Aquatic Botany 141 (2017) 17–21

Contents lists available at ScienceDirect

Aquatic Botany

journal homepage: www.elsevier.com/locate/aquabot

Short communication

A resourceful and adaptable method to obtain data on the status of seagrass meadows

Nicole R. Foster[a,*], Douglas G. Fotheringham[b], Daniel J. Brock[a], Michelle Waycott[a,b]

[a] School of Biological Sciences, University of Adelaide, Adelaide, South Australia 5005, Australia
[b] State Herbarium of South Australia, Botanic Gardens and State Herbarium, Department of Environment, Water and Natural Resources (DEWNR), Adelaide, South Australia 5001, Australia

ARTICLE INFO

Keywords:
Seagrass
Digital photographs
Remote sensing
South Australia
Coastal monitoring
Citizen science

ABSTRACT

Coastline degradation, as well as subsequent ecosystem loss, has long been attributed to anthropogenic stress and is an all too familiar issue affecting coastal habitats. Should management and conservation efforts fail to improve the quality of coastal ecosystems and the services they provide, they may be irrevocably damaged. A significant limitation to conservation efforts is often the ability to track change in seagrass meadows due to the significant time and cost of monitoring efforts in underwater habitats. Remote sensing is often a tool used to improve our knowledge of habitat status, however, ground-truthing remote sensing results is difficult when historical data is required. We apply an innovative and resourceful approach to the attainment of data to check the status of seagrass meadows from resources that are available in many areas due to the collection of other data sets. We employ the use of underwater digital photographs originally taken for monitoring sediment movement patterns. We were successfully able to develop a method to critically and easily evaluate these photographs for habitat status, enabling the generation of a data set unable to be obtained in other ways. This method can further be utilised in a citizen science project, for other underwater digital photographs, to support the assessment of coastal submerged ecosystem habitat status.

1. Introduction

Coastal ecosystems are regarded as the most valuable natural systems in the world, yet they are heavily overused and often subjected to intense anthropogenic stressors (Bernhardt and Leslie, 2013). Deterioration of these environments is all too common phenomenon where climate change, habitat degradation and urbanisation are all strong contributors (Seitz et al., 2014). Humanity has a high dependence on these systems, relying significantly on the ecosystem services they provide (Halpern et al., 2008). As population expansion continues at an alarming rate, such a reliance will put further strain on these vital habitats (Halpern et al., 2008). Within coastal areas, seagrass meadows are one of the most important systems but receive the least attention in comparison to other estuarine and coastal habitats (Barbier et al., 2011). Seagrasses provide some of the most valuable coastal ecosystem services such as protecting coastlines from erosion and sea level rise (Arkema et al., 2013), providing spawning and migration habitat for organisms (Seitz et al., 2014), sequestration of carbon and maintenance of fisheries through habitat provision (Barbier et al., 2011). While seagrasses are regarded as one of the most productive systems on the planet (Orth et al., 2006) and contribute highly valued ecosystem services, they are still declining worldwide (Waycott et al., 2009).

Seagrasses are a major component of coastal and estuarine ecosystems throughout the world including in South Australia, Australia, where they contribute to the aesthetic, economic and societal value of this region (Fotheringham, 2002). The Gulf of St. Vincent is the major metropolitan marine embayment in South Australia and has been denoted a highly productive system, characterised by sandy beaches and sublittoral meadows of seagrass (Neverauskas, 1987). This area has a long history of human induced seagrass decline, correlating strongly with point sources of pollution (Edyvane, 1999). This decline has now become more widespread increasing the susceptibility of these seagrasses to storms and physical erosion (Seddon, 2002). Seagrass monitoring in this region has previously been conducted via airborne hyperspectral imaging and aerial photography where field studies were used to corroborate information (Blackburn and Dekker, 2006). Field studies can be the most important tool for validating remote sensing data and providing accurate ground truth information in order to draw sound conclusions regarding marine and coastal systems (Gutierres et al., 2016). Such validating field data can be succinctly provided by

* Corresponding author at: School of Biological Sciences, University of Adelaide, North Terrace Campus, Adelaide, South Australia 5005, Australia.
E-mail address: nicole.foster@adelaide.edu.au (N.R. Foster).

http://dx.doi.org/10.1016/j.aquabot.2017.04.006
Received 5 November 2016; Received in revised form 25 April 2017; Accepted 25 April 2017
Available online 03 May 2017
0304-3770/

underwater digital photography.

In this study, we utilised the availability of underwater digital photographs that were previously acquired for monitoring coastline sediment movements. We developed a method to evaluate each photograph enabling its use as an estimate of habitat status. A total of nine locations were evaluated over a 16 year time period along the South Australian metropolitan coast. This region is characterised by dense meadows of *Posidonia* spp. sometimes growing alongside *Amphibolis antarctica* and *Amphibolis griffithii* with *Heterozostera tasmanica* occupying the edges and *Halophila australis* in sparse patches (Edyvane, 1999). This region has also experienced intense loss of seagrass meadows with an average loss of 85 ha $year^{-1}$ since the 1940s (Nayar et al., 2012), where this was correlated with areas of intensified human disturbance (Shepherd et al., 1989). Due to the high value ecosystem services seagrasses contribute to this system, conservation and restoration of seagrass meadows in this region is crucial.

