Edith Cowan University
Centre for Marine Ecosystems Research

Keep Watch Seagrass Monitoring 2014 Report for GeoCatch

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Keep Watch Seagrass Monitoring

Annual Report 2014

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April 2014

1 Executive Summary

1.1 Introduction

This report summarises data from the first three years (February 2012, Jan-Feb 2013 and January 2014) of the annual Keep Watch Seagrass Monitoring Program in Geographe Bay. 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, to assess change over time at each site using a number of assessment triggers. Seagrass shoot density is the indicator of seagrass health and a number of other variables are collected to help interpret this indicator, including observations of algal epiphyte cover and seagrass leaf nutrient content. This year two assessment triggers (Trigger 1 and 2) have been used to indicate if there are any concerns.

1.2 Significant findings

This year, five of the seven *Posidonia sinuosa* sites had a decline in shoot density, compared to last year. These declines do not activate Trigger 1, a 50% or more reduction in shoot density from one year to the next. Nor was Trigger 2 activated, a 20% or more reduction two years in a row. At present, there are no concerns about the health of seagrasses in Geographe Bay. The recommendation is to continue monitoring and reassess the changes next year, particularly at Forrest Beach, which had a 23% decline this year and Buayanup (24% decline), and have the potential to activate Trigger 2 if this level of decline continues into 2015.

When we examine the change over time from 2012 to 2014, there was a net increase at Busselton Jetty, Port Geographe and Vasse-Wonnerup, a minimal decline at Vasse-Diversion Drain (1%) and Forrest Beach (7%), and slightly greater decline at Dunsborough (14%) and Buayanup (15%). Changes of this magnitude are regularly observed at other seagrass monitoring sites throughout the state (DPaW, unpublished data).

Over three years the greatest decline has been at the shallowest and most protected sites, which have the highest nutrient content and where very brittle rhizomes have been observed. Epiphyte accumulations and nutrient content no not explain the reduction, as they are both low and of no concern. As these sites are the shallowest, it is possible that they are being exposed to higher temperatures due to warming during summer. With climate change and ocean warming, spikes in temperature can cause increased mortality rates. It is recommended to deploy temperature loggers at the Keep Watch Seagrass Monitoring sites to understand the relationship between temperature and changes in shoot density. The one factor, which may be related to these greater losses, is the very brittle rhizomes. It is not clear what causes the brittleness, but as they break off easily, it may explain the decline. It is recommended to investigate the strength of rhizomes here and at a number of other sites for comparison, and to examine the carbohydrate content of the rhizomes, which if low, may indicate that the plant is under stress.

Two sites increased in shoot density from 2013, Busselton Jetty, which had a 22% increase and Vasse-Wonnerup which had a 10% increase. These two sites also had a positive increase over time, when considering the years 2012-2014. Changes in shoot density are common from year to year, and unless there are large declines or continual declines over time, it is not of concern. Port Geographe, which had shown signs of recent seagrass loss, appears to be recovering. Despite a slight decline this year, there has been a net increase since 2012, and active branching of the shoots indicates that the meadow is growing and attempting to increase the shoot density. If shoot production is greater than shoot mortality the meadow should increase in density over time.

The algal epiphyte cover was greater than last year. Vasse Diversion Drain and Busselton Jetty recorded the highest epiphyte cover to date, and all other sites had a similar cover to 2012. The changes in shoot density are not correlated with changes in algal epiphyte cover.

Nutrient content also increased this year compared to last year, and the highest nitrogen content out of all years was observed. Nutrient content in seagrass leaves may change due to the supply of nutrients, nutrient recycling processes and changes in growth rates of the seagrasses. Despite the increase, the content is relatively very low and is not of concern. There also seems to be a change in the source of nitrogen to *Posidonia* seagrass this year. The nitrogen isotope signature has increased at most sites, which indicates the main source of nitrogen is less likely to be from agricultural fertilisers and fixation of atmospheric nitrogen, and is more likely to be derived from animal wastes, septic tanks or from sources of natural vegetation.

1.3 Recommendations

There are four main recommendations for GeoCatch following this 2014 monitoring.

Recommendation 1

Continue monitoring seagrass health based on the Keep Watch Monitoring protocol, including monitoring of *Posidonia sinuosa* meadows at seven sites, and nutrient monitoring of *A. antarctica* at three sites. Keep Watch on Forrest Beach and Buayanup sites, which have the potential to activate Trigger 2 next year, if the declines continue at a similar rate.

Recommendation 2

If possible, continue the collaborative arrangement with ECU, Department of Parks and Wildlife and Department of Fisheries. This was a very effective and beneficial arrangement.

Recommendation 3

Deploy continuous temperature loggers at each Keep Watch Seagrass Monitoring site to relate changes in seagrass shoot density to patterns in temperature. This will help interpret any changes related to climate change where increased warming is predicted, and will be able to assess whether spikes in temperature occur at the shallower sites.

Recommendation 4

Investigate further the brittle rhizome phenomena observed at Buayanup and also at Dunsborough and Port Geographe. These sites could be compared with other sites in Geographe Bay. Both strength of the rhizome and carbohydrate reserves could be investigated which may indicate if these plants are under stress and if the rhizomes are actually more brittle and could explain the greater loss here.

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 January and 2014 and compares data from the 2012 and 2013 survey. This year the program was funded through collaborative sponsorship from the Water Corporation and in-kind support from the Department of Parks and Wildlife (DPaW) and the Department of Fisheries (DoF). The aim of this program is to assess seagrass health by examining changes over time. There are a number of triggers that have been developed to assess change. Trigger 1 and 2 can be assessed this year but Trigger 3 can not be assessed until 2016 (see 3.1.1 for summary of triggers). This report includes data on *P. sinuosa* shoot density and leaf tissue nutrients (C, N, P and N isotopes), and a summary of all the other observations collected at each site, as well as leaf tissue nutrient data for *Amphibolis antarctica* seagrass from three sites. 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

3.1 Seagrass monitoring

3.1.1 Field program

The "Keep Watch" annual seagrass monitoring program is based on the methods recommended by McMahon (2012) and agreed to by GeoCatch.

Eight seagrass sites were monitored, seven for *P. sinuosa* health (Dunsborough to Forrest Beach) and three for *A. antarctica* nutrient content (Table 1, Figure 1). These were chosen to cover the spatial range of *P. sinuosa* meadows in Geographe Bay, and areas associated with a variety of catchments with different known surface water nutrient inputs. They range from 4-5 m depth. All sites, except for Capel have *P. sinuosa* meadows. Sampling occurred from 28th to the 31st January 2014. At Capel there are high relief rocky reefs surrounded by bare sand. On the reef there are patches of *Amphibolis antarctica* seagrass that were collected for nutrient analysis in 2m depth. *Amphibolis antarctica* was also collected at Busselton Jetty (4) and Forrest Beach (7) sites as a comparison. The *Amphibolis* sampling at three sites has now been undertaken for 2 years.

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	Species assessed
1. Dunsborough	S 33.61654°, E 115.12865°	4	25/2/2013 8:30	Ps
2. Buayanup	S 33.65233°, E 115.24840°	4	24/1/2013 09:50	Ps
3. Vasse Diversion Drain	S 33.64746°, E 115.32379°	4.5	24/1/2013 12:30	Ps
4. Busselton Jetty	S 33.63896°, E 115.34315°	4.5	23/1/2013 14:00	Ps, Aa
5. Port Geographe	S 33.62846°, E 115.38240°	4.5	22/1/2013 13:45	Ps
6. Vasse-Wonnerup	S 33.60188°, E 115.42345°	5	23/1/2013 11:30	Ps
7. Forrest Beach	S 33.57295°, E 115.44908°	5	23/1/2013 9:45	Ps, Aa
8. Capel	S 33.51394°, E 115.51508°	2	22/1/2013 12:00	Aa

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 seagrass site was located at least 30 m from the edge of the meadow and the center 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. The exact locations were determined with a differential GPS (using the WSG 84 grid system), on the water surface, directly above the permanent marker.

