Edith Cowan University
Centre for Marine Ecosystems Research

Keep Watch Seagrass Monitoring 2012 Report for GeoCatch

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Keep Watch Seagrass Monitoring, 2012. Report to GeoCatch

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Keep Watch Seagrass Monitoring

Annual Report 2012

Investigators: Kathryn McMahon

A project funded by GeoCatch

Sept 2012

1 Executive Summary

1.1 Introduction

This report summarises data from the first Keep Watch Seagrass Monitoring Program that was set-up and carried out in February 2012. The aim of the Keep Watch program is to assess the health of seagrass meadows in Geographe Bay in relation to the potential threat associated with the predicted nutrient enrichment from the catchment, and as more annual data is collected, assess change at sites over time.

1.2 Implications & Conclusions

In general, seagrass meadows in Geographe Bay are healthy, as indicated by *P. sinuosa* shoot density data (high compared to other regions) and nutrient content (low compared to other regions). One site, Port Geographe appears to have had recent loss of shoots, potentially linked to the accumulation of wrack at this site which could smother seagrass and leaching of organic materials would lower light reaching the seagrass meadow.

1.3 Recommendations:

There are five main recommendations for GeoCatch following this 2012 monitoring.

Recommendation 1

As GeoCatch has confirmed that volunteers will not be involved in the 2013 Keep Watch Monitoring, ECU should organize and carry out the monitoring, as agreed to in the contract.

Recommendation 2

Continue monitoring shoot density, shoot nutrient content and shoot $\delta^{15}N$ values to assess how they change over time at the seven Keep Watch seagrass monitoring sites.

Recommendation 3

As there was not a *P. sinuosa* seagrass meadow at Capel, and this Keep Watch monitoring program is using *P. sinuosa* as an indicator species, it is recommended not to continue with the site at Capel. However, if GeoCatch is interested in understanding changes in nutrient content of *Amphibolis* seagrass at this site, then samples of *Amphibolis* should be collected from at least two other locations in Geographe Bay as a comparison, to confirm that the differences are due to nutrient sources at the site, not differences due to different seagrass species.

Recommendation 4

Change assessment of shoot density should begin in 2014, after the third monitoring.

Recommendation 5

Water quality monitoring and light monitoring should begin as soon as possible, and be incorporated into the 2013 Keep Watch Monitoring Report.

2 Introduction

This document is produced for GeoCatch by Kathryn McMahon from Edith Cowan University. It reports on the Keep Watch seagrass monitoring survey that was undertaken in February 2012. It includes the data on *P. sinuosa* shoot density and leaf tissue nutrients (C,N,P), and a summary of all the other observations collected at each site. In the future, annual reports should also summarize the light data (average total daily irradiance per week and average maximum daily light attenuation per week) and the water quality data. However, as the Keep Watch program has only just started, this data has not been collected prior to the February 2012 sampling. Also in future annual reports, the shoot density data from each site should also be assessed against all three trigger values.

Trigger 1:

If there is a > 50% reduction in shoot density at a particular site compared to the previous year (Need 2 years of data to assess this, always compare the current year with the previous year).

Trigger 2:

If there is > 20% reduction in shoot density at a particular site compared to the previous year, two years in a row (Need 3 years of data to assess this).

Trigger 3:

If there is a significant trend of a reduction in shoot density at a particular site over all time periods (when there is 3 or more years of data), as determined by trend analysis (Makesens Mann-Kendall trend statistic, Need at least 3 years of data to assess this).

There will be enough data to do this for Trigger 1 in 2013, Trigger 2 in 2014 and Trigger 3 in 2015. All raw data is included in the appendix to this report, and has been submitted to GeoCatch as a digital file.

3 Methods for Keep Watch – Seagrass health monitoring program

The "Keep Watch" annual seagrass monitoring program is based on the methods recommended by McMahon (2012), and modified based on feedback from GeoCatch.

Eight seagrass sites were selected (Table 1, Figure 1). These were chosen to cover the spatial range of *P. sinuosa* meadows in Geographe Bay, and associated with a variety of catchments with different known surface water nutrient inputs. All sites, except for Capel had *P. sinuosa* meadows. At Capel there were high relief rocky reefs surrounded by bare sand. On the reef there were patches of *Amphibolis antarctica* seagrass that were collected for nutrient analysis.

Table 1: Details for eight Keep Watch sites, seven in *Posidonia sinuosa* meadows (1-7) and one in rocky reef with *Amphibolis antarctica* patches (8)in Geographe Bay. Coordinates are decimal degrees based on the WGS80 grid system.

Site Name & #	Coordinates	Depth (m)	Date & Time
1. Dunsborough	S 33.61654°, E 115.12865°	4	26/2/2012 8.25
2. Buayanup	S 33.65233°, E 115.24840°	4	26/2/2012 11:45
3. Vasse Diversion Drain	S 33.64746°, E 115.32379°	4.5	26/2/2012 13:45
4. Busselton Jetty	S 33.63896°, E 115.34315°	4.5	26/2/2012 15:30
5. Port Geographe	S 33.62846°, E 115.38240°	4.5	27/2/2012 14:45
6. Vasse-Wonnerup	S 33.60188°, E 115.42345°	5	27/2/2012 12:55
7. Forrest Beach	S 33.57295°, E 115.44908°	5	27/2/2012 9:45
8. Capel	S 33.51394°, E 115.51508°	2	27/2/2012 8:30

Ideally, we tried to locate each site at the same depth (3.5 m); however, this was not possible for a variety of reasons. In some cases the seagrass was considered too patchy this depth, or did not have a consistent *P. sinuosa* meadow, but was dominated more by *Amphibolis*. It is not a major issue for the monitoring program, as the sites are assessed over time for change, not by comparison between sites. Also, we tried to locate each site in a monospecific *P. sinuosa* meadow. However, this was not possible, particularly at Forrest Beach, where there it was a mixed meadow of *P. sinuosa* and *A. antarctica*.

