One-fourth of the global heat uptake occurs through heat transport pathways in the Indian Ocean and the lack of deep convection and ventilation in the region leads to oxygen minimum zones, impacting marine life; Lombok, Indonesia.

PHOTO COURTESY: LOMBOK

5. Analyzing Challenges around the Oceans

Oceans cover 75 per cent of the planet, cohesively connecting different continents. The significance of understanding and managing oceans for a sustainable economy and adaptation is increasing. There are obstacles in knowledge-solution gaps, infrastructural, foundational and governance-related challenges around the seas and oceans that need to be bridged in order to attain the outcomes for the Ocean Decade delineated in the United Nations decade of Ocean Science for Sustainable Development (2021-2030).

5.1 Introduction

Oceans worldwide play a crucial role in the sustenance of different ecosystems. Covering 75 per cent of the earth, they connect the other parts of the planet with the two poles into a coherent whole and provide diverse ecosystem services that ensure people's livelihood (Kumar, 2023b). The ecosystem services of oceans comprise a significant amount of oxygen-producing phytoplankton, a key to the existence of all life forms. Phytoplankton also serves as an indicator of oceanic warming (Tripathy, 2023).

While on one side, oceans drive the Indian monsoon, on the other, the ocean economy supply chains contribute to national and global GDPs. It supplies 90 per cent of global fisheries, 25 per cent of global biological productivity, and 25 per cent of world energy (Kumar, 2023b). In recent years the ocean economy model's orientation has shifted, and the sustainability aspect has been added, compositely known as the blue economy (Ibid.).

While the Indian Ocean plays a crucial role in meeting societal needs, it conflictingly exposes the coastal population to extreme weather events, climate change and sea-level rise. The Ocean also plays a significant role in the global climate system, as one-fourth of the global heat uptake occurs through heat transport pathways in the Indian Ocean. The

region's lack of deep convection and ventilation leads to OMZs and impacts marine life. The Madden-Julian Oscillation, Indian Ocean dipole and teleconnections with other oceans and Poles influence the region's weather patterns. Operational drivers for the Indian Ocean include improving surface fluxes, ocean data assimilation systems, and sub-S2S forecasting (Kumar, 2023b). The oceanic territory is largely unexplored and mandates observations, which poses a challenge as it demands the development of innovative solutions.

OMZs

oceanic territory

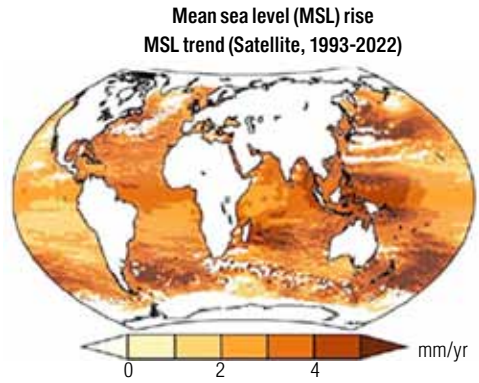
5.2 Objectives and Challenges around the Oceans

The United Nations Decade of Ocean Science for Sustainable Development (2021-2030) aims to achieve the goal of 'science required to ensure the ocean we desire'. This initiative provides a platform for various stakeholders to collaborate on designing and implementing research. It offers practical solutions to support the objectives of the 2030 agenda for a healthy ocean. The United Nations Decade of Ocean Science for Sustainable Development emphasises the significance of capacity building, promoting ocean literacy,

