Bioacoustic Surveys of Macroalgae

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Introduction

Macroalgal communities on shallow (<40 m) reefs in temperate Australia are among the most diverse in the world. Complex reef habitats can comprise canopy forming species, understory species of red, brown and green algae, and turfing or encrusting forms. Macroalgal reefs are among the most productive marine habitats, playing a key role in nutrient cycling and representing critical habitat for diverse vertebrate and invertebrate communities. Factors affecting growth and survival of macroalgae include temperature, light, nutrients, salinity and physical disturbance. Cumulative effects of sea urchin infestations, water temperature regime changes and disease have caused declines in the cover and range of southern Australia's iconic kelp "forests".

Natural values associated with macroalgal beds are recognised in marine protected area management and other conservation initiatives in Australia and worldwide.

Subtidal macroalgae beds, such as these pictured in the Merri Marine Sanctuary (western Victoria), are monitored using quantitative diver surveys that require specialised taxonomic expertise and are subject to limitations of weather, visibility and costs of dive teams.

Monitoring

Macroalgae abundance is monitored as an indicator for environmental change, usually in the form of canopy cover over a transect or points coverage in a quadrate. In shallow waters, canopy cover may also be detectable by remote sensing methods such as aerial imagery or LiDAR. SCUBA diver census or video transecting methods on subtidal reefs are often prone to limitations of sea conditions, visibility, safety and costs. Practitioners seek methods that are quantitative, repeatable and cost-effective. Bioacoustics provides one such tool.

Method

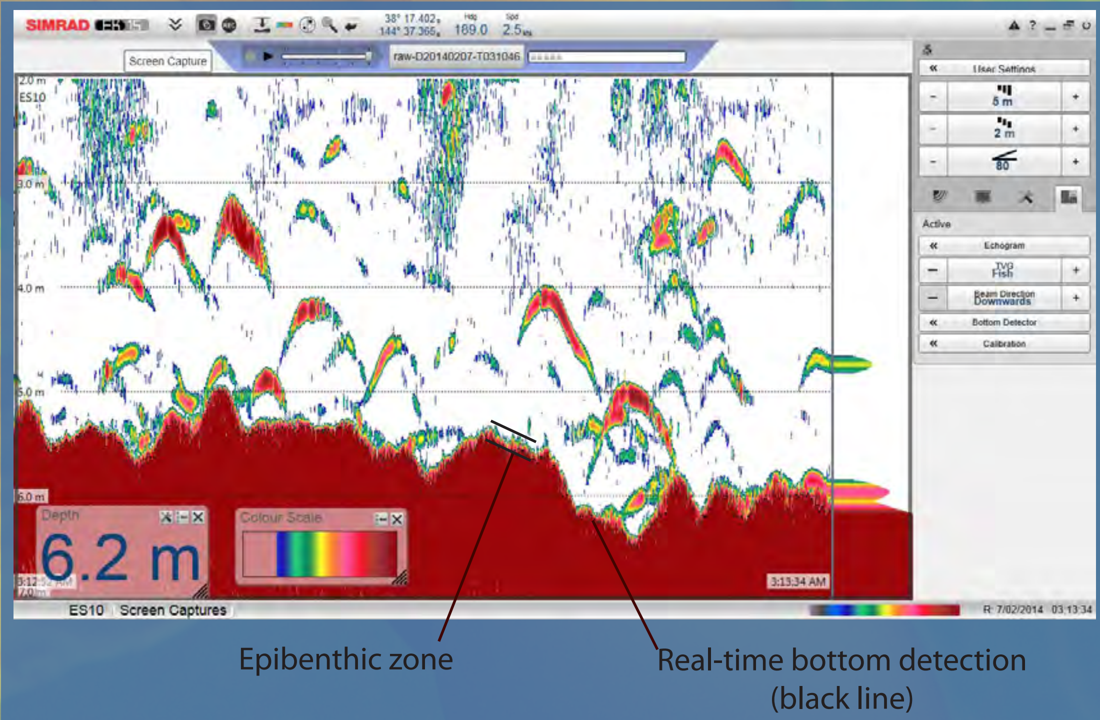
Bioacoustics is an established method that relies on the principals of sound propagation through water and analysis of return signals (echoes) from organsims and substrates that have particular sound scattering properties. Recent advancements in acoustic transducer technology and echo analysis software have resulted in high resolution systems that are well suited to small vessels and shallow waters. The method can be used to estimate macrophyte canopy height, macrophyte area and volume, and provide quantiative area scattering coefficients. The method can be used to survey large areas that could otherwise be logistically impractical or cost-prohibitive using traditional diver surveys and is not dependent on underwater visibility.

