Ocean Decade Tsunami Programme

A FRAMEWORK FOR INTERNATIONAL COOPERATION TO ENHANCE THE END-TO-END TSUNAMI EARLY WARNING AND MITIGATION SYSTEMS

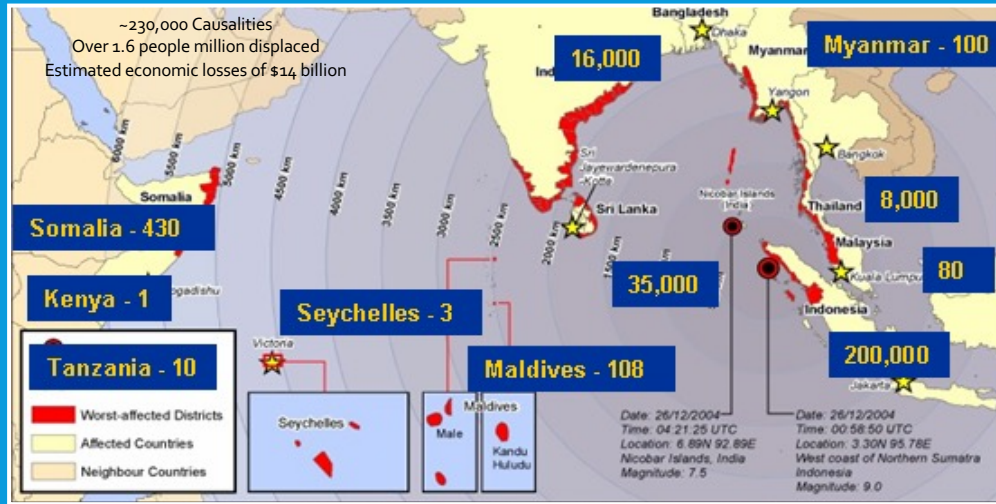**Srinivasa Kumar TUMMALA**

Chair

Ocean Decade Tsunami Programme Scientific Committee (ODTP-SC)

ICG/IOTWMS Steering Group Meeting

05 February 2024, INCOIS, Hyderabad, India

Global Tsunami Warning Systems

~230,000 Causalities
Over 1.6 people million displaced
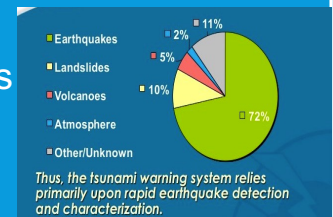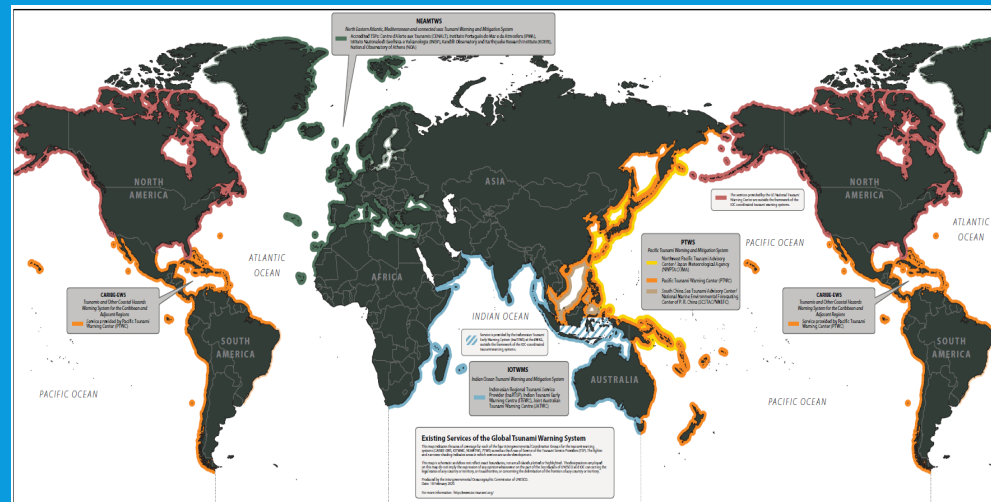Estimated economic losses of $14 billion

Great progress since 2004

- 4 Regional Systems coordinated by the IOC UNESCO - PTWS, IOTWMS, CARIBE EWS, NEAMTWS
- Operate as inter-operable "system-of-systems"
- Network of NTWC/TWFPs receiving tsunami forecast information from one/more TSPs
- Sovereign responsibility of NTWCs/TWFPs to provide warnings, watches, and advisories to their citizens
- Seismic & Sea Level Observing networks, models, computational, communication facilities, DSS and SOPs
- Tsunami Ready
- Successfully monitored and issued warnings for several events

Several challenges evidenced from recent events

- Tsunami warning is race against time - Uncertainties in tsunami warning
- Gaps in Warning and Response capabilities, specially for non-seismic and near-field sources
- Gaps in SOPs and Early Warning Chains
- Gaps in preparedness & response

Thus, the tsunami warning system relies primarily upon rapid earthquake detection and characterization.

Ocean Decade Tsunami Programme

- UN Ocean Decade (2021-30): **Once-in-a-generation opportunity** to achieve **"transformational gains"** in tsunami warning and mitigation system by addressing **gaps in tsunami warning** and **enhancing community preparedness.**
- **IOC Assembly 31** in June 2021 (Dec. A-31/3.4.1) established the **"Ocean Decade Tsunami Programme"** and **"Scientific Committee"** to Develop Research, Development & Implementation Plan
  - **Technological & Observational Advances** to reduce uncertainties in tsunami warning
  - **100 % at risk communities prepared & resilient** to tsunamis by 2030 (Tsunami Ready, etc.)
- Contributing to **"A Safe, Predicted and Accessible Ocean"** Decade Outcomes via Challenge 6 on **"Multihazard Early Warning Services & Community resilience"** and Challenge 9 on **"Capacity Development"** and aligns with all three Decade Objectives related to **Identification, Gerneration and use of knowledge for Sustainable development.** Directly supports **SDG 11** by applying advancements to Ocean Science to saving lives and reducing number of affected people and economic losses in coastal cities and communities.

UN Ocean Decade Tsunami Programme Scientific Committee [Introductions]

Annex to Dec. A-31/3.4.1

Membership:
• Four (4) members nominated by the each of the TOWS-WG Task Teams;
• Three (3) members nominated by the TOWS-WG on the basis of their scientific expertise;

2022-2023

Annex to Dec. A-31/3.4.1 (cont.)

• All members will serve for a period of two years and would be eligible for renewal once.
• In selecting Expert Members, due consideration will be given to geographic, generational and gender balance.

