DISTILLING AN OCEAN OF DATA:

A COMPLIANCE TOOL TO INFORM MARINE PROTECTED AREA MANAGEMENT

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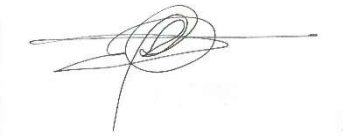

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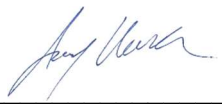

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Amy Work

Abstract

The Maldives Whale Shark Research Programme (MWSRP) collects spatial, biological, oceanographic, and anthropogenic data on whale sharks in the South Ari Atoll Marine Protected Area (SAMPA). There is a need to develop GIS capabilities within the organization in order to further explore, visualize, and analyze data, create 2D maps, and share their findings in a more effective and efficient manner. This need is all the more important in the present time due to the push for better management of SAMPA. In my capstone, I aim to build the GIS capacity at MWSRP by creating a visualization and mapping tool to help create the communication material to contribute to the planning process for better management of SAMPA and to ensure the best conservation measures are taken for the protection of the whale sharks.

Introduction

The Republic of Maldives, located in the Central Indian Ocean, is one of only four atoll nations and is thus, extremely vulnerable to the impacts of sea level rise and climate change.[1] The Maldives is also a popular tourist destination for tourism and water-based activities such as diving and snorkeling. Shark watching is considered an important aspect of dive tourism.[2] Reef sharks such as the white tip shark, black tip reef shark and whale sharks are frequently watched by tourists.

Tourism, although integral to the local economy, also poses several challenges for the conservation of the marine life and habitat of the Maldives. Whale sharks are often sighted with injuries from boat propellers and are also harassed by enthusiastic tourists due to poorly regulated tourism and weak enforcement in the protected waters surrounding the islands.

In the Maldives, whale sharks, *Rhincodon typus*, are a popular draw for tourists since they have a semi-annual residency pattern, thus making it easy to find them throughout the year.[3] They are known to move west from December to April and east from May to November.[4] The Indo-Pacific population has been assessed as threatened by the IUCN and the Atlantic population as vulnerable. However, seeing as that the bulk of the population occurs in the Indo-Pacific, the

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[1] Kench P. (2011) Maldives. In: Hopley D. (eds) Encyclopedia of Modern Coral Reefs. Encyclopedia of Earth Sciences Series. Springer, Dordrecht

[2] Edgar Fernando Cagua et al., *Whale shark economics: A valuation of wildlife tourism in South Ari Atoll, Maldives*, 2014 PEERJ e515 (2014).

[3] Morgan J. Riley et al., *Analysis of whale shark Rhincodon typus aggregations near South Ari Atoll, Maldives Archipelago*, 8 Aquat. Biol. 145–150 (2009).

[4] Giulia Donati et al., New insights into the South Ari atoll whale shark, Rhincodon typus, aggregation (2016).

global population has been assessed as threatened and the overall decline is inferred to be greater than 50%. Globally, the Whale Shark is therefore assessed as Endangered.[5]

MWSRP began as a scientific expedition in 2006 and has now become the only long-term organization dedicated to study the iconic, yet vulnerable whale shark species in the Maldives. For over a decade, MWSRP has been collecting spatial, biological, oceanographic, and anthropogenic data in the field focused on but not restricted to whale sharks. In 2009, their work on the core habitats of this species helped provide the baseline data needed for the creation of the Maldives largest protected area - SAMPA.