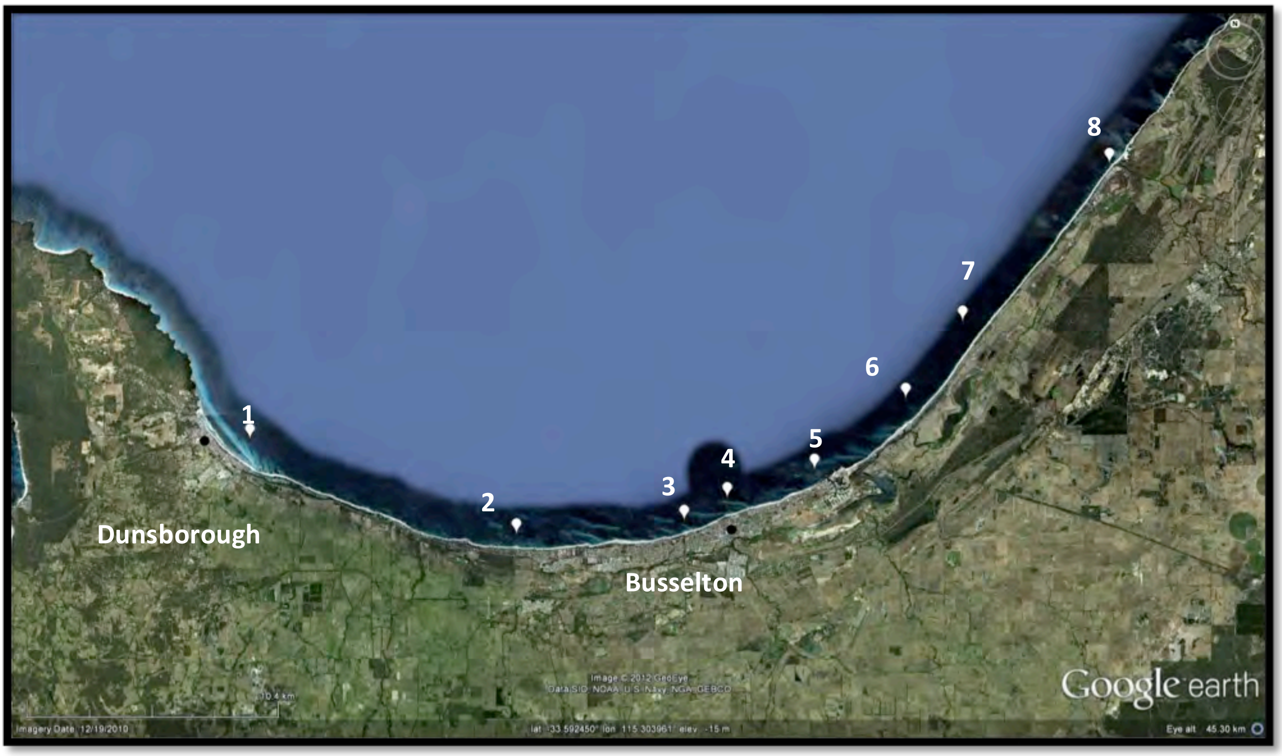

Figure 1: Map of Geographe Bay, showing the location of the 8 seagrass sampling sites (1. Dunsborough, 2. Buayanup, 3. Vasse Diversion Drain, 4. Busselton Jetty, 5. Port Geographe, 6. Vasse-Wonnerup Estuary, 7. Forrest Beach and 8. Capel.

Each site was located at least 30m from the edge of the meadow and the centre of the 50 m diameter site marked with a permanent star picket with a plastic cap (Figure 2). A site label was attached to the star picket, and additional cable ties, which indicated the site number, i.e. 1 for site 1 and 7 for site 7 etc. The exact locations were determined with a differential GPS (using the WSG 84 grid system), on the water surface, directly above the permanent marker.

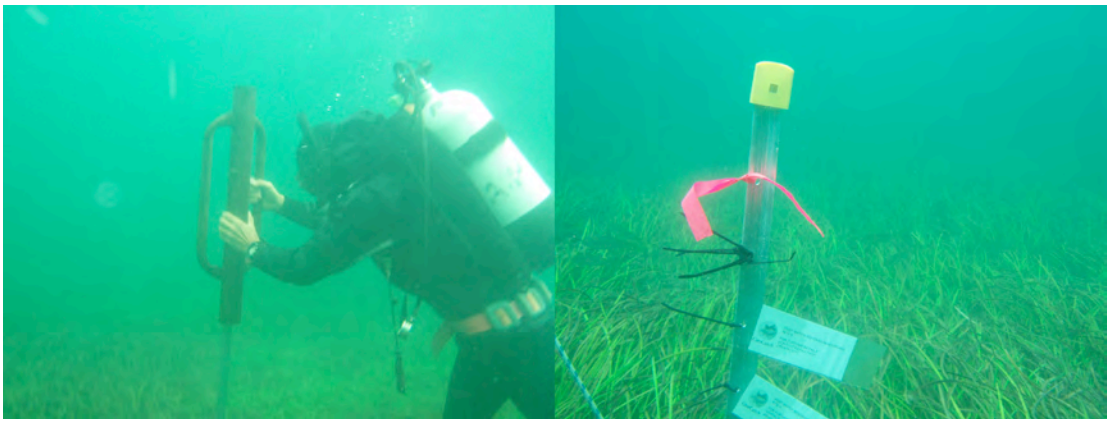

Figure 2: Left: Banging in permanent marker with pole driver. Right: Star picket with cap and plastic coated site label, indicating centre of 50 m diameter Keep Watch seagrass site.

These sites were sampled from 26-27 February 2012. The methods for the Keep Watch seagrass monitoring program (McMahon, 2012) recommended that measurements be carried out in January, as this is the time where peak density is expected and sampling is carried out in similar programs around the state. Seagrass shoot density can decline somewhat after summer, particularly when storms dislodge leaves and shoots. Observations in the field indicated there had not been a lot of disturbance in the meadow, but as a precaution, the data from this year should be considered as a trial, and assessment of change should not occur until 2015, when two years of data has been collected in January.

At each site *P. sinuosa* shoot density was counted in 30 0.2 x 0.2 m quadrats. The position of each quadrat was located randomly. This was achieved by selecting randomly 30 bearings from the central star picket at 20° intervals. These bearings represented transect line from the star picket to the edge of the site (25m i.e. the site was 50 m in diameter and the star picket was in the centre of the site). Then for each bearing selected a distance along that bearing was randomly selected (See Appendix 1 for the bearing and distance along each transect that the quadrats were positioned). A transect tape was swum out on the appropriate bearing using a compass and the quadrat placed at the appropriate distance along the transect (Figure 3). If this happened to be a patch of a different type of seagrass, or a blow-out without seagrass, then the quadrat was moved to the next closest point along the transect in *P. sinuosa* meadow. The quadrats were stabilised by securing to the sediment with tent pegs, to ensure that it did not move during counting.

Figure 3: Left: Determining bearing of transect with compass. Right: Counting *P. sinuosa* shoots in a quadrat.

Only shoots that originated in the quadrat were counted. In the field it was noted that seedlings of *P. sinuosa* were present within the quadrat. These were identified by the small size of the leaves and the seed that was still attached to the seedling. As it is predicted that there can be high mortality of seedlings. These were counted separately, and not included in the shoot density assessment. As there can be an error associated with counting shoots, a quality assurance check was carried out at the first site, before official counts began. Each counter counted one quadrat twice, and this was done with four different quadrats. There was about a 5% error with counting, i.e. a maximum difference of 1-3 shoots at the site where this was carried out. A photograph of seagrass at the site and a video in a circle around the star-picket, 5 m distance away from the star-picket was also taken.

