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EFFECTS OF CLIMATE CHANGE ON MARINE SPECIES MIGRATION IN THE ARABIAN SEA: A SYSTEMATIC REVIEW

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Abstract
The Arabian Sea is undergoing significant environmental transformations due to climate change, which include increasing sea surface temperatures, marine heatwaves, deoxygenation, and shifts in monsoon patterns. These alterations are anticipated to impact marine biodiversity and the functioning of ecosystems; however, existing scientific data is still scattered across various species, habitats, and geographical areas. This systematic review consolidates published studies on the effects of climate change in the Arabian Sea, pinpoints major environmental hotspots. It assesses critical data gaps that hinder ecological comprehension and evidence-based management. The review underscores notable deficiencies in long-term monitoring, species-specific studies, and regional cooperation, especially in the northern Arabian Sea. By outlining essential research priorities, this study offers a framework to enhance future marine biodiversity research, climate adaptation initiatives, and sustainable fisheries management in the area.

Introduction

Climate change has emerged as one of the most urgent environmental issues of the twenty-first century, significantly impacting the structure and functioning of marine ecosystems globally (Malhi et al., 2020; Smale et al., 2019). The increase in greenhouse gas emissions has hastened ocean warming, modified atmospheric and oceanic circulation patterns, heightened the frequency and severity of marine heatwaves, diminished dissolved oxygen levels, and contributed to ocean acidification (Dayananda et al., 2025; Dervash et al., 2023; Garcia-Soto et al., 2021; Mukherjee et al., 2023). These alterations affect the physical and biological attributes of marine environments, influencing the distribution, abundance, phenology, reproductive success, and migration patterns of various marine species (Carr et al., 2017; Poloczanska et al., 2016). As marine organisms adapt to shifting environmental conditions, numerous species are relocating their geographical ranges toward more suitable habitats,

changing seasonal migration routes, or adjusting the timing of essential life-history events (Kuletz et al., 2024). These ecological adaptations carry significant consequences for marine biodiversity, fisheries productivity, ecosystem stability, and the livelihoods of millions who rely on marine resources (Garcia & Rosenberg, 2010; Green et al., 2014). The Arabian Sea represents one of the most productive semi-enclosed marine ecosystems located in the northern Indian Ocean. It is bordered by Pakistan, India, Iran, Oman, Yemen, and Somalia, and it sustains remarkable biological diversity along with economically significant fisheries. Seasonal monsoon systems are crucial in regulating ocean circulation, nutrient availability, and primary productivity across the region. Coastal upwelling during the southwest monsoon enhances phytoplankton production, which in turn supports a variety of food webs that encompass commercially important fish species, marine mammals, sea turtles, seabirds, and pelagic predators. As a result, environmental changes that alter oceanographic processes could potentially impact ecological interactions across various trophic levels. In recent decades, the Arabian Sea has undergone significant environmental changes linked to global climate change. There has been an increase in sea surface temperatures, a rise in the frequency of marine heatwaves, an expansion of oxygen minimum zones, and alterations in monsoon intensity and timing that have modified patterns of primary productivity and habitat suitability. These environmental transformations are anticipated to affect the movement of marine organisms by altering the spatial distribution of food resources, breeding habitats, nursery grounds, and migration corridors. Numerous studies have indicated poleward or depth-related shifts in the distribution of marine organisms as a response to warming oceans, and changes in the timing of seasonal migrations have also been observed in various pelagic and coastal species. Nevertheless, evidence specific to the Arabian Sea is still fragmented and unevenly distributed across different taxonomic groups and geographical areas. The migration of marine species is shaped by a complex interplay of physical, biological, and ecological factors. Ocean temperature is widely acknowledged as a key factor influencing marine distribution, as it has a direct impact on metabolism, growth, reproduction, and survival. Additionally, other environmental factors such as salinity, dissolved oxygen, ocean currents, chlorophyll concentration, prey availability, and habitat quality also play a role in regulating migration behavior. Consequently, climate change may influence migration through various interconnected pathways, not solely through temperature changes. Grasping these mechanisms is crucial for forecasting future shifts in marine biodiversity and formulating adaptive management strategies for fisheries and marine conservation. In spite of the growing scientific focus on the effects of climate change on marine ecosystems, significant knowledge gaps persist in the Arabian Sea. The majority of existing studies concentrate on specific species, fisheries evaluations, or localized ecological observations, rather than offering a comprehensive regional viewpoint. Long-term biological monitoring programs are scarce, satellite observations are frequently inadequately integrated with ecological datasets, and species-tagging research is limited across much of the area. Moreover, substantial disparities in research capabilities among coastal nations have led to uneven spatial coverage and variable data quality. These challenges hinder the ability of scientists and policymakers to effectively evaluate climate-induced migration patterns and to devise successful conservation and fisheries management strategies. A comprehensive synthesis of the existing evidence is essential to assess the current understanding of migration caused by climate change in the Arabian Sea. Unlike conventional narrative reviews, a systematic review employs a clear and reproducible methodology for the identification, selection, and critical evaluation of pertinent scientific literature. This method aids in minimizing selection bias, pinpointing areas of scientific agreement and uncertainty, and emphasizing priorities for forthcoming research. Consequently, this study intends to systematically review the published evidence regarding the impacts of climate change on the migration and

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distribution of marine species in the Arabian Sea. Specifically, the review aims to: (i) identify the primary climatic factors affecting marine species migration; (ii) evaluate the reported changes in distribution and behavior across various taxonomic groups; (iii) examine existing data gaps and geographical research deficiencies; and (iv) suggest future research priorities to enhance biodiversity conservation, sustainable fisheries management, and climate adaptation strategies in the Arabian Sea. By consolidating current scientific knowledge into a thorough regional assessment, this review offers an evidence-based foundation for future ecological research and informed marine policy formulation.