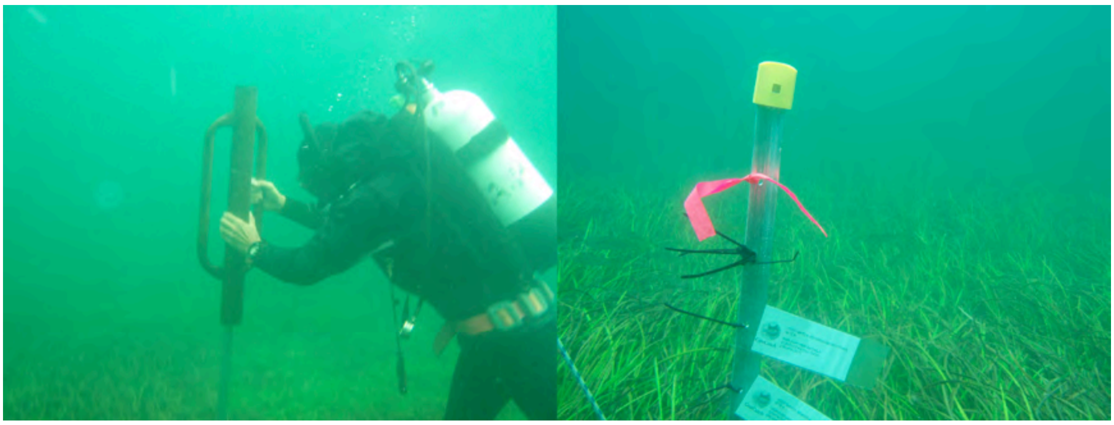

Figure 2: *Left: Banging in permanent marker with pole driver. Right: Star picket with cap and plastic coated site label, indicating center of 50 m diameter Keep Watch seagrass site.*

At each site *P. sinuosa* shoot density was counted in 30 0.2 x 0.2 m quadrats. Only shoots that originated in the quadrat were counted. Seedlings of *P. sinuosa* were also counted; 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 counts were not included in the shoot density assessment. The position of each quadrat was located randomly using a transect tape swum out on a pre-determined bearing using a compass and the quadrat placed at the pre-determined distance along the transect (Figure 3, See Appendix 1 for the bearing and distance along each transect that the quadrats were positioned). If there was a patch of a different species of seagrass such as *Amphibolis antarctica* or *A. griffithii*, or a blow-out without seagrass, then the quadrat was moved to the next closest point along the transect in the *P. sinuosa* meadow. The quadrats were stabilised by securing to the sediment with tent pegs, to ensure they did not move during counting.

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

A quality assurance check was carried with all divers before official counts began. Each counter counted a quadrat twice, and this was done with four different quadrats. This was repeated until there was less than a 5% error with counting, i.e. a maximum difference of 1-3 shoots. Then official counting began.

In addition, a photograph of the seagrass meadow and a video in a circle around the star-picket, 5 m distance away from the star-picket was also taken at each site. As well as the cover of algal epiphytes recorded as Very Low, Low, Moderate, High, Very High (See photo-guide for visual representation of these classifications, Figure 4), 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.

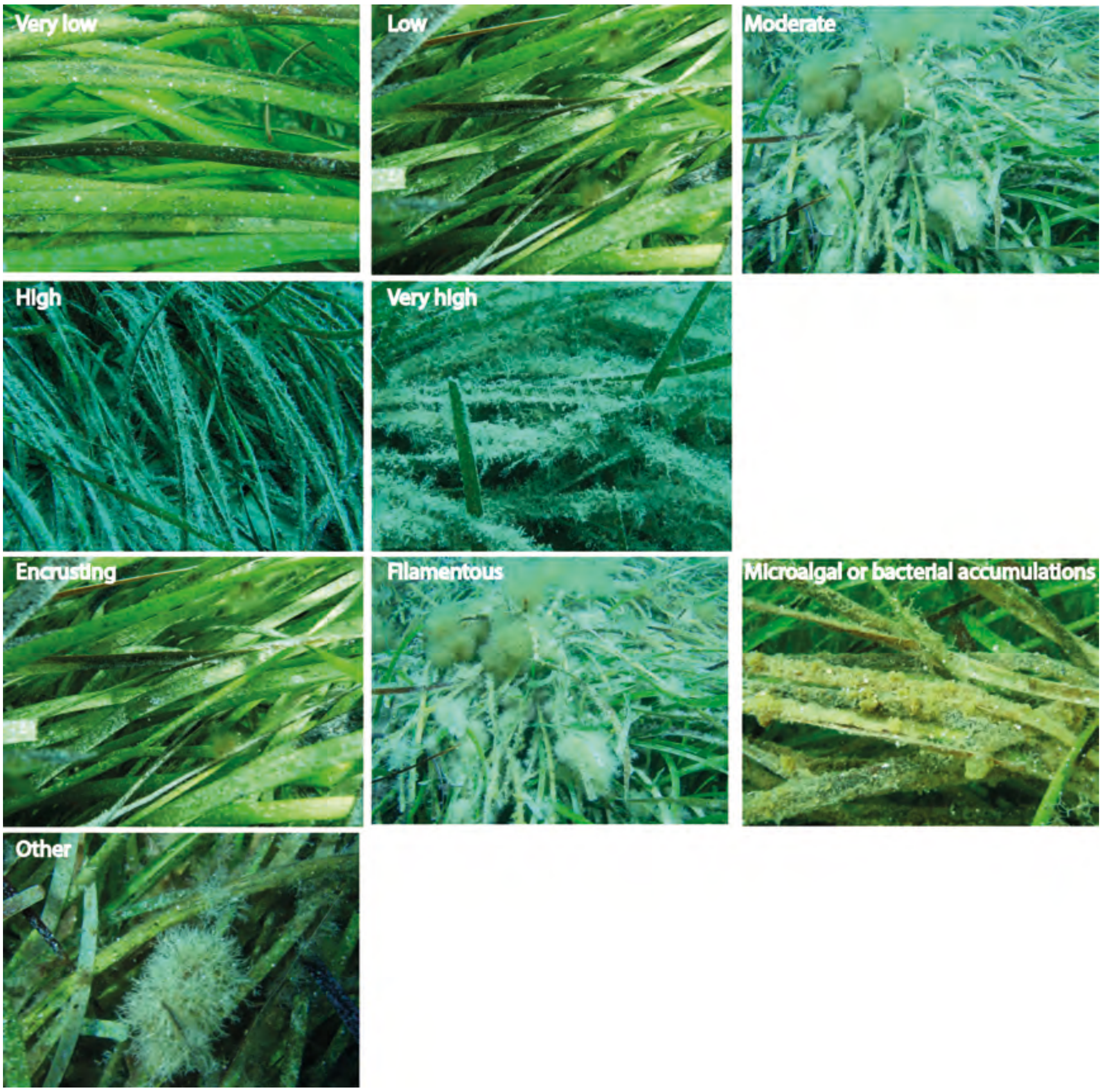

Figure 4: *Classification of epiphytic algal cover and type.*

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 if there was rhizome in the sand, indicating 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; and any signs of anchor damage in the meadow.

Also three samples of *P. sinuosa* seagrass shoots were collected for TN, TP and TC as well as nitrogen stable isotope analysis after the counting was completed. Each sample was collected randomly in the meadow, just outside the 50 m diameter of the site and consisted of 5 shoots. These were placed in separate plastic bags and frozen until processed. Three samples of *A. antarctica* stems and leaves were collected at Capel, Busselton Jetty and Forrest Beach sites for the same type of nutrient analysis.

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

Field work was carried out by Kathryn McMahon (KM) and Udhi Hernawan (UH) from ECU with Michael Rule (MR) from Department of Parks and Wildlife and Dave Abdo provided the boat and boat support from Department of Fisheries.

3.1.2 Laboratory processing

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 50°C 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.

3.1.3 Trigger assessment

To assess change over time, and to keep watch on the health of the seagrass, three triggers were proposed by McMahon (2012) and agreed upon by GeoCatch. If these thresholds are triggered it indicates a potential issue with seagrass health at a particular site that warrants further investigation. These trigger values are for shoot density. All other information collected i.e. seagrass nutrient concentration, water quality and light are complimentary information to help interpret any changes observed in the seagrass shoot density. The trigger value will be triggered as follows:

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 5 or more years of data), as determined by trend analysis (Makesens Mann-Kendall trend statistic, Need at least 5 years of data to assess this).

4 Results

4.1 Shoot density

Shoot density varied from a site average of 844-1302 shoots m^{-2} across the seven sites, this is slightly lower than was observed in 2013 (915-1637 shoots m^{-2}) and 2012 (942-1536 shoots m^{-2})(Figure 5). Once again, the shallower sites, Dunsborough and Buayanup (3.5 m) had the highest shoot density. The minimum shoot density was observed at Vasse-Diversion Drain, and the remaining sites had similar and intermediate shoot densities relative to the other sites. All raw data is in Appendix 3.