Fathom Pacific in collaboration with Australian Marine Ecology Pty Ltd surveyed subtidal reefs in the Port Phillip Heads Marine National Park, Victoria. A Simrad EK15 200 kHz single-beam system was used to record four transects each of 50 m length for a total of 200 m. These were the same transects surveyed by divers using point cover count methods as part of a routine Subtidal Reef Monitoring Program (Parks Victoria). Acoustic data were analysed using Sonar-5 Pro® software.

Results

Data Acquisition

With an average vessel speed of ~1 m/sec, the 200 m transect was traversed in approximately 3 min. For an average water depth of ~7 m, the instantaneous acoustic beam diameter was approximately 3 m giving an ensonified area of ~ 7 m^2 per ping.



Echogram showing real-time software detected seabed (feint black line) associated with very strong backscatter along the bottom contour. An epibenthic zone of lower reflectance is observed overlaying the seabed that coincides with visually-confirmed macroalgae stands. `Fish targets are observed in mid-water.

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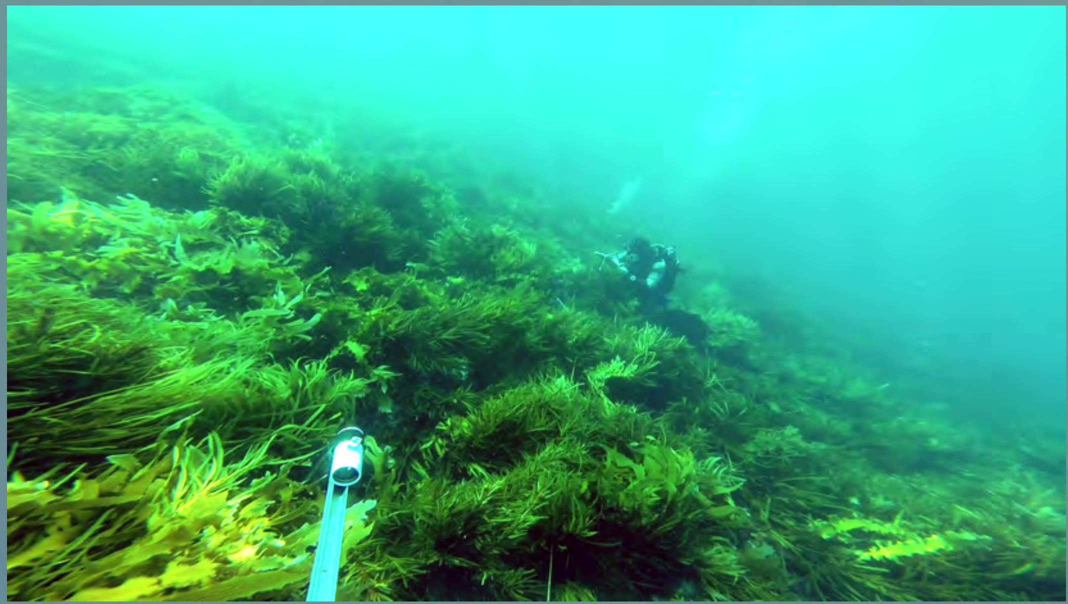
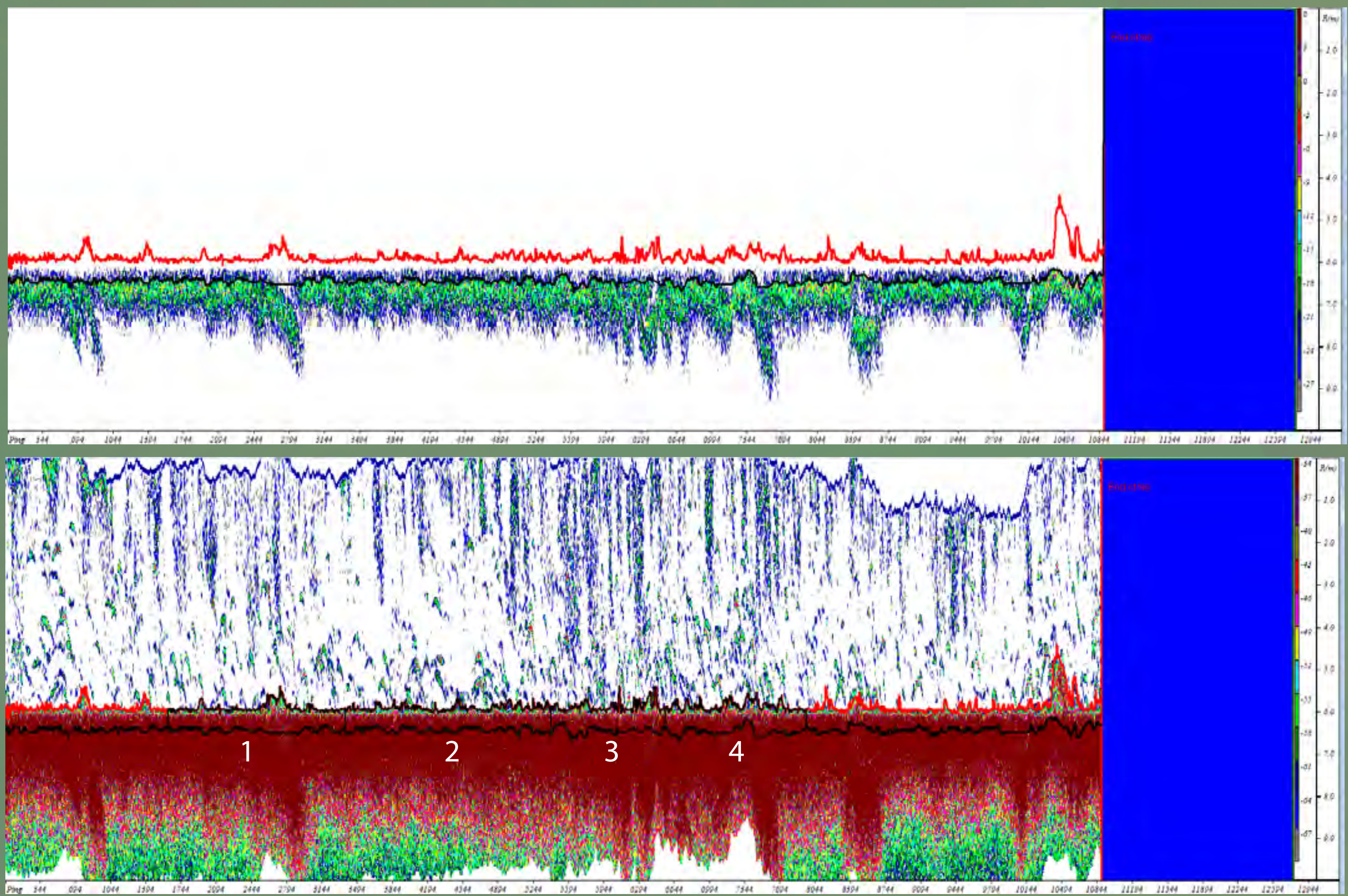
Canopy-forming macroalgae *Phyllospora comosa* and *Ecklonia radiata* on the transect sampled acoustically (shown in previous Figure).