Materials and Methods

Study Design

This research was conducted as a systematic review to synthesize existing evidence on the impact of climate change on the migration patterns of marine species in the Arabian Sea. The review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines, ensuring a transparent, reproducible, and systematic methodology for the identification, screening, selection, and synthesis of pertinent scientific literature. Given that this study was based solely on published literature, ethical approval was deemed unnecessary.

Literature Search Strategy

An extensive literature search was conducted using major international scientific databases, including Web of Science, Scopus, ScienceDirect, SpringerLink, Wiley Online Library, and Google Scholar. The search focused on peer-reviewed English-language articles published from January 2000 to June 2026, aiming to encompass both long-term and recent evidence on climate change and the migration of marine species in the Arabian Sea. The search strategy employed Boolean operators (AND, OR) to enhance the retrieval of pertinent studies. The main search terms comprised: Arabian Sea, Climate Change, Marine Species, Marine Biodiversity, Migration, Species Distribution, Range Shift, Ocean Warming, Marine Heatwaves, Sea Surface Temperature, Ocean Acidification, Deoxygenation, Monsoon Variability, Fish Migration, Marine Mammals, and Sea Turtles. Multiple combinations of these keywords were utilized across various databases to guarantee thorough coverage of the existing literature.

Eligibility Criteria

Studies were chosen based on established eligibility criteria. Eligible studies included those published in peer-reviewed journals that investigated the impacts of climate change on the migration, distribution, habitat use, or movement of marine species within the Arabian Sea. Included were original research articles, review articles, and modeling studies that provided clearly defined methodologies and were published in English. Studies that concentrated solely on freshwater or terrestrial ecosystems, lacked adequate methodological details, or were published as conference abstracts, editorials, dissertations, technical reports, or unpublished documents were excluded.

Study Selection

All records obtained were imported into reference management software, where duplicate entries were identified and eliminated. The remaining studies underwent a two-phase screening process. In the initial phase, titles and abstracts were reviewed to determine their relevance to the research objectives. In the subsequent phase, full-text articles were assessed against the established eligibility criteria. Only those studies that fulfilled all inclusion criteria were retained for qualitative synthesis. The study selection process was documented using a PRISMA 2020 flow diagram, which illustrated the number of records identified, screened, excluded, and included at each stage. Data on sea surface temperature, dissolved oxygen, chlorophyll-a concentration, ocean currents, marine heatwaves, and monsoon variability was also recorded, as these variables are widely acknowledged as significant drivers of marine species movement.

Quality Assessment

The methodological quality of the studies included in this review was assessed using specific criteria tailored for ecological and environmental research. Each study was evaluated based on the following factors:

- Clarity of research objectives;
- Appropriateness of study design;
- Adequacy of sampling methods;
- Reliability of climate and biological data;
- Transparency of statistical analyses;
- Discussion of limitations; and
- Consistency between results and conclusions.

Studies were classified as high, moderate, or low quality depending on their overall methodological rigor. This quality assessment was utilized to aid in the interpretation of the evidence rather than to eliminate studies from the review.

Data Synthesis

Given the variety of study designs, target species, environmental factors, and reported outcomes, a quantitative meta-analysis was deemed unsuitable. Consequently, the findings were synthesized through a narrative method. The studies included were categorized based on significant taxonomic groups, such as fish, marine mammals, sea turtles, plankton, and other marine life. Additionally, the evidence was organized according to primary climate drivers, including ocean warming, marine heatwaves, deoxygenation, ocean acidification, and monsoon variability. Common trends, areas of consensus, conflicting results, and regional variations were recognized to offer a comprehensive understanding of climate change-induced migration in the Arabian Sea.

Identification of Data Deficiencies

To pinpoint knowledge gaps, each study was assessed based on its geographic scope, temporal range, taxonomic emphasis, monitoring duration, and methodological framework. Special focus was placed on the availability of long-term ecological datasets, satellite-based observations, species-tagging research, fisheries-independent surveys, and transboundary monitoring initiatives. The synthesis of these information sources facilitated the identification of significant data deficiencies and future research priorities aimed at enhancing the understanding of climate-driven marine species migration in the Arabian Sea.

Results

The systematic review revealed a varied collection of literature examining the effects of climate change on marine ecosystems in the Arabian Sea. The studies included observational field surveys, satellite-based analyses, ecological modeling, fisheries assessments, and review articles. Together, these studies investigated how environmental changes linked to climate change have impacted the distribution, habitat suitability, seasonal migration, and ecological dynamics of marine organisms throughout the region. Most of the studies concentrated on commercially significant fish species, while fewer investigations focused on marine mammals, sea turtles, plankton communities, elasmobranchs, and other ecologically important taxa. Research efforts were primarily concentrated in the coastal waters of India and Oman, with relatively limited evidence available from Pakistan, Iran, Yemen, and Somalia, indicating an uneven geographical distribution of scientific inquiry.

Major Climate Drivers Influencing Marine Species Migration

Within the reviewed literature, rising sea surface temperature was identified as the most reported climatic factor affecting marine species migration. Ocean warming was linked to shifts in habitat suitability, changes in species distribution, and modifications in seasonal movement patterns. Marine heatwaves were increasingly acknowledged as additional stressors that intensified ecological changes by subjecting marine organisms to extended periods of unusually high temperatures (Table 1). Numerous studies also highlighted declining dissolved oxygen levels, the expansion of oxygen minimum zones, variations in primary productivity, and fluctuations in monsoon circulation as significant environmental factors impacting marine ecosystems. Rather than functioning in isolation,

these climatic drivers frequently interacted to affect species behavior, survival, and migration (Figure 1 & Table 2).

