Restoration of Cold-water Coral along the European Continental Shelf

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Abstract

The population of Cold-water coral in the Northeast Atlantic has been in decline since the early 20th century. Recently, efforts towards the preservation of cold-water corals in this region and other similar regions have been made. This paper aims to use historical data to locate the regions in the Northeast Atlantic most suitable for coral survival. Once these regions are identified, an expedition can be planned to perform restoration activities at these identified regions.

1. Introduction

Coral reefs are typically associated with the shallow-water tropical regions. However, increases in commercial fishing in deep waters as well as advances in remote data collection have revealed a rich coral ecosystem in the cold, deep waters of the North Atlantic. (Freiwald 2002).

Along the European continental shelf, which is the focus of this paper, these rich coral ecosystems boast a diverse range of coral and fish species. They have been a focus of study for ecologists in recent times as they seek to better understand these ecosystems and act to protect them (Frank et al., 2011).

Since as early as the 1920s trawlers and fishing boats were operating in deep waters previously unexplored. Their fishing nets became tangled in the coral resulting in a loss of economic profit. Efforts to map these coral regions began so that fishermen may avoid the areas with deep-water coral (Joubin 1922, Le Danois 1948). The increase of fishing activities in the region along the European continental shelf has resulted in habitat destruction of these ecosystems. Recent conversation efforts have sought to protect habitats in similar regions (Monettseny et al., 2019) but few restoration efforts have been made specifically in the region of the European continental shelf.

Presented here is an analysis of this region which seeks to aid in the conservation effort by identifying the best sites for restoration activities and to develop a potential route an expedition could take to visit these sites.

2. Methodology

Species Distribution Modelling aims to combine environmental data and/or spatial data, often obtained through advances in GIS, with on-site location data. Observances of a species may be made by an ecologist on location. This information can be used with environmental and spatial data to predict species distribution across a larger landscape where available sample data may be sparse (Elith and Leathwick, 2009).

Field observations of coral locations were obtained from the historical maps of Le Danois (1948) and Joubin (1922) which mapped the locations of carbonate mounds and corals respectively. Both of these data sources are presence-only and contain some biases as they only contain information about the presence of coral in common fishing regions. Environmental data of this region was also obtained including the bathymetry, current velocity, oxygen levels, salinity levels, and temperature data of the region. Additional spatial data was calculated from the bathymetry data including the aspect, slope, topographic position index, and topographic ruggedness index.

The Joubin data and the environmental data were used to create a species distribution model using the MaxEnt program (Phillips et al., 2006). MaxEnt is a method that specializes in modeling presence-only data and has been available since 2004, becoming a common method for ecologists around the world (Elith et al., 2011).

From the model, the five largest areas with a probability of at least 0.90 were considered as the primary zones for restoration efforts. The pole of inaccessibility for each zone was used to mark the specific candidate sites within these zones and are referred to as Joubin targets. The pole of inaccessibility for each carbonate mound of the Le Danois data was found separately to generate additional candidate sites known as Le Danois targets. With these candidate sites identified, an expedition can be planned to visit these candidate sites to perform restoration activities.

3. Results

First, a discussion on the chosen candidate sites and the performance of the MaxEnt model will be had. Using the chosen candidate sites, a route for an expedition can be determined.

3.1. Choosing Candidate Sites

The MaxEnt model generated an ROC curve with an AUC of 0.953 (Figure 2) which indicates a model with very good performance. The map in Figure 1 shows the output of the MaxEnt model. Areas of high probability occur along the ridge line which, by visual inspection, aligns with the trends of the location of coral from the historical data sources.

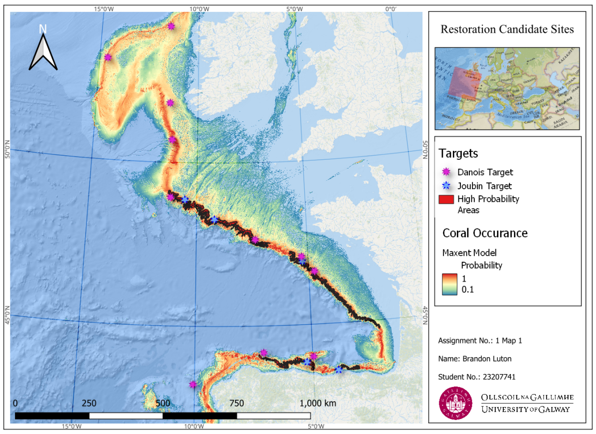

Figure 1. Potential Candidate Sites for Coral Restoration

Figure 3 shows that bathymetry is the most valuable attribute for prediction with a permutation importance of 63.7, far exceeding all other variables. Temperature, while having a high percent contribution, has a low permutation importance likely suggesting that temperature is correlated with bathymetry. Other variables such as TPI, current velocity, and aspect offer little to no insight into making predictions of coral presence. From the MaxEnt output, the five largest areas of positive predictions had a candidate site chosen within that region via a pole of inaccessibility calculation. From the map, it can be seen that the most likely region of coral population is the region of the ridge between 50°0N and 45°0N as that is where the largest areas were found.

