

Ecological indicator report for the Vasse-Wonnerup Wetlands – Benthic macroinvertebrates 2021

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Methods

Benthic macroinvertebrate sampling was undertaken in the Vasse-Wonnerup wetlands at 40 sites in 2021 in summer (January) and spring (November). Monitoring and calculation of indices were undertaken following the methodology outlined in Cronin-O'Reilly et al. (2023)([provide link](#)). The Wetland Benthic Community Index (WBCI) integrates information on various biological variables (metrics). Each of these quantified an aspect of the structure and/or function of the invertebrate community and how they respond to stress. The five measures, namely Simpson's (Diversity) index, qualitative taxonomic distinctness, community dominance, crustacean richness and SIGNAL2, are calculated and summarised into a health score ranging from 100 to 0, with corresponding health grades ranging from A to E. Validation of the WBCI is scheduled for 2024 when sufficient independent data is available. The Spring WBCI scores generated in this report will be used in the Vasse Wonnerup wetlands Report card. This is to allow annual comparison of indicators when macroinvertebrate populations are at their highest to monitor the aim "to maintain healthy populations of macroinvertebrates". Summer indicators are included in this report as additional information to contribute to our understanding of seasonal dynamics of macroinvertebrate communities in the Vasse Wonnerup wetlands.

Key findings and observations 2021

- An average of 220 invertebrates were found in each grab sample over the two sampling seasons, with insects and annelids being the most abundant groups (Table 1). Most invertebrates were found in the Upper Wonnerup and the least occurred in the Vasse Exit Channel. The total abundance of invertebrates was greater in spring than summer, with the numbers generally comparable to previous years (Appendix 1).
- Spring in 2021 was a relatively good year for benthic ecological health in the Vasse-Wonnerup (Appendix 2), with 87.5% of sites awarded a health grade of B (*Good*) or A (*Very good*; Table 2-3). Many metric values for crustacean richness exceeded the score range (0-10) determined in the preceding four years of data, showing that the number of crustacean species (e.g. *Austrachiltonia subtenuis*, *Barnardomelita matilda*, *Mytilocypris mytiloides*) had increased. Overall, this period was awarded consistently higher

scores of all health metrics, except for community dominance in the Vasse Exit Channel (Appendix 3). The healthy condition seen in the system in 2021 is likely due to the rainfall and freshwater inflow that was received over winter.

- Benthic ecological health was reduced in the summer, with the estuary receiving an overall health grade of D (*Poor*; Table 4-5) and the score of all health metrics declining (Appendix 2). This seasonal decline is as expected as freshwater inflow is reduced and the wetland is subjected to seasonal stressors such as higher water temperatures, higher salinities and reduced water levels, extended water residence times and nutrient concentration and retention, with seasonal changes in ecological health commonly occurring in south-western Australian estuaries (Hallett et al. 2012). Predation by waders and other bird species that feed on macroinvertebrate is also likely to contribute to summer declines. Notably, WBCI scores were marginally better in the Wonnerup than the Vasse, with SIGNAL2, qualitative taxonomic distinctness and community dominance remaining relatively high in the Wonnerup (Appendix 3).
- An increase in benthic ecological health between summer and spring 2021 was evident at the regional level (Appendix 2). This includes the invertebrate community in the Vasse Exit Channel (Appendix 2e), a region of the estuary that has exhibited clear signs of ecosystem degradation and ecological stress (e.g. fish kill of 2013; Tweedley et al. 2014). In summer 2021, 6 of the 8 sites (75%) were awarded the lowest index grade of E, indicating *very poor* benthic ecological health. The health later increased considerably in spring 2021, with 75% of sites awarded a WBCI grade of B (*Good*) or A (*Very good*). This substantial shift in the health suggests that the Vasse Exit Channel has the potential to support relatively healthy invertebrate communities under certain environmental conditions (as was also seen in March-October 2017; Appendix 2e). The invertebrate community may also be capitalising from reduced invertebrate competition (e.g. for space or food) and/or reduced fish predation following the mass fish kill in this region in June 2021.
- A summary of the diversity of the invertebrate communities from March 2017 to date is provided in Appendix 4 and 5.

Triggers and management

- Triggers have yet to be established for the benthic macroinvertebrate community. Triggers are due to be proposed together with WBCI validation in 2024.

