Intergovernmental Oceanographic Commission
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71

Indian Ocean Tsunami Warning and Mitigation System (IOTWS)

Implementation Plan

Third Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS-III)
Bali, Indonesia
31 July – 2 August 2006

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EXECUTIVE SUMMARY

This Implementation Plan for the Indian Ocean Tsunami Warning System (IOTWS) specifies detailed requirements of the design and implementation of the tsunami warning and mitigation system for the Indian Ocean. As these are developing and therefore still are subject to changes or modifications, and as the implementation will progress, this Implementation Plan is a dynamic document. In constant use and development, it will only represent the status of the system at a specific time of viewing. As a living document it will be available on the Intergovernmental Oceanographic Commission (IOC) web site and subsequent versions will be distributed at Intergovernmental Coordination Group (ICG)/IOTWS meetings.

The Implementation Plan is structured to reflect the ICG and its Working Groups (WG), WG1, WG2, WG3, WG4, WG5 and a new proposed WG on mitigation, preparedness, and response. After a status summary, details are condensed in Action Plans for all components of the system. Capacity building is explicitly addressed to highlight the importance of training and extend the basis of the people involved in operating the system at all levels. The last chapter summarizes the ongoing effort by a number of international agencies to facilitate the planning and building of national capacity, and the mechanisms put in place to support actions and member states that have made requests. Reflecting the work as its progresses there are parts that are not yet as detailed as required.

The Implementation Plan is only one of the documents that describe the IOTWS and help in managing it. Others are, or will be available. The Interim Tsunami Advisory Service Communications Plan is also being up-dated to continually reflect the enhancements to the monitoring and warning system..

The IOTWS is a complex operation owned and operated by Member States through their designated agencies. Besides the national functions these agencies serve as conduits for information within the system that is amongst all participating partners. These are further augmented into international, mostly regional, functions that serve an agreed regional ensemble of member states. These functions need particular attention for the system to perform as a whole.

The performance of the IOTWS depends on the implementation of all its components, their sustained operation and the adherence to agreed common principles of operation, interaction and data policy. This performance needs to be monitored in order to improve the IOTWS, identify deficiencies and suggest remedial action. A real test of the IOTWS may never, or rarely happen. But it will then highlight the credibility of the system and all its participating partners. The public will only judge the performance or the success of the system from the impact, the loss of lives and the damages that occurred.

The timely and appropriate implementation of the IOTWS is crucial to its success. Recent events have shown that time to prepare, implement and train is short as the events are unpredictable. In its implementation priorities, requirements and details will change or have to be adapted. Member States are therefore asked to prioritize details they feel need special attention on both the national and international level. They also are invited to provide guidance as to further developing governance mechanisms for the IOWTS.

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1.0 INTRODUCTION

When the December tsunami in 2004 hit the coasts of the Indian Ocean and caused widespread damages and loss of lives, there was no tsunami warning system in place. Since this disastrous event, international, regional and national efforts have intensified to establish an end-to-end tsunami warning and mitigation. The United Nations Education Scientific and Cultural Organization's Intergovernmental Oceanographic Commission (UNESCO-IOC) over forty years of involvement in the Pacific Tsunami Warning and Mitigation System (PTWS) provided the basis to immediately, together with Member States around the Indian Ocean and others around the world, design and implement the Indian Ocean Tsunami Warning and Mitigation System (IOTWS). The Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS) is serving as the regional body to plan and coordinate the design and implementation of an effective and durable tsunami warning and mitigation system.

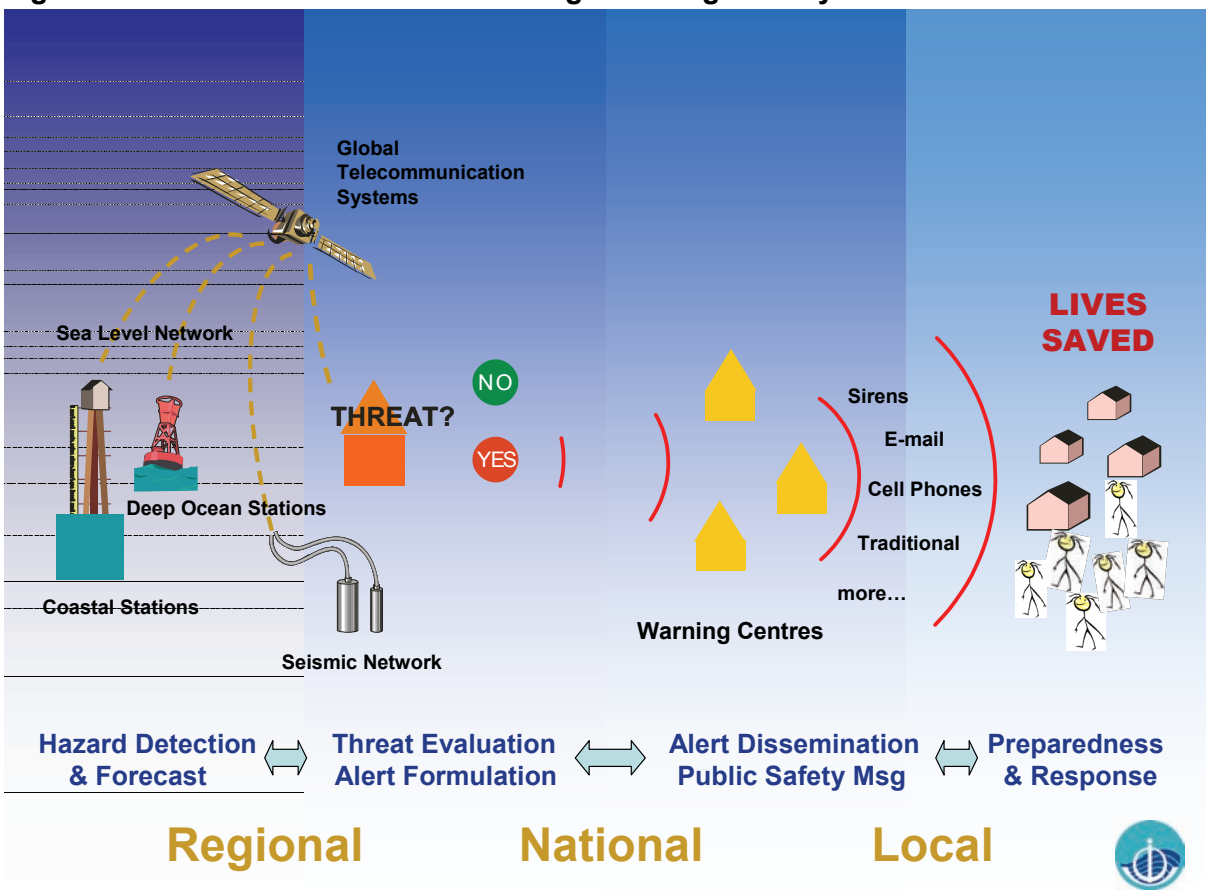
The overall objective of the IOTWS is to efficiently identify and effectively mitigate the hazards posed by local and distant tsunamis. To achieve this objective, an end-to-end tsunami warning system is needed that includes hazard detection and forecast, threat evaluation and alert formulation, alert dissemination of public safety messages, and preparedness and response (Figure 1-1). Regional and national capacity in hazard detection is required to maintain a complex network of instrumentation and communications mechanisms to continuously monitor and detect tsunamigenic events, and model and forecast tsunami wave inundation. Tsunami threats must be evaluated and alerts formulated and disseminated in an understandable manner to regional and national levels and to the public at risk. Well planned and practiced response mechanisms must be in place with the resources necessary to respond in a crisis situation. Finally, structural and non-structural mitigation measures must be planned and incorporated within a multi-hazard framework as part of routine development activities.

The IOTWS has been designed for the Indian Ocean to address the detection of a tsunami and its impact on coastal areas, as well to ensure the required information and data flow, processing and dissemination of standardised message products. It also addresses the measures of awareness, preparedness and resilience required for sustaining vigilance against this infrequent but fatal natural hazard. No country can adequately protect itself from tsunamis without an effective early warning to coastal communities to move people out of harms way ahead of the tsunami's arrival. To trigger the fastest warnings, early detection of tsunamigenic events is needed, and this requires an international network composed of hundreds of observation stations. In order to build this regional system, countries will need to pool their efforts, commit their assets and institutions, and assume responsibility for maintenance and upgrade of the technical monitoring system. As such, the IOTWS will be implemented as a coordinated network of national systems and capacities, and regional functions, and will be part of a global network of early warning systems for all ocean-related hazards.

The transition from an interim tsunami advisory system to a full-fledged end-to-end IOTWS is now being realized through the collaborative efforts of Member Nations in the Indian Ocean region, UNESCO-IOC, World Meteorological Organization (WMO), UN International Strategy for Disaster Reduction (UN-ISDR), and other key partners at international, regional, and national levels. At the 2nd Session of ICG/IOTWS held 14-16 December 2005 in Hyderabad, India, the IOC Secretariat was asked to prepare for

presentation at the 3rd Session of the ICG/IOTWS (31 July – 2 August 2006) an Implementation Plan for the IOTWS.

Figure 1-1: End-to-End Tsunami Warning and Mitigation System



The Chairs of the ICG Working Groups agreed to participate in the compilation of information, as did other ICG members and partners. An intrasessional working group at ICG/IOTWS-II further developed the concept of the Implementation Plan as follows: The key objectives of the plan are to assist in resource procurement, provide a clear vision of the IOTWS, integrate partnerships, provide management guidance, and generate milestones and goals and to depict realistic financial implications. The plan will set forth the requirements for an IOTWS on the time scale from zero out to fifteen years.

