Technical Note

Date	22 September 2011
Project No	WV05024
Subject	**Outer Harbour Development – Hard Coral Cover and Size-Frequency Distribution**

1. Introduction

The subtidal area of State waters potentially affected by the proposed Outer Harbour Development dredging and spoil disposal activities is dominated by coarse mobile sediments with areas of hard substratum (SKM 2009). These areas of hard substratum are either outcropping or covered by a thin veneer of sediment, and there is evidence they may be routinely buried, uncovered, and reburied in response to movements of sediments in response to drivers operating on different spatial and temporal scales including tides, seasonal prevailing winds and periodic storms and cyclones.

The Benthic Primary Producers (BPP, predominantly algae, hard coral and photosynthetic soft corals) and non-BPP (predominantly sponges, non-photosynthetic soft corals and other sessile invertebrates) present within State waters are mainly associated with areas of hard substratum where they comprise a mixed mosaic habitat of low percent cover. The composition of this mixed mosaic exhibits considerable variability through time with seasonally abundant BPP such as macroalgae sometimes evident, but with no one type of biota exhibiting persistently high percentage coverage. Sediment associated BPPs (e.g. seagrass) are spatially and temporally less common (SKM 2009).

Impacts from dredging activities are predicted to result from both increased sedimentation and elevation in suspended sediment levels over hard and soft substrates. The scale of the impacts has been predicted to range from irreversible loss of the benthic community under the infrastructure footprint and within the spoil grounds to reversible (temporary) loss of organisms through smothering and suspended sediment mediated light attenuation. Irreversible losses from the construction of infrastructure and the disposal of dredge spoil are relatively easy to predict based upon the area of these footprints. Reversible losses are less easy to predict and will likely be less reliable as such losses depend upon the intensity, duration and frequency of plume-driven sedimentation/turbidity events and the responses of organisms at the species and individual level.

Hard corals are likely to be the most sensitive BPP within State waters affected by dredging activities. The dominant corals present are from the genus *Turbinaria* and from the families Faviidae and Poritidae (SKM 2011). The dominance of *Turbinaria* spp. and overall low species richness and abundance (0-21.6% from SKM ground-truthing surveys) of corals within subtidal State waters in the Port Hedland area suggest that these coral communities experience, and are adapted to, high turbidity and sedimentation rates. This type of coral community is considered typical of the broader marine environment of the Pilbara region, and is also similar to other *Turbinaria* dominated coral communities in macrotidal, turbid waters elsewhere in northern Australia. No new species have been recorded from surveys in the area (SKM 2011).

Whilst the diversity and abundance of the coral community within subtidal State waters around Port Hedland has been characterised (SKM 2011), there has been little focus on the size-frequency distributions of coral colonies. This type of information can provide insight into the age structure of coral colony populations, which can help predict the recovery time of a coral population in the event of an impact, and provide insight into the frequencies and scales of natural disturbances causing mortality among corals in the region. This has particular relevance to the Environmental Protection Authority (EPA) Environmental Assessment Guideline (EAG) No. 3 (2009) with respect to impacts to BPP.

This technical note provides a summary of *Turbinaria* spp. size (diameter)-frequency distributions obtained by analysing images collected from past SKM surveys of subtidal habitats within Port Hedland State waters. This technical note aims to provide the following:

- Aid in the development of the BPP monitoring and management approach to be applied to the Outer Harbour Development;
- Relate size-frequency distribution to coral age and turnover rates;
- Estimate recovery times for *Turbinaria* spp.-dominated communities; and
- Describe relationships between colony size and health.

2. Method

Turbinaria spp. size-frequency distributions were determined using data collected from two separate sources of coral images:

- Diver surveys of permanent transects at the Weerdee Island (WIS) baseline coral monitoring site (SKM 2011); and
- Remotely operated towed video surveys at three sites monitored as part of a Subtidal BPPH Monitoring Pilot/Baseline Study (refer to Figure 1).

