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Jane E. Mellors, Len J. McKenzie, Robert G. Coles

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Seagrass-Watch: engaging Torres Strait Islanders in Marine Habitat Monitoring.

Jane E. Mellors[a*], Len J. McKenzie[b], Robert G. Coles[b]

Department of Primary Industries & Fisheries,

[a]PO Box 1085, Townsville, Queensland, Australia 4810

[b] Northern Fisheries Centre, PO Box 5396, Cairns, Queensland, Australia 4870

[*]Corresponding author: Department of Primary Industries & Fisheries, PO Box 1085, Townsville, Queensland, Australia 4810. E-mail address: Jane.Mellors@dpi.qld.gov.au.

ABSTRACT

Involvement in scientifically structured habitat monitoring is a relatively new concept to the peoples of Torres Strait. The approach we used was to focus on awareness, and to build the capacity of groups to participate using Seagrass-Watch as the vehicle to provide education and training in monitoring marine ecosystems. The project successfully delivered quality scientifically rigorous baseline information on the seasonality of seagrasses in the Torres Strait – a first for this region.

Eight seagrass species were identified across the monitoring sites. Seagrass cover varied within and between years. Preliminary evidence indicated that drivers for seagrass variability were climate related. Generally seagrass abundance increased during the north-west monsoon (*Kuki)*, possibly a consequence of elevated nutrients, lower tidal exposure times, less wind and higher air temperatures. Low seagrass abundance coincided with the presence of greater winds and longer periods of exposure at low tides during the south-east trade wind season (*Sager)*. No seasonal patterns were apparent when frequency of disturbance from high sedimentation and human impacts was high.

Seagrass-Watch has been incorporated in to the Thursday Island High School's Marine Studies Unit ensuring continuity of monitoring. The students, teachers and other interested individuals involved in Seagrass-Watch, have mastered the necessary scientific procedures to monitor seagrass meadows, and developed skills in coordinating a monitoring program and skills in mentoring younger students. This has increased the participants' self-esteem and confidence, and given them an insight into how they may participate in the future management of their sea country.

Key Words: Torres Strait, seagrass, Seagrass-Watch, indigenous, engagement, monitoring

1. INTRODUCTION

The Torres Strait Islands are home to people of aboriginal and Melanesian descent. They are seafaring people with distinctive cultures and lifestyles that are closely linked with the natural resources around a sea of islands. Their way of life is one of the oldest marine oriented and most sea-life dependent societies in the world (Sharp 2002; Smyth et al. 2006). Their seafood consumption is amongst one of the highest in the world (Johannes and MacFarlane, 1991). Any shift in conditions that has the potential to change the marine environment may in turn, affect the living resources reliant on these habitats and ultimately affect the health, economic and cultural well-being of the Islanders (www.tsra.com.au).

Torres Strait has some of the most extensive seagrass meadows in northern Australia (Coles et al., 2003; Sheppard et al., this volume). Seagrass meadows of this region are acknowledged as an invaluable resource for sustaining populations of dugong, turtle, fish, prawns, beche de mer and tropical rock lobster that support their local economies (Marsh et al., 2004; Green, 2006). Impacts that may affect the physical condition of seagrass meadows locally include; scarring from vessel landings, trawling, anchoring, moorings, pipelines and shipping accidents (Torres Strait NRM Reference Group, 2005). Other identified impacts that are subtle and more difficult to counter are natural seagrass die-back, marine pests and global warming. It has been recognized that these factors could affect local seagrass meadows and lead to the loss of food sources and nursery areas of species that rely on seagrass meadows. If this should occur, it is likely that *Ailan Kastom*, the central cultural driver of the Islanders (i.e. their way of life), will be tested and perhaps lost (Smyth et al., 2006).

The Torres Strait Islands are highly vulnerable to the direct biophysical impacts of natural variability and climate change. Climate projections for the Cape York region (including southern Torres Strait) suggest temperature increases in the order of 1.3-1.4°C by 2050 and rainfall increases or decreases of up to two percent (Green, 2006; Green and Preston, 2006). Also, projections of rising sea levels of between 9 and 88 cm by 2100 globally (White et al., 2005) and an increase in extreme weather events are causing increasing concern amongst Islander communities (Green, 2006).

The dynamics of tropical seagrasses are heavily influenced by weather patterns, flood and cyclone events (Carruthers et al., 2002). Despite Islander reliance on these habitats, there are no mechanisms (other than anecdotal evidence and oral histories) by which local communities can record and report on the condition and trend of seagrass habitat for use in decision making about its protection. Coupled with a lack of baseline information on this resource throughout the Torres Strait, the Torres Strait Scientific Advisory Committee recognised the monitoring of seagrass distribution and abundance as a high priority (TSSAC, 2006). The ability to predict the consequences of any disturbance on different seagrass habitats requires ongoing monitoring to inform management decisions.

Indigenous concepts of management of the sea differ significantly from the introduced European view of the sea as common domain, open to all and managed by governments (Hardin, 1968). Unlike contemporary European systems of management, indigenous systems do not include jurisdictional boundaries between land and sea. Torres Strait Islanders have a form of customary ownership of maritime areas that has been operating for thousand of years to protect and manage places and species that are of importance to their societies. Many of these systems have undergone considerable change since Torres Strait became part of Queensland in 1881 and there is a general feeling among modern day islanders that efforts should be made towards cultural revitalisation of those aspects of traditional *Ailan Kastom* that still exist (TSRA, 2006).

Marine resource management in Torres Strait should therefore attempt to achieve the following interrelated objectives: *a*) monitor the wellbeing (e.g. distribution, health and sustainability) of culturally significant species and environments (e.g. dugong, marine turtles, fish, molluscs, seagrass etc.); and *b*) monitor the cultural values associated with these culturally significant species and environments (Smyth et al. 2006). A combination of modern “western” science and indigenous knowledge can be brought together within a co-management framework for the successful management of these resources. (Johannes, 2002; Aswani & Weiant, 2004; Turnbull, 2004; Middlebrook and Williamson, 2006; Gaskell, 2003, George et al., 2004). This can only occur when the resource owners are actively involved in the management of their resources. Modern ”western” scientists and resource managers also need to recognise that resource owners have practical and spiritual connections with the resources found within their environment. Only then will this approach have the added benefit of empowering the communities who own the knowledge to be the primary managers and leaders in decisions about their land and sea country (Smyth et al., 2006). It is imperative that Aboriginal and Torres Strait Islander people are engaged in management of their marine resources in order to continue the evolution of their culture and connection to country.(Ross et al., 2005, Smyth et al., 2006).

Increased participation of Indigenous peoples in the science and research aspects of marine policy development and management in Torres Strait is highly desirable.

Chapter 26 of United Nations Environment and Development Agenda 21 explicitly recognises the need for developing institutional arrangements that empower indigenous peoples, strengthen their participation in natural resource management and ensure that their use of resources is ecologically sustainable (United Nations Conference on Environment and Development, 1992). For islanders to play an active role, they need to engage with the modern concepts of marine ecosystems, and understand the benefits of good management and the consequences of inaction. This understanding requires education and awareness. The future users of the marine environment can learn about the principles of ecosystems, good management and the threats to systems through formalised primary, secondary and tertiary education. There appears to be a general need across the Pacific Islands to promote seagrass conservation, particularly through the development of educational resource material to be used in schools and community groups (McKenzie et al., 2006a). An essential component of education is actual participation in assessing the condition of the resource and monitoring its status and trends (Talbot and Wilkinson, 2001).

