4.3.7 Establishing Reference and Monitoring Sites to Assess a Key Indicator of Ecosystem Health (Seagrass Health) on the central west Coast of Western Australia

Principal Investigator / Institution

Adj. Prof. Ray Masini — Marine Ecosystems Branch, Department of Environment
PO Box K822, PERTH WA 6842
Email: ray.masini@environment.wa.gov.au

Collaborating investigators / Institutions

Prof. Paul Lavery — School of Natural Sciences, Edith Cowan University
100 Joondalup Drive, JOONDALUP WA 6027

Adj. Prof. Chris Simpson — Marine Conservation Branch
Department of Conservation and Land Management
47 Henry St, FREMANTLE WA 6160

Dr Cam Sim — Marine Ecosystems Branch
Department of Environment
PO Box K822, PERTH WA 6842

Executive Summary

Seagrasses are key elements of shallow marine ecosystems that require protection from human influences in Western Australia (WA). To protect WA's marine environment from the effects of waste discharges, an Environmental Quality Management Framework (EQMF), which explicitly includes seagrass, is being implemented. For physicochemical stressors and biological indicators, operation of the EQMF is based on the collection of monitoring data and the evaluation of these data against criteria that are established from data collected at suitable reference sites. In this study we examine natural spatial and temporal variability in *Posidonia sinuosa* shoot density and use resulting data to evaluate the potential for transferability of criteria established in one region to monitoring data gathered in another. During this study six new *P. sinuosa* seagrass reference sites were established at three depths at two locations within two protected areas of the Jurien Bay Marine Park and seagrass health data were collected on three occasions over the period 2003 to 2005. A 3-way ANOVA (year, location, depth) indicates that the overall structure of *P. sinuosa* meadows measured in terms of shoot density varies significantly among locations and depths. Significant interaction factors in the ANOVA model suggest that factors driving shoot density are likely to be complex and additional to those considered here. Based on comparisons among various percentiles of shoot density data performed here, the transfer of seagrass shoot density criteria derived from one region to monitoring sites in another region may be possible, but will need to give serious consideration to the inter-site variability in shoot densities. Discussions have taken place between the Department of Environment and SRFME researchers to strengthen collaboration by exploring opportunities to investigate potential influence of wave energy on *P. sinuosa* meadows at Jurien. We also discuss the potential implications of strengthening seagrass health criteria if this need was to arise.

Introduction

Seagrasses are key elements of shallow marine ecosystems off the south and west coasts of Western Australia (WA) that require protection from human influences. Impact of human activities on seagrasses can be direct (eg. physical removal by dredging) and/or indirect (eg. marine discharge of nutrient-enriched waste, turbidity generated by dredging). Direct impacts are generally managed though good project planning to avoid losses. To protect the marine environment, explicitly including seagrasses, from the indirect effects of waste discharges, the Department of Environment (DoE) is implementing an Environmental Quality Management Framework (EQMF), which is consistent with the *National Water Quality Management Strategy* documentation (ANZECC and ARMCANZ, 2000). The WA Government has set a mandate to progressively implement the EQMF throughout State waters on a priority basis (Govt of WA, 2003).

In general terms, the operation of the EQMF is based around targeted collection of monitoring data, with these data being evaluated against benchmarks called Environmental Quality Criteria (EQC). For physio-chemical stressors and biological indicators such as seagrass health, the EQC are pre-determined percentiles calculated from data collected at suitable reference sites. As part of the EQMF being given effect in Cockburn Sound through a whole-of-Government *State Environmental Policy* (Govt of WA, 2005), the primary indicator of *Posidonia sinuosa* health is shoot density. Work has been undertaken in SRFME to show that shoot density is a robust early warning indicator of *P. sinuosa* meadow health (Collier, 2005, and Sec. 2.2.1). Part of the EQC for *P. sinuosa* health is met for a 'high level of protection' if the calculated median shoot density at a monitoring site is greater than or equal to the 20th percentile of shoot density measured at a suitable reference site in two consecutive years. Conversely, the EQC would not be met if the median of monitoring site data is less that the 20th percentile of reference site data, and a management response aimed at improving environmental conditions for seagrass must be implemented.

Underlying the above approach is the need for reference sites to be as similar as possible to the monitoring sites, except that they are not influenced by the anthropogenic pressures that the monitoring sites are exposed to. In this context, the reference sites are designed to disentangle anthropogenic and natural changes. It is well established that *P. sinuosa* shoot density is influenced by depth (Collier, 2005). The influence of depth on seagrass shoot density is accounted for in the EQMF by ensuring that reference sites are established in water depths comparable to depths at the monitoring sites. To date it has been assumed that reference sites should ideally be as close to monitoring sites as possible to minimise the introduction of variation that may arise from natural differences between regions. For example, the percentile-based seagrass shoot density EQC applied in Cockburn Sound are established from data collected each year at reference sites located in the adjacent Warnbro Sound. Currently, little is currently known about variability in shoot density over regional scales, and hence the implications for seagrass health assessments if reference sites are located at varying distances from monitoring sites (e.g. kilometres to 100's of km).