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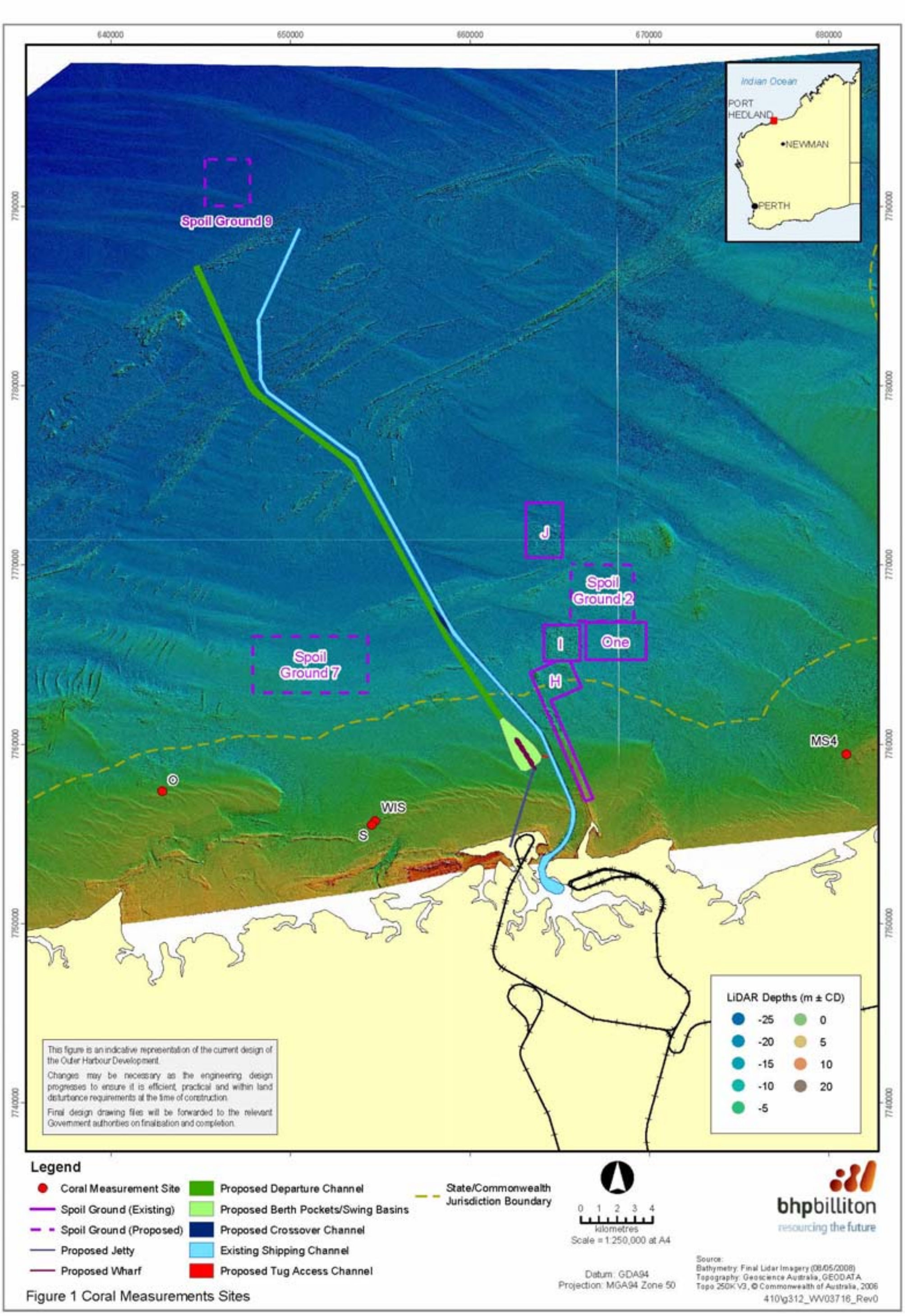


- **Figure 1 Coral Measurement Sites**

2.1 Weerdee Island (WIS) Permanent Transect Images

In May 2008, a coral health and water quality monitoring site Weerdee Island (WIS) was established in State waters to support environmental investigations for the Outer Harbour Development.

Three permanent transects of 10 m each were installed at WIS in an effort to determine changes in the overall composition of sessile biota and recruitment of new corals. A tape measure was spread between the endpoints of each transect. Photographs were taken of the area within a 0.25 m^2 quadrat, positioned at 1 m intervals by divers. Photographs have been utilised for the current study from six monitoring occasions:

- September 2008
- October 2008
- January 2009
- February 2009
- May 2009
- December 2009

The diameter of every *Turbinaria* spp. colony seen on these images was measured using the software program Coral Point Count with Excel extensions (CPCe). To enable measurements to be taken each image was calibrated using the increments of the tape measure visible in each of the images. Two measurements for each colony were taken, a short diameter and a long diameter which was then averaged to account for morphological differences in the shape of the colonies.

A conversion calculation was performed on the mean diameter of each colony to account for the angle of growth of *Turbinaria* spp. colonies. For this, an angle of growth of 36.4° was assumed based on data for *Turbinaria mesenterina* collected by Willis (1987). This was calculated by averaging the angle of growth for 5-10 cm *T. mesenterina* (37.4°) and 10-20 cm diameter *T. mesenterina* (35.6°).

Data were then organised by grouping the size data for coral colonies into 4 cm size classes. This was chosen as an increase in diameter of 4 cm equates approximately to 1 year of growth as shown by Willis (1987), who found average annual linear growth rates (increase in coral radius) for *Turbinaria mesenterina* of 1.73 cm for 5-10 cm corals and 1.94 cm for 10-20 cm corals. Given that these measurements were taken from a 4 m deep site from Magenetic Island, Queensland, which is at a similar depth and latitude, and has similar water temperature, to the

Port Hedland sites studied here, the use of these growth rates was deemed appropriate. Size/age frequency distributions and cumulative frequency distributions were created for each month from this data (**Section 3.1**).

In addition to recording diameter measurements, information on potential damage to *Turbinaria* spp. colonies through smothering of sediment, sponge or algae was recorded. When noted, the percent coverage of the colony was recorded as was the type of covering. This information was then plotted as the proportion of each size/age class affected and as a scatter-plot of size class versus percent of coverage for each type of covering (i.e. sediment, sponge, algae).

2.2 Towed Camera Survey Images

A pilot study using a remotely operated towed video camera was undertaken during Juneto August 2011 at three Port Hedland sites within State waters to the west of the proposed dredging footprint. This study was aimed at determining if this technique could be suitable for monitoring change in percent cover of biota classes over time as an alternative to diver-based monitoring methods. Video footage was collected over 30 transects of 50 m length at each site during each month and this footage then split into 60 discrete images per transect for habitat classification.

