



OCEANS AND THE LAW OF THE SEA: REPORT OF THE SECRETARY-GENERAL (2025)

CONTRIBUTION BY THE WORLD METEOROLOGICAL ORGANIZATION (WMO)

TO THE IMPLEMENTATION OF GA RESOLUTION 79/144 OF 12 DECEMBER 2024 'OCEANS AND LAW OF THE SEA'

For Submission June 2025

Pursuant to United Nations General Assembly [Resolution 79/144](#) of 12 December 2024, entitled "Oceans and the law of the sea", the information below represents the contribution of the World Meteorological Organization (WMO) to the report of the UN Secretary-General, between **1 September 2024 and 31 August 2025**. The work of the WMO is structured around the following WMO long-term goals, each of which is reported in this submission.

Goal 1: Better serve societal needs

Goal 2: Enhance earth system observations and predictions

Goal 3: Advance targeted research

Goal 4: Close the capacity gap on weather, climate, hydrological and related environmental services

Goal 5: Strategic realignment of WMO structure and programmes for effective policy-, decision-making and implementation

EXECUTIVE SUMMARY

The World Meteorological Organization (WMO) is the authoritative voice on the state and behaviour of the Earth's atmosphere, its interaction with the land and ocean, the weather and climate it produces and the resulting distribution of water resources. The ocean provides essential natural resources to humankind and regulates the global climate. WMO contributes to ocean-related issues through the observation and monitoring of the ocean and climate; research on the climate and connected earth systems; development and delivery of marine and hydrological services including forecasts and early warnings for reducing the risk of disaster caused by marine and coastal hazards; capacity development and training; and the provision of science-based information and tools for decision making for policymakers and the general public at national, regional and global levels.

EARLY WARNINGS FOR ALL (EW4All)

WMO advanced Early Warnings for All (EW4All) by strengthening ocean-related services vital to shipping, fisheries, offshore energy, and coastal communities. It supported national services in improving marine hazard monitoring, coastal observations, and impact-based forecasting for threats such as tropical cyclones, storm surges, and marine heatwaves. Promulgation of meteorological Maritime Safety Information (MSI) was enhanced through digital platforms via the Global Maritime Distress and Safety System (GMDSS). WMO worked with partners to co-develop user-focused services, particularly in Small Island Developing States (SIDS) and least

developed coastal states (LDCS). Capacity-building activities and technical support helped ensure timely, actionable marine forecasts, reducing risk and supporting resilience in blue economies.

OCEAN-CLIMATE INDICATORS REVEALED

WMO monitored the ocean-climate indicators that contribute to the SDG 13 (Climate Action) and 14 (Life Below Water). The Annual Global Statement on Climate (WMO-No. 1368) confirmed 2024 as the warmest year on record, with 2015–2024 marking the ten hottest years observed. These global signals are mirrored regionally, as highlighted in the 2024 WMO regional climate reports, reinforcing the urgency of ocean monitoring and early warning capabilities. Key indicators include:

- **Ocean Heat Content (OHC):** Reached a new record in 2024, exceeding 2023 by 16 ± 8 zettajoules (ZJ), with a warming rate of $0.99\text{--}1.07 \text{ W/m}^2$ over 2005–2024.
- **Sea Level Rise:** Global mean sea level reached a record high in 2024, rising at 4.7 mm/year (2015–2024)—more than double the 2.1 mm/year rate from 1993–2002.
- **Sea Surface Temperature (SST):** 2024 was the warmest year on record, with exceptional SSTs driven by widespread marine heatwaves and a strong El Niño event.
- **Sea Ice Extent:** Arctic minimum: $4.28 \text{ million km}^2$ (11 September 2024, 7th lowest). Antarctic minimum: $1.99 \text{ million km}^2$ (20 February 2024, tied for 2nd lowest).
- **Ocean Acidification:** Surface ocean pH is declining at $-0.017 \pm 0.001 \text{ pH units per decade}$ (1985–2023), confirming continued acidification across global ocean basins.

GOAL 1: BETTER SERVE SOCIETAL NEEDS

DELIVERABLES HIGHLIGHTS

- Continued support to METAREA Coordinators through Worldwide Met-Ocean Information and Warning Service (WWMIWS) within GMDSS, fulfilling the International Maritime Organisation (IMO) Convention for Safety of Life at Sea (SOLAS) commitments.
- Hosted the 2nd WMO–IMO Symposium on Extreme Maritime Weather, improving awareness and forecast-user engagement.
- Strengthened marine hazard resilience and early warning systems through Tropical Cyclone Programme.
- Record-breaking ocean climate indicators: sea-level rise, heat content, and sea-ice decline documented in global assessments.
- Advanced integrated coastal flood risk management by combining ocean, river, and groundwater modelling in response to glacier melt and reduced river discharge, with focus on vulnerable SIDS regions.