A reduction in shoot density occurred at 5 of the 7 sites (Table 2). Buayanup (24% reduction), Forrest Beach (23%) and Dunsborough (18%) had the greatest reductions, with much smaller reductions at Port Geographe (7%) and Vasse Diversion Drain (8%). The two remaining sites, Busselton Jetty and Vasse-Wonnerup, increased in shoot density by 22% and 13% respectively. In 2013, no declines were observed, in fact, all bar one site increased in shoot density from 3-18%. When we examine the change over time from 2012-104, there was a net increase at Busselton Jetty, Port Geographe and Vasse-Wonnerup. A minimal decline at Vasse-Diversion Drain (1%) and Forrest Beach (7%), and slightly greater decline at Dunsborough (14%) and Buayanup (15%). So over three years the greatest decline has been at the shallowest and most protected sites.

Once again the shoot density at sites in Geographe Bay are above the minimum and maximum range of site averages from references sites where similar monitoring is carried out in Shoalwater Bay and Jurien Bay Marine Park (Figure 5, data courtesy of DPaW).

P. sinuosa shoot length ranged from an average minimum of 35 cm at Port Geographe to a maximum of 63 cm at Dunsborough and a width of 5.6-6.3 mm (Appendix 4).

Table 2: Change assessment based on Trigger 1. There is a concern with seagrass health when there is a 50% decline in shoot density from one year to the next.

Site Name & #	% change 2012-13	% change 2013-14	Net change 2012-2014
1. Dunsborough	3	-18	-15
2. Buayanup	11	-24	-14
3. Vasse Diversion Drain	6	-8	-1
4. Busselton Jetty	0	22	22
5. Port Geographe	17	-7	10
6. Vasse-Wonnerup	19	13	33
7. Forrest Beach	16	-23	-7

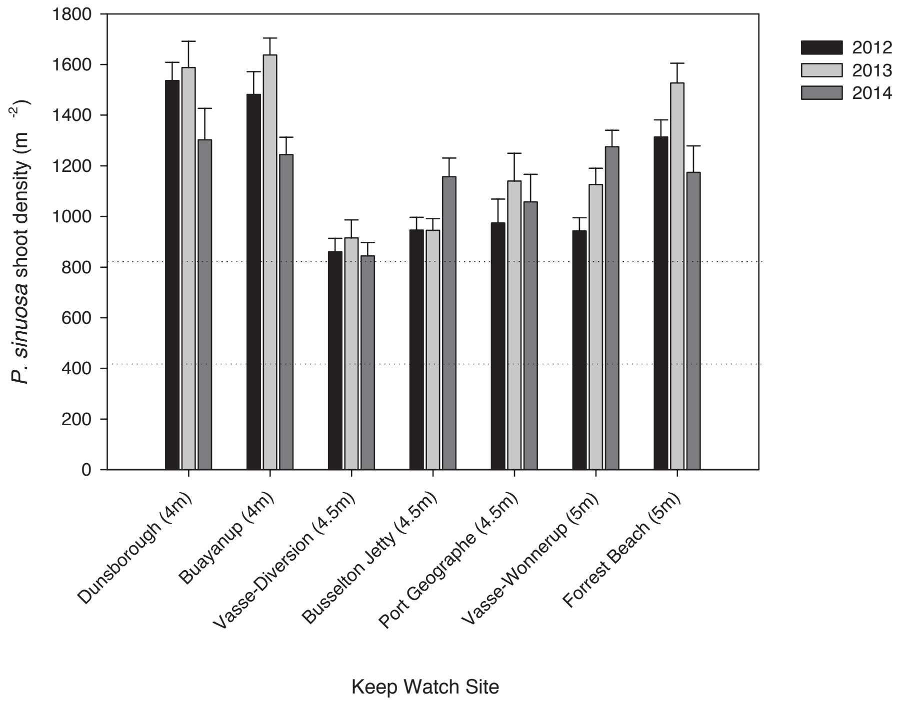

Figure 5: *Shoot density (average* m^{-2} *± se) at the seven Keep Watch seagrass monitoring sites with* P. sinuosa *meadows in February 2012-2014. Dotted lines indicate the minimum and maximum site averages from the reference sites at 3-5 m in Shoalwater Bay and Jurien Bay Marine Parks from 2012-2014 (data courtesy of DPaW, 2014).*

4.2 Trigger assessment

4.2.1 Trigger 1

As there was less than a 50% decline at all seven sites, this threshold was not triggered (Table 2, % change 2013-2014).

4.2.2 Trigger 2

As there was not a 20% decline or more over two consecutive years at any site, this threshold was also not triggered (Table 2, % change 2012-2013 & 2013-2014).

4.2.3 Trigger 3

Trigger 3 relies on trend analysis to detect if there is a significant decline over time. Five years of data is required to be able to interpret this statistic with the amount of data that we have. This will be able to be assessed in 2016.

4.3 Epiphytes

In 2014, epiphyte cover was higher at all sites compared to 2013, but similar to observations from 2012, except for two sites, Vasse Diversion Drain and Busselton Jetty. These sites both had the highest cover compared to all the other sites (Category High) and the highest cover recorded to date, 2012-2014. The epiphyte cover at these two sites was predominantly microalgal accumulations. The dominant epiphytes were microalgal accumulations at 6 of the 7 sites, with either filamentous algae at Vasse-Wonnerup and Forrest Beach, encrusting algae at Port Geographe and others such as branching browns, red and erect calcified at Buayanup and Vasse-Diversion Drain (Figure 6, Table 3). At Dunsborough the main algal types were erect calcified algae and branching browns such as *Dictyota*.

Table 3: 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)			Temp (°C)		
	2012	2013	2014	2012	2013	2014	2012	2013	2014	2012	2013	2014
1. Dunsborough	M	L	M	f,O, m	F,O	O	4.2*	3	3	22.0	22.5	23.1
2. Buayanup	M	L	M	o, M	E,O	M,o	3.5	2.5	3*	22.8	22.6	23.5
3. Vasse Diversion Drain	L	M	H	o, M	E,O	M,o	4.0	3.25	3.5*	23.4	23.8	23.5
4. Busselton Jetty	L	L	H	o, M	O	M	4.2	2.5	3.5	23.4	27.3	23.3
5. Port Geographe	L	VL	L	E, o	E,M	M,e	3.75	2.5	4	23.4	25.5	23.3
6. Vasse-Wonnerup	L	VL	L	E, o, m	E,O	M,f	4.0	2	4.5	23.1	28.4	22.2
7. Forrest Beach	L	VL	L	E, o, M	F,E	M,f	5*	2	4	22.5	23.5	22.1

4.4 Other observations

A. antarctica was present at Sites 1, 3, 4, 5, 7 and 8, and *A. griffithii* was also present at Sites 7 and 8. The remains of flowering shoots were observed at Buayanup, Vasse-Diversion Drain, Busselton Jetty and Vasse-Wonnerup. Seedlings were only observed at Forrest Beach, and there was only one.

There were some bare patches, indicating recent shoot loss at Dunsborough and Port Geographe. There was a decline in shoot density at Dunsborough (17%) and a smaller decline at Port Geographe (7%), which supports these observations of recent shoot loss. In addition, both of these sites as well as Buayanup, which also had a decline in shoot density, had very brittle rhizomes, which easily broke off from the base. This was not the case at Forrest Beach where declines in shoot density also occurred.

There were noticeable accumulations of wrack in the bare patches at Dunsborough and Port Geographe, as well as at Buayanup. Leaves were the longest at Dunsborough and Buayanup, and here the tips of the leaves were noticeably dying back. This is a common growth pattern for *Posidonia*, and may be more noticeable at the Dunsborough end of Geographe Bay, which is more protected from ocean swells.

There was an increase in shoot density at Port Geographe last year, but this year there was a small decline, and a lot of variability among quadrats (Appendix 2, i.e. from 4 -100 shoots per quadrat). The quadrats with high shoot density tended to have a lot of branching shoots.

The branching shoots are a sign that the meadow is actively growing, and if conditions remain suitable it has the potential to increase in density.