In addition to ensuring that reference sites are established in water depths similar to depths at the monitoring sites, it is desirable to locate reference sites in areas that are afforded long-term protection from the effects of discharges and deposits. Sanctuary and other high protection zones within marine conservation reserves meet this desired objective. The Jurien Bay Marine Park (JBMP) has been selected as the focal point for this study because it includes high protection zones (Sanctuary zones and Special Purpose zones), has a statutory management plan, and contains representative elements of the mid-west coast marine environment. Moreover, land adjacent to the JBMP and areas to the south and north are predicted to come under increasing human-use pressure in the future through urban expansion and port development. Accordingly, forward-looking baseline data acquisition and implementation of the EQMF is a high priority to guide decision-making and to ensure management is effective in protecting the environmental quality and conservation values of the JBMP.

In this study we establish six new seagrass health reference sites in the JBMP, monitor them over three consecutive summers and utilise the resultant data to investigate the potential transferability of seagrass health criteria established from a reference site in one region to 'test' sites nearby (kilometres apart) and in another geographic region (~2° latitude and some 220 km away). This project provides an important information base for setting EQC for seagrass health off the central west coast of WA, further development of seagrass health assessment techniques and future performance evaluation of the JBMP.

Study objectives

The objectives of the project are to:

- quantify the natural spatial and inter-annual variability in proposed seagrass health indicators on the central west coast of WA for a period of three years;
- enable comparisons to be made between natural variability in seagrass health indicators at sites in the vicinity of the JBMP and in Perth's southern metropolitan coastal waters;
- provide an information base to make an assessment of the transferability of proposed seagrass health indicators and criteria from the central west coast and other temperate coastal waters in WA;
- enable Government agencies to broaden the geographic coverage of the environmental quality management framework currently being implemented in Perth's coastal waters; and
- enhance strong collaboration between university researchers, key Government natural resource management agencies and SRFME researchers.

Study sites and methods

Study sites

This study focused on the Jurien Bay Marine Park (JBMP). The township of Jurien is located centrally along the length of the Park and is approximately 200 km north of Perth, Western Australia. As part of the data analyses we also utilised *P. sinuosa* shoot density data collected from reference sites located in Warnbro Sound, about 20 km south of Perth (Lavery and Westera, 2003, 2004, 2005).

A pilot survey was undertaken in late March 2003 to locate *P. sinuosa* meadows at suitable depths in proposed protected areas of the JBMP. Reference sites were subsequently established in large *P. sinuosa*-dominated meadows at two locations in the JBMP, hereafter referred to as Boullanger Island (Is.) and Fisherman's Is. The Boullanger Is. is located near the Jurien township in a Special Purpose (*Puerulus*) Zone, while the Fisherman's Is. location is approximately 17 km north of Jurien and is within the Fisherman's Island Sanctuary Zone (Figure 4.12).