Srinivasa Kumar Tummala
Chairperson

Christa von Hillebrandt

Amir Yahav
Maria Ana Baptista

Harkunti Pertiwi Rahayu

David Coetzee

Silvia Chacon

Srinivasa Kumar Tummala

François Schindele
Helene Hebert

Yutaka Hayashi

Michael Angove

Sergio Barrientos

Alexander Rabinovich

UN Ocean Decade Tsunami Programme Scientific Committee
Terms of References (ToRs) (Rev IOC EC-55)

i. ~~Develop a Draft 10-Year Research, Development and Implementation Plan~~ ~~for the Ocean Decade Tsunami Programme based on the concept paper~~ ~~*"Protecting Communities from the World's Most Dangerous Waves: A Framework for Action under the UN Decade of Ocean Science for Sustainable Development"*~~;

ii. Identify and address gaps in global tsunami hazard assessment as follows:

    a. comprehensive assessment to include all potential tsunamis, anywhere in the world, regardless of their source,

    b. strategies to validate historical tsunami sources, through the application of paleotsunami techniques and historical seismology;

iii. Identify gaps in tsunami detection, measurement, forecasting, with a special emphasis on tsunamis generated close to populated coastlines;

iv. Propose to enhance sensing and analysis strategies to enable the rapid characterization of tsunami sources through the combined use of land-based seismic and geodetic sensors, GNSS terminals, coastal sea level gauges, deep-ocean tsunameters, SMART repeaters on deep-ocean fiber-optic cables and satellite-based observations;

v. Propose a roadmap for collaboration with the ITU/WMO/IOC SMART Joint Task Force cable initiative to fully explore the feasibility of widespread deployment of scientific instrumentation on deep-ocean fiber-optic cables to improve capability to rapidly detect and characterize tsunami sources as well as propagating tsunami wave fields;

vi. Consider and propose strategies, programmes and content to enhance societal resilience for tsunami and other ocean hazards;

    a. Build the framework needed to ensure the training and development of the next generation of technical-scientific expertise,

    b. Identify strategies that allow to characterize structural and social vulnerability in tsunami hazard zones

    c. Propose strategies for promoting implementation of community preparedness initiatives such as IOC Tsunami Ready to ensure 100 % at risk communities are prepared & resilient to tsunamis by 2030

vii. ~~Overview the~~ ~~consolidation of inputs~~ ~~received to IOC Circular Letter 2825 on Inventory of actions being considered under the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) in the field of Tsunamis and Other Sea-Level Related Hazards warning and mitigation;~~

viii. ~~Submit a~~ ~~Draft 10-Year Research, Development and Implementation Plan for endorsement by the TOWS-WG at its~~ 16th ~~meeting~~.

UN Ocean Decade Tsunami Programme Scientific Committee

Goal=Draft a 10-Year Research, Development and Implementation Plan for the Ocean Decade Tsunami Programme

Important Milestones in the Development of the Plan

Consultants to draft chapters

Consultations with TSU community (TTs/ICGS)

Consult/contributions Member States (CL)

17 Feb 2022	24-25 Feb 2022	7-8 April 2022	13-17 June 2022	18-20 January 2023	2–3 March 2023	2–30 Jun 2023
SC 1st meeting (online)	**TOWS-WG XV**	**Safe Oceans Lab**	**IOC -EC 55**	**3rd SC meeting (in person)**	**TOWS-WG XVI**	**IOC Assembly**
The purpose of this meeting is to first and foremost meet (virtually) and present each other, but also to broadly discuss the terms of reference and agree on a timeline for delivering the 10-year plan	TOWS-WG is a standard setting and advisory body to the IOC on tsunami and other coastal hazards. This session will discuss among other matters, SMART Cable, Tsunami Ready & UN Decade	Laboratories are innovative formats that function as self-sustaining events. They act as a creative platform to link diverse stakeholders and topics to trigger collaborative efforts regarding the UN Ocean Decade.	IOC Governing body **2nd SC meeting (in person)** 1st Draft of the 10-Year Research, Development and Implementation Plan for the Ocean Decade Tsunami Programme	2nd draft of the 10-Year Research, Development and Implementation Plan for the Ocean Decade Tsunami Programme	Final version of the 10-Year Research, Development and Implementation Plan for the Ocean Decade Tsunami Programme for the Endorsement	10-Year Research, Development and Implementation Plan for the Ocean Decade Tsunami Programme Endorsed by the IOC Assembly

Draft TORs consultancies

4th Call for Decade Actions 31 Jan 2023 – Coastal Resilience

1st Draft to TNCs/TWFPs Dec2022

2nd draft to TOWS-WG/ICGs/TTs Jan2023

Intergovernmental Oceanographic Commission
Technical Series

180

unesco

Research, Development and Implementation Plan for the Ocean Decade Tsunami Programme

UNESCO

The SC developed the Draft 10-Year Research, Development and Implementation Plan for the Ocean Decade Tsunami Programme which was presented and endorsed at the 32nd session of the IOC Assembly in June 2023.
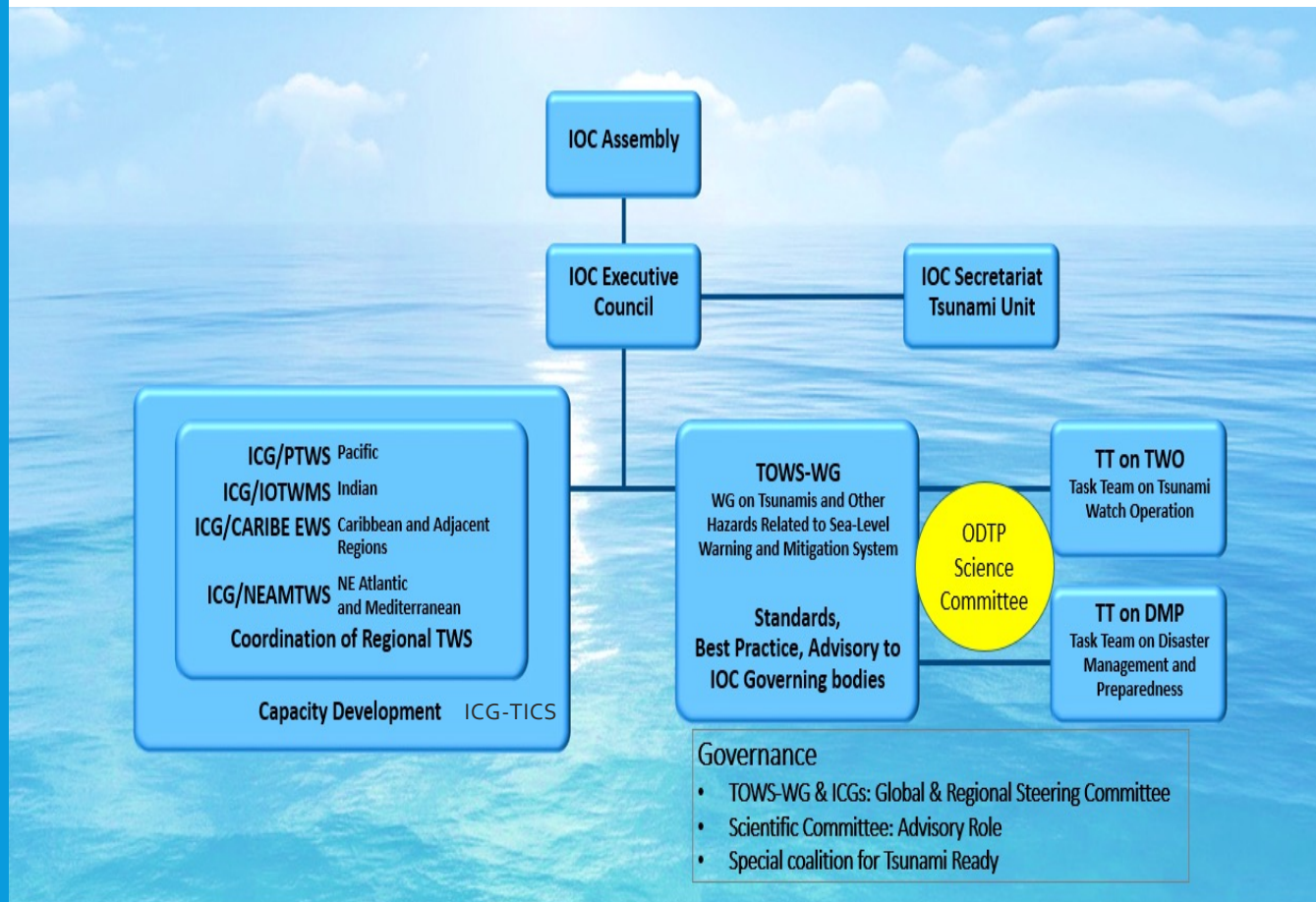
unesco
Intergovernmental
Oceanographic
Commission