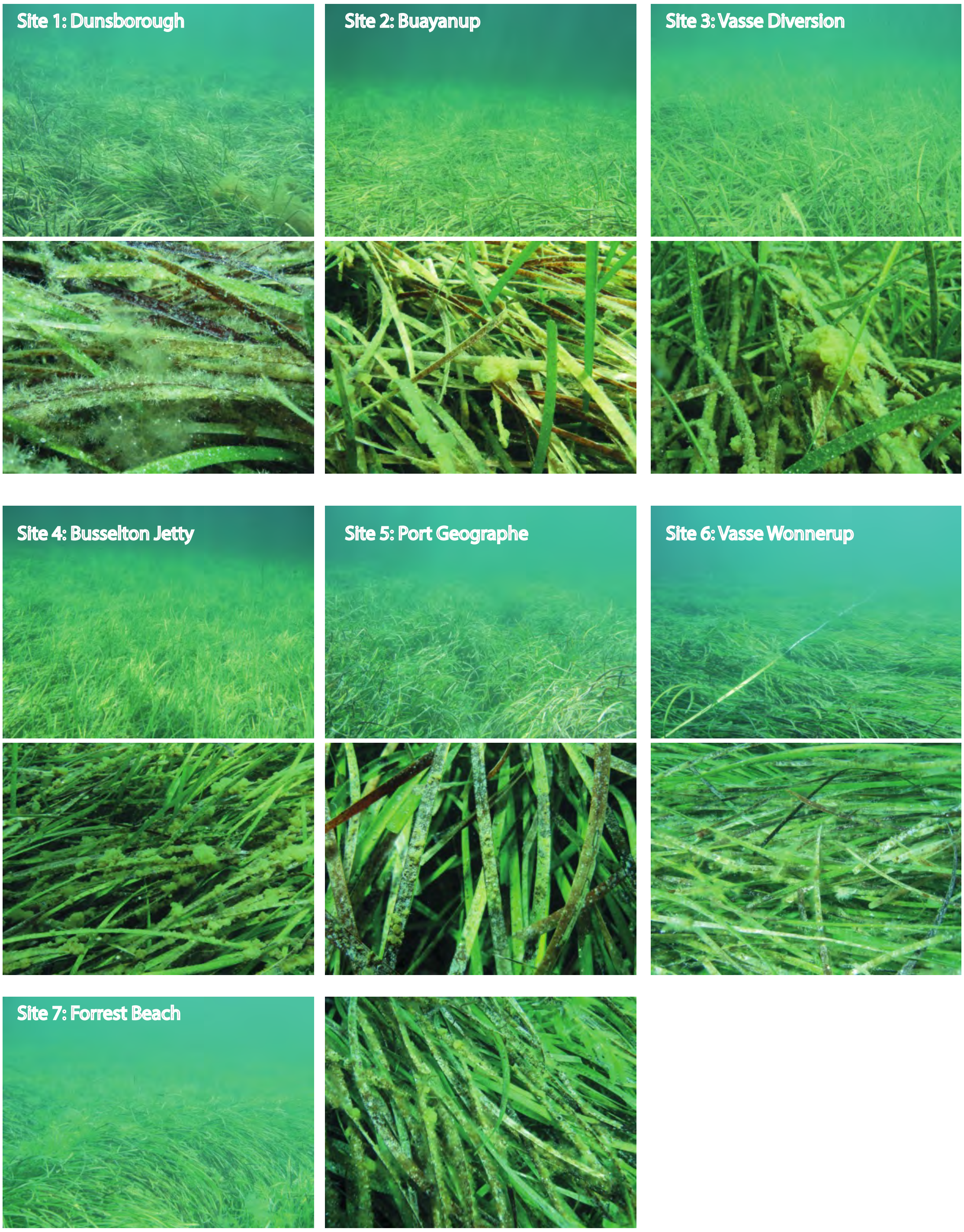

Figure 6: Pictures of seagrass meadow and the dominant algal epiphyte s at each *P. sinuosa* site. (1. Dunsborough, 2. Buayanup, 3. Vasse Diversion Drain, 4. Busselton Jetty, 5. Port Geographe, 6. Vasse-Wonnerup Estuary, 7. Forrest Beach)

4.5 Nutrient content

The nitrogen content of *P. sinuosa* leaves was the highest recorded to date, but still very low, ranging from 0.8-1.1 % DW (Figure 7). The nitrogen content of *A. antarctica* leaves also increased at Busselton Jetty (1.1% DW) and Forrest Beach (0.9% DW), relative to 2013 data, however, there was no increase at Capel where the nitrogen content remained elevated at around 1.8% DW (Figure 8).

The phosphorus content of *P. sinuosa* leaves in 2014 was midway between 2012 and 2013 values ranging from 0.9-0.15 % DW (Figure 8). This is in the range that has been observed in Geographe Bay in the past and these levels are not considered high (Table 4). A similar pattern was observed in *A. antarctica* leaves, which had slightly less P than 2013, from 0.06% DW at Forrest Beach to 1% at Capel and Busselton Jetty (Figure 8).

Table 4: 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	-	-

Nitrogen isotope signals can indicate the main source of nitrogen seagrasses are accessing. Nitrogen derived from the fixation of atmospheric nitrogen or agricultural fertilisers has a signature close to 0‰. Nitrogen derived from native bushland has a signal between 2-5 ‰, whereas nitrogen derived from animal waste or septic tanks is usually in the order of 5-6 ‰ and nitrogen from treated sewerage is usually around 9 ‰ (Jones and Saxby 2003). In Geographe Bay, nitrogen isotope signals measured in seagrass leaves indicate that the meadows are accessing different sources of nitrogen, and these sources vary among sites.

There was more variation in $\delta^{15}N$ of *P. sinuosa* leaves across the seven monitoring sites this year, 1.06 – 3.85 ‰ compared to previous years, and at most sites, there was an increase compared to previous data (Figure 9). At Dunsborough and Port Geographe, the $\delta^{15}N$ signal was similar to 2012-2013, 1.06 ‰ and 1.78 ‰, respectively. There was a slight increase at Buayanup and Busselton Jetty up to, 1.81 ‰ and 2.17 ‰ respectively, a >1 ‰ on average increase at Vasse-Diversion Drain and Vasse-Wonnerup, 3.13 and 2.45 ‰ respectively and the largest increase (>2 ‰) at Forrest Beach, up to an average of 3.85 ‰. The range in the nitrogen isotope signal in the seagrass leaves indicates the seagrasses are mostly receiving a mix of sources. Due to the increase this year at some sites, the main sources at these sites are less likely to be from fixation of atmospheric nitrogen or agricultural fertilisers, as if this was the case, the signal would move closer to 0‰. There is little evidence that nitrogen derived from treated sewerage is the main source for seagrasses, if this was the case, we would expect the signal to be much higher, around 9 ‰.

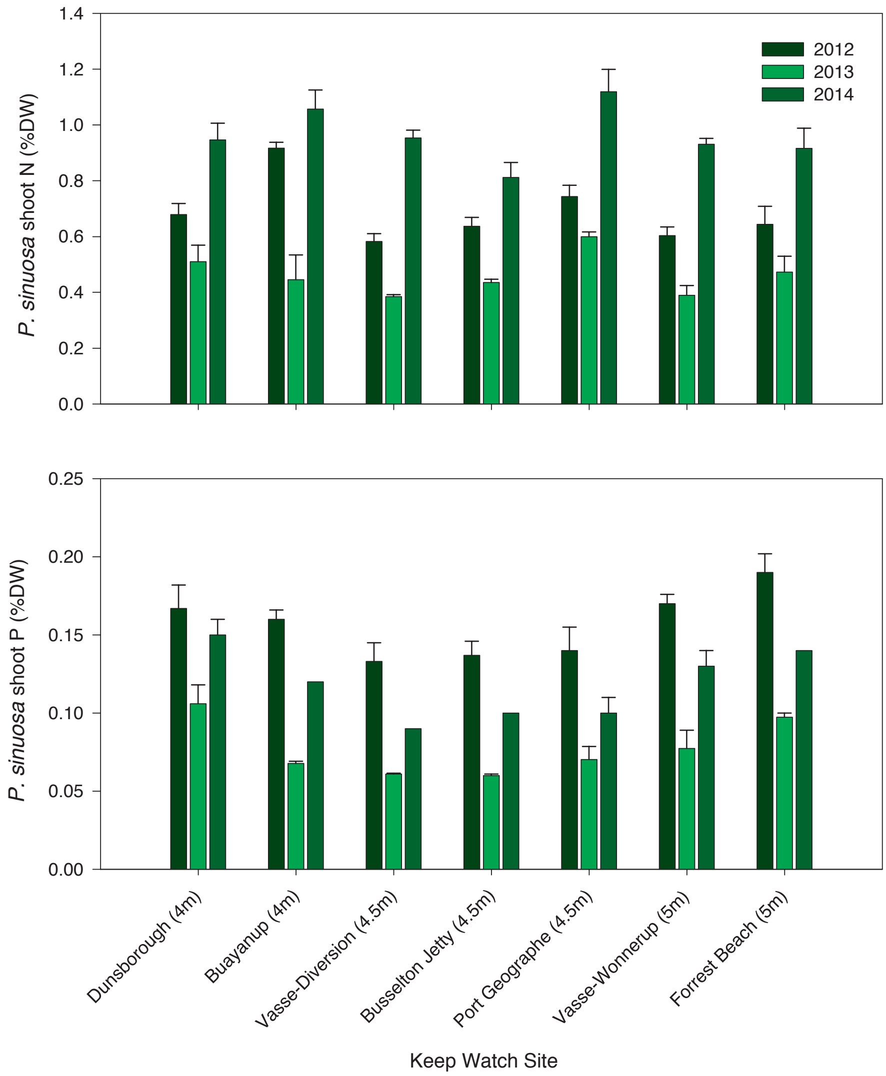

Figure 7: *Nitrogen and phosphorus content (% dw) of* P. sinuosa *leaves (Dunsborough-Forrest Beach) at the Keep Watch* Posidonia *seagrass monitoring sites in 2012-2014.*

