Edith Cowan University
Centre for Marine Ecosystems Research

Keep Watch Seagrass Monitoring 2017 Report for GeoCatch

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Keep Watch Seagrass Monitoring, 2017. Report to GeoCatch

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Keep Watch Seagrass Monitoring

Annual Report 2017

Investigators: Kathryn McMahon

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December 2017

1 Executive Summary

1.1 Introduction

This report summarises data from the first six years (Feb 2012 - Feb 2017) of the Keep Watch Seagrass Monitoring Program in Geographe Bay. The program was developed in collaboration with GeoCatch, Edith Cowan University (ECU), Department of Water and Environmental Regulation, Department of Biodiversity, Conservation and Attractions, and the South West Catch Council. Since 2006 annual seagrass monitoring has been carried out by ECU with in-kind support from the Department of Biodiversity, Conservation and Attractions and funding from the Water Corporation.

The Keep Watch seagrass monitoring program was initiated due to concerns for the health of seagrass meadows in Geographe Bay from predicted increases in catchment nutrients. The aim of the program is monitor near shore seagrass meadows annually to detect any change in seagrass health. Seagrass shoot density of the dominant seagrass species *Posidonia sinuosa* is monitored at seven sites across Geographe Bay as an indicator of seagrass health. Observations of algal epiphyte cover and seagrass leaf nutrient content and nitrogen isotope signals are also measured.

Three management triggers have been established for Geographe Bay to detect changes in shoot density outside normal annual variation. Comparison of shoot densities with temperate seagrass meadows in other areas in Western Australia are also used as a comparison to assess seasonal and site variations.

1.2 Key findings 2012-2017

Key finding 1

The condition of nearshore seagrass in Geographe Bay is good and there are no major concerns regarding seagrass health. Over the last 6 years seagrass shoot density has increased or stayed the same across the seven monitoring sites with no management triggers breached. Shoot densities in Geographe Bay are also higher or above the minimum density recorded in other temperate seagrass meadows in Western Australia.

Key finding 2

Shoot density varies across different sites, consistently the lowest shoot density was recorded at the Vasse Diversion Drain and Port Geographe and highest shoot densities occur within the shallower sites at Dunsborough and Buayanup.

Key finding 3

Algal epiphyte cover has been reasonably consistent across sites and years. The highest epiphyte cover was recorded at sites within central Geographe Bay. The main type of epiphyte on the seagrass, with moderate to high cover is microalgal accumulations. These accumulations are not generally associated with nutrient enrichment. A Masters student from ECU is currently investigating the possible causes of these accumulations.

Key finding 4

Nutrient content of seagrasses in Geographe Bay is low, and no increase in nutrient content detected has been observed compared to samples collected over the last two decades. Nutrient concentration varies across years and sites, and the main difference is 2-4 times higher nitrogen content at Capel compared to other sites.

Key finding 5

The main sources of nitrogen for seagrass at most sites is likely to be from fixation of atmospheric nitrogen or agricultural fertilisers. A higher nitrogen isotope signal at Capel suggests that nitrogen derived from animal wastes, septic tanks or from natural vegetation is also a main source. There is no evidence that nitrogen derived from treated sewerage is a major source of nitrogen for Geographe Bay seagrasses.

1.3 Recommendations

These recommendations are based on the last six years of Keep Watch monitoring and consider GeoCatch's needs into the future.

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. Considering the threat of nutrient enrichment is on-going in the Geographe Bay catchment, monitoring of seagrass health provides an early warning indicator of impacts in Geographe Bay. This program is the only approach in place at present assessing potential impacts in the marine environment, linking the land to the sea.

Recommendation 2

Continue the collaborative arrangement with ECU, Department of Biodiversity, Conservation and Attractions, GeoCatch and the Water Corporation to coordinate, fund and undertake seagrass monitoring. This is a very effective and beneficial arrangement.

Recommendation 3

Investigate the factors influence the growth and formation of microalgal epiphytic aggregations on the seagrass, particularly the potential link with catchment nutrients.

Recommendation 4

Explore options to undertake seagrass extent mapping on a five yearly basis. The total area of seagrass in Geographe Bay was last mapped in 2007 (van Niel et al. 2009). The recommendation from the assessment of monitoring approaches recommended annual monitoring of seagrass health and then five year monitoring of total seagrass area to assess changes at a larger scale (McMahon 2012).

Recommendation 5

Investigate further water quality monitoring points and/or seagrass monitoring sites associated with discharge points to assess if there are increased levels of nutrients in the waters of Geographe Bay. Currently seagrass monitoring occurs at seven sites in Geographe Bay, and water quality monitoring only at one, and this is not a seagrass monitoring location. The ability to elucidate causes of change in seagrass meadows would be greatly enhanced by having linked water quality data including continuous or regular measurements of nutrients and light.

Recommendation 6

Review Keep Watch seagrass monitoring methodology in line with the Ngari Capes Marine Park Management Plan.

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 2017 and compares data from the 2012-2016 surveys.

The objective for the Keep Watch program is to undertake long-term, cost-effective seagrass monitoring for Geographe Bay to monitor the effects of water quality, particularly catchment nutrients on seagrass distribution and health.

This year the program was funded through collaborative sponsorship from the Water Corporation and in-kind support from the Department of Biodiversity, Conservation and Attractions (DBCA).

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, 2 and 3 are assessed this year (see 3.1.3 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 7^{th} to the 9^{th} February 2017. At Capel (8) 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 5 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	27/1/2016 10:18	Ps
2. Buayanup	S 33.65233°, E 115.24840°	4	27/1/2016 12:30	Ps
3. Vasse Diversion Drain	S 33.64746°, E 115.32379°	4.5	27/1/2016 14:13	Ps
4. Busselton Jetty	S 33.63896°, E 115.34315°	4.5	28/1/2016 10:40	Ps, Aa
5. Port Geographe	S 33.62846°, E 115.38240°	4.5	27/1/2016 07:38	Ps
6. Vasse-Wonnerup	S 33.60188°, E 115.42345°	5	28/1/2016 08:59	Ps
7. Forrest Beach	S 33.57295°, E 115.44908°	5	28/1/2016 07:29	Ps, Aa
8. Capel	S 33.51394°, E 115.51508°	2	29/1/2016 09:00	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.

