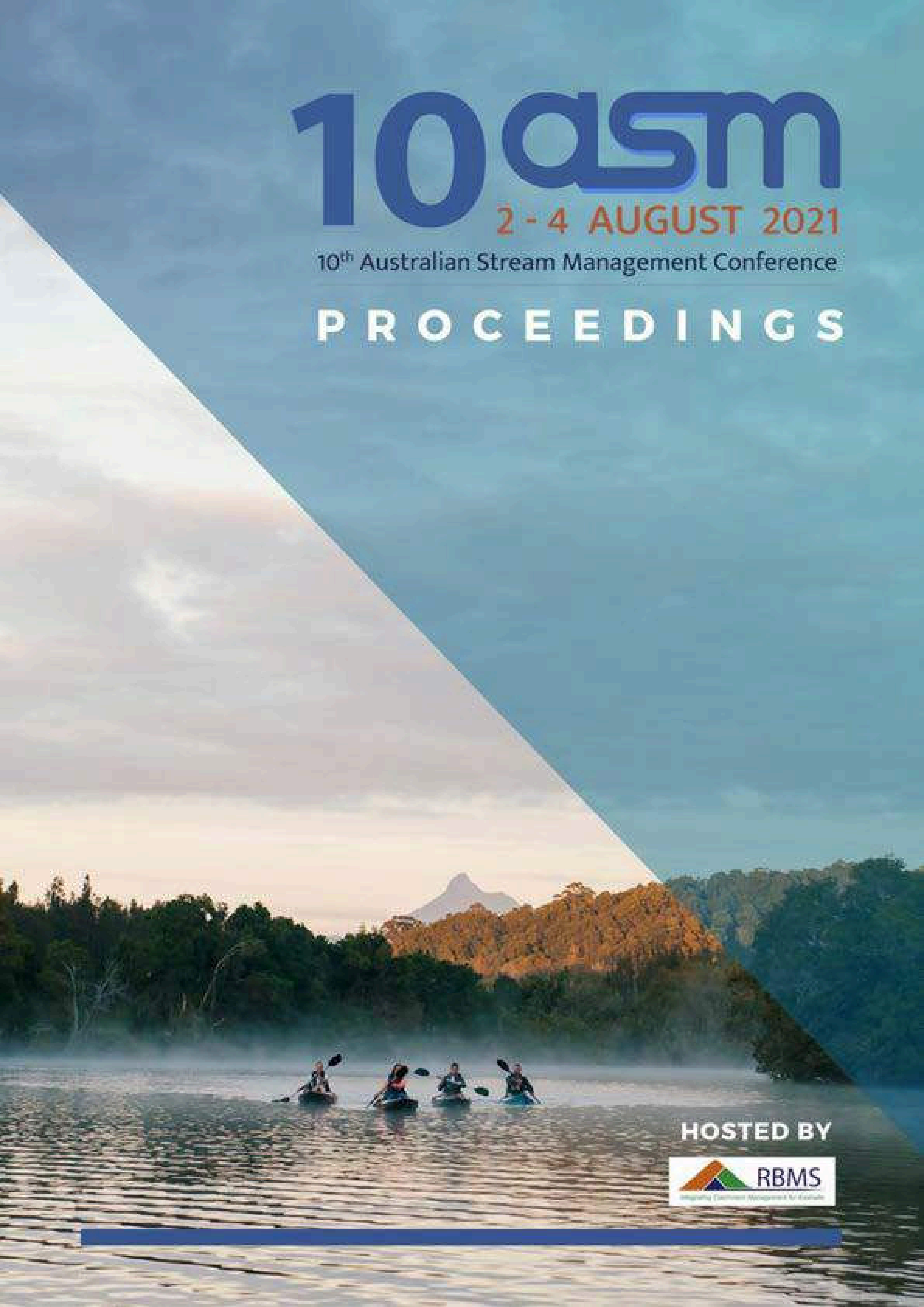
10asm

2 - 4 AUGUST 2021

10th Australian Stream Management Conference

PROCEEDINGS



HOSTED BY

RBMS

Integrating Catchment Management for Australia

A birds eye view: Using remotely sensed data to monitor Limits of Acceptable Change in the Gippsland Lakes Ramsar

