ADDRESSING THE INTERACTION BETWEEN SMALL-SCALE FISHERIES AND MARINE MEGAFAUNA IN GREECE

Technical Report: Phase I (Interim Report)

Pardalou Androniki[1], Giannoulaki Marianna[2], Alberini Amalia[3]

[1]Aristotle University of Thessaloniki, Thessaloniki, Greece, [2]Hellenic Center for Marine Research, Heraklion, Greece,

[3]WWF Greece, Athens, Greece

@N.Godsil/WWF Greece

2021

PARTICIPANTS OF PHASE I OF THE PROJECT

Project Coordinator: Alberini Amalia

<u>Direct partners</u>

WWF Greece team:

Alberini A. (lead),
Margaritis M. (field team coordination),
Apostolopoulos G., Godsil N., Konida A., Stappa P. (field research)

AUTh team:

Pardalou A. (field work and team coordination, data analysis, field research, interim reporting),
Tsikliras A. (data analysis, reporting),
Nalmpanti M. (field research)

HCMR team:

Giannoulaki M. (lead, strandings events analysis),
Tsagarakis K. (advisor, strandings events analysis),
Zannaki K., Solanou M. (field research),
Tsoukali S., Despoti S. (data input & revision of strandings database)

<u>Indirect partners</u>

Andreanidou K. (Mediterranean Association to Save the Sea Turtles - MEDASSET),
Damalas D. (Hellenic Centre for Marine Research - HCMR),
Frantzis A. (Pelagos Cetacean Research Institute),
Kotomatas S. (WWF Greece),
Portolou D. (Hellenic Ornithological Society)

<u>Cite as:</u>

Pardalou A., Giannoulaki M., Alberini A. 2021. *Addressing the interaction between small-scale fisheries and marine megafauna in Greece. Technical Report: Phase I (Interim Report),* p.14.

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Introduction

The project “Addressing the interaction between small-scale fisheries and marine megafauna in Greece”, funded by MAVA Foundation, coordinated by the World Wide Fund (WWF) for Nature Greece in collaboration with the Aristotle University of Thessaloniki (AUTh) and the Hellenic Center for Marine Research (HCMR), aims to collect scientific data at the national level in order to estimate for the first time in detail the rate of incidental catches of key marine megafauna species, including marine mammals (cetaceans and monk seals), seabirds and sea turtles, as well as elasmobranchs in Greece and also fill the gap that exists in estimating the economic loss of small-scale fishers due to gear damage and catch loss by marine megafauna species. Based on the data collected, the competent authorities and involved agencies can develop, establish and implement the appropriate management, financial, and technical measures to limit and address the impact of the interaction between small-scale fishing (SSF) and marine species.

The overall project had a duration of two years, from July 2020 to June 2022, and consisted of two research phases. Phase I (July-December 2020) aiming at determining the current actual SSF fleet and fishing effort in Greece, as well as the “hotspots” of interactions with marine megafauna, and Phase II (January 2021-June 2022) aiming at estimating the economic losses (fishing gear damages and catch loss) and total incidental catch in selected SSF gears via onboard monitoring.

At the initiation of the first phase of the project, training sessions were conducted by the project’s scientific experts for the preparation of the field researchers, in order to ensure that the project staff was fully trained on all details of the techniques applied and updated methodologies. Following the training, the project’s four field teams (AUTh, HCMR, WWF Greece) visited the majority of docking sites along the Greek coastline and implemented interviews with SSF professional fishers to collect data on the active SSF fleet, fishing effort, and the gears predominantly interacting with marine megafauna.

The data collected was then analyzed (October - December 2020) and overlaid with the data from the Institute of Marine Biological Resources and Inland Waters of the Hellenic Center for Marine Research (IMBRIW-HCMR) stranding database on stranding “hotspots” along the Greek coastline, and areas of high conflict between SSF and marine megafauna were revealed. Based on these results and a number of selected criteria, five (5) study areas were chosen. These areas were the Thracian Sea, Thermaikos Gulf, Cyclades (Kythnos and Andros Islands), Dodecanese (Rhodes Island), and Ionian Sea (Zakynthos Island).