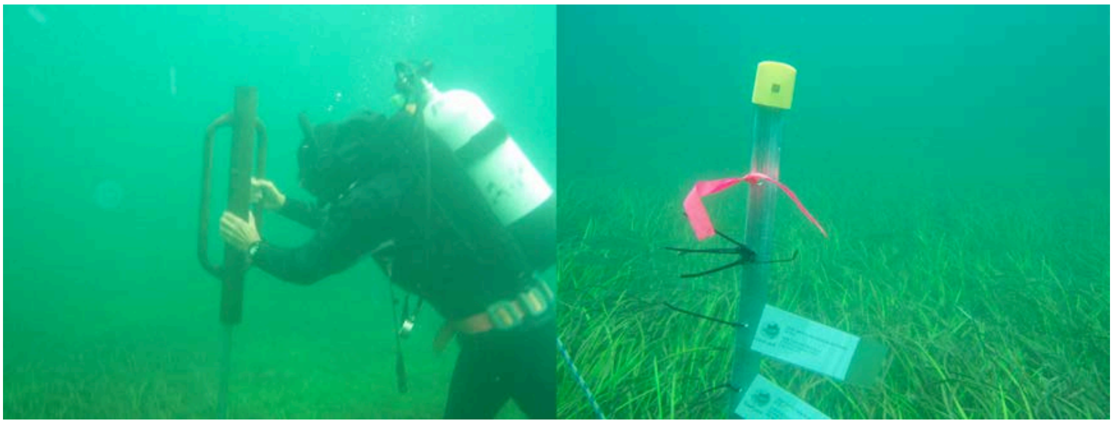

Figure 2: *Left: Banging in permanent marker with pole driver. Right: Star picket with cap and plastic coated site label, indicating center of 50 m diameter Keep Watch seagrass site.*

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.

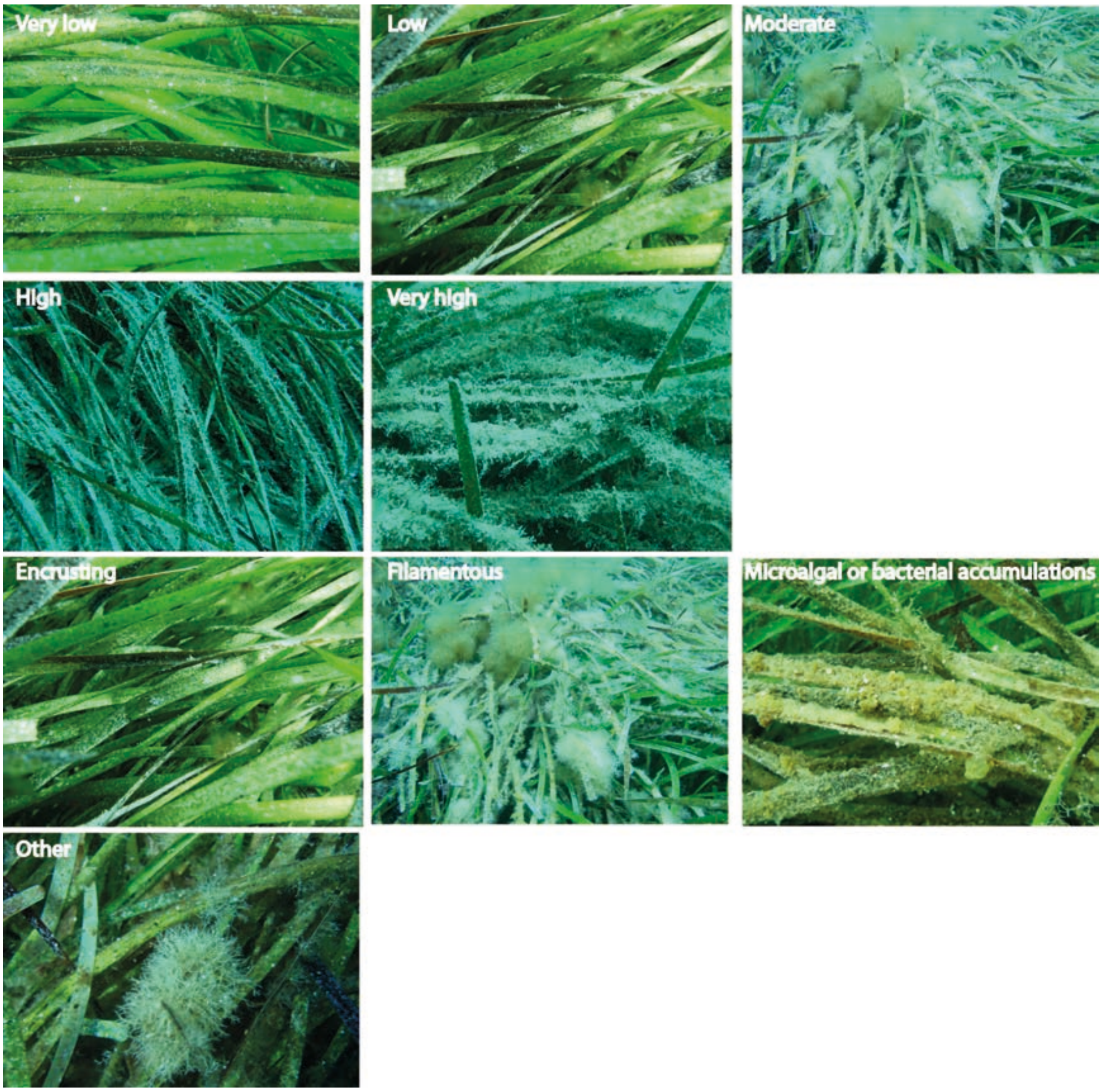

Figure 4: *Classification of epiphytic algal cover and type.*

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) from ECU with Ben French (BF), Matthew Dasey (MD), David Lierich (DL) and Ian Anderson (IA) from Department of Biodiversity, Conservation and Attractions. The boat and tank fills were provided by Department of Biodiversity, Conservation and Attractions. The monitoring program was funded through sponsorship by Water Corporation.