Research, Development and Implementation Plan for the Ocean Decade Tsunami Programme

EXECUTIVE SUMMARY

Approved by the thirty-second Session of the IOC Assembly, UNESCO, 21-30 June 2023

- To explore opportunities and establish connections with Decade programmes, projects, contributions, DCCs and CoPs, Calls for Action

- To align with international frameworks, call for action and multi-lateral environmental agreements – SFDRR, SDGs (3, 8, 11, 14), Paris Agreement on climate change, early warnings for all, UN Global Early Warning Initiative (2023-2027) etc.

- To provide new cooperation opportunities by laying out the building blocks, through an international Science Committee and International Tsunami Ready Coalition while renewing and strengthen existing cooperation with partners

- To encourage and promote inclusiveness and gender diversity, and that youth and early career professionals engage and involve in tsunami early warning systems and actions

- To develop and operationalize a transparent performance monitoring system based on international norms, standards and agreements

Governance
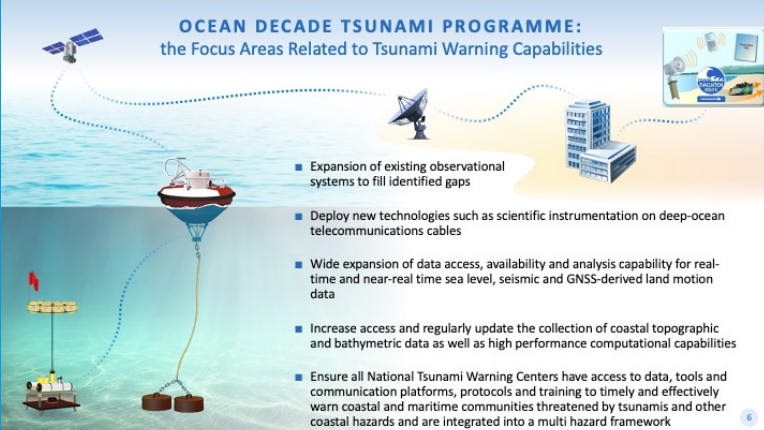
The IOC-UNESCO tsunami programme will oversee the overall implementation of the ODTP through contributions and engagement of Member States, in coordination with the ICGs, and with the collaboration of academic institutions, researchers, industry, philanthropic organisations and other stakeholders

	DAY 1 (25th Jan)	Remarks/lead
09:00-09:30	1. **OPENING AND UPDATES / FOLLOW UP ACTIVITIES RELATED TO THE ODTP RDIP**	Chairperson Head of TSR
[09:30-13:00]	2. **DISCUSS THE UN OCEAN DECADE INITIATIVES AND THEIR RELATIONSHIP WITH ODTP**	
	a. Communities of Practice	Doc available to discuss
10:15-10:30	b. Capacity Building Facility (Mary Frances @10:15)	PTTN by Mary Frances, DCU
10:30-11:00	COFFEE BREAK	
[11:00-13:00]	c. Thematic / Regional Decade Collaborative Centres / Coordination Offices: ○ DCC-PICT (Dr Jérome Aucan) @ 11:00 ○ DCC-PRED (Enrique Alvarez) @11:20 ○ DCC-IOR (Srinivas Kumar) @11:40 ○ DCC-CR (Nadia Pinardi) @12:00 ○ DCO-CAR (TBC)	<u>Several presenters</u>
	d. Vision 2030: Draft White Paper of "WG-6: Increase Community Resilience to Ocean Hazards": DCC-CR & DCC-IOR	Chairperson Doc available to discuss
13:00-14:00	LUNCH BREAK	
14:00: 15: 00	3. **UPDATE ON CURRENT WORK PROGRAMMES OF TOWS-WG TASK TEAM ON TSUNAMI WATCH OPERATIONS AND TASK TEAM ON DISASTER MANAGEMENT AND PREPAREDNESS**	2023 D &R TT DMP and TT TWO available Draft Agenda of 2024 TOWS TTs Meeting Chairperson TTs Tech Secretaries
15:00-15:30	COFFEE BREAK	
15:30 -17:00 END OF DAY 1	4. **REVIEW LIST OF ENDORSED ACTIONS RELATED TO ODTP AND OR CHALLENGE 6 AND COORDINATION WITH TOWS-WG WORK PROGRAMMES**	Denis Chang Seng PPTN and DOC

	Day 2 (26th Jan)	Remarks/lead
09:00-10:30	5. DISCUSS ICG INITIATIVES/COORDINATION WITH RESPECT TO ODTP	Chairperson ICG representatives / Tech Secretaries
10:30-11:00	COFFEE BREAK	
[11:00-13:00]	6. DISCUSS ODTP INVOLVEMENT IN:	
	a. 2nd UNESCO IOC Global Tsunami Symposium: "A Reflection of The Two Decades Post 2004 Indian Ocean Tsunami and Way Forward", 11 – 14 November 2024, and Pre-Event International Scientific Workshop, 8 - 9 November, Banda Aceh, Indonesia, with presentation by Symposium Programme Organizing Committee Co-Chairs	Harkunti Rahayu
	b. 2nd UN Ocean Decade Conference, 10 – 12 April 2024, Barcelona, Spain	Denis Chang Seng
13:00-14:00	LUNCH BREAK	
14:00-15:00	c. UN SG Early Warnings for All initiative	Erica Allis (WMO)
15:00-15:30	COFFEE BREAK	
15:30-16:30	7. REVIEW OF ACTIONS SUBMITTED TO THE UNOD 6TH CALL REFERRING TO ODTP.	Chairperson Denis Chang Seng
16:30-17:00