Sean Phillipson[1], Jennifer Hale[2], Dr Shane Brooks[3]

1 East Gippsland Catchment Management Authority, 574 Main Street Bairnsdale Victoria, 3875. sphillipson@egcma.com.au

2. Aquatic Ecology Consultant, Wandong Victoria 3758. jennihale@bigpond.com.

3. Brooks ecology and Technology, Warrandyte South Victoria, 3134. shane@brooks.eco

Key Points

- The Gippsland Lakes has a range of large-scale monitoring needs for which implementation can be limited by scale and resources.
- The development of a framework for mapping seagrass across the Gippsland lakes using free satellite imagery has provided an opportunity to explore its use in other vegetation types.
- The application of Maximum Likelihood Classification to seagrass, saltmarsh, and freshwater wetland vegetation communities has demonstrated a robust, repeatable and cost-effective method for answering high level monitoring questions across a large landscape.

Abstract

Monitoring Ecological Character within Ramsar sites is critical to meeting obligations under the Ramsar Convention. The Gippsland Lakes is an extensive site with complex monitoring needs. A cost-effective framework was required to understand the extent of different habitat types and help detect changes over time.

A framework to map the extent and density of seagrass within the Gippsland Lakes using satellite imagery was developed. It provided a cost-effective method to produce accurate maps of seagrass distribution, enabling site managers to better understand current conditions.

The GIS mapping techniques developed have been applied to seagrass, saltmarsh, and freshwater wetland vegetation communities to produce vegetation distribution maps.

Through a series of projects, the cost effectiveness and accuracy of mapping based on free satellite imagery has been assessed.

Whilst the resolution of satellite imagery products may limit the development of fine scale habitat mapping, this is often not required to make fundamental management decisions or answer higher level questions, like those related to vegetation extent or density.

The results produced have provided a sound base to answer monitoring questions, where previously resource limitations have been considered a barrier.

Monitoring ecological change across large landscapes can be complex and costly. If monitoring approaches are designed carefully around the questions being asked, more cost-effective and spatially extensive monitoring is achievable by using free remotely sensed data.

Real projects have shown that mapping techniques developed for seagrass can be successfully applied to a range of vegetation types and have potential for further application in aquatic systems

Keywords

Gippsland Lakes, Ramsar, seagrass, saltmarsh, vegetation mapping, remote sensing

Introduction

The Gippsland Lakes Ramsar Site is located approximately 300 kilometres east of Melbourne in in south-eastern Australia. The site extends from Sale Common east to Lake Tyers covering an area of approximately 60,000 hectares and are the land and waters of the Gunaikurnai people. The system comprises a series of coastal lagoons and fringing wetlands which receive inflow from five major river systems and are connected to the Southern Ocean by a narrow, artificially maintained channel at Lakes Entrance.

The ecological values of the site include extensive seagrass beds, a variety of fringing vegetation types, habitat for resident and migratory waterbirds, diverse and abundant fish, and support for other threatened species, including one of only two known populations of the rare Burrunan dolphin. The lakes are central to tourism for the region, also supporting commercial and recreational fisheries, and have outstanding Aboriginal and European cultural values.

The main lakes and the fringing wetlands are in a transition that has been occurring for over 100 years. Drivers of change include increasing population, including of greater Melbourne, for which water is diverted away from the lakes. There have also been changes in land use in the catchment, and the establishment of towns and urban development around the Lakes. Into the future, change is likely to increase with an increasing population and climate change predicted to alter the system further. The Gippsland Lakes will continue to adapt to the changing conditions and, with concerted and coordinated management efforts, key values can be maintained, and new values are likely to emerge.

Figure 1. Location of the Gippsland Lakes, including the Gippsland Lakes Ramsar site boundary.