This Implementation Plan is intended to provide a dynamic framework to capture regional goals for an optimal end-to-end tsunami warning and mitigation system, identify system gaps, and consolidate and track the commitments of countries in the region and international organizations to fill these gaps. The Implementation Plan is structured to reflect the ICG and its Working Groups (WG), WG1, WG2, WG3, WG4, WG5 and a new WG on mitigation, preparedness, and response. After a status summary, details are condensed in Action Plans for all components of the system. Capacity building is explicitly addressed to highlight the importance of training and extend the basis of the people involved in operating the system at all levels. The last chapter summarizes the ongoing effort by a number of international agencies to facilitate the planning and building of national capacity, and the mechanisms put in place to support actions and member states that have made requests. Reflecting the work as its progresses there are parts that are not yet as detailed as required.

2.0 THE STATUS OF THE INDIAN OCEAN TSUNAMI WARNING AND MITIGATION SYSTEM BEFORE AND AFTER THE DECEMBER 2004 TSUNAMI

The Indian Ocean and its bordering countries, and particularly the Sunda Trench west of Sumatra and most of the Indonesian Archipelago have for long been known as very active seismic zones. Tsunamis have occurred, mostly on the regional scale off Indonesia. The need for a tsunami warning system was discussed for a long time. On the occasion of the 120th anniversary of the 1883 Krakatau volcanic eruption and tsunami, an International Tsunami Workshop was held in Indonesia in 2003, and at this time, a strong recommendation to establish an Indonesian National Tsunami Warning System was made. Some progress was made in 2004 that established collaboration between the Indonesian earthquake and sea level monitoring agencies for the building of the warning system. In October 2004, at the 19th session of the International Co-ordination Group for the Tsunami Warning System in the Pacific at its meeting in Wellington, New Zealand the "Group regretted that there are currently no seismic stations available for tsunami warning close to the Philippines and Indonesia, although data are needed in that region. It was noted however, that there are two Comprehensive Test Ban Treaty Organization (CTBTO) stations in the Philippines and 6 in Indonesia. The Group requested the countries owning the stations to make them available for tsunami and earthquake warning purposes." Similar proposals were made for other seismically active regions such as the Caribbean and the Mediterranean.

When the magnitude 9.3 earthquake occurred beneath the sea floor near Aceh, northwestern Indonesia on 26 December 2004, it generated the strongest tsunami in over forty years and the most devastating tsunami in history. No tsunami warning system in place in the Indian Ocean at that time that could have made it possible to warn, evacuate and save countless lives. The resulting wave spread in all directions and across the ocean basin affecting countries throughout the Indian Ocean region. Within months after this event, an interim advisory information service was established through the PTWC and Japan Meteorological Agency (JMA) to provide tsunami-related information to the region (Table 2-1). This chapter provides a summary of the status of the Indian Ocean tsunami warning and mitigation system prior to 26 December 2004, the present status, and future regional goals (Table 2-2).

Table 2-1: Interim Tsunami Advisory Information Service

Nbr	Agency	Origin	Time UTC	1st Message Issued	Elapse time	Magnitude	Magnitude (USGS)	Location
13	PTWC	17-Jul-06	8:19	8:36	17	7.2	7.7	Java, Indonesia
	JMA			8:46	27	7.2		
12	PTWC	16-May-06	15:28	15:42	14	6.9	6.8	Sumatra, Indonesia
	JMA			15:50	22	6.9		
11	PTWC	14-Mar-06	6:58	7:10	12	6.8	6.7	Seram, Indonesia
	JMA		Did Not issue					
10	PTWC	22-Feb-06	22:19	22:35	16	7.2	7	Mozambique
	JMA			22:50	31	7.2		
9	PTWC	19-Nov-05	14:10	14:26	16	6.5	6.5	Sumatra, Indonesia
	JMA			14:32	22	6.5		
8	PTWC	8-Oct-05	3:51	4:04	13	7.5	7.6	Pakistan
	JMA		Did Not Issue (not in responsible area)					
7	PTWC	24-Jul-05	Did Not Issue				7.3	Andaman
	JMA		15:42	16:02	20	7.3		
6	PTWC	5-Jul-05	1:52	2:07	15	6.8	6.7	Sumatra, Indonesia
	JMA			2:15	23	6.7		
5	PTWC	19-May-05	1:55	2:12	17	6.8	6.9	Sumatra, Indonesia
	JMA			2:15	20	6.6		
4	PTWC	14-May-05	5:05	5:21	16	6.9	6.8	Sumatra, Indonesia
	JMA			5:32	27	6.8		
3	PTWC	28-Apr-05	Did Not Issue				6.2	Sumatra, Indonesia
	JMA		14:07	14:30	23	6.6		
2	PTWC	16-Apr-05	16:38	16:57	19	6.7	6.4	Sumatra, Indonesia
	JMA			16:59	21	6.5		
1	PTWC	10-Apr-05	Did Not Issue				6.7	Sumatra, Indonesia
	JMA		10:29	10:56	27	6.8		

Notes:
Compilation, 18 July 2006, UNESCO-IOC
PTWC – US NOAA Pacific Tsunami Warning Center
JMA – Japan Meteorological Agency

Through the concerted efforts of member states of the UNESCO-IOC and international organizations, an interim tsunami warning system has been established since April 2005, supported by the PTWC and JMA (Table 2-1). At the present time, twenty-six countries in the region have established official Tsunami Warning Focal Points (TWFP) to receive interim advisory information based only on seismological and sea level information from the operational centres serving the Pacific in Hawaii and Tokyo. These countries are: Australia, Bangladesh, Comoros, East Timor, France, India, Indonesia, the Islamic Republic of Iran, Kenya, Madagascar, Malaysia, the Maldives, Mauritius, Mozambique, Myanmar, Oman, Pakistan, Seychelles, Singapore, South Africa, Sri Lanka, Tanzania, Thailand, the United Arab Emirates, the United Kingdom and Yemen. The WMO's Global Telecommunications System (GTS) is being used as the backbone for the distribution of Tsunami Warning System bulletins to countries of the Indian Ocean rim region as part of the Interim Tsunami Advisory Information service, and will have the added long-term advantage of providing the basis for an all-hazards information exchange system for the future.

The operations of the warning system are described in the IOTWS Communications Plan for the Interim Tsunami Advisory Information Service for the Indian Ocean region which summarizes the services provided by the PTWC and JMA. The Plan provides a general overview of the operational procedures, lists the seismographic and sea level stations participating in the warning system, the criteria for the reporting and issuing of tsunami information messages by PTWC and JMA, the recipients of the information, and the methods by which the messages are sent. In close cooperation and under the agreed-upon protocols, the PTWC has been designated the lead in issuing bulletins, which are closely followed in time by JMA bulletins. The first advisories that are issued are usually based only on seismic information. As additional sea level stations are installed or upgraded for real or near-real time data transmission, the Centres will be able to provide watch and warning advisories based on the confirmation of tsunami generation on coastal or deep-ocean sea level gauges.

The future optimal IOTWS would be comprised of a robust end-to-end system responsive to new requirements and technologies for tsunami detection. In that sense, new technologies should be evaluated with respect to their relevance to an operational system. Its implementation into real-time operational systems will depend on national requirements, additional funding and system conformity. ICG/IOTWS working groups should have an active role in addressing these matters.

Table 2-2: Indian Ocean Tsunami Warning and Mitigation System Status

System Status	Tsunami Hazard Detection and Forecast	Threat Evaluation and Alert Formulation	Alert Dissemination and Public Safety Message	Preparedness and Response
Pre-December 26, 2004 ***No Warning System***	• No regional collaboration for tsunami detection and forecast • No capacity to detect tsunamis in the IO Region • No deep ocean sea level monitoring for IO region • Coastal sea level and seismic stations not meeting standards for tsunami detection	• No regional collaboration for tsunami threat evaluation and alert formulation • No tsunami alert formulation capacity	• No regional collaboration for alert dissemination • Limited alert dissemination mechanisms at national or local levels • Protocols for warning dissemination absent	• No regional collaboration for tsunami preparedness and response • Emergency response mechanisms fragmented • Disaster management training and capacity building programs occurring throughout the region do not include tsunamis
Present ***Interim Warning System***	• Interim tsunami-related information provided to countries in the Indian Ocean region by PTWC and JMA • ICG/IOTWS Working Groups on sea level and seismic monitoring and modelling functional and establishing regional goals and plans of action • Sea level and seismic station upgrades being conducted throughout the region • Core network of priority upgrades and new station requirements identified through IO-ICG process	• ICG/IOTWS Working Groups on hazard risk assessment and modelling functional and establishing regional goals and plan of action • Capacity of national warning centres being upgraded to collect and analyze information	• ICG/IOTWS Working Group on warning centres functional and establishing regional goals and plan of action • Information dissemination mechanisms being developed at regional, national, and local levels	• ICG/IOTWS Working Group on emergency response and preparedness functional and establishing regional goals and plans of action • Local response mechanisms being developed in coastal regions

