03/2009	15.0m	T4	Turbinaria spp	1		Y	IV & I			P5080345 - P5080348
COX	6/03/2009	15.0m	T5	Turbinaria spp	1		Y	IV & I			P5080349 - P5080352
COX	6/03/2009	15.0m	T6	Turbinaria spp	1		Y	IV & I			P5080353 - P5080355
COX	6/03/2009	15.0m	T7	Turbinaria spp	1		Y	I			P5080356 - P5080359
COX	6/03/2009	15.0m	T8	Turbinaria spp	1				Y	IV	P5080360 - P5080361 & P5080434
COX	6/03/2009	15.0m	T9	Turbinaria spp	1		Y	IV & I			P5080362 - P5080364
COX	6/03/2009	15.0m	T10	Turbinaria spp	1		Y	IV & I			P5080365 - P5080368
COX	6/03/2009	15.0m	T11	Turbinaria spp	1				Y	IV	P5080369
COX	6/03/2009	15.0m	T12	Turbinaria spp	1		Y	I			P5080370 & P5080435 - P5080436
COX	6/03/2009	15.0m	T13	Turbinaria spp	1						no gametes identified - recut
COX	6/03/2009	15.0m	T14	Turbinaria spp	1		Y	I			P5080371 - P5080372
COX	6/03/2009	15.0m	T15	Turbinaria spp	1				Y	III & IV	P5080373
COX	6/03/2009	15.0m	T16	Turbinaria spp	1		Y	IV & I			P5080374 - P5080375
COX	6/03/2009	15.0m	T17	Turbinaria spp	1				Y	IV	P5080376 - P5080377
COX	6/03/2009	15.0m	T18	Turbinaria spp	1				Y	IV & I	P5080378 - P5080380
COX	6/03/2009	15.0m	T19	Turbinaria spp	1		Y	IV & I			P5080381 - P5080383
COX	6/03/2009	15.0m	T20	Turbinaria spp	1				Y	III & IV	P5080384
COX	6/03/2009	15.0m	O01	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O02	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O03	Montipora spp	1						no gametes identified

CORAL SAMPLES APRIL 2009											
Site	Coll Date	Depth	Speci	Species	No.	ST	Ova	Stage	Sperm	Stage	Information
COX	6/03/2009	15.0m	O04	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O05	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O06	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O07	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O08	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O09	Montipora spp	1						no gametes identified
COX	6/03/2009	15.0m	O10	Montipora spp	1						no gametes identified
COR	6/03/2009	12.5m	O01	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O02	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O03	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O04	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O05	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O06	Gon/Fav spp	1		Y	III	Y	III	P5080385 - P5080389
COR	6/03/2009	12.5m	O07	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O08	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O09	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	O10	Gon/Fav spp	1						no gametes identified
COR	6/03/2009	12.5m	A1	Acropora spp	1		Y	I			P5080390 - P5080391
COR	6/03/2009	12.5m	A2	Acropora spp	1		Y	I			P5080392- P5080393
COR	6/03/2009	12.5m	A3	Acropora spp	1						no gametes identified
COR	6/03/2009	12.5m	A4	Acropora spp	1		Y	I & II			P5080394- P5080395
COR	6/03/2009	12.5m	A5	Acropora spp	1		Y	I			P5080396
COR	6/03/2009	12.5m	A6	Acropora spp	1		Y	I			P5080397 - P5080398
COR	6/03/2009	12.5m	A7	Acropora spp	1		Y	I & II			P5080399 - P5080401

CORAL SAMPLES APRIL 2009											
Site	Coll Date	Depth	Speci	Species	No.	ST	Ova	Stage	Sperm	Stage	Information
COR	6/03/2009	12.5m	A8	Acropora spp	1		Y	II			P5080402 - P5080404
COR	6/03/2009	12.5m	A9	Acropora spp	1						no gametes identified
COR	6/03/2009	12.5m	A10	Acropora spp	1		Y	I & II			P5080405 - P5080407
COR	6/03/2009	12.5m	A11	Acropora spp	1		Y	I & II			P5080408
COR	6/03/2009	12.5m	A12	Acropora spp	1		Y	I & II			P5080409 - P5080411
COR	6/03/2009	12.5m	A13	Acropora spp	1		Y	II			P5080412 - P5080413
COR	6/03/2009	12.5m	A14	Acropora spp	1		Y	II			P5080414 - P5080415
COR	6/03/2009	12.5m	A15	Acropora spp	1		Y	I & II			P5080416 - P5080418
COR	6/03/2009	12.5m	A16	Acropora spp	1		Y	I & II			P5080419 - P5080420
COR	6/03/2009	12.5m	A17	Acropora spp	1		Y	I & II			P5080421 - P5080422
COR	6/03/2009	12.5m	A18	Acropora spp	1		Y	III			P5080423 - P5080424
COR	6/03/2009	12.5m	A19	Acropora spp	1		Y	I			P5080425 - P5080426
COR	6/03/2009	12.5m	A20	Acropora spp	1	30	Y	II			P5080427
				Total		180					