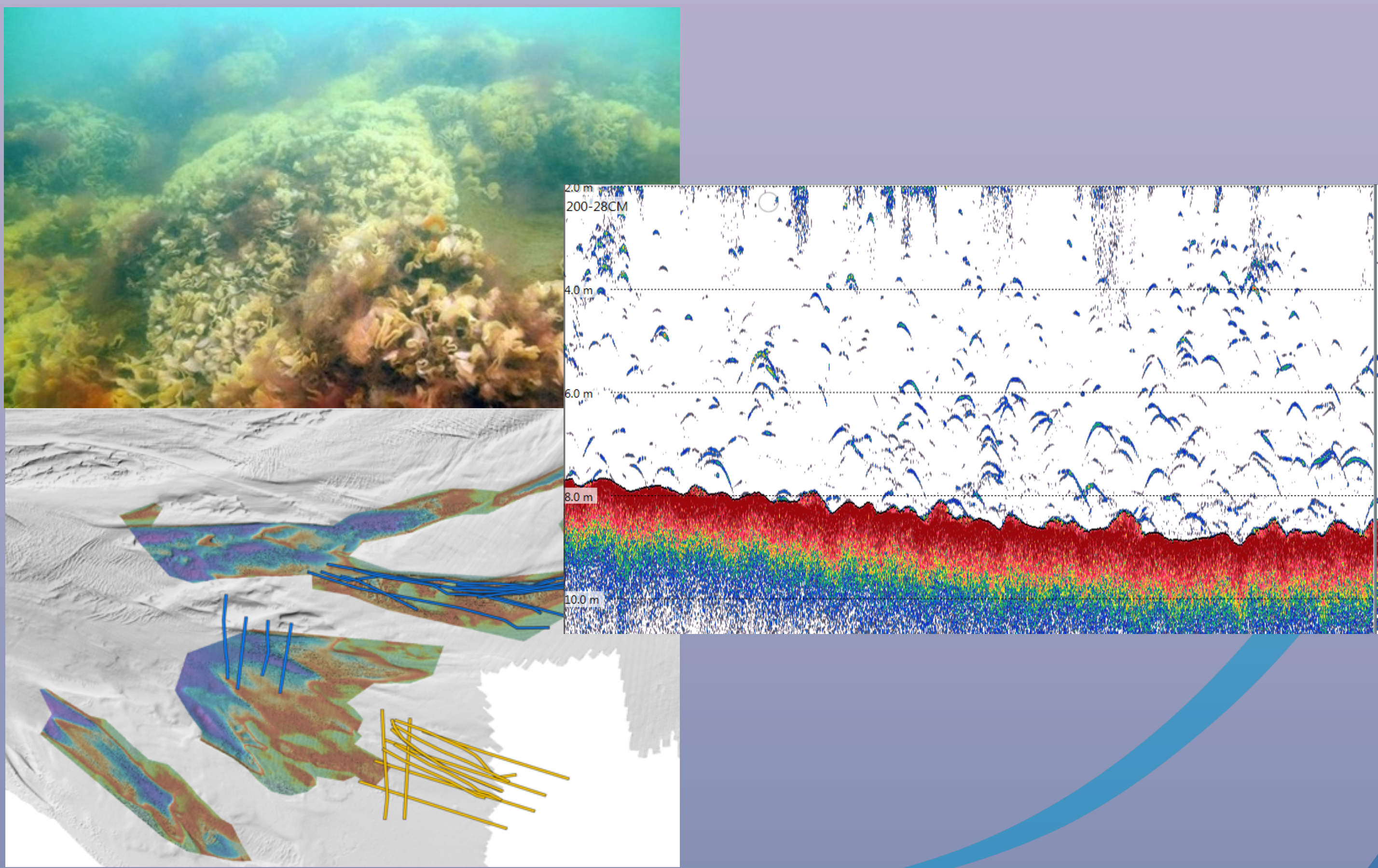
Western Port Bryozoan Reefs Project

Report 5: Bioacoustic Survey of Fish Biomass



Report to Port Phillip and Western Port Catchment Management Authority

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Report 5: Bioacoustic Survey of Fish Biomass