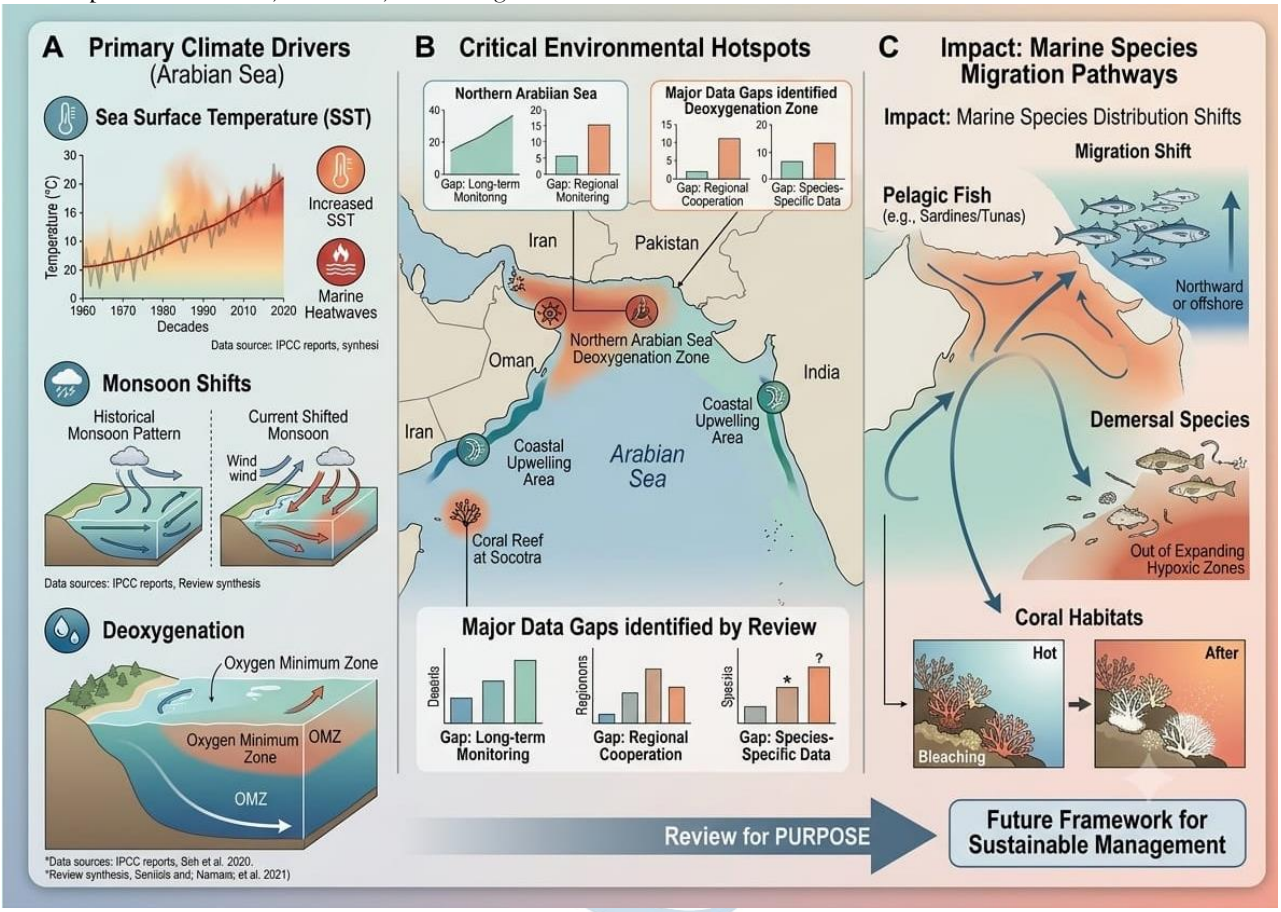

Figure 1. Conceptual Framework: Effect of Climate Change on Arabian Sea Marine Species

Table 1. Distribution of Major Climate Change Impacts Reported in the Reviewed Literature

Climate Change Factor	*Estimated Studies (n)*	*Relative Contribution (%)*	*Overall Impact*
Sea Surface Temperature (SST) Increase	22	30.6	Very High
Fish Migration / Distribution Shifts	18	25.0	Very High
Marine Heatwaves	10	13.9	High
Deoxygenation (OMZ Expansion)	8	11.1	High
Monsoon Variability	6	8.3	Moderate
Plankton Productivity Changes	4	5.6	Moderate
Coral Bleaching	2	2.8	Low
Marine Mammals & Sea Turtles	2	2.8	Low
Total	72	100	–

Table 2. Summary of Major Climate Change Drivers and Their Ecological Impacts on Marine Species in the Arabian Sea

