Supplementary Information

Getting edgy: Implications of fragmented seagrass meadows for fish assemblages. *Landscape Ecology*.
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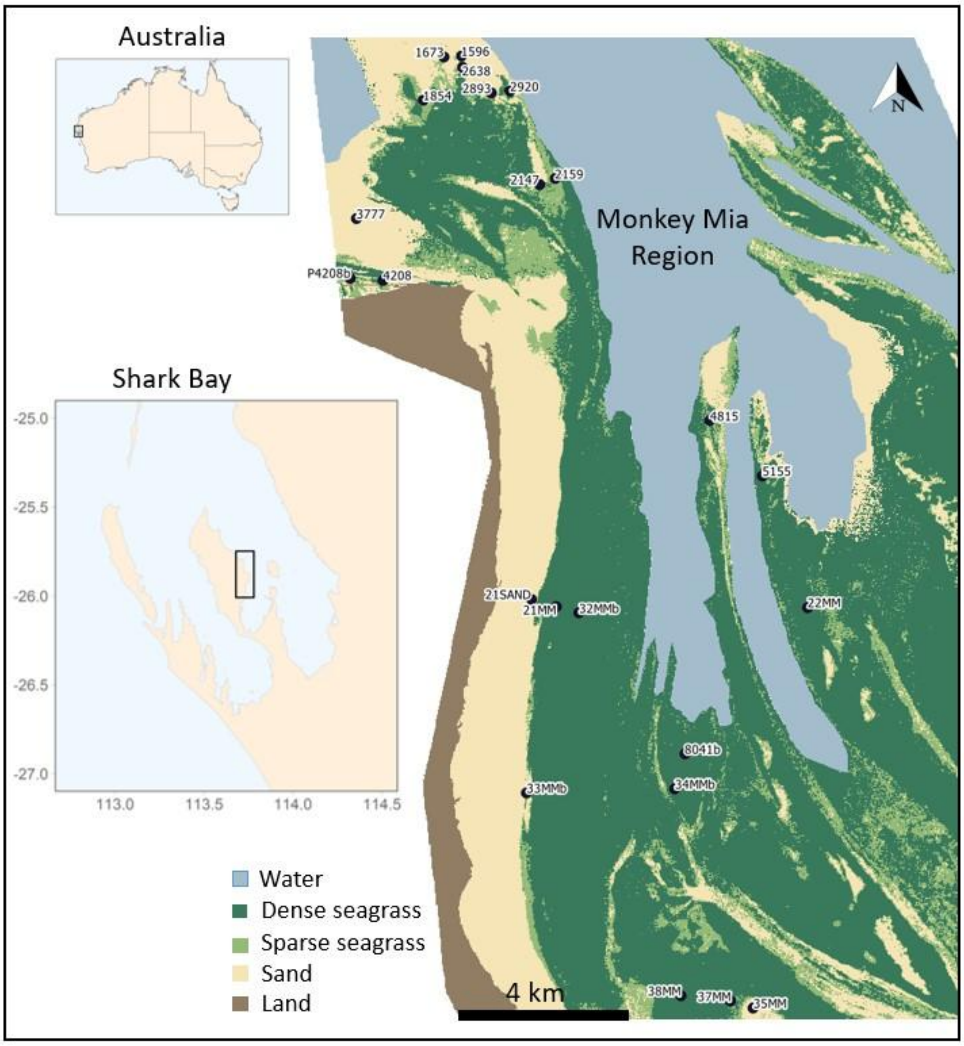

Fig. S1 Location of study site within the Shark Bay World Heritage Area. Black circles with site codes denote data collection sites within the Monkey Mia region which was overlaid onto the 2020 habitat map depicting seagrass (dense and sparse), sand, land and deepwater classes

Table S1 Variable description and associated references for the seascape metrics used

Metric name	Metric description (units)	Metric level	Ecological justification supported by examples from the literature
PERIM	Length of perimeter (m) of patch (including internal holes)	Patch	Edges are indicative of distinct change in habitat type and changes in key ecological processes such as predation e.g., foraging predatory fishes (Connolly & Hindell 2006, Boström et al 2006, Smith et al 2011, Stavely et al 2016, Salita et al 2003).
AREA	Total area of patch (ha)	Patch	Seagrass patch size effects available habitat and fish abundance (Laurel et al. 2003), (Boström 2006); (Boström et al 2011, 2017; Fahrig 2003). In conjunction with patch-quality variables such as seagrass cover and height (Boström et al 2011, Smith et al 2010,