In addition to counting shoots, the cover of algal epiphytes was recorded as Very Low, Low, Mod, Hi, Very High, and the dominant or co-dominant type of algal epiphytes at each site were recorded from observations of the seagrass leaves, based on the following categories:

Filamentous algae;

Encrusting algae;

Microalgal accumulations; and

Other epiphytic algae (any type of algae that is not as above such as erect, branched, foliose, leathery or jointed calcareous).

A photograph of the dominant epiphytic algae was also taken.

Finally, the following points were noted:

If other seagrass species were present at the site,

If there were any bare patches of sand within the meadow, and there was rhizome in the sand, indicating that a loss of shoots from the area. Movement of sand bars through the seagrass meadow is common in this area, so it is likely that these will be noted.

Any signs of anchor damage in the meadow

Also three samples of *P. sinuosa* seagrass shoots were collected for TN & TP analysis after the counting was completed. Each sample was collected randomly in the meadow and consisted of 5 shoots. These were placed in separate plastic bags and frozen until processed.

At each site the Secchi disk depth (m) and temperature were recorded.

In the laboratory the three seagrass shoots were measured for total length and width, just above the sheath. Then all algal epiphytes were removed by gently scraping, and the leaves placed in the oven at 50ºC for 24 hours or until dry, then ground into a fine powder with a Ball Mill grinder. This material was then analysed for total C, N and $\delta^{15}N$ (external error of analysis 1 standard deviation) at UWA using a continuous flow system consisting of a Delta V Plus mass spectrometer connected with an Thermo Flush 1112 via Conflo IV (Thermo-Finnigan/Germany). Total phosphorus (<0.05 $mg.P.g^{-1}$) was analysed at Marine and Freshwater Research Laboratory at Murdoch University using method 4500.

4 Results

4.1 Shoot density

Shoot density varied from 34 – 62 shoots per 0.04 m^2 (Figure 4). The shallower sites, Dunsborough and Buayanup (3.5 m) had the highest shoot density, followed by Forrest Beach (5 m). The remaining sites at 4.5-5 m had a similar shoot density.

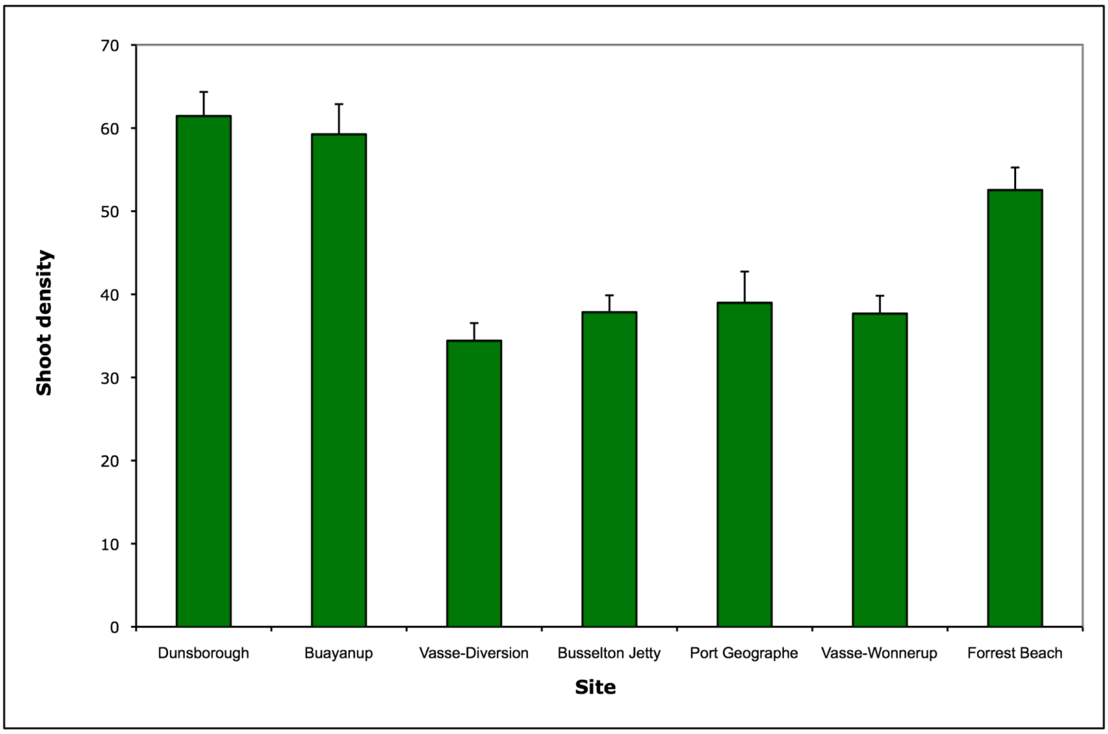

Figure 4: Shoot density (average ± se) at the seven Keep Watch seagrass monitoring sites with *P. sinuosa* meadows in February 2012.

4.2 Tissue nutrients

The nitrogen content of *P. sinuosa* leaves ranged from 0.58 – 0.91 % N. The *A. antarctica* leaves at Capel had the highest content, 1.1% (Figure 5). The highest content of nitrogen in *P. sinuosa* leaves was observed at Site 2, Buayanup. The phosphorus content of *P. sinuosa* leaves ranged from 0.13 – 0.19 % P. The *A. antarctica* leaves at Capel had the lowest content, 0.12% (Figure 5).

The C:N and C:P ratios for each site were also calculated. C:N ratios ranged from 40-62 at *P. sinuosa* sites and 34 for *A. antarctica* leaves at Capel. Whereas C:P ratios ranged from 194-270 at *P. sinuosa* sites and 315 for *A. antarctica* leaves at Capel (Appendix 2). Buayanup had the most nitrogen relative to carbon at the *P. sinuosa* sites, and Forrest Beach had the most phosphorus relative to carbon.

The $\delta^{15}N$ of *P. sinuosa* leaves ranged from 1.14 – 1.82 ‰, the highest at Vasse Diversion Drain. The *A. antarctica* leaves at Capel had the highest $\delta^{15}N$, 3.08 ‰ (Figure 6).

