Investigating the distribution of foraging sites of loggerhead sea turtles, *Caretta caretta*, in the Mediterranean Sea

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Abstract

- A better understanding on the distribution of highly migratory marine megafauna and the potential exposure of their habitats to anthropogenic activities is essential for their effective protection.

- Here, we deliver a comprehensive view on the distribution of foraging grounds for the representatives of marine megafauna, loggerheads, *Caretta caretta*, in the Mediterranean Sea, along with an assessment on their exposure to fisheries.

- Using the available published satellite tracking information on the adult Mediterranean foraging loggerheads, we built a series of distribution models to develop a map of the foraging grounds across the basin. We also assessed the exposure of the delineated foraging grounds to the cumulative risk due to different types of fisheries.

- Our findings revealed that the foraging grounds for adult loggerheads extended over the 9% of the Mediterranean Sea. We identified well-established areas in the central Mediterranean Sea but also sites, at the western part, for which the current knowledge was restricted. The exposure of the foraging grounds to fisheries differed across the basin, with the Adriatic Sea being under the highest level of risk.

- The developed approach, combining modeling techniques and risk assessment, allowed to reveal critical sites for loggerheads on which conservation actions should focus.

Keywords: bycatch; conservation planning; ecological niche models; marine turtles; risk assessment

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Introduction

Loggerhead sea turtles:

- ✓ representatives of charismatic marine megafauna
- ✓ highly migratory species
- ✓ use distinct areas for different life-cycle stages

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Introduction

Mediterranean loggerhead sea turtles:

- ✓ represent a distinct population with specific biogeographical, demographic and genetic characteristics

- ✓ local studies have been conducted at the basin focusing on foraging period

? What is the distribution of foraging areas at the basin scale?

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Introduction

Mediterranean loggerhead sea turtles:

- ✓ fisheries represent a major threat

- ✓ over 132000 incidents of bycatch have been recorded on a yearly basis

- ✓ more than 44000 deaths have been estimated per year

❓ To what extent are foraging grounds subjected to risk due to fisheries?

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Aim

➢ The delineation of foraging grounds of adult loggerhead sea turtles in the Mediterranean basin

➢ The assessment of the exposure of these habitats to the cumulative risk due to different types of fisheries

Methods

Step 1:

- **Collection** of presence points of foraging sea turtles via literature review
  - ✓ Adult individuals
  - ✓ Spatial data from satellite telemetry
  - ✓ Exclusion of rehabilitated turtles

- **Georeference** and **digitization** of presence points (n=119)
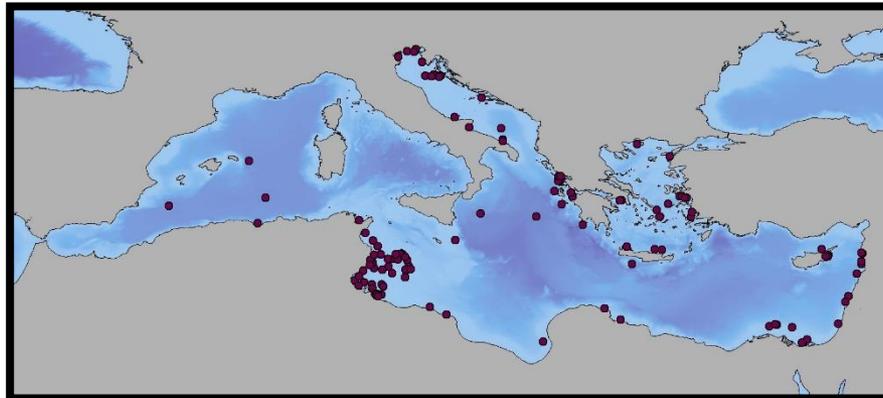
Methods

Step 2:

- **Determination of current climatic conditions**
  - ✓ Sea surface temperature (SST) data for the Mediterranean Sea
  - ✓ 0.0625° spatial resolution over the period 1991-2020

SSTs from September to March ➡️ the most representative period of foraging activity in the region