Gippsland Lakes Ramsar Site Listing

The Gippsland Lakes were listed as a Wetland of International Importance under the Ramsar Convention in 1982. The Ecological Character Description (ECD) for the Gippsland Lakes identifies eight components, two processes, and two services that are critical to the ecological character of the Ramsar site (Table 1). The condition of each critical component, process and service (CPS) is benchmarked at the time of listing to allow for any change to be monitored and reported to the Convention.

Table 1. Critical CPS for the Gippsland Lakes Ramsar Site (BMT WBM 2101).

Components		Processes and Services
C1- Marine subtidal aquatic beds	C5- Saltmarsh	P1- Hydrological regimes,
C2- Coastal brackish or saline lagoons	C6- Abundance and diversity of waterbirds	P2- Waterbird breeding sites
C3- Freshwater wetlands	C7- Threatened frog species;	S1- Maintaining threatened species.
C4- Brackish wetlands	C8- Threatened wetland flora species	S2 – Fishery resource value

The mechanism against which change in ecological character is assessed is via comparison with limits of acceptable change (LAC). LAC are defined as the variation that is considered acceptable in a particular component or process, without indicating change in ecological character that may lead to a reduction or loss of the criteria for which the site was Ramsar listed (modified from definition adopted by Phillips 2006). Exceedance of a LAC triggers further investigation into the potential changes in character recognising that, variability will occur as aquatic ecosystems are rarely static and stable.

Managing and monitoring the Gippsland Lakes

In addition to meeting reporting obligations under the Convention, information of the distribution and condition of key ecological communities within a Ramsar site is required for site management. The information can be used to both inform management actions and track overall condition of key indicators of the health of the lakes. The site is large and there are multiple agencies and organisations that have a role in site management. The Traditional Owners, the Gunaikurnai people, and multiple land, waterway, and other environmental managers have jurisdictions that cover the lakes system, with varying objectives as well as responsibilities.

To provide clear priorities for actions to implement across such a large and complex site, a consolidated approach between responsible agencies, managers and community is required. A comprehensive monitoring framework that provides regular updates on the status of important values that contribute to the ecological character of the site underpins the current management approach.

The need for a different approach

The Gippsland Lakes Ramsar Site covers an extensive area, much of which can be logistically challenging to access. Additionally, many of the habitats that require regular monitoring to detect change or condition are also extensive or spatially dispersed. Consequently, past vegetation mapping and condition assessments have either been time consuming and resource intensive. Resources for managing the ecological character of the Gippsland Lakes Ramsar Site are limited and a balance must be struck between using funds for monitoring and for managing threats. With insufficient resources to regularly monitor vegetation communities using traditional field-based methods a novel approach that would allow us to monitor key habitat types in both a time and cost-effective manner was necessitated.

Case Study 1: Determining the best technique (Gippsland Lakes Seagrass Monitoring Framework)

Marine sub-tidal beds (seagrass) are listed as a high priority value and a critical CPS in the ECD (see Table 1). The Gippsland Lakes Ramsar Site Management Plan (GLRSMP) identifies several high priority threats that are potentially impacting these communities including nutrient and sediment inflows, climate change and impacts of marine pests. The GLRSMP also identified fluctuations in seagrass communities, including thresholds of significant change as a knowledge gap with respect to the Ramsar site. The development of a framework and method to routinely assess these threats and identify extent and density trends will help address this gap and provide a foundational activity for actions to protect this critical CPS.

A project was commenced to select the most appropriate method to meet the identified monitoring needs and develop a framework to guide its implementation. The strengths and limitations of different methods were evaluated. The evaluation was informed by both a literature review and pilot testing several methods in a section of the Gippsland Lakes.

Selecting methods for seagrass monitoring in the Gippsland Lakes was based on the likelihood of the technique(s) to meet the criteria of:

- **Feasibility** – is the method likely to be able to collect information on mapped extent and density to assess against LAC and management targets in the Gippsland Lakes?
- **Cost-effectiveness** – can the data be collected, analysed and evaluated within a moderate budget?
- **Repeatability –** can the method be repeated at annual time scales?