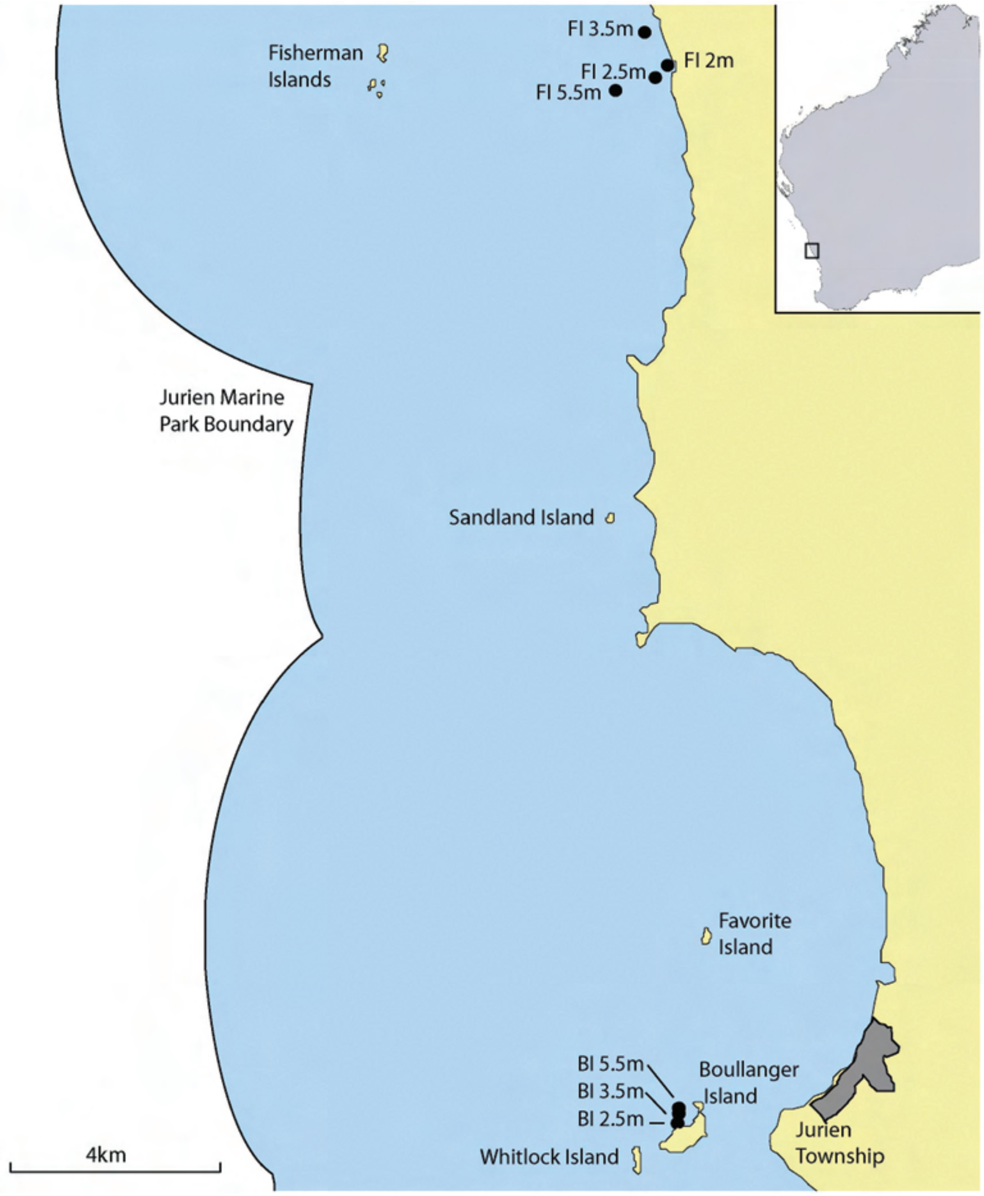

Figure 4.12: Location of sampling sites within the Jurien Bay Marine Park.

At each location, reference sites were established at approximately 2.5 m, 3.5 m and 5.5 m water depth over the period 1-3 April 2003. These depths were selected to correspond to water depths at the reference sites located in Warnbro Sound. Following subsequent spatial analysis, it was found that a 2.0 m deep site at Fisherman's Is. fell just outside the gazetted Fisherman's Islands sanctuary zone. To maximise the long-term protection of the site, a new site was established and sampled within the Fisherman's Is. sanctuary zone in 2004, in a water depth of 2.5 m. The site outside the sanctuary zone still contains permanently marked quadrats, but has not been re-sampled since 2003. The Global Positioning System coordinates for each reference site in the JBMP are shown in Table 4.2.

Table 4.2. Global Positioning System coordinates for seagrass health reference sites in the Jurien Bay Marine Park

Location	Depth	UTM Coordinates (WGS84 datum)		Comment
		East	North	
Fisherman's Is.	2.0 m	307408	6664795	2003 site–not sampled 2004-05
	2.5 m	307146	6664594	Replaces 2.0m site in 2004
	3.5 m	306940	6665428	
	5.5 m	306417	6664328	
Boullanger Is.	2.5 m	307929	6644723	
	3.5 m	307955	6644916	
	5.5 m	307971	6645019	
Warnbro Sound	2.5m	378957	6423948	
	3.2m	378967	6423933	
	5.5m	378938	6423789	

Methods

The reference sites were established, and sampled each year, using methods described by Lavery and Westera (2003) and outlined below.

At the 'centre' of each site, a star picket was driven into the sediment to locate the site. Four transects were then randomly located by assigning compass bearings from the central star picket to a start point of each transect. Each transect then continued along the same bearing for a length of 10 meters. A depth measurement was made at the end of each transect to ensure it was within the allowable depth limits for that site (±0.2m of the assigned depth for that site). If the depth at the end of the transect was outside the allowable depth limits the end of the transect was rotated until it satisfied the minimum depth requirements.

Six 20 x 20 cm quadrats were established at random distances along each 10 m transect. Stainless steel pegs were driven into the seabed in each corner of the six randomly allocated 20 x 20 cm quadrats to aid relocation on subsequent sampling occasions. Once set in place, each permanent relocatable quadrat was sampled for shoot density, percentage cover, maximum and average shoot height. For those quadrats where the randomly assigned position was either on bare sand (ie. no shoots) or contained other seagrass species other than *P. sinuosa*, the quadrat was moved until it contained shoots of only *P. sinuosa*. This process was carried out at each of the seven sites established at Jurien. A total of 24 permanent quadrats were sampled at each site on 3 occasions: 1-3 April 2003; 27-28 February 2004; and 11 and 24 January 2005.