Results of Phase I of the project

Section 1: Active small-scale coastal fisheries fleet determination

When the project started (July 2020), the National Fleet Register (CFR) had not been updated to reflect the actual number of fishing vessels operating in the Greek waters of the Aegean and Ionian Seas. Thus, during Phase I of the project it was necessary to update this information and record the actual number of fishing vessels operating in the Greek waters of the Aegean and Ionian Seas in order to calculate the fishing effort of the small-scale coastal fleet (SSF) per gear, season and area.

The determination of the actual fishing fleet in detail was achieved, by conducting visits to fishing ports and recording the registry numbers of the professional SSF vessels found along the Greek coastline (Figure 1). A total of 524 docking sites were visited (73% of the ports along the Greek coastline), with the number of professional SSF vessels recorded being 5,152.

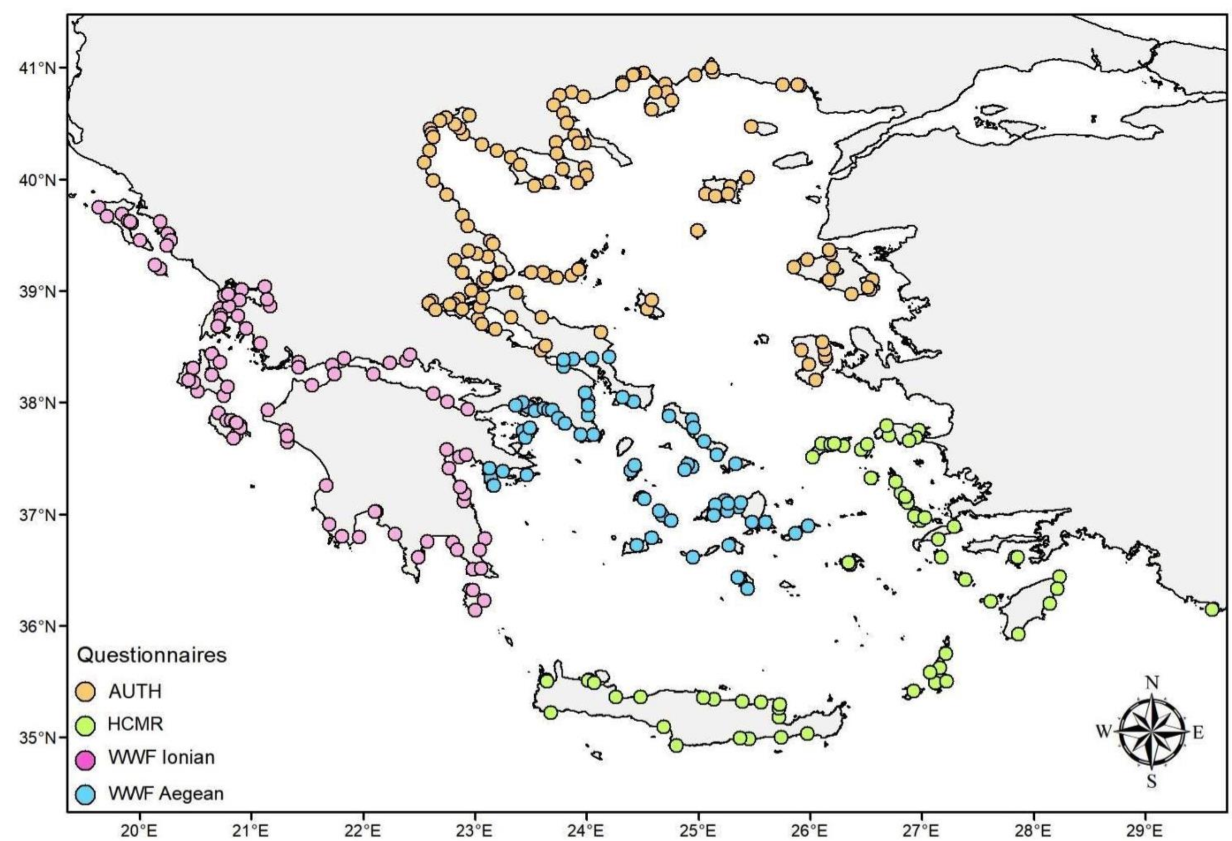

Figure 1. Map of the docking sites where interviews with professional SSF fishers were conducted. The different colors denote the four field teams. The circles denote the multiple docking sites where the interviews were conducted.