END OF DAY 2 | 8. AGREE SC-ODTP 2024 WORK PROGRAMME | |

ODTP- Objectives

OCEAN DECADE TSUNAMI PROGRAMME:
the Focus Areas Related to Tsunami Warning Capabilities

- Expansion of existing observational systems to fill identified gaps
- Deploy new technologies such as scientific instrumentation on deep-ocean telecommunications cables
- Wide expansion of data access, availability and analysis capability for real-time and near-real time sea level, seismic and GNSS-derived land motion data
- Increase access and regularly update the collection of coastal topographic and bathymetric data as well as high performance computational capabilities
- Ensure all National Tsunami Warning Centers have access to data, tools and communication platforms, protocols and training to timely and effectively warn coastal and maritime communities threatened by tsunamis and other coastal hazards and are integrated into a multi hazard framework

1. **To develop the warning systems' capability to issue actionable and timely tsunami warnings for tsunamis from all identified sources to 100% of coasts at risk**

2. **100% of communities at risk be prepared and resilient to tsunamis by 2030 through programmes like the IOC-UNESCO Tsunami Ready Recognition Programme (TRRP)**

Key Elements of the Research, Development & Implementation Plan
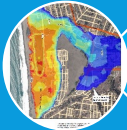
1. Tsunami Risk Knowledge: Identify and prioritise at-risk communities
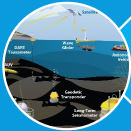
2. Tsunami Detection, Analysis and Forecasting: Expand existing, and deploy new observing technologies and warning systems

3. Warning, Dissemination and Communication: Access to data, tools, communication platforms, protocols and training to effectively warn coastal and maritime communities

4. Preparedness and Response Capabilities: To build tsunami-resilient communities

5. Capacity Development, SIDS and LDCs, Multi-hazard Framework: Underpinning elements

6. Governance and Pathways to Implementation

Tsunami Risk Knowledge - Goals
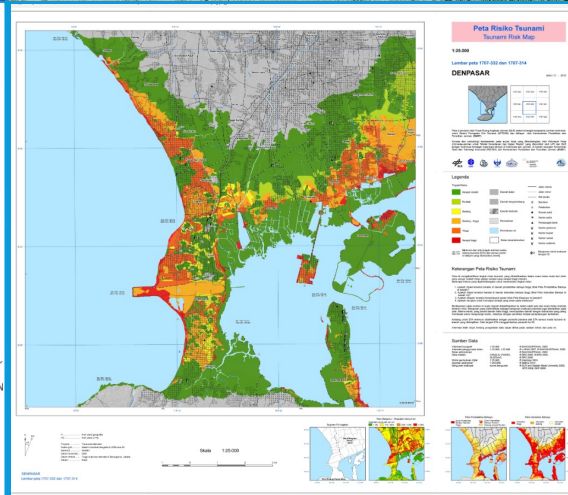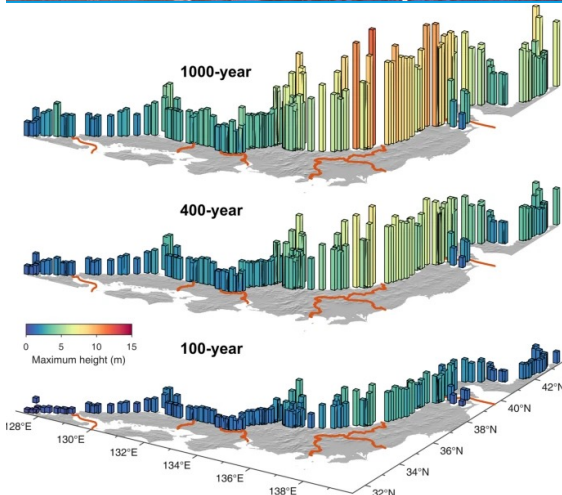
Definition of inundation areas, flow depths and arrival times through Tsunami Hazard Assessments

- Catalogue of historical tsunami records
- Database of tsunami source scenarios
- Coastal digital elevation data
- Access to Tsunami numerical models
- At least one person able to do tsunami modelling
- Defined the inundation area for the chosen community

Definition of vulnerability and exposure

- Identified critical infrastructure at risk
- Identified vulnerable groups
- Identified number of population
- Identified economic assets
- Identified built & natural environment

Definition of methodology to calculate risk

Definition of capacity to respond

- Bridged the gaps on legal framework
- Bridged the gaps on institutional framework
- Bridged the gaps on EWS

Using results from Tsunami Risk Assessments

- Performed TRA studies
- Developed tsunami risk reduction tools

Tsunami Risk Knowledge

Definition of inundation areas, flow depths and arrival times through Tsunami Hazard Assessments

Challenges	Solutions	Goals
Historical tsunami records are scarce or absent	Densify sea level networks, perform historical data research and perform paleo-tsunami studies	Each country to have their catalogue of historical tsunami records by 2025
Scenario definition (seismic and non-seismic) are required as input forcing for numerical models	Seismic, GNSS, Geophysical Volcanic Monitoring; Densify Sea level networks; Scientific Research; Experts Meetings	Each ICG to have a database of tsunami source scenarios, including non-seismic by 2025
High-resolution digital elevation data is required for numerical models but is lacking in many countries. Lack of qualified staff to conduct surveys; lack of equipment including boats.	Increase staff; Capacity building; Funding to buy/rent equipment	Each country has coastal digital elevation data in chosen communities by 2026 and each ICG has database of existing data and metadata
Lack of data to validate numerical models	Densify sea level networks; Perform historical data research; Perform paleo-tsunami studies	Each country has access to tsunami numerical models by 2026
Lack of qualified staff to conduct numerical modelling	Funding to hire and train staff	Each country has at least one person able to do tsunami modelling by 2025
		Each country has defined the inundation area for the chosen community by 2026

Tsunami Risk Knowledge

Definition of vulnerability and exposure

Challenges	Solutions	Goals
Inventories of critical infrastructure inside the inundation area (accessibility e.g., airport, ports) (telecomms, energy, food, fresh water & medical supply)	Multistakeholder resources (trained staff and funding) and coordination	Each Member State has critical infrastructure identified and prioritized by 2026
Ability to identify the vulnerable groups within the inundation area		Each country has identified vulnerable groups within tsunami inundation areas by 2026
Number of residents and visitors with their fluctuation (daily and seasonal) within the inundation area		Each country has identified number of populations at-risk within tsunami inundation areas by 2026
Identifying and prioritizing economic assets		Each country has identified and prioritized economic asset at land and ocean by 2026
Identifying and prioritizing critical infrastructure for economic impact		Each Member State has identified and prioritized critical infrastructure for economic impact at land and ocean by 2026
Identifying and prioritizing the built environment		Each Member State has identified and prioritized the built environment at land and ocean by 2026
Identifying and prioritizing the natural environment		Each Member State has identified and prioritized the natural environment at land and ocean by 2026