3.1.2 Laboratory processing

In the laboratory the three seagrass shoot samples 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 a 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 algal cover 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 856-1482 shoots m^{-2} across the seven sites, this is very similar to what was observed in 2015 (846-1489 shoots m^{-2}) (Figure 5). Once again, the shallower sites, Dunsborough and Buayanup (3.5 m) had the highest shoot density (1482 and 1453 shoots m^{-2}, respectively. The minimum shoot density was observed at Vasse Diversion Drain (856 shoots m^{-2}) and Port Geographe (863 shoots m^{-2}), and the remaining sites had intermediate shoot densities. All raw data is in Appendix 2.

There was a reduction in shoot density at 4 of the 7 sites, but at three of these sites, this was a minor change, with less than a 3% decline at Dunsborough, Busselton Jetty and Forrest Beach (Table 2). Port Geographe had the greatest decline (23% decline) compared to last year. The remaining sites had a slight to moderate increase in shoot density, with the greatest increase at Vasse Diversion (19% increase), followed by Vasse Wonnerup (4% increase) and Buayanup (2% increase). Compared to 2012, when these surveys began, two sites have shown moderate increases, Vasse-Wonnerup (30% increase), Busselton Jetty (19% increase), one site a slight decline, Port Geographe (7% decline) and the remaining four sites have shown little overall change (±5% change).

The shoot density at most sites in Geographe Bay are above the minimum (320 m^2) and maximum (1 180 m^2) 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 DBCA). However, this year, the three sites in the middle of Geographe Bay, Vasse Diversion Drain, Busselton Jetty and Port Geographe have dropped below the maximum site average at the Shoalwater and Jurien Bay Marine Park sites, but they are above the minimum site average (Figure 5).

P. sinuosa average shoot length ranged from a minimum of 47 cm at Buayanup to a maximum of 64 cm at Vasse Diversion Drain and a range in width of 5.5-6.2 mm (Appendix 3).

Table 2: Change assessment based on Trigger 1 and 2. There is a concern with seagrass health when there is a 50% decline in shoot density from one year to the next (Trigger 1) or when there is more than a 20% decline two years in a row. A negative number indicates a decline in shoot density and orange shading is a decline of more than 20%.

Site Name & #	% change 2012-13	% change 2013-14	% change 2014-15	% change 2015-2016	% change 2016-2017	Net change 2012-2017
1. Dunsborough	3	-18	7	9	-3	-1
2. Buayanup	11	-24	20	-7	2	4
3. Vasse Diversion	6	-8	0	-15	19	3
4. Busselton Jetty	0	22	-4	1	-1	19
5. Port Geographe	17	-7	12	-6	-23	-7
6. Vasse-Wonnerup	19	13	-4	-3	4	30
7. Forrest Beach	16	-23	2	5	-3	-3

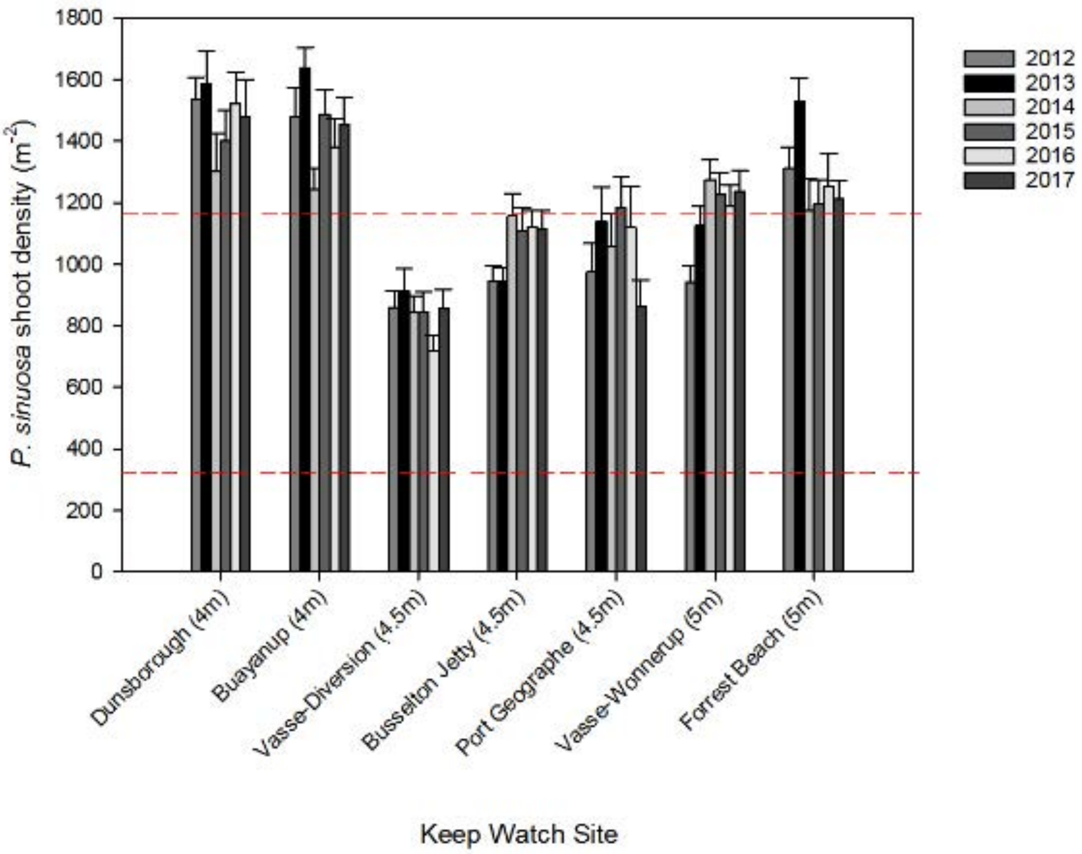

Figure 5: *Shoot density (average m^{-2} ± se) at the seven Keep Watch seagrass monitoring sites with* P. sinuosa *meadows in February 2012-2017. Dotted lines indicate the minimum and maximum site averages from the reference sites at 3-5 m in Shoalwater Bay and Jurien Bay Marine Parks from 2012-2017 (data courtesy of DBCA, 2017).*

4.2 Trigger assessment

4.2.1 Trigger 1

As a decline of 50% was not detected at any of the seven sites, this threshold was not triggered (Table 2, % change 2016-2017).