Images from two of these sites, Site S and Site O collected during June 2011 have been used for the purpose of taking *Turbinaria* spp. colony measurements. Site S is located close to, and on the same ridgeline, as the WIS monitoring site. June 2011 images were chosen as there was less canopy algae present during this month, which had the potential to obscure *Turbinaria* spp., particularly smaller colonies (i.e. <5 cm).

In addition, images from site MS4 were also used, which was briefly ground-truthed during August 2011 as a potential monitoring site for further baseline towed video monitoring. Footage was collected along transects of 100-200 m and split into discrete images.

As with the images from the permanent transects at site WIS, *Turbinaria* spp. diameter measurements were taken using CPCe. However for these images there was no reference scale (i.e. tape measure) present on the images to calibrate length measurements. To account for this, it was assumed from previous experience with the equipment, that the camera collected images at a position between 50 cm and 100 cm from the seabed at sites S and O and between 50 cm and 75 cm at site MS4. Based on these assumptions a calibration of the field of view was conducted with the camera above water at these distances from a known scale (ruler). From this calibration it could be determined that at 50 cm, images comprise 18.5 pixels cm^{-1}, at 75 cm they comprise 15.0 pixels cm^{-1}, whilst at 100 cm images comprise 11.5 pixels cm^{-1}. Using these calibration factors, measurements were taken in CPCe for the first 100 coral colonies encountered from images at sites S and O. This meant that images were taken from 6 transects at site S and 7 at site

O. For the site MS4, the first 200 coral colonies were measured to ensure that images were used from two transect in order to achieve a better representation of corals at the site.

Before a conversion of coral measurements was undertaken, to account for the angle of growth of corals, a conversion to account for the magnification of coral sizes due to water refraction was needed for these images. This was needed since the calibration of the images was performed above water but the calibration factor was used for images collected underwater. A magnification factor of 1.3x was assumed for this correction. This correction was applied by dividing the measured diameters by this amount, which reduced the diameter measurements since coral sizes appear larger on the images underwater than they would above water.