- **Estimation of bioclimatic variables**
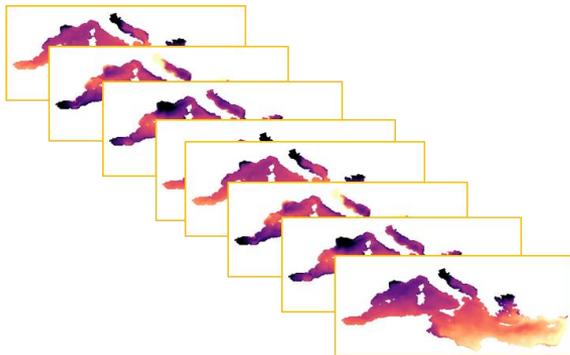
Exclusion of highly correlated variables

Mean diurnal range
SST range of the 7month period
SST seasonality
Minimum SST of the coldest month

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Methods

Step 3:

- **Development of species distribution models**

Bioclimatic variables

ensemble modelling approach

| GAM | GLM |
| RF | MARS |

Presence points

Distribution map with continuous probability of occurrence
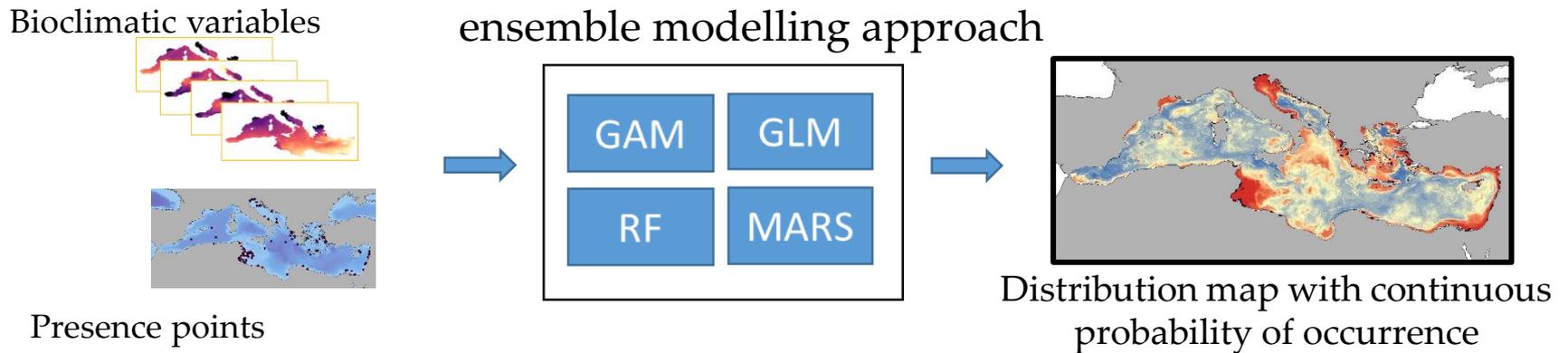
- **Delineation of foraging grounds across the Mediterranean Sea**

  ✓ Transformation of the continuous model output to binary **presence/absence** map

  ✓ Intersection with neritic zone, i.e., **depth less than 200m**

  ✓ Intersection with the seven **marine ecoregions** in the basin

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Methods

Step 4:

- Collation of data on fishing effort for four types of fishing gears:
  - ✓ longline
  - ✓ trawling
  - ✓ fixed net
  - ✓ purse seine
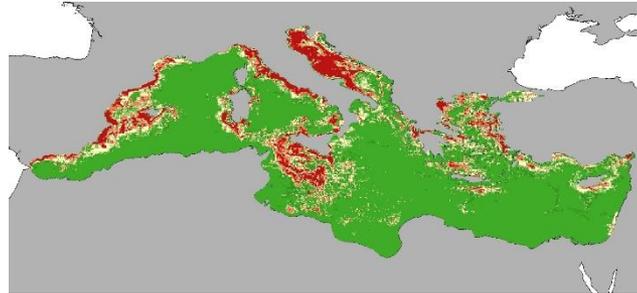
- Estimation of cumulative risk from the different types of fisheries
- Ranking risk values within five classes with equal number of features based on their probability distribution.