Tsunami Risk Knowledge

Definition of capacity to respond

Challenges	Solutions	Goals
Definition of legal framework existing and desirable. Identifying gaps and priorities.		Each Member State has bridged the gaps on legal framework by 2026
Definition of institutional framework existing and desirable. Identifying gaps and priorities.	Strategy and funding to bridge the gap	Each Member State has bridged the gaps on institutional framework by 2026
Definition of EWS elements available and desirable. Identifying gaps and priorities.		Each Member State has bridged the gaps on EWS by 2026

Definition of methodology to calculate risk

Challenges	Solutions	Goals
Develop methodologies for tsunami risk assessments including multi-scenario, location-based risk assessment of tsunami hazard characteristics, vulnerability, exposure, likelihood and Consequences	Document methodology (include multi-scenario, location-based hazard inundation mapping)	Each Member State has defined their tsunami risk assessment methodology by 2026
Multistakeholder definition of methodologies for tsunami risk Assessments	Developing and publishing of Supporting guidance and templates	

Tsunami Risk Knowledge

Using results from Tsunami Risk Assessments

| Challenges	Solutions	Goals
Conduct and periodically review tsunami hazard risk assessments, using agreed methodologies	Resources (trained staff and funding) and coordination	Each Member State has performed TRA studies by 2026
Translate risk assessment findings to the appropriate stakeholders and sectors.	Coordination	Each Member State has developed tsunami risk reduction tools according with results from TRA studies by 2028

Tsunami Detection, Analysis And Forecasting - Goals

- Tsunami Threat Life Cycle : Initial indicators, confirmation, forecasting, validation and cancellation

- Throughout the threat life cycle it is possible to provide information on the potential threat

- Initial indicators based on seismic proxy provide necessary timelines but can be inaccurate

- Additional challenges with non-seismic and near-source tsunamis

- Greatly expand international cooperation in tsunami warning and mitigation, to improve capability to directly detect and measure tsunamis and reduce reliance on seismic proxy relationships in terms of projecting impacts

- To develop the warning systems' capability to issue actionable and timely tsunami warnings for tsunamis from all identified sources to 100% of coasts at risk

- Most urgently, the ODTP will aim to provide tsunami confirmation within 10 minutes or less of origin for the most at-risk coastlines
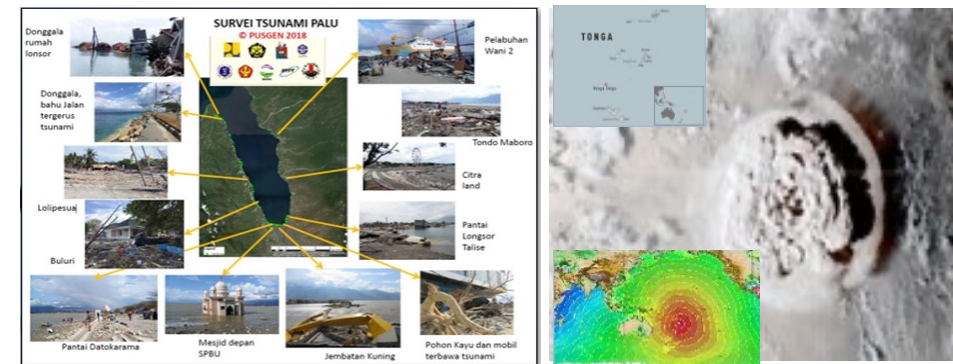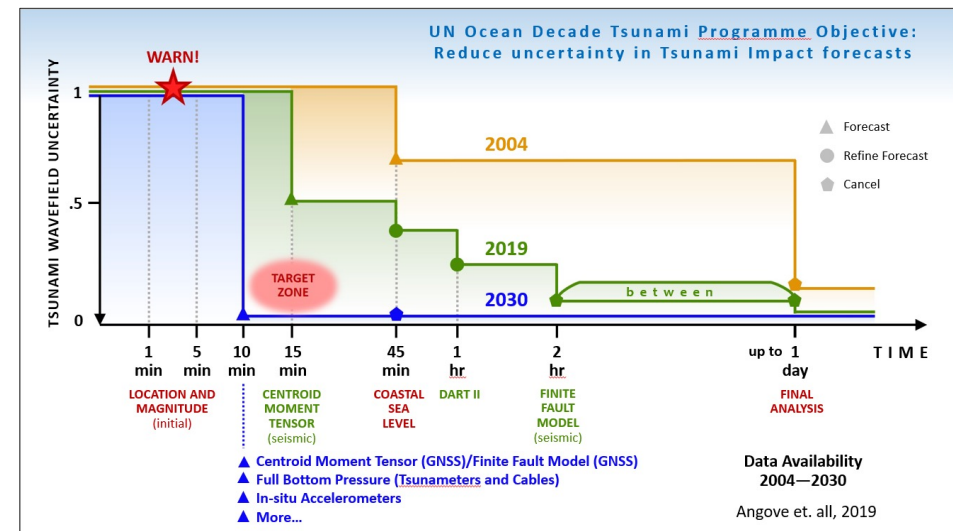
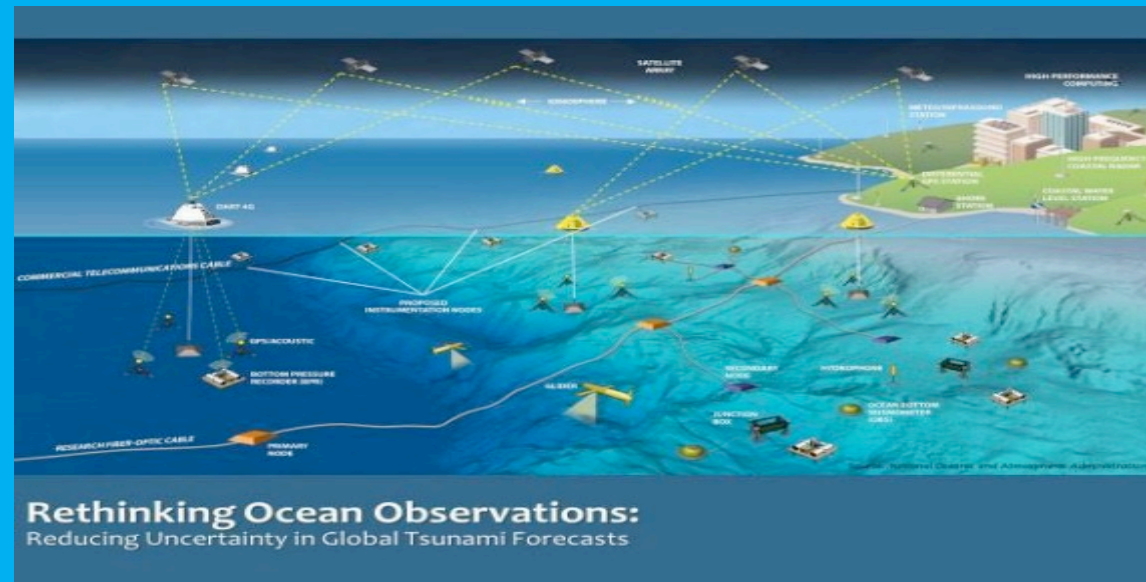# Tsunami Detection, Analysis And Forecasting