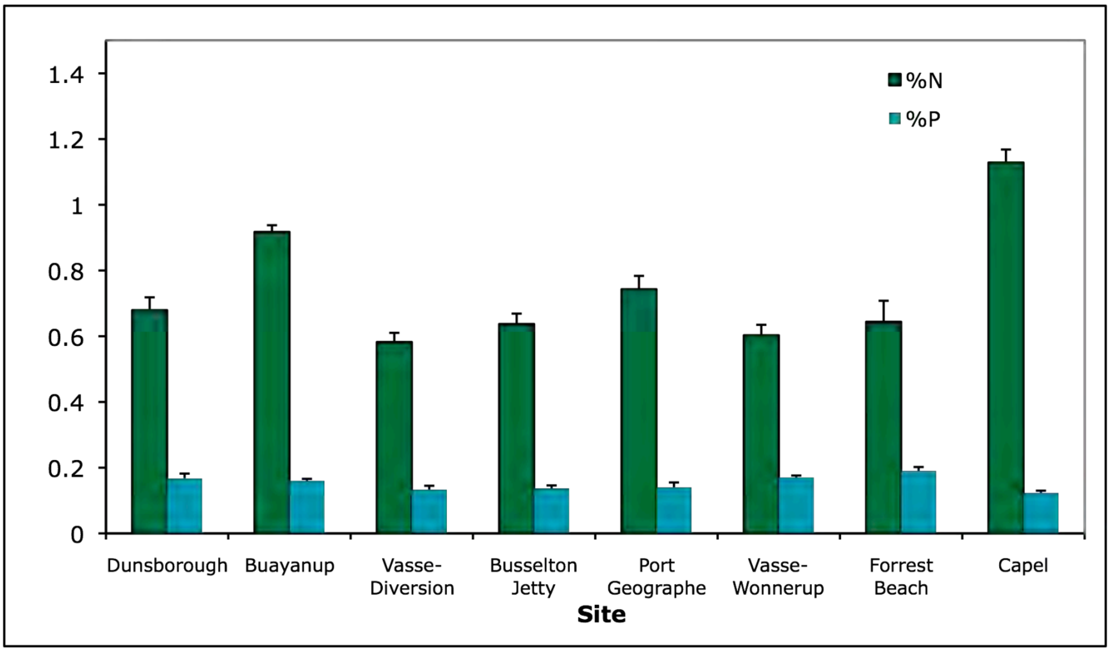

Figure 5: Nitrogen and phosphorus content (% dw) of *P. sinuosa* leaves (Dunsborough-Forrest Beach) and *A. antarctica* leaves (Capel, average ± se) at the Keep Watch seagrass monitoring sites, February 2012.

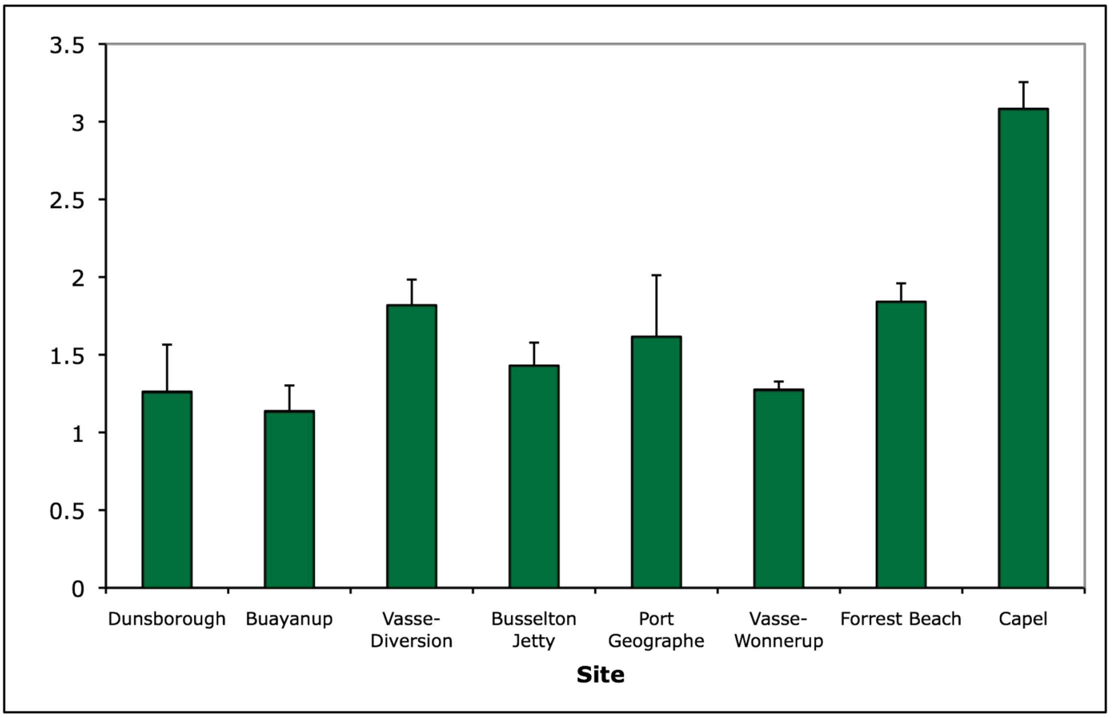

Figure 6: $\delta^{15}N$ of *P. sinuosa* leaves (Site 1-7) and *A. antarctica* leaves (Site 8, average ± se) at the Keep Watch seagrass monitoring sites, February 2012.

4.3 Algal epiphytes

Algal epiphyte cover was low at most sites, and moderate at Dunsborough and Buayanup. The dominant epiphytic algal type was Other at Site 1-Dunsborough, Microalgae at Sites 2, 3, 4, 7 and encrusting algae at Sites 5,6 and 7 (Table 2, Figure 7).

Table 2: Algal cover and water quality measures at the Keep Watch seagrass monitoring sites, February 2012. Algal cover categories were Very low, Low, Moderate, High and Very High. Algal types were F=filamentous, E= encrusting, M=microalgal aggregations and O=other. If the category is capitalised it means it is dominant, lowercase indicates present but not dominant. *=Secchi disk depth on bottom.

Site	Algal cover	Algal Type	Secchi disk depth (m)	Temperature (°C)
1. Dunsborough	Moderate	f,O, m	4.2*	22.0
2. Buayanup	Moderate	o, M	3.5	22.8
3. Vasse Diversion Drain	Low	o, M	4.0	23.4
4. Busselton Jetty	Low	o, M	4.2	23.4
5. Port Geographe	Low	E, o	3.75	23.4
6. Vasse-Wonnerup	Low	E, o, m	4.0	23.1
7. Forrest Beach	Low	E, o, M	5*	22.5

4.4 Other observations

A. antarctica was present at Sites 1, 3, 5, 7 and 8, and *A. griffithii* was also present at Sites 7 and 8. There appeared to be recent shoot loss at Port Geographe as there was exposed rhizome without connected shoots. Old flowers were observed at Sites 1, 2, 6 and many seedlings at Sites 1 and 2. Based on previous studies, the microalgal aggregations are likely to be cyanobacteria. There was old leaf material accumulated under the seagrass canopy at Forrest Beach. This site also had large patches of *Amphibolis* and harder substrate. *P. sinuosa* shoot length ranged from 43.7-62.3 cm and width 5.2-6.1 mm (Appendix 3).

4.5 Water quality

Water temperature ranged from 22-23.4°C. Secchi disk depth ranged from 3.5 – 5.0 m and was on the bottom at Site 1 and 7.