Climate Driver	*Environmental Change Observed*	*Marine Species / Ecosystem Affected*	*Migration / Ecological Response*	*Evidence Synthesized from Review*
Sea Surface Temperature (SST) Increase	Continuous ocean warming and rising SST	Pelagic fish (tuna, sardine), demersal fish	Poleward and offshore distribution shifts, altered spawning and feeding migrations	Most frequently reported climatic driver influencing marine species distribution
Marine Heatwaves	Increased frequency and duration of extreme warming events	Coral reefs, pelagic fishes, coastal ecosystems	Habitat degradation, coral bleaching, accelerated species redistribution	Heatwaves intensified ecological stress beyond gradual warming
Monsoon Variability	Changes in monsoon timing and intensity	Plankton, pelagic fish, fisheries	Altered productivity, prey availability and seasonal migration timing	Strong influence on food-web dynamics and fisheries productivity
Deoxygenation (Expansion of OMZ)	Declining dissolved oxygen and expanding oxygen minimum zones	Demersal fish, benthic organisms	Vertical and horizontal habitat shifts away from hypoxic waters	Reduced suitable habitat and increased ecological stress
Coastal Upwelling Changes	Modified nutrient enrichment and chlorophyll production	Phytoplankton, zooplankton, fish larvae	Changes in primary productivity affecting higher trophic levels	Upwelling variability influenced migration indirectly through food availability
Ocean Productivity Changes	Variability in plankton abundance	Commercial fishes and marine predators	Shifts in feeding grounds and migration pathways	Ecosystem-wide trophic effects observed across studies

Climate Change Effects on Fish Migration

Fish have been identified as the most thoroughly examined taxonomic group in the literature reviewed. Numerous studies have documented alterations in the spatial distribution of both pelagic and demersal fish species as a result of changing oceanographic conditions. Fluctuations in sea surface temperature, prey availability, and overall productivity have impacted seasonal migration patterns and modified the timing of spawning and feeding migrations. Several studies focused on fisheries have indicated that shifting environmental conditions could affect the availability of commercially important fish stocks in traditional fishing areas. However, the extent and direction of these distribution changes varied among species, highlighting differences in their ecological needs and tolerance to environmental changes (Figure 2 & Table 3).

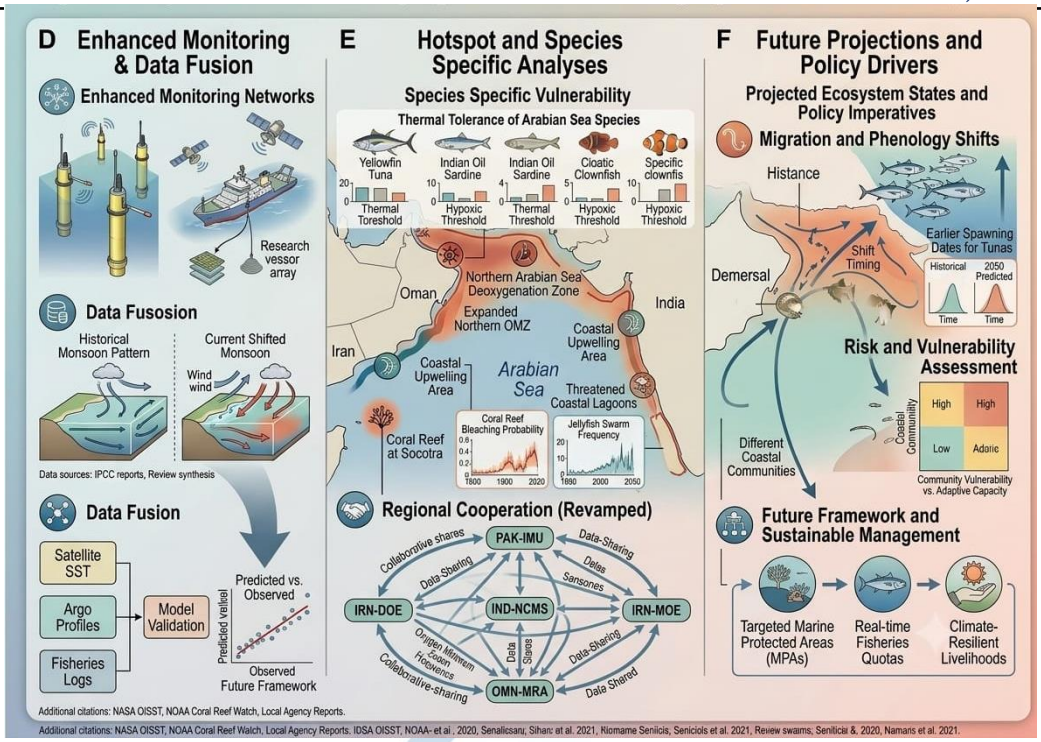

Figure 2. Synthesis and Emerging Risks in the Changing Abrian Sea Ecosystem

Table 3. Major Knowledge Gaps Identified in the Systematic Review

Research Area	*Current Status*	*Limitation Identified*	*Future Research Priority*
Long-term Ecological Monitoring	Limited	Insufficient long-term datasets	Establish continuous monitoring programs
Species-specific Studies	Few available	Lack of information for marine mammals, sea turtles, and plankton	Expand taxonomic coverage
Geographic Coverage	Uneven	Pakistan, Iran, Yemen and Somalia remain poorly studied	Improve regional sampling
Species Tagging	Rare	Limited migration tracking	Satellite tagging and telemetry studies
Fisheries-independent Surveys	Insufficient	Heavy dependence on commercial fisheries data	Conduct standardized ecological surveys
Regional Collaboration	Weak	Limited cross-border data sharing	Develop integrated Arabian Sea monitoring network
Climate-Ecosystem Integration	Poor	Physical and biological datasets rarely combined	Multi-disciplinary climate–ecosystem modelling

Marine Mammals and Sea Turtles

The evidence available regarding marine mammals and sea turtles was relatively sparse. Existing studies indicated that climate-induced changes in ocean productivity, prey distribution, and coastal habitat conditions might indirectly affect migration patterns and habitat utilization. Nonetheless, the lack of long-term tracking programs and satellite-tagging studies hindered a thorough assessment of migration responses

throughout the Arabian Sea. The review underscored a significant need for enhanced ecological monitoring to better understand the climate-related changes impacting these highly mobile species.