Detection and Measurement

- **Maximize and expand current capabilities**
  - Seismic networks, Tsunameters, Coastal sea level gauges, GNSS, Dedicated observatories
  - Supporting capabilities - Coastal bathymetry, Sensor siting analysis, Global digital synthetic database, Model codes, Potential tsunami sources including non-seismic, Science to practice, Training on tsunami warning operations
- **Implementation of existing capabilities not being applied to tsunami operations**
  - Coastal RADARs
  - Passive/Active Remote Sensing
  - Infrasound
- **Identification of new candidate capabilities**
  - Ionospheric tomography – TEC
  - Fibre Optic Applications – Distributed acoustic sensing

Characterization and Forecasting

- **Research on nature of tsunamis, source mechanisms and characterisation**
- **Probabilistic Tsunami Forecasting Techniques**
- **New Forecast methods**
  - Database Applications and matching Schema for updated Global Threat Database including non-seismic sources
  - AI – ML to relate, discrete or combine observations to potential outcomes
  - Dynamic Characterization using Rapid update cycle models

- **Optimal notional global network design in all ICGs**
  - Mix of observational platforms for tsunami operations in terms of locations, sensors, telemetry, data formats, etc
  - New Technologies for Communication, Sensors, Repeaters,
  - New use cases for Data (multi-hazard, climate, science)
  - Collaboration with Scientific Groups, International Organisations, Industry, etc. for expansion of networks, R&D of new systems, Operationalisation
- **Optimal observing network implementation in all ICGs**
- **Enhanced data sharing in all ICGs**
- **High-Resolution Coastal Bathymetry and Topography**
- **Advanced computing/modelling/impact forecasting/assimilation/analytics in all TSPs**
- **Access to data, tools and communication platforms in all TWCs**

Rethinking Ocean Observations:
Reducing Uncertainty in Global Tsunami Forecasts

Tsunami Detection, Analysis And Forecasting

Overall		
Challenges	Solutions	Goals
100 percent detection and measurement of all significant tsunamis within an actionable timeframe from generation (Table 1)	Optimal notional global network design consisting of a mix of observation platforms/types including seismographs, tide gauges, tsunameters, GNSS, SMART, research cables, interferometers, etc.	Optimal global network design in all ICGs by 2023
Table 1 Specific aspirational targets of the ODTP related to tsunami detection, analysis and forecasting 	Tsunami Source	Initial indicators (time after origin)	Tsunami detected (time after origin)	Tsunami constrained (time after origin)
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Earthquake	3 min	10 min	45 mins
Non-earthquake (known)	10 mins	45 mins	60 mins
Non-earthquake (unknown)	60 mins	90 mins	120 mins		Optimal observing network implementation	Optimal network implementation in all ICGs from 2025 onwards
	Enhanced data sharing	Enhanced data sharing in all ICGs by 2024
	Coastal Bathymetry and Topography where necessary (GEBCO/2030)	High-resolution digital elevation data in all vulnerable coastal regions by 2030
	High Performance Computing / modelling and impact forecasting / assimilation / analytics including AI-ML / uncertainty reduction	Advanced computational capabilities in all Tsunami Service Providers by 2027
	Warning centres have access to the analysis (data, tools and communication platforms) for effective warning to impacted populations	Access to data, tools and communication platforms in all Tsunami Warning Centres by 2030

Tsunami Detection, Analysis And Forecasting

Coastal Sea Level Measurements (Tide Gauges)		
Challenges	Solutions	Goals
Current network is not adequate from the perspective of: a) Not all gauges measure time (1 min) /height (1mm) /spatial resolution that is optimal for operational warning and better scientific understanding of the hazard b) Not all existing gauges transmit data in real-time	Review and update TOWS WG report on requirements - recommendations on optimal core network for tsunami operations from the perspective of locations, sensors, telemetry, standardized formats, reporting units, etc.	Review and update TOWS-WG report by 2023
	Ensure groups working on other sea level applications such as GLOSS take onboard the requirements of tsunami so that the stations address multi-hazard requirements	Engage with all relevant groups by 2025
	Identify hotspots from tsunami / climate perspective for prioritization and redundancy of installations	In all ICGs by 2025
	Advocacy and Awareness among Member States, Network Operators, International Organisations (IHO, etc) to install new or enhance existing tide gauge networks that comply with agreed standards recommendation; real-time data sharing and access	In all ICGs by 2025
	Multi-purpose instrumentation and platforms	In all ICGs by 2030

Tsunami Detection, Analysis And Forecasting

Open Ocean Sea Level Measurements (Tsunameters)		
Challenges	Solutions	Goals
The current networks of tsunameters are used primarily for tsunami warning validation and unit source inversion of seismic sources for limited range of locations and forecasting of tsunamis; The networks are not adequate for characterising tsunamis from all tsunamigenic zones and for all types of sources; Challenges with long-term maintenance;	Design a global optimal network of ocean bottom pressure sensors that can provide the capability for direct detection of tsunami wave fields from all sources in reasonable time for tsunami warning (not tied to unit sources)	In all ICGs by 2023
	Technical solutions for better communication (acoustic modems, cable-connected, hybrid, etc.)	Pilot implementation by 2027
	Technological solutions to implement sensors (pressure gauges and seismometers, etc.) to deep sea floors for high S/N, high reliability, and high durability of observations	Pilot implementation by 2027
	New use cases of Tsunameter Data for other applications such as ocean circulation, climate, MJO, etc. and promote technologies for possible co-deployment of sensors (pressure gauges and seismometers) with met-ocean moorings to enhance network coverage and maintenance	Pilot implementation by 2025
	Big data Analytics, High Performance Computing and Processing techniques for real-time data analysis and Forecasting	Pilot implementation by 2024
	A workshop involving observing, data utilisation, analysis, modeling and data assimilation communities for tsunami and other ocean applications	In all ICGs by 2025