For 4,527 SSF vessels, the registration number could be verified in the EU Community Fisheries Registry database, whereas 625 vessels were "ghost" vessels (Figure 2). Furthermore, more than 300 SSF vessels were found to be derelict or possibly inactive among the verified registries, confirming the initial assumption of the Fleet Register not reflecting the actual size of operational vessels.

We estimate that the total active SSF fleet does not exceed 8,000 vessels, which is about 55% of the CFR registered vessels based on the database accessed in September 2019 (Figure 2). Despite the limitation of a single sampling effort in summer 2021, this percentage exceeds the 10% of inactive vessels (defined as those not engaged in fishing during the year of reference) that had been previously reported for 2018 (Anonymous 2020).

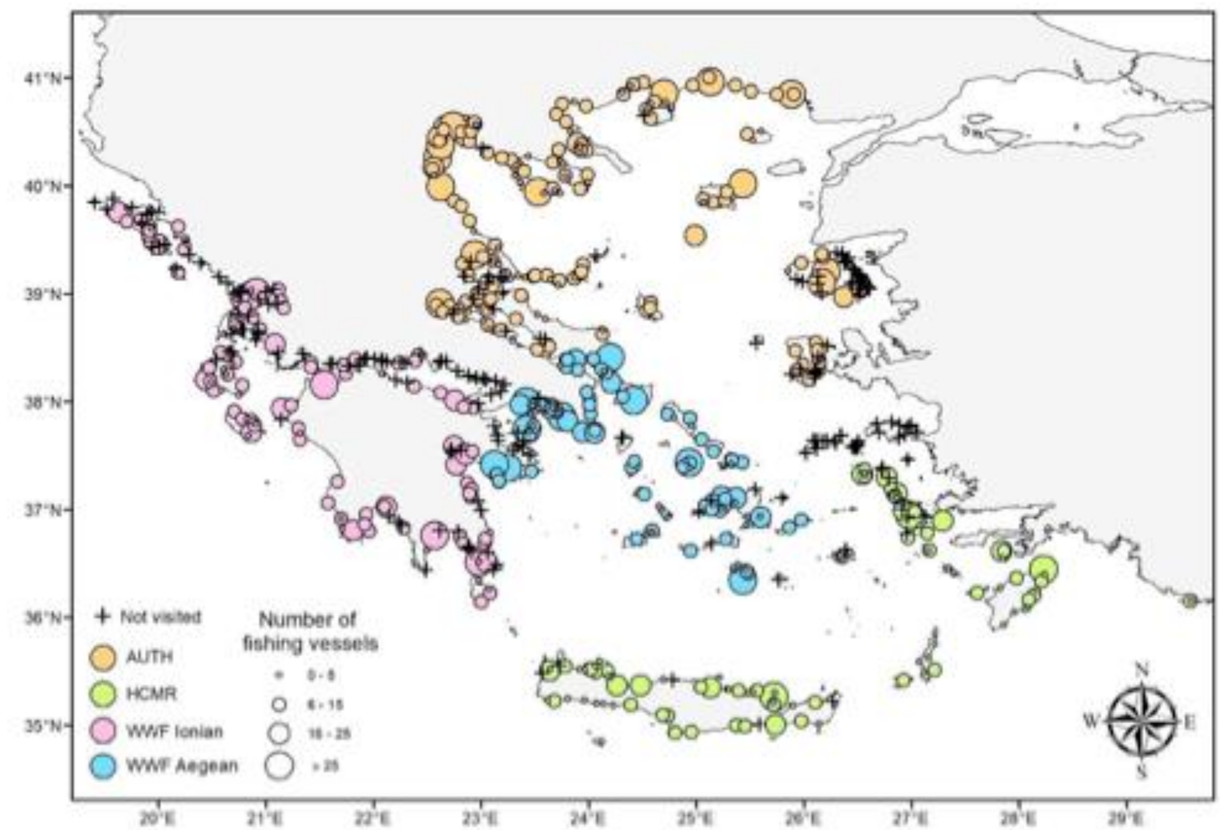

Figure 2. Map of the docking sites visited and fleet registration results. The different colors denote the four field teams. The circles denote the multiple docking sites visited during the first phase of the project, whereas the size of the circles denotes the number of SSF vessels recorded (binned). The crosses (+) denote the docking sites that were not visited.

Section 2: Questionnaires

In parallel with determining the actual size and distribution of coastal SSF fleet, information on the *métiers* (combination of gear, target species, depth and area) and seasonal fishing effort for the gears predominantly interacting with marine megafauna, mainly gill nets, trammel nets and set longlines, was gathered during the port visits, through 890 *in-situ* interviews with SSF fishers and with a total number of 913 interviews (23 of them were held via phone).

Overall, fishing effort, approximated here as the number of fishing vessels operating near their docking port, was estimated to be higher in areas of high fleet congregation (e.g., in Thermaikos, Pagasitikos and Saronikos gulfs) and in cases where prevailing weather conditions are not restrictive (as in the case of some Cyclades Islands). More specifically, fishing effort for gillnets and trammel nets is mainly concentrated in the northern Aegean Sea, but both gears are in general those most frequently used by the SSF fishers across the Greek seas. Longlines are mostly common in the Ionian Sea, the Dodecanese and the Cyclades Islands.

