

6. Warming Of Earth's Ocean- Geography

In 2025, Earth's oceans were warmer than ever. A 2025 study reveals that oceans absorbed a record 23 Zettajoules of heat, driven largely by anthropogenic emissions, leading to intensified ocean stratification and marine heatwaves. This warming trend threatens marine ecosystems through deoxygenation and nutrient scarcity while fueling stronger tropical storms, with the Indian Ocean warming faster than the global average.

Context- Record-Breaking Ocean Heat

Study Title- 'Ocean Heat Content Sets Another Record in 2025'.

Core Finding- Oceans absorbed more heat in 2025 than in any year since modern measurements began in the 1960s.

Focus Area- The study specifically analyzed the top 2,000 meters of the ocean, which acts as the primary reservoir for stored heat.

Key Findings of the Study

1. Record-Breaking Ocean Heat Content (OHC)

Heat Absorption- In 2025, Earth's oceans absorbed an additional 23 Zettajoules (ZJ) of heat.

Comparison- This represents a 44% increase compared to 2024, when the absorption was 16 ZJ.

Significance- It surpasses all previous records maintained since the 1960s.

2. Rising Global Sea-Surface Temperatures (SSTs)

Rank- 2025 recorded the third-highest Global Average SSTs.

Deviation- Temperatures were approximately 0.5°C above the 1981–2010 baseline.

Fastest-Warming Regions

1. South Atlantic Ocean
2. North Pacific Ocean
3. Southern Ocean

3. Anthropogenic Heat Absorption

Buffer Role- The oceans have absorbed nearly 90% of the excess heat trapped by Greenhouse Gases (GHGs) since the industrial era.

Consequence- This massive absorption drives steady, long-term warming of the waters, even during periods when atmospheric temperature rise appears to slow down temporarily.

4. Increased Ocean Stratification

Mechanism- Rising heat content intensifies stratification, creating a barrier that separates

- a. Warm, light, nutrient-poor surface waters.
- b. Cooler, denser, nutrient-rich deep waters.

Impact on Vertical Mixing- The separation reduces the vertical mixing of water layers, leading to-

1. Reduced CO₂ Absorption- The ocean's ability to act as a carbon sink diminishes.
2. Oxygen Depletion- Deeper waters face deoxygenation.
3. Nutrient Scarcity- Marine life near the surface is deprived of essential nutrients rising from the deep.

5. Threats to Marine Ecosystems

Base of Food Web- Stratification and warming directly threaten phytoplankton populations.

Cascading Effect- A decline in phytoplankton triggers a collapse across the food chain, affecting

- a. Zooplankton
- b. Fish and Crustaceans
- c. Corals

6. Intensification of Marine Heat Waves (MHWs)

Definition- Ocean regions where temperatures remain 3–4°C above average for at least 5 days.

Trend- MHWs are becoming more frequent, longer, and more intense.

Historical Data- According to the IPCC (2021), the frequency of MHWs doubled between 1982 and 2016.

Consequences

1. Severe coral bleaching.
2. Reduced coral reproduction.

3. Altered fish migration patterns.

7. Stronger Tropical Storms

Fuel Source- Warmer oceans provide the energy fuel for tropical storms, cyclones, and hurricanes.

Mechanism- Increased evaporation and heat transfer lead to

1. Stronger wind speeds.
2. Heavier rainfall.
3. More severe flooding upon landfall.

Drivers and Causes of Ocean Warming

Primary Driver- Human-induced climate change involving Greenhouse Gas (GHG) emissions.

Key Gases- Accumulation of Carbon Dioxide (CO₂), Methane (CH₄), and Nitrous Oxide (N₂O) traps heat in the atmosphere.

Secondary Causes

Deforestation & Industrial Emissions- Reduction of natural carbon sinks.

Altered Circulation- Changes in ocean circulation patterns influenced by atmospheric warming.

Thermal Expansion- As water warms, it physically expands.

Impacts- Physical vs. Biological

The following table differentiates the impacts of ocean warming on physical oceanography versus marine biology.

Category	Key Impacts
Physical Impacts	Thermal Expansion- Contributes significantly to global sea-level rise. Altered Currents- Changes in density and circulation patterns. Feedback Loops- Warmer water absorbs less CO ₂ , and melting polar ice reduces the albedo effect (further increasing heat absorption). Weather Systems- Amplification of events like El Niño.
Biological Impacts	Coral Bleaching- 70–90% of reefs are expected to be lost if warming exceeds 1.5°C. Migration Shifts- Fish stocks are moving toward cooler waters, disrupting global fisheries. Stressors- Deoxygenation and acidification create hostile environments for marine life.

Regional Focus- The Indian Ocean

Warming Rate- The Indian Ocean has warmed by 1.2°C since 1950, a rate faster than the global average.

Weather Impact- This rapid warming contributes to

- a. Intense monsoon patterns.
- b. Variability in cyclones.

The Arabian Sea- This region is particularly vulnerable, witnessing a notable rise in severe cyclonic storms.

Coastal Threat- The India Meteorological Department (IMD) links increasing Ocean Heat Content (OHC) to sea-level rise, posing threats to India's coastal ecosystems and communities.

Mitigation and Global Action

1. Global Frameworks

UN Decade of Ocean Science (2021–2030)- Focuses on sustainable development through-

1. Enhanced marine observation networks.
2. Transitioning to renewable energy to reduce emissions.
3. Blue Carbon Initiatives- Restoration of mangroves and seagrasses to sequester carbon.

2. India's Initiatives

Agencies Involved- National Centre for Coastal Research (NCCR) and Ministry of Earth Sciences (MoES).

Deep Ocean Mission- Initiation of long-term ocean observation programs to understand warming effects and develop mitigation strategies.

Conclusion

The 2025 record for Ocean Heat Content signals a critical acceleration in climate change. The compound effects of stratification, marine heatwaves, and feedback loops threaten not only marine biodiversity but also global weather stability, necessitating urgent global and regional interventions.

Source- <https://indianexpress.com/article/explained/explained-climate/2025-earth-oceans-warmer-10465821/>