Table 2-2: Indian Ocean Tsunami Warning and Mitigation System Status

System Status	Tsunami Hazard Detection and Forecast	Threat Evaluation and Alert Formulation	Alert Dissemination and Public Safety Message	Preparedness and Response
Future ***End-to-End Warning and Mitigation System***	• Regional core network of coastal sea level stations and deep ocean stations, meeting instrument requirements and standards, operational by 2010 and being maintained by countries in the region • Regional core network of seismic stations meeting instrument requirements and standards, operational by 2010 and being maintained • National meteorological and/or geophysical services strengthened and operational 24/7 as part of a multi-hazard approach to national warning systems • Standardized hazard risk assessment methods and products developed and employed to reduce vulnerability and strengthen coping capacity of coastal communities to tsunami hazards throughout the Indian Ocean region • Assessment of environmental flashpoints at subnational level for use in preparedness and spatial planning and disaster risk reduction • Sustained capacity to apply numerical modelling for source generation, wave propagation and inundation in the region	• National tsunami warning centres established and operating as authoritative source for tsunami advice and warnings • Coordinated regional warning system for the entire Indian Ocean region established, composed of network of interoperable Regional Tsunami Watch Providers and National Tsunami Warning Centres	• Tsunami alerts disseminated to the “last mile” through effective communications programs	• Promote, share and develop tsunami good practice examples, tools, and best practice information for capacity and resilience building and emergency management to improve the management of tsunami risk through mitigation, preparedness, response and recovery activities • Mainstream tsunami warning and mitigation systems into development planning and practice, including policy and institutional development, project identification, sector policies, risk mitigation, and recovery processes • Interagency coordination committees and organizations responsible for disaster risk reduction and disaster management established to lead, monitor, and coordinate the emergency response in countries throughout the Indian Ocean region • National and local emergency response plans for coastal regions prepared and regular preparedness exercises and drills undertaken in countries throughout the Indian Ocean region • Coastal communities undertake sustained efforts to reduce risks from tsunamis and other coastal hazards • Education and outreach campaigns under-taken on tsunami risks, warning systems, and response in coastal regions

3.0 ACTION PLANS

This section describes actions needed to develop and maintain different components of an end-to-end tsunami warning and mitigation system for the Indian Ocean region for a 15 year planning horizon. Action plans represent a consolidation of planned, ongoing, and proposed actions based on working group decisions of the ICG/IOTWS and work plans of ongoing national and international programmes in the region. These action plans are intended to provide a framework to periodically be updated and to monitor the status at a regional level. At present, long-term actions have not been specifically identified beyond the year 2010. This is a major gap for all action plans in realizing a sustainable tsunami warning and mitigation system for the Indian Ocean.

3.1 Seismic Monitoring

Seismic stations have been selected to provide essential and appropriate seismic data relevant to monitoring and detecting earthquakes that can trigger tsunamis. The core network of seismic stations is comprised of stations that meet these requirements and in addition, have been in operation long enough to provide information on their performance. In areas where the station density was considered inappropriate to fulfil the requirements for tsunami detection, new sites have been proposed and sometimes initiated. In addition to the Core Network of the Indian Ocean, national seismic networks are a necessary enhancement to address specific national requirements and constraints.

High quality, broadband seismic waveform data are essential to ensure accurate and rapid determination of hypocentral parameters. A delay of even a minute in the dissemination of earthquake information and public warning can result in increased casualties from earthquake and tsunami disasters. Countries in the Indian Ocean region agreed to share data from a core set of stations to monitor regional seismicity.

Likely sources of earthquake-related tsunamis are in the eastern Indian Ocean, near the trench extending south and east from Sumatra, and in the Makran zone of the north-west Indian Ocean. Vulnerable areas that lie within a 30-minute travel time of a tsunami need a dense network. Earthquake location and magnitude need to be determined within 2 to 3 minutes of the earthquake. Strong motion sensors such as accelerometers are needed for these areas. Vulnerable areas greater than a 30-minute travel time (Sri Lanka, East African countries, Australia) have more time to analyse seismic data and try to observe the tsunami at a sea level gauge before issuing an alert or warning.

Regional Goals

Regional goals for seismic monitoring are in the process of being developed by ICG/IOTWS WG1. The interim regional goal provided below will be revised pending inputs from WG1.

- **Core network of seismic stations, meeting instrument requirements and standards, operational by 2010 and being maintained.**

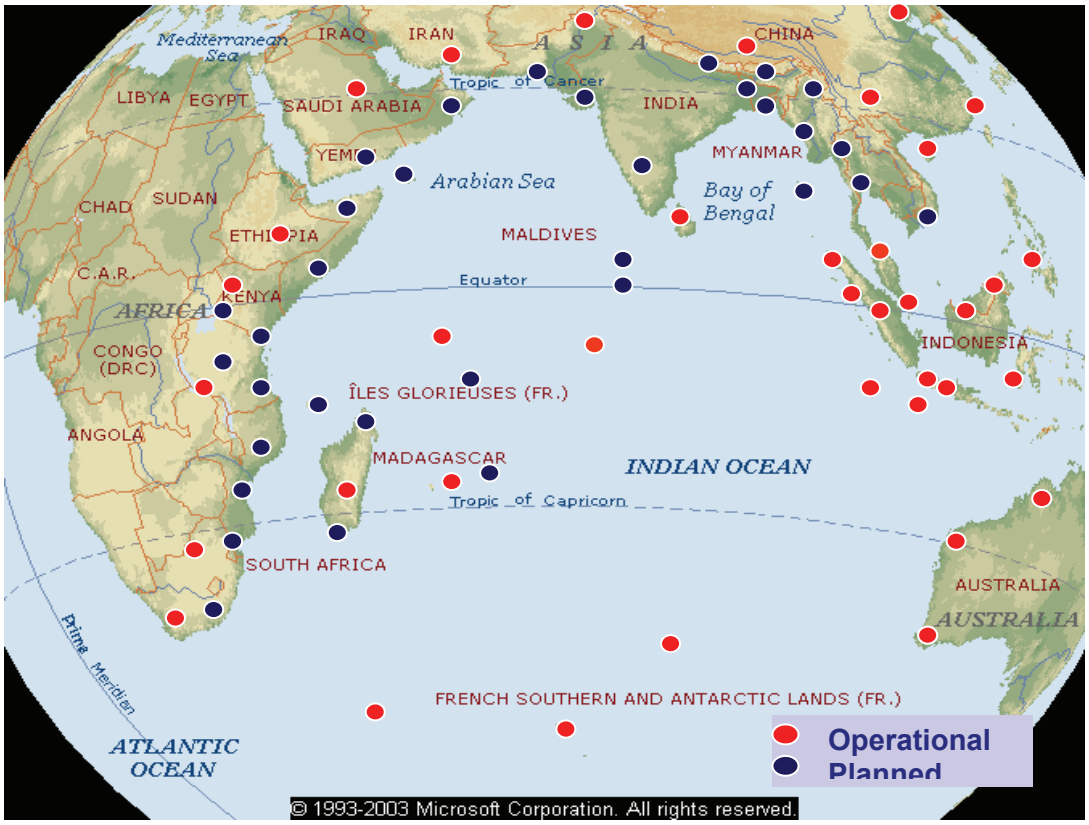
Instrumentation Requirements and Standards

- Ensure that all earthquakes of magnitude 6 or greater can be reliably located and quantified in a timely manner.
- Reduce the time required for earthquake source characterization to meet a local warning response of 5 to 10 minutes.
- Core network stations must have data latency values of less than 20 seconds.

Gaps and Deficiencies

National seismic networks meeting instrumentation requirements and standards are needed to cover core stations for regional data sharing and increased density of stations in many countries (Figure 3-1). Details of the core regional seismic network for the Indian Ocean are given in Annex B. Capacity building and long-term plans and resources for continued maintenance of these networks are needed.

Figure 3-1: Core Regional Seismic Network for the Indian Ocean



Action Plan

Planned, ongoing, and proposed actions for seismic monitoring as part of a regional implementation plan are provided in Table 3-1. Key activities include:

- Phased establishment and integration of national seismic networks
- Review and make recommendations regarding upgrading and enhancements to the network, communications, processing and analysis components.

Table 3-1: Seismic Monitoring Action Plan

Task/Milestone	Country/ Location	Responsibility (agency, donor)	Estimated Cost	Estimated Completion			Status[1]
				2010	2015	2020	
Upgrade seismic and global positioning systems	India Thailand Indonesia Maldives Sri Lanka	IOC Australia China France Germany Japan US IOTWS Program		6/2007			
Conduct seismic capacity building training	India Thailand Indonesia Maldives Sri Lanka	US IOTWS Program		8/2006			O
Regional data sharing of seismic and GPS capacity building	Regional	US IOTWS Program		9/2007			O
Capacity building exchanges in geologic assessment of earthquake and tsunami hazards	Regional	US IOTWS Program		9/2007			O

Table 3-1: Seismic Monitoring Action Plan

Task/Milestone	Country/ Location	Responsibility (agency, donor)	Estimated Cost	Estimated Completion			Status[1]
				2010	2015	2020	
Establish new broadband seismic stations to initiate seismic data interchange in real time	Tanzania Madagascar Somalia Kenya Malaysia Australia Indonesia Thailand India Sri Lanka Mauritius Pakistan Bangladesh Myanmar Yemen	IOC Australia France Germany Japan					C - Malaysia O - other countries No budget - Myanmar
Upgrade 30 stations in Indian Ocean countries	Regional	Germany					O
Data from a core set of stations to monitor regional seismicity to be shared	Regional	WG1 members		12/2006			P
Long-term capacity building for seismic station operation and maintenance		IOC US IOTWS Program Japan					O

Notes:
1 – Status: P – Planned, C – Completed, O – Ongoing

3.2 Sea Level Monitoring

Real time sea level observations are a key element in tsunami warning systems, as these observations are used to help confirm the existence of a major tsunami or to cancel a tsunami watch or warning following an earthquake. Two types of measurement systems are used to measure sea level changes: tide gauges, typically installed in harbours and at piers, and pressure sensors deployed on the open ocean sea floor.