			Van Lier et al 2018), is an indicator of quantity of within-patch habitat in each buffer zone.
PARA	Ratio of patch perimeter (m) to area (ha); Indicative of shape	Patch	Both patch size and edges should be considered in fish studies to assess edge effects (Smith et al. 2010). PARA is a common shape metric useful as an indicator of fragmentation (Calabrese & Fagan 2004; Grober-Dunsmore 2007) previously correlated with fish density (Macreadie et al. 2009).
Class Area	Total area (Ha) of each class mapped as sparse seagrass (5-40 % cover), dense seagrass (>40 % cover) and sand per year	Class	Quantity of each habitat type (class) in the seascape which could influence fish assemblage structure (Hyndes & Kendrick 2003, Hasselbarth et al 2019, Yeager et al 2011, Rotherham & West 2002, Grober-Dunsmore 2007, Pittman et al 2004)
Number of Patches	Total number of patches per class	Class	Provides quantitative estimate of the number of patches per seagrass class. Used to infer temporal shifts in the proportion of sparse vs dense seagrass patches and changes in habitat quality/ fragmentation (Pittman 2004)
Total Edge	Total amount of edge measured (km) between classes	Class	Higher edge values tend to indicate greater fragmentation in the seascape (Connolly & Hindell 2006, Pittman 2004). Similar to PARA, although that is measured at the Patch level, whereas Total Edge is included at the Class level here.
Site water depth	Depth (m) recorded on the same day at fish collection sites	Site	Fish species occupy specific depth ranges and depth is known to influence the type and distribution of faunal assemblages (Murphy et al 2010; Connolly & Hindell 2006)
Distance to channel	Distance (m) measured using QGIS ruler tool from site location to nearest channel edge	Site	Channels may act as corridors that influence connectivity for mobile species and supply on recruits, alternatively they may act as barriers for less mobile fishes that are less inclined to cross open areas (Turgeon et al. 2010)
Distance to land	Distance (m) measured using QGIS ruler tool from site location to nearest point of coastline (based on high tide line)	Site	Physical discontinuities created by water depth or coastal geomorphology influence fish hotspots (Kennedy et al 2016); inshore areas are usually more sheltered.
Seagrass structural complexity	Seagrass height (cm), cover (%) and species present	Site	Fishes display preference for particular seagrass architecture types that represent different levels of structural complexity. This may relate to the seagrass species (Hyndes et al. 2003), canopy height (Gullström et al. 2008), (Gratwicke and Speight 2005) (Hori et al. 2009), and seagrass cover (Heithaus 2004).

Table S2 Full list of all fish species (and family) captured by method type (trawl or URUV) and the associated minimum, maximum and mean lengths (cm)