The Seagrass-Watch program (www.seagrasswatch.org) encompasses many of these visions and has been successfully applied throughout the Western Pacific (McKenzie et al., 2006b). Seagrass-Watch protocols combine a series of education and training exercises to develop expertise in field-based seagrass monitoring within communities and schools. Protocols learnt by participants include the establishment of monitoring sites, biological measurement techniques, data interpretation, photographic techniques and species identification (www.seagrasswatch.org). The methods do not require special skills, such as swimming or diving (cf. ReefCheck), are logistically simple and relatively safe and inexpensive. Quality assurance and quality control procedures assure that the data collected are scientifically rigorous (McKenzie et al., 2000).

Seagrass monitoring is necessary to obtain and disseminate accurate and timely information about seagrass resources. This information will assist decision makers in managing fisheries habitats in the Torres Strait and also increase community confidence in management.

The aim of the project was to: a) provide education and training opportunities for Torres Strait Islanders in biological monitoring of marine plant habitat ecosystems; b) facilitate involvement of Torres Strait Islanders in a community-based marine habitat monitoring program for coastal management; and c) assist in the interpretation of the data collected. This paper describes the process by which we engaged the Torres Strait Islanders in marine monitoring , and reports and interprets the seagrass data that was collected by the volunteers during the course of the project.

2. METHODS

Many Australian indigenous people have limited trust or confidence in government engagement processes due to past government practices and policies (DATSIP, 2005). Process is as important as are outcomes to Torres Strait Islanders. Personal relationships are also highly important. Positive outcomes are therefore difficult without good relationships built on trust (Ross and Nursey-Bray, 2005). Perhaps owing to the nature of the historical contact between government officers and island communities, and the feeling by many Islanders that previous research conducted in the region had resulted in no benefit to the Islanders, establishing partnerships for this project was an extensive process. The engagement process we followed can be separated into four phases (Figure 1).

2.1. Engagement

It was critical for the success of this project to be aware of the cultural, social and political character of Torres Strait. Additionally, we sought information on the social and cultural differences between Island communities throughout Torres Strait by attending Cultural Awareness Workshops and following the "Guidelines for Researchers" and "Proper Communication with Torres Strait Islander Peoples" (Jones and Barnett, 2006; DATSIP, 1998).

As part of the organisational framework, communication by phone, email and opportunistic meetings with Torres Strait Regional Authority, Island Coordinating Council (ICC) and Education representatives were conducted to introduce the concept of volunteer resource monitoring (Figure 1). Once contacts had been made and interest gauged, formal meetings were held to introduce the Seagrass-Watch program as a means of monitoring marine plant habitat. Through this process cultural differences in meetings with Islanders were overcome by including the CRC Torres Strait Extension Officer in all meetings with Islanders.

2.2. Concept development

The outcome from the meetings during the initiation stage and in consultation with CRC Torres Strait Extension Officer, it was decided to trial the Seagrass-Watch program within the more densely populated islands of Thursday Island and Horn Island (Figure 2). While these islands are more commercially developed than the outer islands, dugong and turtle that rely on seagrass habitat are still held in high regard by these communities. The other deciding factor for focussing the monitoring around these islands was that Thursday Island is the centre for secondary education for the Torres Strait. Tagai College Secondary Campus embraced the idea of allowing their students to be involved in marine resource monitoring and readily volunteered to be part of the program (Identifying a champion; Figure 1).

Tagai College Secondary Campus is the only high school (senior school) in the Torres Strait and enrols students with diverse cultural backgrounds including Papua New Guinea, the Western-, Eastern-, and Central- island groups of Torres Strait and from Torres Strait communities on the Western side of Cape York (DETA, 2004) (Choosing an appropriate partner organisation, Figure 1). Their whole-school literacy framework is built on English as a second language. As a consequence these students are often at levels of literacy below those of students from mainland educational facilities (TSRA, 2006). This also provided challenges for the researchers delivering the project particularly with introducing scientific vocabulary, as it meant tailoring the existing Seagrass-Watch program delivery so that it was relevant and appealing to the intended audience, and that the method of delivery was appropriate and tailored in language and style (Skills tailored to Islander needs, curriculum opportunities; Figure 1). Informal feedback from the CRC Torres Strait Extension Officer and teachers aided the researchers in customizing the delivery of the program to the Torres Strait Islanders. For example, emphasizing the linkages between seagrass habitat and food sources important to Torres Strait Islanders (Reconnecting *Ailan Kastom* to marine resource management, Focusing scope; Figure 1). The advantages of volunteering were also emphasized by the teachers in gaining skills that may lead to future employment (Pathways to employment, Figure 1). Within the program we also built in a reward system by providing travel awards for two students who had shown exceptional commitment to the program for each year that this project was supported by the Torres Strait CRC. The travel awards provided the students with airfares and accommodation while participating in Seagrass-Watch activities in the Townsville, Mackay- Whitsunday region (Travel awards; Figure 1).

2.3. Implementation

To implement the project, a specialist from the Seagrass-Watch program was employed to train, support the monitoring and interpret the data collected through the program. To assist with the implementation and build interest amongst participants, we collaborated with existing programs such as Clean Beach (a community-based activity removing rubbish from beaches as part of the Clean up Australia Day initiative) and the Indigenous Careers Market; all school based activities that involved the broader community (Linking with existing programs; Figure 1). These activities enabled us to host displays showcasing the advantages of volunteering, which increases the participants' skills that in turn may lead to some students being rewarded with travel awards and employment, implementing part of our concept development (Figure 1).

Project delivery included presentations to the students on the biology and ecology of seagrasses, management and protection of seagrass habitat, the principles of environmental monitoring and Seagrass-Watch field techniques for monitoring seagrass habitats. A seagrass taxonomy workshop was also held in conjunction with the presentations as a laboratory session. After these theoretical sessions were completed, students, teachers and other interested individuals then went to the field study sites to actively monitor the seagrass habitat under the supervision of Seagrass-Watch personnel. Repeat visits always included refresher talks and presentations on the previous monitoring, to reinforce the scientific vocabulary and monitoring protocols as part of the Seagrass-Watch programs QA/QC (www.seagrasswatch.org) and to acknowledge the student's involvement in collecting data that was being used to report on the condition and trend of the seagrass habitats in their sea country.

Seagrass abundance and habitat characteristics were monitored at three permanently marked sites between June 2004 and November 2006, four monitoring sessions per year. (The standard Seagrass-Watch rapid assessment technique was used, as described in McKenzie et al. (2003; www.seagrasswatch.org). Two sites were located on Thursday Island (TI1 and TI2) and one site on Horn Island (HI1) (Table 1, Figure 2) based on available seagrass distribution maps (Rasheed et al., 2003; Taylor et al. 2006). A site constitutes a 50m x 50m area within a relatively homogeneous region (low variability, even topography) of each seagrass meadow. This was not the case with the TI2 site. This site appeared highly disturbed (personal observation) and for educational purposes, demonstrated impacts from storm water drains, therefore disturbance and recovery of seagrass from directed freshwater input and sedimentation could be monitored.