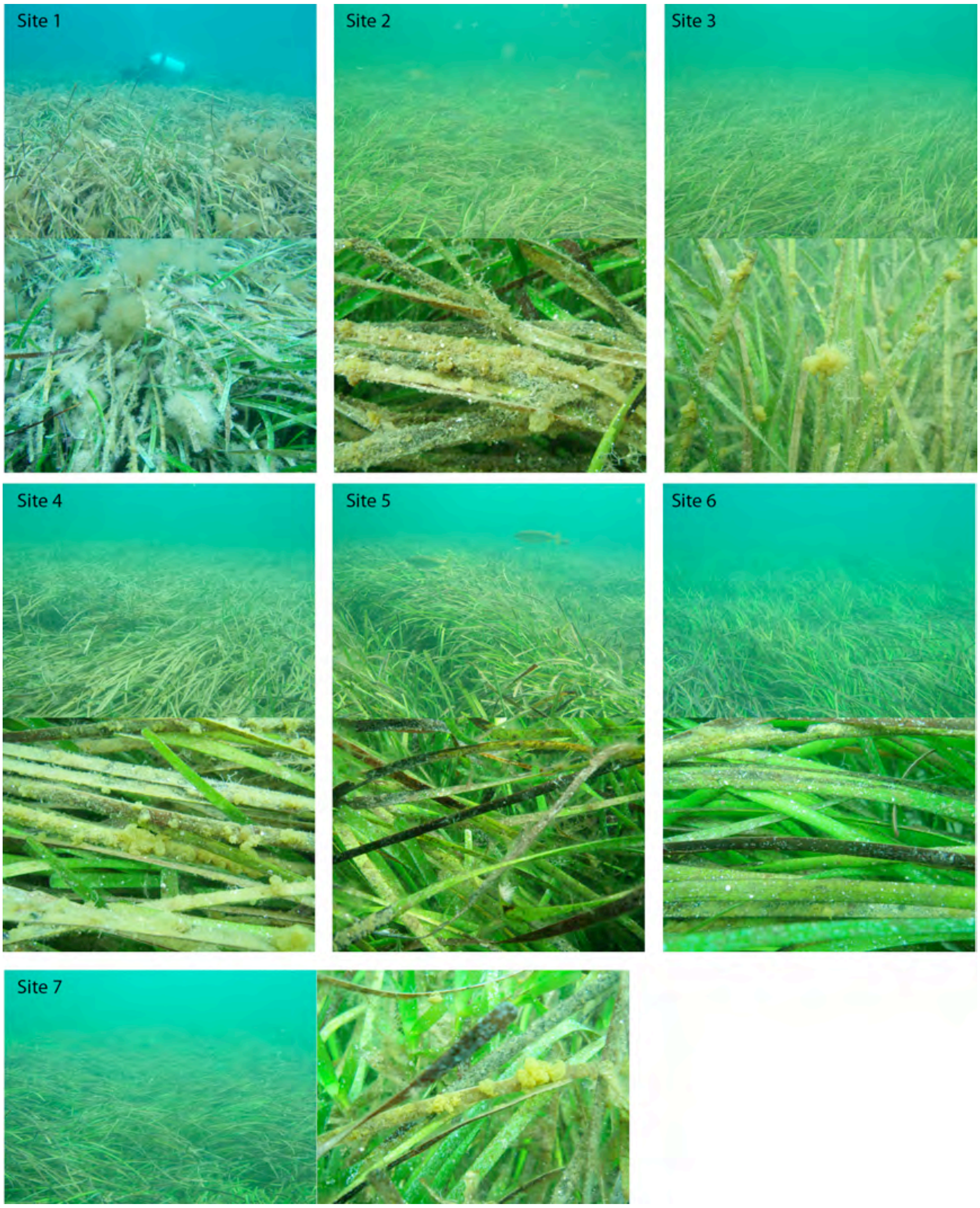

Figure 7: Pictures of seagrass meadow and the dominant algal epiphyte s at each *P. sinuosa* site. (1. Dunsborough, 2. Buayanup, 3. Vasse Diversion Drain, 4. Busselton Jetty, 5. Port Geographe, 6. Vasse-Wonnerup Estuary, 7. Forrest Beach)

5 Discussion

As this is the first year that this monitoring has been carried out, we can not do any of the analysis recommended in the Keep Watch program, however, we can assess how this data compares to other locations, and data collected previously in Geographe Bay.

In Cockburn Sound the reference sites are located at 3.2 and 5m, whereas in Geographe Bay the sites were located at 4-4.5 m. The deeper the meadows are located, the less light they receive, so it is likely that the shoot density will be less. For comparisons sake, we will compare both the 3.2 and 5 m reference sites in Cockburn and Warnbro Sound to the 4-5 m sites in Geographe Bay. In addition, reference sites from Shoalwater Islands Marine Park, Marmion Marine Park and Jurien Bay Marine Park form 3-5.5 m will also be compared to Geographe Bay.

Based on the Keep Watch monitoring, average shoot densities among sites in Geographe Bay ranged from 34 – 61 shoots in 0.04 m^2 in 2012 . These densities are on average higher than those observed in Cockburn Sound, Shoalwater Islands Marine Park and Marmion Marine Park at similar depths, and similar to the densities observed at Jurien Bay Marine Park (Table 3). Other studies in Geographe Bay in previous years recorded similar densities as observed in the 2012 in the Keep Watch monitoring program (Table 3).

Table 3: Shoot densities of *P. sinuosa* from other locations and other studies in Geographe Bay. Data is average from unimpacted (reference) sites with the range, min-max in brackets.

Study	Location and time of sampling	Depth ~3m	Depth ~ 5m
Cockburn Sound Seagrass Health	Garden Island Jan 2011	28 (7-65)	29 (14-46)
Cockburn Sound Seagrass Health	Warnbro Sound Jan 2011	18 (2-38)	25 (2-64)
DEC Marine Park Monitoring$_a$	Shoalwater Island Marine Park		25 (1-60)
DEC Marine Park Monitoring$_a$	Marmion Marine Park		17 (1-80)
DEC Marine Park Monitoring$_a$	Jurien Bay Marine Park		33 (0-85)
Westera 2009	Geographe Bay – Dunsborough Jan 2008	35 (7-58)	28 (13-56)
Westera 2009	Geographe Bay –Wonnerup Jan 2008	25 (5-42)	30 (14-46)
Barnes 2008$_a$	Geographe Bay Jan 2007		49 (33-76)
Oldham et al 2010	Geographe Bay- Siesta Park 2009		31 (6-60)
Oldham et al 2010	Geographe Bay- Forrest Beach 2009		31 (15-60)

a: data from sites 3-5.5 m deep

A more detailed comparison of shoot density can be made with data collected by Barnes et al 2008 from the summers of 2006/07 and 2007/08 where they measured shoot density from similar sites in a similar depth. When comparing within sites at the two different times, shoot densities were generally similar (Table 4). The only exception was Port Geographe where shoot densities had declined and Forrest Beach where shoot densities had increased. The decline in shoot density at Port Geographe is consistent with the observations of exposed seagrass rhizome and old leaf sheaths without any shoots attached, indicating recent shoot loss. Note that average shoot densities were based on six quadrats in Barnes et al 2008 and 30 in this monitoring program.