Type	Family	*Species*	Min	Max	Mean
Trawl	Monacanthidae	*Acanthaluteres spilomelanurus*	45.00	49.00	47.00
Trawl	Aploactinidae	*Acanthosphex leurynnis*	27.00	47.00	35.00
Trawl	Gobiidae	*Acentrogobius nebulosus*	42.00	75.00	53.43
Trawl	Gobiidae	*Amblygobius phalaena*	72.00	72.00	72.00
Trawl	Monacanthidae	*Anacanthus barbatus*	108.00	108.00	108.00
Trawl	Ophichthidae	*Brachysomophis henshawi*	131.00	131.00	131.00
Trawl	Centrogenyidae	*Centrogenys vaigiensis*	35.00	83.00	52.88
Trawl	Chaetodontidae	*Chelmon marginalis*	56.00	56.00	56.00
Trawl	Platycephalidae	*Cymbacephalus nematophthalmus*	65.00	220.00	123.67
Trawl	Labridae	*Halichoeres brownfieldi*	2.00	78.00	47.04
Trawl	Syngnathidae	*Hippocampus angustus*	111.00	112.00	111.50
Trawl	Syngnathidae	*Hippocampus breviceps*	74.00	74.00	74.00
Trawl	Pseudochromidae	*Labracinus lineatus*	131.00	131.00	131.00
Trawl	Monacanthidae	*Monacanthus chinensis*	2.00	102.00	47.26
Trawl	Apogonidae	*Ostorhinchus rueppellii*	4.00	73.00	44.46
Trawl	Apogonidae	*Ostorhinchus victoriae*	29.00	75.00	50.00
Trawl	Terapontidae	*Pelates octolineatus*	15.00	75.00	34.41
Trawl	Terapontidae	*Pelates quadrilineatus*	16.00	16.00	16.00
Trawl	Terapontidae	*Pelates sexlineatus*	10.00	73.00	35.67
Trawl	Nemipteridae	*Pentapodus vitta*	43.00	98.00	70.67
Trawl	Blenniidae	*Petroscirtes breviceps*	28.00	78.00	40.95
Trawl	Latidae	*Psammoperca waigiensis*	95.00	180.00	118.00
Trawl	Pseudochromidae	*Pseudochromis punctatus*	63.00	63.00	63.00
Trawl	Labridae	*Pteragogus enneacanthus*	79.00	79.00	79.00
Trawl	Siganidae	*Siganus canaliculatus*	64.00	64.00	64.00
Trawl	Apogonidae	*Siphamia cephalotes*	21.00	37.00	30.30
Trawl	Tetraodontidae	*Torquigener pleurogramma*	66.00	66.00	66.00
URUV	Terapontidae	*Amniataba caudavittata*	120.16	184.53	141.82
URUV	Labridae	*Choerodon cauteroma*	124.77	153.95	139.35
URUV	Labridae	*Choerodon cephalotes*	271.87	271.87	271.87
URUV	Labridae	*Choerodon cyanodus*	68.66	241.11	169.71
URUV	Labridae	*Choerodon spp*	139.35	139.35	139.35
URUV	Labridae	*Halichoeres brownfieldi*	26.66	26.66	26.66
URUV	Syngnathidae	*Hippocampus spp*	74.01	74.01	74.01
URUV	Pseudochromidae	*Labracinus lineatus*	131.00	131.00	131.00
URUV	Lethrinidae	*Lethrinus laticaudis*	194.54	213.34	203.94
URUV	Lethrinidae	*Lethrinus spp*	203.93	203.93	203.93
URUV	Monacanthidae	*Monacanthus chinensis*	44.62	158.71	76.02
URUV	Apogonidae	*Ostorhinchus angustatus*	61.47	61.47	61.47
URUV	Apogonidae	*Ostorhinchus rueppellii*	66.01	66.01	66.01
URUV	Terapontidae	*Pelates octolineatus*	34.41	187.06	118.72
URUV	Nemipteridae	*Pentapodus vitta*	70.66	164.35	108.69
URUV	Blenniidae	*Petroscirtes breviceps*	46.00	50.66	47.55
URUV	Ephippidae	*Platax batavianus*	506.92	506.92	506.92
URUV	Sparidae	*Rhabdosargus sarba*	57.92	131.36	110.76
URUV	Nemipteridae	*Scaevius milii*	150.00	158.59	154.30
URUV	Sillaginidae	*Sillago spp*	189.66	217.38	203.52
URUV	Apogonidae	*Siphamia cephalotes*	34.50	38.66	36.58
URUV	Sphyraenidae	*Sphyraena obtusata*	194.78	293.04	249.23
URUV	Tetraodontidae	*Torquigener pleurogramma*	44.62	123.63	95.37
URUV	Pomacentridae	*Unknown spp*	58.12	58.12	58.12
URUV	Mullidae	*Upeneus tragula*	91.00	178.75	137.39

Table S3 Full subsets model output list for comparison. The best models with * were those displayed in Fig. 5 of the Results section.