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1. Introduction

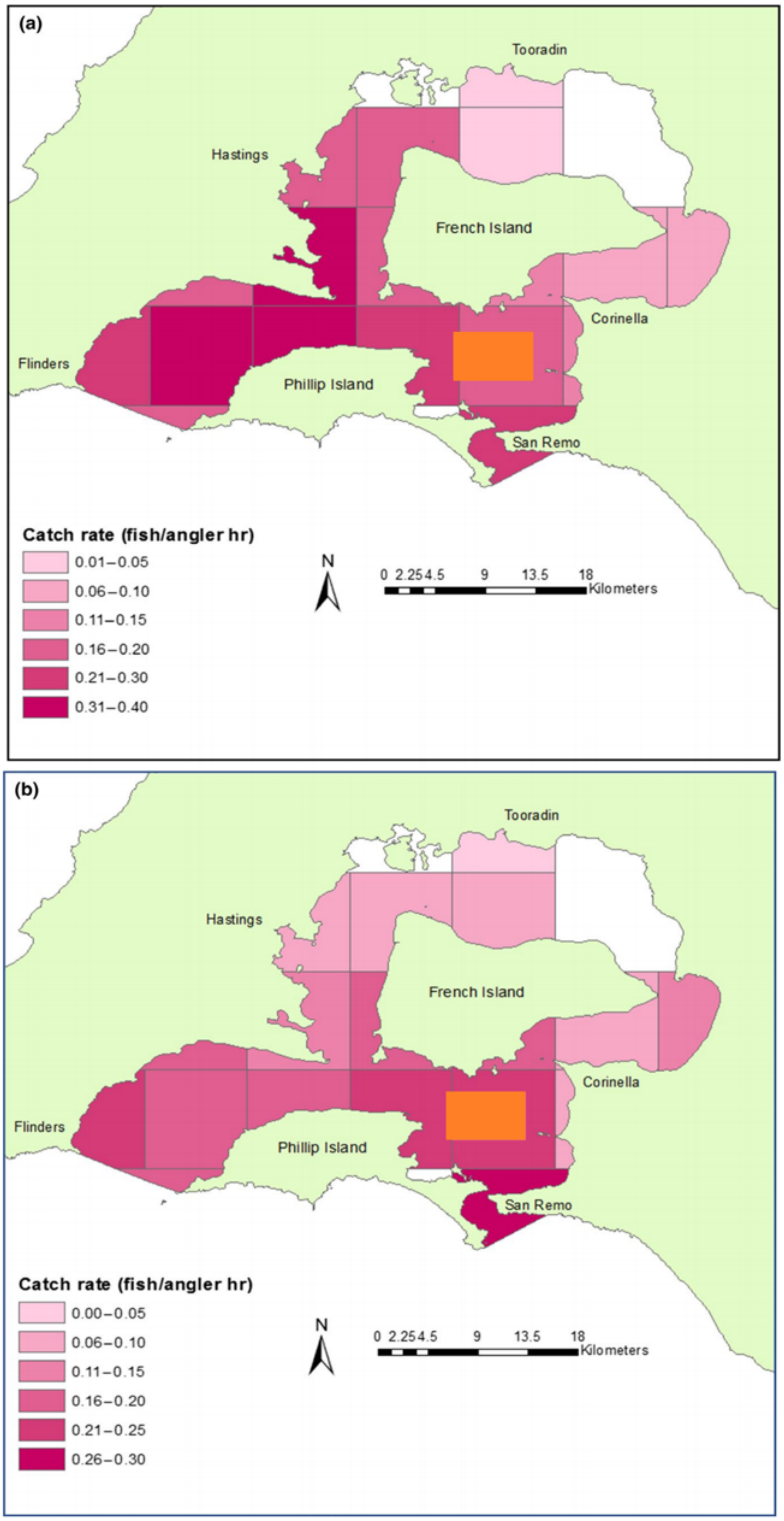
1.1. Background

The Western Port bryozoan reefs were first identified in 2016 and are the subject of a collaborative research project. The first primary bryozoan reef report was completed in 2019 (Fathom Pacific 2019). Mapping of the reefs by multibeam echosounding is described in partner Report 2 (Fathom Pacific 2020a), aspects of the biology of the reefs are described in partner Report 3 (Fathom Pacific 2020b) and a citizen science-based monitoring approach is described in partner Report 4 (Fathom Pacific 2020c). The biotope is of national and global significance and is exposed to natural and anthropogenic pressures that warrant close monitoring.

Western Port is home to a high diversity and abundance of fish species. Commercial fishing in the bay is limited and all netting was phased out in 2009. Recreationally, Western Port is the second largest fishery in the state with the primary target species being King George whiting, (*Sillaginodes punctatus)*, snapper (*Pagrus auratus)* and Gummy shark, (*Mustelus antarcticus)*. The biomass of the main species targeted recreationally show high seasonal fidelity to structure and differing residence times (Jenkins et al. 1997). For example, whiting spawn offshore in the winter months (Jenkins et al. 2000) and generally a decline in biomass within the bay during that period (Jenkins & Conron 2015). Whiting and garfish in particular have a preference for seagrass habitat whereas other species range widely (Keough et al. 2011) feeding predominantly on a variety of invertebrate prey. Other recreationally and ecologically significant demersal fish species range over a variety of benthic habitat types, feeding opportunistically (Jenkins et al. 2020). Pelagic species are also targeted recreationally and biomass in the bay is also seasonal. Their distribution in the bay is highly tide-dependent and these species include Australian salmon (*Arripis trutta)*, Australian herring (*Arripis georgianus)*, yellowtail scad (*Trachurus novaezelandiae)*, cowanyoung (*Trachurus declivis)*, and blue mackerel (*Scomber australasicus)* (Keough et al. 2011).

While seagrass and mangrove-associated fish populations are relatively well studied, there is less information available for those associated with *Amphibolis antarctica* seagrass beds, *Caulerpa* beds, reef-macroalgae and other diverse range of sediment beds in Western Port, including rhodolith beds (Keough et al. 2011). To date there have been no studies of fish assemblages associated with the bryozoan reefs.

The bryozoan reefs are known to recreational fishers as "The Corals" and the area is known to be particularly productive for snapper and gummy shark through spring and summer. The bryozoan reefs are located within a heavily fished region of the bay (Jenkins et al. 2020; Figure 1). However, it is unknown to what extent fishing on the bryozoan reefs themselves contributed to the high fishing effort in the large survey box of Jenkins et al. (2020). Fisher positioning information being gathered in partner research in this project aims to elucidate this further (Figure 2). Partner Report 3 (Fathom Pacific 2020b) showed that the bryozoan reefs harbour a high diversity and abundance of matrix-associated invertebrate species, particularly crustaceans, that are known to feature in the diet of snapper and other demersal fish species (Parry et al. 1995). This may account for the popularity of the site in fisher lore.



Source: Adapted from Jenkins et al. (2020).

Figure 1. Spatial distribution of the catch rate of snapper, (a) kept fish, (b) released fish. Orange box = approximate boundary of the Western Port bryozoan reefs.

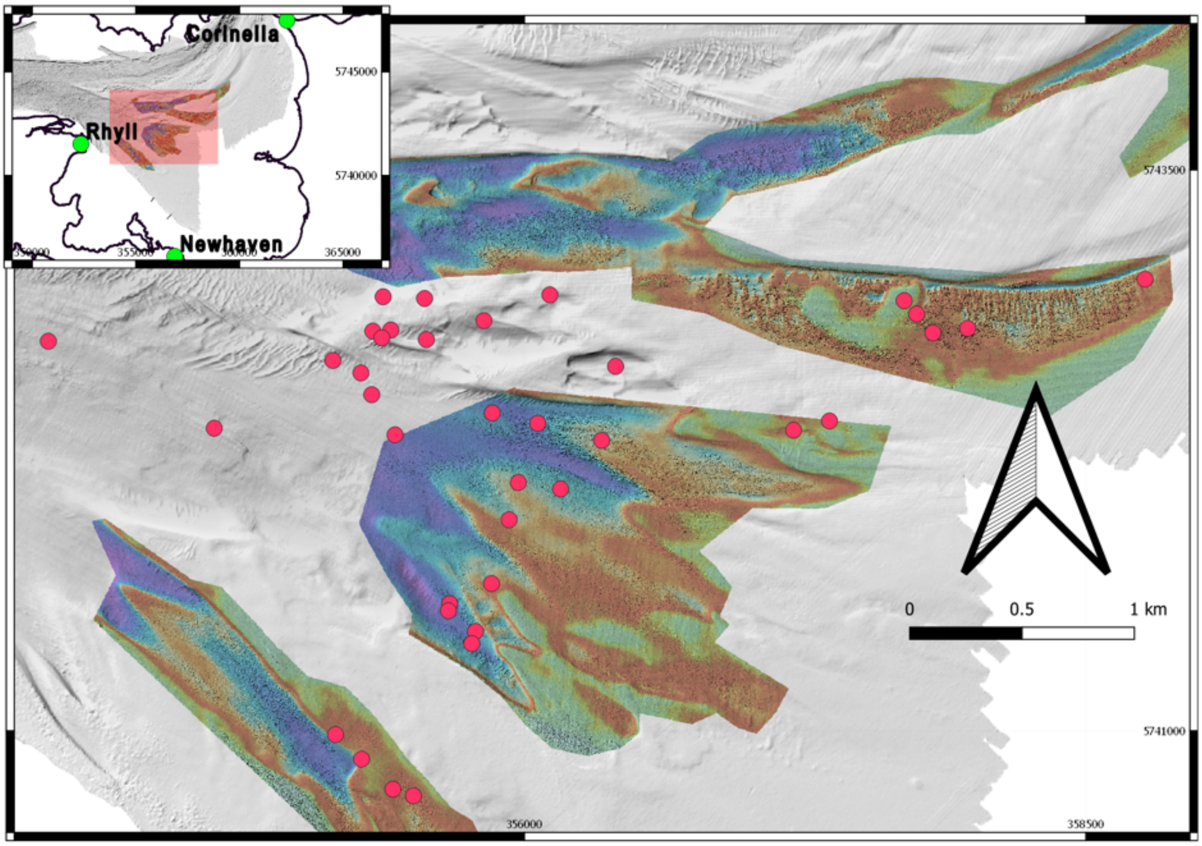


Figure 2. Location of recreational fishers logged to date by Fathom Pacific and Victoria Fisheries Authority. Spatial grid in meters, GDA94.

