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

Vasiliki Almpanidou1*, Anastasia Chatzimentor1, Vasiliki Tsapalou1,2, Antonios D. Mazaris1

1 Department of Ecology, School of Biology, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
2 Groningen Institute for Evolutionary Life Sciences, University of Groningen, 9712 CP Groningen, The Netherlands

* Corresponding author: valmpani@bio.auth.gr

This research is co-financed by Greece and the European Union (European Social Fund- ESF) through the Operational Programme «Human Resources Development, Education and Lifelong Learning» in the context of the project “Reinforcement of Postdoctoral Researchers - 2nd Cycle” (MIS-5033021), implemented by the State Scholarships Foundation (IKY).
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
Introduction

Loggerhead sea turtles:

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

Step 3:

- Development of species distribution models
  - Distribution map with continuous probability of occurrence
  - Ensemble modelling approach
    - GAM
    - GLM
    - RF
    - MARS
  - 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

- Delineation of foraging grounds across the Mediterranean Sea
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.
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.
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.
Results and Discussion

- 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.

- 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.
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.
Acknowledgments

This research is co-financed by Greece and the European Union (European Social Fund- ESF) through the Operational Programme «Human Resources Development, Education and Lifelong Learning» in the context of the project “Reinforcement of Postdoctoral Researchers - 2nd Cycle” (MIS-5033021), implemented by the State Scholarships Foundation (IKY).