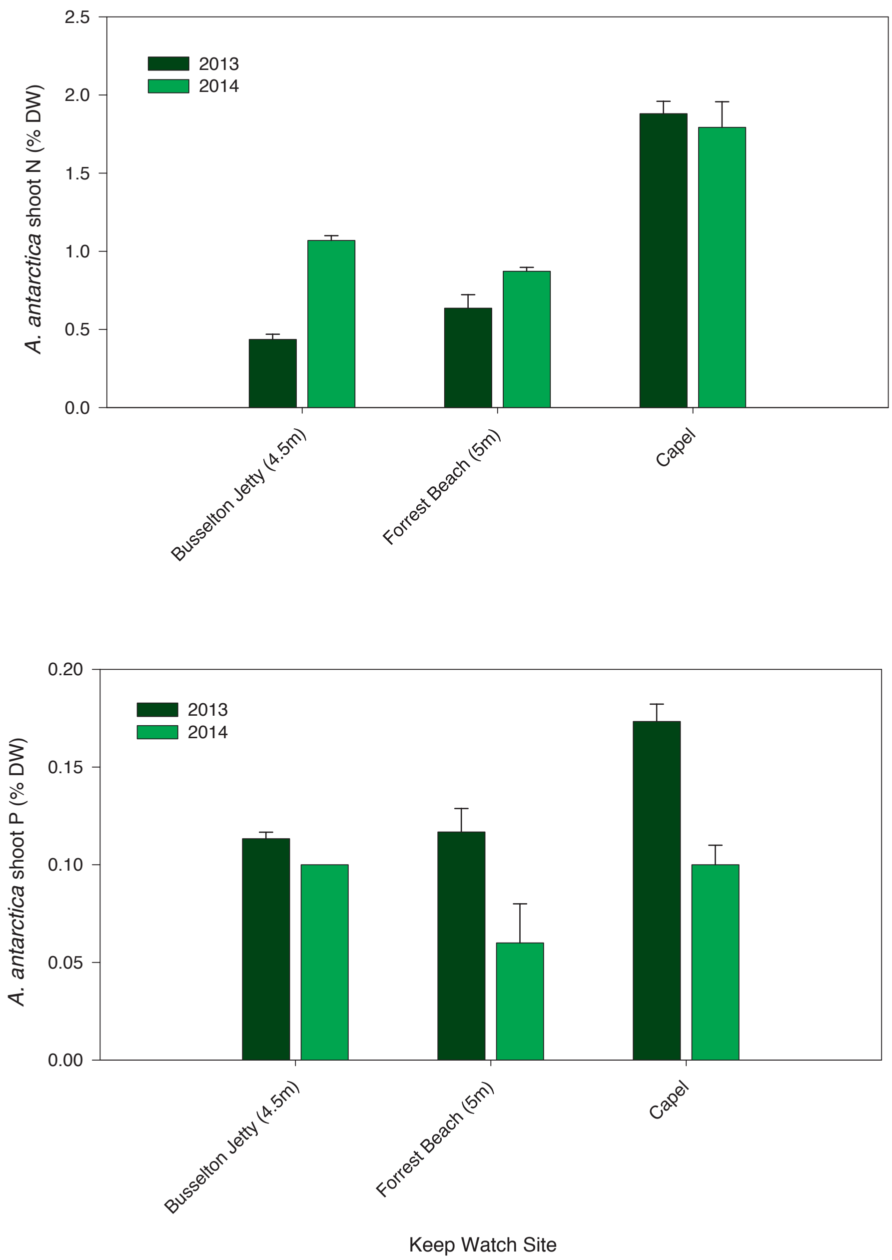

Figure 8: *Nitrogen and phosphorus content (% dw) of* A. antarctica *leaves (average ± se) at the Keep Watch* Amphibolis *seagrass monitoring sites in 2013-2014.*

Elevated $\delta^{15}N$ signals were also detected at all of the 3 *Amphibolis* monitoring sites in 2014 compared to 2013 (Figure 9), across all sites the increase was around 1 ‰. The relative differences among sites remained constant with the lowest values at Busselton Jetty (2.02 ‰), followed by Forrest Beach (3.22 ‰) and then the highest values at Capel (3.80 ‰).

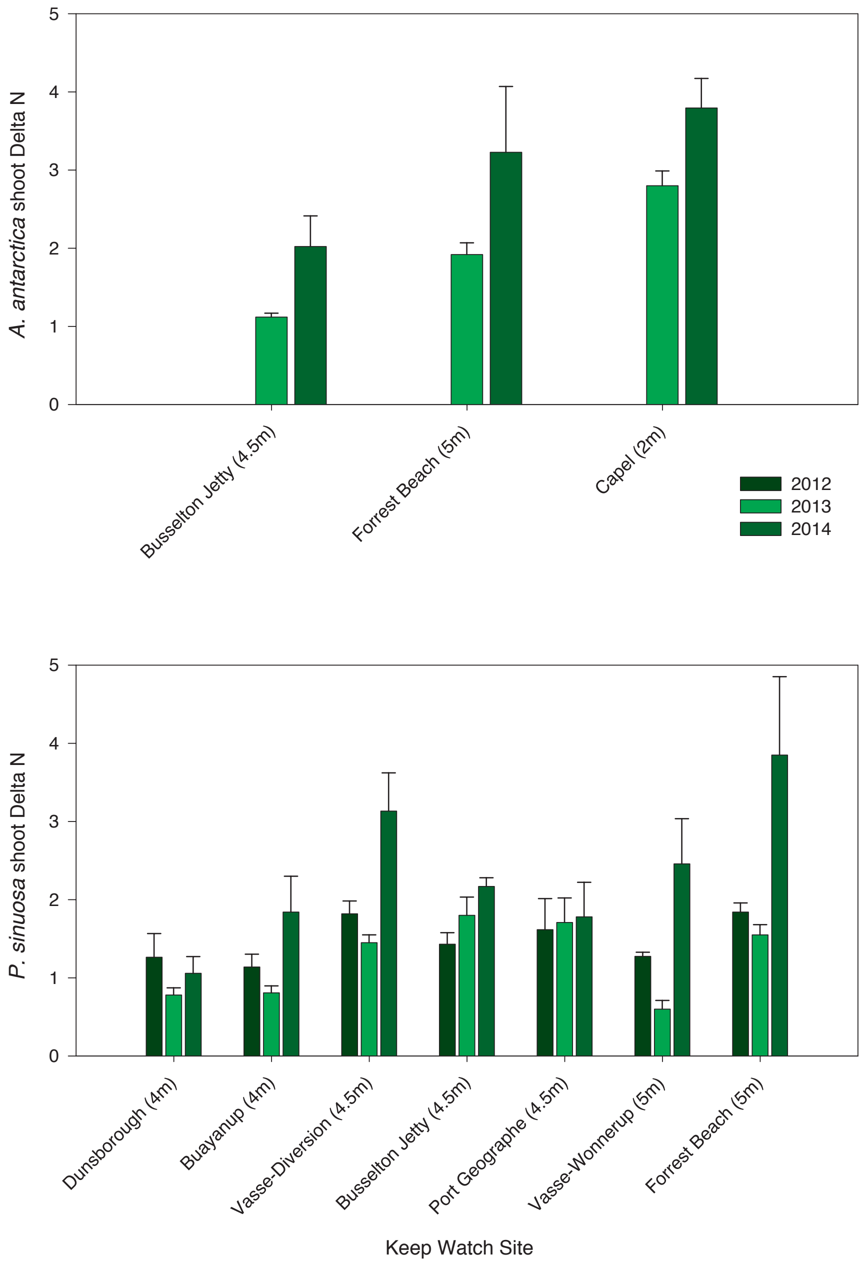

Figure 9: *$\delta^{15}N$ of* P. sinuosa *leaves (Site 1-7) and* A. antarctica *leaves (Site 4,7 & 8 average ± se) at the Keep Watch seagrass monitoring sites in 2012-2014. Note that only Capel was measured in 2012, and is not included in these graphs.*

4.6 Water quality

Water temperature at the Keep Watch seagrass sites ranged from 22.1-23.5°C. Secchi disk depth ranged from 3-4.5 m. With two sites (Buayanup and Vasse-Diversion Drain) the Secchi disk was visible on the bottom 3-3.5 m. These Secchi disk depth readings were greater than 2013, possibly due to very clear and calm conditions during sampling compared to the cloudy conditions in 2013 (Table 3).