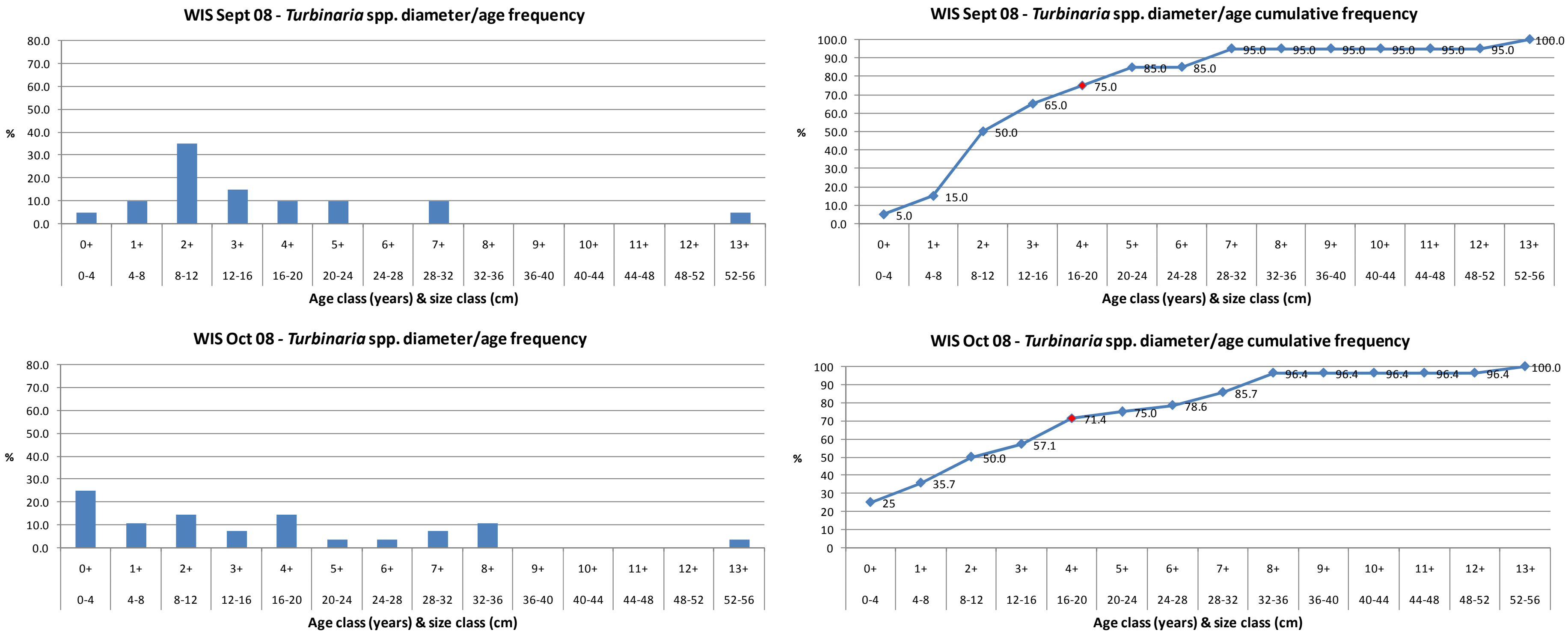
3. Results

3.1 Weerdee Island (WIS) Permanent Transects

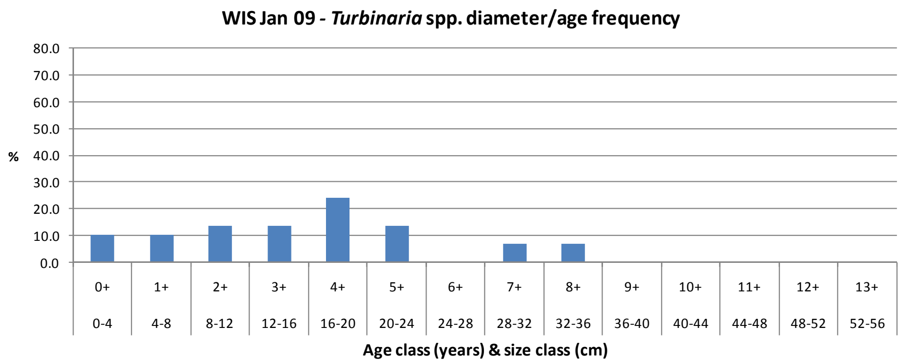
Turbinaria spp. diameters ranged between 0 and 56 cm, which represents colonies up to 14 years of age. With the exception of a few individuals within this 13+ age class all corals were <10 years of age (**Figure 3-1** to **Figure 3-3**). For all but one month, at least 50% of all colonies measured were <12 cm diameter or <3 years of age, whilst the proportion of corals aged <5 years ranged from 71.4 to 92.3%.

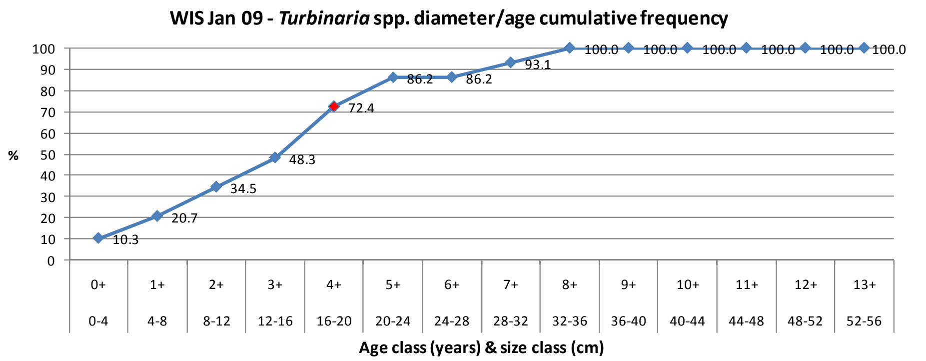
The dominant age class was typically 0+ or 1+ years, although 2+ age class corals were the most common age class observed in September 2008 and 4+ age class corals were the most common observed in January 2009 (**Figure 3-1** to **Figure 3-3**). The presence of macroalgae likely hampered the ability to locate the smaller age classes and potentially led to overestimation of larger size classes for these months. For all months, except May 2009 and December 2009, individual age classes contributed <40% each to the total colony abundance. In May and December 2009 the *Turbinaria* spp. community was dominated by the 0+ age class which comprised *ca* 70 and 60% of all colonies, respectively.

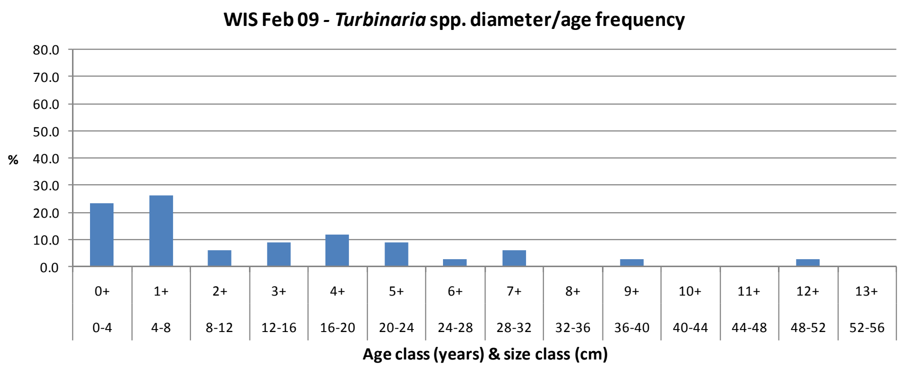
Smothering of *Turbinaria* spp. colonies by sediment or biota was recorded at this site. Smothering of colonies was observed within all age classes <6 years, with the proportion of colonies smothered generally increasing up to the 4+ age class of which *ca* 35% of colonies were affected (**Figure 3-4**). The type and percent coverage of smothering was dependent upon the size class of the colony. Smaller colonies <8 cm diameter, which roughly equates to colonies <2-years of age, were usually partially covered by sediment. Colonies >8 cm, which were ≥2 years of age were typically overgrown by algae or sponge. In the case of sponge growth, these larger colonies were usually completely overgrown (100% smothered, **Figure 3-5**).