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 2015-2016 & 2016-2017). Port Geographe needs to be assessed in 2018 for Trigger 2 as it is the only site that could breach this trigger next year due to the 23% decline in 2017.

4.2.3 Trigger 3

This is the second year that Trigger 3 was assessed. No sites showed a significant trend over the six years, either increasing or decreasing in shoot density (Table 3). Individual plots showing change over time are located in Appendix 4.

Table 3: Mann-Kendall Trend statistic to assess if there has been a significant decline over time in shoot density.

Site Name & #	Significance ($p<0.05$)	Overall slope	R^2
1. Dunsborough	ns	-ve	4%
2. Buayanup	ns	-ve	5%
3. Vasse Diversion	ns	-ve	25%
4. Busselton Jetty	ns	+ve	56%
5. Port Geographe	ns	-ve	48%
6. Vasse-Wonnerup	ns	+ve	52%
7. Forrest Beach	ns	-ve	29%

4.3 Epiphytes

The amount of epiphyte cover is the same as 2016 at all sites, except Forrest Beach where it has declined to Very Low. High cover has been maintained at Buayanup and Vasse Diversion Drain, Moderate cover at Busselton Jetty and Port Geographe and Low cover at Dunsborough and Vasse-Wonnerup (Table 4). The dominant epiphyte where there was both High and Moderate cover were microalgal accumulations. The sites with Low or Very Low cover were dominated by the encrusting or branching red algal epiphytes. (Figure 6, Table 4).

Table 4: Algal cover at the Keep Watch seagrass monitoring sites, 2012-2017. 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.

Site	Algal cover						Algal Type					
	-12	-13	-14	-15	-16	-17	-12	-13	-14	-15	-16	-17
1. Dunsborough	M	L	M	M	L	L	O,f,m	F,O	O	O,m	O	O,e,m
2. Buayanup	M	L	M	M	H	H	M,o	E,O	M,o	M,o	M , o	M,e,o
3. Vasse Diversion Drain	L	M	H	H	H	H	M,o	E,O	M,o	M,o	M , o	M,o
4. Busselton Jetty	L	L	H	H	M	M	M,o	O	M	M,f	O, e, m	M,o,e
5. Port Geographe	L	VL	L	L	M	M	E, o	E,M	M,e	M,f	O, f	M,o,e
6. Vasse-Wonnerup	L	VL	L	M	L	L	E, o, m	E,O	M,f	O	E,o,m	E,m
7. Forrest Beach	L	VL	L	L	L	VL	E, M,o	F,E	M,f	O,e	E,o	E,o

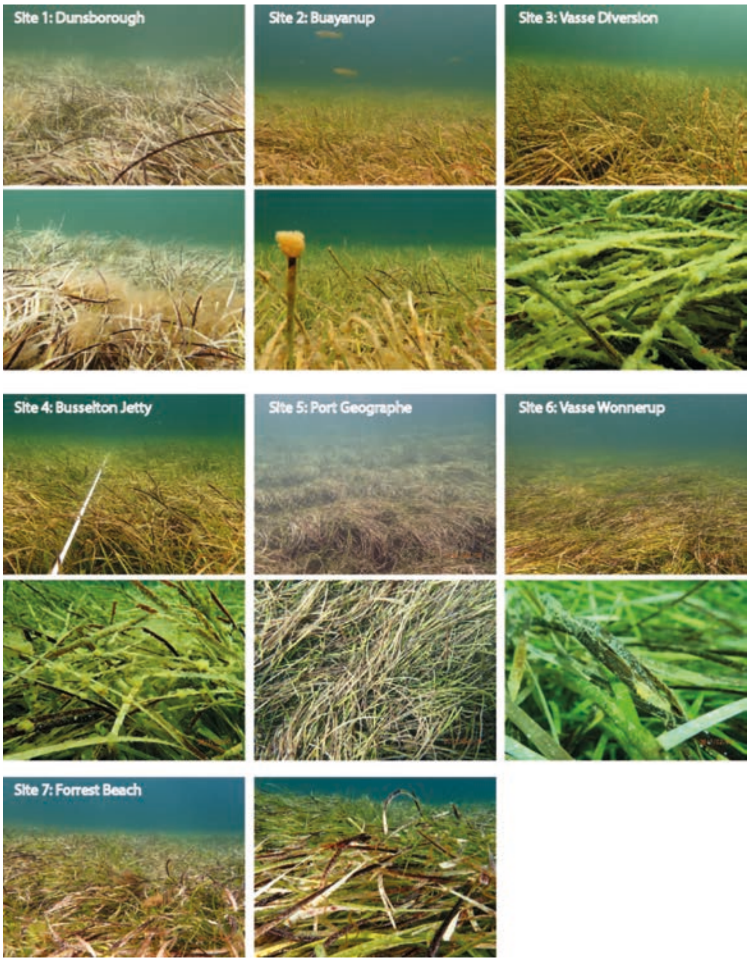

Figure 6: Pictures of seagrass meadow and the dominant algal epiphytes at each *P. sinuosa* site. (1. Dunsborough, 2. Buayanup, 3. Vasse Diversion Drain, 4. Busselton Jetty, 5. Port Geographe, 6. Vasse-Wonnerup Estuary, 7. Forrest Beach)

4.4 Other observations

A. antarctica was present at Dunsborough, Buayanup, Vasse Diversion Drain, Busselton Jetty, Port Geographe, Forrest Beach and Capel. *A. griffithii* was also noted at Forrest Beach and Capel. The remains of flowering shoots were observed at Vasse-Diversion Drain, Busselton Jetty, Vasse-Wonnerup and Forrest Beach. In addition, seedlings were observed at Vasse-Wonnerup and Forrest Beach.