Recommendations

- Further investigations of potential hydrological drivers of the metric score differences evident between the Vasse and Wonnerup estuaries, particularly in the summer period. Elucidating the reasons for a lessened seasonal decline in WBCI scores in the Wonnerup Estuary during the summer can help to inform management actions to maintain a healthy wetland.
- Given the considerable variation in benthic ecological health seen in the Vasse Exit Channel, and the general understanding that variation in invertebrate community structure is a symptom of ecosystem stress (Warwick & Clarke

1993), we recommend ongoing ecological monitoring of this region seasonally to discern if such patterns stabilise or become more variable with time.

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Results

Table 1. Density (individuals per 225 cm², \pm 1 standard error) of dominant groups of benthic macroinvertebrates in 2021 averaged across the two sampling seasons. Note that insects (Hexapoda) are now considered crustaceans, but are separated from other crustaceans (amphipods, ostracods etc.) here for convenience.

	Total	Annelida and Nematoda (worms)	Mollusca (Gastropods)	Hexapoda	Crustacea
Vasse Wonnerup wetlands	220 \pm 49	69 \pm 24	14 \pm 7	79 \pm 15	59 \pm 22
Regions					
Upper Vasse	153 \pm 50	7 \pm 4	0 \pm 0	79 \pm 27	67 \pm 30
Lower Vasse	262 \pm 73	40 \pm 14	52 \pm 33	117 \pm 47	54 \pm 23
Upper Wonnerup	402 \pm 206	156 \pm 99	8 \pm 3	92 \pm 32	146 \pm 99
Lower Wonnerup	233 \pm 89	136 \pm 55	7 \pm 3	64 \pm 26	26 \pm 14
Vasse exit channel	54 \pm 35	4 \pm 2	2 \pm 1	45 \pm 33	3 \pm 2

Table 2. Wetland Benthic Community Index (WBCI) scores (\pm 1 standard error) and health grades for the Vasse-Wonnerup wetland in spring 2021 (November).

Ecological region	Index Score	Grade
Vasse-Wonnerup Wetlands	75.9 \pm 1.5	B
Regions		
Upper Vasse	74.0 \pm 3.6	B
Lower Vasse	72.3 \pm 2.5	B
Upper Wonnerup	81.1 \pm 2.3	A
Lower Wonnerup	81.6 \pm 2.2	A
Vasse Estuary Channel	70.4 \pm 3.8	B

Table 3. Annual Wetland Benthic Community Index (WBCI) health grades for the Vasse-Wonnerup wetland in spring 2017-21 (October/November). Boundary grades are provided for scores of the WBCI within 1 score point of the grade boundary, with the first letter listed and colour indicating the side of the boundary that the WBCI score fell on.

Ecological region	2017	2018	2019	2020	2021
Vasse-Wonnerup Wetlands	B	B	C	B	B
Regions					
Upper Vasse	B	B	D	B	B
Lower Vasse	B/C	B	C/D	B	B
Upper Wonnerup	A/B	B/A	B	B	A
Lower Wonnerup	A	A	B	C	A
Vasse Exit Channel	B	C	C	D	B

Table 4. Wetland Benthic Community Index (WBCI) scores (± 1 standard error) and health grades for the Vasse-Wonnerup wetland in summer 2021 (January).