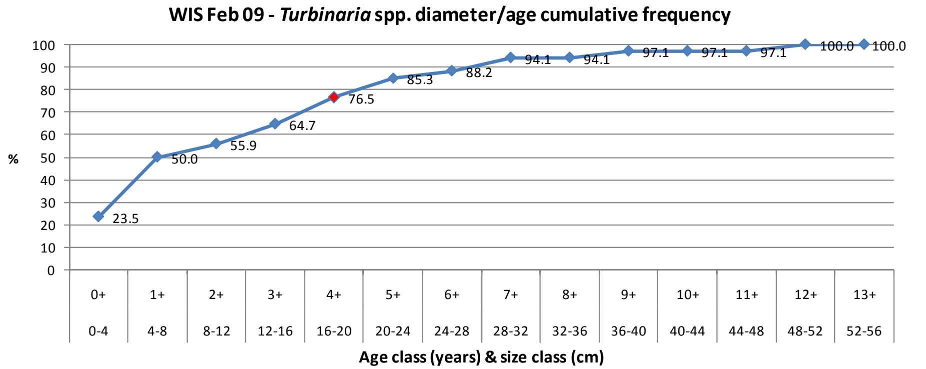


■ **Figure 3-1. Diameter/age frequency and cumulative frequency graphs for *Turbinaria* spp colonies at WIS during September and October 2008**