1 cell

or   or   or   or

| Very low | Low | Medium | High | Very high |
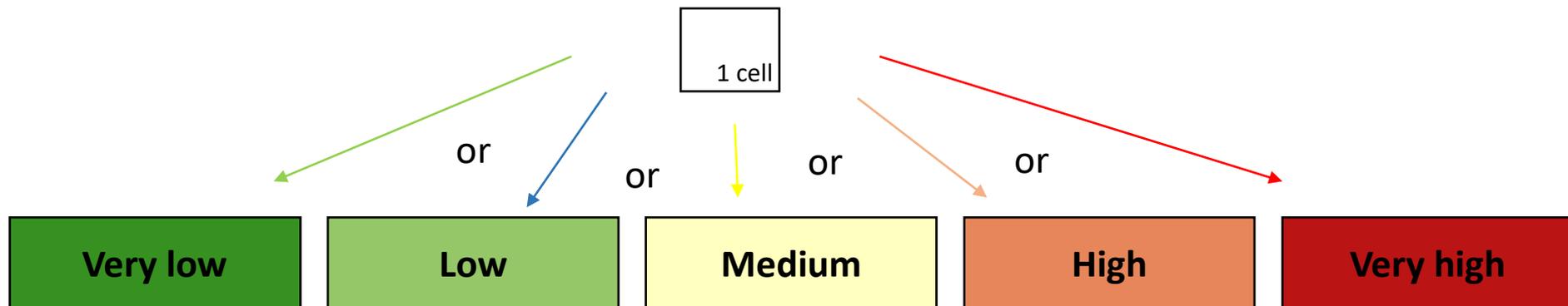
Results and Discussion

- Foraging grounds for adult loggerheads covered the 9% of the Mediterranean Sea
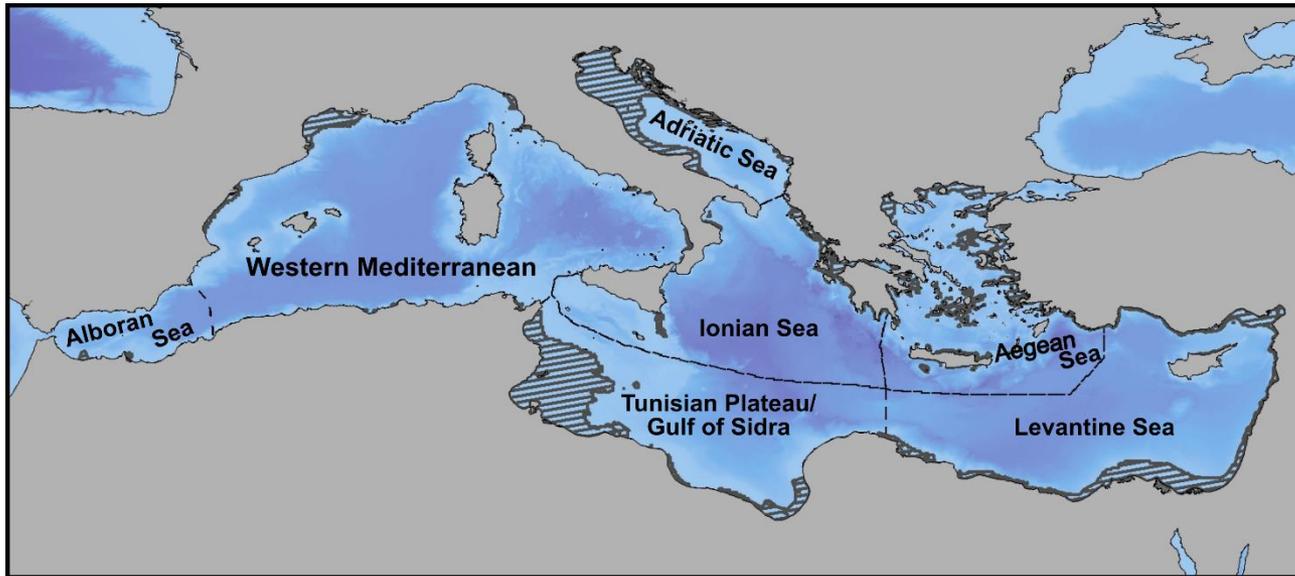
- *Largest percentage* of foraging grounds was located at the **Central** and **Eastern Mediterranean**