2030

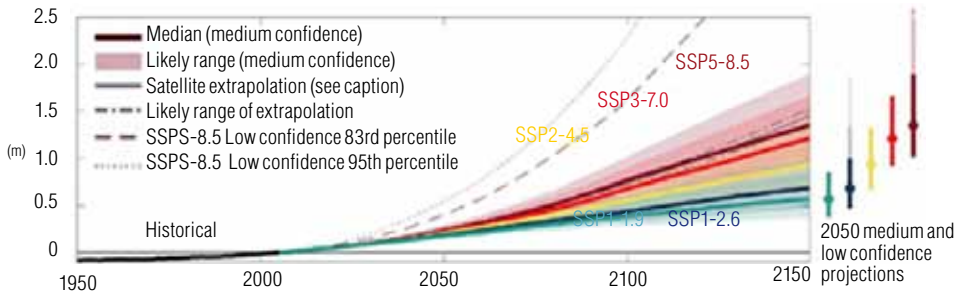
ocean literacy

Fig. 5.1: Trends in global sea level taken from AVISO data and sea level projections



Source: Swapna, 2023

Fig. 5.2: Projected mean sea level rise under different scenarios



Sea levels along the entire Indian coast are rising faster than the global average: WMO report 2022. Rate of sea-level rise was 4.7 mm/yr (global) and 5.5 mm/yr (IO), 2013 to 2020

Source: Swapna, 2023

and eliminating obstacles to achieving gender, generational, and geographic diversity. The challenges around Oceans can be categorised into three broad pillars: knowledge and solution, infrastructural and foundational (Kumar, 2023b).

5.2.1 Knowledge-Solution Challenges

marine resources

The knowledge solution challenge highlights the information gap and the associated solutions for oceanic ecosystems. For instance, knowledge about marine pollution, threats to coastal ecosystems, environmental and climatic variables, sustainable utilization of marine resources, etc. needs to be augmented. Also, understanding the relationship between ocean-climate interactions and their dynamic impacts on oceans and surrounding ecosystems needs to be developed. The impact of various stressors on the ocean ecosystems to develop strategies for monitoring, protecting, and restoring the ecosystem and biodiversity needs to be understood.

5.2.2 Infrastructural Challenges

harmful algal blooms
sea level rise

Infrastructural challenges include ocean-related risks/ hazards and the need for ocean observation and digital representation to address these hazards. Ocean-related risks and hazards such as rise in sea level, harmful algal blooms, destructive storms and unpredictability require significant investment and development of relevant technologies. Out of all the potential hazards, the threat of sea level rise ranks topmost, impacting communities adversely, particularly those living along the coasts. A rise in global temperatures, the consequent melting of glaciers, and the thermal expansion of seawater are causing sea levels to rise. For instance, the Arctic is warming, causing the Greenland ice sheet to melt at an accelerated rate. Glaciers cover a tenth of the planet's land surface, a significant part of which lies in Greenland. The melting Greenland ice sheet can contribute to 24.5 per cent of the sea level rise (Swapna, 2023). Also, oceans absorb 93 per cent of the sun's heat, leading to the thermal expansion of oceanic water (Shenoi, 2023). This expansion increases the volume of overall water, leading to a rise in sea levels. Effective strategies can holistically address rising sea levels and require an intense understanding of such and more underlying mechanisms.

Greenland ice sheet

Furthermore, the variability in the global rate of change in sea levels needs to be understood in greater detail. For instance, sea levels in the Indian Ocean have been rising at a rate of 5.5 mm per year from 2013-2020 compared to the global rise of 4.7 mm per year (Fig. 5.1 and 5.2). The Indian Ocean region, therefore, faces a faster sea-level rise, well above the global average (Swapna, 2023) and poses a considerable challenge for India and its coastal communities.