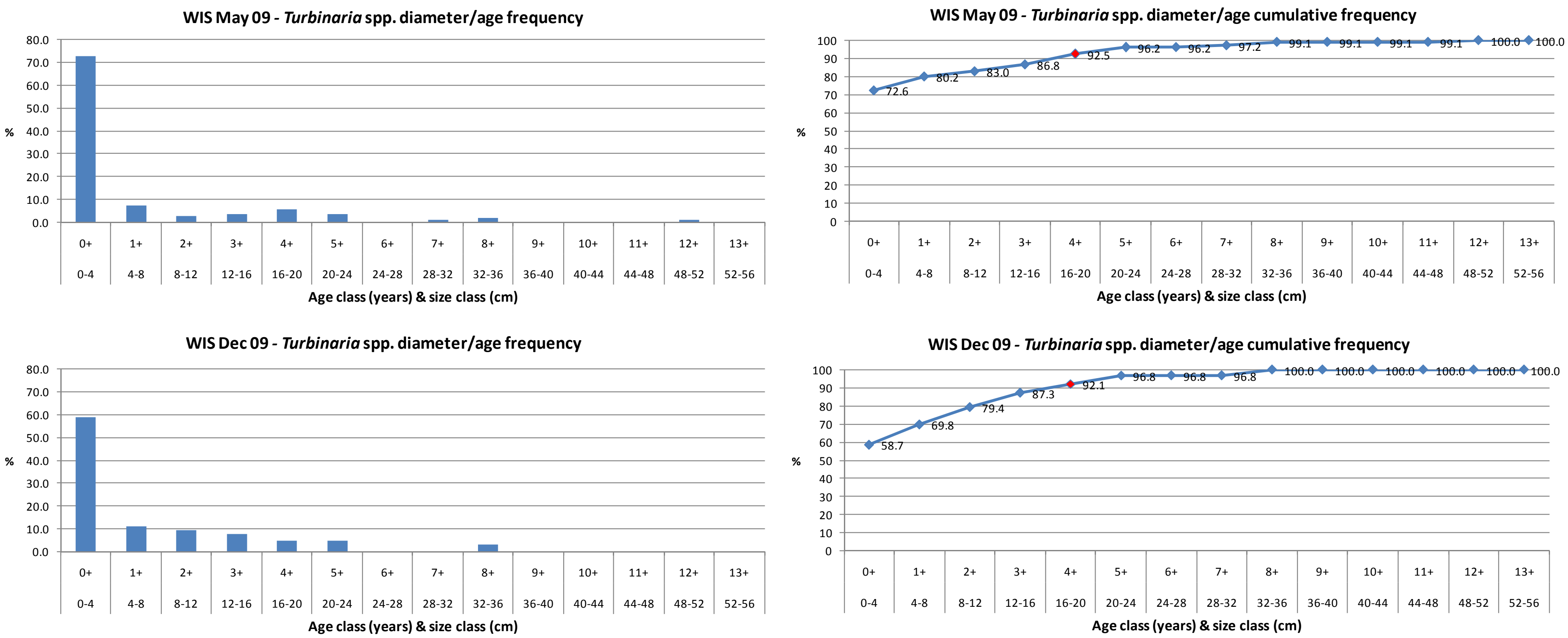




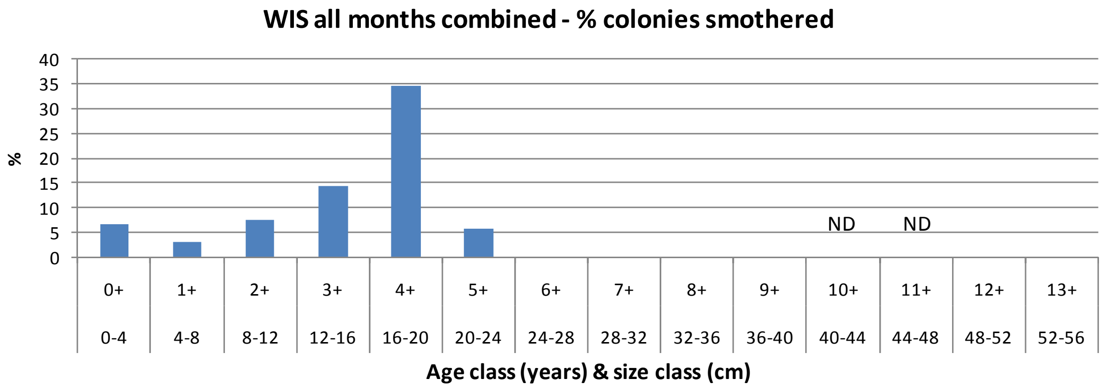




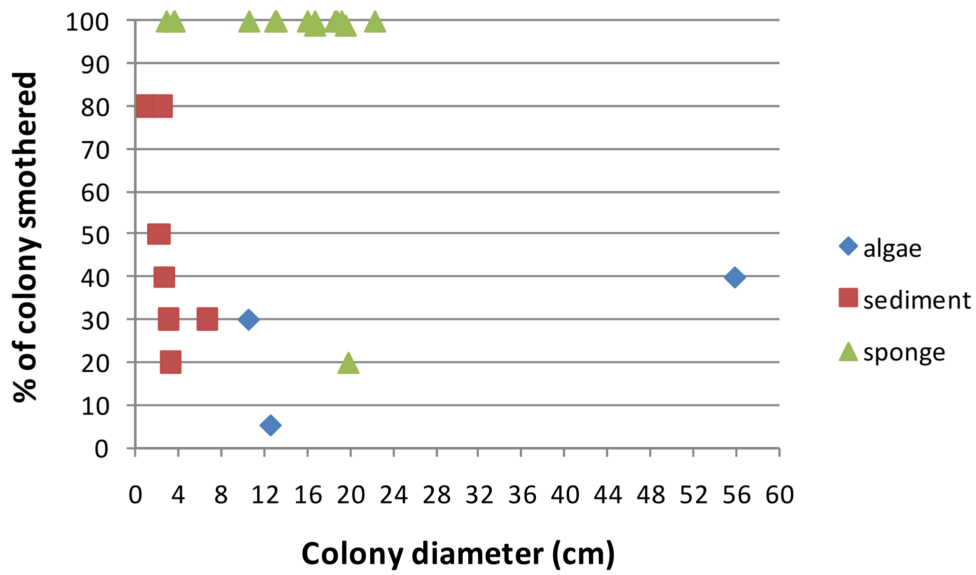
- **Figure 3-2 Diameter/age frequency and cumulative frequency graphs for *Turbinaria* spp colonies at WIS during January and February 2009**



- **Figure 3-3 Diameter/age frequency and cumulative frequency graphs for *Turbinaria* spp colonies at WIS during May and December 2009**



- **Figure 3-4 Proportion of colonies in each size/age class smothered by sediment, sponge or algae. ND= no data**



- **Figure 3-5 Percent of *Turbinaria* sp. colony smothered vs colony size (diameter) for 25 affected colonies at site WIS**

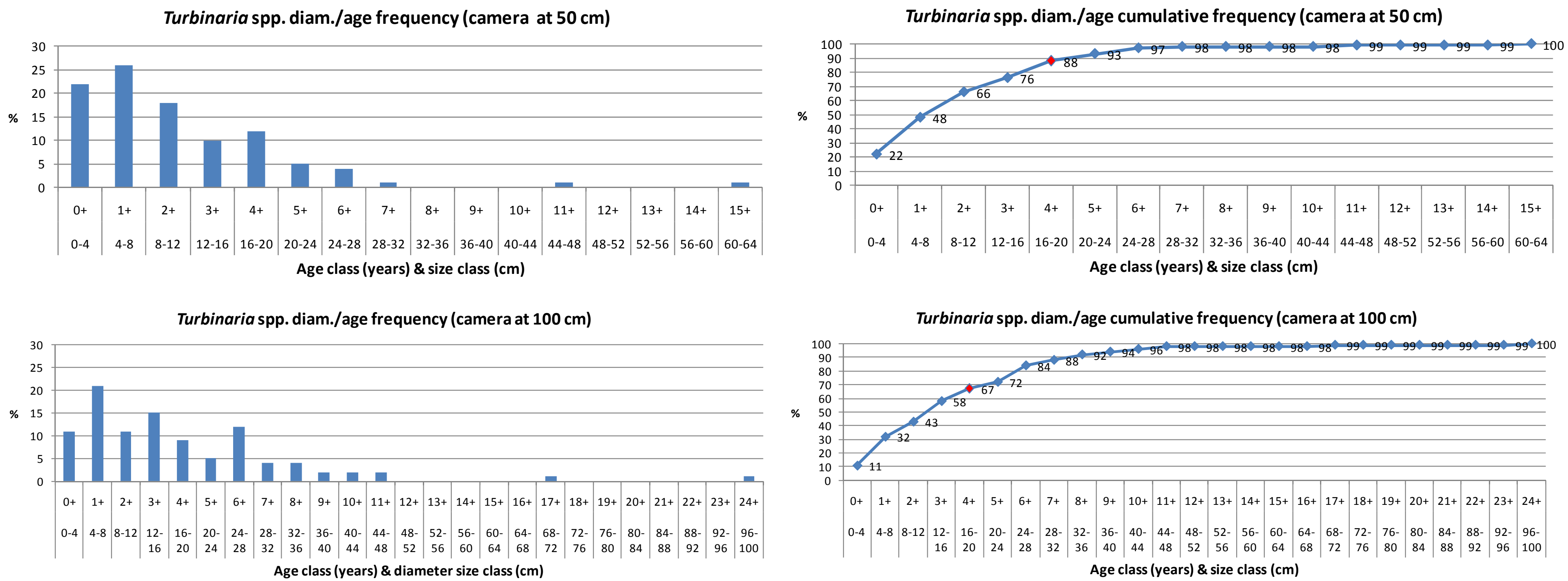
3.2 Towed Video Transects at sites S, O and MS4

The age structure of *Turbinaria* spp. colonies differed among sites but showed some broadly consistent patterns. At least *ca* 90% of all corals were <10 years of age at each site and the 0+ or 1+ age classes were always the most dominant within the community in terms of abundance (**Figure 3-6** to **Figure 3-8**). The percent contribution of age classes then decreased more or less progressively from the 1+ age class onwards.