Data were collected as follows.

Shoot Density

On each sampling occasion, the number of *P. sinuosa* shoots within each 20 x 20 cm quadrat was recorded by a diver on SCUBA. The measured shoot density in each quadrat was then expressed as a density of shoots per square meter (m^{-2}).

Maximum Shoot Height

The maximum shoot height was recorded by placing a one metre rule on the seabed and measuring the tallest leaf inside each 20 x 20 cm quadrat.

Average Shoot Height

The average shoot height was recorded by placing a one meter rule on the seabed and measuring the height above the sea floor of 80% of the seagrass leaves inside the 20 x 20 cm quadrat (i.e. the tallest 20% of leaves are ignored; as per Duarte & Kirkman, 2001). The 80th percentile was estimated visually by a diver on SCUBA.

Percentage Cover

Within each 20 x 20 cm quadrat leaves were stood upright and an estimate of the percentage of the quadrat containing seagrass was made the divers.

Light measurement

Submersible Odyssey data loggers with 2π light sensors were deployed to measure photosynthetically active radiation (PAR) in the field. Two PAR loggers, each with automatic wiper units to minimise sensor fouling, were deployed in an arrangement to enable continuous assessment of light attenuation at the 5.5 m sites at Fisherman's and Boullanger Islands. Another logger was deployed at a shore station at the CALM District office in Jurien to measure ambient surface PAR.

Data analysis

Spatial and inter-annual variability in seagrass shoot density among the JBMP and Warnbro Sound reference sites was analysed by a 3-way ANOVA model in which Location, Depth and Year were fixed factors. Seagrass shoot data from the 2.0 m Fisherman's Is. site established in 2003 were omitted from the ANOVA.

To assess potential transferability of seagrass health indicators and numerical EQC between Perth and the central west coast and other areas of WA, a series of comparisons were made to determine the effect of using each site as a reference for the other two sites. This was done using seagrass shoot density data collected at Fisherman's Is., Boullanger Is. and Warnbro Sound. For each test, two sites were chosen to represent 'test' sites. The 50th percentile of shoot density was calculated for these sites and compared against the 20th percentile of the chosen 'reference' site. The comparisons between percentile values are similar to those used to test the health of seagrass at monitoring sites in Cockburn Sound against reference site data collected in Warnbro Sound (EPA, 2005a&b). Percentile values were calculated from the total data sets for all years at each site to maximize size of the data set (n=72) and minimize the interpolation necessary to calculate the percentiles. Due to the relocation of the Fisherman's Is. 2.5 m site in 2004 and because the comparison of percentiles relies on data collected from the same site over time, the 20th and 50th percentiles of shoot density at this site were calculated using 2004 and 2005 data only (n=48). Tests were made for all combinations of 'test' and 'reference' sites.

Results

Spatial and temporal variation in *P. sinuosa* shoot density

Over the three years of this study and across the three depths sampled, average *P. sinuosa* shoot density ranged from 727 to 973 shoots m^{-2} at Boullanger Is. and 734 to 1511 shoots m^{-2} at Fisherman's Is. (Table 4.3). Average shoot density at reference sites in Warnbro Sound varied over the same three years and at similar depths from 738 to 1100 shoots m^{-2} (Table 4.3).

Table 4.3. Mean shoot densities (±standard error) for each region, year and depth.

Year	Depth 2.5m	Depth 3.5m	Depth 5.5m
	Boullanger Island		
2003	866 (64)	861 (74)	727 (49)
2004	950 (78)	974 (95)	838 (65)
2005	878 (58)	805 (86)	797 (51)
	Fisherman's Island		
2003	1116 (50)	735 (60)	9188 (54)
2004	1511 (92)	794 (63)	934 (68)
2005	1275 (81)	734 (53)	1061 (74)
	Warnbro Sound		
2003	980 (80)	1100 (132)	860 (55)
2004	958 (68)	917 (118)	781 (43)
2005	1100 (84)	833 (81)	738 (61)

Spatial and temporal patterns in mean *P. sinuosa* shoot densities at the sites monitored are illustrated in Figure 4.13. Mean shoot density was higher at the 2.5 m Fisherman's Is. site than at any of the other sites (Figure 4.13). Mean shoot densities at Boullanger Is. and Fisherman's Is. show similar patterns of inter-annual variation, which is characterised by an increase in 2004 compared with 2003, and then followed by a slight reduction in 2005. This pattern did not hold for sites at Warnbro Sound, where mean shoot densities were generally highest in 2003 and declined in 2004 and 2005, particularly at the 3.5 m site and less so at 5.5 m (Figure 4.13).