In more detail, fishing effort for gillnets and trammel nets was the highest all year round in major gulfs, namely Thermaikos Gulf, Pagasitikos Gulf, northern Evoikos Gulf, Saronikos Gulf, Argolikos Gulf, Amvrakikos and Patraikos Gulfs, Corinthiakos Gulf, Kyparissiakos, Lakonikos and Messiniakos Gulfs. Among the Greek islands, Kos and Kalymnos hold most of net fishing effort in the Dodecanese region, Naxos and Paros area distinguish in the Cyclades (along with Milos and Santorini islands) and Kerkyra, as well as the area between Lefkada and Kalamos islands, stand out in the eastern Ionian Sea. In the eastern Aegean, Limnos and Lesvos islands concentrate the majority of SSF fishing effort in the area.

In contrast to the use of nets (gillnets and trammel nets), the use and effort of set longlines is not catholic throughout Greece. Most fishing effort for set longlines is concentrated in the Thassos-Keramoti Region and Skioni port, in northern Evoikos Gulf, in Ikaria and Samos area all the wider area of Kos island, western Crete, Karpathos island, Elafonissos strait, and Kyparissiakos Gulf and finally the inner Ionian Sea archipelago. In general, analysis of fishing effort as reported by the fishers did not reveal important differences between summer and winter.

The geographical and temporal distribution of effort was then overlaid to the results of the IMBRIW-HCMR strandings database to reveal areas of stronger marine megafauna and small-scale fisheries interactions (see next section and figures therein).

Section 3: Hotspot areas of interaction & marine megafauna stranding events analysis

A stranding event is the occurrence of a pinniped or marine mammal or sea turtle (dead, ill, or healthy) immobilized on the beach (SPA/RAC ACCOBAMS 2004). Specifically, cetacean Mass Stranding is considered the stranding event of two (except from mother with calf) or more cetaceans near in time and space (SPA/RAC ACCOBAMS 2004). Stranding events information is often ignored, however, it can provide a unique opportunity to learn more about the population dynamics, and improve our understanding of the causes of morbidity and mortality of cetaceans and sea turtles (ACCOBAMS 2021).

