

Impact of Climate Change on Sardine Availability in the Al Hoceima Region (Moroccan Mediterranean Coast)

Ilham Kebdani¹, Yahya El Hammoudani¹, Fouad Dimane¹ and Achraf El Kasmi¹

¹ LSIA Laboratory, ENSAH, Abdelmalek Essaadi University, Tetouan, Morocco

Abstract

Sardine fisheries represent one of the most important marine resources in the Al Hoceima region located along the Moroccan Mediterranean coast. However, climate change, particularly the increase in sea surface temperature, has progressively affected the availability and sustainability of sardine stocks. This study evaluates the relationship between climatic variability and sardine catches in Al Hoceima between 2008 and 2023. Annual catch statistics were analyzed together with sea surface temperature trends obtained from GIS-based thermal analyses and climatic datasets. The results indicate a significant decrease in sardine catches after 2010, coinciding with rising temperatures and increasing thermal anomalies in the region. The warming trend appears to affect sardine reproduction, migration, and food availability, leading to reduced stock abundance. These findings confirm the vulnerability of Mediterranean small pelagic species to climate change and highlight the importance of sustainable fisheries management and environmental monitoring strategies.

Keywords: Climate change; Sardine; Al Hoceima; Mediterranean Sea; Fisheries; Sea surface temperature.

1. Introduction

Small pelagic fish, particularly sardines (*Sardina pilchardus*), constitute an essential component of marine biodiversity and fisheries production in Morocco (Garcia et al., 2015). In the Mediterranean region of Al Hoceima, sardine fisheries play an important economic and social role by contributing to employment, food security, and local commercial activities (Ministère de l'Agriculture et de la Pêche Maritime, 2019).

Marine ecosystems are increasingly exposed to the effects of climate change, including sea surface warming, ocean acidification, and modifications in oceanographic circulation (UNEP, 2022). These environmental changes directly influence the distribution, migration, reproduction,

and survival of marine species, especially small pelagic fish (Lam & Chen, 2019).

Several studies conducted in the Mediterranean basin have demonstrated that sardines are highly sensitive to thermal variability because their biological cycle and recruitment depend strongly on water temperature and plankton productivity (Pires & Khalil, 2017; Garcia et al., 2015). In recent years, northern Morocco has experienced increasing marine temperatures accompanied by a noticeable decline in sardine catches.

The main objective of this study is to evaluate the impact of sea surface temperature variability on sardine availability and fisheries production in the Al Hoceima region between 2008 and 2023 using fisheries statistics and GIS thermal analyses.

2. Materials and Methods

2.1 Study Area

The study area is located in Al Hoceima along the Moroccan Mediterranean coast. This region is characterized by important fishing activities and favorable environmental conditions for small pelagic species. Al Hoceima constitutes one of the principal fishing zones in northern Morocco.

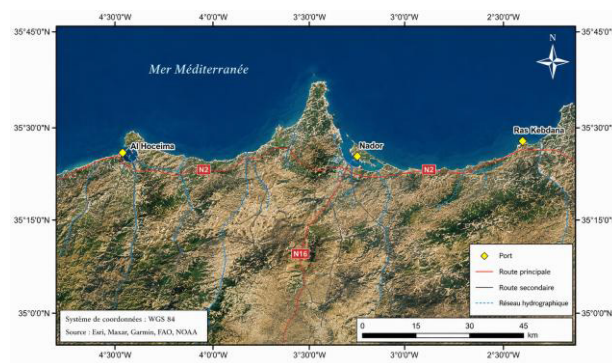


Figure 1 . Location map of the study area showing the main ports (Al Hoceima, Nador, and Ras Kebdana) along the Moroccan Mediterranean coast.

2.2 Data Collection

Annual sardine catch data covering the period from 2008 to 2023 were collected from the Department of Maritime Fisheries in Al Hoceima. Climatic information related to sea surface temperature was obtained from satellite observations and GIS thermal maps (El Asri, 2018).

2.3 GIS and Statistical Analysis

The study area map was produced using ArcGIS software, which was also employed to analyze spatial and temporal variations in sea surface temperature. Descriptive statistical analyses and temporal trend analyses were performed to evaluate changes in sardine catches and their relationship with climatic variability.

3. Results and Discussion

The analysis of fisheries statistics revealed a substantial decline in sardine catches in Al Hoceima between 2008 and 2023. The highest production level was recorded in 2010 with approximately 6.58 million units, whereas the lowest level was observed in 2023 with only 111,520 units. These results demonstrate a continuous downward trend in sardine abundance.