The sites for implementing a system for monitoring sea level changes in the Indian Ocean are the result of extensive deliberations in ICG/IOTWS Working Group 2 (WG2) and define the most appropriate network at this time. The technical selection criteria have been based on relevance, gauge availability and data access.

The global network of tide gauges under the Global Sea Level Observing System (GLOSS) in the Indian Ocean provides the back-bone of the basin-wide Indian Ocean Tsunami Warning and Mitigation System. These sites have been identified because of the proven quality, relevance, and long-time availability of the data. They are part of a multi-user/multi-purpose sea level observing network that serves both research and operational purposes (i.e. monitoring long-term sea level change, storm surge monitoring, and port operations). The multi-purpose nature of these stations maximizes the likelihood of ongoing maintenance and the continued functioning of the sea level network.

On the national level, additional sea level gauge sites have been identified to serve as a regional enhancement of the IOTWS system. They serve an important purpose in providing valuable additional information to improve monitoring and forecast capabilities. Details of these national plans have been given in the report of the 2nd Meeting of the ICG/IOTWS in Hyderabad, India.

Sea level measurement at deep ocean stations, such as those made by the Deep-ocean Assessment and Reporting of Tsunami (DART) buoys, are critical to improve the rapid detection and forecast of tsunamis as they can be deployed offshore, near tsunamigenic areas. Each DART system includes a seafloor bottom pressure-recording instrument that can detect small sea level changes and send data to a companion surface buoy with satellite transmitters for real-time communications.

Regional Goals

Regional goals for sea level monitoring are in the process of being developed by ICG/IOTWS WG2. The interim regional goal provided below will be revised pending inputs from WG2.

- **Regional core network of coastal sea level stations and deep ocean stations, meeting instrument requirements and standards, operational by 2010 and being maintained by countries in the region**

Instrumentation Requirements and Standards

The optimal design of a sea level monitoring network for tsunamis must include standards and specifications for:

- Sampling interval
- Accuracy/resolution
- Frequency of transmission
- Spatial density
- Data loss thresholds
- Optimal site selection (open ocean vs. coastal vs. island vs. harbour)

Preliminary specifications for in situ sea level sites within 1 hour travel time and/or 100 km of tsunami generation areas include:

Subregional
- A sampling of 1 min averages and a continuous transmission cycle of 1 minutes for sites within 1 hour travel time of the tsunamigenic zones
- Immediate retransmission via WMO's GTS to JMA, PTWC, and other appropriate warning centers. (The European and Japan geostationary meteorological satellites can not be used as they are limited to a 15 minute transmission cycle)

National
- A sampling of 1 min averages and a continuous or 1 minute transmission cycle for sites within 100 km of the tsunamigenic zones
- Immediate retransmission via WMO's GTS to JMA, PTWC, and other appropriate warning centres
- Configure as existing multi-purpose coastal sea level stations

Instrument Requirements and Standards for Core Network of Coastal Sea Level Stations

- For the interim sea level network, coastal sea level stations need to conform to:
  - IOC/GLOSS or equivalent proven equipment in the field
  - Minimum standards for any alternate instrument with the capacity to detect tsunamis at coastal locations, but which do not need to meet the GLOSS requirement, are to be established
- Minimum number and siting of instruments

Instrument Requirements and Standards for Core Network of Deep Ocean Stations

- Measurement type - tsunami amplitude over time for input into forecast models
- Measurement accuracy - 0.5 cm
- Measurement sample rate – 1 minute or less
- Measurement processing – within 2 minutes
- Measurement availability – within 5 minutes to assimilate into forecast models
- Measurement access – a reliable request mode
- Interoperability – data must be placed on GTS operated by the WMO
- Minimum number and siting of instruments

Gaps and Deficiencies

A number of coastal sea level stations in the basin-wide sea level network are presently being upgraded (Figure 3-2). Several nations are also making efforts to upgrade their national enhanced sea level network, often as part of a multi-hazard warning system approach (see Annex C). Seen in the basin wide perspective there are a small number of sea level stations in the GLOSS Core Network where there are no upgrade plans. This is due to funding priorities and/or technical/political difficulties in upgrading and sustaining some particular sea level stations. Much of the initial sea level station upgrade efforts have been concentrated in the eastern and central Indian Ocean. However, there is also need to establish a tsunami monitoring network in the northwestern portion of the Indian Ocean near the Makran subduction zone (Pakistan, Iran, Oman).

As the installation phase of the sea level stations comes to a close, a major challenge for the medium term is to maintain and broaden the user base for these observing networks. Some countries have mechanisms, structures, and funds in place to carry this foreword. Others will need to develop these.

Training courses and activities of various kinds, including maintenance of sea level stations, sea level data analysis, and modelling should be a continuing component of the IOTWS (as well as for other regional tsunami warning systems). Nations may also consider pooling resources into shared technician teams that can travel around the region and maintain the observing system network.

Real-time data delivery constitutes an important, if not crucial aspect of the sea level monitoring system. Optimal use of this information is only ensured if all data are available to all partners at all times as they provide a substantial benefit to improve tsunami detection qualities and enhance the required national capacities.

Figure 3-2: Sea Level Upgrade Locations in Indian Ocean

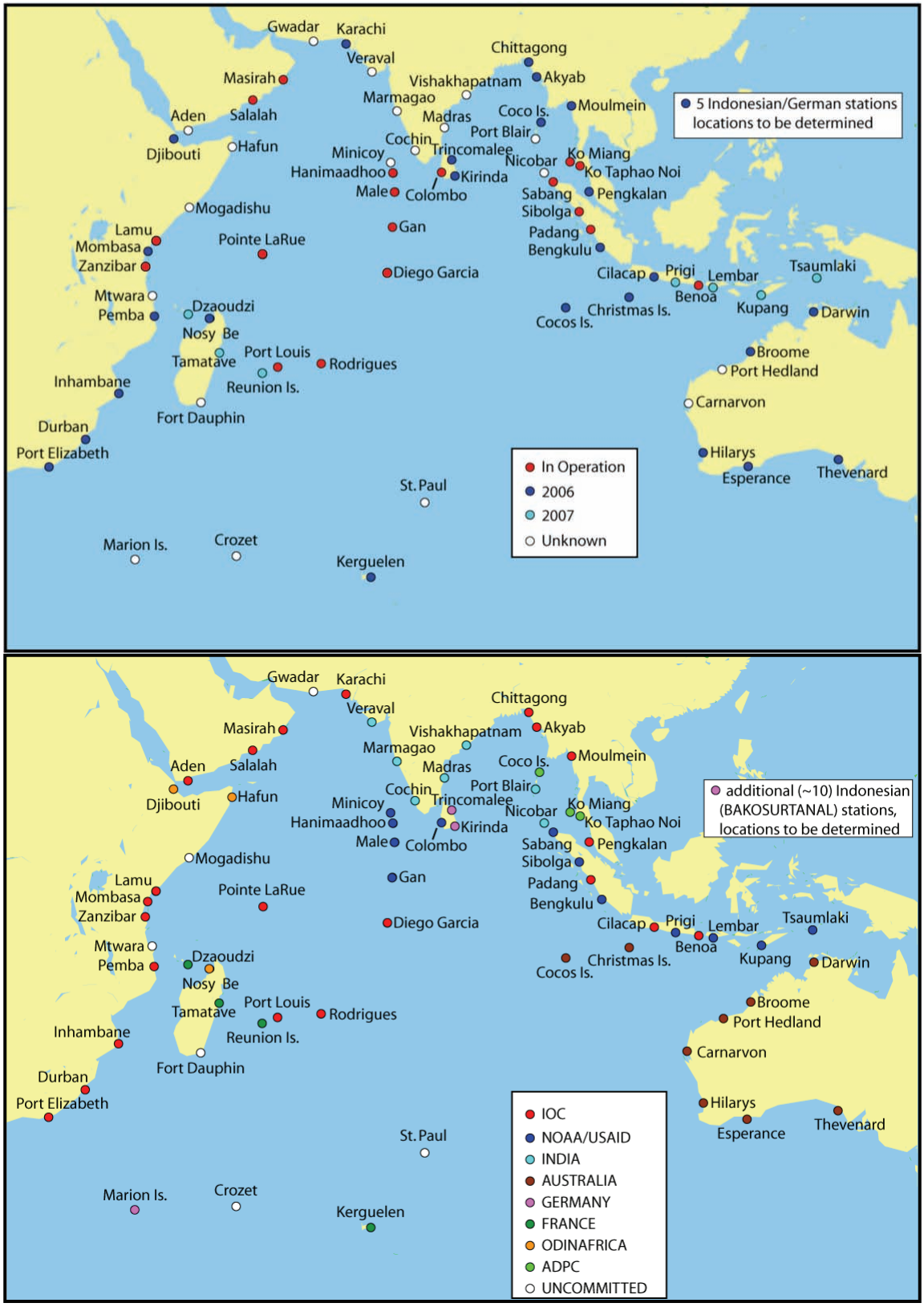
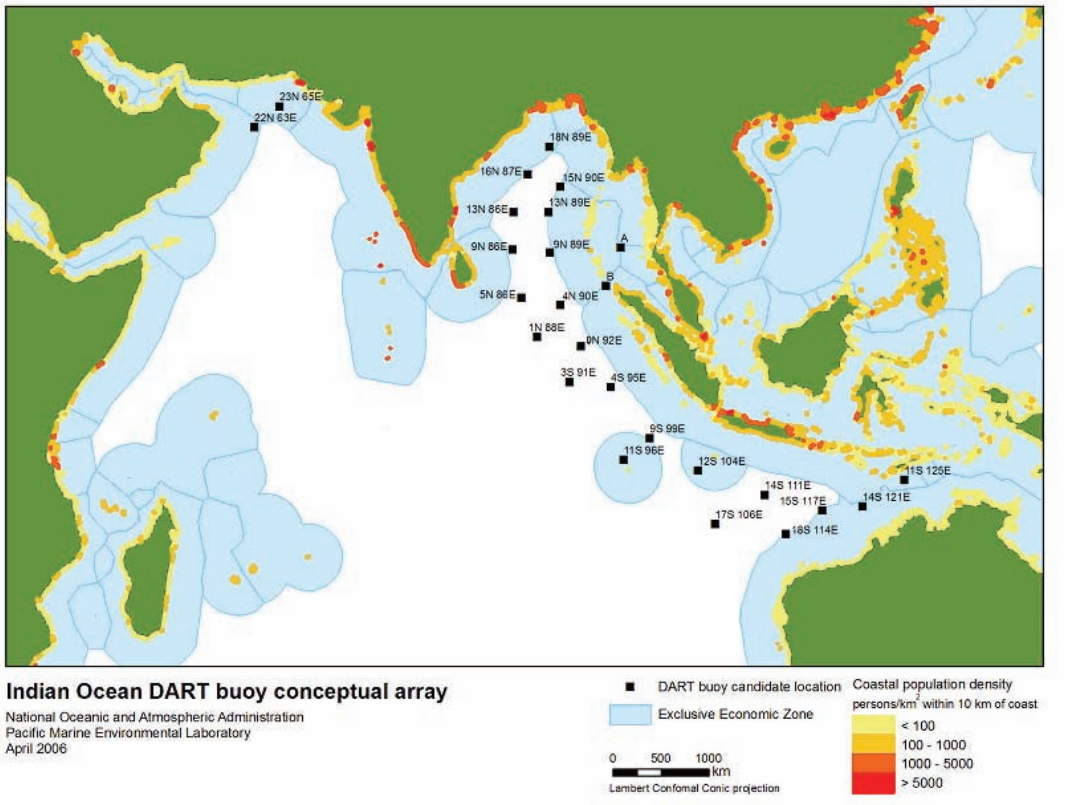