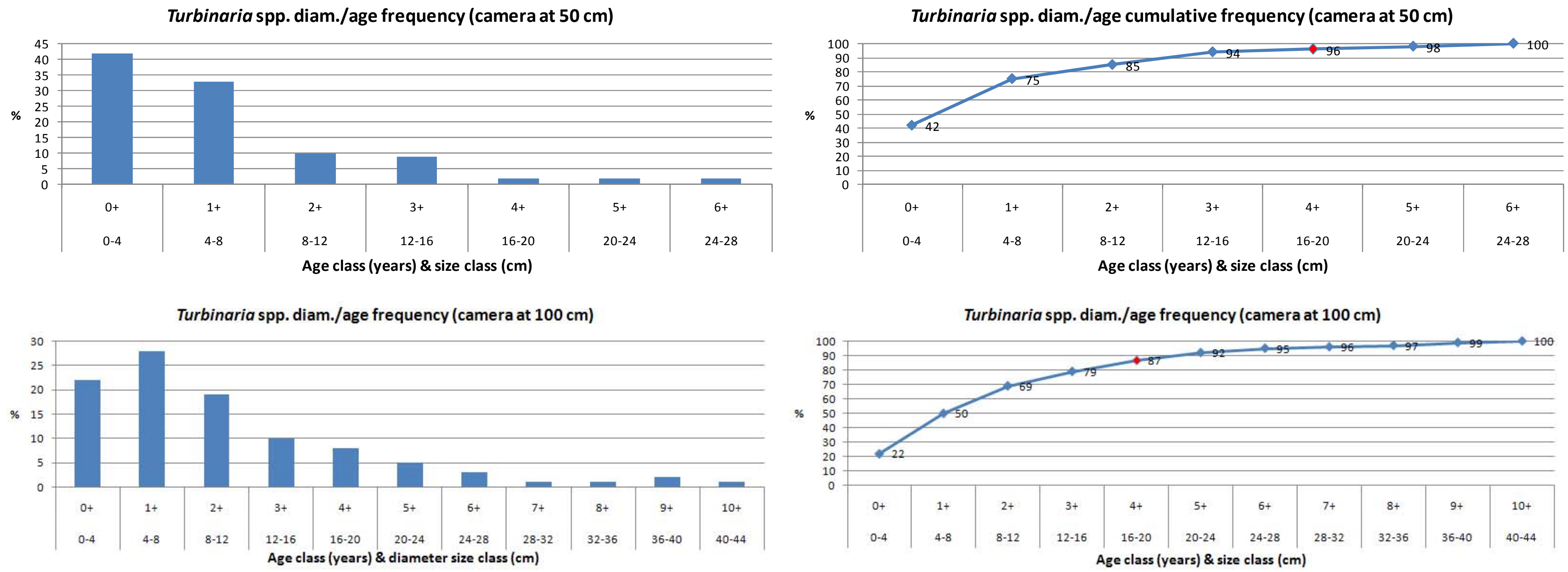
The *Turbinaria* spp. community at site O was the youngest of the three sites with 50-75% of the community <2 years of age and between 87 and 96% of the community <5 years of age (**Figure 3-6**). The oldest colony observed here was likely between 6 and 11 years of age.

The *Turbinaria* spp. community at site S was older than that at site O with 32-48% of the community <2 years of age and between 67 and 88% of the community <5 years of age (Figure 3-7). The oldest colony observed here was likely between 15 and 25 years of age.

The *Turbinaria* spp. community at site MS4 was the oldest observed with 27-33.5% of the community <2 years of age and between 58.5 and 75.5% of the community <5 years of age (Figure 3-8). The oldest colony observed here was likely between 17 and 24 years of age.



- **Figure 3-6 Diameter/age frequency and cumulative frequency graphs for *Turbinaria* spp. colonies at site S during June 2011 assuming camera 50 cm (top) and 100 cm (bottom) above seabed**



- **Figure 3-7 Diameter/age frequency and cumulative frequency graphs for *Turbinaria* spp. colonies at site O during June 2011 assuming camera 50 cm (top) and 100 cm (bottom) above seabed**