- **Compatibility** – will the data collected be able to be compared to the extent and density measures of historical seagrass assessments (Roob and Ball, 1997 and Kitchingman, 2016)?

Given that both density and extent were required to meet reporting requirements, a combination of remote sensing with ground truthing was determined to be the best approach.

Testing indicated that the use of the free Sentinel satellite imagery is of sufficient resolution to provide an indicative map of seagrass extent ion the Gippsland Lakes. It was also noted that in the future, free satellite imagery is almost certain to improve in resolution and the framework was designed to account for improvements in technology.

Case Study 2: Testing the use of satellite imagery (Gippsland Lakes Seagrass Mapping)

To assist in determining the effectiveness and applicability of the selected satellite imagery-based technique, key evaluation questions were identified:

- What is the extent of seagrass across two density classes (sparse-medium and dense) in the Gippsland Lakes?
- Is seagrass extent and density within the LAC?
- Is seagrass extent and density progressing towards management targets?

The recommended method to provide data to answer these questions involved the classification of seagrass in Sentinel-2A/B Earth observation imagery using maximum likelihood classification. Available data from field studies collected across the Gippsland Lakes in 2016 (Kitchingman et al. 2016) were used both for training the image classification and to validate completed maps.

Sentinel-2 imagery for the Gippsland Lakes can be obtained free of charge from the Sentinel Australasia Regional Access (SARA) portal https://copernicus.nci.org.au/sara.client/#/home. The portal can be used to search for cloud free images between a date range

The accuracy and repeatability of image analysis is maximised by eliminating all terrestrial, ocean and deep water pixels to focus on the shallow water habitat where seagrass is found. A mask was created that isolated the water areas shallower than 4m to the shoreline Figure 2. Due to differences in water colour and turbidity from the source rivers to the entrance it is necessary to divide the lakes area into distinct zones that were analysed separately and aggregated.

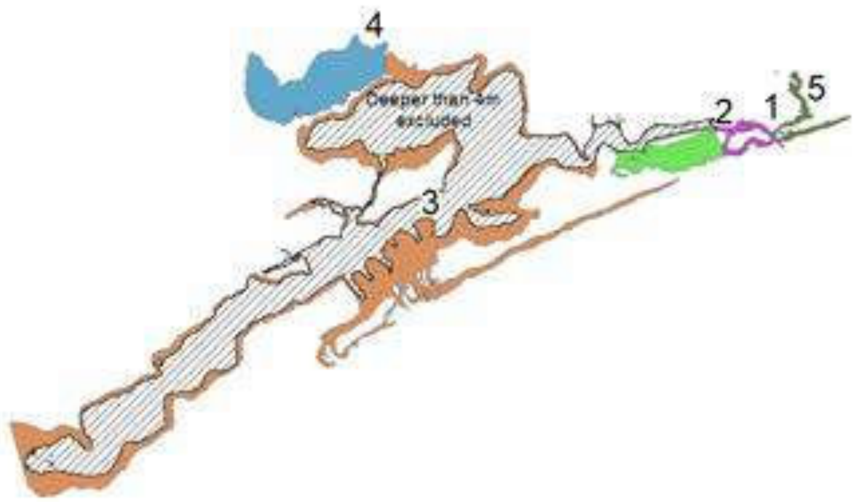


Figure 2: Shallow water mask from 4m depth to the shoreline divided into five zones to partition variation in water colour and turbidity.

Each zone was visualised using the red, green and blue bands, however the classification will use all five bands. For viewing in ESRI ArcGIS software a "Histogram Equalize" symbology greatly enhances the ability to visualise seagrass extent (Figure 3).