Tsunami Detection, Analysis And Forecasting

Seismic / GNSS		
Challenges	Solutions	Goals
Lack of adequate offshore broadband seismic stations; Lack of adequate onshore GNSS stations for direct measurement of co-seismic displacement; Lack of adequate onshore low gain (strong-motion) broadband seismic stations as countermeasures for tsunami earthquakes and huge earthquakes;	Design a global optimal network of ground-based and offshore Broadband/Strong motion/GNSS stations with priority deployment areas identified that can provide the capability for detection of tsunamigenic earthquakes in all source zones within a reasonable time for tsunami warning	A global optimal observational network design document in all ICGs by 2023
	Instrument/communications design	Pilot Implementation by 2025
	Keep track of the new technology developments in geodetic observing systems and include them in the update of the plan	In all ICGs by 2027

Tsunami Detection, Analysis And Forecasting

SMART		
Current networks (S-net, DONET) are targeting very limited seismic source zones; Lack of adequate network for detecting large non-seismic tsunami before arrival to coastal area; Currently not used for operational tsunami warning; Industry dependencies related to deployment locations, repeater design, etc; Significant upfront cost;	Design a global optimal network of SMART cables that can provide the capability for direct detection of tsunami wave fields from all sources in reasonable time for tsunami warning and other ocean applications	In all ICGs by 2023
	Technical solutions for production of Commercially Off The Shelf (COTS) repeaters, sensors and allied components to be deployed on SMART cables that meet the purpose of tsunami warning and other ocean Applications	Pilot Implementation by 2024
	Advocacy with all stakeholders including Private Industry, Intergovernmental organisations and Scientific Expert Teams for rapid development and implementation of SMART cables	Ongoing in all ICGs

Other future potential observing technologies (Coastal Radars, Altimeters, Infrasound & TEC Measurements, etc.)		
Challenges	Solutions	Goals
Challenges with network coverage, data latency, accuracy, data analysis methodologies for implementation in operational tsunami warning	Promotion of Research & Development in potential future observing technologies and analysis methodologies that could enhance operational tsunami warning of tsunamis from all sources.	In all ICGs by 2027
	Development and testing of instruments and methodologies to detect tsunami waves	Pilot Implementation by 2028

Tsunami Detection, Analysis And Forecasting

Characterisation and forecasting of all significant tsunamis within an actionable timeframe from generation		
Challenges	Solutions	Goals
Challenges with integration of data from enhanced observing networks and new methodologies for defining the tsunami wave fields for operational tsunami warning including detection, verification, characterisation and impact	Research on the nature of tsunamis, source mechanisms and characterisation from various observation data	Contributing capabilities identified by 2024
	Probabilistic Tsunami Forecasting Techniques - assign confidence level (0.0-1.0) to wavefield definition	Prototype wavefield predictor developed by 2023
	Development of new forecast methods for operational impact forecasting of all significant tsunamis within an actionable timeframe from tsunami generation – • Database applications and matching schema for updated global threat database including non-seismic sources • AI-ML applications to relate, discrete or combine observations to potential outcomes • Dynamic characterization using rapid update cycle models	Improved forecasting methods deployed and operationalised at the TSPs and NTWCs by 2030

Tsunami Warning, Dissemination and Communication – Goals

The ODTP goal is that by 2030 there will be significant improvements in the national decision making to warn, and mechanisms in place for the effective and inclusive construction, dissemination and communication of warnings.

- 100% of the national authorities will be able to effectively warn communities and population at risk.

- Communities at risk will be able to use these advances to improve local tsunami preparedness and response capabilities and become Tsunami Ready

Key elements that need to be addressed

- **Effective decision making to warn** - National/local tsunami warning chains and standard operating procedures; Decision Support Tools (Co-design, Competency Development)

- **Effective construction of warnings** – Time constraints, Inclusive, Actionable content (Use of IT, understand target audience, impact-based warning content)

- **Effective dissemination and communication of warnings** – Institutional capacity, Communication mechanisms, Multi-Hazard Warning Systems, Multiple sources of information (Standards & Formats, CAP, Broadcast & Social Media)

Tsunami Warning, Dissemination and Communication

National and local tsunami warning chains and SOPs

Challenges	Solutions	Goals
Parameters needed by the National and Local DMO to advice response	Co-design of warning information and SOP requirements among the TSPs, NTWC, N/L DMO, and other relevant stakeholders	Updated Global Service Definition Document for Tsunami Watch Operations by 2024
Decision Matrix on Warning	Competency training for NTWC and National and Local DMO staff	100% countries at-risk for tsunamis have national tsunami warning response plans and SOPs by 2027
Construction of the Warning		
Time Constrain	The use of IT	100% countries at-risk of tsunamis by 2027
Languages and fit for audience (not inclusive)	Understanding the target audience (culture, education, capacity, abilities, inclusiveness, etc.)	100% countries at-risk of tsunamis by 2027
The lack of actionable content of warning.	Develop impact based warning content (consequences)	100% countries at-risk of tsunamis by 2025

Tsunami Warning, Dissemination and Communication

Warning Dissemination and Communication Options

Challenges	Solutions	Goals
The lack of redundant mechanism in receiving and disseminating warning and Communication	Redundant mechanism in receiving and disseminating warning and communication	100% countries at-risk of tsunamis by 2027
The lack of standard format for warning and Communication	Promote Common Alert Protocol (CAP) and Training of NTWC staff on CAP	100% countries at-risk of tsunamis by 2030
The lack of national standard format and mechanism for warning and communication for people with Different Functional Abilities (Difable) - check with SFDRR	National standard format and mechanism for warning and communication for People with Difable	
Conflicting and multiple source of warning information	Effective use of Broadcast and Social Media. Media Training for NTWC staff and Training for Media Broadcaster and Social Media Influencers	
Technology Gap and/or not fully utilized	New/emerging technologies (Digital and Communication)	In all ICGs by 2024
Lack / limited Interoperability	Multi-hazard Early Warning Alignment (resources, capacity, information, SOP, etc.)	100% countries at-risk of tsunamis by 2027

Preparedness and Response Capabilities - Goals

Aspirational social outcome of the Ocean Decade Tsunami Programme is that 100% of communities at risk from tsunamis are prepared for and resilient to tsunamis by 2030 through efforts like the IOC-UNESCO Tsunami Ready Recognition Programme

Key elements to be addressed

- **Risk Perception and Awareness** – Risk perception studies need to be encouraged across all regions

- **Preparedness**
  - All at-risk communities have tsunami hazard, inundation, evacuation maps, TEMPP trainings
  - Public display of tsunami information, Tsunami Signage
  - Locally relevant education and awareness resources, institutionalizing tsunami education
  - promote communities to actively participate in the World Tsunami Awareness Day
  - 100% of communities at risk conduct a local tsunami exercise every two years

- **Response Capability**
  - All countries with tsunami risk should have agreed parameters at the national and local level for warning and have approved response plans
  - 100% of at-risk communities have multiple effective and sustainable communication methods in place
  - Inclusive, inventory of resources, natural signs and self-evacuation, multihazard, capacity building

- **Mitigation**
  - Communities have access to an inventory of best practices of plans and structural and nature-based solutions
  - More communities have implemented plans and measures to minimize impacts to critical infrastructure and marine assets from tsunamis and other coastal hazards,
  - Mainstreaming disaster risk reduction into urban planning