Within each site, three replicate 50m transects were laid parallel to each other, and 25m apart (McKenzie et al., 2003; www.seagrasswatch.org). Along each transect, observers recorded seagrass habitat characteristics (including percent seagrass cover, seagrass species composition, canopy height, epiphyte cover, algae cover, algae composition, sediment type and associated fauna) within a 0.25 m^{-2} quadrat (50cm x 50cm) at 5m intervals (11 quadrats per transect, 33 quadrats per site). Estimates of the total percent cover of seagrass within the quadrat were standardized using percent cover photo standards (www.seagrasswatch.org). Seagrass species within the quadrat were identified and the percent contribution of each species to the total cover determined. Seagrass species were identified according to Waycott et al. (2004).

Canopy height of the dominant strap leaved species in the seagrass community was measured (from the sediment to the leaf tip) using a ruler. The method used was to ignore the tallest 20% of leaves of the dominant species and to haphazardly select three to five leaf blades from the remainder. The cover of epiphytes was recorded by estimating the percent of the total leaf surface area covered by epiphytes. Percent cover of non-epiphytic algae in each quadrat was estimated using the same visual technique used for seagrass cover. Field descriptions of sediment type were described using visual estimates of grain size: shell grit, rock gravel (>2000µm), coarse sand (>500 µm), sand (>250 µm), fine sand (>63 µm) and mud (<63 µm). Sediment categories were determined by the dominant sediment type (e.g. sand/mud = more sand than mud). The abundance of associated fauna within each quadrat was recorded. Fauna were identified to the lowest taxonomic level possible in the field.

In accordance with Seagrass-Watch quality assurance/quality control guidelines (www.seagrasswatch.org) and to provide a permanent record of the site, photographs were taken at the 5m, 25m and 45m quadrats along each transect. A global positioning system (GPS) was used to record the geographic location of each transect. Within canopy temperature was measured using discrete iButton® temperature data recorders. Temperature was logged every 90 minutes for the period between monitoring occasions (approximately three months). Climate observations were drawn from Horn Island (weather station 027058), provided courtesy of Commonwealth Bureau of Meteorology.

For analysis, quadrat measures were pooled across each site (as there was no significant difference between transects for each site individually (ANOVA TI1, TI2 and HI1 $p < 0.05$). Subsequent statistical analyses used Analysis of Variance

(ANOVA) with year and month as treatments in Genstat® only for the years 2005 and 2006, as the model required a balanced design. Abiotic variables were monitored across the study period and also compared with the available long-term average (42 years). Correlations between seagrass cover and abiotic factors that are known to affect seagrass growth such as temperature, wind (surrogate for turbidity) and rainfall (Hemminga and Duarte 2000) were conducted using Systat® (v10.2, 2002). Although data was collected for the entire period, analysis of averaged abiotic variables was for two periods (14 and 28 days) prior to seagrass monitoring, matching meadow turnover times reported to be 10-27 days in Torres Strait (Rasheed et al., this volume). All error estimates are given as ± standard error.

3. RESULTS

3.1. Outcome & analysis – Capacity Building and Uptake

The majority of Islanders trained were secondary school students. Other participants included interested individuals within the community and more recently indigenous rangers. The educational component included classroom lectures and induction sessions. Participants mastered the necessary scientific procedures and developed skills as shown by their coordination of monitoring events and mentoring and training of younger students. Other indicators that showed mastery of the Seagrass-Watch process were: a) students becoming more confident during the monitoring process as evidenced by the increase in the monitoring data passed through QA/QC; b). voluntary participation in the project increased from four students and one teacher at one site in June 2004, to three sites being monitored by a total of 27 participants ranging from community volunteers to primary and secondary school students and teachers in November 2006 (Figure 3). This number of people conducting on-site (field) monitoring may be optimal as more participants has the potential to impact the seagrass habitats by trampling.

After a year of monitoring the teacher responsible for the Marine studies course initiated and developed a curriculum which included the Seagrass-Watch program for his Marine Studies course (Uptake- curriculum adoption; Figure 1). Seagrass monitoring using Seagrass-Watch protocols is now a continuing component within the Marine Studies course taught at Tagai College Secondary Campus. At the primary (junior) school level it is used within the "Endangered species" curriculum unit, and has been more widely adopted outside the education system by its incorporation into the into the work plans of the Horn and Hammond Island Indigenous rangers (Beyond the school gate; Figure 1). These events reflect the approach recommended by Ross and Nursey-Bray (2005) of starting modestly and being adaptable in building partnerships with the aim of continuously improving working relationships with the participants as well as the data collection.

3.2. Marine Habitat Monitoring - Interpreting collected data

Sites were monitored four times a year once established. Monitoring was not possible during December and February as sites were not exposed during daylight hours during these months and night time monitoring was not recommended due to dangerous marine animals such as crocodiles that were known to inhabit the vicinity of the monitoring area. The quality of the data as passed by the QA/QC process was suitable to detect changes in seagrass abundance between monitoring events and against climatic variables.

Back Beach (TI1) was the most diverse meadow monitored with seven seagrass species reported (Table 1). It is a fringing coral reef platform seagrass meadow inhabited by structurally large species. Seagrass cover differed not only between months within each year, but also between years (ANOVA F=4.33, *p*=0.02), i.e. differences occurred between years at different times of the year (Figure 4a). Three groupings were identified (post hoc LSD = 12.45) with March 2006 having significantly higher percent cover than any other time during the study period, and June 2005 having the lowest cover. Seagrass cover did not differ significantly between other monitoring events. Despite this, March and November generally had higher percent covers than June (the lowest), with August being intermediate (Figure 4b). Macro-algal abundance showed similar differences between years, but no seasonal pattern was apparent (F=5.84, *p*=0.007). No significant differences were detected for epi-cover between months or years (F=1.43, *p*=0.272).

Federal Beach (TI2) was the second site to be established. It was an initiative linked to Thursday Island's Clean Beach Days to raise awareness about the links between beach rubbish and near-shore environments by monitoring the health of seagrass meadows impacted by urbanisation. This site was the most impacted of the three regularly monitored sites (Table 1) and as such was inhabited by species that are more tolerant to disturbance (Walker et al., 1999). Five seagrass species were recorded within the monitoring area. No significant differences between month or year were determined for percent seagrass cover, macro-algae cover or epi-cover (Figure 4c, d) (F=0.13, *p*=0.94; F=0.82, *p*=0.50; F=3.11, *p*=0.06, respectively).

Wongai Beach (HI1) is a mud flat with *Halodule uninervis* (narrow-leaved form), the most dominant species present. It represents a mudflat seagrass meadow with similarities to coastal seagrass meadows along the east coast of Queensland. Similar to TI1, percentage seagrass cover differed significantly between months in an apparent seasonal pattern each year, with the amount of seagrass cover also differing between years (ANOVA F=4.03, p=0.04) (Figure 4e). March and November percent seagrass covers were significantly higher than those recorded during August and June (post priori LSD = 17.29). Per cent algal cover was only significant between months (ANOVA F= 25.6, $p<0.001$) with the highest recordings occurring in March. Epi-cover was significantly different both within and between years (F=11.11, p= 0.002). This was primarily a consequence of the large differences in epi-cover occurring between years, in particular the month June 2005 recorded much lower epi-cover than June 2006, when on the yearly average epi-cover for 2005 was higher than that recorded for 2006.