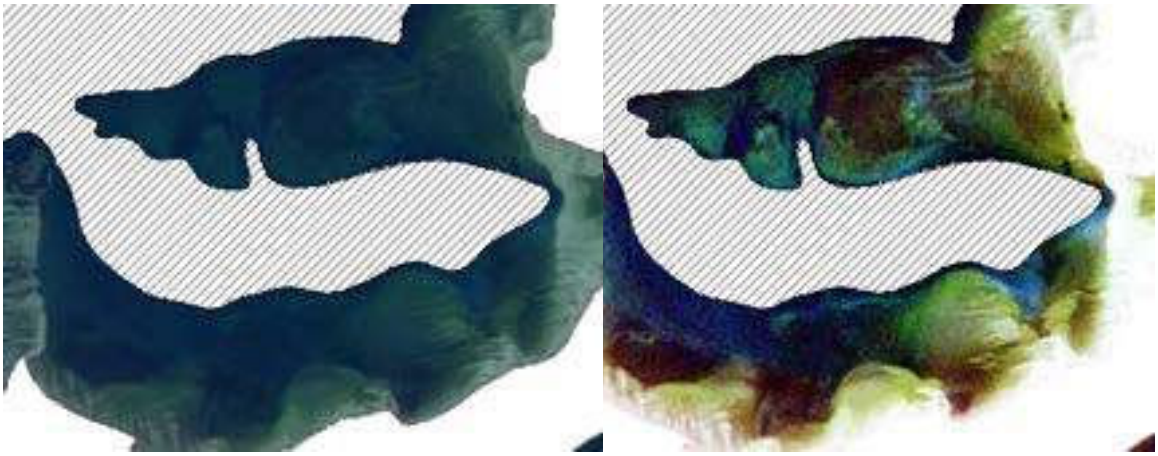


Figure 3: Equal histograms (right side) for red, green and blue greatly aids visual interpretation of seagrass extent required for training area selection.

Maximum likelihood classification requires the user to designate training areas for each class. Pixels over the full extent of the image are then assigned to those classes based on the likelihood that the combination of values for each of the five colour bands in the multi-spectral image fits the characteristics of the training area.

Four classes are used to map seagrass extent: Dense seagrass; Medium-sparse seagrass; Bare sediment; and Deeper water/ indistinct benthos.

Training areas were identified to clearly encompass an area of the image conforming to each class. (Figure 4).

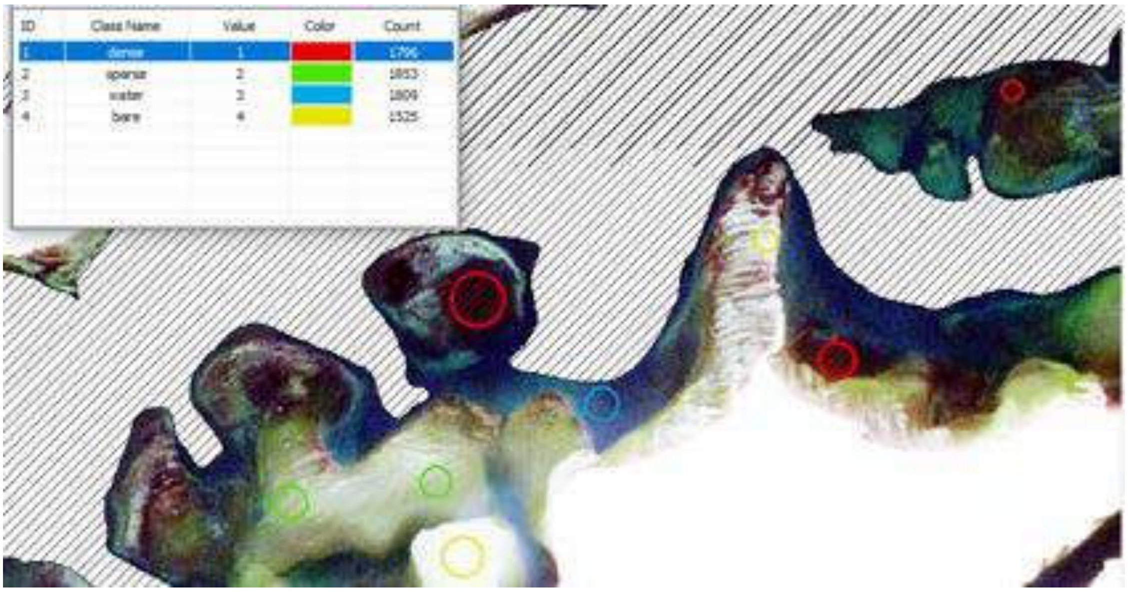


Figure 4: Circular training areas located in patches of dense and sparse seagrass and bare sediment. A single training area for the deeper water/undistinguishable benthos class is also visible (blue circle).