Table 4: Comparison of shoot densities of *P. sinuosa* at a number of sites in Geographe Bay between the Keep Watch data 2012 and the study of Barnes eta l 2008. Data expressed as number of shoots per m^2 with standard error. Red shading indicatives a decline, and green indicates an increase in shoot density from 2008 – 2012.

Study site	Keep Watch 2012	Barnes et al 2008 (3-5 m) avg for summer 2006-2008
1. Dunsborough	1537 ± 72	1917 ± 311
2. Buayanup	1482 ± 90	1479 ± 194
3. Vasse Diversion Drain	861 ± 53	829 ± 169
5. Port Geographe	975 ± 93	1338 ± 85
6. Vasse-Wonnerup	942 ± 53	938 ± 81
7. Forrest Beach	1314 ± 67	921 ± 77

The nitrogen content of *P. sinuosa* leaves in the Keep Watch monitoring was on average 0.68 % DW, the site averages ranged from 0.58-0.91 %. These values are slightly lower than has been observed previously in Geographe Bay, although, within the range of observations, and lower than observed in Shoalwater Bay. In contrast the phosphorus content of *P. sinuosa* leaves was similar to what has been observed previously, average across all sites of 0.16 % DW, the site averages range from 0.14-0.19% DW (Table 5). In contrast, the $\delta^{15}N$ values of *P. sinuosa* leaves is lower than has been observed in 1994, average 1.48, with the site averages ranging from 1.13-1.84. This reduction in $\delta^{15}N$ values over 18 years indicates a reduction in the contribution of sewerage-derived nitrogen and an increase in the contribution of fertilizer derived nitrogen as generally fertliser derived nitrogen has a signature from 0-1 and sewerage-derived nitrogen has a higher signature, 6-9 (Heaton 1986, Costanzo et al 2001, Udy and Dennison 1997).

The nutrient content of *A. antarctica* was assessed at one site only, Capel. Here the nitrogen content (1.13 % DW) was slightly higher than has been observed previously in Geographe Bay, and in Shoalwater Bay, where it has been generally < 1% (Table 5). In addition, the phosphorus content was also slightly higher than previous observations in Geographe Bay, 0.12 vs. 0.10. The $\delta^{15}N$ value of leaves is similar to what was observed in 2008, but higher than observations from 1994. Indicating that in this example, seagrass at Capel is exposed to more sewerage derived nitrogen. It is also important to note that different species i.e. *Posidonia* and *Amphibolis* can have different isotope signatures, due to differences in there physiology, so to be confident that there is a different source of nutrients at Capel, compared to other places in Geographe Bay, samples of *Amphibolis* should be collected from other locations.

Table 5: Comparison of shoot tissue nutrient concentrations and $\delta^{15}N$ values of *P. sinuosa* and *A. antarctica* leaves in Geographe Bay. Data are expressed as averages of all sites from the study with the range of observations in brackets, min-max.

Date collected	Study	*P. sinuosa*			*A. antarctica*		
		TN (% DW)	TP (% DW)	$\delta^{15}N$	TN (% DW)	TP (% DW)	$\delta^{15}N$
1994/95 Apr, Jan	McMahon and Walker 1998 Geographe Bay	0.8 Jan 1.032 Apr	0.13	-	-	-	-
1994 Apr, Jul, Sep	McMahon 1994 Geographe Bay	1.26 (0.06-1.66)	0.18 (0.9-0.28)	3.30 (2.61-5.24)	0.95 (0.79-1.14)	0.10 (0.07-0.14)	2.52 (0.8-4.18)
2008 Aug	Oldham et al 2010 Geographe Bay	1.43 - (1.30-1.56)	-	3.66 (3.30-4.36)	0.97 (0.9-1.16)	-	4.51 (4.01-4.8)
Autumn	Paling 2000 Shoalwater Bay	1.8	-	-	0.6	-	-

6 General conclusions and recommendations

This is the first time this monitoring program has been carried out in Geographe Bay. It is feasible to carry out this monitoring with 2-3 experienced divers over 2-3 days. If this was going to be carried out by volunteers it is likely that it will take longer, until they are trained and competent with the techniques.

Recommendation 1

GeoCatch has confirmed that volunteers will not be involved in the 2013 Keep Watch Monitoring, so ECU should organize and carry out the monitoring

P. sinuosa shoot densities varied across the sites in Geographe Bay, and compared to similar depth sites in other temperate regions of WA, shoot densities were generally higher in Geographe Bay. Nutrient concentrations were within the range expected for seagrasses, and in some cases, were slightly lower than what has been observed previously in Geographe Bay and in the region. At one site, Port Geographe, there appeared to be recent shoot loss, and densities were lower than has been reported here previously.

Recommendation 2

Continue monitoring shoot density, shoot nutrient content and shoot $\delta^{15}N$ values to assess how they change at the seven Keep Watch monitoring sites over time.

It was not possible to establish a site at Capel as there was not a continuous meadow of *P. sinuosa* present. The nutrient status of *A. antarctica* plants indicate that this site is receiving nitrogen inputs of a different source to the other areas, with more of a signal of sewerage or animal manure than the other sites, and particularly more nitrogen relative to the other sites. However, to be confident of this, samples of *Amphibolis* should be collected at other sites.

Recommendation 3

As there was not a *P. sinuosa* seagrass meadow at Capel, and this Keep Watch monitoring program is using *P. sinuosa* as an indicator species, it is recommended not to continue with the site at Capel. However, if GeoCatch is interested in understanding changes in nutrient content of *Amphibolis* seagrass at this site, then samples of *Amphibolis* should be collected from at least two other locations in Geographe Bay as a comparison, to confirm that the differences are due to nutrient sources at the site, not differences due to different seagrass species.

This 2013 survey should be carried out in January as recommended in the Keep Watch monitoring program, rather than February, as was the case in 2012. Therefore assessment of change should be carried out at each site from 2014, based on the triggers in the Keep Watch Monitoring Program. In addition, the other aspects of the program, water quality monitoring at Busselton Jetty and light measurements above the seagrass canopy near Busselton Jetty, should begin as soon as possible, and be incorporated into next years monitoring.

Recommendation 4

Change assessment of shoot density should begin in 2014, after the third monitoring.

Recommendation 5

Water quality monitoring and light monitoring should begin as soon as possible, and be incorporated into the 2013 Keep Watch Monitoring Report.