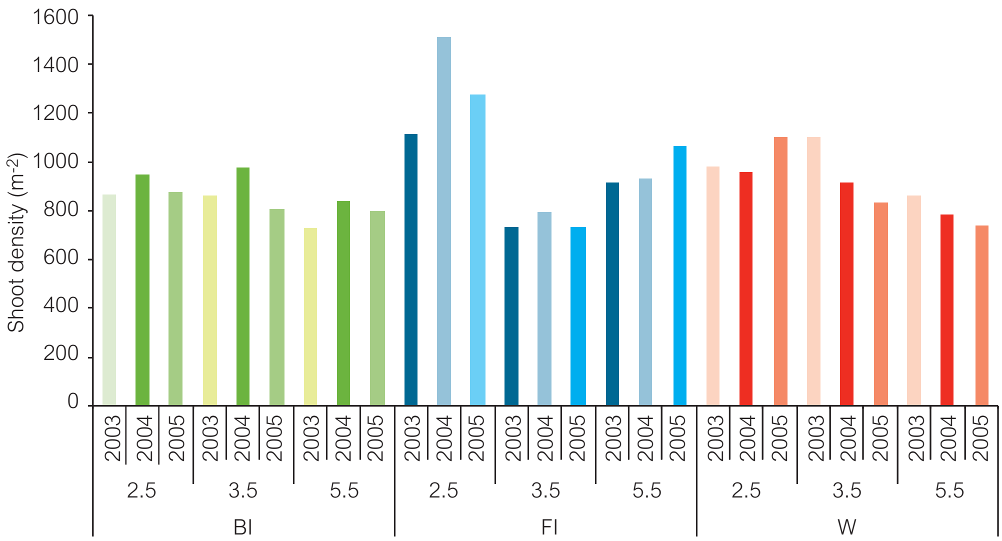

Figure 4.13: Mean shoot densities (m^{-2}) of *Posidonia sinuosa* at Boullanger Is. (BI), Fisherman's Is. (FI) and Warnbro Sound (W) at different depth in 2003-05.

Results of 3-way ANOVA indicate that location and depth both significantly affected *P. sinuosa* shoot density at the sites surveyed over the 3 years sampled (Table 4.4). The significant interactions between Year and Location, and Location and Depth suggest that the differences in shoot density among locations were only statistically significant at some depths and in some years. The interaction of Location and Depth was driven by a minimal change in shoot density over depth at Boullanger Is., but more significant among-depth differences at the other two sites, particularly Fisherman's Is. where shoot density at the 3.5 m site was considerably less than at the 2.5 m site. As noted earlier, Boullanger Is. and Fisherman's Is. sites showed similar patterns of inter-annual variation in shoot density, while at the Warnbro Sound sites, the three-year inter-annual variation was generally quite different.

Table 4.4. Results of 3-way ANOVA testing for effects of Year, Region and Depth on *P. sinuosa* shoot density.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	31882.263(a)	26	1226.241	6.089	.000
Intercept	869800.858	1	869800.858	4319.05	.000
YEAR	599.681	2	299.841	1.489	.226
LOCATION	4105.124	2	2052.562	10.192	.000
DEPTH	10413.794	2	5206.897	25.855	.000
YEAR * LOCATION	2155.394	4	538.848	2.676	.031
YEAR * DEPTH	1660.055	4	415.014	2.061	.084
LOCATION * DEPTH	10391.707	4	2597.927	12.900	.000
YEAR * LOCATION * DEPTH	2169.613	8	271.202	1.347	.217
Error	122443.145	608	201.387		
Total	1027641.000	635			
Corrected Total	154325.408	634			

a R Squared = .207 (Adjusted R Squared = .173)

The overall shoot density structure of *P. sinuosa* meadows was also examined by evaluating the between-location variation in the estimates of selected percentiles. There were differences in the percentile values calculated for each site at any given depth (Table 4.5). The maximum divergence in the estimates of percentile values tended to occur at the 2.5 m depth where the 50^{th}, 20^{th}, 5^{th}, and 1^{st} percentiles at Boullanger Is. were 59%, 67%, 52% and 26% of the maximum estimates for corresponding percentiles, which were all calculated for Fisherman's Is. In absolute terms, these maximum discrepancies equate to between 320 and 430 shoots m^{-2}. Greater discrepancy among sites also tended to occur for the smaller percentiles (i.e. 1^{st} and 5^{th}), particularly at 2.5 m and, to a lesser degree, the 3.5 m sites.

Table 4.5. Variation in estimates of percentile values for shoot density, expressed as a proportion of the maximum percentile value, for combined 2003-05 data at each depth at Boullanger Is. (BI), Fisherman's Is. (FI) and Warnbro Sound (W).