The maximum likelihood classification maps the extent of each class (Figure 5). A visual assessment can be made to compare the classified map to the imagery. Poor alignment may indicate that training areas need to be revised, perhaps with additional expert knowledge or ground truthing and the classification re-run. Area is calculated from the pixel count x resolution (e.g. for Sentinel imagery each 10m pixel is $100m^2$ or 100 pixels per hectare).

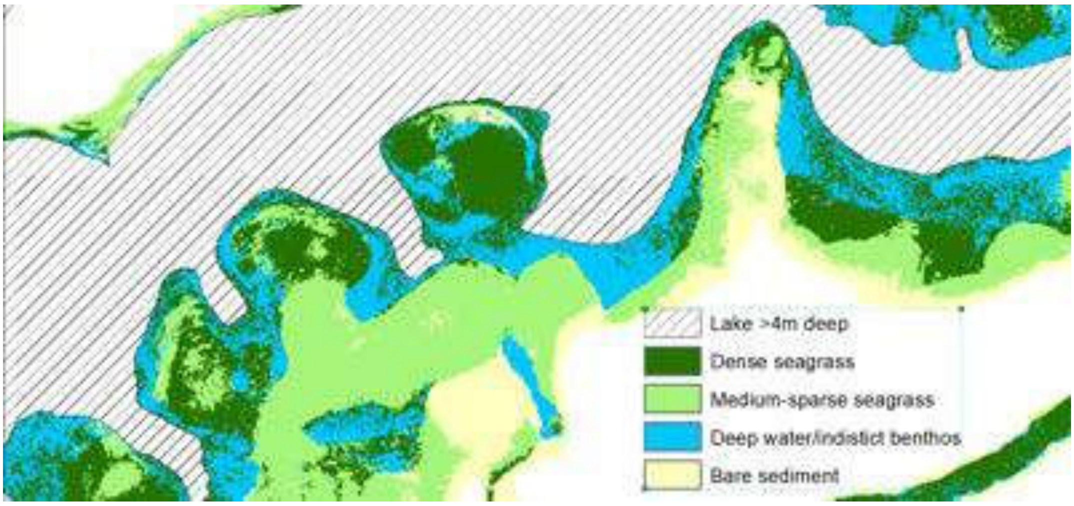


Figure 5: Maximum likelihood classification of the four benthic classes.

The selection of training areas should not solely rely on the visual interpretation of the imagery. Historical mapping, aerial photography, dive surveys, expert observation, and citizen science all provide complementary data to improve confidence in assigning training areas in the first instance, or for reviewing resulting maps. If discrepancies in the maps are identified they may be resolved by using complementary data to revise training areas to generate a more accurate map.

The aggregated zone seagrass extents are then able to be compared against: historical seagrass extent; Limits of Acceptable Change; and Resource Condition Targets, providing data to answer the identified key evaluation questions.

Case Study 3: Application of the technique to other vegetation types (Gippsland Lakes Freshwater Wetland Vegetation Mapping)

Sale Common and Macleod Morass are the only freshwater wetlands within the Gippsland Lakes Ramsar Site, and two of very few freshwater wetlands in the region. They have been identified as critical to the ecological character of the Ramsar site and there are LAC associated with each (BMT WBM 2010).

A method to map wetland vegetation areal extent at Macleod Morass and Sale Common to meet Ramsar reporting requirements was required. The mapping and assessment approach needed to be easily replicable and cost effective to allow repeated applications to track and report change through time. This would not only meet Ramsar reporting obligations but will also support adaptive management of the site.