CISM
IITM-ESM

Various models, such as CISM and IITM-ESM, predict the current sea level rise and future scenarios (Swapna, 2023). As per the simulations done by the IITM model, the potential impact of Greenland ice melt will likely change the surface level of oceanic waters. For instance, freshwater inflow may impact the oceanic waters' thermohaline in

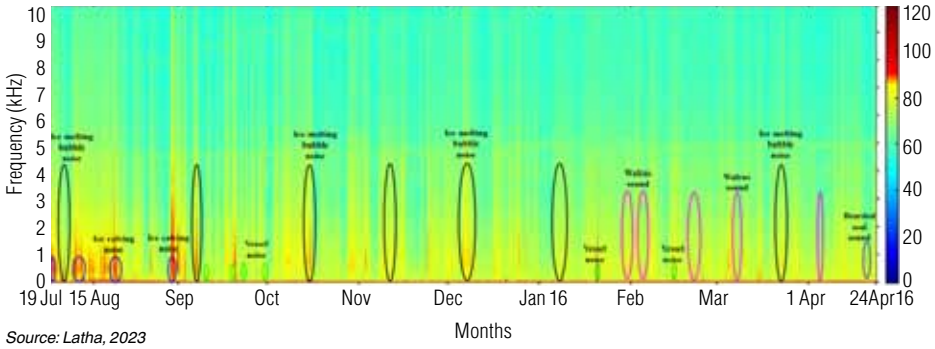
the Atlantic, changing the temperature and salinity in deeper layers, over 2,000 m. The circulation pattern in that scenario would become slow, and with the further melting of glaciers, the global oceanic conveyor belt is predicted to be weakened by about 25 per cent (Swapna, 2023).

As per a new study, between 2000 and 2019, glaciers collectively lost 267 billion tonnes of ice annually (Ramesh, 2023). Assuming all the water from melting glaciers eventually reaches the ocean, its contribution to sea level rise can be estimated at 0.74 mm yearly. Furthermore, the 'thinning rate' of glaciers has also accelerated. On average, glaciers' annual 'thinning rate' was 36 cm in 2000 but increased to 69 cm by 2019 (Ibid.).

thinning rate

The geographical features or the landlocked nature of the Indian Ocean further enhance the rise in the sea level, with increased heat retention resulting in significantly rising

Fig. 5.3: Soundscape components and temporal patterns in the Kongsfjorden, Arctic Ocean



Source: Latha, 2023

temperatures (Swapna, 2023). However, the drivers of sea-level rise are different for different regions. In the global sea level budget, 38 per cent of sea level rise is attributable to thermal expansion (Ibid.). With relevant infrastructure and technological solutions, these challenges may be addressed.

sea level budget

5.2.3 Foundational Challenges

Foundational challenges relate to capacity building in domains, such as technical skilling across all domains to move from the 'Ocean we have' to the 'Ocean we want'. Another aspect of achieving this vision is the behavioural, stemming from humanity's connection with the oceans. Both issues demand a fundamental change in the approach toward sustainable ocean use. Oceans are dynamic and offer a 'sea of opportunities' (Ravichandran, 2023b). However, with opportunities, there are 'sea of challenges' too (Shenoi, 2023). Climate change, plastic pollution and competing interests for marine resources present challenges with potentially dire consequences. The blue economy model will also likely have repercussions in the coming years (Shenoi, 2023).

sustainable ocean use
plastic pollution

Ocean observation and monitoring systems help understand trends. However,

Acoustic recordings innovations

maintenance and deployment of the ocean observation and monitoring systems are complex due to their substantial power requirement (Latha, 2023). Acoustic recordings consisting of high-frequency samples at 50kHz, sampled autonomously every ten minutes for a year, require significant power (Fig. 5.3). This power requirement in the subsea provides scope for technical innovations.

forecasting warning systems

Robust observation, monitoring and forecasting and warning systems, relevant data sets, digital representation of the oceans and other efficient technologies need to be developed. It can facilitate understanding the current state of oceans, how they are changing, their potential impacts, and appropriate steps to adapt to these changes (Kumar, 2023b).

Capacity building policymakers

Capacity building and skilling the stakeholders–scientists, policymakers and civil society people to better manage the oceans and sustainable utilization of resources is the need of the hour. There is a lack of awareness among the public in terms of the influence of the ocean on climate change and vice versa. The youth must be motivated and enthused to undertake oceanic research and opt for ocean-based careers to achieve Sustainable Development Goal 14: 'conserve and sustainably use the oceans, seas and marine resources for sustainable development' (Atmanand, 2023).