At a number of sites this year small patches of dieback were observed with the type of dieback varying among sites. At Dunsborough and Buayanup there were small patches, < 20 cm in diameter where there were no shoots and just rhizomes present with the sheaths attached, indicating recent shoot loss (Figure 7). A few anchor damage scars were also evident at Buayanup. At Busselton Jetty and Port Geographe there were larger bare patches (Figure 7), 2-5 m across. At Port Geographe these have been present since the Keep Watch seagrass monitoring began in 2012 and no recovery is evident. However, this is a new occurrence at the Busselton Jetty site. A number of patches were evident where the shoots had thinned, and in some cases in the process of thinning. Both dead shoots of *P. sinuosa* and *A. antarctica* were obvious.

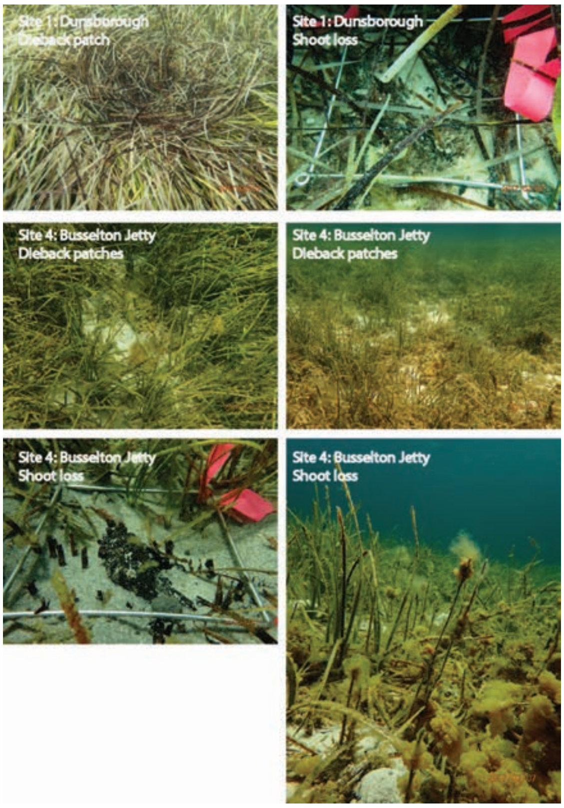

Figure 7: Bare patches within the seagrass meadow observed at Dunsborough and Busselton Jetty.

4.5 Nutrient content

The nitrogen content of *P. sinuosa* leaves ranged from 0.4-0.7 % N dry weight (DW) (Figure 8). At some sites (Buayanup, Vasse Diversion, Busselton Jetty and Port Geographe) there was a small decline compared to last year, and the remaining sites (Dunsborough, Vasse Wonnerup and Forrest Beach), little change. The nitrogen content of *A. antarctica* leaves decreased slightly at Forrest Beach and increased slightly at Busselton Jetty and Capel (Figure 9). The nitrogen content remains greater at Capel, 1.4 % DW or 2-4x greater than the other sites.

The phosphorus content of *P. sinuosa* leaves in 2017 ranged from 0.09-0.17% P DW (Figure 8). Compared to last year, some sites were very similar (Dunsborough, Busselton Jetty and Forrest Beach), some declined (Buayanup, Vasse Diversion Drain and Port Geographe) and Vasse Wonnerup slightly increased. For *A. antarctica* leaves, the phosphorus content ranged from 0.10-0.11% DW. There was a slight decline compared to last year at Forrest Beach, a larger decline at Capel and a slight increase at Busselton Jetty and Capel (Figure 9). Due to the decline at Capel, this is the first year that P content was not at highest at this location (Figure 9). All raw data is in Appendix 5.

This nitrogen and phosphorus concentrations continue to be in the range that has been observed in Geographe Bay in the past and these levels are not considered high (Table 5).

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 & Walker 2008) 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 & McComb 2000) Shoalwater Bay	1.8	-	-	0.6	-	-
Summer 2003	(Collier et al. 2008) Cockburn Sound	1.2-1.4	-	-			
Autumn 2008	(Hyndes et al. 2012) Warnbro Sound	-	-	4			