SOLAS commitments via Worldwide Met-Ocean Information and Warning Service (WWMIWS)

WMO continues to support the METAREA Coordinators through the Worldwide Met-Ocean Information and Warning Service (WWMIWS), to provide warnings and forecasts to meet the obligations for the meteorological maritime safety information as articulated in the SOLAS Convention. This is undertaken in partnership with the IMO and International Hydrographic Organization (IHO) via joint meetings, collaborative maintenance of related publications and documentation, and close cooperation with the IMO recognised mobile satellite service providers.

The 2nd WMO-IMO International Symposium on Extreme Maritime Weather

The symposium played a crucial role in highlighting the impacts of extreme weather and the resultant economic losses and disruptions to trade from delays or damage to cargo shipments. By fostering collaboration between meteorologists and maritime industries, the event showcased advancements in forecasting and early warning systems, which have the potential for reducing the risk of costly ship losses, cargo loss, and port closures as well as highlighting the needs and requirements of the user communities.

Tropical Cyclone Programme

Tropical cyclones, intensified by warming ocean temperatures, remain a key focus of the EW4All initiative led by WMO. In 2024–2025, major storms like Cyclones Chido, Fengal, and Hurricanes Beryl and Helene prompted technical reviews by WMO regional bodies. The WMO Hurricane Committee emphasized the ocean's role in storm development and supported expanded ocean observations. Over 2,500 ocean profiles were collected using underwater gliders in the Caribbean and Mexican Pacific, improving forecast accuracy. Initiatives like the Fishing Vessel Observation Network (FVON), Argo floats, and OceanGliders helped fill observation gaps. These efforts strengthen marine hazard resilience, support early warning systems, and contribute to fulfilling obligations under the United Nations Convention on the Law of the Sea (UNCLOS).

State of Global Water Resources and Coastal Inundations:

The WMO Annual State of Global Water Resources 2024 (WMO - No.1362) highlighted that extreme heat in 2023 drove severe hydrological impacts. Around 50% of global river basins recorded drier-than-normal conditions, affecting freshwater input to coasts and disrupting navigation and ecosystems. Glacier melt exceeded 600 Gt, marking the largest mass loss in five decades, and remains the second-largest contributor to sea-level rise after thermal expansion. In response, WMO and partners are advancing integrated approaches to coastal flood risk management, combining ocean, river, and groundwater modelling. Particular attention is given to SIDS in the Pacific, Caribbean, and Indian Ocean regions, where vulnerabilities to coastal inundation are greatest.

GOAL 2: ENHANCE EARTH SYSTEM OBSERVATIONS AND PREDICTIONS

DELIVERABLES HIGHLIGHTS

- Ocean observations, coordinated through Global Ocean Observing System (GOOS), Global Climate Observing System (GCOS) and WMO Integrated Global Observing System (WIGOS), are vital for accurate weather, climate, and environmental predictions, efforts made for inclusion of Essential Climate Variables (ECVs) for the ocean.
- Supported African countries in improving marine data quality via WDQMS.
- Initiated inclusion of ocean variables in Global Basic Observing Network (GBON) to address data gaps.
- Upgraded to WMO Information System 2.0 (WIS2.0) to improve access to ocean and climate data.
- Continued global collaboration through WIPPS, adding marine emergency response and storm surge prediction components.
- Supported Members—particularly in LDCs and SIDS - through donor-funded initiatives that enhance ocean-related observation, forecasting, and implementation of international technical standards across its Long-Term Goals.

WMO Integrated Global Observing System (WIGOS) with ocean components

Ocean observations are a critical infrastructure for weather, climate, water, and environmental prediction, enabling life-saving decisions, protecting property, and supporting sustainable development. These observations are coordinated through the GOOS, a joint initiative of Intergovernmental Oceanographic Commission of UNESCO (IOC), WMO, United Nations Environment Programme (UNEP), and International Science Council (ISC), and form part of WIGOS. Analyses confirm that surface and subsurface ocean data significantly enhance medium-range weather forecasts and seasonal predictions of extremes such as heatwaves, droughts, and floods. In 2024, WMO supported 24 African countries to integrate marine observing stations into the WIGOS Data Quality Monitoring System (WDQMS), improving data reliability. Efforts are also underway to define core ocean observations for the GBON to address global data gaps. Through voluntary and multilateral funding, WMO assists LDCs and SIDS in strengthening observation and forecasting capabilities, supporting the implementation of international technical standards across WMO's long-term goals.