		Percentile			
Depth	Site	50th	20th	5th	1st
2.5 m	BI	0.59	0.67	0.52	0.26
	FI	1.00	1.00	1.00	1.00
	W	0.69	0.72	0.64	0.47
3.5 m	BI	0.89	0.95	0.63	0.40
	FI	0.78	1.00	1.00	1.00
	W	1.00	0.83	0.53	0.54
5.5 m	BI	0.83	0.79	0.76	0.71
	FI	1.00	1.00	1.00	0.90
	W	0.80	0.77	0.97	1.00

Potential transferability of indicators and criteria

Figure 4.14 shows multiple comparisons of median seagrass shoot densities verses 20th percentiles for all combinations of location and depth. In all cases but one, median seagrass shoot densities for the selected ‘test’ sites were greater than the 20th percentile calculated for selected ‘reference’ site. The median seagrass shoot density for Boullanger Is. 2.5 m (863 shoots m^{-2}) was the only median less than a 20th percentile value (<975 shoots m^{-2}, Fisherman’s Is. 2.5m). The Boullanger Is. 2.5 m median was greater than the 5th percentile of Fisherman’s Is. 2.5m data (734 shoots m^{-2}).

2.5 m	655 (B)		975 (F)		700(W)	
Ref (20th%ile)	<1450	<1000	>863	<1000	<863	<1450
Test (median)	(F)	(W)	(B)	(W)	(B)	(F)
3.5 m	500 (B)		525 (F)		435 (W)	
Ref (20th%ile)	<775	<1000	<888	<1000	<888	<775
Test (median)	(F)	(W)	(B)	(W)	(B)	(F)
5.5 m	575 (B)		725 (F)		555 (W)	
Ref (20th%ile)	<950	<762	<788	<762	<788	<950
Test (median)	(F)	(W)	(B)	(W)	(B)	(F)

Notes:
< signifies ‘compliance’ of the median test site seagrass shoot density against the 20th percentile of the selected reference site data.
> signifies ‘non compliance’ with the above test.

Figure 4.14: Multiple comparisons of medians verses 20th percentiles for all combinations of sites at Jurien Bay Marine Park and Warnbro Sound. (Ref = ‘reference site’, Test = ‘test’ site, F = Fisherman’s Island, B = Boulanger Island, W = Warnbro Sound).

Other indicators

Posidonia sinuosa shoot height was measured along with shoot density. At each depth, shoots were longer at Boullanger Is. than at Fisherman Is. (Figure 4.15). This pattern was particularly strong at the 2.5 m and 5.5 m sites. Shoot density was strongly negatively related to shoot height at the same depths. A similar relationship between shoot height and shoot density at the two locations was not observed at 3.5m.

Odyssey PAR data loggers were deployed at the Boullanger Is. and Fisherman’s Is. 5.5 m sites on two occasions. The loggers either failed to record or logged erroneous and unstable data on both occasions. Accordingly, we have not been able to investigate the variability of PAR among the reference sites in Jurien or Perth.