1.2. Fish Bioacoustics

Underwater visibility in the region of the BR and surrounds is generally poor, rendering visual techniques of fish assessment such as baited cameras and underwater visual census ineffective. Additionally, baited cameras and underwater visual census techniques generate a positive bias towards predators and scavenger species and ignore other niches (Harvey et al. 2007) making it inappropriate. Furthermore, the fragile biogenic structure of the reef and its sensitivity to physical damage precludes the use of trawled gear. Similarly, netting and other lethal sampling techniques were also out of scope of the present study for the aforementioned and additional ethical reasons. Therefore, fish bioacoustics was identified as a non-destructive and parsimonious method for assessing the relative importance of the bryozoan reefs as fish habitat. Fish bioacoustics provides data that can contribute to condition metrics and establish a robust baseline against which future changes can be assessed.

Fish bioacoustics provides information on abundance and biomass and is a standard method in stock assessments (Simmonds & MacLennan 2005, ICES 2015). The informative role acoustics can play for fisheries assessment has been known since around World War II (Sund 1935; Balls 1948) and increased technological capacity has seen its uptake in fisheries research. Fundamentally, bioacoustics provides a measure of fish biomass by detecting the resonance of gas-filled swim bladders and backscatter from any biological material. For swim-bladdered fishes, knowledge of the fine scale anatomy and changes in the detected resonance can provide insight to the size and species of fish being recorded. For example, in Hawaii, Au & Benoit-Bird (2003). and Benoit-Bird et al. (2003) used similar broadband bioacoustics techniques to those employed in the present study to investigate acoustic properties of lutjanid snapper. In cases where such studies are done, for example in northern hemisphere fjord and estuarine environments with low diversity of target species, bioacoustics can estimate biomass at the species level.

In Australian and New Zealand waters, the most common application of bioacoustics has been in the areas of abundance, biomass and behaviour of orange roughy (*Hoplostethus atlanticus*) (Kloser et al. 2015; Ryan & Kloser 2016) and mesopelagic fishes (Verma et al. 2017).

Bioacoustics cannot differentiate species without extensive research on sound scattering qualities of species and the use of split-beam systems. However, functional ecological groups can be differentiated based on their relative size and position in the water column. The bioacoustics methods presented here are contextualised with known fish communities in Western Port and provide area-based biomass estimation.

1.3. Objectives

The present study did not aim to contribute new data to the knowledge of fish community structure in Western Port and the bryozoan reefs as the fish diversity in the bay is generally understood. Rather, this study investigated the seasonal distribution and fidelity of fish biomass to these structures. Due to the enhanced localised benthic invertebrate abundance associated with bryozoan reefs, it was hypothesised that fish biomass over reef habitat is greater than that in the neighbouring non-reef habitats and that overall biomass would be higher in summer than winter.

Furthermore, the study aimed to assess bioacoustics as a cost-effective, non-lethal and non-destructive sampling technique that is suitable for the Western Port environment for the purpose of monitoring fish abundance at meaningful spatial scales.

2. Methods

2.1. Location

The bryozoan reefs study area is located, in the so-called Rhyll segment of East Arm, Western Port, Victoria, Australia (Figure 3). A total of 28 bioacoustic transects were recorded in bryozoan reef (BR) habitat and in the neighbouring bare sediment–*Caulerpa cactoides* bed habitat (SCC) in the Austral summer 2019 and winter 2020.

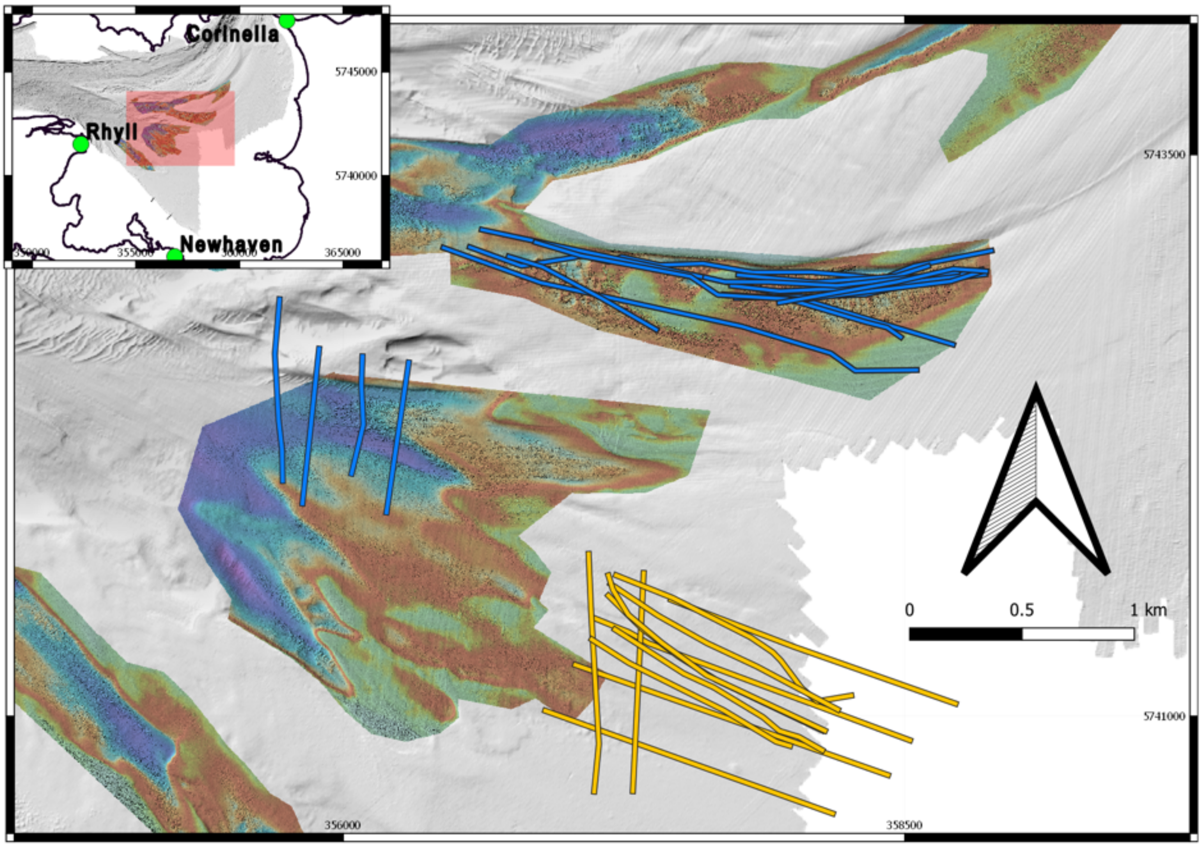


Figure 3. The bioacoustics study area. Blue transects are located over bryozoan reef (BR). Orange transects are located over bare sediment-*Caulerpa cactoides* habitat (SCC). Spatial grid in meters, GDA94.