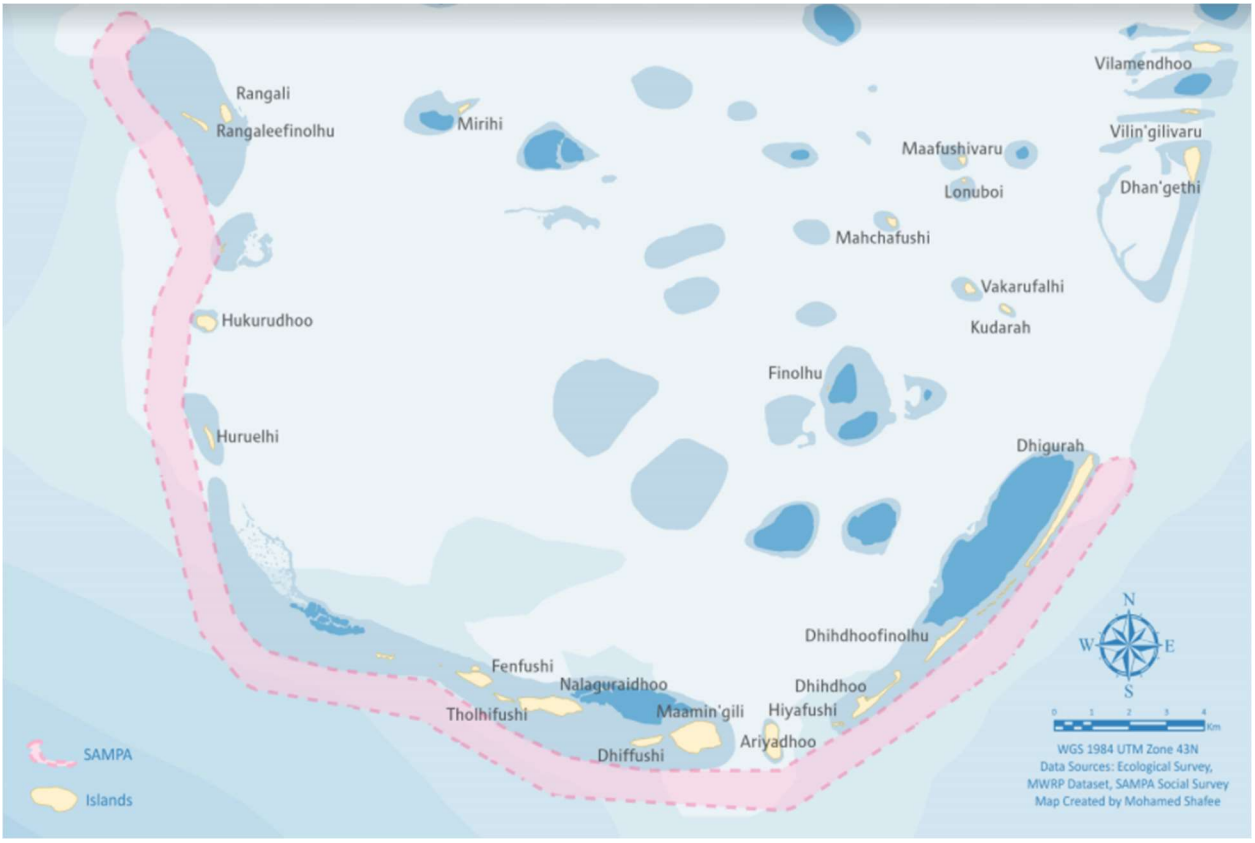

Figure 1: SAMPA boundary

MWSRP provides annual reports with their research findings that assist in informing the government (Environmental Protection Agency) of the status of the whale sharks and local marine habitat, the issues and challenges present in the area and the best practices and measures to ensure their protection and conservation.

[5] Pierce, S.J. & Norman, B. 2016. Rhincodon typus . The IUCN Red List of Threatened Species 2016: e.T19488A2365291.

There is a need to develop GIS capabilities within the organization in order to further explore, visualize, and analyze data, create 2D maps, and share their findings in a more effective and efficient manner. This need is all the more important in the present time due to the push for better management of SAMPA.

Recent government action has resulted in the creation of a planning committee that conducted a stakeholder consultation to hear the needs of all interested parties. The goal is determining the best ways to improve the management and enforcement in the marine protected areas. As a part of their mission and their status as the only organization that conducts data collection and research on the whale shark species, MWSRP plays an important role in being able to inform the governing body of the latest findings and what needs to be prioritized while putting such measures into place.

Objective

In this project, my aim was to help design and begin the development of a platform – an interactive mapping and visualization tool – that will help communicate the data collected by MWSRP.

The Design

The platform is a web-based application currently hosted by Rshiny io. The tool (Figure 2) was developed using R, Rshiny, and leaflet packages.

The goal is to provide an interface for the data and allow the user to filter through it and visualize it in table and map form. The tool has the following parts –

1. Input section for user selections (Figure 3)
   a. Temporal filtering
   b. Indicator choice
2. Output section for the filtered data
   a. Map form (Figure 4)

Figure 2: Overview of the tool

b. Table format (Figure 5)

I. User input selection

A. Temporal filtering –

The user can filter the data temporally using the input fields provided in the tool (Figure 3).

1. Seasons
    a. High Season – December to April
    b. Low Season – May to November

2. Year

3. Month

4. Day of the week

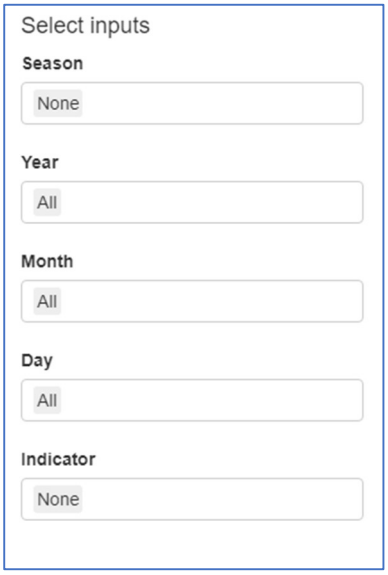

Figure 3: User input selection fields

B. Indicator –

The user can also select an indicator from the drop-down menu.