5.2.4 Governance Challenges

treaties UNCLOS BBNJ

Various international laws and treaties govern the oceans. Being part of the global commons, the seabed, ocean floor and subsoil of the oceans are governed by UNCLOS with the clause that no state shall claim or exercise sovereignty or sovereign rights over any part of the area or its resources (Parmar, 2023). The ISA under the UNCLOS is entrusted with the seabed and sub-seabed areas beyond the national jurisdiction and authority over international waters. While the recently signed BBNJ Treaty, also under UNCLOS, envisions governing the high seas to protect biodiversity. It includes environmental impact assessment, marine protected areas, transfer of technology and capacity building, amongst others (Rajan, 2023).

The diverging and converging of such mechanisms lead to challenges to the governance of oceans with ambiguities and conflicting nature of the laws; the discordance between scientists and technologists on the one hand and legal brains on the other hand; and personal prejudices among the stakeholders against and for the law of the sea (Rajan, 2023). Additionally, nations vying for existing and potential resources is a matter of governance (Parmar, 2023).

ISA

The overlapping mandates of ISA and BBNJ may bring the authorities into conflict with each other (Rajan, 2023). Also, the effectiveness of BBNJ lies in its implementation, which depends on the subjective interpretation of nations (Parmar, 2023). However, the body has been paradoxically criticized and praised for its work (Rajan, 2023). Moreover, non-signatory countries of the UNCLOS are not bound by its regulations.

5.3 Ocean Decade Outcomes

It is important to promote clean, healthy, resilient, productive, predicted, safe and accessible oceans, whether it is in the coastal regions or beyond national jurisdiction (Meenakumari, 2023). The ocean decade outcomes aim to inspire and engage people to take action for ocean conservation. The programme addresses the growing concerns of marine pollution, plastic waste, and climate change impacts on the ocean's health and resilience. The outcomes also aim to promote sustainable and responsible use of ocean resources while protecting the ocean's biodiversity and ecosystems. Through collaborative efforts and innovative technologies, India will strive to create a more sustainable and prosperous future for the Indian Ocean region and the world.

accessible oceans
national jurisdiction
innovative
technologies

5.4 Recommendations

In order to address the challenges around oceans and attain the ocean decade outcomes, the following recommendations are made:

i. The energy potential of oceans should be utilized through the OTEC technology with good scalability (Atmanand, 2023).

ii. India possesses a coastline stretching 7,500 km, with a capability to generate 140 GW of offshore wind energy. Measures should be taken to utilize this potential (Atmanand, 2023).

iii. Developing advanced instruments to measure small changes in ocean observations and making them globally accessible is crucial for tackling pressing issues like global warming and ocean acidification. These instruments can aid in forecasting, evaluating data, and creating models for the ocean and atmosphere (Atmanand, 2023).

iv. New technologies should be developed along with conventional methods to clean the beaches. Technologies like ocean-cleaning robots and other litter traps should be developed (Atmanand, 2023).

v. Research on bio-plastic should be done to develop a sustainable alternative to plastic pollutants (Atmanand, 2023).

vi. Cost-effective newer technologies should be developed for carbon capture and sequestration to capture them in deep earth and oceans (Atmanand, 2023).

vii. To address the lack of awareness about the influence of oceans on climate change, youngsters should be encouraged to take up an ocean-based career (Atmanand, 2023).

viii. The rate of sea level rise along the Indian Ocean was 5.5 mm/yr from 2013- 2020 (Swapna, 2023). Restricting construction along vulnerable areas and preparing the population for planned relocation should be arranged as an adaptation measure.

ix. For better ocean observations, autonomous recording systems of high sampling frequency with enhanced power capabilities that can work for more than one year are needed (Latha, 2023).