2.2. Bioacoustics

2.2.1. Data collection

A calibrated Simrad EK15 bioacoustic echosounder was used to record bioacoustic data. The transducer operated at a frequency of 200 kHz (Table 1). Ping interval was maximised to provide best possible discrimination between individual targets. The transducer has a beam width of 26 degrees. At depths of 8 m, the transducer ensonified a seabed area of approximately 280 m^2. Vertical bin depth of an individual ping using this system was 2 cm.

Table 1. Bioacoustic sampling descriptive summary.

Datetime (AEST)	Transect no.	Season	Biotope	Tidal cycle
20-01-2020 09:43	T224327	Summer	BR	Ebb: 1.13 hrs after high
20-01-2020 10:15	T231506	Summer	BR	Ebb: 1.66 hrs after high
20-01-2020 10:43	T234333	Summer	BR	Ebb: 2.13 hrs after high
21-01-2020 11:38	T003827	Summer	SCC	Ebb: 2.3 hrs after high
21-01-2020 11:57	T005720	Summer	SCC	Ebb: 2.62 hrs after high
21-01-2020 12:14	T011444	Summer	SCC	Ebb: 2.9 hrs after high
21-01-2020 12:34	T013419	Summer	SCC	Ebb: 2.85 hrs to low
25-01-2020 16:33	T053343	Summer	BR	Ebb: 2.98 hrs after high
25-01-2020 16:58	T055834	Summer	BR	Ebb: 2.62 hrs to low
25-01-2020 17:07	T060702	Summer	BR	Ebb: 2.46 hrs to low
25-01-2020 17:31	T063124	Summer	BR	Ebb: 2.07 hrs to low
25-01-2020 17:51	T065147	Summer	SCC	Ebb: 1.73 hrs to low
25-01-2020 18:05	T070522	Summer	SCC	Ebb: 1.5 hrs to low
21-02-2020 09:09	T220911	Summer	BR	Flood: 1.52 hrs to high
21-02-2020 09:20	T222025	Summer	BR	Flood: 1.33 hrs to high
21-02-2020 09:29	T222946	Summer	BR	Flood: 1.18 hrs to high
21-02-2020 10:03	T230303	Summer	SCC	Flood: 0.62 hrs to high
21-02-2020 10:15	T231530	Summer	SCC	Flood: 0.42 hrs to high
21-02-2020 10:29	T232929	Summer	SCC	Flood: 0.18 hrs to high
16-07-2020 9:31	T233117	Winter	BR	Ebb: 1.13 hrs after high
16-07-2020 11:06	T000644	Winter	BR	Ebb: 2.72 hrs after high
16-07-2020 11:39	T003954	Winter	BR	Ebb: 2.72 hrs to low
16-07-2020 12:00	T010025	Winter	BR	Ebb: 1.9 hrs to low
16-07-2020 12:32	T012322	Winter	SCC	Ebb: 1.37 hrs to low
16-07-2020 12:40	T014045	Winter	SCC	Ebb: 1.37 hrs to low
16-07-2020 12:54	T015423	Winter	SCC	Ebb: 1 hr to low
16-07-2020 13:12	T021225	Winter	SCC	Ebb: 0.7 hrs to low
16-07-2020 13:39	T023929	Winter	BR	Ebb: 0.25 hrs to low

Footnote: BR=bryozoan reef biotope. SCC=bare sediment–*Caulerpa cactoides* biotope. For all transects, Time Varied Gain (TGV) was set to 40 log and ping rate was 2000 ms.

Transects were planned to traverse the core of the BR biotope and neighbouring bare sediment and *Caulerpa cactoides* biotopes. The distribution of *Caulerpa cactoides* is not confirmed, with thisalgae apparently occurring in patches throughout the bare sediment sampling area. The presence of *C. cactoides* was evident in bioacoustic records as bottom-attached structure. The depth of this bottom-attached structure is outside the range of seagrass distribution in this area. Transects over bare sediment and *C. cactoides* beds were combined (SCC) for the purposes of this study. The comparison between the BR and SCC biotopes also coincides with the invertebrate biodiversity study described in Partner Report 3 (Fathom Pacific 2020b).

The orientation of transects maximised biotope coverage while minimising vessel movement according to the onsite conditions (e.g. wind and tide) experienced at the time of the surveys.

Fish distributions in Western Port are strongly driven by seasonal, tidal and diel cycles. This project did not measure season and tidal cycle as continuous variables. However, sampling targeted mid-summer and mid-winter to capture the hypothesised peak high and low fish abundance scenarios in Western Port. Sampling endeavoured to target a period 2 hours before or after a high or low slack tide, which is generally believed to represent periods of maximum fish catchability, however this was not always possible (Table 1).

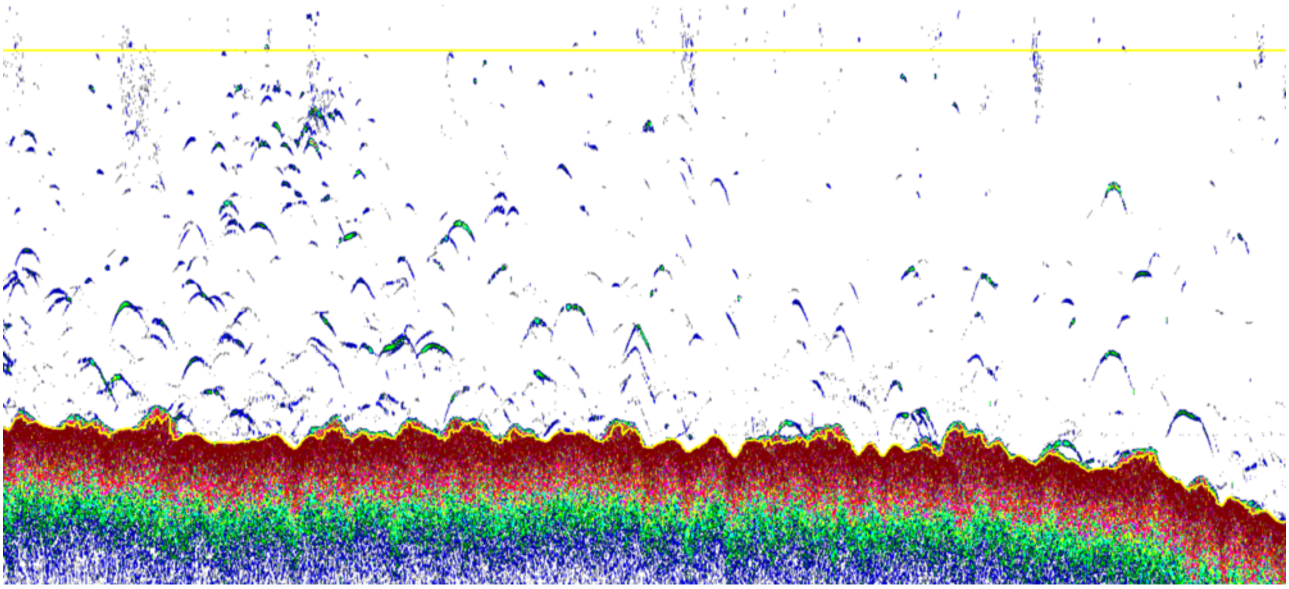
2.2.2. Data analysis

The raw sonar files were processed using the Sonar5 Pro software (Balk & Lindem 2013). For each raw sonar file, processing involved the following steps:

