RAPID ASSESSMENT OF SEAGRASS COVER CHANGE USING MIXTURE TUNED MATCHED FILTERING

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KEY WORDS: Seagrass, Mixture Tuned Matched Filtering, Landsat, Philippines

ABSTRACT: Seagrasses are submerged aquatic vegetation which are declining in cover through the years. Natural and anthropogenic factors contribute to this decline. Mapping coastal habitats using satellite imagery has always been a challenge because of the effects of the water column. Common methods require immense field data validation which are difficult and time consuming to collect. This paper discusses the ability of Mixture Tuned Matched Filtering (MTMF) to rapidly map and assess the change of seagrass cover using Landsat satellite multispectral images from years 2000, 2005, 2010 and 2015 along the eastern coast of Samar and Leyte, Philippines which took damage due to Typhoon Haiyan (Yolanda) last 2013. The Landsat images were radiometrically calibrated and atmospherically corrected using FLAASH (Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes). Field data taken last November 2015 was used to choose pure pixels for MTMF and also for accuracy assessment.

1. INTRODUCTION

The Philippines is composed of approximately 7,100 islands. It has one of the longest coastlines and most diverse coastal ecosystems in the world. Most of its people depend on marine and coastal biodiversity for their livelihood. Protection and proper management of coastal resources are important for a country like the Philippines.

Seagrasses are unique flowering plants (Kuo and McComb 1989), being the only angiosperms which are able to live completely submerge in water (Polina 2011). They produce flowers, fruits and seeds and they have an extensive root system to anchor themselves firmly to the sea bottom. They are from the lily family (Liliaceae) (L. J. McKenzie 2008) and should not be confused with seaweeds. Compared with other benthic marine primary producers, they are not taxonomically diverse having only 12 genera (Enhalus, Thalassia, Halophila, Posidonia, Syringodium, Halodule, Cymodocea, Amphibolis, Thalassodendron, Zostera, Heterozostera and Phyllospandix) (Kuo and McComb 1989) and 50-60 recognized and described species (Hartog 1970). In the Philippines, there are 10 known seagrass species (UNEP 2004).

Seagrass beds play an important role in marine environments. They are part of a complex ecosystem that supports different forms of life. For one, they are food to several marine species (PNSC 2004). Seagrasses also serve as breeding and nursing ground and habitat for fish and crustaceans. They also function as refuge to smaller marine animals hiding from their predators (IOSEA 2012). Moreover, when seagrasses die, they become organic matter that produces nutrients (nitrogen, phosphorus) (IOSEA 2012). Seagrasses also contribute to the physical structure of the environment. Sediments, as they pass through seagrass beds, settle which stabilizes the seabed and reduces erosion. Seagrasses also, in a way, maintain coastal water quality and clarity. They also act as wave and current absorber. Also, they help with the reduction of greenhouse gases by absorbing carbon dioxide and producing oxygen by photosynthesis (IOSEA 2012). Unfortunately, they are the most neglected coastal habitat. There are fewer research on seagrass compared to corals. Priorities for studies are aimed at other resources with immediate economic impacts, i.e., corals, seaweeds, animals, or fish that either live in coastal habitats or are associated with them.

Figure 1. Seagrasses in Leyte, Philippines

Assessment and monitoring of our marine environment is essential for coastal resource management. Being able to map seagrasses augment our knowledge of the seagrass ecology, emphasizes threats to seagrasses, and helps in finding ways of preventing possible losses and degradation (Polina 2011). Accurate, precise, and up to date information about the location and distribution of seagrasses is important for the sustainable preservation of the coastal ecosystem. Remote sensing techniques offer this capability in a cost-effective way but it has its limitations.

The Philippines, with an estimate of more than 60% of its population (Philippines Coastal & Marine Resources: An Introduction, 2005) living in coastal communities, posts a huge threat to seagrass meadows. Activities like fishing have direct effects on seagrasses while pollution and sediment runoff from communities causes indirect effects on them (PNSC, 2004). In the last 50 years, seagrass loss in the country amounts to about 30-50% (UNEP, 2004).

The objective of this research is to assess the seagrass cover change in Samar and Leyte, Philippines. Conventional classification methods require intensive fieldworks. If supervised classification will be used for mapping benthic habitats such as seagrasses, it will require several regions of interests to process the data. To rapidly assess the seagrass change, Mixture Tuned Matched Filtering (MTMF) is used in this research.

Mixture Tuned Matched Filtering uses the combination of matched filtering and infeasibility. Matched filtering is utilized to locate the abundances of endmembers which were defined by the user while the infeasibility image is used to lessen the false positives (Harris Geospatial Solutions, 2016).

2. MATERIALS AND METHODS

2.1 Study Area

The study area is in the eastern coast of Leyte and Samar, Philippines. Both provinces are found in Eastern Visayas. Last November 8, 2013, Yolanda, one of the strongest tropical cyclones ever recorded, made landfall in this area destroying natural and man-made resources. Seagrasses are among those affected by the typhoon.