2. Methods

2.1. Collation of data

Since 1997, seabed monitoring for erosion and deposition of sediment has occurred along the South Australian Metropolitan coast. Numerous brass rods have been placed along transects orientated perpendicular to the shoreline and are used annually to measure seabed height (Fotheringham, 2002). Along with these measurements, there is a collection of digital underwater photographs taken at each rod approximately at the four compass points (i.e. N, E, S, W) with associated field notes to validate the photographs. Photographs were not necessarily taken using the same camera, however, the camera was usually set to a wide-angle. We collated 2084 of these digital underwater photographs from various rods and years and compiled a database in FileMaker Pro™ (FileMaker Inc.) where the photographs could then be scored and comparisons made. Overall, this study incorporated nine locations along the South Australian coastline from 1997–2013 (Henley Beach 34.920°S 138.490°E, Taperoo 34.804°S 138.485°E, Semaphore Park 34.865°S 138.474°E, Tennyson 34.886°S 138.481°E, West Beach 34.937°S 138.495°E, Somerton Park 34.996°S 138.507°E, North Glenelg 34.965°S 138.506°E, North Brighton 135.007°S 138.501°S and North Brighton 235.016°S 138.510°E).

2.2. Scoring method

The scoring method was devised to elucidate all possible information from the underwater digital photographs and yet was simplified enough to be easily implemented into a citizen science project. Initially a flow diagram (Figure S1) was constructed for the scorer in order to aid them in deciding how they should proceed for each photograph. The possible categories that were scored are outlined below:

2.2.1. Seagrass presence

Every photograph was scored for seagrass presence regardless of frame size, however, in the instance the photograph quality was too poor the photo was removed from the analysis. This category was divided into four subcategories: No = When there was absolutely no seagrass, Yes living = All seagrass that was living, defined as being rooted to the ground, whether it was fully grown or just shoots, Yes dead = Yes there was seagrass and it was attached to rhizomes but it was dead, Yes drift = There was seagrass present but it was unattached to anything and was just lying on the sediment where it likely drifted in from another site, Can't tell = When the photo did not fall into any of the above four categories or when the scorer was unsure. Subcategories were looked at in the order shown above so that the photo was placed into whichever category first described it the best. For example, when there was both living and drift seagrass in the photo the category 'Yes living' was selected.

2.2.2. Percentage cover

Photographs were not standardised and therefore they were initially parametrised on the basis of their field of view i.e. whether the photo was angled to the horizon (Fig. 2B) or angled to the substrate (Fig. 2D). Only photographs angled to the horizon, encompassing an estimated 5 m^2 of landscape proceeded to be scored for percentage cover. The photo was scored as either < 5%, 5–30%, 31–60%, 61–80%, or > 80% as a part of the whole photograph. Drift and dead seagrass was only ever scored as < 5%. Each of these categories was given a corresponding number (1–5 respectively) in order to average the percentage cover for one rod i.e. N, S, E, W and for an entire transect.

2.2.3. Community structure

Photographs were then scored for species composition only if they met the requirement for having high resolution. A key was constructed for the scorer to easily identify species (Figure S2). The options provided were: 'Pos' – *Posidonia*, 'Pos_a' – *Posidonia australis*, 'Pos_s' – *Posidonia sinuosa*, 'Amph' – *Amphibolis*, 'Am_a' – *Amphibolis antarctica*, 'Am_g' – *Amphibolis griffithii*, 'Hal' – *Halophila*, 'Zos' – *Zostera*, 'Z_muel' – *Zostera muelleri*, 'Can't tell'. These were all listed under four subcategories: Single species = When only one species of seagrass was present whether living or dead, One species dominant = When there were clearly two species present whether they were living or dead but one was clearly more dominant than the other. Another category was available here to quantify percentage cover of the dominant species (see percentage cover section), No species dominant = When multiple species were present whether living or dead but the dominant species was not clear (multiple species could then be chosen), Unknown = This category was for when the scorer was unsure in any way, when the amount of seagrass was too small to determine the species i.e. percentage cover was < 5%, when there were multiple drift pieces or when epiphytes were too heavy to see the seagrass properly.

2.2.4. Sediment structure

Sediment structure was an additional comparison aspect between the photographs and shed some light on type of sediments seagrass were, or were not, growing in. This category was only scored if the photographs were of high resolution. The following four categories were established here: 'Sandy', 'Coarse', 'Flat', 'Obscured' and 'Can't tell'. 'Coarse' sediment was characterised by shells and small rocks within the sediment, the 'Obscured' category was useful for when the sediment type could not be observed as it was dominated by seagrass. The 'Can't tell' category pertained to photos where seagrass was in the front and sediment was in the back so a judgement could not be accurately made.

2.2.5. Epiphytes, other characteristics and other observations

This category was only scored when the photograph had high resolution. Epiphytic algae growing on the seagrass was simply classified as either 'Heavy', 'Light' or 'Can't tell' – for when the scorer was unsure. The 'Other characteristics' category was used to establish any reproductive structures present. Sub-categories for this were 'Flowering or fruiting' which was used for when there were any flowers or fruits on the seagrass. 'No reproduction' was used for when there was seagrass present but there were no observable reproductive structures (drift seagrass was also placed in this category). Finally there was 'Unknown reproduction' which was used when there were heavy epiphytes obscuring the image. 'Other observations' was the final category established in order to document anything that had not already been given a category such as other marine organisms present or a differing sediment structure.

2.3. Analysis

In order to validate the repeatability of the method and substantiate its implementation in a citizen science project, independent scoring of