Trawl Models	ΔAICc	ωAICc	R^2	edf
Biomass ~ Cover*	0	0.21	0.4064	3.19
Biomass ~ Class + Depth*	0.83	0.139	0.7398	5.91
Biomass ~ 50m_Area	1.214	0.115	0.3415	2.29
Abundance ~ Cover*	0	0.232	0.2837	2.69
Abundance ~ Channel + Height*	1.125	0.132	0.6091	4.63
Abundance ~ Cover + 500m_Perimeter*	0.656	0.167	0.3672	3.72
Mean Length null	0	0.181	0	1
Mean Length ~ Height	1.309	0.094	0.9308	2
Mean Length ~ Distance to land	1.509	0.085	0.7617	2
OL:ML ~ Cover	0	0.177	0.2469	2.05
OL:ML ~ Height	1.552	0.082	0.1890	2
OL:ML ~ Height + Distance to land	1.8	0.072	0.5288	4.22
Richness ~ Cover	0	0.127	0.3071	2.57
Richness ~ 50m_Area	0.66	0.092	0.3303	3.62
Richness null	0.226	0.083	0	1
Richness ~ Cover + 500m_PARA	1.536	0.043	0.4268	3.64
Taxonomic Distinctness ~ 50m_PARA*	0	0.334	0.3526	2
Taxonomic Distinctness ~ Height*	1.72	0.152	0.3225	2
Productivity ~ 50m_Area*	0	0.321	0.3138	2
Productivity ~ Cover*	1.482	0.153	0.2768	2
Simpson Diversity ~ Height	0	0.152	0.1344	2
Simpson Diversity ~ Distance to land	0.083	0.12	0.1250	2
Simpson Diversity null	0.526	0.117	0	1
Simpson Diversity ~ 50m_Perimeter	1.117	0.087	0.0861	2
URUV Models				
Biomass null	0	0.234		1
Biomass ~ Depth	1.508	0.11	0.1788	2.37
Abundance null	0	0.106	0	1
Abundance ~ Height	0.117	0.1	0.1361	2
Abundance ~ 500m_Area	0.601	0.078	0.1189	2
Abundance ~ Height + Distance to land	0.682	0.075	0.2182	3
Abundance ~ Cover	0.75	0.073	0.0802	2
Abundance ~ 500m_PARA	0.801	0.071	0.1183	2.06
Abundance ~ 500m_Area + Distance to land	0.915	0.067	0.0205	3
Abundance ~ distance to land	0.959	0.065	0.0882	2
Abundance ~ distance to land + 500m_PARA	1.657	0.046	0.2051	3
Mean Length ~ 500m_PARA*	0	0.406	0.6629	3.64
Mean Length ~ Channel + Cover*	0.727	0.282	0.7084	4.2
OL:ML null	0	0.204	0	1
OL:ML ~ 500m_PARA	1.126	0.116	0.3624	3.12
OL:ML ~ Distance to land	1.376	0.102	0.1107	2
OL:ML ~ 500m_Area	1.904	0.079	0.0790	2
Richness ~ 50m_Perimeter	0	0.092	0.1520	2
Richness ~ 500m_Perimeter	0.137	0.086	0.2224	2.47
Richness ~ 50m_Area	0.167	0.085	0.2962	2.83
Richness ~ 50m_PARA	0.286	0.08	0.2610	2.87
Richness null	0.326	0.078	0	1
Richness ~ Distance to land	0.998	0.056	0.1872	2.91
Taxonomic Distinctness null	0	0.253	0	1
Productivity null	0	0.184	0	1

Productivity ~ 500m_PARA	0.579	0.138	0.0787	2
Productivity ~ Distance to land	0.816	0.122	0.0755	2
Productivity ~ 500m_Area	1.823	0.074	0	2.01
Productivity ~ 50m_PARA	1.854	0.073	0.0513	2
Simpson Diversity null	0	0.571	0	1