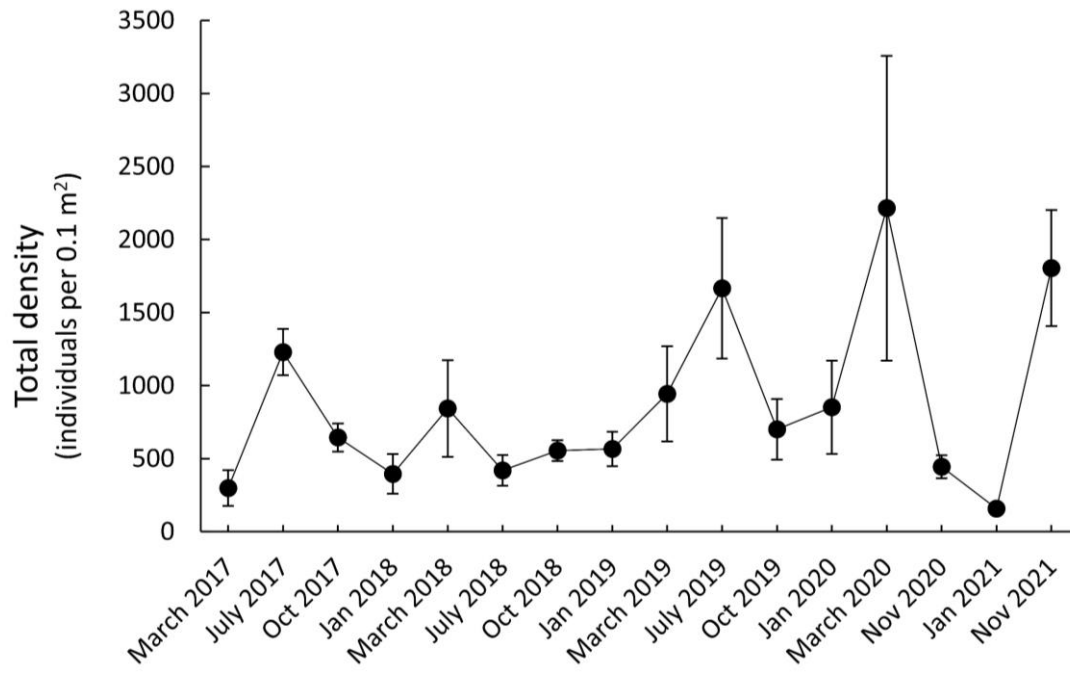
Ecological region	Index Score	Grade
Vasse-Wonnerup Wetlands	50.1 \pm 4.3	D
Regions		
Upper Vasse	49.7 \pm 7.4	D
Lower Vasse	63.3 \pm 5.5	C
Upper Wonnerup	68.6 \pm 2.8	B
Lower Wonnerup	62.5 \pm 4.5	C
Vasse Exit Channel	6.3 \pm 5.5	E

Table 5. Annual Wetland Benthic Community Index (WBCI) health grades for the Vasse-Wonnerup wetland in summer (January) 2018-21. Boundary grades are provided for scores of the WBCI within 1 score point of the grade boundary, with the first letter listed and colour indicating the side of the boundary that the WBCI score fell on.

Ecological region	2018	2019	2020	2021
Vasse-Wonnerup Wetlands	C/B	C	D	C
Regions				
Upper Vasse	B	D	B/C	D
Lower Vasse	C/B	C	D	C
Upper Wonnerup	B	B	D	B
Lower Wonnerup	C/D	B/C	C	C
Vasse Exit Channel	C/D	E	D	E