Figure 3-3: Network of Deep Ocean Station for the Indian Ocean

Planned - Germany
Deployed - Germany
Planned - US
Planned and Deployed - Malaysia
Planned - Thailand

Source: ICG/IOTWS WG 2

Figure 3-4: Proposed Deep Ocean Tsunami Detection Stations outside the EEZ



Action Plan

Planned, ongoing, and proposed actions for sea level monitoring as part of a regional implementation plan are provided in Table 3-2. Key activities include:

- Installation and upgrade of additional coastal and deep ocean sea level monitoring stations,
- Completion of t the installation of several deep ocean sea level monitoring stations, particularly in the NW Indian Ocean,
- Training and capacity building for long-term maintenance and upgrade of sea level monitoring stations.

The exchange and sharing of data and information on the international level is of high importance in order to:

- Provide nations with important complementary observations to help assess alerts and warnings and to increase warning times
- Provide warnings to nations without a national observation network

Table 3-2: Sea Level Monitoring Action Plan

Task/Milestone	Country/ Location	Responsibility (agency, donor)	Estimated Cost	Estimated Completion			Status[1]
				2010	2015	2020	
• Upgrade core coastal sea level monitoring stations and continue maintenance of basin-wide Indian Ocean Tsunami Warning System	India Indonesia Kenya Malaysia Thailand	IOC/GLOSS ADPC Australia Finland France Germany Government of Flanders India Indonesia Japan Kenya Malaysia Thailand US IOTWS Program		2007	Cont'd	Cont'd	O
• Upgrade national (enhanced) sea level networks tailored to specific national needs. This must include national commitment for ongoing maintenance of sea level station network.	Member States	Member States & Donors		2009			O
• Build capacity to maintain coastal sea level stations		IOC & Nations		2010	Cont'd	Cont'd	O
• Secure and broaden sea level data exchange		IOC & Nations		2010			O
Establish deep ocean sea level monitoring stations in core network				2008			O
• 12 buoys	Indonesia	Indonesia/ Germany		2008			O
• 3 buoys	Malaysia	Malaysia		2006			O
• 10 buoys	India	India		2006			O

Table 3-2: Sea Level Monitoring Action Plan

Task/Milestone	Country/ Location	Responsibility (agency, donor)	Estimated Cost	Estimated Completion			Status[1]
				2010	2015	2020	
• 3 buoys • 2 buoys • 2 buoys	Thailand	Thailand Australia USA		2007 2008 2007			O O O
Build capacity to maintain deep ocean sea level monitoring stations and secure funding for long-term maintenance and replacement				Cont'd	Cont'd	Cont'd	O

Notes:
1 – Status: P – Planned, C – Completed, O – Ongoing

3.3 Hazard Risk Assessment

Hazard risk assessment for tsunamis and other coastal hazards is a critical component of a regional end-to-end tsunami warning and mitigation system for the Indian Ocean. Hazard assessment and risks are characterized based on documentation of historical events and impacts, wave propagation and inundation modelling of an expected range of hazard scenarios, modelling (see section 3.4), and traditional knowledge. Hazard maps are developed and used to communicate risk to vulnerable coastal communities. Further data sets required for a proper analysis of risk include the assessment of critical lifeline, infrastructure, marine port facilities, as well as population demographics and land use designations. The use of geographic information or geographical information system (GIS) to display these multi-disciplinary data sets is encouraged. The results of hazard risk assessment serve as the basis for decision support mechanisms and to identify and implement a range of mitigation measures that will reduce the vulnerability of coastal communities to tsunami and other hazards.

Regional Goals

The development of a tsunami early warning system for the Indian Ocean needs to be put into a risk management framework that can be applied at global, regional, national, and local levels. Regional goals for hazard risk assessment are in the process of being developed by ICG/IOTWS WG3. The interim regional goals provided below will be revised pending inputs from WG3.

- **Standardized hazard risk assessment methods and products developed and employed to reduce vulnerability and strengthen coping capacity of coastal communities to tsunami hazards throughout the Indian Ocean region**

- **Assessment of environmental flashpoints at subnational level for use in preparedness and spatial planning and disaster risk reduction**

Gaps and Deficiencies

Most countries in the Indian Ocean region have limited information to support hazard risk assessment for tsunamis. Historical records of earthquakes are available in many countries, but not historical tsunami records due to the episodic nature of these events. Little work has been done to extend the record of historic and prehistoric tsunamis through the study of tsunami deposits, as has been carried out in the Pacific. Few countries have incorporated local and traditional knowledge in the evaluation of risk.

There is now a general trend to improve the risk assessment capabilities in the region within the framework of overall disaster management. The need for a uniform guideline for risk assessment has been identified based on the wide experience available among countries in the region. While there has been considerable work related to risk assessment of the countries as a whole, and regions and cities within the countries, there is no uniform structure for the definition of risk assessment, implementing risk assessment studies, and the preparation of reports arising from such studies. The capabilities of the respective countries vary considerably based on the availability of expertise, tools for analysis, and quality data, which

are all essential requirements for risk assessment. Some case studies have been implemented with minimum data.

The need to develop mathematical models for nearshore and onshore tsunami wave propagation (see Section 3.4) that can accommodate all local features, and for training on the use of such models for scenario modelling for risk assessment, has been identified. Evacuation maps based on hazard risk assessments and incorporation of traditional and community knowledge are needed as one part of an overall goal to reduce vulnerability and promote coastal community resilience. The following table shows the results of national assessments of hazard risk assessment capacity of 16 countries in the Indian Ocean.

Assessment of Hazard Risk Assessment Capacity in the Indian Ocean Region	% of "Yes" Responses from 16 Countries
Tsunami hazard evaluation conducted prior to December 26, 2004	44%
Historical record of past earthquakes and tsunamis documented	38%
Tsunami vulnerability assessment conducted	22%
Geographical information systems used as a decision support tool during emergency response	34%
Post-tsunami impact assessments conducted	56%
Local risk assessments conducted to incorporate traditional/community knowledge of multi-hazard response	6%
Tsunami evacuation maps, evacuation routes, and evacuation signage developed for some areas	16%

Source: UNESCO-IOC et al., 2005

Action Plan

Planned, ongoing, and proposed actions for hazard risk assessment as part of a regional implementation plan are provided in Table 3-3. Key activities include:

- Prepare guidelines for tsunami risk assessment as part of a multihazard risk management framework.
- Provide guidance to emergency response managers on the preparation of risk assessment products
- Facilitate the application and use of model outputs for tsunami hazard and risk assessment (see also Section 3.4)
- Facilitate data sharing, including access to and development of databases, incorporating exposure, tsunami hazard and vulnerability
- Facilitate capacity building, including knowledge transfer, in the form of workshops, training programs and case studies for risk assessment in all Indian Ocean countries
- Facilitate and promote the process of developing cost-effective and practical mitigation options and measures
- Liaise with other modelling committees (including other ICG/IOTWS working groups) and organisations or professional groups that are developing models and data for their implementation

Expected results from these activities include:

- Hazard maps showing areas of high potential for tsunami inundation.
- Inundation maps (inundation and run-up) for maximum credible tsunami scenarios for areas of high vulnerability or risk (see also section 3.4)
- Risk maps capturing the potential aggregated impact of all tsunami sources on the built environment, population and local and regional economy
- Evacuation maps, which include safe areas and shelters, how to get there, and where to go, based on hazard risk assessments
- Decision support for appropriate mitigation options