5 General conclusions

5.1 Declines in shoot density

This year five of the seven *Posidonia sinuosa* had a decline in shoot density, compared to last year. Buayanup (24%) and Forrest Beach (23%) had the greatest reduction, with Dunsborough 18%, the Vasse Diversion Drain 8% and Port Geographe 7%. These declines do not activate Trigger 1, a 50% or more reduction in shoot density from one year to the next. Nor was Trigger 2 activated, a 20% or more reduction two years in a row. Inter-annual variation in shoot density commonly occurs in seagrass meadows due to regional changes i.e. climate and nutrient inputs and small-scales drivers i.e. storms, variation in shoot production and mortality. At present, there are no major concerns in Geographe Bay for seagrass health. The recommendation is to continue monitoring and reassess the changes next year, particularly at Forrest Beach, which had a 23% decline this year and Buayanup (24% decline), and have the potential to activate Trigger 2 if this level of decline continues into 2015.

Since 2012, the largest declines in shoot density have at occurred at Buayanup and Dunsborough, the shallowest and most protected sites, and where we have observed very brittle rhizomes. Since 2012 epiphyte cover at these sites has been low to moderate and dominated by microalgal accumulations, therefore, the epiphyte accumulations to do not explain this loss. Phosphorus and nitrogen content are low, which indicates that nutrients are not a concern. However, Dunsborough and Buayanup were two of the top four sites for nutrient content. This does not necessarily suggest that these higher concentrations are causing the decline, but the higher content may be a function of nutrient supply, nutrient recycling and plant growth rates at these sites, which all influence the amount of nutrient present in the leaf tissue. Higher growth rates tend to result in lower nutrient content. So if there is another factor reducing growth, the nutrient content could increase. At Dunsborough the source of nitrogen does not appear to have changed, as the nitrogen isotope value is similar from 2012-2014, but at Buayanup, there appears to have been a change in 2014, with a higher nitrogen isotope signal. As already stated, since the concentrations are so low, this change in source does not indicate a mechanism for decline.

Another potential hypothesis that could be explored to help understand the fluctuations at these sites, is the effect of temperature. Declines in shoot density have been detected over the last ten years (Lavery and McMahon, 2010, Mohring and Rule 2013) in Warnbro Sound, near Perth, a relatively unimpacted site. The hypothesis is that the declines may be associated with ocean warming. Increased temperatures can increase shoot mortality (Marba and Duarte 2010), and shallower sites would be more impacted as shallower water warms more during the summer. Impacts due to temperature are often related to the maximum temperature or duration of time above a certain temperature. Therefore the one-off measure of temperature collected during the Keep Watch Monitoring is not very useful at detecting these peaks in temperature, and deployment of continuous loggers would be much more effective. To improve our understanding of the relationship between changes in shoot density with temperature, particularly at these shallow sites, it is recommended to deploy temperature loggers at each site.

Finally, the one observation, which may be related to the loss, but the mechanism is not clear, is the brittleness of the rhizomes. It was noted when sampling this year that the rhizomes were very brittle and shoots could easily break off at Buayanup and Dunsborough, and also at Port Geographe. Across all these sites, shoot loss was also observed. However, the brittle rhizomes were not observed at Forrest Beach, which also experienced declines in shoot density. Further investigations could be conducted to understand this phenomena. For example the strength of rhizomes could be compared with other sites in the bay and the rhizome carbohydrate stores assessed, which would determine if the plants are under stress. In addition, regular water quality monitoring could be conducted at these sites to gain an understanding of the environmental conditions.

5.2 General trends in Geographe Bay

When we examine the change over time from 2012 to 2014, there was a net increase at Busselton Jetty, Port Geographe and Vasse-Wonnerup. A minimal decline at Vasse-Diversion Drain (1%) and Forrest Beach (7%), and as stated previously, a slightly greater decline at Dunsborough (14%) and Buayanup (15%). Port Geographe, which had shown signs of recent seagrass loss, appears to be showing signs that the meadow may recover. Even though there was a slight decline this year, there has been a net increase since 2012, and active branching of the shoots indicates that the meadow is growing and attempting to increase the shoot density. If shoot production is greater than shoot mortality the meadow should increase in density over time.

This year, across all sites, epiphyte cover was greater than last year, increasing by one category with the exception of Busselton Jetty, which increased by two categories up to High. Vasse Diversion Drain and Busselton Jetty recorded the highest epiphyte cover to date, and all other sites had similar cover to 2012. The cover of epiphytes recorded here does not correlate with changes in seagrass cover. For example Busselton Jetty had the highest epiphyte cover but the greatest increase in shoot density, and the site with one of the lowest epiphyte covers, Forrest Beach, had a decline of 18%.

Overall nutrient content in the seagrass leaves is very low. For *Posidonia* there was an increase in shoot nitrogen at all sites this year, compared to last year, and the highest recorded since monitoring began. There was also an increase in phosphorus compared to 2013 levels, but the values recorded in 2014 were not as high as in 2012. These patterns in nutrient content were consistent across all sites. These annual variations may be due to a combination of regional variation in nutrient inputs, nutrient recycling in Geographe Bay and growth rates which all influence the amount of nitrogen present in the leaf tissue. For nitrogen, the highest content across all years was observed at Port Geographe, followed by Buayanup and then Dunsborough. For phosphorus, the highest content across all years was observed at Forrest Beach and Dunsborough, followed by Vasse-Wonnerup.

The nitrogen isotope signals, which give an indication of nitrogen sources for seagrasses have increased at most sites this year. Half of the sites have had an increase of > 1 ‰, resulting in a $\delta^{15}N$ signals ranging from an average 2.45-3.85 ‰ across these particular sites. These increases in the $\delta^{15}N$ signals indicate that the main source of nitrogen that seagrasses are using at these sites is different compared to last year. It is less likely to be dominated by agricultural fertilisers or atmospheric nitrogen fixation sources, and is more likely to be dominated by nitrogen derived from animal wastes or septic tanks or sources from natural vegetation.

5.3 Comparison with other regions in WA

When we compare the change over time from 2012-2014 at Shoalwater Bay Marine Park and Jurien Marine Park with Geographe Bay, no consistent patterns are obvious (Table 4). For example from 2012-2013, changes in shoot density ranged from an increase up to 38% and a decline of 16% at the reference sites north of Geographe Bay, where at the same time there was either no change or up to a 19% increase in shoot density. From 2013-2014, only a 2% decline was observed at one site and up to a 23% increase at another. This highlights the variability from year to year at a site, and the changes in Geographe Bay are within the range seen in other locations.

Table 4: Comparison of change over time at sites in Geographe Bay with reference sites from Shoalwater Bay Marine Park and Jurien Bay Marine Park from a similar depth range (Data courtesy of DPaW).

Site Name & #	% change 2012-13	% change 2013-14
Geographe Bay		
1. Dunsborough	3	-18
2. Buayanup	11	-24
3. Vasse Diversion Drain	6	-8
4. Busselton Jetty	0	22
5. Port Geographe	17	-7
6. Vasse-Wonnerup	19	13
7. Forrest Beach	16	-23
Shoalwater Bay MP		
WS 3.2m	38	1
WS 5.2m	-16	23
Jurien Bay MP		
BI 3.5m	10	-2
BI 5.5m	-16	8

6 References

Jones and Saxby 2003. Assessing nutrient sources. Available online at http://ian.umces.edu

Lavery, P and McMahon, K (2011). Review of Cockburn Sound SEP Seagrass Monitoring Program. For Cockburn Sound Management Council.