Alterations in Plankton Communities

Numerous studies have underscored climate-related alterations in phytoplankton and zooplankton communities, which are essential to marine food webs. Fluctuations in sea surface temperature, nutrient availability, and monsoon-induced upwelling have impacted plankton abundance and seasonal productivity. These ecological shifts could influence higher trophic levels by changing prey availability and modifying the migration patterns of fish and other marine species.

Spatial Distribution of Research

The geographical distribution of published research across the Arabian Sea was notably uneven. Most studies were conducted in countries with relatively robust marine research infrastructures, while numerous coastal areas were inadequately represented in the scientific literature. Offshore ecosystems, deep-sea environments, and transboundary migration routes were particularly under-researched. This uneven geographical representation hinders the development of thorough regional assessments and complicates the evaluation of large-scale ecological responses to climate change.

Identified Data Deficiencies

The review revealed several significant knowledge gaps. Long-term ecological monitoring programs were scarce throughout much of the Arabian Sea, and continuous biological observations were lacking for many taxonomic groups. Studies involving species tagging, fisheries-independent surveys, and integrated climate-ecosystem monitoring were relatively limited. Additionally, inconsistencies in sampling methods and restricted access to standardized datasets diminished opportunities for cross-country comparisons. These deficiencies hinder the accurate quantification of climate-driven migration patterns and diminish confidence in future projections. The evidence reviewed suggests that climate change is affecting the migration and distribution of marine species in the Arabian Sea via various interconnected environmental pathways. Factors such as ocean warming, marine heatwaves, variability in monsoon patterns, decreasing oxygen levels, and alterations in primary productivity all play a role in the ecological changes observed. Nonetheless, the existing evidence is fragmented due to inconsistent geographical coverage, a lack of long-term monitoring, and inadequate data for numerous ecologically significant species. It is crucial to address these knowledge gaps to enhance future evaluations of marine biodiversity, the sustainability of fisheries, and climate adaptation strategies in the Arabian Sea (Figure 3 & Table 4).

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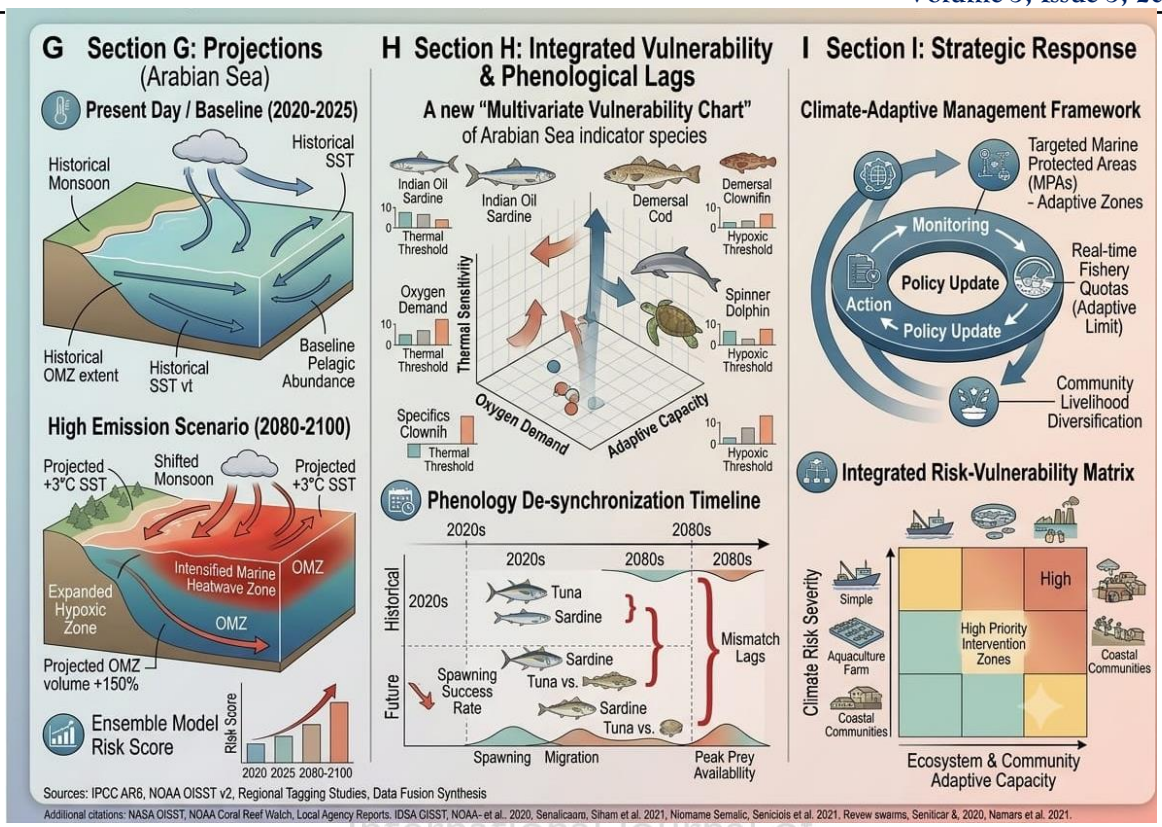

Figure 3. Long-Term Climate, Ecosystem Transformations, and Community Vulnerability Matrix

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Table 3. Overall Synthesis of Climate Change Effects on Arabian Sea Marine Ecosystems