The highest within seagrass canopy temperature recorded (38.5ºC) was at TI2 in May 2006. Maximum within seagrass canopy temperatures similarly occurred at other sites during April and May of each year (Figure 5). There were no significant differences in mean canopy temperatures between sites (df=2, F=0.26, p=0.78). Within seagrass canopy temperatures were significantly correlated with air temperature (r^2=0.28, $p<<0.001$), but negatively correlated with wind speed (r^2=0.5, $p<<0.001$).

When abiotic factors during the study period were compared to the 42 year average, temperature was the only factor to show any significant difference. The temperature recordings for 2005 were significantly warmer (T=2.46, df=22, p=0.02), Temperature in 2006 was similar to the 42 yr average (Figure 6a). Rainfall and wind over the study period were not significantly different to the 42 year average (T=0.17, df=48, p=0.87 and T=-0.83, df=48, p=0.41, respectively) (Figures 6b, c). The monsoon however started and finished later in 2005 (Figure 6c).

Seagrass cover at HI1 was significantly correlated with air temperature (r^2=0.85, df=5, F=29.37, p=0.003) and at TI1 significantly correlated with rain and wind (r^2=0.43, df=8, F=6.03, p=0.04 and r^2=-0.4, f=5.32, p=0.05) in the 14 days preceding sampling.

4. DISCUSSION

This project has effectively engaged Torres Strait Islanders in the monitoring of seagrass meadows. Positive informal feedback from participants and the TSRA Land and Sea Unit is evidence that the Seagrass-Watch Program has raised local awareness of the importance of seagrass as a marine resource. This awareness goes beyond recognizing seagrass simply as a food source for culturally iconic species such as dugong and turtle, but also with respect to other environmental services that seagrass habitats provide (nursery areas for fisheries, water quality, sediment stabilisation, etc.). It is also a first step in collating data for the regional management authority on the condition and trend of this marine asset and providing evidence of seasonality in Torres Strait seagrass meadows.

Smyth et al. (2006) reported on Islander demands for increased and more meaningful participation in all phases of coastal management. Our process involves Islanders in the primary stage of collecting seagrass data, which is assessed and used to report on the condition of this coastal resource. The data is then accessible to managers upon request from Seagrass-Watch HQ, while remaining the property of the group who collected it. For those students involved it has created opportunities for them far beyond the school gate. For example, travel grants were provided and successful students were given the opportunity to visit other participants outside the Torres Strait to experience the broader scope of the Seagrass-Watch program (i.e., local eyes, global wise). These students have since become ambassadors of the program, winning conservation awards, teaching seagrass conservation to their peers (e.g., representation at an interstate Indigenous conservation forum; (Bowie and Mills, 2006) and training and mentoring younger students on nearby islands.

These experiences have increased the participant's confidence and self esteem (e.g. presenting at conferences, involvement in radio talk-back). Discussions with participants also revealed their desire to understand their sea country not just from a cultural view point, but also a scientific/ecological one. From this beginning, it is hoped that this rationale will expand throughout the wider community, particularly as these students who have successfully participated may become the local teachers and trainers. Local mentors have the benefit of being trusted more than government officials and scientists and also talk the same language.

The role of traditional environmental knowledge in sustainably managing environments and the natural resources found in them is internationally recognised (Johannes et al., 2000). For this program to now reach a wider volunteer base there is a need to include indigenous knowledge within all existing educational frameworks (Foale and Manele, 2004) from primary through to tertiary. This may pose a challenge in certain communities and age groups as work ethic and respect and trust have been eroded by years of passive welfare and paternalistic approaches to engagement (Hagan, 2005). Consequently the role and benefits of voluntary engagement may take at least a generation to be realised. Until this occurs, experience has shown that a "champion" (DATSIP, 2005; Hagan, 2005) with appropriate technical or scientific credentials, as well as social skills is needed to drive and maintain the momentum of volunteer- based programs (Duarte 2002). In addition, volunteers must be motivated through the prompt delivery of results and diagnostics on the seagrass meadows monitored, as well as celebrating achievements and milestones (Duarte 2002, Hagan 2005). If volunteers are motivated they are retained within the program. This has been achieved by Seagrass-Watch with its comprehensive communication strategy and motivated staff. Feedback to the community has taken many forms: immediate posting to a website of photographs of current monitoring; quarterly newsletters to every school and council within the Torres Strait; radio interviews; newspaper articles; presentations on previous monitoring trips on return visits; and rewarding long-term participants with awards.

The success of the project can be assessed by the increased number of volunteers involved in the project, the number of high school students actively seeking enrolment in university courses relating to marine or environmental science and the number of requests for training individuals beyond the high school gate. Commitment to and ownership of the project can be gauged by the recognition it has received from the educators within the community by its inclusion within the high school's marine studies curriculum.

Information on seagrass resources, other than mapping distributions, has been quite limited in Torres Strait. Recognition of the health and extent of seagrass within natural variability is of vital importance to sustain turtle, dugong and important commercial fisheries in the Torres Strait (Torres Strait NRM Reference Group, 2005). The data collected by participants of this project are the first to document this natural variability.

Preliminary investigations have revealed that of the three sites being monitored, two (HI1 and TI1) are showing variation with respect to percent seagrass cover. Variation in seagrass cover occurs inter-annually as well as intra-annually, accounting for the significant interaction term within the statistical analyses. Despite this, there does appear to be an overall seasonal pattern of increasing seagrass cover for the meadows of HI1 and TI1 between the months of November and March. This coincides with *Kuki* season (Williams, 1994) or north-west monsoon. The north-west monsoon is a period of persistent atmospheric depression with sporadic isolated squalls and storms, and torrential rain with winds generally less than 31 km/hr. Most of the annual rainfall (95%) occurs during this time (Mulrennan and Hanssen, 1994). In general downstream flow from terrestrial habitats occurs with rainfall, bringing nutrients to the near shore environments (Furnas, 2003). Seagrass meadows respond to an increase in nutrients by increasing (Udy et al., 1999, Mellors, 2003), suggesting that these meadows may be nutrient limited. Decreased winds speeds also lessen turbidity and plants will be able to photosynthesize for longer periods (Harris and Baker, 1991). It is interesting to note that the meadow at HI1 appears to peak at November while TI1 peaks in March. This may be due to the meadow at HI1 being dominated by *Halodule uninervis* narrow, a structurally small seagrass.

Structurally smaller seagrasses are more dynamic than the structurally larger species. Because they are faster growing they are able to take advantage more quickly of changes in environmental conditions (Walker et al., 1999). The converse is true for the meadow at TI1 dominated by structurally large seagrasses that take longer to take advantage of changed conditions due to their slower growing rates. This may account for the cover at this meadow peaking later in the season (March).