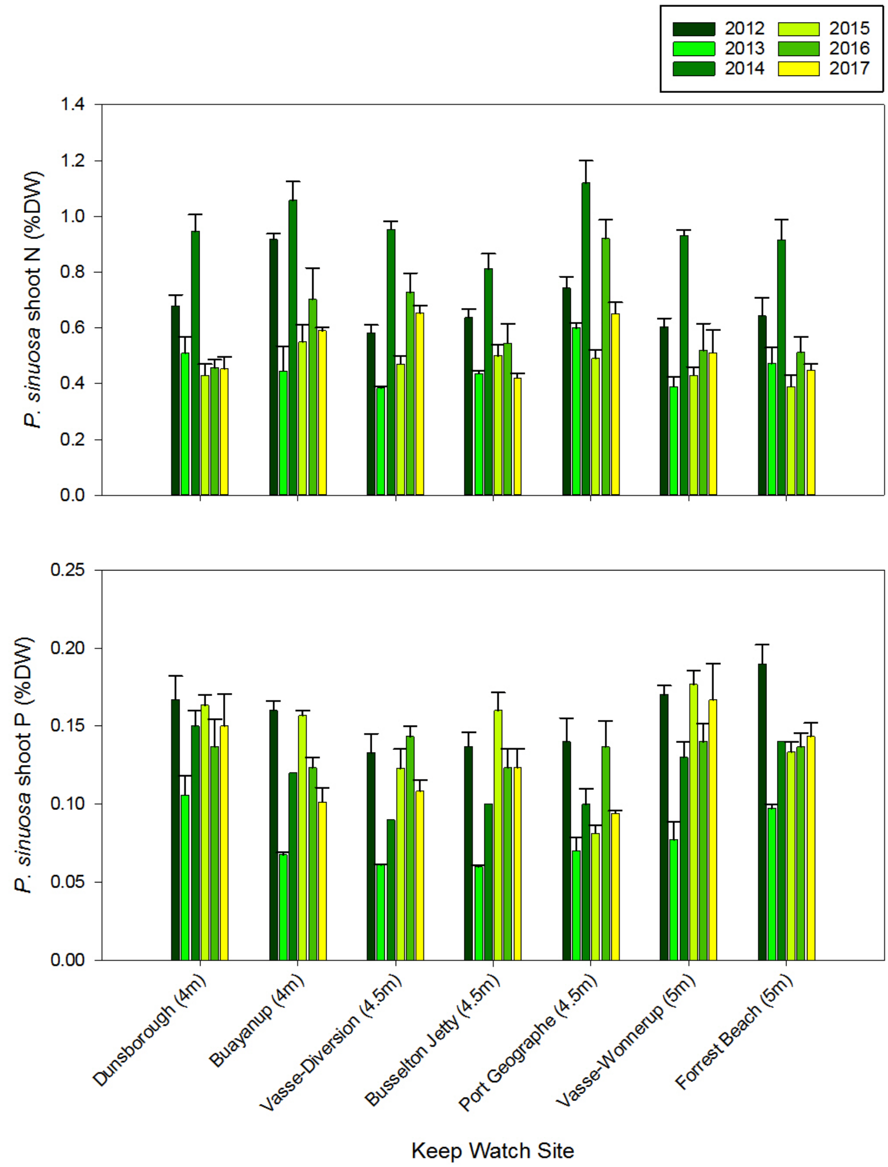

Figure 8: *Nitrogen and phosphorus content (% dw) of* P. sinuosa *leaves (Dunsborough-Forrest Beach) at the Keep Watch* Posidonia *seagrass monitoring sites in 2012-2017.*

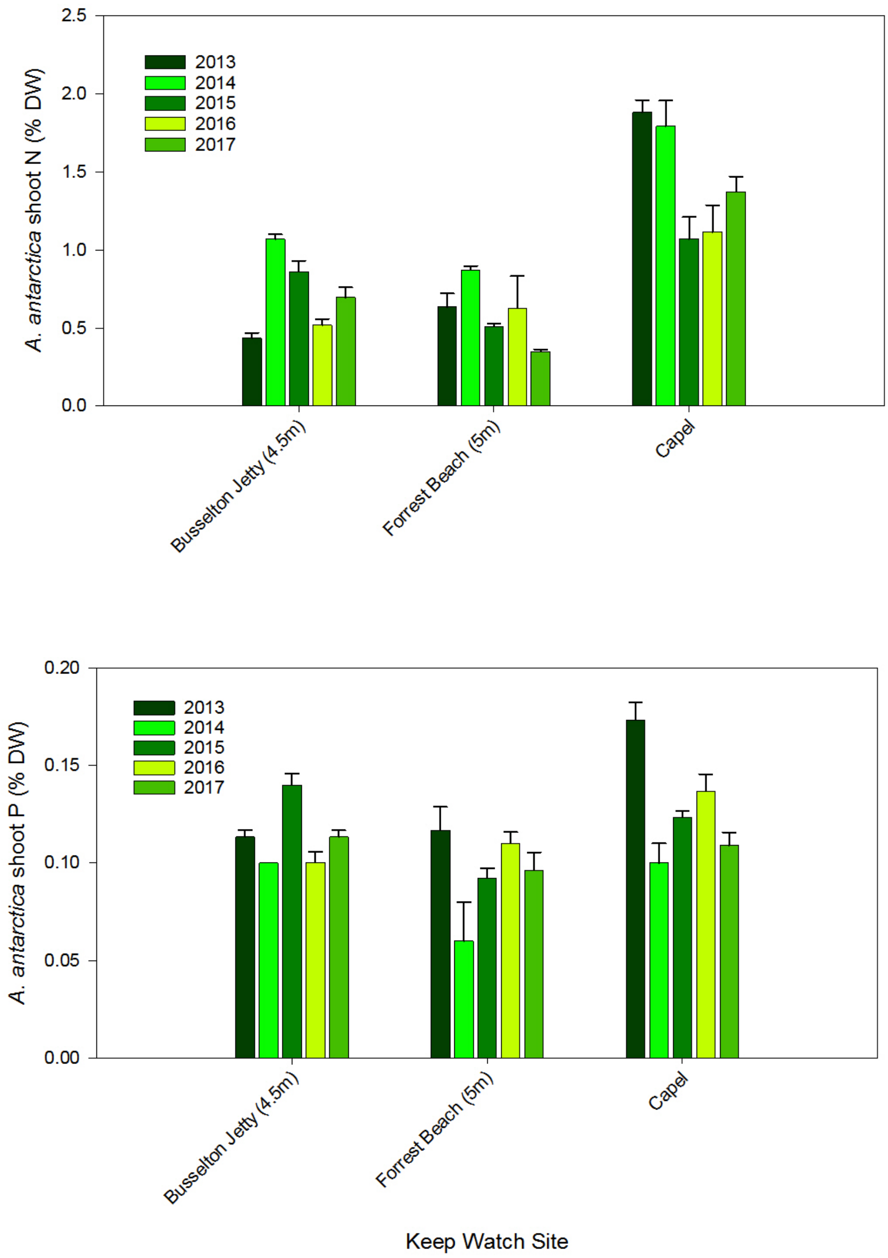

Figure 9: *Nitrogen and phosphorus content (% dw) of* A. antarctica *leaves (average ± se) at the Keep Watch* Amphibolis *seagrass monitoring sites in 2013-2017.*

Nitrogen isotope signals can indicate the main sources 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 & 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.