Marba. N and Duarte, C 2010. Mediterranean warming triggers seagrass (*Posidonia oceanica*) shoot mortality. Global Change Biology 16: 2366-2375

McMahon, K. 2012. Proposed methodology for a seagrass health-monitoring program in Geographe Bay. Report to GeoCatch. Edith Cowan University, Joondalup.

7 Appendix 1: Randomly generated quadrat positions

Quadrat #	Bearing	Distance
1	0	1
2	0	12
3	20	1
4	20	11
5	20	12
6	40	9
7	60	13
8	100	6
9	100	16
10	100	23
11	140	8
12	140	19
13	140	24
14	140	25
15	160	22
16	200	3
17	200	17
18	240	3
19	260	5
20	260	12
21	260	17
22	280	2
23	280	7
24	280	9
25	280	18
26	320	15
27	340	1
28	340	14
29	340	23
30	340	24

8 Appendix 2: Shoot density data for the seven Keep Watch Seagrass Monitoring Sites including the seedling counts, and the person who counted each quadrat, 2014.

	In 20 x 20 cm quadrat																				
Year	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014
Date	30th January			30th January			30th January			29th January			28th January			29th January			29th January		
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	25	0	UH	47	0	UH	37	0	UH	42	0	UH	34	0	UH	27	0	MR	38	1	UH
2	39	0	UH	45	0	UH	16	0	UH	25	0	UH	51	0	UH	31	0	MR	13	0	UH
3	29	0	UH	47	0	UH	31	0	UH	31	0	UH	4	0	UH	38	0	MR	67	0	UH
4	31	0	UH	39	0	UH	41	0	UH	40	0	UH	28	0	UH	40	0	MR	35	0	UH
5	37	0	UH	33	0	UH	36	0	UH	57	0	UH	38	0	UH	60	0	MR	7	0	UH
6	20	0	UH	52	0	UH	12	0	UH	29	0	UH	67	0	UH	67	0	MR	57	0	UH
7	42	0	UH	32	0	UH	43	0	UH	23	0	UH	93	0	UH	44	0	MR	49	0	UH
8	32	0	UH	28	0	UH	45	0	UH	61	0	UH	41	0	UH	59	0	MR	34	0	UH
9	25	0	UH	28	0	MR	37	0	UH	21	0	UH	65	0	UH	41	0	MR	38	0	UH
10	24	0	UH	72	0	MR	29	0	KM	33	0	UH	61	0	KM	28	0	MR	11	0	UH
11	68	0	MR	55	0	MR	40	0	MR	26	0	MR	31	0	All	46	0	MR	62	0	MR
12	56	0	MR	64	0	MR	22	0	MR	53	0	MR	12	0	All	74	0	MR	54	0	MR
13	77	0	MR	34	0	MR	32	0	MR	51	0	MR	100	0	All	49	0	MR	68	0	MR
14	41	0	MR	42	0	MR	47	0	MR	69	0	MR	55	0	All	42	0	MR	27	0	MR
15	89	0	MR	45	0	MR	34	0	MR	78	0	MR	77	0	All	61	0	MR	12	0	MR
16	19	0	MR	48	0	MR	42	0	MR	50	0	MR	67	0	MR	46	0	MR	75	0	MR
17	54	0	MR	30	0	MR	52	0	MR	58	0	MR	15	0	MR	59	0	MR	35	0	MR
18	60	0	MR	67	0	MR	28	0	MR	44	0	MR	47	0	MR	75	0	MR	48	0	MR
19	63	0	MR	79	0	MR	28	0	MR	47	0	MR	17	0	MR	42	0	MR	53	0	MR
20	38	0	MR	60	0	MR	46	0	MR	62	0	MR	16	0	MR	75	0	MR	61	0	MR
21	31	0	MR	44	0	MR	34	0	MR	79	0	MR	48	0	MR	63	0	MR	58	0	MR
22	56	0	MR	86	0	MR	29	0	MR	51	0	MR	22	0	MR	47	0	KM	72	0	MR
23	67	0	MR	36	0	KM	8	0	MR	62	0	MR	39	0	MR	64	0	KM	31	0	MR
24	25	0	MR	64	0	KM	42	0	MR	49	0	MR	29	0	MR	59	0	KM	24	0	MR
25	73	0	KM	48	0	KM	31	0	KM	31	0	KM	64	0	MR	56	0	KM	66	0	MR
26	49	0	KM	52	0	KM	23	0	KM	36	0	KM	24	0	KM	43	0	KM	37	0	MR
27	114	0	KM	56	0	KM	37	0	KM	56	0	KM	23	0	KM	70	0	KM	65	0	KM
28	60	0	KM	69	0	KM	43	0	KM	36	0	KM	27	0	KM	53	0	KM	109	0	KM
29	97	0	KM	44	0	KM	12	0	KM	60	0	KM	32	0	KM	44	0	KM	67	0	KM
30	122	0	KM	47	0	KM	56	0	KM	28	0	KM	42	0	KM	28	0	KM	36	0	KM
Average	52.10	0.00		49.77	0.00		33.77	0.00		46.27	0.00		42.30	0.00		51.03	0.00		46.97	0.03	
Median	45.50	0.00		47.00	0.00		35.00	0.00		48.00	0.00		38.50	0.00		48.00	0.00		48.50	0.00	
se	4.99	0.00		2.76	0.00		2.15	0.00		2.95	0.00		4.35	0.00		2.59	0.00		4.18	0.03	

9 Appendix 3: Leaf morphology data

	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014
	S1	S1	S2	S2	S3	S3	S4	S4	S5	S5	S6	S6	S7	S7
	Dun.	Dun.	Buayanup	Buayanup	Vasse Div.	Vasse Div.	Buss Jetty	Buss Jetty	Port Geo	Port Geo	Vasse Won	Vasse Won	Forrest B	Forrest B
	Shoot Length (cm)	Shoot Width (mm)	Shoot Length (cm)	Shoot Width (mm)	Shoot Length (cm)	Shoot Width (mm)	Shoot Length (cm)	Shoot Width (mm)	Shoot Length (cm)	Shoot Width (mm)	Shoot Length (cm)	Shoot Width (mm)	Shoot Length (cm)	Shoot Width (mm)
	56.0	8.0	52.5	5.5	61.2	5.5	74.9	6.5	29.0	6.0	51.0	6.5	49.6	7.0
	51.7	7.0	71.9	6.5	38.6	6.0	41.5	6.5	19.5	5.0	57.0	5.5	47.0	7.5
	58.7	7.0	48.6	5.0	55.0	5.5	51.0	6.5	33.0	7.0	48.0	6.0	46.5	7.0
	57.5	6.0	46.8	5.5	42.3	6.5	63.5	6.0	26.1	5.5	37.0	6.0	51.0	7.0
	60.4	8.0	64.2	5.0	49.0	5.5	49.4	5.5	34.0	6.5	66.0	5.5	44.6	7.0
	56.2	7.0	63.0	5.5	47.6	6.0	53.0	6.5	23.4	6.5	71.0	6.0	33.8	8.0
	53.3	7.5	56.5	6.0	38.3	6.0	55.7	6.5	30.5	6.5	61.7	6.5	41.3	7.5
	70.5	8.0	57.5	6.0	35.5	6.5	55.2	6.5	28.2	6.5	58.6	6.5	38.7	5.5
	58.7	8.0	56.5	6.0	44.2	5.5	58.2	6.0	11.6	5.0	36.0	5.5	34.7	7.0
	62.2	8.0	47.5	5.5	37.5	5.5	64.8	6.0	22.0	5.5	41.7	6.0	32.3	6.5
	78.5	6.5	45.6	5.5	41.0	5.5	56.3	6.5	39.8	6.0	50.1	6.0	51.7	6.0
	55.0	6.5	50.6	5.0	45.6	5.0	48.6	7.0	51.0	5.5	30.5	6.0	53.6	5.5
	84.6	5.5	64.7	5.5	35.4	5.5	57.8	5.0	52.8	6.0	50.0	6.0	56.8	6.0
	80.4	5.0	51.2	5.5	37.1	5.5	54.6	5.5	64.0	5.5	30.7	5.5	43.4	6.0
	90.3	5.5	47.7	5.5	65.2	5.5	54.9	6.0	42.2	5.5	65.1	6.0	36.5	6.0
	97.5	6.0	54.1	6.0	50.8	6.0	65.2	6.0	42.6	6.5	59.6	5.5	39.8	5.5
	65.0	6.0	50.8	5.0	32.2	5.0	57.1	6.0	25.8	5.5	47.0	6.5	58.3	5.5
	61.2	5.0	45.7	5.5	68.0	5.5	49.4	6.5	29.0	5.0	48.0	5.5	45.5	5.5
	81.1	5.5	33.4	5.0	37.0	5.0	55.4	5.5	41.3	5.5	51.5	6.0	47.3	5.5
	88.8	5.5	53.6	4.5	41.1	4.5	34.0	5.0	48.0	6.0	47.6	6.0	49.9	5.5
	55.0	5.5	54.3	5.0	69.7	6.5	45.0	5.0	37.0	4.5	76.4	7.0	37.4	5.5
	49.8	5.5	47.5	5.5	55.9	7.0	58.0	5.5	42.2	5.5	59.6	6.5	30.1	4.5
	52.0	5.5	56.0	5.5	64.9	6.5	61.2	5.5	39.5	5.5	54.1	5.5	44.6	4.5
	36.7	6.0	45.0	6.5	52.0	6.5	53.2	6.0	43.0	5.5	44.0	5.5	31.9	5.0
	47.2	6.0	58.8	6.5	53.5	6.0	44.6	5.0	47.0	6.5	62.0	6.0	22.3	4.5
	56.3	5.5	62.6	5.5	53.7	5.5	54.8	6.0	49.7	6.0	44.9	6.5	36.2	6.0
	52.7	5.5	56.2	5.0	53.6	6.0	33.2	6.0	32.3	5.0	56.3	5.5	32.3	5.5
	60.3	6.0	47.0	6.5	58.2	6.0	22.8	4.5	49.0	6.5	70.7	6.5	29.3	5.5
	44.7	5.5	36.9	6.0	71.5	6.5	48.9	7.0			23.3	5.5	25.7	5.5
	67.6	5.5	47.2	6.5	60.4	6.0	35.5	7.0			32.4	6.0	25.9	5.5
average	63.0	6.3	52.5	5.6	49.9	5.8	51.9	6.0	36.9	5.8	51.1	6.0	40.6	6.0
se	2.685078	0.18057	1.496928	0.1	2.092424	0.103391	1.960751	0.119706	2.228699	0.116237	2.387403	0.07762	1.756662	0.167698