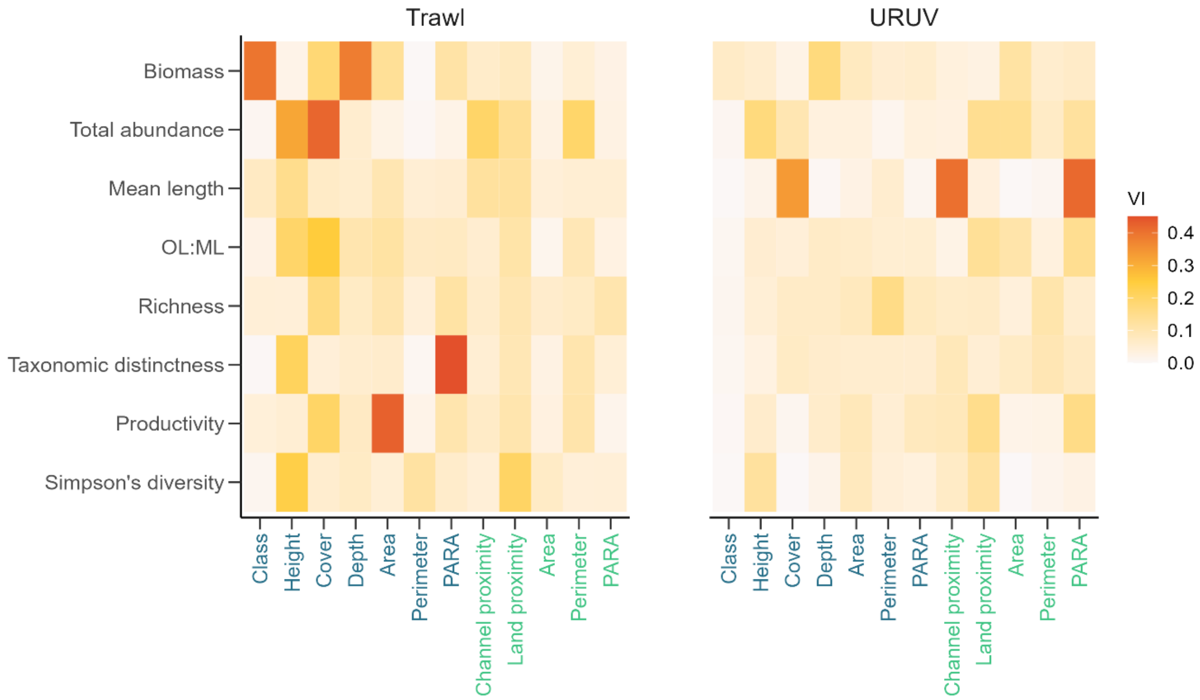

Fig. S2 Variable importance heatmap for trawl and URUV fish communities. The blue text on the x-axis denotes small-scale variables measured within sites (e.g. seagrass cover, height, depth) or Area, Perimeter and PARA at the 50 m scale. The green text denotes larger-scale variables such as Area, Perimeter and PARA measured at the 500 m scale, as well as channel and land proximity.

Table S4 Full subsets model output list for the genera level analyses. The best models are marked with *

Genera Trawl Models	ΔAICc	ωAICc	R^2	edf
Halichoeres abundance ~ 500m_Area + Distance to land	0	0.488	0.3064	4.15
Halichoeres abundance ~ 500m_Area + Depth	0.929	0.307	0.3732	5.61
Monacanthus abundance ~ Height + Distance to land	0	0.993	0.5204	6.83
Ostorhinchus abundance ~ 50m_Area + Channel*	0	0.464	0.6823	4.15
Ostorhinchus abundance ~ Channel + 50m_PARA*	1.276	0.245	0.6241	4.21
Ostorhinchus abundance ~ 500m_Area + Distance to land	1.773	0.191	0.6590	5.47
Pelates abundance ~ Channel + Cover*	0	0.440	0.6081	3.82
Pelates abundance ~ Cover + 500m_Perimeter*	0.64	0.320	0.6590	4.36
Petroscirtes abundance ~ 50m_Perimeter	0	0.464	0.2710	3.67
Genera URUV Models				
Choerodon abundance Depth + 50m_PARA	0	0.244	0.05842	4.78
Choerodon abundance Depth + 50m_Perimeter	0.077	0.235	0.32724	4.97
Choerodon abundance Cover + Depth*	1.492	0.116	0.28847	3
Sphyraena abundance 50m_PARA	0	0.152	0.16904	3.27
Sphyraena abundance 50m_Perimeter	0.727	0.106	0.17777	2
Sphyraena abundance 50m_Area	0.919	0.096	0.37731	3.25
Sphyraena abundance Channel + 50m_Perimeter*	1.567	0.070	0.21116	3
Sphyraena abundance 500m_Perimeter	1.741	0.064	0.13626	2