7 References

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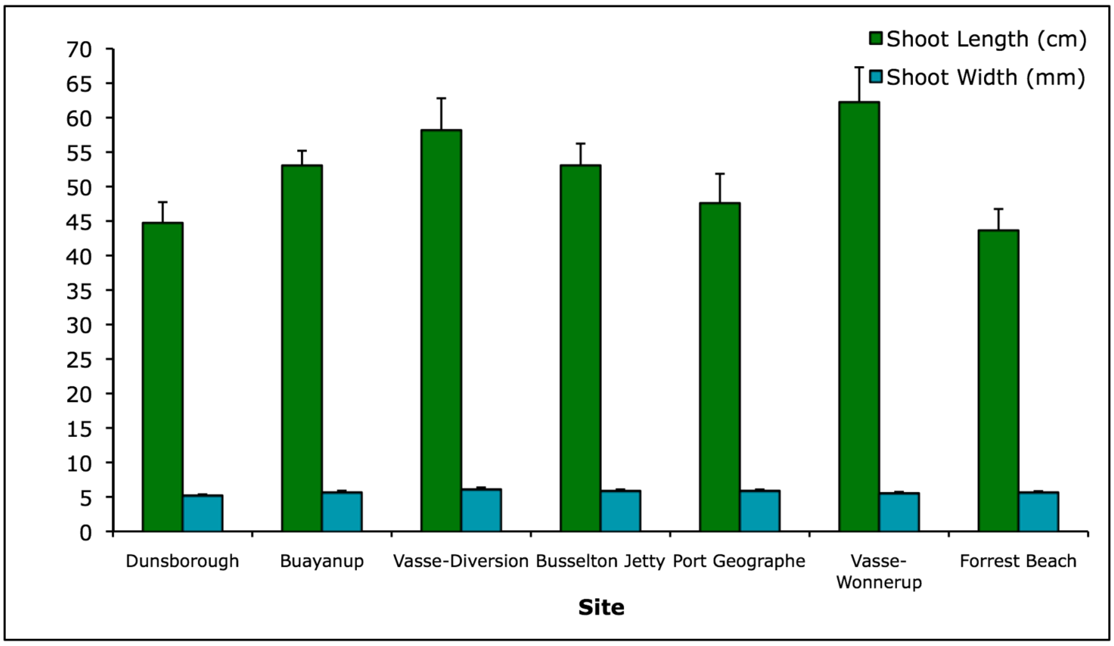
8 Appendix 1: Randomly generated quadrat positions

Site 1 Quad #	Site 1 Bearing	Site 1 Distance
1	0	15
2	0	17
3	0	20
4	20	6
5	40	4
6	60	10
7	60	18
8	80	7
9	80	16
10	100	4
11	120	6
12	120	11
13	140	1
14	140	17
15	160	7
16	160	13
17	180	16
18	200	5
19	200	9
20	220	4
21	220	7
22	220	16
23	240	2
24	240	15
25	240	16
26	280	3
27	280	8
28	320	13
29	340	1
30	340	19

9 Appendix 2: C:N and C:P ratios for seagrass leaves (*P. sinuosa* sites 1-7, and *A. antarctica*, site 8).

Site	C:N		C:P	
	Avg	se	Avg	se
1. Dunsborough	55	3	225	21
2. Buayanup	40	1	232	10
3. Vasse Diversion Drain	63	3	277	28
4. Busselton Jetty	59	3	277	20
5. Port Geographe	50	3	272	33
6. Vasse-Wonnerup	62	3	220	9
7. Forrest Beach	58	5	194	12
8. Capel	34	1	315	17

10 Appendix 3: *P. sinuosa* shoot length and width



11 Appendix 4: Shoot density data for the seven Keep Watch Seagrass Monitoring Sites including the seedling counts, and the person who counted each quadrat, 2012.

	26th Feb 2012			26th Feb 2012			26th Feb 2012			26th Feb 2012			27th Feb 2012			27th Feb 2012			27th Feb 2012		
Rep	1. Dunsborough			2. Buayanup			3. Vasse Diversion			4. Busselton Jetty			5. Port Geographe			6. Vasse-Wonnerup			7. Forrest Beach		
	Shoots	Seedlings	Counter	Shoots	Seedlings	Counter	Shoots	Seedlings	Counter	Shoots	Seedlings	Counter	Shoots	Seedlings	Counter	Shoots	Seedlings	Counter	Shoots	Seedlings	Counter
1	53	0	KM	59	0	RC	29	0	RC	32	1	RC	49	0	RC	41	0	RC	30	0	RC
2	64	3	KM	45	0	RC	44	0	RC	18	0	RC	23	0	RC	51	0	RC	36	0	RC
3	56	0	KM	37	3	RC	25	0	RC	54	0	RC	23	0	RC	29	0	RC	43	0	RC
4	64	8	RC	46	0	RC	41	0	RC	33	1	RC	40	0	RC	15	0	RC	59	0	RC
5	50	0	RC	82	0	RC	28	0	RC	36	2	RC	44	0	RC	31	0	RC	53	1	RC
6	56	5	RC	58	0	RC	19	0	RC	31	0	RC	78	0	RC	54	1	RC	42	0	RC
7	48	1	RC	106	0	RC	31	0	RC	38	0	RC	38	0	RC	33	0	RC	47	0	RC
8	51	2	RC	86	0	RC	51	0	RC	23	0	RC	17	0	RC	32	0	RC	66	1	RC
9	59	0	RC	61	0	RC	24	0	RC	14	1	RC	57	0	RC	19	0	RC	26	0	RC
10	55	2	RC	55	1	RC	26	0	RC	37	0	RC	68	0	RC	61	0	RC	36	0	RC
11	23	2	RC	52	2	RC	13	0	RC	24	1	RC	65	0	RC	55	0	RC	56	1	RC
12	63	4	RC	46	2	RC	33	0	RC	41	0	RC	36	0	RC	29	0	RC	38	0	RC
13	71	2	RC	67	2	RC	63	0	RC	26	0	RC	21	0	RC	50	0	RC	62	0	RC
14	64	1	RC	42	2	RC	36	0	RC	38	0	RC	65	0	RC	52	0	RC	60	0	RC
15	37	2	RC	92	2	RC	47	0	RC	40	0	RC	57	0	RC	31	0	RC	54	0	RC
16	65	1	RC	39	0	RC	34	0	RC	56	0	RC	44	0	RC	38	0	RC	45	0	RC
17	65	0	KM	77	0	KM	43	0	KM	31	0	RC	47	0	KM	28	1	KM	39	0	RC
18	91	0	KM	53	0	KM	50	0	KM	34	0	KM	73	0	KM	26	0	KM	80	0	KM
19	64	0	KM	33	0	KM	25	0	KM	44	0	KM	20	0	KM	53	0	KM	46	0	RC
20	65	0	KM	88	0	KM	33	0	KM	28	1	KM	51	0	KM	39	0	KM	53	0	KM
21	60	0	KM	40	0	KM	30	0	KM	38	0	KM	10	0	KM	23	0	KM	49	0	KM
22	45	1	KM	42	0	KM	16	0	KM	51	0	KM	22	0	KM	36	0	KM	68	0	KM
23	63	0	KM	45	0	KM	44	0	KM	37	1	KM	45	0	KM	40	0	KM	37	0	KM
24	97	0	KM	75	0	KM	31	0	KM	41	0	KM	48	0	KM	42	1	KM	80	0	KM
25	58	0	KM	51	0	KM	40	0	KM	48	0	KM	46	0	KM	43	0	KM	54	0	KM
26	72	1	KM	36	0	KM	27	0	KM	45	1	KM	19	1	KM	32	0	KM	50	0	KM
27	69	1	KM	53	0	KM	29	0	KM	38	0	KM	6	0	KM	43	0	KM	66	0	KM
28	52	0	KM	69	0	KM	45	0	KM	56	0	KM	10	0	KM	37	0	KM	59	0	KM
29	61	0	KM	50	0	KM	26	0	KM	56	0	KM	8	0	KM	22	0	KM	56	0	KM
30	103		KM	93	0	KM	50	0	KM	48	0	KM	40	0	KM	46	0	KM	87	0	KM
Average	**61.47**			**59.27**			**34.43**			**37.87**			**39.00**			**37.70**			**52.57**		
Median	62.00			53.00			32.00			38.00			42.00			37.50			53.00		
se	**2.89**			**3.61**			**2.10**			**2.01**			**3.74**			**2.12**			**2.69**		