Figure 2. Location Map of the Study Site

2.2 Methodology

To map the seagrass cover change in Eastern Leyte and Southern Samar specifically Tacloban, Basey, Lawaan, Balangiga and Marabut. Landsat images dated 2000, 2005, 2010, 2013 and 2014 were used. The 2013 and 2014 images were utilized to detect seagrass cover change after the Yolanda typhoon hit the Philippines last November 2013.

Table 1. Satellite Images Processed

Satellite Image	*Date of Acquisition*
Landsat 8	July 12, 2014
Landsat 8	July 9, 2013
Landsat 7	May 22, 2010
Landsat 7	March 5, 2005
Landsat 7	September 15, 2000

All images were radiometrically corrected using ENVI to obtain radiance values and were then converted to band interleaved by line format. To correct for the effects of the atmosphere, Fast Line-of-sight Atmospheric Analysis of Hypercubes (FLAASH) was employed. This tool uses the MODTRAN 4 algorithm. After such corrections, land features and deep water areas were masked to eliminate pixels not useful for this research.

Field data was gathered last November 10-12, 2015 to locate seagrass areas to be used as training dataset. A handheld GPS was used to mark the location of the seagrasses.

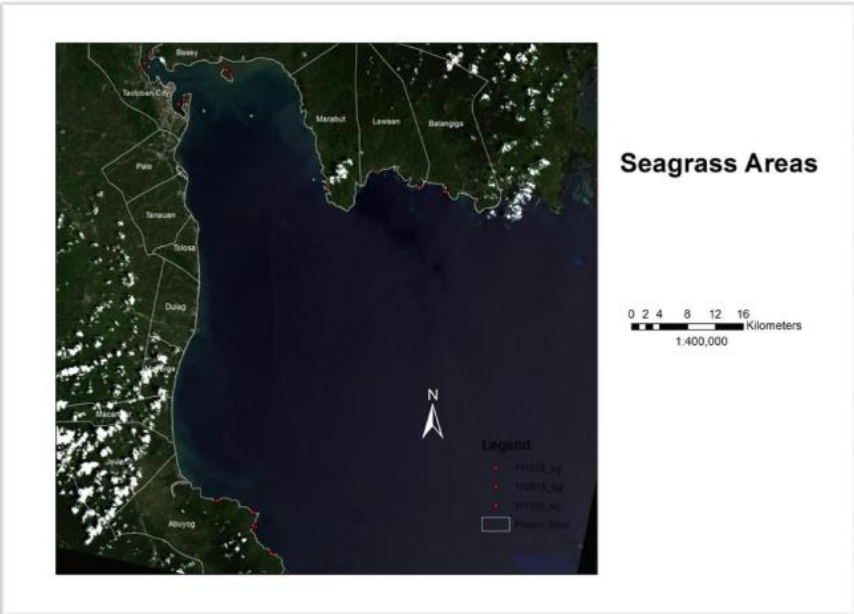


Figure 3. Field Data Points of Seagrasses

Mixture Tuned Match Filtering (MTMF) was the classification scheme used to map the seagrasses. The result of MTMF are the Matched Filtering (MF) score and the infeasibility score. These set of rule images were based on pure seagrass pixels selected from the original image. The pure pixels were selected from the gathered field data. A 2D scatter plot of the MF score and infeasibility score was created to select the values with high MF score and low infeasibility scores. These selections will correspond to pixels with high probability of seagrass cover. Selected pixels were then converted to classes. Majority analysis, a post classification method, was used to eliminate isolated pixels or noise from the classification output. The final classification was converted to vector format (shapefile) for mapping purposes.

3. RESULTS AND DISCUSSION

The seagrass location and area were calculated and mapped based on the results of the MTMF classification. Validating these results is difficult because there are no available field data of seagrasses from the previous years when the satellite images were captured. Figure 4 shows the seagrass maps before and after Yolanda hit the Philippines.