The filtered data needs to be put into a context that directly relates to proposed regulations. Therefore, defining useful indicators that can help inform management decisions is very important. These indicators signify what we want to understand from the filtered data in order to meet a management need. They help us put the data in a context that needs to meet a certain criterion to help gauge the level of compliance. Examples of indicators are whale shark behaviour, number of vessels at a whale shark encounter.

II. Output

A. Map –

The filtered data points can be viewed in the bottom panel in a map of the Maldives as seen in Figure 3. The map will update as the user input selections are modified and is zoomable. An overlay of the SAMPA boundary on the map can help provide additional context to the data points on the map.

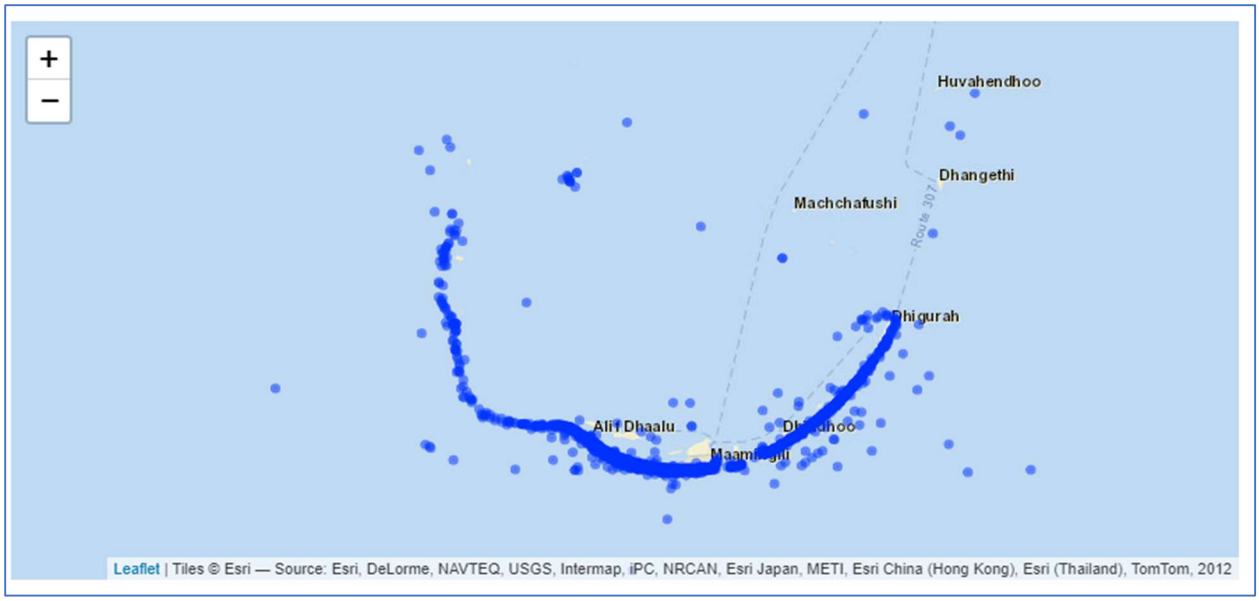

Figure 4: Output map

B. <u>Data tables</u> –

The filtered data points can also be viewed in table format as seen in figure 4.

In this example, we can see the location of the data point, the year it was recorded in, the month number, the behaviour of the whale shark, and the exact latitude and longitude of the whale shark.

Whale shark behaviour can be classified as:

1. C – Cruising
2. I – Interactive
3. E – Evasive
4. F – Feeding

Summary | DataTable

name	years	months	behaviours	lat	long
Maldives	2006	4	C	3.47	72.80
Maldives	2006	4	E	3.47	72.81
Maldives	2006	4	C	3.47	72.81
Maldives	2006	4	C	3.47	72.81
Maldives	2006	4	C	3.47	72.82
Maldives	2006	4	E	3.47	72.81
Maldives	2006	4	C	3.47	72.80
Maldives	2006	4		3.48	72.81
Maldives	2006	4	E	3.47	72.82
Maldives	2006	4	C	3.47	72.80
Maldives	2006	4	C	3.48	72.79
Maldives	2006	5	F,E,I	3.48	72.88

Figure 5: Output data table and summary

Usage examples

1. Using the indicator for whale shark behaviour, the tool can be used to view the behaviour observed during encounters. If a comparison is made between the observed behaviour during the high and low seasons, it could help us better understand the impact of tourism on whale shark behaviour and thus inform policy making accordingly.