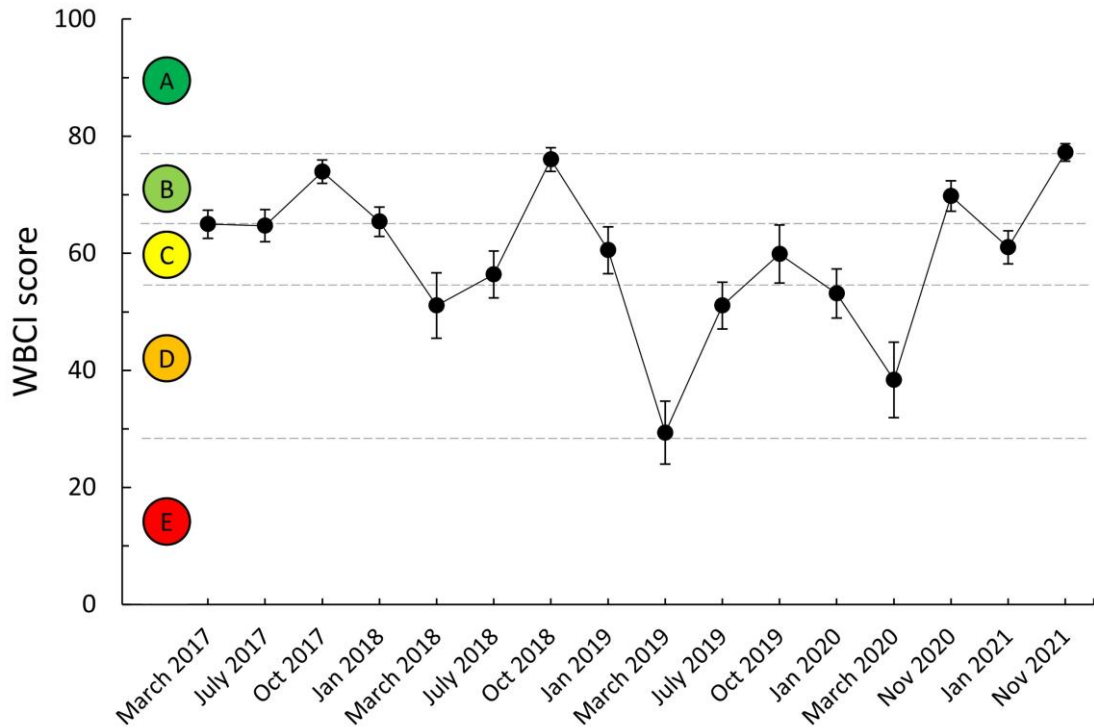
Appendices

Appendix 1. The total density of invertebrates (individuals per 0.1 m², \pm 1 standard error) recorded on each sampling occasion between 2017 and 2021.

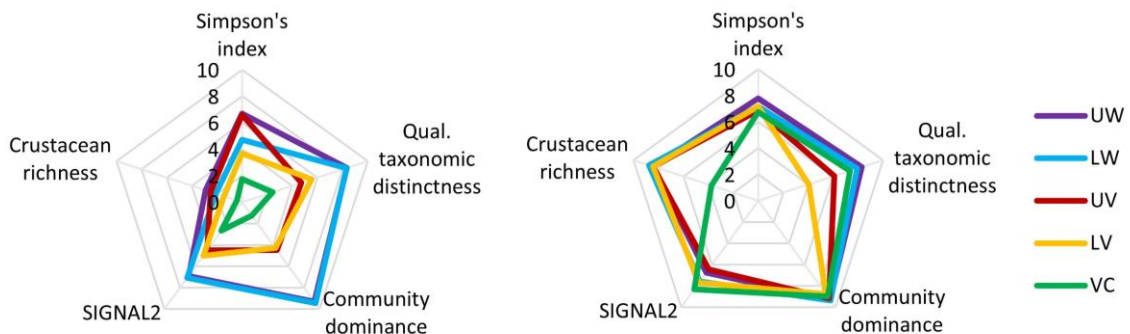


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Appendix 2. WBCI scores (± 1 standard error) for regions above the surge barriers (excluding the Vasse Exit Channel) over the full monitoring period (March 2017-November 2021), with dashed lines depicting the score thresholds for each health grade (A-E). The number of samples was 16 per season (except in March 2017, 15 samples) prior to November 2020, and 32 per season thereafter.