The variation in $\delta^{15}N$ of *P. sinuosa* leaves across the seven monitoring sites was less than last year, from 0.6 to 1.7 ‰ (Figure 10), the values were not as low at Dunsborough and Forrest Beach. There was an increase at these sites of 0.5‰, a decline at Buayanup and Busselton Busselton of 0.5‰, and all other sites were very similar to last year. The nitrogen isotope signals in the seagrass leaves indicate that this year seagrasses are mostly receiving a mix of sources, but the main sources could be either from fixation of atmospheric nitrogen or agricultural fertilisers, as the signal is close to 0‰. There is no 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 ‰.

The $\delta^{15}N$ signal of *Amphibolis*, compared to last year, increased at Busselton Jetty and Forrest Beach but remained the same at Capel (Figure 10). Once again the highest values were observed at Capel (3.6 ‰ compared to 1.4 ‰ at the other sites), indicating a different source of nitrogen at this site. All raw data is in Appendix 5.

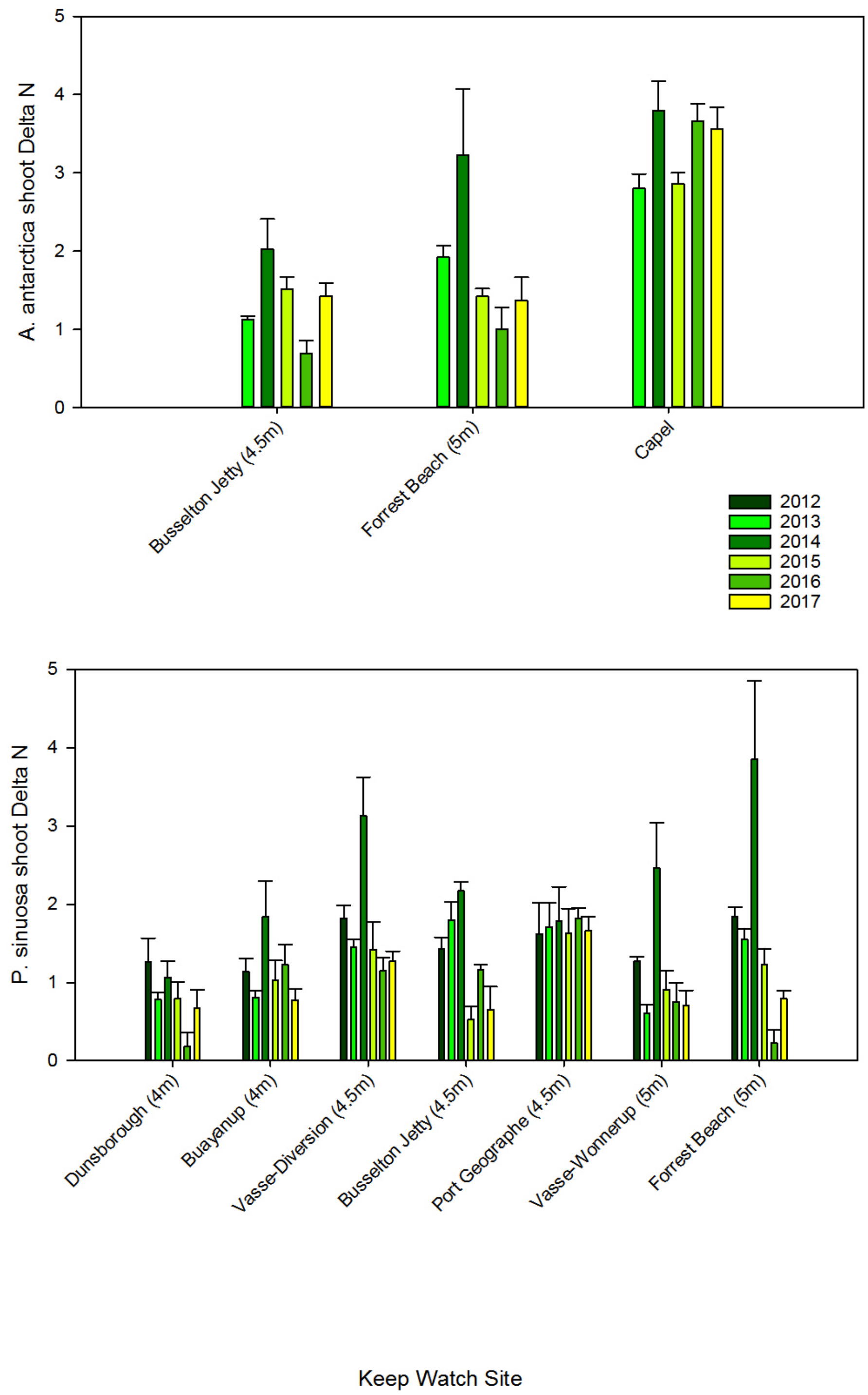

Figure 10: *δ^{15}N of* P. sinuosa *leaves (Site 1-7) and* A. antarctica *leaves (Site 4, 7 & 8 average ± se) at the Keep Watch seagrass monitoring sites in 2012-2017. Note that only Capel was measured in 2012, and is not included in these graphs.*

4.6 Water quality

Water temperature at the Keep Watch seagrass sites ranged from 22.0-22.8°C. Water clarity was high and at all sites, the Secchi disk was observed on the bottom (Table 6).

Table 6: Water quality measures at the Keep Watch seagrass monitoring sites from 2012-2017, *=Secchi disk depth on bottom.