Given that classification of Sentinel-2 imagery has been used successfully to map seagrass in Gippsland Lakes and similar methods are used to map wetland vegetation elsewhere, the same approach was applied to map vegetation communities within Macleod Morass and Sale Common to help make an assessment against the relevant LAC.

Sentinel-2 image data was accessed from the Sentinel Australasia Regional Access (SARA) portal. The search function of the portal was used to identify suitable cloud-free images from each wetland, selecting the best recent image. For Sale Common, reference vegetation mapping from ground surveys was available from 2015 (Frood et al. 2015) and an image that matched closely to the time and water regime form this on-ground mapping was also sourced. Images were pre-processed using the Sentinel Application Platform.

There are two types of classification that are commonly used to map vegetation: unsupervised (calculated by software) and supervised (human-guided). Trials of both methods were applied to the imagery at Macleod’s Morass, but at Sale Common, only unsupervised classification was used, due to the water regime conditions and an inability to apply adequate training methods. In both instances, mapped units were assigned to one of five categories: Open water; Deep marsh; Reed bed; Swamp scrub / woodland; and Bare ground

The accuracy of the results was found to be similar for both Macleod morass and Sale Common, the example of Macleod Morass has been used to demonstrate the outcomes here.

The unsupervised and supervised classification of Macleod Morass produced similar results (Table 2) despite some differences in the allocation of the shallow marsh category, both of which are actually giant rush dominated vegetation assemblages, but the deep marsh category has more open water and clumps of giant rush. This difference has no bearing on the interpretation of the LAC as both classes are freshwater emergent vegetation.

Table 2. Macleod Morass. Areas of wetland classes comparing results of unsupervised and supervised classification of Sentinel-2 18/06/2020 image. Emergent wetland vegetation types highlighted green.

Vegetation categories	LAC categories	Unsupervised area (ha)	Supervised area (ha)
Open water	Open water	28	19
Deep marsh (open water with clumps of giant rush)	Open water	90	79
Shallow marsh (giant rush)	Native emergent vegetation	43	84
Reed bed (Typha and common reed)	Native emergent vegetation	201	179
Swamp scrub / woodland (paperbark)	Woody vegetation	59	62
Dry / damp basin	Open water when inundated	44	49
Bare ground, grass	None	31	24
Sum of emergent macrophytes		**244**	**263**

The mapped output (Figure 6) was validated through local knowledge (Parks Victoria, East Gippsland CMA, BirdLife East Gippsland, Greening Australia), with no suggested alterations to the produced map, increasing confidence in the mapped outputs.