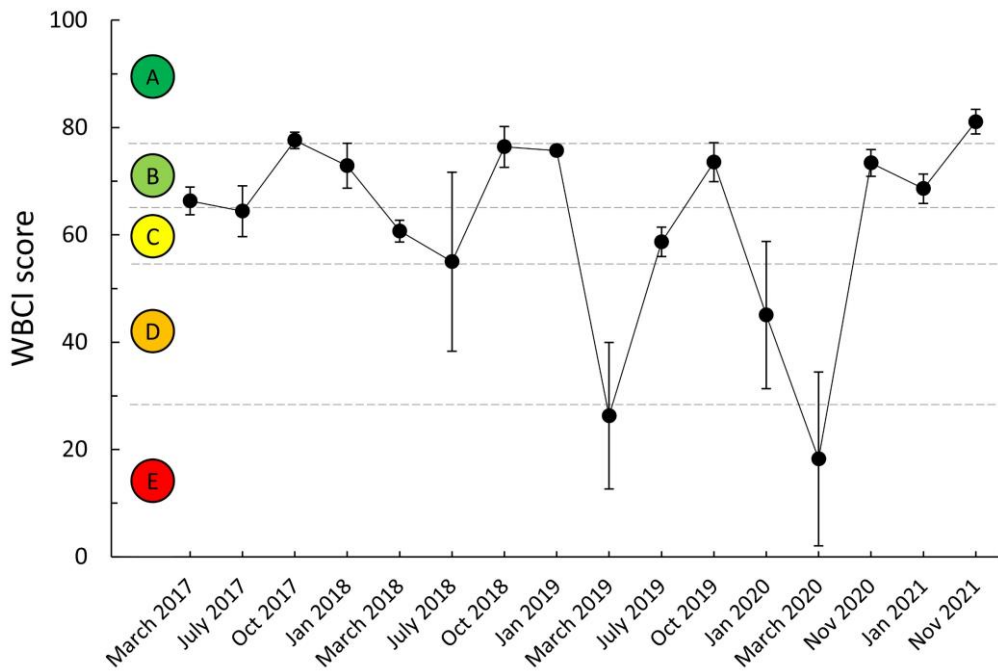


Appendix 3. Average metric scores (0-10) for each community metric measured in each region (UW, Upper Wonnerup; LW, Lower Wonnerup; UV, Upper Vasse; LV, Lower Vasse; VC, Vasse Exit Channel) in summer (January, left) and spring (November, right) 2021. The larger the area covered by the radar plot, the better the benthic ecological health of that region.

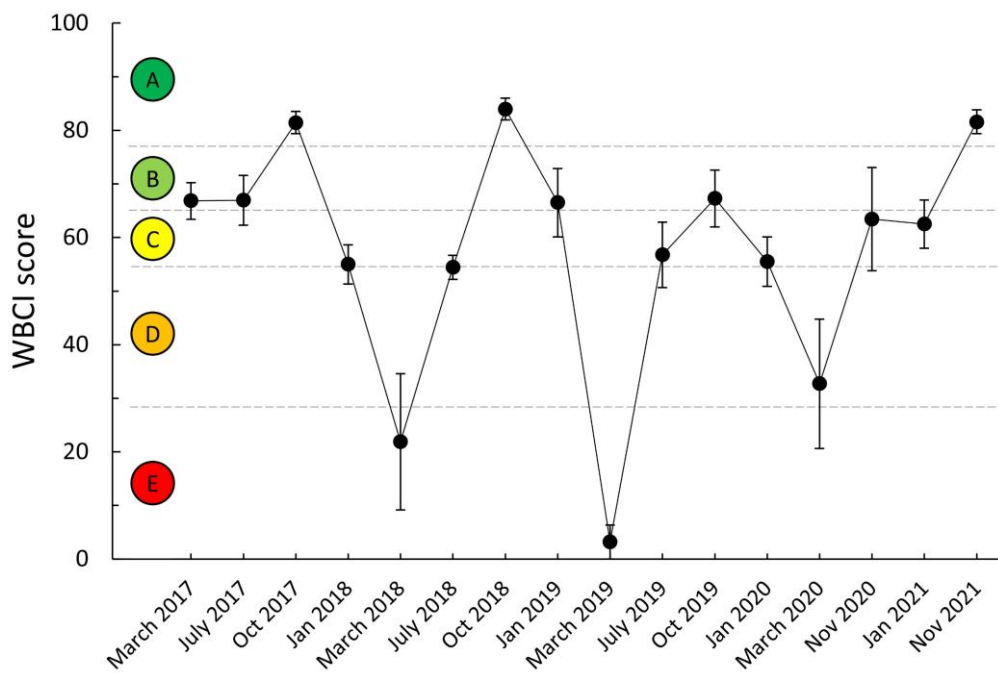


Appendix 3. WBCI scores (± 1 standard error) for the (a) Upper Wonnerup, (b) Lower Wonnerup, (c) Upper Vasse, (d) Lower Vasse and the (e) Vasse Exit Channel, over the full monitoring period (March 2017-Nov 2021), with dashed lines depicting the score thresholds for each health grade (A-E). The number of samples was 4 per region (except in the Lower Wonnerup in March 2017, 3 samples) prior to November 2020, and 8 per region thereafter.