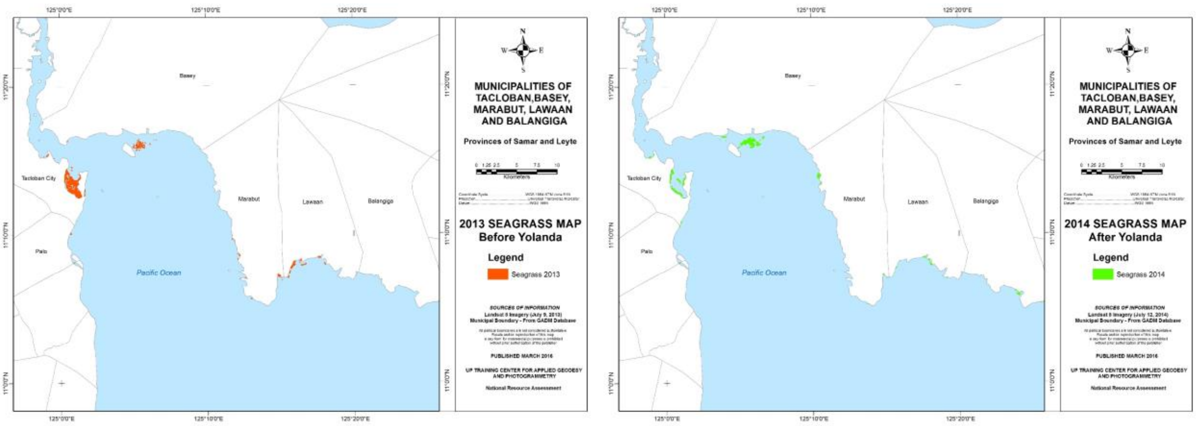
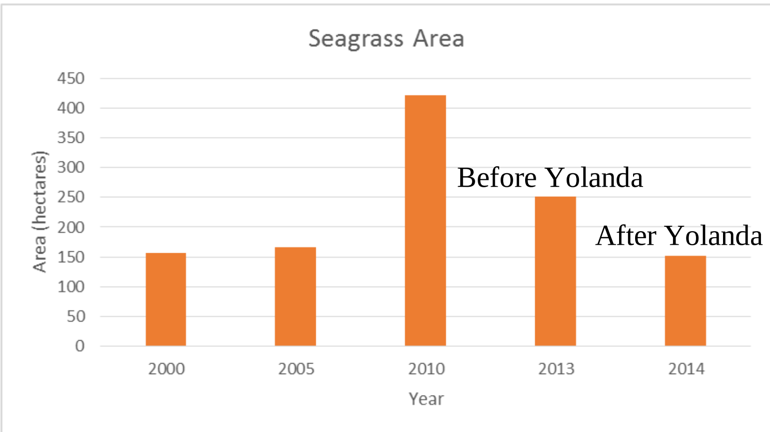


Figure 4. Seagrass Maps Before (Left) and After (Right) Yolanda

The seagrass cover was largest in area in 2010 while it was lowest in 2000. There was a decrease in seagrass cover area from 2010 to 2013.

Table 2. Comparison of Seagrass Area



The seagrass cover decreased after Yolanda hit the Philippines in November 2013. The area near Tacloban was damaged most by the typhoon while the seagrasses in Basey and Lawaan also decreased in area as shown in Figure 5.

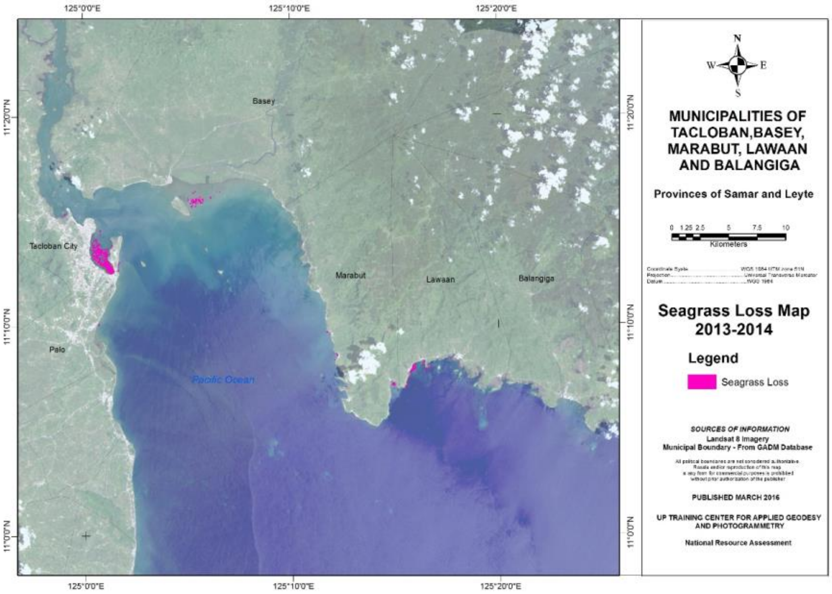


Figure 5. Seagrass Loss Map After Yolanda

Mixture Tuned Matched Filtering (MTMF) is an effective tool to rapidly assess the seagrass cover change in an area. Extensive fieldwork data is not mandatory to be able to use this method. The need to locate other benthic covers is also not necessary which decreases the duration of fieldwork needed. It is recommended to assess the accuracy of the method by using recent images which corresponds to the period of field data gathering.

4. ACKNOWLEDMENTS

The authors would like to thank the Climate Change Commission for funding the National Resource Assessment project and the Department of Science and Technology for funding the dissemination of this research.

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