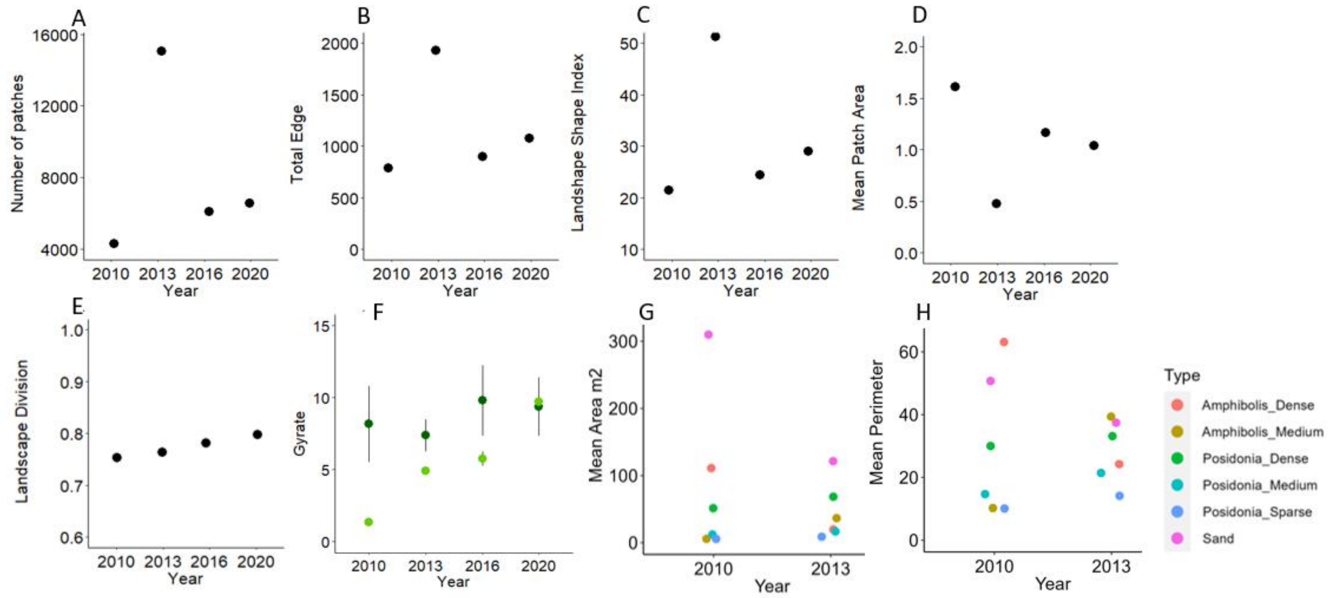

Fig. S3 Temporal change in spatial configuration metrics at the landscape scale (A-E), and Gyrate for the class scale (F), which is an 'Area and edge metric' using distance from each cell to the patch centroid based on centroid distances (i.e. characterises both the patch area and compactness). Plots G and H relate to mean area and perimeter of seagrass classes for 2010 and 2013 respectively.

Table S5 Individual accuracy measures (%) for habitat classes (Sand, Dense seagrass, Sparse seagrass) and overall accuracy and Kappa statistics per year. Overall mean accuracy shown in bold.

Year	Accuracy indicator	Sand	Dense	Sparse	Overall Accuracy	Kappa statistic
2010* Using all field data available including training	Producer	83.33	97.73	-	**0.87**	0.61
	User	55.56	93.48	-		
2010** Using randomly selected sites	Producer	94.20	97.31	-	**0.85**	0.68
	User	76.47	88.29	-		
2013	Producer	89.83	80.62	14.12	**0.62**	0.39
	User	60.23	65.41	46.15		
2020	Producer	91.94	85.14	65.22		
	User	79.17	93.13	60.81	**0.82**	0.70

*2010: Overall accuracy is a percentage (%) between correctly classified classes and the total number of field observations; 55 sites were suitable for field validation and 36 of these were used for training the image. As no additional *insitu* field sites were available, additional validation was made via visual assessment of a 2010 World View 2 image (natural enhancement using bands 4,3 and 2). The sparse seagrass category only occurred in 5 of the field sites used to validate 2010, however, this class was rarely found in the classification (i.e. accounting for 0.00045 % of the seagrass extent).

**2010: For the visual assessment, the sample size was 290 sites with the Sparse seagrass class included, and 255 without it.

For 2013, validation was made via visual assessment of a 2010 World View 2 image (natural enhancement using bands 4,3 and 2). This classification was 39 % better than than if we randomly assigned a class to each image pixel; the visual assessment sample size was 273 sites. This value is comparatively lower because the Sparse seagrass class did not perform well and lowered the accuracy of the overall classification, which may have been due to the presence of green algae, a common occurance following marine heatwaves. For 2019, the classificaiton was not formally assessed as it was a intermediatory dataset to assist with site selection for fish trawls. For 2016, the classification was formally assessed in Strydom et al., 2020. For 2020, the validation assessment was made from visual assessment of a natural enhancement using bands 3,2 and 1 of a 2020 GeoStat 2 image (European Space Agency), and based on the sample size of 306 sites .

Table S6 Individual accuracy measures (%) for species habitat classes (Sand, *Amphibolis antarctica*, *Posidonia australis*) and overall accuracy and Kappa statistics per year.

Year	Accuracy indicator	Sand	*Amphibolis antarctica*	*Posidonia australis*	Overall Accuracy	Kappa statistic
2010	Producer	96.55	95.45	58.33	**0.84**	0.76
	User	93.33	70.00	93.33		

Species Classification for 2010: Overall accuracy is a percentage (%) between correctly classified classes and the total number of field observations; 75 sites were available and suitable as field validation and 36 of these were used for training the image, and additional 23 sand sites were visually assessed in each class of a 2010 World View 2 image. As no additional *insitu* field assessed sites were available to assess the classification for seagrass species, half of the validation sites were previously used for training, subsequently the resulting classification should be used with caution.