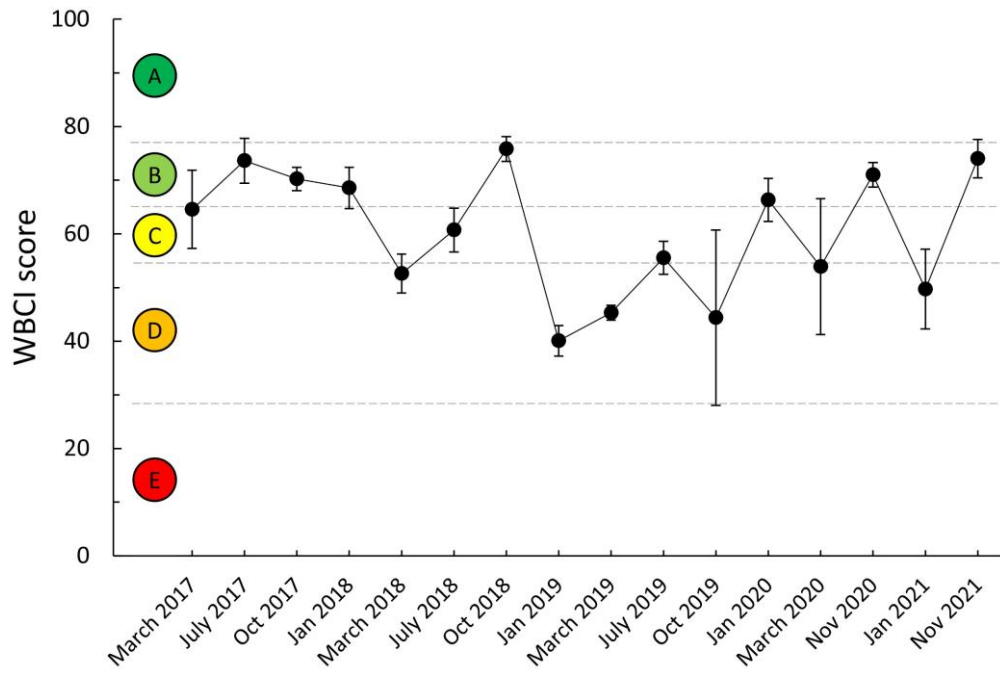
(a) Upper Wonnerup



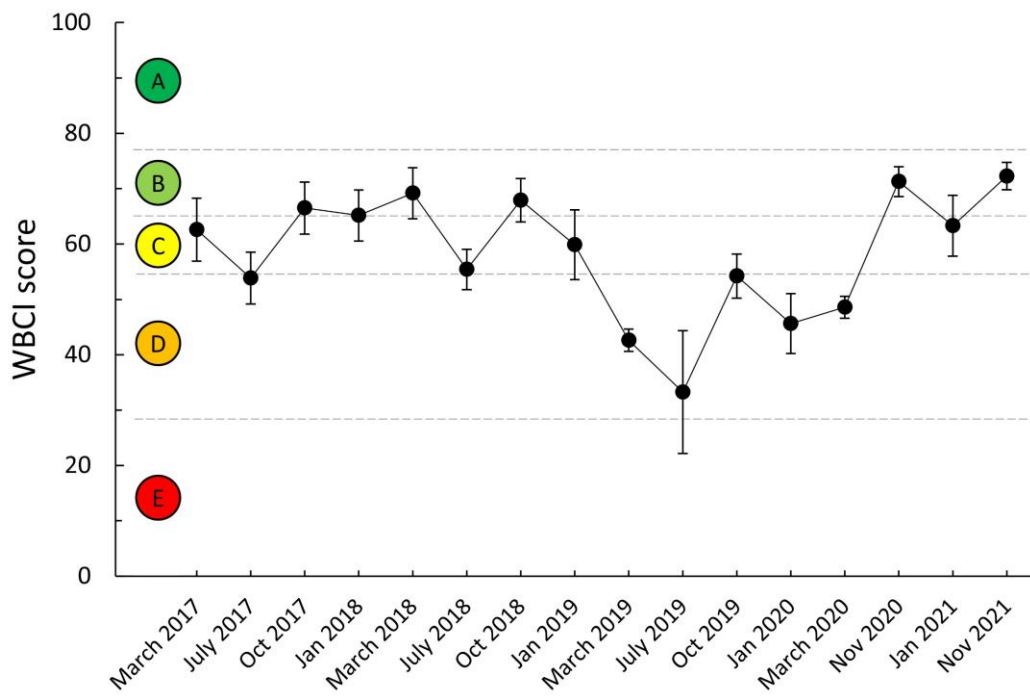
(b) Lower Wonnerup



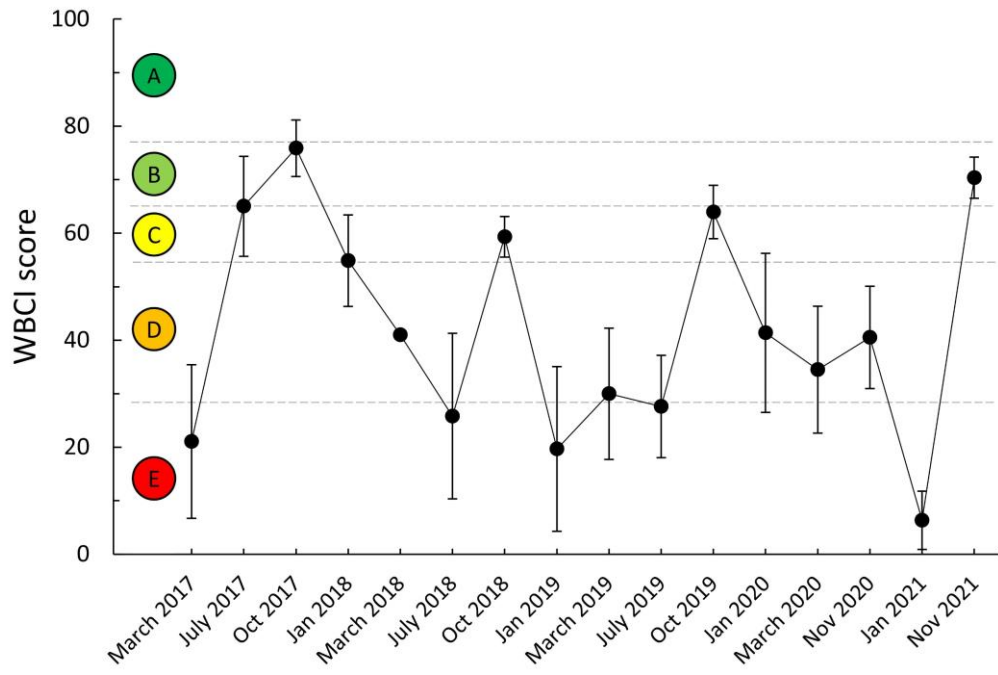
(c) Upper Vasse



(d) Lower Vasse



(e) Vasse Exit Channel



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Appendix 4. Summary of the mean number of species, density (invertebrates per 225 cm²), Simpson’s (Diversity) Index and qualitative taxonomic distinctness and the proportion of infaunal and epifaunal individuals to the total invertebrate fauna in the subtidal waters of each region of the Vasse-Wonnerup in spring 2017-2021. The values for the first four metrics separately are reflected in their colour shading from red (low) through yellow (intermediate) to green (high values). Proportions of invertebrates classified as infauna (living within the sediment) and epifauna (living on top of the sediment) are also provided, with greater proportions of these faunal types shaded dark blue. Grey shading and NS = No sampling conducted.