Table 3-3: Hazard Risk Assessment Action Plan

Task/Milestone	Country/ Location	Responsibility (agency, donor)	Estimated Cost	Estimated Completion			Status[1]
				2010	2015	2020	
Develop risk assessment case studies	Regional	IO-ICG WG3		6/2006			O
• Indonesia case study	Indonesia	IO-ICG WG3					O
• Kenya case study	Kenya	IO-ICG WG3					O
• Sri Lanka case study	Sri Lanka	IO-ICG WG3					O
• Subregional case study - Oman Sea area							O
Develop tsunami risk assessment methodology and guidelines	Regional	USGS, NIED, UNU-IEHS, CRED, UNESCO-IOC, UN-ISDR	$.5 million	2008			O
Enhance risk assessment case studies to include mitigation options and decision support mechanisms in the following areas:	Regional	IO-ICG WG3		12/2006			P
• Environmental barriers		IO-ICG WG3					P
• Artificial countermeasures		IO-ICG WG3					P
• Land cover and land use		IO-ICG WG3					P
• Tsunami resistant infrastructure		IO-ICG WG3					P
• Evacuation plans		IO-ICG WG3					P
• Harness indigenous knowledge		IO-ICG WG3					P
Develop guidelines and best practices methodology for mitigation options and decision support systems	Regional	IO-ICG WG3		6/2007			P
Conduct workshops and training exercise on hazard risk assessment to facilitate knowledge transfer and information sharing and supplement case studies	Regional	IO-ICG WG3		TBD			P

Table 3-3: Hazard Risk Assessment Action Plan

Task/Milestone	Country/ Location	Responsibility (agency, donor)	Estimated Cost	Estimated Completion			Status[1]
				2010	2015	2020	
Develop an Integrated Regional Hazard Model that includes:	Regional	IO-ICG WG3					P
• Identification of hazard sources and the associated probabilities		IO-ICG WG3					P
• Vulnerability assessment/impact		IO-ICG WG3					P
• Community resilience		IO-ICG WG3					P
Develop and conduct training on hazard analysis tool for community level application	Regional	US IOTWS Program		5/2007			O
Determine historical tsunami record • Digital historical database	Regional	UNESCO-IOC US IOTWS Program Russian Federation					O
• Tsunami deposit studies	Regional	US IOTWS Program		9/2007			O

Notes:
1 – Status: P – Planned, C – Completed, O – Ongoing

3.4 Modelling

Numerical modelling, forecasting, and scenario development are integral components of an end-to-end tsunami warning and mitigation system for the Indian Ocean region. One of the primary results of numerical simulations is the prediction of arrival time and tsunami heights, hopefully as a forecast before the tsunami attacks. Although much advancement has been made since the 1990's through the collection of post-tsunami survey data that are used to improve the models, accurate predictions are still not routinely possible because many of the crucial parameter values are not available until some time after the event. Nonetheless, simulations of worst case scenarios are an important component of planning for emergency response as well as for preparedness and mitigation.

Regional Goals

Numerical modelling is a critical component of a risk management framework for IOTWS. Regional goals for modelling are in the process of being developed by ICG/IOTWS Working Group 4 (WG4). Interim regional goals provided below will be revised pending inputs from WG4.

- **Widely provide benchmarked and validated numerical modelling methods and software applicable for use in the Indian Ocean**

- **Develop and sustain national and regional capacity to apply numerical modelling for tsunami source generation, wave propagation, and coastal inundation in the Indian Ocean**

Gaps and Deficiencies

Technical assistance and training in numerical modelling was one of the most requested activities of countries in the Indian Ocean. Few countries have the capacity to conduct numerical modelling, and accurate bathymetric and topographic data needed for inundation models are absent for the most vulnerable coastlines. Inundation maps are needed as the basis for risk assessment, and emergency response.

Building the science expertise in the region to conduct tsunami inundation modelling, which has traditionally taken years to develop and been carried out by technical agencies and research scientists, will be a challenge; in addition to training programmes and advanced degrees through universities, one promising tool for reaching a large community will be through computation portals or other web-based technologies that can offer ways to transfer modelling expertise and capabilities to many.

The following table shows the results of national assessments of modelling capacity of 16 countries in the Indian Ocean.

Assessment of Modelling Capacity in the Indian Ocean Region	% of "Yes" Responses from 16 Countries
Post-event data surveys to assess damage and collect tsunami run-up/inundation data conducted	47%
Numerical modelling studies conducted to calculate inundation from tsunamis	22%
Accurate bathymetry and topography data exist for the coastlines	25%

Source: UNESCO-IOC et al., 2005

Action Plan

Planned, ongoing, and proposed actions for modelling as part of a regional implementation plan are provided in Table 3-4. Key activities include:

- Develop standards for operation and application of models, including peer review process, model documentation, benchmark criteria
- Facilitate the development: source, deep water propagation, and inundation and forecast models
- Develop benchmark tests for model verification and validation.
- Facilitate the development of a web-based community model
- Develop credible case scenarios for model application for the entire Indian Ocean including all possible sources (Sunda Arc, Makran region etc)
- Facilitate capacity building and knowledge transfer in the form of web-based tools and training programs
- Liaise with other working groups, especially WG3, regarding tsunami hazard detection, characterization, and risk assessment for model requirements and effective model usage and application

Expected results from these activities include:

- Web-based community forecast model available for use in Indian Ocean region
- Inundation maps developed for coastal communities throughout the Indian Ocean region

Table 3-4: Modelling Action Plan

Task/Milestone	Country/ Location	Responsibility (agency, donor)	Estimated Cost	Estimated Completion			Status[1]
				2010	2015	2020	
Develop inundation maps for the coastal communities of the Indian Ocean region	Regional				2015		O
Develop inundation maps for different scenarios, including translation of the inundation projections to evacuation maps over a 10-year (or less) time-frame	Regional				2015		
Model standards and scenarios accepted and implemented	Regional						
Conduct training for member states including both short-term and long-term strategies:							
• Short course with some form of IOC certification or award of diploma (similar to that implemented by the WMO)	Regional	UNESCO-IOC	$400K	2007			O
• Postgraduate training in the form of 50 IOC fellowships over 5 years	Regional	UNESCO-IOC Japan	$40K per annum	2006			O
Develop web-based community forecast model computation portal for inundation and forecast modelling	Regional	US IOTWS Program US NSF		2007			O
Support long-term training requirements for model maintenance, ongoing consultation, and support at selected institutions							
User-friendly Tsunami Digital Data Repository for all tsunami observations, starting with 26 Dec 2006 tsunami	Regional	US NSF,US NGDC, WDC-Tsunamis, UNESCO-IOC		2006			O

Notes:
1 – Status: P – Planned, C – Completed, O – Ongoing

3.5 Warning Centres

In order to achieve the overall objective of establishing an end-to-end tsunami warning and mitigation system for the Indian Ocean region, warning centres are required that collect and analyse information and formulate and disseminate appropriate warnings. Warning centres include Regional Tsunami Watch Providers (RTWP) and National Tsunami Warning Centres (NTWC). Currently, the interim tsunami advisory information service provided by PTWC and JMA issues only watches for the region. With the upgrade of the regional sea level network, warning centres at regional and national levels will be able to confirm in a timely manner that a tsunami was generated thus enabling them to issue warnings.

Regional Goals

Regional goals for warning centres are in the process of being developed by ICG/IOTWS Working Group 5 (WG5). The interim regional goal provided below will be revised pending inputs from WG5.

- **National tsunami warning centres established and operating as authoritative source for tsunami advice and warnings**

- **Coordinated regional warning system for the entire Indian Ocean region established composed of the network of interoperable Regional Tsunami Watch Providers and National Tsunami Warning Centres**

- **Tsunami alerts disseminated to the "last mile" through effective communications programs**

The capabilities required of an RTWP include:

- Operations as a multi hazard/multipurpose centre, where feasible, that operates on a 24/7 basis
- Contingency plans, secure infrastructure, and uninterruptible power supply to ensure continuous operation
- Capacity to back up another RTWP and continue the other provider's full capabilities
- The capacity to collect all available data in real time (seismic and oceanographic), analyse and interpret the information, and the ability to undertake numerical modelling
- A communications infrastructure capable of effectively disseminating all information to all recipients

Amongst several systems under review for providing the relevant information to the final recipient, RANET is a community based communications program designed to reach the "last mile" in developing nations and remote locations. The program is a collaborative effort of meteorological services, related national agencies, and nongovernmental organizations (NGO) to make weather, climate, and related information available and useful to rural or remote communities. To move critical information from city centres to rural populations, the RANET program has combined unique satellite broadcast capacities with Internet applications and the use of FM radio, HF radio, and other terrestrial broadcast capacities.

Gaps and Deficiencies

The PTWC and JMA are working in close coordination to provide interim tsunami watch support to the Indian Ocean region until a regional warning centre is established. PTWC, in Hawaii, is the operational warning centre for the International Pacific Tsunami Warning and Mitigation System, comprising 30 member states in the Pacific Ocean and marginal seas. The JMA operates the Northwest Pacific Tsunami Advisory Center, providing sub-regional warning services for the Northwest Pacific, including interim services for the South China Sea region. While the interim tsunami warning centres have no authority or responsibility to issue tsunami warnings outside their regions of responsibility, NOAA's PTWC and JMA, working with the IOC, has provided tsunami-relevant information to Indian Ocean nations since April 2005 on an interim basis. As the IOTWS is developed and made operational, RTWPs that comprise the IOTWS will assume this responsibility from the interim centres. No timeline has been set as to how quickly the IOTWS will become operational.