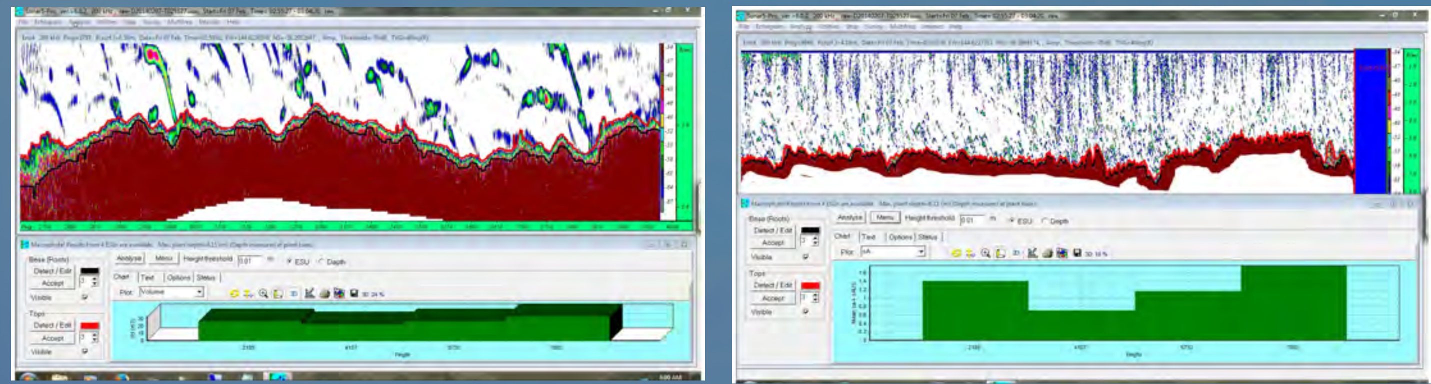
Analysis

A strong acoustic return from the seabed could be resolved across the transect by thresholding the bottom return signal to omit mid-water and epibenthic targets in post-processing. A threshold of -30 dB was selected for automated bottom detection which successfully distinguished substrate from overlying macroalgae.



Top - Artificially "flattened" echogram showing thresholding effect (-30 dB) to omit weaker returns and detect the seabed (black line). Bottom - Same echogram thresholded (-70 dB) to allow weaker targets into the analysis region and a detection of the top of the macrophyte bed. The four 50 m transect segments are shown.

Automated software detection was prefered because it is a rapid process and the speed and success of automated analysis was central to the question of the utility of acoustic methods for cost-efficient monitoring. The automated detection of the top of macrophytes was checked across the 200 m transect for this trial. The detection of the top of macrophytes was found to be very accurate, most likely as a result of the clear differentiation in acoustic properties between rocky reef substrate, long and dense macroalgae, and the overlying water.



Left - Magnified view of a transect segment showing the result of automated bottom detection (black line) and macrophyte tops detection (red line) and thus the macrophyte biomass and analysis region between those lines . Right - Full transect showing analysis region. Graph shows area-scattering coefficient (*sA*) for each of the four 50 m transects (see text for further explanation).

With the seabed and macrophytes detected, further analysis of macrophyte height, area and volume could be made. The table below shows the key ecologically significant results. Mean macrophyte height, area and volume are biological measures that are familiar and easily communicated to environmental practitioners and stakeholders alike. Volume backscattering strength (*Sv*) and area scattering coefficient (*sA*) are supported and accepted indices that describe the acoustical properties of the macroalgal community. The biological measures and acoustic indices are quantiative and conducive to monitoring and impact assessment.

Transect No.	Mean Height (cm)	Macrophyte Area (m^2)	Macrophyte Volume (m^3)	Mean *Sv* (dB)	Mean *sA* (m^2/ha)
1	53	154.7	82.7	-24.3	251.1
2	60	152.7	91.3	-25.8	204.5
3	60	152.6	91.8	-24.7	253.0
4	50	151.5	76.4	-23.9	258.3

Conclusions

Bioacoustics provides a promising tool to meet the challenges of quantitative monitoring and impact assessment of kelp and other macroalgae communities, particularly under logistical, OHS and budgetary constraints. The speed and flexibility of in-field data acquistion and the automation of analysis steps are key advantages. The limitation is that the technique does not provide species-level data. However, sites that have been surveyed using diver-based methods provide opportunities for ground-truthing and a phased adoption of acoustic techniques. The technique will be trialed in other temperate and tropical vegetated habitats including seagrass beds on uncosolidated sediments.