2. Another indicator is the number of boats present at a whale shark encounter. This indicator can be used to compare the presence of vessels between the different days of the week to gain better insight into current trends. This could help inform the limits and regulations to impose on vessel permits and entry into SAMPA.

Further expansion

I. User input selection

Apart from allowing temporal filtering, the user could be allowed to spatially filter the data points by zones proposed for SAMPA such as dive zones, whale shark zones, fishing zones, and multi-use zones (Figure 6).

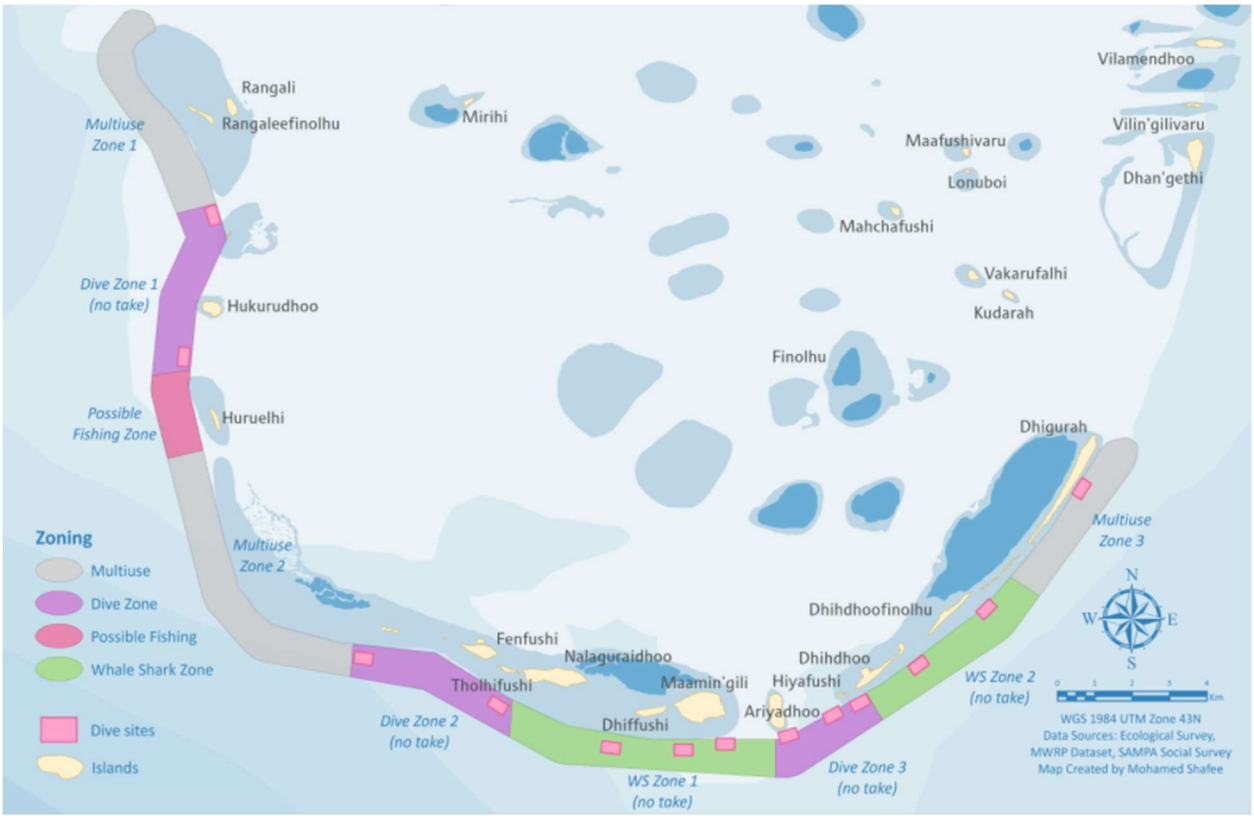

Figure 6: SAMPA proposed zones

II. Output

Based on the indicator selected, additional supporting data can be viewed in the Summary tab in this output section as well in the form of tables, histograms and other graphs.

Acknowledgement
This capstone project would not have been possible without the support of my Capstone Advisory Committee and the MAS MBC staff at Scripps Institution of Oceanography. Additionally, I would like to thank Clara Perez (Operations Manager, MWSRP) and Jessica Harvey-Cox (Data Manager and Scientific Advisory Board Member, MWSRP) for their tireless support. Lastly, I would like to thank my lovely friends and family for their constant encouragement.