Metric	Date	Upper Vasse	Lower Vasse	Vasse Channel	Lower Wonnerup	Upper Wonnerup
Number of species	Oct-17	10	7	9	11	9
	Oct-18	12	6	5	9	8
	Oct-19	4	6	5	5	8
	Nov-20	7	10	3	7	7
	Nov-21	11	12	5	13	14
Density (inds. per 225 cm ²)	Oct-17	237	81	89	157	162
	Oct-18	207	133	145	77	62
	Oct-19	13	263	52	291	169
	Nov-20	76	210	10	148	56
	Nov-21	288	441	103	426	773
Simpson's Diversity	Oct-17	0.38	0.63	0.53	0.78	0.56
	Oct-18	0.66	0.57	0.37	0.78	0.69
	Oct-19	0.62	0.23	0.33	0.49	0.48
	Nov-20	0.63	0.72	0.48	0.48	0.66
	Nov-21	0.61	0.60	0.54	0.60	0.68
Qual. Taxonomic Distinctness	Oct-17	76.5	76.7	77.5	76.0	66.5
	Oct-18	74.5	79.7	90.8	73.1	73.7
	Oct-19	37.0	73.0	69.1	84.5	75.5
	Nov-20	73.3	66.4	60.9	72.1	77.0
	Nov-21	67.6	69.8	66.7	76.6	78.9
% infaunal species	Oct-17	19.2	15.2	3.4	25.0	3.6
	Oct-18	6.0	7.5	74.8	2.6	23.5
	Oct-19	23.1	94.1	41.3	72.1	2.8
	Nov-20	14.2	4.9	73.1	51.0	30.0
	Nov-21	0.3	1.6	3.8	57.9	39.5
% epifaunal species	Oct-17	80.8	84.8	96.6	75.0	96.4
	Oct-18	94.0	92.5	25.2	97.7	76.5
	Oct-19	76.9	5.9	58.7	27.9	97.2
	Nov-20	85.8	95.1	26.9	49.0	70.0
	Nov-21	99.7	98.4	96.2	42.1	60.5