Global Climate Observing System (GCOS):

In the past 33 years, The Global Climate Observing System, co-sponsored by WMO, IOC, UNEP and ISC has contributed centrally to global climate monitoring, understanding, and prediction. It has done by providing a coordination framework for atmospheric, oceanic and terrestrial observing networks, enabling scientists to track changes across multiple domains and ensuring the reliability, accuracy, and relevance of climate data, which is used for climate modelling and to underpin decision-making processes. Through its ocean panel of experts, in partnership with the GOOS and World Climate Research Programme (WCRP), GCOS defines the observational requirements for a global ocean observing system. GCOS is currently revisiting its list of Essential Climate Variables (which currently includes 19 ocean variables) to better respond to current societal needs.

WMO Information System 2.0 Operational for ocean data

In January of 2025 the global services underpinning the WMO Information System 2.0 (WIS2.0) became operational, marking the start of the transition from the WMO Global Telecommunication System (GTS). This significant upgrade enhances data exchange within the WMO, supporting the WMO Unified Data Policy and enabling the rapid, open and free access to WMO 'Core' data for all users. These data include observations from the Global Ocean Observing System (GOOS) that underpin the warnings and forecasts provided by the WWMIWS. WIS2.0 also facilitates the publication and exchange of WMO 'Recommended' data, with the data providers determining the level of access control for these data.

WMO Integrated Processing and Prediction System (WIPPS) and Marine Forecasts:

The WMO Integrated Processing and Prediction System (WIPPS) provides operational access to weather, climate, water, and environmental products through a global network of WMO-designated centres. Marine services are supported by 24 WIPPS Designated Centres across METAREAs, with additional centres focused on ocean wave prediction, tropical cyclone forecasting, and global ocean modelling. Two new focus areas - marine emergency response and global storm surge prediction - have been added, with designation of responsible centres underway. Under the Earth System Modelling and Prediction (ESMP) approach, WIPPS is incorporating more ocean parameters to address growing user needs across sectors. WMO also explored future collaboration with the OceanPredict Science Team during the 2024 OceanPredict Symposium.

GOAL 3: ADVANCE TRAGETED RESEARCH

DELIVERABLES HIGHLIGHTS

- Through Climate and Ocean Variability, Predictability and Change (CLIVAR)/WCRP, WMO supported research on ocean-atmosphere interactions, tropical basin coupling, and marine heatwaves.
- PCAPS/WWRP project advanced forecasting in polar regions, integrating AI, ML, and regulatory analysis (e.g., Polar Code).
- Enhanced modelling and forecasting research linked to rapid cyclone intensification and glider-collected ocean profiles.
- Strengthened partnerships on multidisciplinary climate science.
- Contributed to serve as lead agency in the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) Working Group 38 (WG38) on Atmospheric Inputs to the Ocean.

CLIVAR Contributions to Ocean-Climate Science:

The WCRP supports international collaboration to advance climate knowledge for societal benefit. Among its six Core Projects, CLIVAR plays a central role in ocean-focused research. CLIVAR aims to understand, and model coupled climate system dynamics, with emphasis on ocean-atmosphere interactions across sub-seasonal to centennial timescales. Current research foci

include "Tropical Basin Interaction" and "Marine Heatwaves in the Global Ocean." CLIVAR also partners with the "My Climate Risk" Lighthouse Activity to establish regional ocean hubs addressing local climate risks. CLIVAR actively collaborates with GOOS, GCOS, and other scientific programmes such as IOC, Past Global Changes (PAGES), Integrated Marine Biosphere Research (IMBeR), Surface Ocean - Lower Atmosphere Study (SOLAS science), North Pacific Marine Science Organization (PICES), and Future Earth, to enhance multidisciplinary cooperation and strengthen the global ocean observing system.

Polar Coupled Analysis and Prediction for Services (PCAPS)/World Weather Research Programme (WWRP):

Launched in 2024 under the WWRP, the Polar Coupled Analysis and Prediction for Services (PCAPS) project seeks to improve the accuracy, reliability, and usability of environmental forecasts in polar regions. Through the integration of artificial intelligence, machine learning, and expanded observational capabilities, PCAPS supports better forecasting of sea-ice conditions, surface winds, and visibility - critical for maritime navigation and operational planning. PCAPS has established several Task Teams to support its objectives, including enabling informed decision-making to reduce risks to human life and the polar environment. This includes identifying institutional and regulatory enablers and barriers, such as those under the IMO Polar Code, and examining their impact on the development and delivery of enhanced Weather, Water, Ice and Climate (WWIC) services.