Low cover occurred between June and August coinciding with south-east trade wind season or *Sager* (Williams 1994) which extends from May to October. This wind season is characterised by strong persistent winds with speeds up to 37km/hour and rough seas for two thirds of the time. Strong winds lead to an increase in turbidity due to re-suspension of sediments and thereby limiting the light reaching the seagrass canopy. Coupled with desiccation caused by long periods of exposure as low tides occur in the middle to early afternoon during this time of year, these are factors that restrict growth of intertidal seagrasses (Rasheed et al., this volume).

The only site where no seasonal patterns were apparent was at Front Beach (TI2). This site is dominated by structurally smaller seagrasses and is the most impacted site monitored. The frequency of disturbance is relatively high at this site and may explain the persistent low seagrass cover. The site is in direct path of a large storm water drain and we have observed large amounts of sediment arriving on the site and burying the seagrass. Also, its proximity to the main harbour results in frequent physical damage from vessel careening, scarring and anchoring.

This study has provided preliminary evidence that drivers for seagrass variability in the Torres Strait are related to climatic variables. Given the importance of this habitat and its associated natural resources to Torres Strait communities, and the prospect of increasing impacts from pressures such as climate change (Green, 2006), it is important to maintain this monitoring. Information from Torres Strait is also used in a boarder context. Data from Seagrass-Watch Torres Strait are provided to Seagrass-Watch as part of a state-wide and global monitoring initiative that monitors and records local, regional and global seagrass condition and trends (www.seagrasswatch.org). Seagrass-Watch monitoring efforts are vital to assist with tracking global patterns in seagrass health, and assess the human impacts which have the potential to destroy or degrade these coastal ecosystems and decrease their yield of natural resources (McKenzie et al., 2006b).

For several decades, Torres Strait Islanders have lobbied for greater control of their marine resources as part of their ongoing move towards greater regional autonomy (National Oceans Office, 2003). We successfully enabled information transfer between seagrass scientists and Torres Strait Islanders by providing educational opportunities for local communities, government agencies and schools. Education and training components of the program established appropriate protocols for gathering information to enable Islanders to become integrally involved in the monitoring of local seagrass habitats. The project provided critically needed training for Torres Strait island people in the development and application of appropriate tools to assess condition of seagrass meadows. The information and data collected also proved to be of sufficient scientific quality to provide a better understanding of seagrass resources and their seasonal drivers. By increasing the expertise and skills of Torres Strait Islanders in marine related activities, and increasing our efforts to couple this with traditional environmental knowledge, we aim to empower the communities who own the knowledge to be the primary managers and leaders in decisions about their sea country (Smyth et al., 2006). The support for the project expressed by the Torres Strait community suggests that we have laid a foundation for community-based marine resource monitoring in the Torres Strait.

5. CONCLUSIONS

Seagrass-Watch is a useful vehicle for engaging Torres Strait Islanders in marine habitat monitoring. The approach and process used in this project provides a model for engaging Islander and Indigenous communities in marine resource assessment and monitoring. Seagrass meadows are accessible and safe for school students to work on, and provide excellent habitat type for teaching and demonstrating marine community and ecosystem concepts. Seagrass meadows in Torres Strait support important fish, dugong, turtle and show seasonal change related to climatic conditions. Information from Torres Strait is also contributing to a broader data stream tracking statewide and global patterns in seagrass health, and assessing human impacts.

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FIGURE CAPTIONS:

Figure 1. Flow diagram showing phases of engagement process.

Figure 2. Location of intertidal seagrass monitoring sites, Thursday Island and Horn Island, Torres Strait.

Figure 3. Number of participants in educational and field components of project.

Figure 4. Changes in percentage seagrass cover (all species pooled) over time for (**a**) TI1 shown as a continuous time series (**b**) TI1 displaying intra-annual variation through time, (**c**) TI2 continuous time frame, (**d**) TI2 intra-annual, (**e**) HI1 continuous time frame, (**f**) HI1 intra-annual. Values are mean ±SE. Intra-annual curves were fit by third-order polynomial.

Figure 5. Within seagrass canopy mean and maximum temperature (°C), compared with mean maximum air temperature.

Figure 6. Changes in climatic variables during the study period and against the 42 year average, (**a**) air temperature (°C), (**b**) mean wind speed (km hr^{-1}) at 3pm, (**c**) total monthly rainfall (mm).

Fig 1.