The work conducted in this section consists of the analysis of the IMBRIW-HCMR strandings database (mainly cetaceans, monk seals and sea turtles). This analysis, combined with the data from the small-scale fishers' interviews conducted during the project's Phase I, provided further insights into the identification of potential "hotspots" of interaction between marine megafauna and small-scale fisheries in Greece (Figures 3, 4, 5). The analysis focused on exploring the temporal and seasonal patterns and trends in strandings, and identifying possible causes of death related to human activity.

Within the project the stranding events' analysis focused on the revision of the IMBRIW-HCMR database, reported by the port authorities, of the charismatic species throughout the Greek Seas. Specifically, it involved:

- Analysis of the stranding events per target species
- Exploration of temporal trends in the number of strandings per target species
- Differentiation of reported causes of death into the following categories:

    1. "Human/ fisheries related" in the case that: serious one or several wounds (i.e. head, abdominal, pelvic, tail), gunshots, internal bleeding due to use of explosives, net or fish hook entanglement were identified in the photos or reported
    2. Disease including virus infection or encephalitis
    3. Unknown

- Application of spatial analysis to identify hotspot areas. This involved:

1. Conversions of any reference to a georeferenced data and production of GIS compatible files
2. Estimating and mapping the annual stranding rate of a. total strandings and b. those related to human activity
3. Producing density maps to show “hotspot stranding” areas and “human related” interaction hotspot stranding areas.

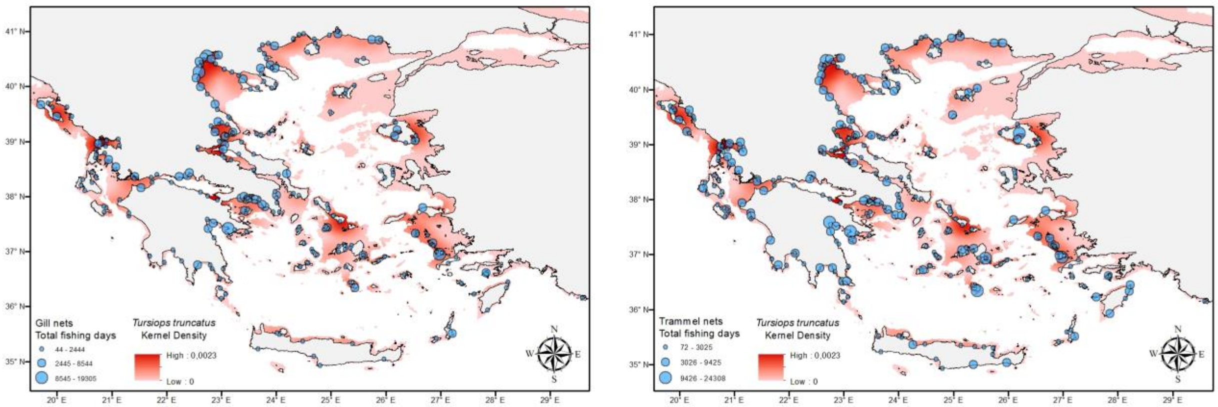

Figure 3. Map overlaying Kernel Density estimates for bottlenose dolphin strandings records with yearly fishing effort (total fishing days) for gillnets and trammel nets. Only ports with available information are shown. The size of the circles denotes the level of fishing effort. Intensely red areas denote areas of high density of strandings for the species.