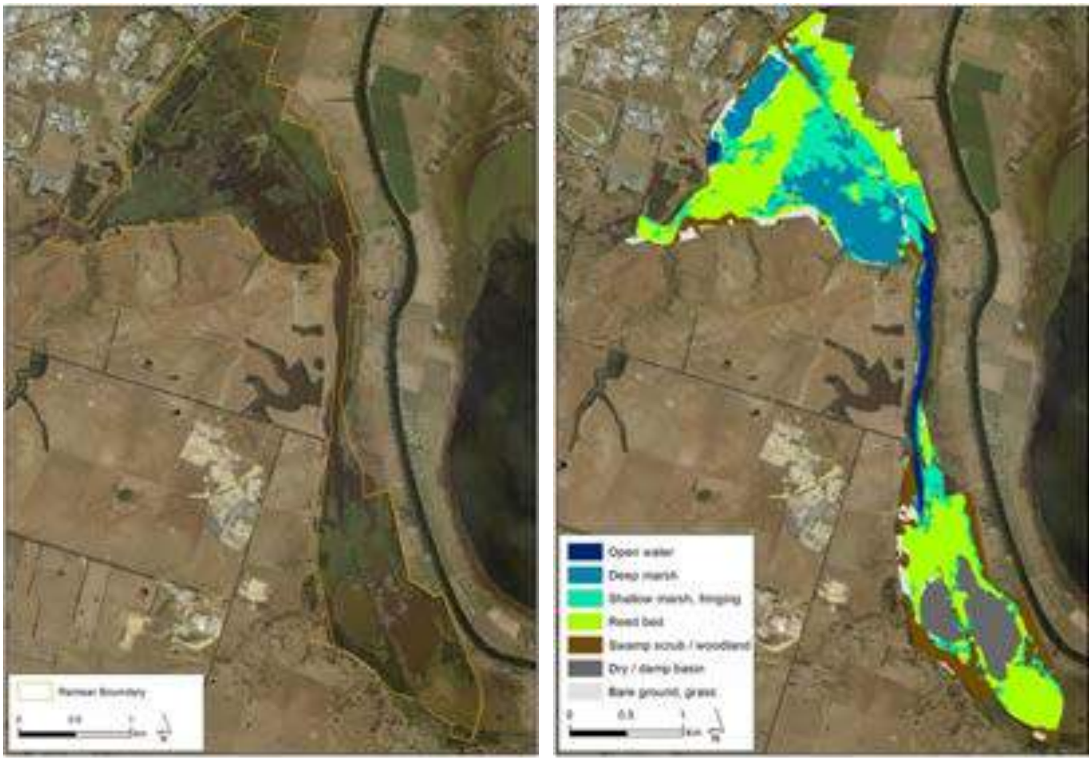


Figure 6. Macleod Morass aerial image (left) Maximum likelihood classification of Macleod Morass (right)

Conclusions

Initial investigations into alternative monitoring of habitat types within the Gippsland lakes Ramsar site have proved helpful in reducing costs and increasing the capacity to more robustly and reliably monitor key vegetation communities.

The Gippsland Lakes is an extensive Ramsar site with complex monitoring needs and a more cost-effective framework was required to understand the extent of different habitat types and help detect changes over time.

The GIS mapping techniques developed for seagrass mapping within the lakes have now been applied to seagrass, saltmarsh (not discussed in this paper), and freshwater wetland vegetation communities to produce vegetation distribution maps with high levels of confidence. The resulting maps are consistent with existing historical mapping and have matched the expectation and understanding of experience on ground practitioners when tested with them.

Whilst the resolution of satellite imagery products may limit the development of fine scale habitat mapping, this is often not required to make fundamental management decisions or answer higher level questions, like those related to vegetation extent or density.

The results produced have provided a sound base to answer monitoring questions, where previously resource limitations have been considered a barrier.

Monitoring ecological change across large landscapes can be complex and costly. If monitoring approaches are designed carefully around the questions being asked, more cost-effective and spatially extensive monitoring is achievable by using free remotely sensed data.

Acknowledgments

Thanks goes to Jennifer Hale and Dr Shane Brooks for their outstanding work in the development of these techniques for the Gippsland Lakes on behalf of the East Gippsland Catchment Management Authority. I would also like to acknowledge the Victorian Government and the Australia Governments National Landcare Program for providing funds that facilitated the design and implementation of this project.

References

BMT WBM. (2010). *Ecological Character Description of the Gippsland Lakes Ramsar Site*. Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra

EGCMA (2015). *Gippsland Lakes Ramsar Site Management Plan*, East Gippsland Catchment Management Authority, Bairnsdale.

Frood, D., Boon, P., Oates, A., Reside, J., and Maxwell, R. 2015. *Benchmarking Wetland Flora in the Lower Latrobe Wetlands*. West Gippsland CMA, Traralgon

Hale, J., and Brooks, S. 2019. *Gippsland Lakes Seagrass Monitoring Framework*. Report for the East Gippsland Catchment Management Authority, Bairnsdale.

Kitchingman, A. 2016. Gippsland Lakes Seagrass Mapping. Arthur Rylah Institute for Environmental Research, Heidelberg, Victoria.

Roob, R., and Ball, D. 1997. Seagrass: Gippsland Lakes: a report for Fisheries Victoria, Department of Natural Resources and Environment. Marine & Freshwater Resources Institute, [Melbourne].