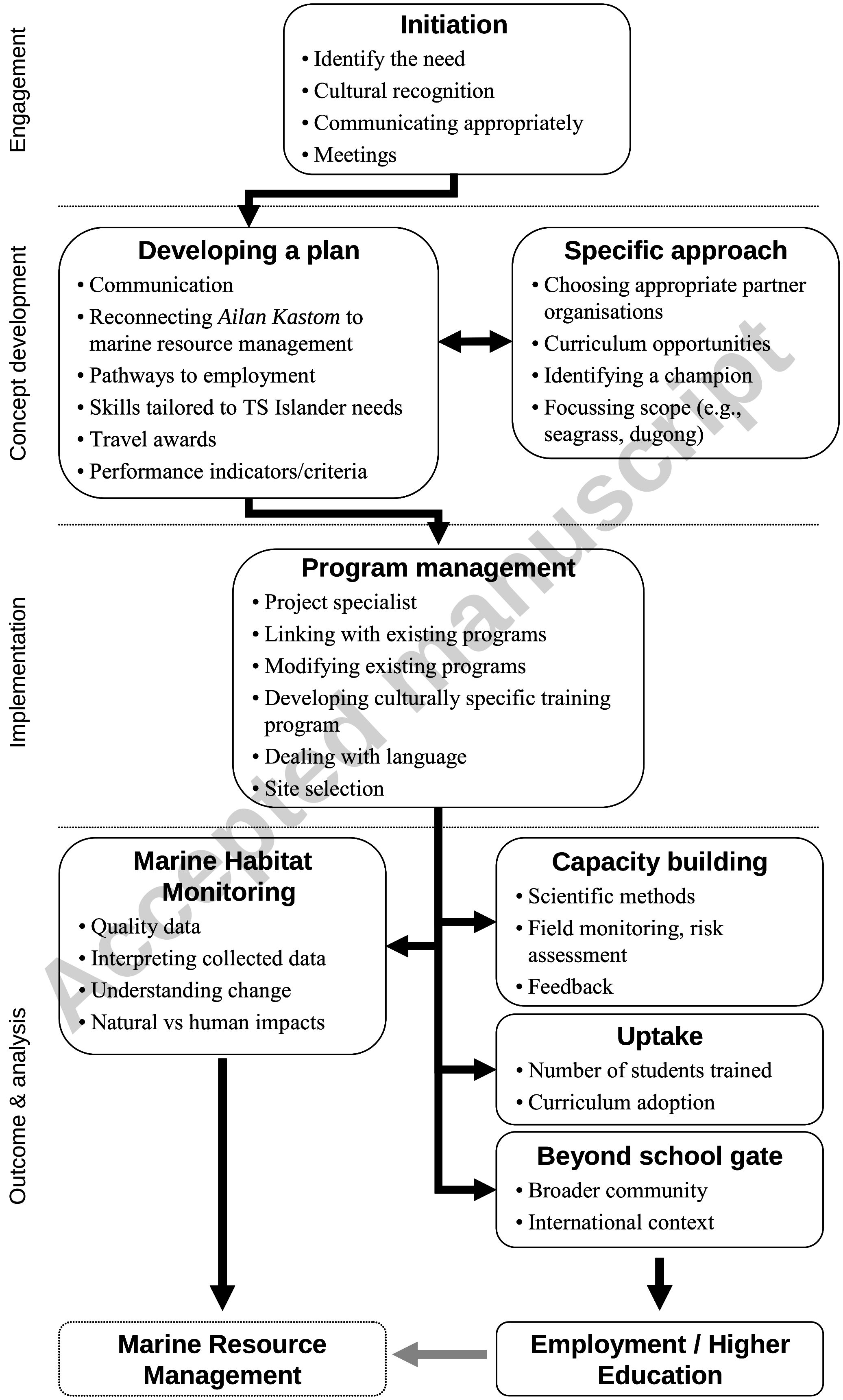
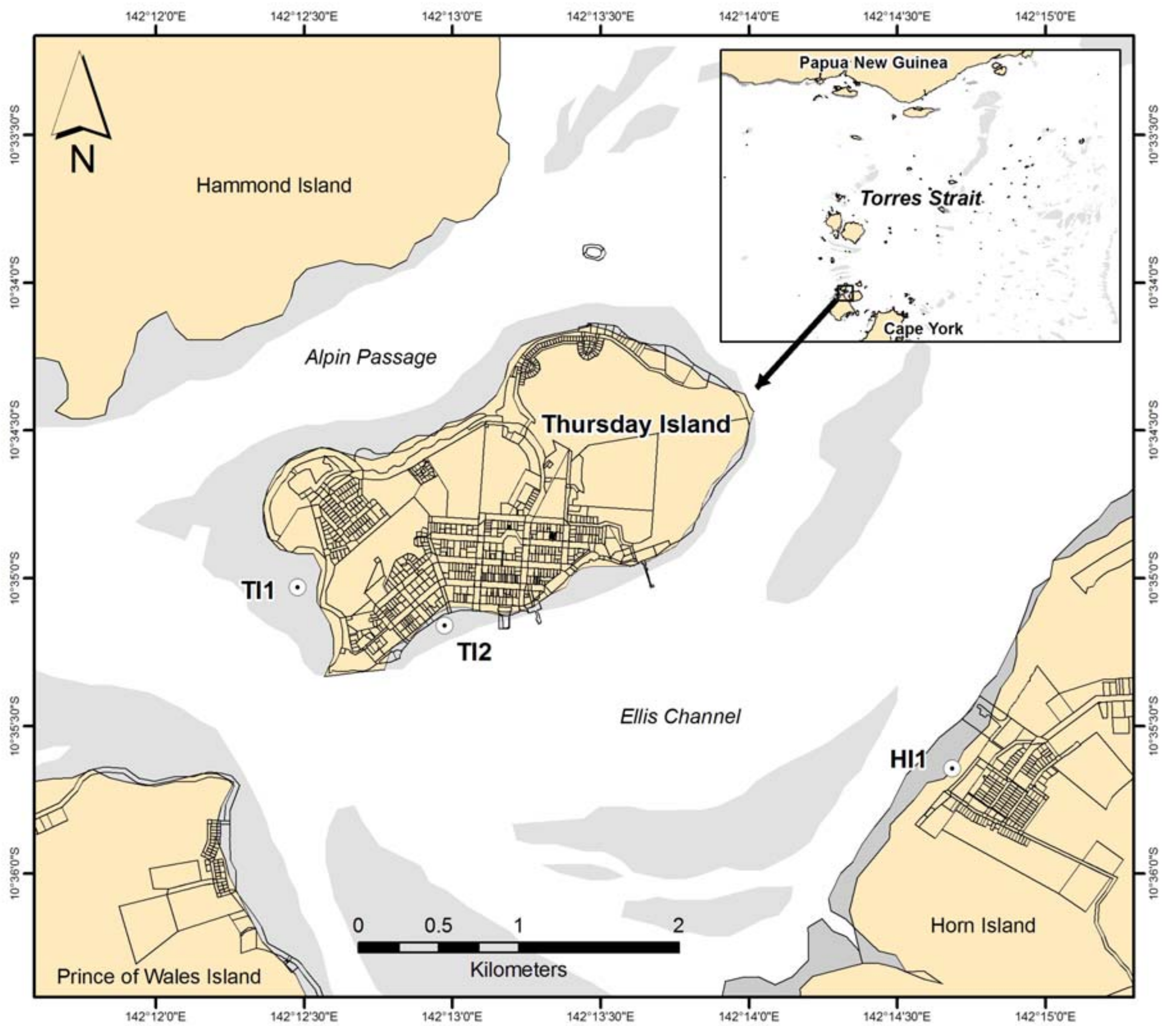

Engagement
Concept development
Implementation
Outcome & analysis
Initiation
• Identify the need
• Cultural recognition
• Communicating appropriately
• Meetings
Developing a plan
• Communication
• Reconnecting Ailan Kastom to marine resource management
• Pathways to employment
• Skills tailored to TS Islander needs
• Travel awards
• Performance indicators/criteria
Specific approach
• Choosing appropriate partner organisations
• Curriculum opportunities
• Identifying a champion
• Focussing scope (e.g., seagrass, dugong)
Program management
• Project specialist
• Linking with existing programs
• Modifying existing programs
• Developing culturally specific training program
• Dealing with language
• Site selection
Marine Habitat Monitoring
• Quality data
• Interpreting collected data
• Understanding change
• Natural vs human impacts
Capacity building
• Scientific methods
• Field monitoring, risk assessment
• Feedback
Uptake
• Number of students trained
• Curriculum adoption
Beyond school gate
• Broader community
• International context
Marine Resource Management
Employment / Higher Education

Fig 2.



142°12'0"E
142°12'30"E
142°13'0"E
142°13'30"E
142°14'0"E
142°14'30"E
142°15'0"E
10°33'30"S
10°34'0"S
10°34'30"S
10°35'0"S
10°35'30"S
10°36'0"S
N
Hammond Island
Papua New Guinea
Torres Strait
Cape York
Alpin Passage
Thursday Island
TI1
TI2
Ellis Channel
HI1
Prince of Wales Island
Horn Island
0
0.5
1
2
Kilometers

Fig 3.