Atmospheric Inputs to the Ocean/Global Atmosphere Watch (GAW)

The GAW Programme remains the lead sponsor of GESAMP WG38 on Atmospheric Inputs to the Ocean. In 2025, WG38 launched a new initiative with WMO to improve estimates of atmospheric deposition to the ocean, addressing key gaps in modelling and measurements. An expert workshop in April 2025 brought together ocean and atmosphere scientists to identify priority research questions. Outcomes will be published in the GESAMP Report Series and a peer-reviewed article. WMO also co-sponsors GESAMP Working Groups 41 and 42 on ocean-based climate interventions and contaminant impacts. The Head of GAW serves as WMO's Technical Secretary to GESAMP, reinforcing WMO's leadership in ocean-atmosphere science coordination.

Goal 4: CLOSE THE CAPACITY GAP ON WEATHER, CLIMATE, HYDROLOGICAL AND RELATED ENVIRONMENTAL SERVICES

DELIVERABLES HIGHLIGHTS

- Continued implementation of global Marine Services Course initiative cross regions.
- Spearheaded for ocean-related early warnings systems with clear implementation plan in Africa.
- Ocean Panel at Hurricane Committee fostered collaboration on tropical cyclone forecasting and ocean governance for the North, Central America and the Caribbean.
- Enhanced integration of marine services aligned with the WMO Strategic Plan and global legal instruments (UNCLOS, EW4All) in Europe.
- Strengthened collaboration with hydrological community in Asia and South-West Pacific, including coastal early warning systems vulnerable low-lying SIDS.
- Regional Coastal Inundation Forecasting Initiative (CIFI) planed by Pacific Islands Marine and Ocean Services (PIMOS).

WMO Marine Services Course in regions.

In 2024-2025, WMO continued the implementation of its global Marine Services Course, delivering two Phase-II courses to Member States in South America (Spanish) and North America, Central America, and the Caribbean (English), one Phase I Course for Arabic-speaking countries and one Phase I Course for Southeast Asia. These courses were focused on enhancing technical forecasting skills, such as wave forecasting and impact-based forecasting, through a combination of online and face-to-face training. The object of the course is to improve the services provided by individual coastal states to the various customers within their waters of national jurisdiction as well as enhance the service providers' understanding of the various user needs and

requirements. The course aimed to strengthen NMHS marine services in support of EW4All and the UN Decade of Ocean Science.

Ocean and Marine Services Initiatives in Africa:

Significant regional activities across Africa in 2024 advanced marine and climate resilience. A virtual regional meeting identified gaps in climate observation and early warning systems, currently covering only 40% of Africa, and called for expanded coverage and sustainable water management solutions. The regional Hydrological and Water Coordination Panel (HWCP) adopted a 2024–2027 programme to enhance hydrological capacity, develop integrated flood and drought services, and improve data systems, advancing the implementation of the WMO Hydrological Plan of Action and EW4All in Africa.

Ocean and Marine Services Initiatives in North, Central America and the Caribbean:

During the 47th Session of the Hurricane Committee in El Salvador, the Ocean Panel gathered 60 regional participants to highlight the importance of ocean observations in tropical cyclone forecasting. The Caribbean and Mexican Pacific remain under-sampled, but 2024 glider deployments collected around 2,500 vertical profiles, improving model accuracy and operational forecasts. The Fishing Vessel Observation Network (FVON) offers a cost-effective way to expand data collection. Research stressed the use of ocean heat content to identify areas of rapid cyclone intensification, with models such as Tropical Cyclone Ocean-coupled Potential Intensity Model (TOPIM) providing near real-time storm intensity forecasts. The Caribbean Institute for Meteorology and Hydrology (CIMH) is advancing marine services and regional ocean governance. Key recommendations included transitioning from MSR permissions to regional agreements, expanding glider capacity, integrating ocean data into operations, and increasing government support for marine observation and training.

Ocean and Marine Services Initiatives in Europe:

WMO continues to strengthen ocean observation, marine hazard monitoring, and research in the region in support of global frameworks such as the UNCLOS and the EW4All initiative. The Working Group on Services assists Members in developing integrated marine services aligned with the WMO Strategic Plan (2024–2027). The Working Group on Research is addressing emerging issues, including potential changes in ocean circulation such as a weakening Gulf Stream, with regional linkages to be discussed at the forthcoming Scientific Forum. The Working Group on Infrastructure is establishing marine-focused WIGOS Centres to improve coordination, data quality, and observation coverage, especially for early warnings in vulnerable coastal zones. The Regional Climate Centre contributed to the 2024 European State of the Climate report, confirming Europe as the fastest-warming WMO region with record-high sea surface temperatures and increasing marine heatwave risks.