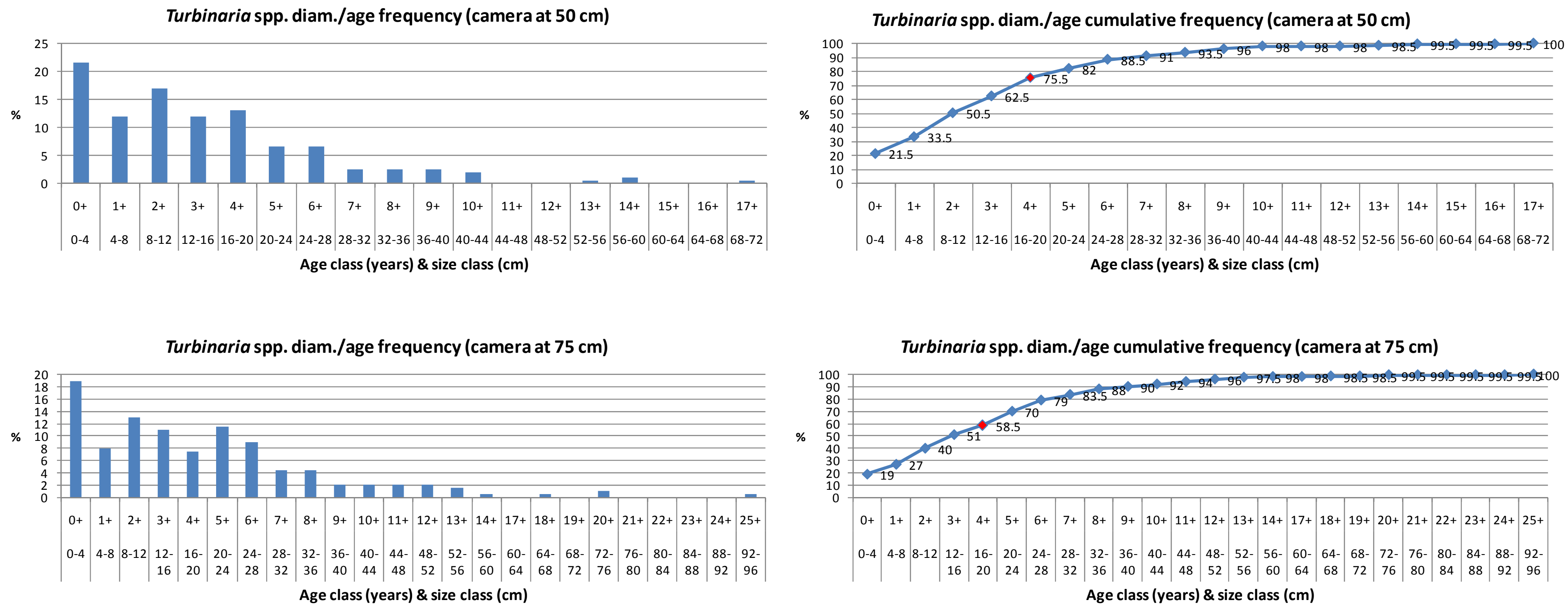


Figure 3-8 Diameter/age frequency and cumulative frequency graphs for *Turbinaria* spp. colonies at site MS4 during August 2011 assuming camera 50 cm (top) and 75 cm (bottom) above seabed

4. Discussion

Turbinaria spp. communities from the sites examined here exhibited age structures that were strongly skewed toward younger colonies, particular the 0+ and 1+ age classes. Coral communities that are susceptible to disturbance (i.e. cyclones, outbreaks of predators or disease) tend to have age and size-frequency distributions that are skewed towards earlier successional stages (Done 1999). The age structures observed here suggest regular successful annual recruitment of the 0+ age class at each site; this cohort dominates the community, in terms of abundance, for up to two years but then reduces in number over time due to mortality. The extremely high number of the 0+ age class observed at site WIS in May and December 2009 highlights this annual recruitment.

Observations of *Turbinaria* spp. colonies from the Port Hedland region suggest that mortality is likely driven in part by sedimentation in combination with overgrowth by other biota, e.g. sponges or algae, whilst physical damage from cyclonic events is also likely to occur. *Turbinaria* spp. colonies from the sites studied here were often observed protruding from apparently deep sediment, indicating the movement of a sand sheet over previously exposed hard substratum. Data presented from site WIS showed smothering of sediment to be more prevalent in younger age classes of ≤2 years of age, whilst smothering by other biota including algae, and in particular sponges, was observed in older age classes. It is difficult to infer whether smothering by biota occurs on live coral colonies or whether it occurs after mortality caused by other factors, such as disease, sedimentation or stress (i.e. thermal stress or reduced light availability). It is likely that younger age classes are more susceptible to smothering by mobile sand sheets due to their reduced height above the limestone pavement.

The differences in age structure observed at the three sites surveyed by towed video shows that there is likely a high level of spatial variability in the disturbances that lead to *Turbinaria* spp. mortality in the subtidal State waters of Port Hedland. Site O, which was the furthest from the shoreline, supported a comparatively young community of *Turbinaria* spp. This site is characterised by a relatively low relief with a veneer of coarse sediment overlying much of the limestone pavement. Such a site may be more susceptible to movement and smothering from sand sheets in response to tidal currents and storm events.

While the age structure of the coral communities studied here highlights their history of disturbance, it is more difficult to predict how long it would take communities at these sites to recover from a major disturbance and what this recovered community would look like. For the sites studied here there is evidence that the majority of age classes (58.5 to 96% depending upon the specific site) could return after 5 years in the event of complete mortality, provided that larval supply of new recruits and the availability of hard substratum for settlement remained at similar levels. It is considered likely that even in the event that all age classes could successfully return following such an event, the proportion of colonies within each age class, and the total number and percent cover of colonies may differ given the stochastic nature of major natural disturbances such as storms and cyclones. Such temporally-variable natural events may mean that the coral communities within State waters of Port Hedland never reach a constant stable state but instead exhibit flexible percent cover and age structure states over time.

References

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