Appendix 5. Summary of the mean number of species, density (invertebrates per 225 cm²), Simpson’s (Diversity) Index and qualitative taxonomic distinctness and the proportion of infaunal and epifaunal individuals to the total invertebrate fauna in the subtidal waters of each region of the Vasse-Wonnerup in summer 2018-2021. The values for the first four metrics separately are reflected in their colour shading from red (low) through yellow (intermediate) to green (high values). Proportions of invertebrates classified as infauna (living within the sediment) and epifauna (living on top of the sediment) are also provided, with greater proportions of these faunal types shaded dark blue. Grey shading and NS = No sampling conducted.

Metric	Date	Upper Vasse	Lower Vasse	Vasse Channel	Lower Wonnerup	Upper Wonnerup
Number of species	Jan-18	6	6	3	4	4
	Jan-19	3	5	2	8	8
	Jan-20	5	4	2	4	3
	Jan-21	3	4	1	5	6
	Jan-22	3	2	1	6	6
Density (inds. per 225 cm ²)	Jan-18	43	114	20	251	18
	Jan-19	291	179	10	103	54
	Jan-20	23	573	5	327	31
	Jan-21	17	84	5	40	31
	Jan-22	7	33	4	296	306
Simpson's Diversity	Jan-18	0.76	0.42	0.28	0.36	0.68
	Jan-19	0.02	0.34	0.10	0.37	0.77
	Jan-20	0.59	0.05	0.54	0.21	0.23
	Jan-21	0.43	0.29	0.01	0.60	0.75
	Jan-22	0.59	0.33	0.17	0.41	0.57
Qual. Taxonomic Distinctness	Jan-18	83.2	83.6	86.9	93.3	80.1
	Jan-19	89.3	87.4	23.2	77.5	71.6
	Jan-20	81.7	85.0	50.0	92.0	72.6
	Jan-21	78.3	83.0	12.5	68.0	80.5
	Jan-22	45.2	51.8	24.4	84.8	82.5
% infaunal species	Jan-18	32.9	26.9	17.9	60.3	9.9
	Jan-19	99.1	23.6	5.3	1.5	2.8
	Jan-20	58.1	97.3	42.1	98.4	78.4
	Jan-21	80.9	86.2	97.2	63.6	21.5
	Jan-22	27.3	0.8	8.6	74.2	54.2
% epifaunal species	Jan-18	67.1	73.1	82.1	39.7	90.1
	Jan-19	0.9	76.4	94.7	98.5	97.2
	Jan-20	41.9	2.7	57.9	1.6	21.6
	Jan-21	19.1	13.8	2.8	36.4	78.5
	Jan-22	72.7	99.2	91.4	25.8	45.8

References

- Cronin-O'Reilly S, Cottingham A, Tweedley J (2023) Development of a multimetric index for assessing the condition of the Vasse-Wonnerup based on benthic invertebrate communities. Murdoch University, Prepared for the Department of Water and Environmental Regulation
- Hallett C, Valesini F, Clarke K, Hesp S, Hoeksema S (2012) Development and validation of fish-based, multimetric indices for assessing the ecological health of Western Australian estuaries. *Estuarine, Coastal and Shelf Science* 104-105:102-113
- Tweedley J, Keleher J, Cottingham A, Beatty S, Lymbery A (2014) The fish fauna of the Vasse-Wonnerup and the impact of a substantial fish kill event. Report prepared for the Australian Federal Government
- Warwick R, Clarke K (1993) Increased variability as a symptom of stress in marine communities. *Journal of Experimental Marine Biology and Ecology* 172:215-226

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