Ocean and Marine Services Initiatives in Asia and the South-West Pacific:

WMO has established expert teams on marine meteorological and oceanographic services, working in coordination with hydrology panels and WMO technical commissions. Their efforts support advancements in marine observations, hazard forecasting, and service delivery, including coastal early warning systems such as the flag system being implemented in the Solomon Islands with Climate Risk and Early Warning Systems (CREWS) support. These initiatives are integrated into the 2025–2027 regional work programmes and contribute to the WMO Strategic Plan, including the Hydrological Plan of Action and the EW4All initiative. The PIMOS Panel conducted a feasibility study for regional CIFI.

Goal 5: Strategic realignment of WMO structure and programmes for effective policy- and decision-making and implementation

DELIVERABLES HIGHLIGHTS

- The Joint WMO–IOC Collaborative Board (JCB) prioritized action areas including Ocean GBON; Data interoperability; Coastal resilience; and Joint capacity development with two dedicated subgroups.
- Participated in the 3rd International Ocean Data Conference and IODE-28 to align oceanographic data efforts with WMO systems.

Joint WMO–IOC Collaborative Board (JCB): Strengthening Ocean-Climate Cooperation

Established in 2019, the Joint WMO–IOC Collaborative Board (JCB) enhances cooperation between WMO and IOC across the full value chain - observations, data, prediction, and services - supporting global goals in disaster risk reduction, climate action, and sustainable development. At its first in-person meeting in September 2024, members prioritized four key areas for joint action: (1) Ocean GBON - co-defining a Global Basic Observing Network for the ocean; (2) Data Interoperability - enhancing integration between WIS2.0 and ODIS, supported by collaboration between Standing Committee on Information Management and Technology (SC-IMT) and International Oceanographic Data and Information Exchange (IODE), including participation in IODE-28 and the 3rd Ocean Data Conference; (3) Coastal Resilience - supporting EW4All through improved ocean hazard services; and (4) Capacity Development - coordinating training across both organizations. A new sub-group was formed to advance cross-agency data ecosystems. These priorities will guide future efforts to build resilient, ocean-informed societies through integrated science, services, and innovation.

Acronyms

CIFI	Coastal Inundation Forecasting Initiative
CIMH	Caribbean Institute for Meteorology and Hydrology
CLIVAR	Climate and Ocean Variability, Predictability and Change
CREWS	Climate Risk and Early Warning Systems
ESMP	Earth System Modelling and Prediction
EW4All	Early Warnings for All
FVON	Fishing Vessel Observation Network
GA	General Assembly
GAW	Global Atmosphere Watch
GBON	Global Basic Observing Network
GCOS	Global Climate Observing System
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GMDSS	Global Maritime Distress and Safety System
GOOS	Global Ocean Observing System
GTS	Global Telecommunication System
IHO	International Hydrographic Organization
IMBeR	Integrated Marine Biosphere Research
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission of UNESCO
IODE	International Oceanographic Data and Information Exchange
JCB	Joint WMO-IOC Collaborative Board
LDCS	least developed coastal states
MSI	maritime safety information
NMHSs	National Meteorological and Hydrological Services
OceanPredict	OceanPredict Science Team
PAGES	Past Global Changes
PCAPS	Polar Coupled Analysis and Prediction for Services
PICES	North Pacific Marine Science Organization
PIMOS	Pacific Islands Marine and Ocean Services
SC-IMT	Standing Committee on Information Management and Technology
SIDS	small island developing states
SOLAS	International Convention on Safety of Life at Sea
SOLAS (science)	Surface Ocean - Lower Atmosphere Study
TOPIM	Tropical Cyclone Ocean-coupled Potential Intensity Model
UNCLOS	United Nations Convention on the Law of the Sea
WCRP	World Climate Research Programme
WDQMS	WIGOS Data Quality Monitoring System
WIGOS	WMO Integrated Global Observing System
WIPPS	WMO Integrated Processing and Prediction System

WIS	WMO Information System
WIS2.0	WMO Information System 2.0
WWIC	Weather, Water, Ice and Climate
WWMIWS	Worldwide Met-Ocean Information and Warning Service
WWRP	World Weather Research Programme