Action Plan

Planned, ongoing, and proposed actions for warning centres as part of a regional implementation plan are provided in Table 3-5. Key activities include:

- Implementation of the modalities of operation, methods, and standards for development and issuance of warnings, and requirements in terms of coordination and operating within a multi-hazard approach
- Development of guidelines for the distribution of tsunami warnings by NTWCs to emergency centres in their country, the media and the public. These Guidelines will be included in the IOTWS Implementation Plan
- Provide the ICG for decision further detailed elaboration of the roles of RTWPs (including responsibility for advisories) and NTWCs

Table 3-5: Warning Centres Action Plan

Task/Milestone	Country/ Location	Responsibility (agency, donor)	Estimated Cost (US$)	Estimated Completion			Status[1]
				2010	2015	2020	
Strengthen national warning centres and national and local collaboration	Regional	UNESCO-IOC, WMO, JMA, PTWC, UN-ISDR	$1 million	2008			O
Agree on two-tier interoperable system of Regional Tsunami Watch Providers (RTWP) and National Tsunami Warning Centers (NTWC) where:	Regional and Countries	National Focal Point or Representative		12/2008			O
• Nations are responsible for issuing warnings within their own territories	Regional and Countries	National Focal Point or Representative		12/2008			O
• Related relevant information will be freely available	Regional and Countries	National Focal Point or Representative		12/2008			O
• Some nations will derive their own warnings from primary seismic and sea-level observations and seismic and ocean models	Regional and Countries	National Focal Point or Representative		12/2008			O
• Other nations will receive watches upon bilateral arrangements from RTWPs that should assist them in preparing and issuing their own national warnings	Regional and Countries	National Focal Point or Representative		12/2008			O
RTWPs serving as NTWCs will issue the following messages:	Regional and Countries	National Focal Point or Representative		12/2008			O
• An Earthquake Alert message for potentially tsunamigenic under-sea earthquakes as soon as possible after the event's detection, followed by:	Regional and Countries	National Focal Point or Representative		12/2008			O
• A Tsunami Detection Alert message within 15 minutes of detection	Regional and Countries	National Focal Point or Representative		12/2008			O
• A Nil Tsunami Advisory providing confirmation	Regional and Countries	National Focal Point or Representative		12/2008			O
Profile capabilities	Countries	Australia, France		4/2006			O
Develop standardized watch and warning	Regional	UNESCO-IOC, UNDP,		4/2006			O

Table 3-5: Warning Centres Action Plan

Task/Milestone	Country/ Location	Responsibility (agency, donor)	Estimated Cost (US$)	Estimated Completion			Status[1]
				2010	2015	2020	
guidelines and information, including standard operating procedures, and regional and national concept of operations		US IOTWS Program, Indonesia, Maldives, Sri Lanka					
Develop generic guidelines for the “last mile” of warning/watch, i.e. RANET	Regional	US IOTWS Program, ADPC		4/2006			O
Communication and collaboration/platforming among NWTCs-RTWPs (including backup systems	Regional	Germany, US IOTWS Program					O
Communication and collaboration/platforming among NWTCs and RTWPs, including backup systems	Regional	Germany, US IOTWS Program		4/2006			O
Provide notifications and other tsunami-relevant information to all countries	Regional	US IOTWS Program					O
Build capacity for national dissemination of tsunami warning with Tsunami Alert and Rapid Notification System (TARNS)	Thailand, Sri Lanka	US IOTWS Program		9/2007			O
Enhance local and regional information centres to receive critical warning information and disseminate warnings to the last mile, e.g. through RANET	Sri Lanka, Thailand, Indonesia, Regional	US IOTWS Program		6/2007			O

Notes:
1 – Status: P – Planned, C – Completed, O – Ongoing

3.6 Mitigation, Preparedness, and Response

While a tsunami cannot be prevented, its impact can be mitigated through community and emergency preparedness, timely warnings, effective response, and public education. Mitigation, preparedness, and response to tsunamis and other coastal hazards are key components of an end-to-end tsunami warning and mitigation system for the Indian Ocean region.

Structural mitigation measures need to be incorporated into site selection, design, and construction of structures and support infrastructures. Nonstructural mitigation measures, such as the establishment of coastal buffer zones and protection of coastal vegetation and habitats, reduce vulnerability of coastal populations to tsunamis and other hazards. Preparedness activities initiated or led by responsible government agencies together with community organizations and the private sector are essential in building the advance capacity to respond to the consequences of a tsunami. Systems and infrastructure for receiving and responding to tsunami alerts must be in place and regularly tested. Evacuation plans based on hazard risk assessment are needed, and regular drills must be conducted to ensure that the public knows how to respond. National emergency response and recovery plans and mechanisms are needed in each country to respond to disaster events caused by tsunamis and other coastal hazards. These include regular assessment of critical infrastructure and lifeline support facilities, capacity for rescue operations, and emergency assistance.

Regional Goals

Regional goals for emergency response, preparedness, and mitigation are in the process of being developed by ICG/IOTWS in a new working group. A Regional Workshop on Mitigation, preparedness and Development of Tsunami Early Warning Systems in the Indian Ocean Region, 14-16 June 2006, sponsored by the UN-ISDR, UNESCAP, UNESCO-IOC, and the ISDR Asia Partnership, formulated strategies to strengthen the overall national resilience to tsunamis, and provide consultation on the Terms of Reference for the new working group. The interim regional goals provided below will be revised pending inputs from the ICG/IOTWS.

- **Promote, share, and develop tsunami good practice examples, tools, and best practice information for capacity and resilience building and emergency management to improve the management of tsunami risk through mitigation, preparedness, response, and recovery activities**

- **Mainstream tsunami warning and mitigation systems into development planning and practice, including policy and institutional development, project identification, sector policies, risk mitigation, and recovery processes**

- **Establish interagency coordination committees and organizations responsible for disaster risk reduction and disaster management to lead, monitor, and coordinate the emergency response in countries throughout the Indian Ocean region**

- **National and local emergency response plans for coastal regions prepared, and regular preparedness exercises and drills undertaken in countries throughout the Indian Ocean region**

- **Coastal communities undertake sustained efforts to reduce risks from tsunamis and other coastal hazards**

- **Education and outreach campaigns undertaken on tsunami risks, warning systems, and response in coastal regions**

Gaps and Deficiencies

In order to reduce risks from tsunamis and other coastal hazards, focused attention must be given to developing and practicing tsunami evacuation plans based on hazard risk assessment. Community and local government disaster preparedness should be assessed on a regular basis. Structural and nonstructural mitigation measures need to be mainstreamed.

Most coastal areas in the Indian Ocean region do not have emergency response plans or infrastructure that could effectively reach all vulnerable coastal and rural communities. Furthermore, response procedures are not tested on a routine basis. The following table shows the results of national assessments of tsunami mitigation, preparedness, and response capacity of 16 countries in the Indian Ocean.

Assessment of Tsunami Mitigation, Preparedness, and Response Capacity in the Indian Ocean Region	% of "Yes" Responses from 16 Countries
Structural mitigation measures established to reduce tsunami impact	13%
Non-structural mitigation measures established to reduce tsunami impact	31%
Tsunami emergency plans, tsunami evacuation plans, and/or signage exist indicating evacuation routes to safety or higher ground	19%
Critical infrastructure and lifeline support facilities for disaster response identified	34%
Local government disaster preparedness and emergency response assessed	59%
Community and ordinary citizen disaster preparedness and emergency response assessed	25%
Designated agency receiving tsunami warning issues public evacuations	44%
Procedures or criteria exist for determining when it is safe for responders or the public to return	50%
Response procedures for regional or locally-generated tsunami in place	19%
Response procedures for earthquakes in place	34%
Response procedures have been tested or exercised	19%
Public is aware of what a tsunami is, and how to respond to both locally-generated and distant tsunamis	28%

Source: UNESCO-IOC et al., 2005

Action Plan

Planned, ongoing, and proposed actions for tsunami mitigation, preparedness, and emergency response as part of a regional implementation plan are provided in Table 3-6. Key activities include:

- Building capacity of national and local agencies and institutions to prepare for and respond to emergencies
- Develop national and local tsunami emergency response plans with evacuation maps
- Assess critical infrastructure for emergency response
- Conduct emergency response drills for all stakeholders, including the public
- Conduct regular public awareness campaigns, and include tsunami and disaster preparedness in education curricula of schools
- Building partnerships for effective communication of risk, warning, and response with communication media
- Implementing structural and non-structural mitigation measures to reduce tsunami impact

Table 3-6: Mitigation, Preparedness, and Response Action Plan

Task/Milestone	Country/ Location	Responsibility (agency, donor)	Estimated Cost	Estimated Completion			Status[1]
				2010	2015	2020	
Develop community-based approaches, tools, and strategies for improved tsunami preparedness and mitigation	Regional	UNDP, UNEP, ADRC, ADPC, IFRC, UNESCO, UN-ISDR	$1.5 million	2008			O
Develop public awareness and educational tools, outreach materials, and campaigns to promote disaster risk reduction	Regional	ADRC, ADPC, ABU, UNESCO-IOC, WMO, UN-ISDR, Special Envoy Office for Tsunami	$2 million	2008			O
Strengthen regional recovery and risk reduction efforts through the support of early warning systems, training, and learning and information management	Thailand, India, Indonesia, Maldives, Sri Lanka	UNDP	$3 million	2006			O
Develop *TsunamiTeacher* training modules and conduct training throughout the region	Regional	UNESCO-IOC					O
Develop International Tsunami Training Institute (ITTI) to sustain capacity building in the region	Regional	US IOTWS Program		9/2007			O
Develop Coastal Community Resilience (CCR) Guidelines, Tools, and Best Practices throughout the region	Regional	US IOTWS Program		9/2007			O
Conduct regular updates of national end-to-end assessments to identify new capacity building needs and support	Regional	UNESCO-IOC, WMO, ISDR					P
Prepare standard operating procedures and communication plans to support rapid and efficient warning and emergency response	Regional, Indonesia, Maldives, Sri Lanka	UNESCO-IOC, UNDP, UN-ESCAP Trust Fund, US IOTWS Program		2006 09/2007			P