10 Appendix 4: Nutrient data

		2012	2012	2012	2012	2012	2013	2013	2013	2013	2013	2014	2014	2014	2014	2014
Site	**Species**	**δ15N [‰ AIR]**	**δ13C [‰ VPDB]**	**N [wt %]**	**C [wt %]**	P (% DW)	**δ15N [‰ AIR]**	**δ13C [‰ VPDB]**	**N [wt %]**	**C [wt %]**	P (% DW)	**δ15N [‰ AIR]**	**δ13C [‰ VPDB]**	**N [wt %]**	**C [wt %]**	P (% DW)
Dunsborough	Posidonia	1.84	-9.45	0.6	37.2	0.14	0.78	-10.66	0.42	38.41	0.093	0.66	-10.58	0.9	37.7	0.15
Dunsborough	Posidonia	1.14	-10.95	0.6	36.2	0.17	0.93	-11.31	0.48	39.64	0.095	1.39	-10.87	0.9	39.6	0.13
Dunsborough	Posidonia	0.81	-10.17	0.8	37.2	0.19	0.61	-10.84	0.62	38.91	0.130	1.13	-10.77	1.1	40.2	0.17
Buayanup	Posidonia	1.30	-9.38	0.9	37.5	0.15	0.88	-10.56	0.62	38.29	0.070	2.55	-7.82	1.1	40.2	0.11
Buayanup	Posidonia	1.31	-8.36	0.9	36.7	0.16	0.92	-8.49	0.32	38.41	0.068	1.99	-8.73	1.1	39.7	0.12
Buayanup	Posidonia	0.81	-8.36	1.0	36.5	0.17	0.64	-10.06	0.40	39.28	0.065	0.99	-8.19	0.9	38.8	0.12
Vasse-Diversion	Posidonia	1.49	-9.24	0.6	36.1	0.14	1.28	-8.73	0.39	38.16	0.061	3.28	-7.39	1.0	38.6	0.096
Vasse-Diversion	Posidonia	1.97	-8.60	0.6	36.6	0.11	1.46	-9.07	0.39	38.01	0.062	3.90	-6.81	0.9	37.5	0.089
Vasse-Diversion	Posidonia	2.00	-9.41	0.6	36.2	0.15	1.62	-9.11	0.37	37.69	0.060	2.23	-7.10	0.9	36.3	0.099
Busselton Jetty	Posidonia	1.40	-8.81	0.7	37.9	0.12	1.53	-8.91	0.42	39.05	0.058	2.39	-8.49	0.9	38.0	0.095
Busselton Jetty	Posidonia	1.19	-9.14	0.6	37.3	0.14	2.26	-9.07	0.46	37.85	0.061	2.09	-8.27	0.8	36.5	0.1
Busselton Jetty	Posidonia	1.70	-9.57	0.7	37.4	0.15	1.60	-8.12	0.43	38.26	0.061	2.03	-7.50	0.7	37.5	0.11
Port Geographe	Posidonia	1.73	-10.52	0.8	37.2	0.15	1.65	-8.58	0.61	39.95	0.058	2.56	-5.90	1.0	37.5	0.084
Port Geographe	Posidonia	0.88	-10.10	0.7	36.8	0.16	2.28	-9.71	0.57	40.55	0.086	1.03	-9.30	1.3	39.5	0.13
Port Geographe	Posidonia	2.24	-9.63	0.8	37.1	0.11	1.21	-10.79	0.63	39.96	0.067	1.74	-7.06	1.1	39.3	0.098
Vasse-Wonnerup	Posidonia	1.38	-9.75	0.7	37.8	0.16	0.67	-10.65	0.45	40.18	0.080	1.33	-7.58	0.9	37.3	0.13
Vasse-Wonnerup	Posidonia	1.20	-9.32	0.6	37.0	0.18	0.75	-10.17	0.40	39.13	0.096	3.22	-8.38	0.9	38.6	0.11
Vasse-Wonnerup	Posidonia	1.25	-9.47	0.6	37.0	0.17	0.38	-9.52	0.33	38.64	0.056	2.83	-8.14	1.0	38.6	0.16
Forrest Beach	Posidonia	2.06	-12.29	0.8	36.5	0.21	1.30	-9.76	0.40	38.58	0.100	3.86	-6.59	1.0	39.6	0.13
Forrest Beach	Posidonia	1.65	-10.26	0.6	36.8	0.19	1.62	-10.06	0.44	38.96	0.092	2.11	-7.73	0.8	38.0	0.14
Forrest Beach	Posidonia	1.82	-12.56	0.6	36.4	0.17	1.74	-11.56	0.58	39.39	0.100	5.58	-7.79	1.0	39.7	0.14
Busselton Jetty	Amphibolis						1.21	-11.78	0.37	38.55	0.110	2.15	-10.37	1.0	40.2	0.11
Busselton Jetty	Amphibolis						1.10	-11.52	0.48	39.45	0.120	1.29	-8.51	1.1	40.8	0.096
Busselton Jetty	Amphibolis						1.04	-11.91	0.45	38.88	0.110	2.63	-8.70	1.1	39.7	0.1
Forrest Beach	Amphibolis						2.09	-13.09	0.70	39.08	0.140	3.48	-10.53	0.9	40.2	0.01
Forrest Beach	Amphibolis						2.05	-12.51	0.74	38.97	0.100	4.54	-9.78	0.8	38.7	0.079
Forrest Beach	Amphibolis						1.62	-13.14	0.47	39.97	0.110	1.66	-11.46	0.9	43.5	0.084
Capel	Amphibolis	3.32	-11.42	1.2	38.7	0.13	2.44	-13.17	2.04	40.56	0.190	4.13	-9.76	1.5	38.3	0.078
Capel	Amphibolis	3.18	-11.61	1.1	38.9	0.13	2.89	-13.39	1.79	38.56	0.170	4.21	-10.11	1.8	37.6	0.1
Capel	Amphibolis	2.75	-10.42	1.1	38.3	0.11	3.06	-13.37	1.81	39.45	0.160	3.04	-10.37	2.1	40.6	0.12