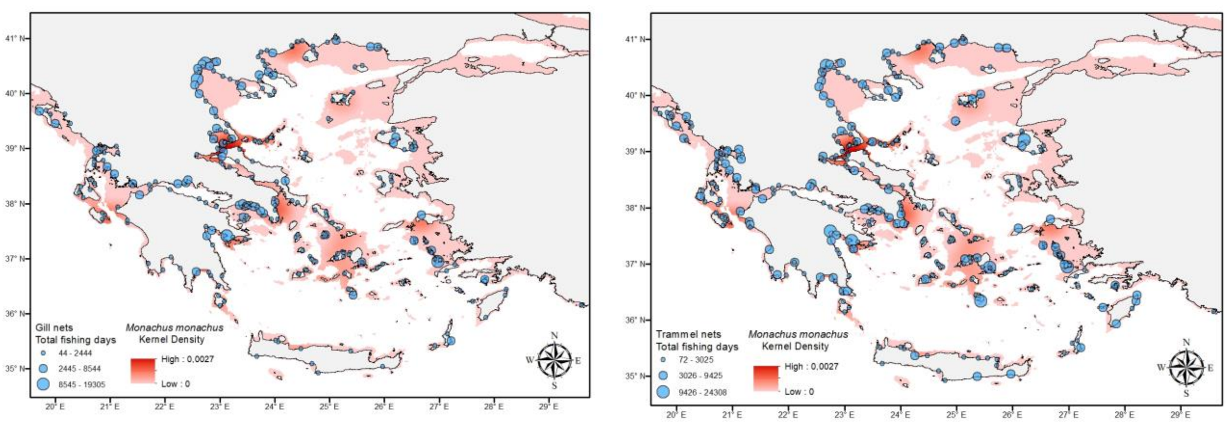

Figure 4. Map overlaying Kernel Density estimates for Mediterranean monk seal strandings records with yearly fishing effort (total fishing days) for gill nets and trammel nets. Only ports with available information are shown. The size of the circles denotes the level of fishing effort. Intensely red areas denote areas of high density of strandings for the species.

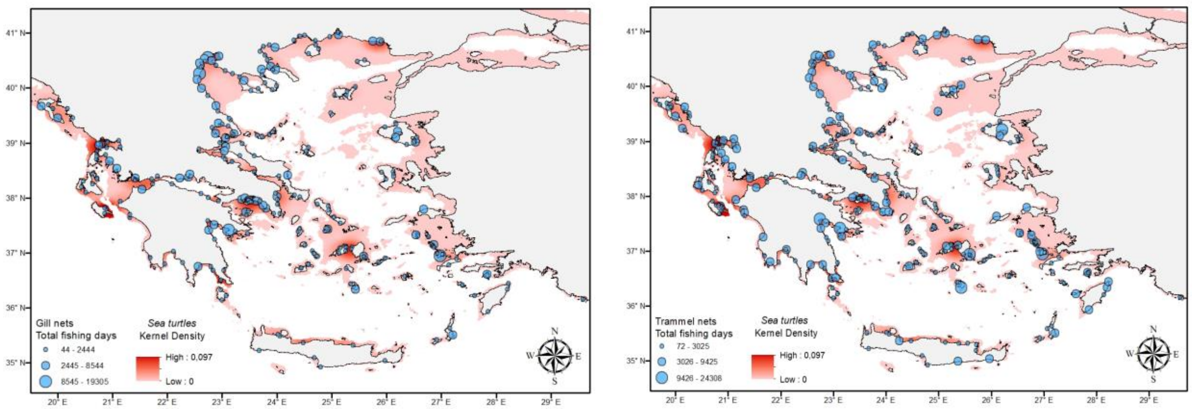

Figure 5. Map overlaying Kernel Density estimates for marine turtle strandings records with yearly fishing effort (total fishing days) for gill nets and trammel nets. Only ports with available information are shown. The size of the circles denotes the level of fishing effort. Intensely red areas denote areas of high density of strandings for the species.

A total number of 1,126 stranded animals regarding pinnipeds (i.e. monk seal) and cetacean species (i.e. common dolphin, bottlenose dolphin, striped dolphin and harbor porpoise) were reported to the IMBRIW-HCMR database in the period 2010-2020. The number of sea turtles is five times higher for the period 2010-2019 including almost ~5,770 green and loggerhead turtles. This number can be even higher if you consider that many times a stranded cetacean or sea turtle was not recognized at a species level and thus reported as such. Regarding the total strandings, an increasing statistical significant temporal trend was identified in the case of loggerhead turtle, striped dolphin, common dolphin and monk seal.