1. Convert the raw files into the desired data format (.uuu file);
2. Convert the embedded time from UTC to AEST;
3. Apply a noise reduction filter window to the .uuu file. A 3x3 filter window was used for ease of studying fish targets and at the recommendation of the software developers. Dimensions are measured the desired frequency to be cut off.
4. Run an automated 'bottom detection' algorithm to demarcate a seafloor from the water column analysis window (Figure 4). This process involved some experimentation to find a suitable acoustic backscatter strength that discriminates between the seabed and epibenthic biological structure. This is important because the BR and *Caulerpa cactoides* fronds contributed significant acoustic backscatter to the echogram and inclusion of those data within the analysis window will affect the calculated biomass. The priority for this study was to define a threshold and applying it consistently across the transects. While this may introduce some error in the absolute biomass estimates (due to the inclusion or exclusion of epibenthic structure in the analysis window), relative biomass comparisons will be consistent. Examples of epibenthic biological structure being included in the analysis can be seen in Figure 4, evident as echo returns laying above the algorithmically-detected seabed. For this study, the seabed was detected using -30 dB threshold and a 3x3 filter window.
5. Setting threshold filtering in the analysis window. Echograms recorded acoustic energy from any scattering material in the water column including drift algae/seagrass, bubbles and other interferences. After analysis of the interference signatures at the site, a threshold -60 dB was selected which excluded interference but retained the smallest potential fish signatures.
6. Categorisation of transects on BR or SCC using fine-scale multibeam data obtained from previous studies.
7. Fish detection and biomass analysis (Figure 5). Biomass is estimated by tallying up the detections and generates the results using built in algorithms.

Three bioacoustic indices were derived from this analysis:

- Mean volume back scattering strength (sA) measured in the transect segment recalculated over a coefficient of area sampled (backscatter strength/m^2/ha).
- Mean volume back scattering strength (Sv) measured in the transect segment (dB).
- Fish density per hectare (F/ha).



Footnote: Bottom yellow line is the algorithm-detected seabed using the thresholding parameters and the top yellow line demarcates the 2 m depth mark. The water column between yellow lines defines the analysis window.

Figure 4. Bottom detection using Sonar5 Pro for a BR transect.

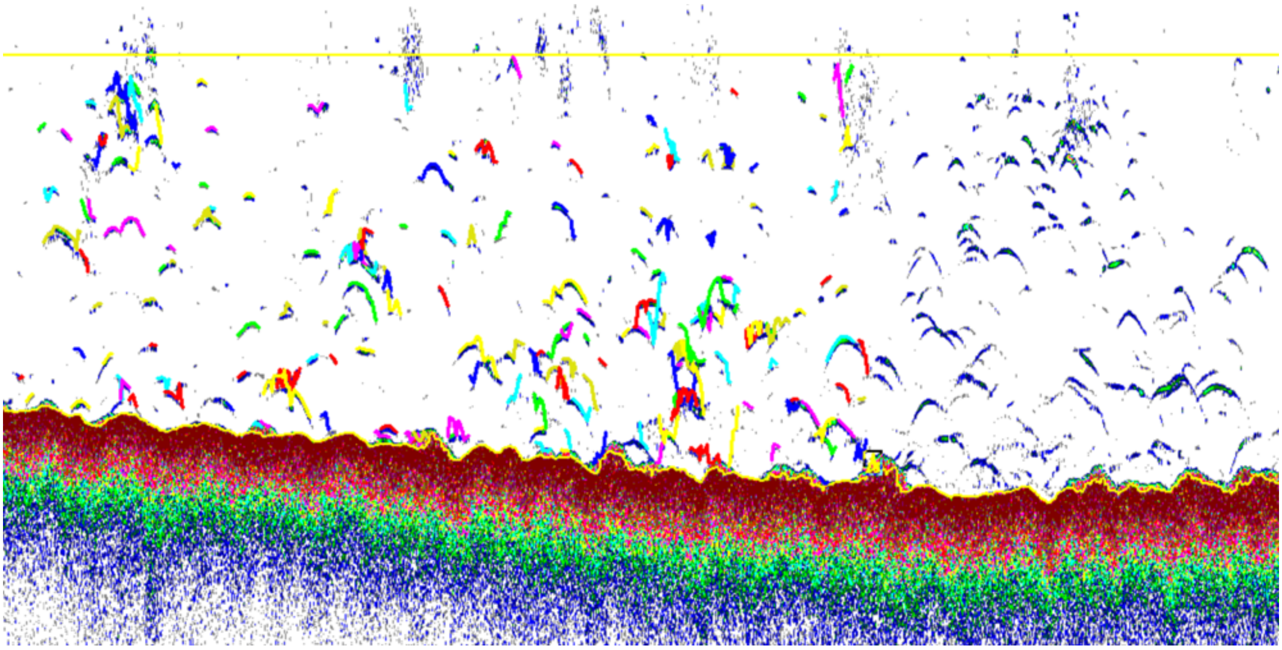


Figure 5. Biomass estimation using Sonar5 Pro for a BR transect, showing individual detected "fishes" (multicoloured arches).

2.2.3. Seasonal and spatial analyses

An initial investigation of the dataset revealed that two large fish schools were recorded during the survey (Figure 6). Both schools were encountered during summer sampling. These schools were located both in the BR and SCC biotopes, extending into the pelagic zone. The school within the BR biotope was measured in nine to ten meters water depth and the school within the SCC biotope was measured in approximately six meters water depth. One of these schools was observed to be associated with diving seabirds, suggesting that the schools were associated with mobile pelagic fishes. The transects associated with detection of these large schools were therefore excluded from further analysis.