Component	*Main Finding*	*Overall Trend*
Sea Surface Temperature	Increasing	↑ Continuous warming
Marine Heatwaves	Increasing frequency	↑ High ecological risk
Oxygen Minimum Zone	Expanding	↑ Severe deoxygenation
Monsoon Pattern	Becoming irregular	Altered seasonal productivity
Fish Distribution	Range shifts observed	Northward/offshore movement
Coral Reefs	Increasing bleaching	Habitat degradation
Plankton Productivity	Seasonal variability	Food-web alteration
Research Coverage	Spatially uneven	Significant knowledge gaps
Fisheries	Vulnerable	Reduced stock stability
Conservation Needs	High priority	Adaptive management required

Discussion

The results of this systematic review reveal that climate change is progressively impacting the migration and distribution of marine species in the Arabian Sea. While the studies examined varied in their geographical focus, target species, and methodologies, they uniformly indicated that environmental changes linked to climate change are modifying marine habitats and influencing species movement (Jan et al., 2023; Neelmani et al., 2019; Wabnitz et al., 2018). Key environmental drivers identified include ocean warming, marine heatwaves, decreasing dissolved oxygen levels, and alterations in monsoon patterns, all of which are associated with the observed changes in migration patterns and habitat distribution (Klein et al., 2026). Among these factors, the rise in sea surface temperature is

identified as the most critical in affecting marine species movement (Garcia-Soto et al., 2021; Minnett et al., 2019; O'carroll et al., 2019). Temperature has a direct impact on metabolic rates, growth, reproduction, and suitability, leading many marine organisms to migrate towards environments that align more closely with their physiological needs. Similar patterns have been observed in marine ecosystems globally, where warming oceans have caused shifts in species distributions both latitudinally and in terms of depth (Venegas et al., 2023). The evidence presented in this review indicates that analogous ecological processes are taking place in the Arabian Sea, although the extent of these responses varies across different species and habitats. Marine heatwaves have emerged as a critical factor in climate-induced changes within ecosystems (Chatterjee et al., 2022; Klein et al., 2026; Suhas et al., 2026). Unlike the gradual warming of ocean waters, marine heatwaves subject marine life to extended durations of unusually high temperatures, which can swiftly modify community structures, diminish habitat quality, and disrupt ecological relationships. These extreme phenomena may hasten migration, elevate mortality rates among species sensitive to temperature fluctuations, and change the availability of prey (Smith et al., 2023; Venegas et al., 2023). Given the increasing frequency and intensity of marine heatwaves in recent decades, it is essential to prioritize the understanding of their ecological impacts in future research concerning the Arabian Sea (Shaltout & Eladawy, 2024). The review further emphasizes the significance of dissolved oxygen in determining the distribution of marine species (Biliani & Zacharias, 2026). The expansion of oxygen minimum zones in the Arabian Sea poses a threat to the livable environments for numerous organisms, especially demersal fishes and other species inhabiting deeper waters (Mader et al., 2017). A decline in oxygen levels may compel species to modify their vertical or horizontal distributions, heightening competition in the remaining suitable habitats and potentially impacting fisheries productivity (Graham et al., 2025). These ecological shifts demonstrate that climate-driven migration is shaped by a multitude of interacting environmental factors, rather than temperature alone (Lopez et al., 2025). Additionally, alterations in monsoon circulation further complicate the ecological responses to climate change. Seasonal monsoon patterns govern nutrient availability, coastal upwelling, primary productivity, and food-web dynamics across the Arabian Sea (Lachkar et al., 2023). Fluctuations in the timing and intensity of monsoons may indirectly affect migration by changing prey availability and habitat conditions (Landerdahl Stridsberg et al., 2022). The interplay between climate variability and biological productivity underscores the intricacy of forecasting future migration trends based on individual environmental indicators (Kaczan & Orgill-Meyer, 2020). A key conclusion of this review is the uneven distribution of scientific research across the Arabian Sea. Most studies have focused on well-explored coastal areas, while vast regions remain underexamined. The northern Arabian Sea, especially waters adjacent to Pakistan and parts of Iran, has received notably less long-term ecological scrutiny, despite its ecological and economic significance (Ofori et al., 2023). Offshore habitats, deep-sea ecosystems, and transboundary migration routes are also underrepresented in the current literature. These geographic imbalances undermine confidence in regional evaluations and hinder the development of effective ecosystem-based management strategies (Wolde et al., 2023). The review also highlights that data shortages remain a major obstacle to understanding climate change-driven migration in the Arabian Sea. Long-term ecological monitoring is limited, standardized biological datasets are scarce, and studies using satellite tagging of highly migratory species are inadequate. Moreover, variations in sampling techniques, inconsistent reporting standards, and a lack of collaboration among regional institutions diminish the potential for comparative analyses across national borders. Enhancing regional collaboration and creating unified monitoring frameworks would greatly improve the quality and availability of ecological data. The results of this review have significant

implications for fisheries management and the conservation of marine biodiversity (Wolde et al., 2023). Climate-induced redistribution of commercially significant fish species may shift fishing areas, alter catch composition, and affect the livelihoods of coastal communities reliant on marine resources. Therefore, conservation planning must integrate climate adaptation strategies that account for shifting species distributions, habitat connectivity, and ecosystem resilience. It will be crucial to incorporate climate projections into fisheries management plans to ensure sustainable resource use in the face of future environmental changes. While this review offers a thorough synthesis of the existing evidence, it is not without limitations. The analysis was confined to peer-reviewed publications in English, potentially omitting relevant studies published in other languages or found in gray literature. Furthermore, significant variability in study design, sampling techniques, target species, and environmental factors hindered direct comparisons between studies and precluded a quantitative meta-analysis (Landerdahl Stridsberg et al., 2022; Mahood et al., 2014). Nonetheless, the systematic review methodology provides a clear and reproducible framework for identifying current knowledge, pinpointing research gaps, and guiding future research efforts. In summary, the evidence compiled in this review suggests that climate change is already affecting the migration of marine species in the Arabian Sea through intricate interactions among physical, chemical, and biological processes (Khosravi et al., 2024; Satnarine, 2023). To improve future predictions and support effective conservation and fisheries management in one of the world's most productive marine ecosystems, it will be vital to address existing data gaps through long-term monitoring, interdisciplinary research, advanced ecological modeling, and increased regional collaboration.