The majority of strandings are characterized by “unknown” cause of death. This is around 61% to 77% depending on the species. Subsequently, a percentage around 18% to 33% depending on the species is characterized as “human/fisheries related” including apparent marks of one or several wounds (i.e. head, abdominal, pelvic, tail), net or fish hook entanglement and to a lesser extent gunshots or internal bleeding due to dynamite. In the case of sea turtles, as boat collision injuries were reported for a high number of strandings, the “human/fisheries related” category was further split into “injured” and “Fisheries related” strandings. Indeed, in the case of sea turtles “injured” strandings alone represented a percentage of 82% and 70% of the “human/fisheries related” strandings for green turtle and loggerhead, respectively.

When it comes to the “human related” strandings, a statistical significant increasing trend towards the recent years was identified only in the case of loggerhead turtles and striped dolphins. Loggerhead turtles were further explored, splitting into “injured” and “fisheries related” strandings. The number of “injured” stranded animals (included alive ones) was indeed increased significantly in recent years, whereas no significant trend was identified in the case of the “fisheries related” stranded animals.

The analysis on the seasonality of the strandings and ANOVA tests also showed differences among species. Loggerhead turtle, *Caretta caretta,* strandings were significantly higher in the “May to September” period in all cases, independently of the cause of death. The opposite pattern was revealed for the monk seal, *Monachus monachus*, where strandings were significantly higher in the “October to April” period in all cases, independently of the cause of death. In the case of bottlenose dolphin, *Tursiops truncatus*, strandings were significantly higher in the “October to April” period only in the case of “human related” strandings. Common dolphin, *Delphinus delphis*, strandings were significantly higher in the “October to April” period only in the case of total number of strandings whereas no significant difference was observed in the case of “human related” or “unknown cause of death”. No statistical significant differences between seasons, independently of the cause of death, were revealed in the case of green turtles, *Chelonia mydas* and striped dolphin, *Stenella coeruleoalba*.

Based on the mapping of strandings, the mean annual stranding’ rate as well as the estimated density maps in the Greek Seas allowed us to define the hotspot stranding areas per species. Mapping highlighted the differentiation in the strandings of sea turtles between Ionian and Aegean Sea, with a much higher stranding rate being estimated in the majority of the Ionian sites that, besides Amvrakikos Gulf, coincided with important nesting sites of the loggerhead turtle in the eastern Mediterranean. Certain areas were generally highlighted as hotspot stranding areas as they involved more than two species. Such areas included the wider **Alexandroupoli area in east Thracian Sea** (for the common dolphin, striped dolphin, harbor porpoise, loggerhead turtle and green turtle), **North Evoikos Gulf, Pagasitikos Gulf and Oraioi Strait** (bottlenose dolphin, common dolphin, monk seal, loggerhead turtle and green turtle), **Thermaikos Gulf** (bottlenose dolphin, common dolphin, loggerhead turtle and green turtle), **Corinthiakos Gulf** (for common dolphin, striped dolphin, loggerhead turtle), **Kavala Gulf-west Thracian Sea** (for bottlenose dolphin, striped dolphin, monk seal and loggerhead turtle), **South Evoikos** (for bottlenose dolphin, loggerhead turtle and green turtle). In the special case of stranded animals associated with “human related” cause of death, the highlighted hotspot stranding areas included: the wider **Alexandroupoli area in east Thracian Sea** (for the common dolphin, striped dolphin, harbor porpoise, loggerhead turtle and green turtle), **North Evoikos Gulf and Oraioi Strait** (bottlenose dolphin, common dolphin, monk seal, loggerhead turtle and green turtle), **Thermaikos Gulf** (bottlenose dolphin, common dolphin, loggerhead turtle and green turtle), **Corinthiakos Gulf** (for common dolphin, striped dolphin, loggerhead turtle), **Amvrakikos Gulf** (for bottlenose dolphin, loggerhead turtle), **Zakynthos island** (for monk seal and loggerhead turtle). The north part of **Cyclades plateau** and especially the islands of Mykonos and Milos were identified as hotspots for the monk seal and Tinos and Mykonos islands for the bottlenose dolphin whereas Paros and Naxos islands for loggerhead turtle. In **Dodecanese**, Kos island was identified as hotspot for the common dolphin and Rhodes island for the loggerhead turtle.

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