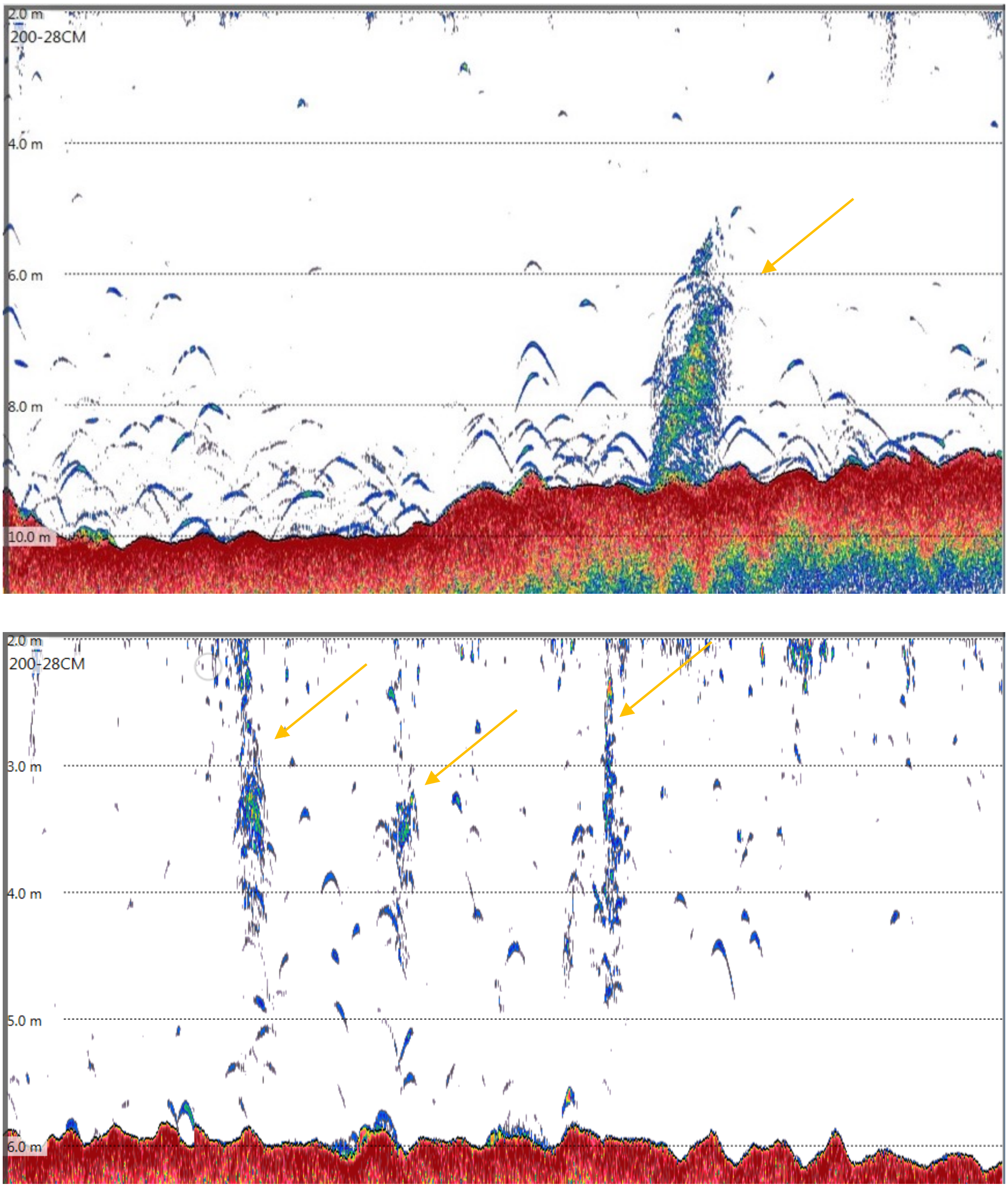
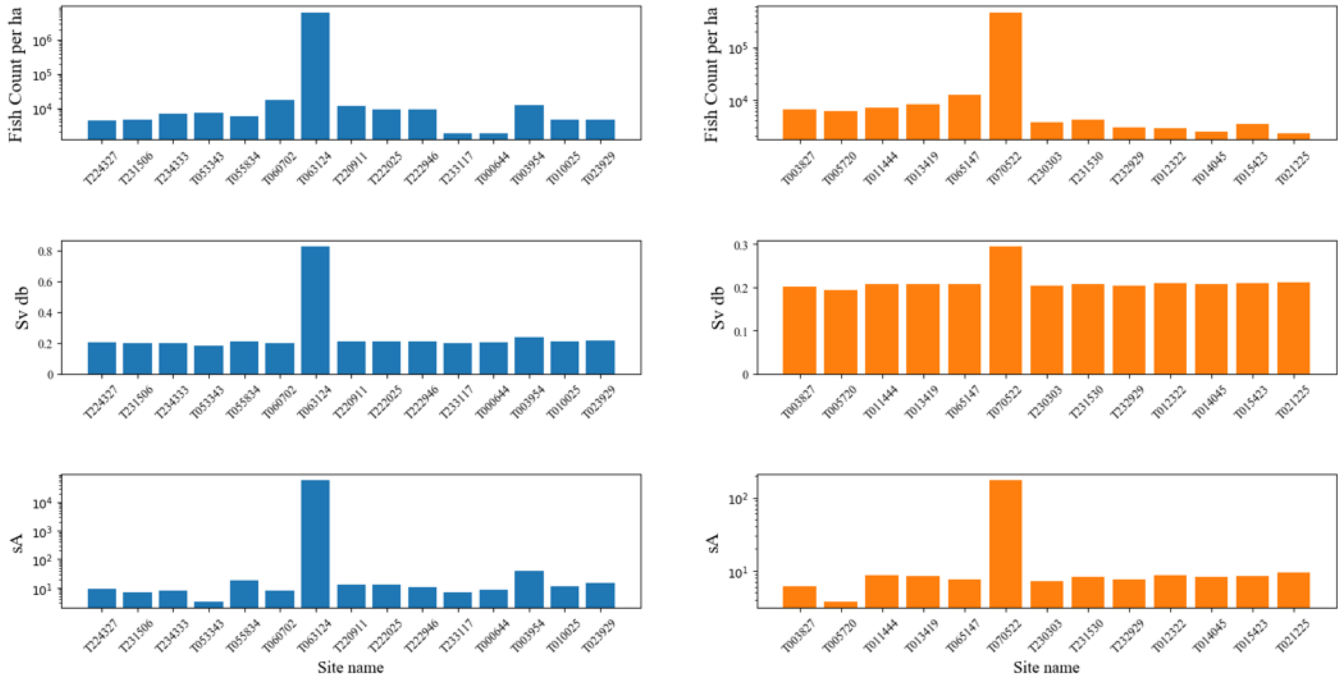


Figure 6. Detection of large fish schools (arrows) in the BR (top) and SCC (bottom) biotopes.

These schools generated very high biomass outliers (Figure 7). These two transects were excluded from further analysis.



Footnote: Note y-axis is logarithmic scale for F/ha and sA. The values for Sv dB were standardised for visualisation purposes.

Figure 7. Effect of school detection in preliminary analysis, generating large spikes in both the BR and SCC biotopes.

