THE ROLE OF THE TUNAMED OBSERVATORY FOR ASSESSING ENVIRONMENTAL VARIABILITY AND CLIMATE CHANGE IMPACTS ON LARGE PELAGIC FISH POPULATIONS IN THE MEDITERRANEAN

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SUMMARY

TunaMed is a collaborative Mediterranean observatory and scientific coordination initiative focused on understanding how environmental variability and climate change affect tuna and other large pelagic fish populations in the Mediterranean Sea. The initiative integrates oceanographic, ecological, and fisheries-related indicators to support ecosystem-based assessment and management. This document summarizes recent activities developed within TunaMed and their transfer to the Species Working Groups of the ICCAT Standing Committee on Research and Statistics (SCRS). Main activities include the development of environmental indicators linked to Atlantic bluefin tuna abundance indices, the integration of climate variability into larval habitat and catchability analyses for Mediterranean albacore, and the assessment of climate-related shifts in swordfish spawning phenology. TunaMed promotes the incorporation of environmental information into stock assessment, management strategy evaluation, and ecosystem monitoring frameworks, while strengthening scientific cooperation across Mediterranean research institutions.

RÉSUMÉ

TunaMed est un observatoire méditerranéen collaboratif et une initiative de coordination scientifique visant à comprendre comment la variabilité environnementale et le changement climatique affectent les populations de thonidés et d'autres grands poissons pélagiques en mer Méditerranée. Cette initiative intègre des indicateurs océanographiques, écologiques et liés à la pêche afin de favoriser une évaluation et une gestion fondées sur les écosystèmes. Le présent document résume les activités récentes menées dans le cadre de TunaMed ainsi que leur transmission aux groupes d'espèces du Comité permanent pour la recherche et les statistiques (SCRS) de l'ICCAT. Les principales activités comprennent l'élaboration d'indicateurs environnementaux liés aux indices d'abondance du thon rouge de l'Atlantique, l'intégration de la variabilité climatique dans les analyses de l'habitat larvaire et de la capturabilité du germon de Méditerranée, ainsi que l'évaluation des changements liés au climat dans la phénologie de la reproduction de l'espadon. TunaMed favorise l'intégration d'informations environnementales dans les cadres d'évaluation des stocks, d'évaluation des stratégies de gestion et de suivi des écosystèmes, tout en renforçant la coopération scientifique entre les instituts de recherche méditerranéens.

RESUMEN

TunaMed es un observatorio mediterráneo colaborativo y una iniciativa de coordinación científica centrada en comprender cómo la variabilidad medioambiental y el cambio climático afectan a las poblaciones de túnidos y otros peces pelágicos de gran tamaño en el mar Mediterráneo. La iniciativa integra indicadores oceanográficos, ecológicos y relacionados con la pesca para facilitar la evaluación y la ordenación basadas en los ecosistemas. El presente documento resume las actividades recientes llevadas a cabo en el marco de TunaMed y su transmisión a los Grupos de especies del Comité Permanente de Investigación y Estadística (SCRS) de ICCAT. Entre las principales actividades se incluyen el desarrollo de indicadores medioambientales vinculados a los índices de abundancia del atún rojo del Atlántico, la integración de la variabilidad climática en los análisis del hábitat larvario y la capturabilidad

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del atún blanco del Mediterráneo, y la evaluación de los cambios relacionados con el clima en la fenología reproductiva del pez espada. TunaMed promueve la incorporación de información medioambiental en los marcos de evaluación de stocks, de evaluación de estrategias de ordenación y seguimiento de los ecosistemas, al tiempo que refuerza la cooperación científica entre las instituciones de investigación del Mediterráneo.

KEYWORDS

Climate change, Mediterranean zone, tuna fisheries, indicators, monitoring systems, ecosystem approach to fisheries

1. Introduction

Climate variability and long-term oceanographic changes can strongly affect the distribution, productivity, recruitment, and survival of large pelagic fish populations. In the Mediterranean Sea, species such as Atlantic bluefin tuna, albacore, and swordfish are particularly sensitive to environmental fluctuations during their early life stages. The mission of the Mediterranean Tuna Habitats Observatory (TunaMed, https://oostop.wixsite.com/tunamed) is to promote the conservation and restoration of large pelagic species populations in the Mediterranean through effective fisheries management that incorporates the impacts of climate change into the scientific advisory process. The vision of this observatory is to establish a pioneering collaborative structure in linking environmental variability with sustainable management of large pelagic species, driving adaptive strategies that safeguard marine biodiversity and ecosystem health in a changing climate.