- Well established areas such as the **Adriatic sea** (24% of the total foraging area) and the **Tunisian Plateau** (31.75%)

- Known frequented areas such as the **Levantine Sea** (19.19%) and parts of the **Aegean Sea** (13.05%)

- Limited extent of foraging grounds was found at the **Western Mediterranean**, at French and Spanish coasts (7.13% of the total foraging area), for which the current knowledge was restricted.

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Results and Discussion

- More than 40% of the foraging grounds were exposed from medium to very high levels of threat, with variations being detected across the Mediterranean Sea
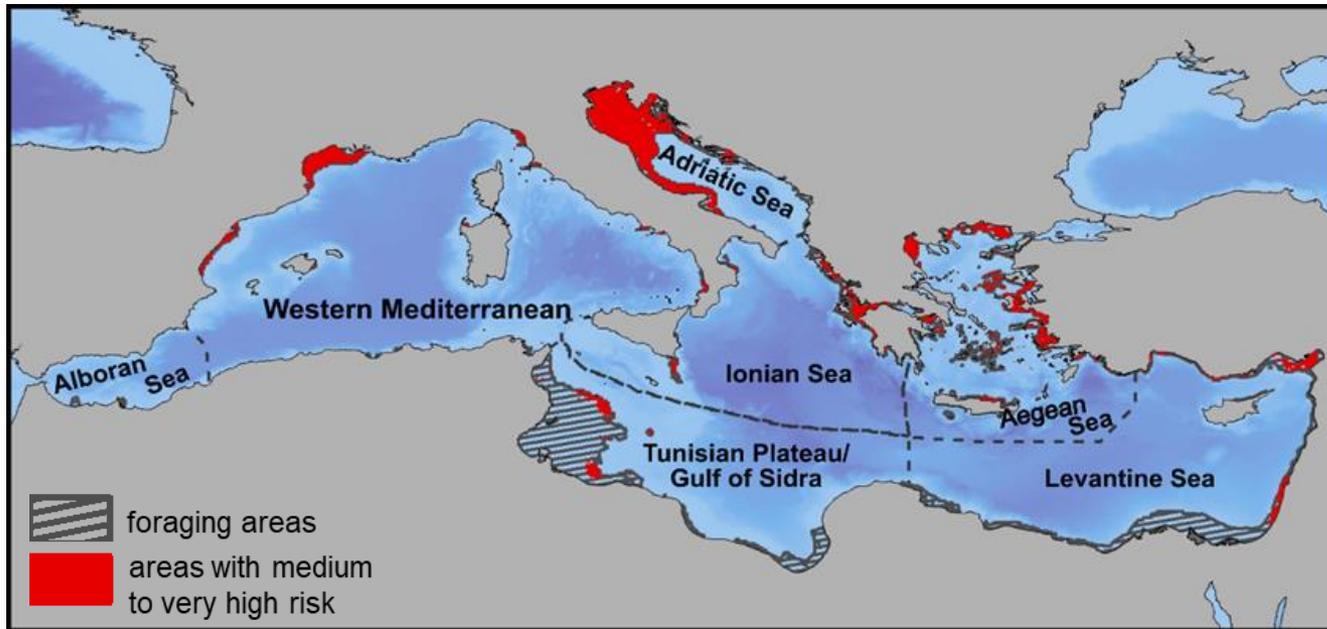
- **Adriatic sea**: a *hotspot* of risk of interaction with fisheries (73.47% of its extent subjected to high and very high risk)

- **Western Mediterranean**: 57.51% of the foraging grounds under *high* and *very high* levels of threat, confirmed by large number of capture events in Spanish waters.