12 Appendix 5: Nutrient data

Site Id	Rep	δ15N [‰ AIR]	N [wt %]	C [wt %]	C/N [wt]	TOTAL P %	C/P
1. Dunsborough	1	1.84	0.65	37.2	57	0.14	266
	2	1.14	0.63	36.2	57	0.17	213
	3	0.81	0.76	37.2	49	0.19	196
1. Dunsborough	**Average**	**1.26**	**0.68**	**36.86**	**55**	**0.167**	**225**
	SE	**0.30**	**0.04**	**0.33**	**3**	**0.015**	**21**
2. Buayanup	1	1.30	0.89	37.5	42	0.15	250
	2	1.31	0.90	36.7	41	0.16	230
	3	0.81	0.96	36.5	38	0.17	215
2. Buayanup	**Average**	**1.14**	**0.92**	**36.93**	**40**	**0.16**	**232**
	SE	**0.16**	**0.02**	**0.31**	**1**	**0.006**	**10**
3. Vasse Diversion Drain	1	1.49	0.56	36.1	65	0.14	258
	2	1.97	0.55	36.6	66	0.11	333
	3	2.00	0.64	36.2	57	0.15	241
3. Vasse Diversion Drain	**Average**	**1.82**	**0.58**	**36.29**	**63**	**0.133**	**277**
	SE	**0.16**	**0.03**	**0.17**	**3**	**0.012**	**28**
4. Busselton Jetty	1	1.40	0.68	37.9	56	0.12	316
	2	1.19	0.57	37.3	65	0.14	266
	3	1.70	0.66	37.4	57	0.15	250
4. Busselton Jetty	**Average**	**1.43**	**0.64**	**37.56**	**59**	**0.137**	**277**
	SE	**0.15**	**0.03**	**0.19**	**3**	**0.009**	**20**
5. Port Geographe	1	1.73	0.76	37.2	49	0.15	248
	2	0.88	0.67	36.8	55	0.16	230
	3	2.24	0.80	37.1	46	0.11	337
5. Port Geographe	**Avergae**	**1.62**	**0.74**	**37.03**	**50**	**0.14**	**272**
	SE	**0.40**	**0.04**	**0.10**	**3**	**0.015**	**33**
6. Vasse-Wonnerup	1	1.38	0.67	37.8	57	0.16	236
	2	1.20	0.57	37.0	65	0.18	206
	3	1.25	0.58	37.0	64	0.17	218
6. Vasse-Wonnerup	**Average**	**1.28**	**0.60**	**37.28**	**62**	**0.17**	**220**
	SE	0.05	0.03	0.27	3	0.006	9
7. Forrest Beach	1	2.06	0.77	36.5	47	0.21	174
	2	1.65	0.57	36.8	65	0.19	194
	3	1.82	0.59	36.4	61	0.17	214
7. Forrest Beach	**Average**	**1.84**	**0.64**	**36.57**	**58**	**0.19**	**194**
	SE	**0.12**	**0.06**	**0.14**	**5**	**0.012**	**12**
8. Capel	1	3.32	1.20	38.7	32	0.13	298
	2	3.18	1.13	38.9	35	0.13	299
	3	2.75	1.06	38.3	36	0.11	349
8. Capel	**Average**	**3.08**	**1.13**	**38.65**	**34**	**0.123**	**315**
	SE	**0.17**	**0.04**	**0.16**	**1**	**0.007**	**17**

13 Appendix 6: Other data

	26th Feb 2012 Dunsborough	26th Feb 2012 Buayanup	26th Feb 2012 Vasse Diversion	26th Feb 2012 Busselton Jetty	27th Feb 2012 Port Geo	27th Feb 2012 Vasse-Wonnerup	27th Feb 2012 Forrest Beach
Rep	Shoot Length (cm)	Shoot Length (cm)	Shoot Length (cm)	Shoot Length (cm)	Shoot Length (cm)	Shoot Length (cm)	Shoot Length (cm)
1	50.5	49.1	64	61.8	38.7	46.1	38.5
2	61.7	43.2	45.5	50.5	44.1	51.6	40.8
3	47.3	63.6	44.7	36.9	39.9	62.5	37.2
4	34.4	49.6	57.3	69.6	51.7	80.4	50
5	36.2	55	60.4	53	47.3	53	37.3
6	40	49	75.1	57	49	46.3	37.3
7	46.1	59	35.2	44.8	48.4	75	64.3
8	35.7	58.2	67.5	54.1	82.5	87	49.5
9	50.8	51	74	50.1	40.5	58.4	38
10					34		
Average	45	53	58	53	48	62	44
SE	3	2	5	3	4	5	3

	26th Feb 2012 Dunsborough	26th Feb 2012 Buayanup	26th Feb 2012 Vasse Diversion	26th Feb 2012 Busselton Jetty	27th Feb 2012 Port Geo	27th Feb 2012 Vasse-Wonnerup	27th Feb 2012 Forrest Beach
Rep	Shoot Width (mm)	Shoot Width (mm)	Shoot Width (mm)	Shoot Width (mm)	Shoot Width (mm)	Shoot Width (mm)	Shoot Width (mm)
1	5	7	7	6	6	6	6
2	6	6	7	6	6	5	6
3	5	6	7	6	6	5	6
4	6	5	6	7	6	5	6
5	5	5	5	6	5	6	5
6	5	5	6	6	6	6	5
7	5	6	6	5	6	6	6
8	5	5	6	5	5	5	6
9	5	6	5	6	7	6	5
10					6		
Average	5.2	5.7	6.1	5.9	5.9	5.6	5.7
SE	0.1	0.2	0.3	0.2	0.2	0.2	0.2