TunaMed integrates environmental observations, fisheries-independent surveys, and ecological indicators to support SCRS species assessment activities (see **Figure 1** with link to the project home page). The initiative aims to facilitate the transfer of environmental knowledge to ICCAT Species Working Groups and to contribute to the development of climate-informed management approaches.



Figure 1. Web page of TunaMed (https://oostop.wixsite.com/tunamed).

2. Activities developed for transference to SCRS Species Working Groups

Atlantic Bluefin Tuna

Activities focused on improving the interpretation of aerial survey abundance indices through the incorporation of environmental indicators. The analysis of a 15-year overlapping time series identified environmental trends and regime shifts potentially affecting bluefin tuna distribution and detectability. TunaMed developed a set of 10 environmental indicators at two spatial scales (see **Table 1**, **Figures 2** and **3**). The description of these indicators and ecological background for the indicator design can be found at Alvarez-Berastegui et al. (2025, see **Appendix 1**).

Additional activities included the evaluation of environmental variability effects on tuna larval growth and survival during early life stages, the development of larval fitness models and the integration of environmental outputs into Management Strategy Evaluation (MSE) processes. See **Figure 4**.

Table 1. Environmental variables for the study of aerial surveys and other abundance indices in the Balearic Islands (2010-2025).

Variable	Acronym	Units	Temporal scale	Spatial resolution (decimal degrees)
Bottom depth	Depth	m	-	0.25º
Slope	Slope	degrees	-	0.25º
Sea surface temperature	SST	ºC	daily	0.25º
Sea surface chlorophyll	CHL	mg m^{-3}	daily	0.25º
Sea surface salinity	SSS	-	daily	0.25º
Mixed layer depth	MLD	m	daily	0.25º
Spatial gradient of sea surface temperature	GradSpat_SST	ºC	daily	0.25º
Spatial gradient of sea surface salinity	GradSpat_SSS	-	daily	0.25º
7-day increment of sea surface temperature	sst7dinc	ºC	7 day	0.25º
15-day increment of sea surface temperature	sst15dgrad	ºC	15 day	0.25º

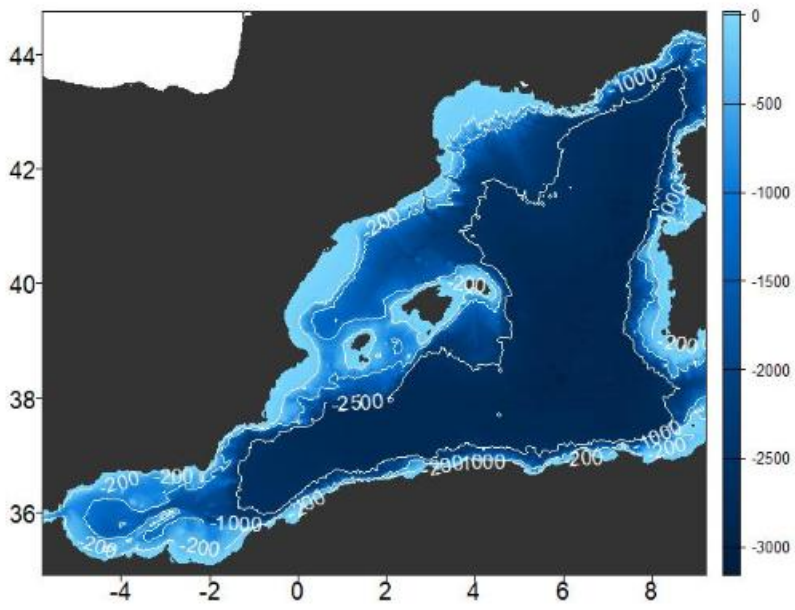


Figure 2. Western Mediterranean study area.

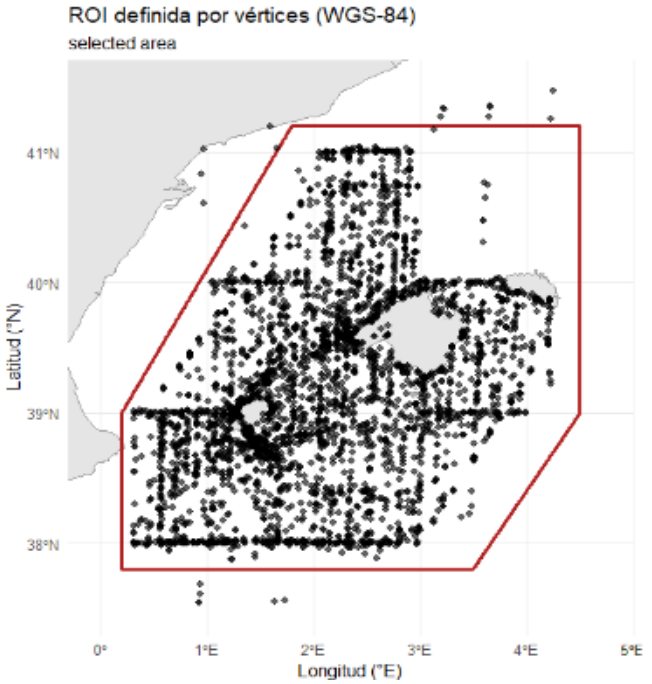


Figure 3. Western Mediterranean spawning ground area covering aerial surveys of GBYP.