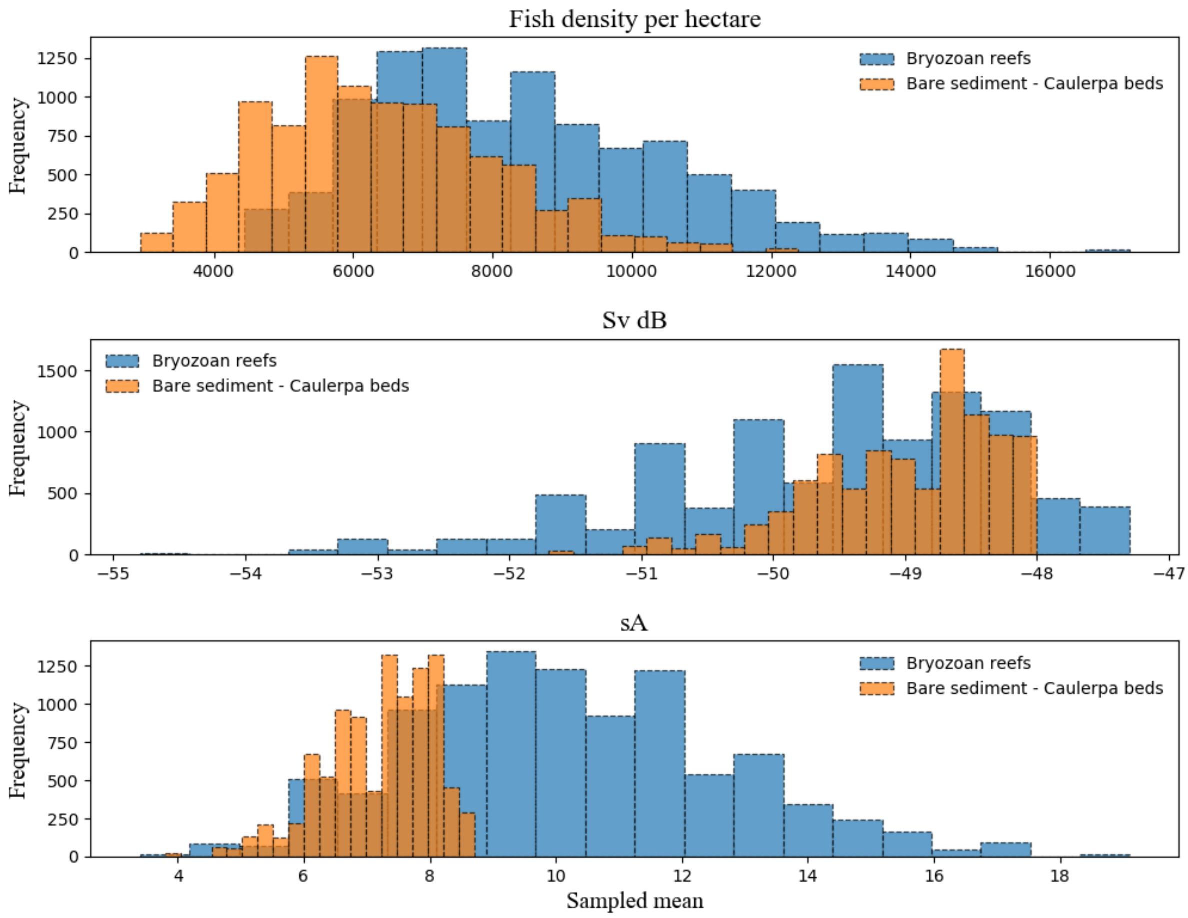
The final dataset was analysed for differences in the three metrics of bioacoustic indices (sA, Sv and F/ha) between BR and SCC biotopes in summer and winter. Spatial and seasonal analysis was conducted in Python. Transects were treated as samples, and the samples were bootstrapped, resampled using three random samples and 9999 iterations. The Mann Whitney U-test was used to test for differences in the distributions of the biomass metrics between BR and SCC biotopes, using the Stats module from Scipy (Virtanen et al. 2020). A significant result from the Mann Whitney U-test is interpreted as the two samples possess different medians.

3. Results

Values for all three of the bioacoustic indices (sA, Sv and F/ha) were higher in the BR than in SCC biotope, in both summer (Figure 8) and winter (Figure 9). Mann Whitney tests indicated that the recorded differences in data distribution for BR and SCC biotopes were significantly different in both the summer and winter ($P < 0.01$, Table 4). Winter results are viewed with some caution due to the relatively low number of samples.

Skewness of the data distributions in the summer samples are informative (Figure 8). The right-skewed data distributions in F/ha and sA for the BR biotope show that this biotope harbours a higher number of smaller fishes. Left-skewed distributions in Sv show that transects in the BR biotope also recorded a higher number of larger sized fish (negative dB corresponds to greater backscatter return from larger targets). The Sv results also indicate that larger numbers of smaller targets were detected in the BR biotope (right-skewed portion on the Sv distribution).

Collectively, the results indicate that BR harboured higher fish biomass in both seasons and higher numbers of fishes of the largest and smallest size range, than the neighbouring bare sediment-*Caulerpa cactoides* biotope.



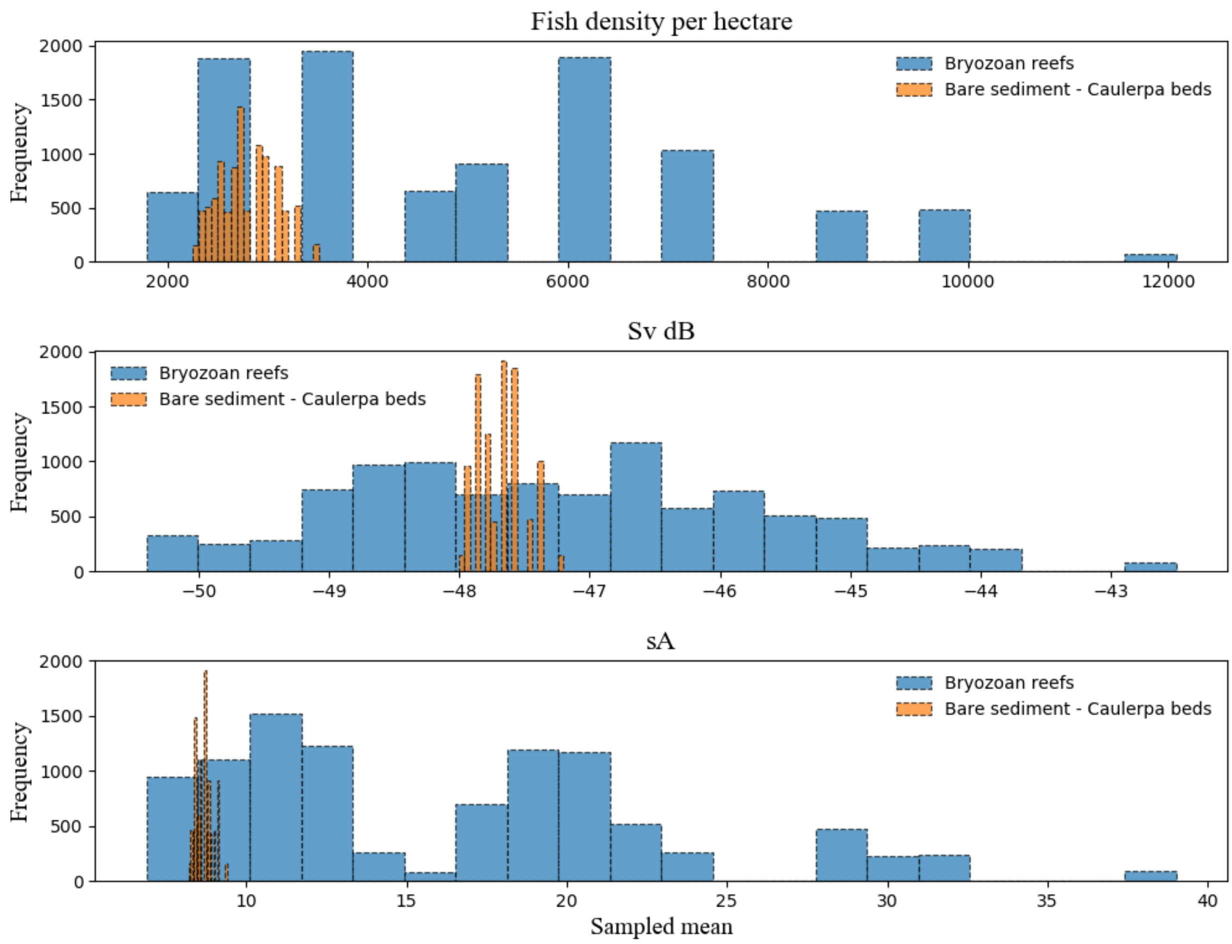
Footnote: Sv is measured in dB and more negative backscatter corresponds to higher backscatter return and larger sized targets.