3.2. The Expedition

With the candidate sites located, eight candidate sites were selected as stops on the expedition. These eight candidate sites were selected based on their location relative to other candidate sites. Restoration sites that were far away from other sites were not feasible to go to whereas candidate sites that were close together were given priority since an agreement between the Le Danois and the Joubin historical data would suggest a site with greater potential for good results.

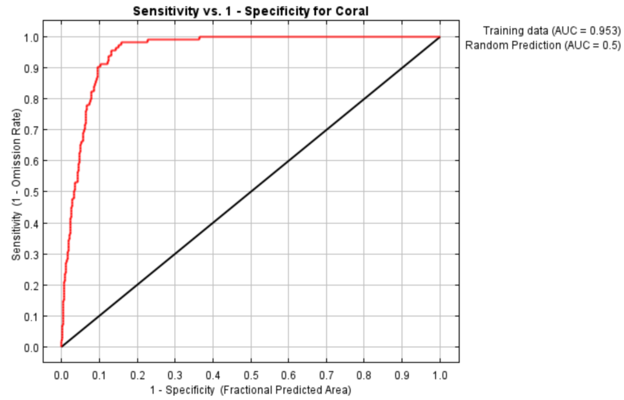

Figure 2. ROC Curve for MaxEnt Model

Table 1. Analysis of Variable Contributions

Variable	Percent contribution	Permutation importance
temperature	41.9	6.8
bathy	19.7	63.7
oxygen	13.4	1.2
slope	9.9	2.2
salinity	9.3	8.5
tri	2.9	13.8
current_velocity	1.7	2.1
aspect	1	1
tpi	0.2	0.7

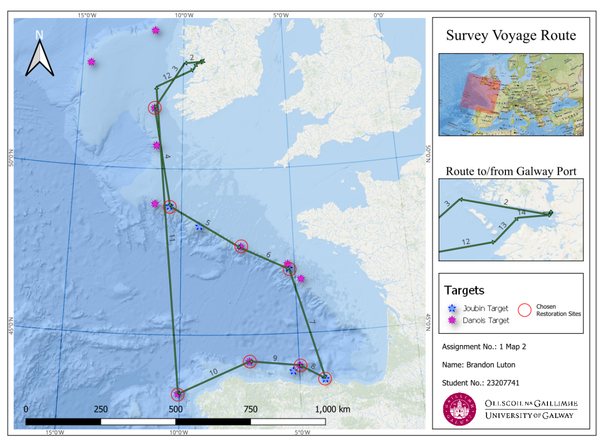

Figure 3. Route of the Celtic Explorer

Once the eight restoration sites were chosen, a route was planned with the Celtic Explorer leaving from Galway City and returning there after the expedition. The exact route can be seen in Figure 3.

The distances between the restoration sites are calculated along with the estimated times to travel to each site in Table

Table 2. Expedition Time Table

ID	Station #	Length (NM)	Distance (NM)	Time (hr)
	Mobilization			24
	Weather			12
1		1.695		
2		33.059		
3		96.951	131.705	16.4631
	1			24
4		180.025	180.025	22.5031
	2			24
5		147.483	147.483	18.4354
	3			24
6		96.367	96.367	12.0459
	4			24
7		207.361	207.361	25.9201
	5			24
8		52.419	52.419	6.55238
	6			24
9		90.203	90.203	11.2754
	7			24
10		142.577	142.577	17.8221
	8			24
11		556.741		
12		73.906		
13		11.836		
14		11.902		
15		1.685	656.07	82.0088
	Demobilization			24

2. A total of 20 days was allocated for this expedition with the assumption that the Celtic Explorer travels an average of 8 knots. This time estimate includes traveling to all the restoration sites, 24 hours at each site to perform the necessary tasks, 48 hours total for mobilization and demobilization, and 12 hours to account for bad weather conditions.

4. Conclusion

From the historical data provided by Joubin and Le Danois and the environmental data of the Northeast Atlantic, a species distribution model, using the MaxEnt model, was able to predicate the locations of probable coral activity in which to focus the coral restoration efforts. These regions of high coral probability are found along the ridge and specifically between 50°0N and 45°0N. Eight candidate sites were chosen for an expedition to visit and a route for the expedition was planned along with an estimate of the time of the voyage. This analysis should aid in future coral restoration efforts in the Northeast Atlantic.

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