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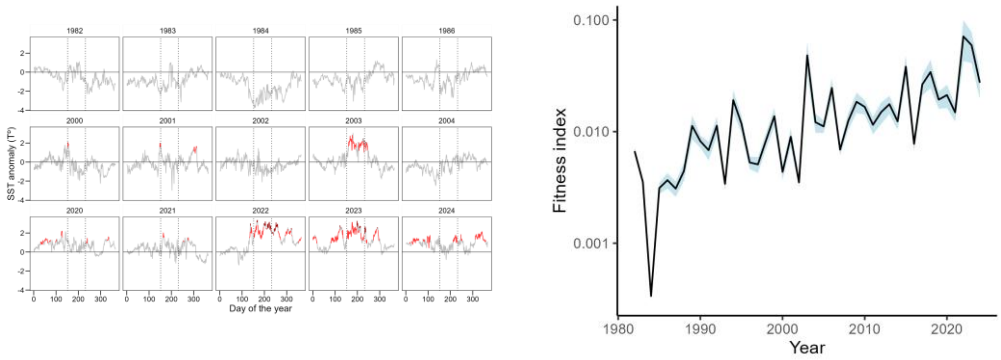


Figure 4. Example of the surface temperature and heat wave indicators in the western Mediterranean spawning ground (left) and larval fitness in the same area (right).

Mediterranean albacore

TunaMEd activities for Mediterranean albacore focused on improving larval abundance indices through the inclusion of environmental variability indicators. Main developments included larval growth back-calculation curves, standardization of larval catchability associated with spatial changes in habitat distribution, and fishing gear standardization approaches.

Mediterranean swordfish

Activities related to swordfish examined the effects of climate change on larval stages and spawning phenology. Analyses explored long-term shifts in the timing of larval occurrence in relation to increasing sea surface temperatures in the Balearic Sea. Habitat suitability models were used to identify temperature thresholds associated with larval presence (See **Figure 5**).

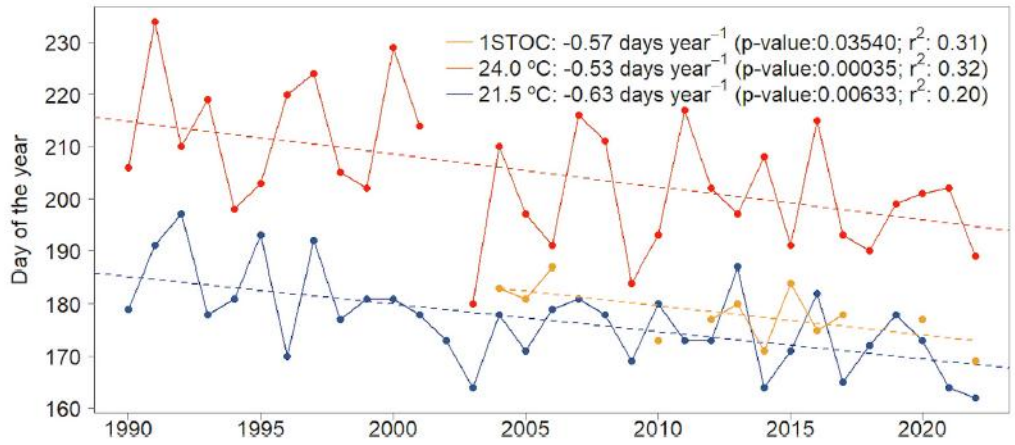


Figure 5. Example of indicators on swordfish larval habitat, changes on dates of adequate temperature conditions and dates of first larval identification (from https://doi.org/10.1016/j.pocean.2025.103610).

3. Scientific background supporting the development of indicators

Extensive peer-reviewed literature supports the indicators developed within TunaMEd. Here we point to some of the most relevant ones (see **Appendix 1**).

4. Conclusions

TunaMed provides a collaborative framework to integrate environmental variability and climate change information into SCRS species assessment activities. The initiative supports the development of ecosystem-based and climate-informed approaches for the assessment and management of Mediterranean large pelagic fish populations with practical transference to SCRS species working groups.

5. Acknowledgements

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Appendix 1

List of relevant documents supporting the development of indicators in TunaMed

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