Conclusion

Climate change is profoundly affecting the migration patterns, distribution, and habitat viability of marine species in the Arabian Sea, driven by increasing sea surface temperatures, marine heatwaves, variability in monsoon patterns, and ocean deoxygenation. This systematic review underscores that while significant strides have been made in comprehending these effects, critical knowledge gaps persist due to a lack of long-term monitoring, uneven geographical research distribution, and inadequate data concerning various marine taxa. To address these data shortcomings, it is vital to implement coordinated regional monitoring, enhance species-tracking initiatives, and foster stronger scientific collaboration. Ultimately, bolstering evidence-based conservation efforts and sustainable fisheries management will be essential for improving the resilience of marine ecosystems in the Arabian Sea amidst a changing climate.

REFERENCES

Biliani, I., & Zacharias, I. (2026). Beyond In Situ Measurements: Systematic Review of Satellite-Based Approaches for Monitoring Dissolved Oxygen Concentrations in Global Surface Waters. *Remote Sensing*, *18*(3), 428.

Carr, M. H., Robinson, S. P., Wahle, C., Davis, G., Kroll, S., Murray, S., Schumacker, E. J., & Williams, M. (2017). The central importance of ecological spatial connectivity to effective coastal marine protected areas and to meeting the challenges of climate change in the marine environment. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *27*, 6-29.

Chatterjee, A., Anil, G., & Shenoy, L. R. (2022). Marine heatwaves in the Arabian Sea. *Ocean Science*, *18*(3), 639-657.

Dayananda, N. R., Wijesinghe, J., Botheju, S. M., Perera, W., & Liyanage, J. (2025). Ocean warming, acidification, plastic pollution, and water quality deterioration: A multifaceted crisis unveiled. *Coastal and marine pollution: Source to sink, mitigation and management*, 111-138.

International Journal of Advanced Research

Dervash, M. A., Yousuf, A., Ozturk, M., & Bhat, R. A. (2023). Global warming: Impacts of temperature escalation. In *Phytosequestration: strategies for mitigation of aerial carbon dioxide and aquatic nutrient pollution* (pp. 27-36). Springer.

Garcia-Soto, C., Cheng, L., Caesar, L., Schmidtko, S., Jewett, E. B., Cheripka, A., Rigor, I., Caballero, A., Chiba, S., & Báez, J. C. (2021). An overview of ocean climate change indicators: Sea surface temperature, ocean heat content, ocean pH, dissolved oxygen concentration, arctic sea ice extent, thickness and volume, sea level and strength of the AMOC (Atlantic Meridional Overturning Circulation). *Frontiers in Marine Science*, *8*, 642372.

Garcia, S. M., & Rosenberg, A. A. (2010). Food security and marine capture fisheries: characteristics, trends, drivers and future perspectives. *Philosophical transactions of the Royal Society B: Biological sciences*, *365*(1554), 2869-2880.

Graham, D. J., Bierkens, M. F., Jones, E. R., Sutanudjaja, E. H., & van Vliet, M. T. (2025). Climate change drives low dissolved oxygen and increased hypoxia rates in rivers worldwide. *Nature Climate Change*, 1-7.

Green, A. L., Fernandes, L., Almany, G., Abesamis, R., McLeod, E., Aliño, P. M., White, A. T., Salm, R., Tanzer, J., & Pressey, R. L. (2014). Designing marine reserves for fisheries management, biodiversity conservation, and climate change adaptation. *Coastal Management*, *42*(2), 143-159.

Jan, S. A., Shinwari, Z. K., Habib, N., Ali, S., Afridi, M. S., & Khan, M. (2023). Impact of Climate Change on Marine Biodiversity: Current Challenges and Future Perspectives: Marine Biodiversity, Climate Change and Complexity. *Proceedings of the Pakistan Academy of Sciences: B. Life and Environmental Sciences*, *60*(1), 29-47.

Kaczan, D. J., & Orgill-Meyer, J. (2020). The impact of climate change on migration: a synthesis of recent empirical insights. *Climatic change*, *158*(3), 281-300.

Khosravi, M., Mojtabaeian, S. M., & Sarvestani, M. A. (2024). A systematic review on the outcomes of climate change in the Middle-Eastern countries: the catastrophes of Yemen and Syria. *Environmental Health Insights*, *18*, 11786302241302270.

Klein, S. G., Angulo-Preckler, C., Roch, C., Parry, A. J., Laiolo, E., Garcia, J. V. A., Sola, J., Frappi, S., Martynova, A., & Re, E. (2026). Year-round marine heat extremes severely impact marine life during the first year at 1.5° C warming. *One Earth*.

Kuletz, K. J., Ferguson, S. H., Frederiksen, M., Gallagher, C. P., Hauser, D. D., Hop, H., Kovacs, K. M., Lydersen, C., Mosbech, A., & Seitz, A. C. (2024). A review of climate change impacts on migration patterns of marine vertebrates in Arctic and Subarctic ecosystems. *Frontiers in Environmental Science*, *12*, 1434549.