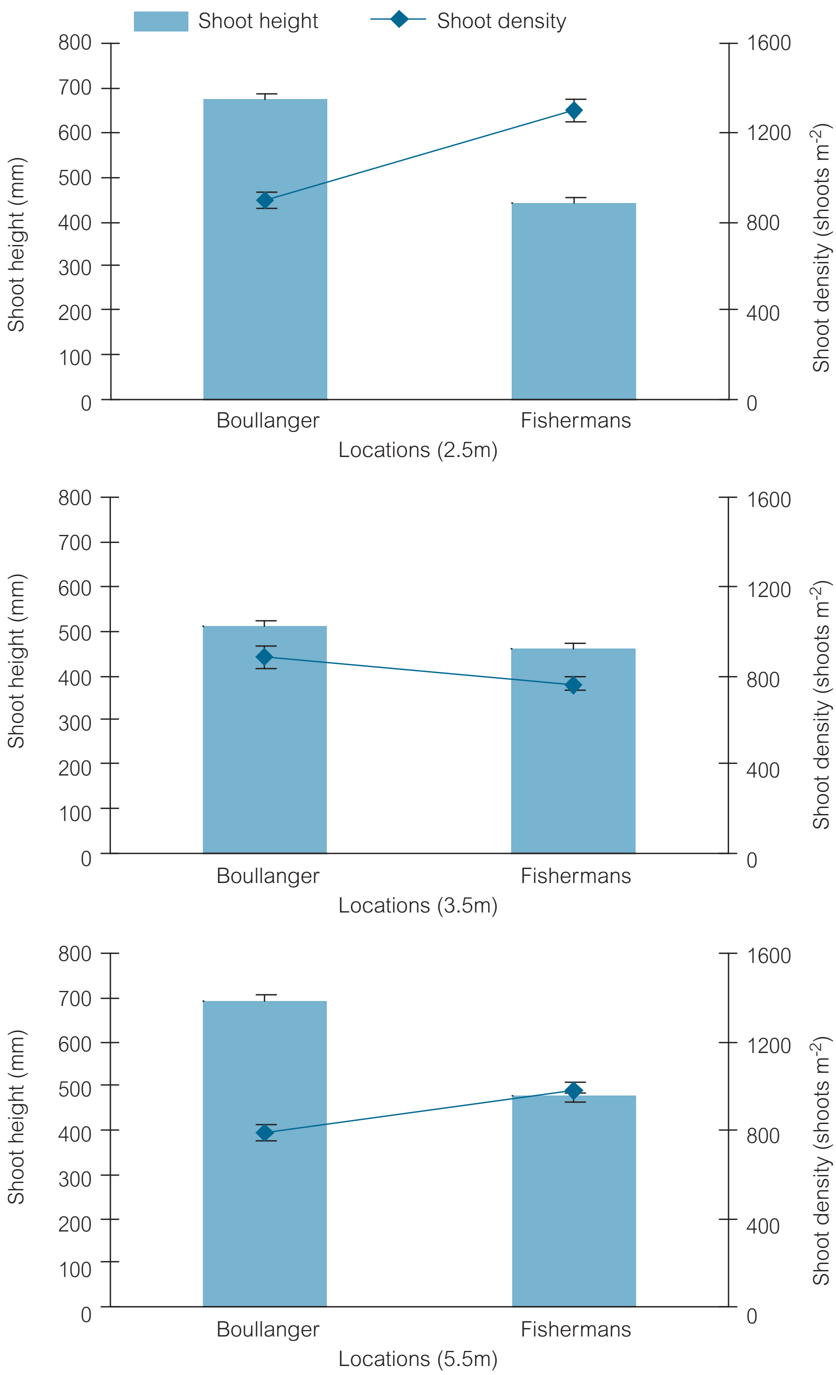

Figure 4.15: Average *P. sinuosa* shoot height and shoot density at 2.5 m, 3.5 and 5.5 m sites at Boullanger Is. and Fisherman's Is.

Discussion

Establishing six new seagrass health reference sites in protected areas of the Jurien Bay Marine Park and monitoring them over three summers has improved understanding of the natural spatial and temporal variation in overall shoot density structure of *Posidonia sinuosa* meadows off the mid-west coast and near Perth, and increased confidence in the approach being taken to assess seagrass health.

The results of statistical analysis performed here suggest that the overall shoot density structure of *P. sinuosa* meadows in the JBMP and Warnbro Sound varied significantly among the locations and depths monitored during this study. Interactions among the main factors in the ANOVA model also suggest that variability in overall meadow shoot density structure is complex and is probably driven by a variety of environmental factors, including depth (Collier, 2005), but possibly also including hydrodynamics, exposure to wave energy, and sediment type and depth.

Variation among estimates of percentiles of shoot density also provide insight into the overall structure of seagrass meadows at the sites monitored. Most variation among locations occurred for small percentiles and at 2.5 m deep sites. It is likely that a contributor of variation among small percentiles of *P. sinuosa* shoot density was sample size. In this study we calculated percentiles from three years of shoot density data (n=72, except Fisherman Is. 2.5 m were n=48). It is worth noting that to maximise confidence in calculated 1st and 5th percentiles, the Standard Operating Procedures for monitoring in Cockburn Sound (EPA, 2005b) recommend using a minimum of five years data (n=120). A minimum of 20 samples should be used to calculate the 20th percentile (ANZECC/ARMCANZ, 2000). It is also possible that seagrass inhabiting extremes of the depth range (e.g. very shallow or very deep water) may exhibit greater variability than seagrass inhabiting mid-range depths. While it is beyond the scope of this work to address this possibility, additional research could be designed and undertaken to test the applicability of the intermediate disturbance hypothesis in the context of *P. sinuosa* meadow structure using the reference sites established in the JBMP.

The finding based on analyses performed here that the three reference locations examined (Fisherman's Is., Boullanger Is. and Warnbro) were assessed as being as 'healthy' as each other has important management implications. Firstly, this suggests that the transfer of seagrass shoot density criteria derived from one region to monitoring sites in another region may be possible, but will need to give serious consideration to the inter-site variability in shoot densities. For example our data indicate that shoot density structure of *P. sinuosa* meadows at Fisherman's Is. sites, particularly the 2.5 m site, is different to that observed at Boulanger Is. and Warnbro Sound.

Fisherman's Is. is geo-morphologically most distinct from the other two sites, being located on a wide tombola-like structure formed in the shelter of the offshore islands. Fisherman's Is. sites are exposed to winds waves and swells from most directions. It has a thin veneer of sand over hard limestone. Boullanger Is. site is in a sheltered embayment on deeper sands, protected from southerly winds and swells and, while still differing in some important respects, is more similar to Warnbro Sound than is Fisherman's Is. The fact that the outcomes for Warnbro Sound and Boullanger Is. were similar, despite some significant differences in the degree of exposure and depth gradients, indicates a potential to apply reference site data from one geographical region to a monitoring site in another region.