Preparedness and Response Capabilities

Preparedness		
Challenges	**Solutions**	**Goals**
Limited availability of easily understood tsunami evacuation maps	Training on Tsunami Evacuation Maps, Plans and Procedures (TEMPP)	30% of community to have easily understood evacuation maps by 2025 75% by 2027 100% by 2030
	Identification of Tsunami Hazard Zones and development of Tsunami Inundation Map	
	Enhancing GIS capacity within country	
	Data and information for evacuation maps (sensitive and critical infrastructures)	
	Inclusion and guidance on effectiveness of tsunami evacuation map (social and culture)	
	Community participatory approach in tsunami evacuation map	
Limited public display of tsunami information in tsunami prone areas	Establish a national standard of Tsunami Signage (i.e. take ISO)	100% by 2030
	Inventory of the type of tsunami signages used by different countries, Engage local artist	

Preparedness and Response Capabilities

Preparedness		
Challenges	Solutions	Goals
Limited local context in tsunami awareness and education resources (language, culture, local threat, risk, etc.)	Adaptation of tsunami education resources to the local context (language, culture, local threat, risk, etc.)	100% by 2030
	Use local authority social media and website for public awareness and Education	Increment of 10% annually
Limited people with difable are included in preparedness and response actions	Development of specialized tsunami awareness education resources for people with difable	At risk communities have engagement and inclusion of people with Difable 100% by 2030
	Engagement and inclusion with People with difable (association, communities, authorities, etc.)	
Limited inclusion of tsunami in school curricula	Institutionalizing tsunami education and awareness into school curricula	100% by 2030
	Share best practices and lessons learnt on tsunami education and awareness in school curricula	
	Engage with other global frameworks on School DRR, i.e. GADRRRESS	

Preparedness and Response Capabilities

Preparedness		
Challenges	Solutions	Goals
Limited effective outreach -activities for people in tsunami prone area	Community at risk to conduct at least three outreach activities annually	Community at risk engagement in World Tsunami Awareness Day 100% by 2030
Lack of validation of tsunami response capacity due to infrequent Tsunami	Community at risk to conduct tsunami exercise	Community tsunami exercise at least once every two years 100% by 2030. Engagement of community at risk in ICGs wave exercises as well as other national tsunami exercises 100% by 2030
Response Capabilities		
Lack of understanding of the Tsunami Ready Community, especially to scope and definition of community	Advocacy and promote of Manual and Guide 74 on Tsunami Ready	100 % Number of at risk community in each country by 2024
	Training of UNESCO-IOC Tsunami Ready Recognition Programme (i.e. OTGA)	

Preparedness and Response Capabilities

Response Capabilities		
Challenges	Solutions	Goals
Undetermined number and location of at-risk Communities	To identify the location and number of at-risk communities	100% of at-risk communities prepared and Resilient by 2030
	To include the location and number of at-risk communities in the national tsunami response Plan	
Limited National support/ structure/ mechanism to implement Tsunami Ready Recognition Programme	Establishment of the National Tsunami Ready Board	Number countries that implement Tsunami Ready Recognition Programme established NTRB by 2025

Number of at-risk communities that implement UNESCO-IOC Tsunami Ready community are recognized by 2030 |
	Advocacy and campaign (Global, Regional, and National) of UNESCO-IOC Tsunami Ready Recognition Programme (i.e through the Tsunami Ready Coalition, ICGs, TICs, Permanent Delegation to UNESCO, UNESCO National Commission, IOC National Contact	
	Training of UNESCO-IOC Tsunami Ready Recognition Programme (i.e. OTGA)	
	Share best practices and lessons learnt on the Implementation of Tsunami Ready Recognition Programme	

Preparedness and Response Capabilities

Response Capabilities		
Challenges	Solutions	Goals
In near field tsunami, the time to issue tsunami warning might exceed the time for effective response	Understanding of natural signs	100% of at-risk communities prepared and Resilient by 2030
	Self-evacuation (escape / run) arrangement (evacuation decided by individuals)	
	Preventive evacuation arrangement (evacuation decided by authority)	
Un-known resources and capacities within the community to support tsunami emergency response	Inventory of the available resource and capacity for tsunami emergency response within at risk Community	100% by 2030
Local tsunami response plan do not exist in all at risk Communities	To use TEMPP training or other multihazard trainings	
Insufficient capacity to manage tsunami response activities in at risk Communities	Optimising resources available for all Hazards	
Lack of redundant mechanism to receive tsunami warning at risk communities	To use existing methods of other hazards and traditional means of communication for receiving warnings	
Lack of redundant mechanism to disseminate tsunami warning at risk communities	To use existing methods of other hazards and traditional means of communication for disseminate warnings	

Preparedness and Response Capabilities

Mitigation		
Challenges	Solutions	Goals
Lack of availability of safe area in tsunami at risk communities considering the lead time of tsunami arrival.	Best practices of structural mitigation intervention and consult with experts (engineers, scientist, and researchers)	100% by 2030
Availability of coastal protection infrastructures	Best practices of structural and nature intervention consult with experts (engineers, scientist, and researchers)	
Plans to minimize impacts to critical infrastructure and marine assets	Best practices of structural and nature-based mitigation intervention consult with experts (engineers, scientist, and researchers)	

Capacity Development - Goals

- Ensure investment in capacity development for the different stakeholders including the generators and the users of the tsunami early warning system

  - National, regional and local level initiatives to reach the objective of 100% at-risk communities to be prepared and resilient to tsunami

  - Facilitate equitable access to data, information, knowledge, technology, and infrastructure, leaving no-one behind

  - ICG-TICs and OTGA – STCs as the means for the delivery of capacity development

  - Special consideration to be capacity requirements of SIDs and LDCs

Pathways to Implementation

- The ODTP provides a framework for identifying gaps, suggesting solutions, prioritise resources, and implementing actions within the timeframe of the Ocean Decade

- This plan outlines the pathways for achieving overall objectives of ODTP including challenges, solutions, performance indicators, milestones and target dates for the four main components of the tsunami early warning system

- Considering the nature of tsunami hazard, the optimal solutions should have a global design, address regional imperatives, and be implemented through contributions and actions of Member States and other stakeholders

- Scientific objectives of the tsunami warning enhancements will be achieved by maximizing and expanding current capabilities, identifying capabilities that exist but are not currently applied to tsunami, and developing new capabilities through innovation and research

- Member States should endeavour to dovetail their national tsunami warning system plans/programmes with the ODTP objectives

- Member states, academic institutions and industries will seek, possibly through ICG consultation to identify candidate proposals aimed at addressing the solutions

- R&D community and Industry has the opportunity to develop and contribute to scientific understanding, technological solutions, product development and capacity building.

- The intent of the plan is to offer contribution pathways that cover the full spectrum or financial commitment by targeting the objectives most important to advancing Member State capabilities

THANK YOU