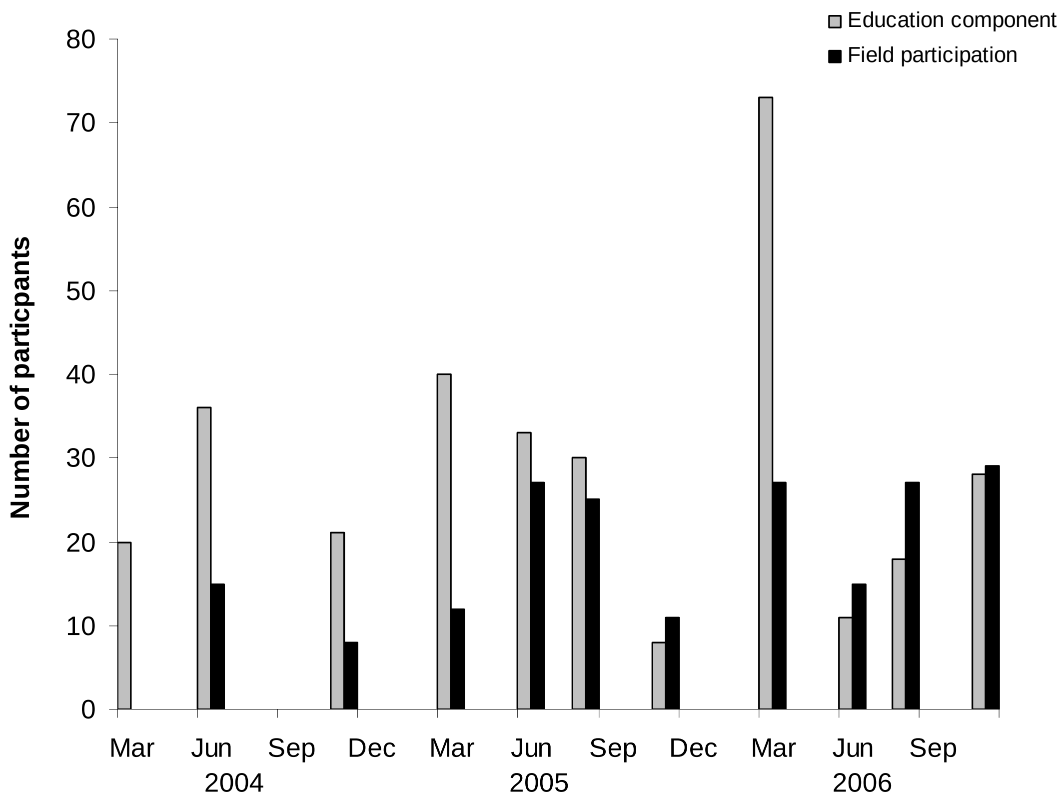

Education component
Field participation
Number of particpants
80
70
60
50
40
30
20
10
0
Mar
Jun
Sep
Dec
Mar
Jun
Sep
Dec
Mar
Jun
Sep
2004
2005
2006

Fig. 4.

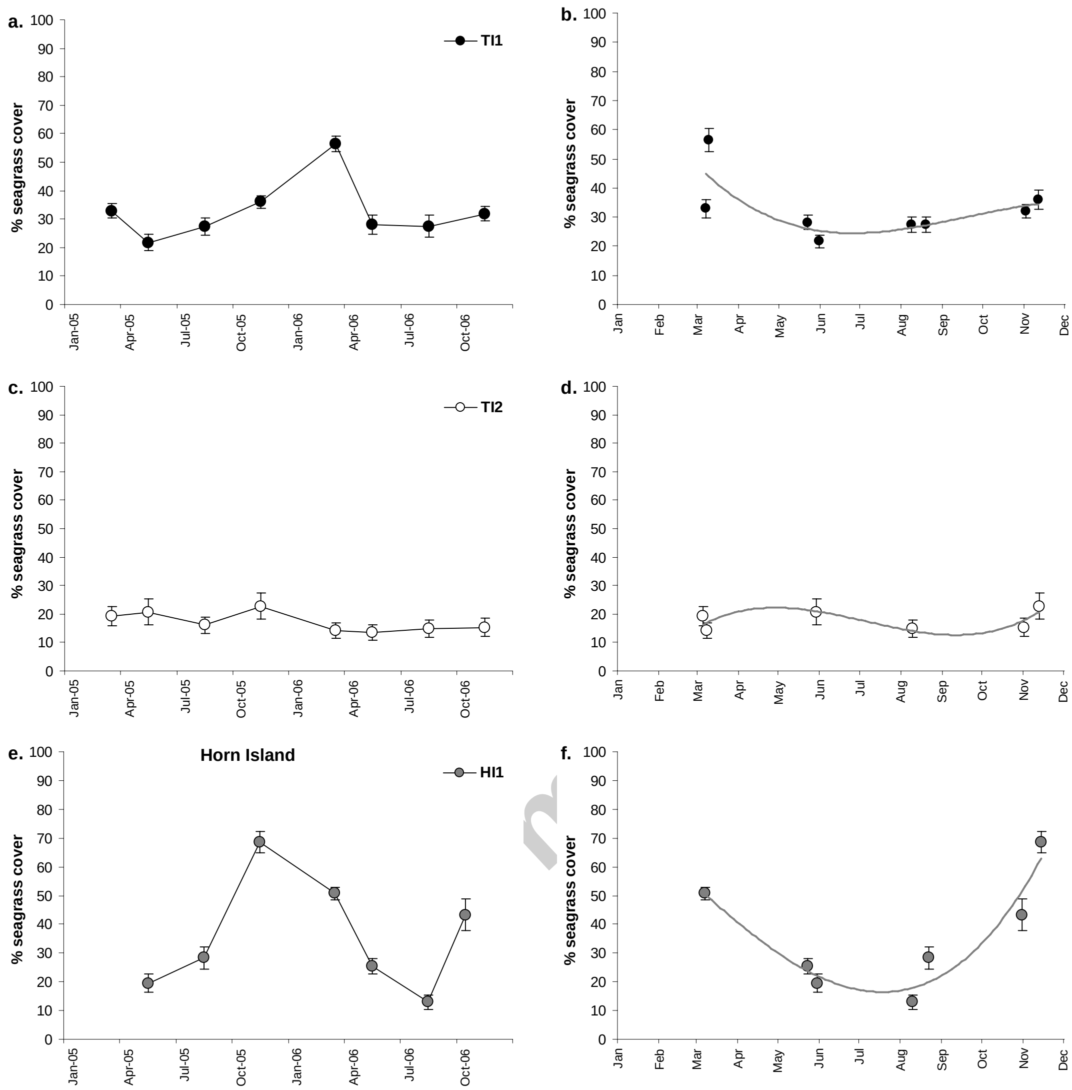

a.
b.
c.
d.
e.
f.
% seagrass cover
TI1
TI2
HI1
Horn Island
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
0
10
20
30
40
50
60
70
80
90
100

Fig. 5.