Figure 8. Summer bootstrapped results for the three bioacoustic indices (F/ha, Sv and sA) in BR (blue) and SCC (orange) biotopes.

Table 2. Summary statistics for the three bioacoustic indices in summer.

	BR			SCC		
	Mean	**Median**	**St. Dev**	**Mean**	**Median**	**St. Dev**
F/ha	8434.7	8078.1	2160.6	6382.4	6206.4	1644.2
Sv	-49.5	-49.3	1.3	-49	-48.9	0.7
sA	10.2	10.0	2.5	7.2	7.3	0.9

Footnote: Sv is measured in decibels and negative decibel results correspond to energy returned to the transducer lower than that generated by the transducer pinging. Therefore, a more negative the value is interpreted as more energy absorbed by targets.



Footnote: Sv is measured in dB and more negative backscatter corresponds to higher backscatter return and larger sized targets. Note overall low target detection in winter, particularly in the SCC habitat.

Figure 9. Winter bootstrapped results for the three bioacoustic indices (F/ha, Sv and sA) in BR (blue) and SCC (orange) biotopes.

Table 3. Summary statistics for the three bioacoustic indices in winter.

	BR			SCC		
	Mean	**Median**	**St. Dev**	**Mean**	**Median**	**St. Dev**
F/ha	4957.5	4611.6	2163.6	2782.3	2740.3	279.5
Sv	-47.2	-47.4	1.6	-47.7	-47.7	0.2
sA	16.2	14	6.8	8.7	8.7	0.3

Footnote: For description of Sv refer to footnote in Table 2

Table 4. Mann Whitney U test results

	Summer		Winter	
	Statistic	**P value**	**Statistic**	**P value**
F/ha	216284	< 0.001	192524	< 0.001
Sv	395356	< 0.001	405355	< 0.001
sA	123117.5	< 0.001	93978.5	< 0.001

4. Conclusions and Recommendations

The results of this study indicate that the fish biomass is higher in the bryozoan reef biotope than in neighbouring bare sediment-*Caulerpa cactoides* beds. The bryozoan reef biotope recorded a higher number of targets at the highest and lowest ends of the backscatter range, hypothesised to represent higher abundance of the smallest and largest fishes. These results are consistent with the findings of Fathom Pacific (2020a) that reported enhanced benthic invertebrate diversity and abundance, particularly for crustaceans, in bryozoan reef samples compared with the same neighbouring biotopes. Crustaceans were the most abundant prey recorded in the stomachs of snapper in Port Phillip Bay, along with molluscs, polychaetes and fishes (Parry et al. 1995), and similarly in gummy shark elsewhere (Simpfendorfer et al. 2001). These prey items are also more diverse and abundant in the bryozoan reef compared to surrounding habitat (Fathom Pacific 2020b). Demersal fish species in Western Port that are not reef associated are generalist predators that range over multiple habitats to feed. Diets vary seasonally, reflecting changes in seasonal abundance of prey (Officer & Parry 1997). Spring-summer enhancement of fish biomass in the bryozoan reef habitat concords with known seasonal trends in Western Port, and may be supported at this site by enhanced benthic invertebrate abundance on the reefs (Wilson, in prep.)

The findings of the present work, along with those of the partner studies, suggest that the bryozoan reefs may provide enhanced foraging opportunity and refuge for demersal species in the East Arm of Western Port. Known as "The Corals" to recreational fishers, the bryozoan reefs are generally known to be productive recreational fishing sites, particularly in the late-spring to early-summer period. Fishing in this sector of the bay during these times targets principally snapper and gummy shark, although several demersal species are taken (Jenkins & Conron 2015). Anchor damage by recreational fishing is identified as one of key threat to the fragile, habitat-forming structures of the bryozoan reefs and a partner study currently underway in collaboration with Victorian Fisheries Authority will further elucidate fine-scale fisher site-selection in relation to reef habitat and quantification of pressure levels.

In Port Phillip Bay and several other locations, biogenic reef is known to represent productive fish habitat (Ford and Hamer 2016). Destruction of these habitats is considered detrimental to fish abundance and considerable efforts are underway to restore lost biogenic reefs in the interest of enhancing recreational fishing opportunities and general biodiversity and habitat value (Gillies et al 2018). A precautionary approach assumes that detrimental impacts to the bryozoan reefs could diminish fish biomass and the recreational fishing ecosystem service in this sector of the bay.

Bioacoustics proved to be a cost-effective method of estimating fish biomass and other features of the fish population on whole-of-biotope spatial scales. The indices generated are repeatable and objective and are relatable to fish functional guilds and size ranges. Building up repeated transecting over a set temporal basis could be used to monitor fish distribution and biomass in relation to the BR which, along with the other measures recommended in partner studies, could represent condition metrics for monitoring. In future work, a split beam system is recommended to further discriminate fish sizes. Relating bioacoustic results to species would require additional bioacoustic techniques and ground-truthing. Side-by-side fish trapping and citizen science-based line fishing were scoped as potential ground-truthing methods, but these were not able to be deployed for the present study.

5. Acknowledgements

This work is a part of the Western Port Bryozoan Reefs Research Project funded by Port Phillip and Western Port Catchment Management Authority. The project has benefitted greatly from the collaborations with Port of Hastings Development Authority, Victorian Fisheries Authority and the Western Port Biosphere, Western Port Seagrass Partnership, Parks Victoria, AGL and La Trobe University.

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