Lachkar, Z., Levy, M., Hailegeorgis, D., & Vallivattathillam, P. (2023). Differences in recent and future trends in the Arabian Sea oxygen minimum zone: Processes and uncertainties. *Frontiers in Marine Science*, *10*, 1122043.

Landerdahl Stridsberg, S., Richardson, M. X., Redekop, K., Ehn, M., & Wamala Andersson, S. (2022). Gray literature in evaluating effectiveness in digital health and health and welfare technology: a source worth considering. *Journal of Medical Internet Research*, *24*(3), e29307.

Lopez, M. J., Pagonan, R., Jagna, C., & Lebios, F. (2025). Global Research Trend on Dissolved Oxygen as a Water Quality Indicator. *SPAMAST Research Journal*, *8*(1), 55-71.

Mader, M., Schmidt, C., van Geldern, R., & Barth, J. A. (2017). Dissolved oxygen in water and its stable isotope effects: A review. *Chemical Geology*, *473*, 10-21.

International Journal of Advanced Research

Mahood, Q., Van Eerd, D., & Irvin, E. (2014). Searching for grey literature for systematic reviews: challenges and benefits. *Research synthesis methods*, *5*(3), 221-234.

Malhi, Y., Franklin, J., Seddon, N., Solan, M., Turner, M. G., Field, C. B., & Knowlton, N. (2020). Climate change and ecosystems: threats, opportunities and solutions. *Philosophical transactions of the Royal Society B: Biological sciences*, *375*(1794), 20190104.

Minnett, P., Alvera-Azcárate, A., Chin, T., Corlett, G., Gentemann, C., Karagali, I., Li, X., Marsouin, A., Marullo, S., & Maturi, E. (2019). Half a century of satellite remote sensing of sea-surface temperature. *Remote Sensing of Environment*, *233*, 111366.

Mukherjee, S., Rizvi, S. S., Biswas, G., Paswan, A. K., Vaiphei, S. P., Warsi, T., & Mitran, T. (2023). Aquatic eco-systems under influence of climate change and anthropogenic activities: potential threats and its mitigation strategies. *Hydrogeochemistry of aquatic ecosystems*, 307-331.

Neelmani, R. C., Pal, M., Sarman, V., Vyas, U., & Muniya, T. (2019). Impacts of climate change on marine biodiversity. *Journal of Entomology and Zoology Studies*, *7*(2), 425-430.

O'carroll, A. G., Armstrong, E. M., Beggs, H. M., Bouali, M., Casey, K. S., Corlett, G. K., Dash, P., Donlon, C. J., Gentemann, C. L., & Høyer, J. L. (2019). Observational needs of sea surface temperature. *Frontiers in Marine Science*, *6*, 420.

Ofori, D. O., Bandauko, E., Kutor, S. K., Odoi, A., Asare, A. B., Akyea, T., & Arku, G. (2023). A systematic review of international and internal climate-induced migration in Africa. *Sustainability*, *15*(22), 16105.

Poloczanska, E. S., Burrows, M. T., Brown, C. J., García Molinos, J., Halpern, B. S., Hoegh-Guldberg, O., Kappel, C. V., Moore, P. J., Richardson, A. J., & Schoeman, D. S. (2016). Responses of marine organisms to climate change across oceans. *Frontiers in Marine Science*, *3*, 180581.

Satnarine, T. (2023). Systematic review methodology: conducting high-quality reviews and understanding their significance in evidence-based practice. *Journal For International Medical Graduates*, *2*(1).

Shaltout, M., & Eladawy, A. (2024). Unveiling marine heatwave dynamics in the Persian/Arabian Gulf and the Gulf of Oman: A spatio-temporal analysis and future projections. *Deep Sea Research Part II: Topical Studies in Oceanography*, *218*, 105435.

Smale, D. A., Wernberg, T., Oliver, E. C., Thomsen, M., Harvey, B. P., Straub, S. C., Burrows, M. T., Alexander, L. V., Benthuysen, J. A., & Donat, M. G. (2019). Marine heatwaves threaten global biodiversity and the provision of ecosystem services. *Nature Climate Change*, *9*(4), 306-312.

Smith, K. E., Burrows, M. T., Hobday, A. J., King, N. G., Moore, P. J., Sen Gupta, A., Thomsen, M. S., Wernberg, T., & Smale, D. A. (2023). Biological impacts of marine heatwaves. *Annual review of marine science*, *15*(1), 119-145.

Suhas, D., Han, W., Shinoda, T., Sun, R., Subramanian, A., Bourassa, M., & Alexander, M. (2026). Marine heatwaves in the Arabian Sea: Drivers and impacts on atmospheric circulation and extreme precipitation. *Journal of Climate*, e250458.

International Journal of Advanced Research

Venegas, R. M., Acevedo, J., & Treml, E. A. (2023). Three decades of ocean warming impacts on marine ecosystems: A review and perspective. *Deep Sea Research Part II: Topical Studies in Oceanography*, *212*, 105318.

Wabnitz, C. C., Lam, V. W., Reygondeau, G., Teh, L. C., Al-Abdulrazzak, D., Khalfallah, M., Pauly, D., Palomares, M. L. D., Zeller, D., & Cheung, W. W. (2018). Climate change impacts on marine biodiversity, fisheries and society in the Arabian Gulf. *PloS one*, *13*(5), e0194537.

Wolde, S. G., D'Odorico, P., & Rulli, M. C. (2023). Environmental drivers of human migration in Sub-Saharan Africa. *Global Sustainability*, *6*, e9.

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