It is probably the case that the particular habitat conditions at any given site are more crucial to the shoot density of a seagrass meadow than the general location. It is well known that light is a major determinant of shoot density, but the influence of other factors that can vary among sites, such as sediment depth and type and hydrodynamic conditions, is less clearly understood. In order to determine whether a site is suitable as a reference against a monitoring site, it would be important to determine that the sites were comparable with respect to key non-anthropogenic factors that can affect shoot density. Further investigations are required to be conducted into the factors that affect shoot density at sites not influenced by anthropogenic disturbance in order to determine which characteristics should determine the comparability of monitoring and reference sites. Research undertaken by SRFME scientists has revealed that reef algal diversity is correlated with orbital velocity generated by waves. Discussion with the SRFME ecological modeller has taken place to explore opportunities for collaboration to broaden this existing SRFME work to investigate whether correlations exist between orbital wave velocity and the seagrass meadow variables measured during this study.

A second and related key finding is that the assessments of Warnbro Sound against Fisherman's and Boullanger Islands reference sites confirm that Warnbro is 'healthy' according to the criteria applied and, from this perspective, is therefore an appropriate reference site.

Thirdly, the data gathered during this study provide an opportunity to examine the effect of strengthening the seagrass shoot density criteria to provide greater protection should the need arise in the future. Figure 4.16 provides an indication of the sensitivity of the seagrass health assessment methodology to strengthening the criteria in order to provide greater protection to the environment. If Warnbro Sound or Boullanger Is. sites are used as reference sites, the median values for the other two 'test' sites are consistently higher than the 35th percentile of the selected reference site (Figure 4.16). This suggests that, for these sites, the methods applied are robust enough to accommodate a strengthening of the EQC by reducing the allowable departure from a reference condition. The median values of selected 'tests' sites is more likely to be less than the nominal 35th percentile of reference site data if Fisherman Is. sites are the reference sites. This is most likely due to shoot densities at the 2.5 m and 5.5 m Fisherman's Is. sites being high relative to shoot densities measured in similar depths at the other locations. These findings, while promising, also point to the need for work into what are the most important factors that drive comparability of reference and monitoring sites.

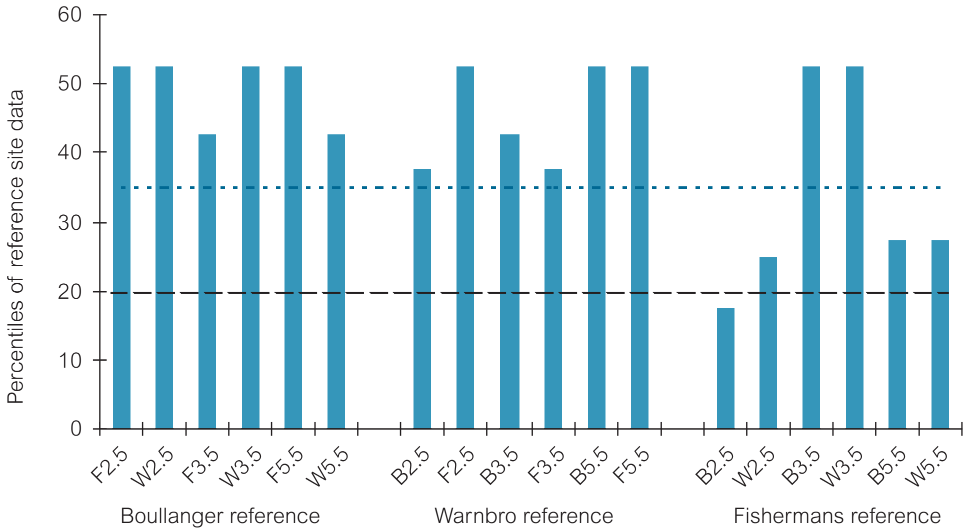

Figure 4.16: Estimates of median seagrass shoot density at as percentiles of three selected reference sites. The 35th percentile is marked as the horizontal line.

In addition to providing a critical scientific information base from which to broaden the geographic coverage of the EQMF, the outcomes of this work provide a basis for establishing a seagrass health baseline and longer-term data set. This information has direct utility for gauging the performance of the JBMP against long-term targets set out in the Park's Management Plan and also could inform broader-scale assessment of the condition of WA's marine environment through processes such as State of Environment reporting.

Acknowledgements

The investigators thank the SRFME Joint Venture Management Committee for agreeing to support this project. We are also grateful to Prof. Paul Lavery and Mr Jason Howe for their guidance and advice, analysis of the seagrass shoot density data and preparation of annual and final data reports which informed the preparation of this report.

Thanks are also due to the skipper of the DoE vessel, Mr Tim Daly and staff and students of the ECU School of Ecosystem Management who assisted in the field. We also acknowledge the local assistance and advice provided by Mr Keith Hockey and Mr Kevin Crane (CALM Jurien District).

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