The decline observed after 2010 coincides with increasing sea surface temperatures recorded in the Mediterranean waters of northern Morocco (Dupont et al., 2022). Rising temperatures may negatively affect sardine spawning success, larval survival, and food availability, leading to reduced recruitment and stock abundance (Lam & Chen, 2019).

Year	Catches (kg)	Biological Observations / Context
2008	4 852 976	N/A
2009	6 341 553	Important production phase
2010	6 584 745	Historical production peak
2011	3 586 226	Beginning of fluctuation in landings.
2012	3 588 468	Maintaining capture levels
2013	5 927 830	Resumption of significant production.
2014	5 878 694	Maintaining capture levels
2015	4 046 810	Transition towards a phase of decline
2016	2 736 850	Decline in reproduction.
2017	1 615 196	Acceleration of stock decline

Year	Catches (kg)	Biological Observations / Context
2018	2 305 360	Slight year-to-year fluctuation
2019	1 393 326	Low biomass level
2020	280 520	Effondrement des captures (Crise sanitaire/climat).
2021	280 520	Stagnation à un seuil critique
2022	363 820	Persistance de la chute de reproduction globale
2023	111 520	Niveau de capture minimal record

Tableau 1. Sardine catch statistics in Al Hoceima and indicators of biological phases (2008–2023)

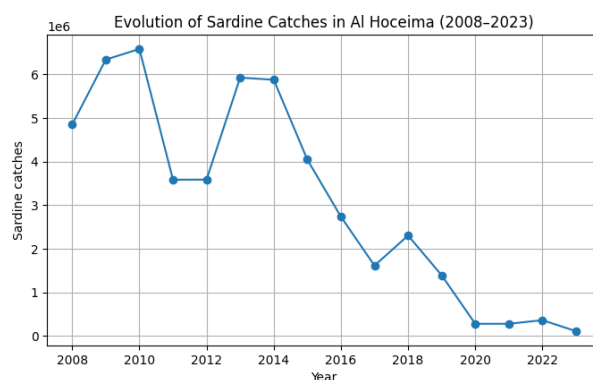


Figure2. Evolution of Sardine Catches in Al Hoceima

Figure 2 illustrates a major decline in sardine catches after 2010. The reduction in fisheries production appears to be associated with the warming trend affecting the Mediterranean marine ecosystem. Similar observations have been reported in previous Mediterranean studies investigating the relationship between climate change and small pelagic fisheries (Garcia et al., 2015; Pires & Khalil, 2017).

Climate warming may also modify plankton productivity and oceanographic circulation, forcing sardines to migrate toward cooler and deeper waters. Such environmental disturbances can significantly reduce the availability of sardines in coastal fishing areas such as Al Hoceima (El Asri, 2018).

4. Conclusion

This study demonstrates a strong relationship between climate change and the decline of sardine catches in the Al Hoceima region between 2008 and 2023. The increase in sea surface temperatures appears to negatively influence sardine reproduction, migration, and stock abundance, and the progressive reduction in catches confirms the vulnerability of Mediterranean small pelagic species to climatic variability. The findings of this research highlight the importance of strengthening environmental monitoring systems and implementing sustainable fisheries management strategies to preserve marine resources and biodiversity in northern Morocco.

References

- [1] Dupont, A. M., Martin, B. B., & El Hassan, R. (2022). Climate change impacts on Moroccan fisheries: Case study of Al Hoceima. *Revue Maritimes et Environnement*, 15(2), 110–128.
- [2] El Asri, R. (2018). Cartographie des températures de surface et production halieutique dans le nord du Maroc. *Journal of Marine Geography*, 12(3), 210–225.
- [3] Garcia, M., López, A., & Rahmani, A. (2015). Temperature trends and sardine recruitment in the western Mediterranean. *Marine Ecology Progress Series*, 520, 189–205.
- [4] Lam, P., & Chen, Y. (2019). Ocean warming and pelagic fish: Case study in the Mediterranean. *Journal of Sea Research*, 150, 25–34.
- [5] Ministère de l'Agriculture et de la Pêche Maritime (2019). Rapport sectoriel sur les ressources maritimes et leur gestion. Rabat, Maroc.
- [6] Pires, J., & Khalil, S. (2017). Fisheries and climate change: Impacts on Mediterranean small pelagics. *Fisheries Research*, 193, 67–78.
- [7] UNEP,(2022), Global trends in climate and oceans.
- [8] Département de la Pêche Maritime d'Al Hoceima. (2025). Données de capture de 2008 à 2023 Al Hoceima, Maroc.
- [9] Coll, M., et al. (2026, April 13). What fish redistribution in the Mediterranean is telling us about species' climate resilience. *The Conversation*.