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Results and Discussion
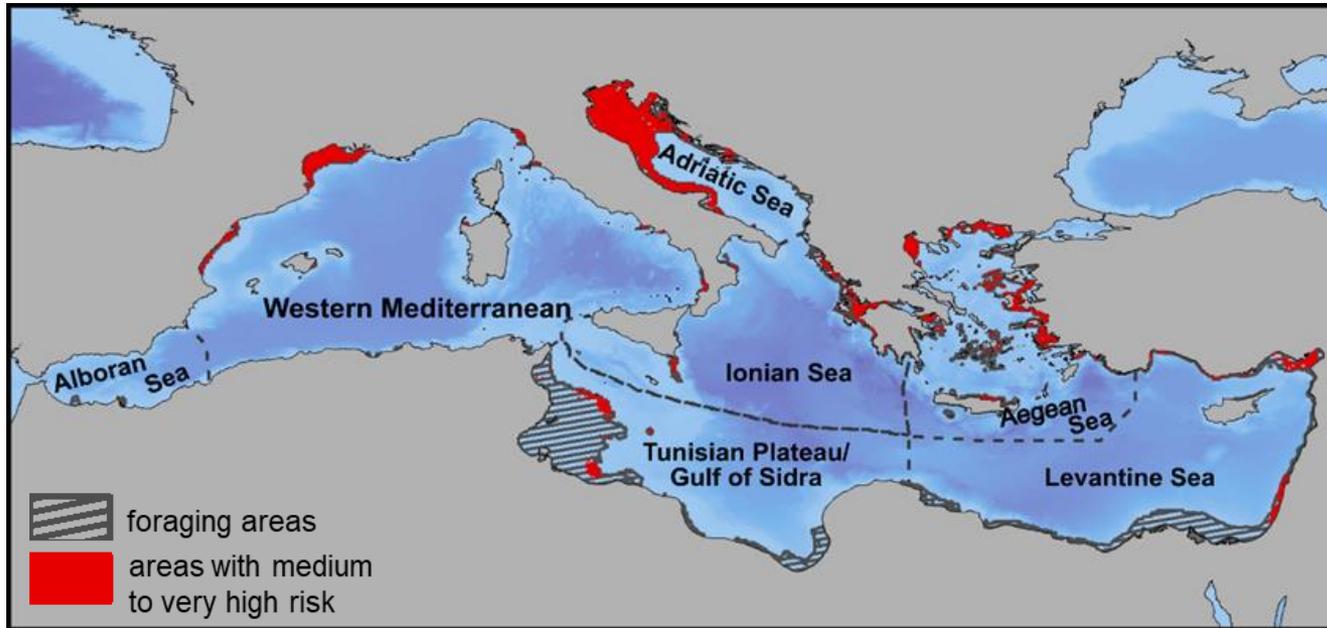
- Lower percentages of risk detected at **Levantine Sea** and **Tunisian Plateau/Gulf of Sidra**; however, they should be treated with caution due to poor coverage of fisheries data.

- More than half of the foraging area hosted within the **Aegean** and **Ionian Sea** exposed from *medium* to *very high* levels of risk (54.38% and 51.52% of the foraging area, respectively), with increased frequency of interactions between fishermen and sea turtles to have been observed both in Greece and Turkey

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Conclusions

➢ The current study provided a profound knowledge on the distribution of key foraging sites for loggerhead sea turtles across the entire Mediterranean basin.

➢ The assessment of the exposure of the foraging grounds to different types of fisheries allowed us to identify critical regions for which potential interventions should be considered

➢ Additional fine-scale assessments should be conducted to provide specific guidelines for an effective protection and conservation of the habitats of loggerhead sea turtles.

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Acknowledgments

ΕΣΠΑ
2014-2020
ανάπτυξη - εργασία - αλληλεγγύη

Ευρωπαϊκή Ένωση
European Social Fund

**Operational Programme
Human Resources Development,
Education and Lifelong Learning**

Co-financed by Greece and the European Union

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2021