Site	Secchi disk depth (m)						Temperature (°C)					
	2012	2013	2014	2015	2016	2017	2012	2013	2014	2015	2016	2017
1. Dunsborough	4.2*	3	3	3.2*	3*	3.5*	22.0	22.5	23.1	23.3	22.9	22.5
2. Buayanup	3.5	2.5	3*	3.2*	3.5*	2.5*	22.8	22.6	23.5	25.2	23.7	22.8
3. Vasse Diversion Drain	4.0	3.25	3.5*	3.6*	3.5*	5*	23.4	23.8	23.5	24.5	23.9	22.0
4. Busselton Jetty	4.2	2.5	3.5	3.6*	3.5*	2.5*	23.4	27.3	23.3	26.3	22.6	22.5
5. Port Geographe	3.75	2.5	4	4.1*	3.5	4.5*	23.4	25.5	23.3	24.3	23.0	22.5
6. Vasse-Wonnerup	4.0	2	4.5	4.6*	4.5*	4*	23.1	28.4	22.2	26.1	22.3	22.3
7. Forrest Beach	5*	2	4	4.2*	4.5*	4*	22.5	23.5	22.1	25.1	23.3	22.5

5 General conclusions

5.1 No significant declines in shoot density

No management criteria were triggered in 2017 for all three triggers. Most sites were within 5% of last years shoot density. The exceptions were Port Geographe where a 23% decline was observed and Vasse-Diversion Drain where a 19% increase was observed. In the previous year Vasse Diversion Drain had a 15% decline, and an overall decline relative to 2012 of 16%. However, with the increase this year, this pattern of decline has been reversed. Port Geographe had the biggest decline recorded to date this year, with the lowest shoot density observed since the start of monitoring in 2012. This site is 'On Watch' to assess against Trigger 2 next year (two consecutive years of a decline of 20%). This level of decline has been observed twice previously in 2014 at Buayanup and Forrest Beach. In these cases the decline was reversed the following year or no further reduction were observed. Despite this change at Port Geographe, there are no major concerns in Geographe Bay for seagrass health. The recommendation is to continue monitoring and reassess the changes next year.

5.2 Dieback

This year small patches of dieback were observed at Dunsborough and Busselton Jetty, however this did not impact on the average shoot density measured compared to 2016. At both sites 1-2 quadrats had either no living shoots or a lower number of shoots with evidence of recent shoot loss, due to the presence of leaf sheaths without leaves in them. The size of the dieback was much smaller at Dunsborough compared to Busselton Jetty, and at Dunsborough the dead leaves were generally still in the area. However, at Busselton Jetty the bare sediment was noticeable and some of the dead leaves had moved away. If this dieback occurs it is likely to impact shoot density of the meadow into the future. The cause of the dieback is not clear and changes in shoot density, epiphyte cover and nutrient content do not provide any plausible explanations. At both sites, shoot density has been relatively stable over the six years of monitoring. Over the last two years, epiphtyte cover has been low at Dunsborough and moderate at Busselton Jetty, although prior to that it was high at Busselton Jetty. Nitrogen and phosphorus content has not changed at the two sites compared to last year, and there are no consistent patterns in relation to the nitrogen isotope signal. Within other seagrass systems, small-scale dieback patches has been linked to sediment conditions. Higher amounts of organic carbon can deplete oxygen and create more anoxia, through bacterial respiration (Borum et al. 2005). Hydrogen sulphide is commonly produced in the anoxic sediments of seagrass meadows (Borum et al. 2005, Marba et al. 2006). Hydrogen sulphide is toxic to seagrasses and can permeate into underground seagrass roots, and up into shoot meristems causing mortality, particularly when oxygen release from root tips is reduced or stopped. There is evidence that sediment anoxia and increased hydrogen sulphide production can directly impact the survival of adult plants (Borum et al. 2005, Raun & Borum 2013). A number of indicators have been proposed to assess exposure to sulfide and *Posidonia* species are quite sensitive to exposure (Holmer & Hasler-Sheetal 2014, Kilminster et al. 2014). The recommendation to investigate the potential causes of this dieback is to measure the sulfide indicators in seagrass. Material collected in the 2017 survey could be used, and compared to previous years samples that have been preserved.

5.3 Microalgal accummulations continue to dominate where epiphyte cover is high

High to moderate epiphyte cover was maintained in the central Geographe Bay sites (Buayanup, Vasse Diversion Drain, Busselton Jetty and Port Geographe), and in these locations the dominant epiphyte form is microalgal accumulations. This is a unique feature of Geographe Bay. It is not clear why these microalgal accumulations form and what maintains the aggregations. They are certainly more common in the more protected areas of the bay (i.e. Buayanup to Port Geographe). This continues to be a knowledge gap in our understanding of the ecology of these seagrass epiphytes, and further research is warranted into understanding the factors that promote its abundance, particularly in relation to links with catchment nutrients, and the potential impacts on seagrass density and health. A Masters student at ECU, supervised by Kathryn McMahon will begin a study on abundance and composition of periphyton (small sized epiphyte accumulations) in 2017, as well as investigating the nutrients that affect the abundance and composition.

5.4 Capel receives a different nutrient source

The seagrass at Capel once again has higher nitrogen content, indicating that it has been exposed to more nutrients or that its growth is limited and so does not use as much of the nutrient in growth compared to other sites. However, the phosphorus content has dropped this year to levels similar to other sites. This indicates that the seagrass at Capel is exposed to less phosphorus compared to the previous two years. The nutrient content in the seagrass leaves at all other sites for both *Amphibolis* and *Posidonia* continues to be low.

Capel also has a much higher nitrogen isotope signal than the other sites, 3.6‰ compared to a range from 0.65-1.6‰. In this area, the potential sources, which tend to have a higher nitrogen isotope signal include nitrogen derived from animal wastes or septic tanks or sources from natural vegetation.

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7 Appendix 1: Randomly generated quadrat positions from 2017 survey

Quadrat #	Bearing	Distance
1	0	1
2	0	8
3	0	10
4	0	21
5	60	5
6	60	13
7	60	15
8	60	21
9	80	13
10	80	15
11	80	16
12	80	19
13	140	4
14	140	10
15	140	13
16	140	15
17	180	12
18	180	15
19	180	20
20	180	25
21	240	2
22	240	4
23	240	6
24	240	16
25	260	10
26	260	11
27	260	18
28	300	12
29	300	15
30	300	20