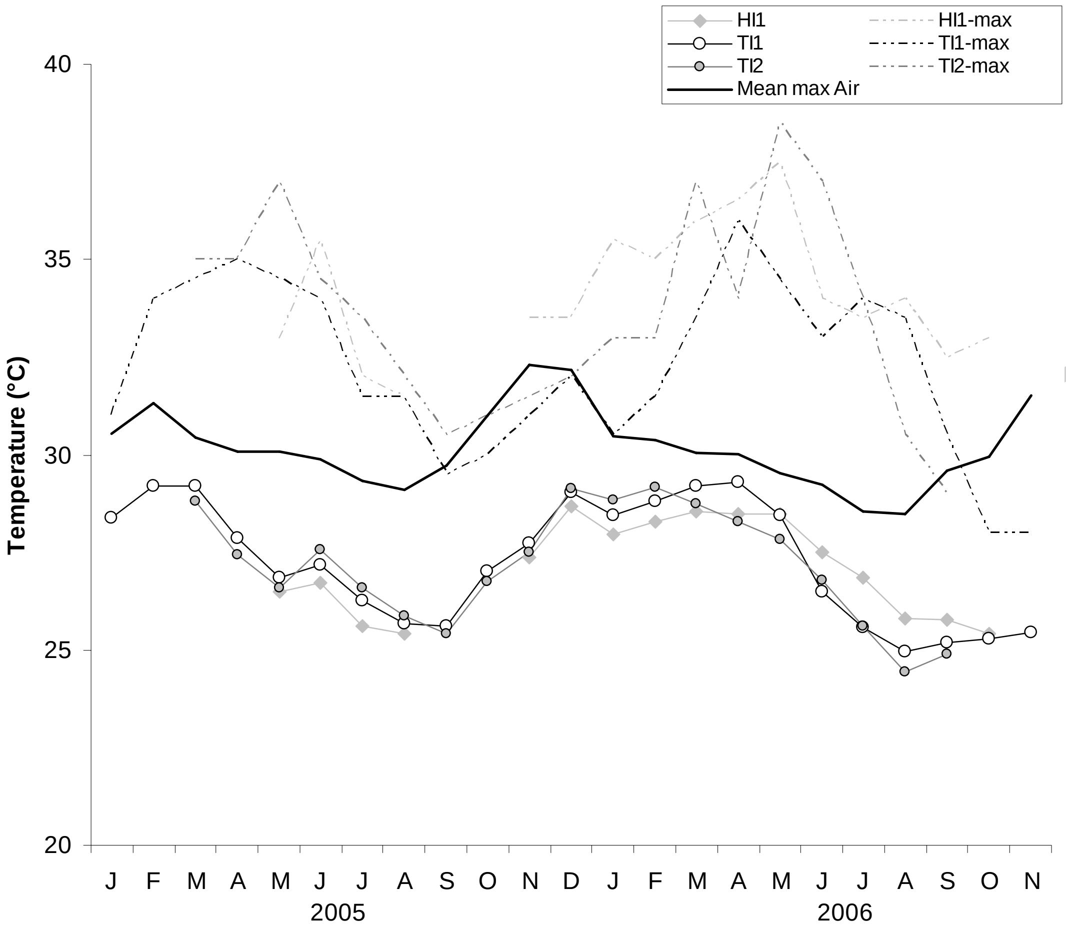

HI1
TI1
TI2
Mean max Air
HI1-max
TI1-max
TI2-max
40
35
30
25
20
Temperature (°C)
J F M A M J J A S O N D J F M A M J J A S O N
2005
2006

Fig. 6.

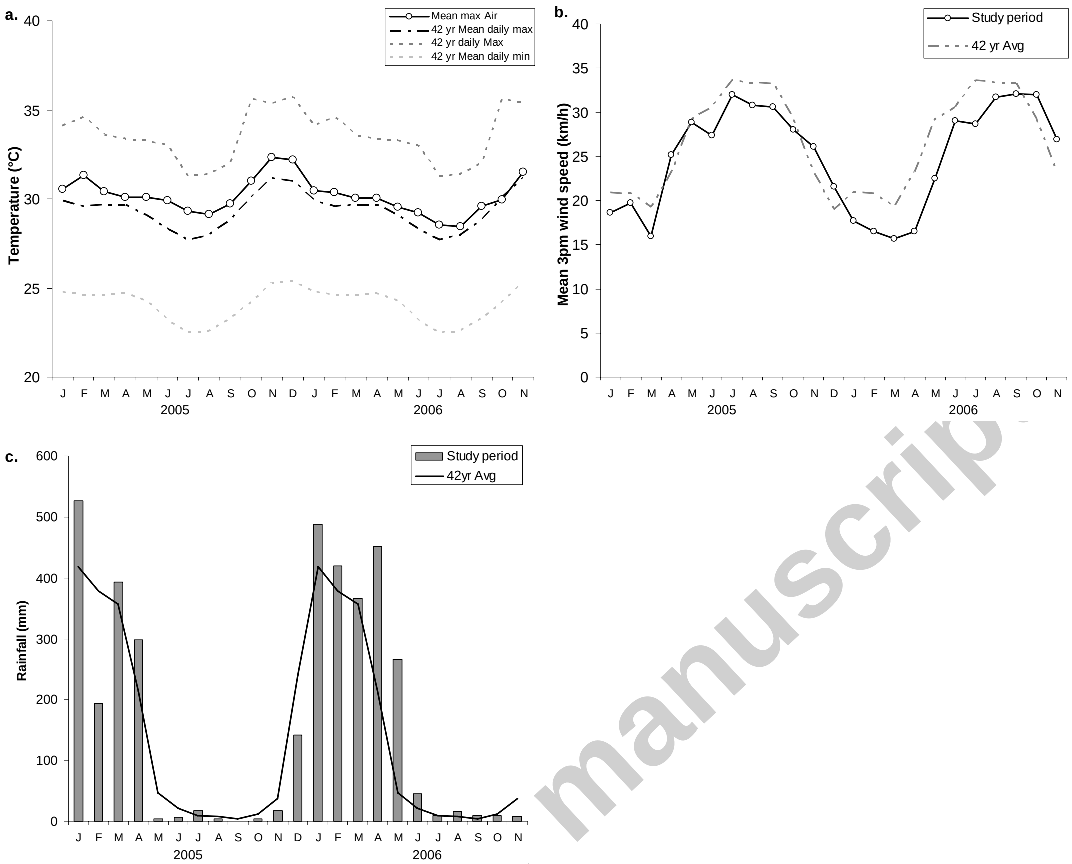

a.
Mean max Air
42 yr Mean daily max
42 yr daily Max
42 yr Mean daily min
Temperature (°C)
40
35
30
25
20
J F M A M J J A S O N D J F M A M J J A S O N
2005
2006
b.
Study period
42 yr Avg
Mean 3pm wind speed (km/h)
40
35
30
25
20
15
10
5
0
J F M A M J J A S O N D J F M A M J J A S O N
2005
2006
c.
Study period
42yr Avg
Rainfall (mm)
600
500
400
300
200
100
0
J F M A M J J A S O N D J F M A M J J A S O N
2005
2006

Table 1. Description of monitoring sites

Site	Name	Description	Lat and Long	Seagrass species (% comp)	Issues/threats
TI1	Back Beach, Thursday Island	Reef flat (sand/mud/shell)	10º 35.036´S 142º 12.494´E	*Cymodocea rotundata (11)* *Cymodocea serrulata (4)* *Enhalus acoroides (10)* *Halodule uninervis (wide leaf) (42)* *Halophila ovalis (5)* *Syringodium isoetifolium (3)* *Thalassia hemprichii (25)*	Occasional gleaning, trampling and boat traffic.
TI2	Federal Beach, Thursday Island	Sand flat (sand/mud)	10º 35.149´S 142º 12.965´E	*Cymodocea serrulata (<1)* *Enhalus acoroides (2)* *Halodule uninervis (47)* *Halophila ovalis (23)* *Thalassia hemprichii (25)*	Urban run-off, burial by sediment, trampling, boat traffic, anchoring, and careening of vessels
HI1	Wongai Beach, Horn Island	Mud flat (mud/sand)	10º 35.653´S 142º 14.698´E	*Enhalus acoroides (<1)* *Halodule uninervis (narrow leaf (78)* *Halophila ovalis (20)* *Zostera capricorni (<1)* *Thalassia hemprichii (<1)*	Terrestrial run-off during monsoon season, trampling, boat traffic, located adjacent to a breakwater, close to an area that was the site of a relatively recent diesel spill