Table 3-6: Mitigation, Preparedness, and Response Action Plan

Task/Milestone	Country/ Location	Responsibility (agency, donor)	Estimated Cost	Estimated Completion			Status[1]
				2010	2015	2020	
Conduct simulation exercises at regular intervals to test the effectiveness of tsunami warning systems and readiness at national and local levels and interoperability among warning centres	Regional	UNESCO-IOC and national governments					P
Strengthen cooperation and information exchange at regional, sub-regional, and bilateral levels for preparedness and effective response	Regional	ISDR					P
Develop and conduct special education and training programs for broadcast media as part of the end-to-end tsunami warning system	Regional	ABU, UNESCO-IOC, ISDR					P

Notes:
1 – Status: P – Planned, C – Completed, O – Ongoing

4.0 CAPACITY BUILDING SUMMARY

Capacity building is needed to achieve an effective and durable tsunami warning and mitigation system in the Indian Ocean. Capacity-building activities need to be planned and programmed both at regional levels and individual country levels. Capacity building must encompass a broad spectrum of activities including; training, institutional development; and technology development, enhancement, and transfer for all components of an end-to-end tsunami warning and mitigation system. This section provides a summary of regional goals and actions to build capacity, share experiences and lessons learned, and sustain an effective and durable end-to-end tsunami warning and mitigation system in the Indian Ocean.

Regional Goals

Regional goals for capacity building are in the process of being developed by ICG/IOTWS. The interim regional goals provided below will be revised pending inputs from the ICG/IOTWS.

- **Intermediate and long-term plans are developed and resources allocated to build capacity to sustain an end-to-end tsunami warning and mitigation system**

- **Capacity-building activities identified by working groups are addressed through international, multilateral, bilateral and national funds**

- **Tsunami-related capacity building activities are developed targeting integration within national disaster management frameworks**

The growing gap between countries in their capacity to understand and use the ocean effectively and sustainably is of concern to UNESCO-IOC. The UNESCO-IOC recognizes that building capacity is a large, complex and long undertaking, and must be addressed along with partners. These partners must have the same mission and long-term goal of "sustainable" capacity-building. Some principles are therefore needed to guide the formulation of the UNESCO-IOC strategy for capacity building and to be used in harmonizing its future capacity building interventions and when collaborating with partners, including in the framework of the IOTWS Implementation Plan.

Principles incorporated into UNESCO-IOC's Capacity-Building Strategy include:

- Capacity-building interventions need to be imbedded in ongoing regional projects that contribute directly to the larger IOC mandate: "to promote international cooperation on protection of the marine environment and preservation of human life and property in the ocean and coastal areas and work toward sustainable development."
- Capacity-building programs should be structured based on proposals drafted by regional scientists who define and determine their own capacity-building programs. The proposals should:
  - Identify areas for regional collaboration
  - Seek partners through clear enunciation of their requirements
  - Seek funds in a "business" mode, by delivering products of public good.

- Capacity-building interventions should be structured to have enduring long-term impacts. This requires interventions both in "know why" and in "know how."
- Interventions should target development of both research and operational capabilities.
- Capacity building must be approached in a holistic manner involving, as appropriate, decision-makers, directors of institutes, scientists, technicians, and civil society.
- Interventions must be treated as investments. Active contact should be maintained with participants. Strategic partners, collaborating institutions, key decision makers, sponsors/funding organizations, and thought leaders in relevant scientific disciplines are also important elements in capacity building, and active contact must be maintained with all of them.
- Capacity-building interventions must optimize limited resources and reduce or eliminate duplication and overlap. This requires liaising closely with other agencies that also provide capacity-building services, to improve coordination and increase efficiency. IOC will also ensure that it applies best practices in capacity-building to every intervention that it sponsors.
- A majority of capacity-building initiatives should focus on developing regions.

The IOC's Capacity-Building Strategy will be focused and address prioritized needs of Member Countries within the regional/global framework. The implication of these principles is that with limited resources, IOC cannot and should not address all capacity building requirements.

The IOTWS process should make full use of the Tsunami Regional Trust Fund, a regional initiative managed by UNESCAP, established after the December 26, 2004 tsunami to build institutional and technical capacity in the Indian Ocean. The Regional Trust Fund was established through contributions from the Government of Thailand in September 2005 and Government of Sweden in December 2005 and is currently capitalized at $12.5 million.

Gaps and Deficiencies

Capacity building gaps and deficiencies have been identified in national assessments conducted with Indian Ocean Member Countries (UNESCO-IOC *et al.* 2005) and through ICG/IOTWS Working Groups (UNESCO-IOC 2005a and b). Some of the identified regional capacity-building needs can be summarised as follows:

- Training to achieve instrumentation standards and requirements for regional seismic and sea level monitoring core stations
- Training and software for numerical modelling is needed to develop inundation maps and evaluate tsunami hazards and vulnerability
- Long-term capacity building programme to build capacity to upgrade and maintain tsunami detection instrumentation, warning centres, and dissemination systems
- Long-term capacity building programme to build coastal community resilience to tsunami and other coastal hazards

Action Plan

A summary of planned, ongoing, and proposed actions for capacity building as part of a regional implementation plan is provided in Table 4-1. Key activities include:

- Developing guidance documents and training modules on all components of the end-to-end tsunami warning and mitigation system
- Providing technical assistance and training at national and local levels

Table 4-1: Capacity-Building Action Plan

Task/Milestone	Country/ Location	Responsibility (agency, donor)	Estimated Cost	Estimated Completion			Status[1]
				2010	2015	2020	
Develop *TsunamiTeacher* training modules and conduct training throughout the region	Regional	UNESCO-IOC					O
Establish International Tsunami Training Institute (ITTI) to sustain capacity building in the region	Regional	US IOTWS Program		9/2007			O
Establish UNESCO Tsunami Information Center (TIC) in Indonesia	Indonesia	UNESCO-IOC & CIDA-CANADA	CAD$0.5M	09/2006			O
Develop Coastal Community Resilience (CCR) Guidelines, tools, training and best practices throughout the region	Regional	US IOTWS Program		9/2007			O
Regional workshops, exchanges, and training programs on all components of end-to-end tsunami warning and mitigation system, disaster management, and coastal management	Regional	UNESCO-IOC US IOTWS Program ADPC		2009			O
Tsunami Disaster Mitigation Graduate Training Courses	Japan	Japan International Cooperation Agency (JICA), Building Research Institute		9/2009			O

Notes:
1 – Status: P – Planned, C – Completed, O – Ongoing

5.0 INDIAN OCEAN CONSORTIUM

While satisfactory progress is being made to build the regional infrastructure for the IOTWS, 20 of the 29 countries participating in the system have yet to develop their own National Plan for a Tsunami Early Warning and Response System (NP/TEWRS). Without an effective national infrastructure, tsunami warnings are unlikely to reach people at risk along coastlines, or in cases where warnings do reach the coast, communities and local authorities at the receiving end are unlikely to be sufficiently prepared to take the necessary actions to save lives. There is an urgent need to accelerate national efforts and better synchronize them with regional developments to bring a truly "end-to-end" system into operation.

On 27 March 2006, a Roundtable on Indian Ocean Tsunami Warning and Response Systems was convened by UNESCO-IOC and the ISDR secretariat during the Third International Early Warning Conference (27-29 March 2006, Bonn, Germany), in the presence of former US President Clinton, the UN's Special Envoy for Tsunami Recovery. The roundtable brought together key players, including governments from the Indian Ocean region, donor countries, and technical agencies, to take stock of ongoing efforts and progress, and to discuss what needs to be done in order to make an end-to-end early warning system operational without delay. An important part of this roundtable was the formation of a consortium of ISDR system partners that would provide an immediate package of advisory support to the governments of the Indian Ocean tsunami-affected countries. The coordinated package aims at assisting up to 10 governments, initially, in planning and building capacity for tsunami early warning and response systems. It will be provided to the first 10 governments upon request. The consortium members include UNESCO-IOC, WMO, OCHA, IFRC, UNDP, UNEP and World Bank. The ISDR secretariat will provide overall coordination, monitoring, and reporting as needed, including through its regional outreach offices in Bangkok and Nairobi.

The consortium of ISDR system partners listed above is offering a package of advisory and related support to governments in the Indian Ocean region that are in urgent need for capacity building. Support will cover capacities in policy design and planning, institutional and operational infrastructure for national tsunami early warning, and response systems, within the context of regional and multi-hazard warning systems. A framework covering seven core objectives of a national system is proposed. The seven consortium objectives listed below are incorporated as regional goals for action plans described in preceding sections.

1. National tsunami centre established and operating as the authoritative source for tsunami advice and warnings. [Lead partner: UNESCO/IOC]
2. Strengthening of operational 24/7 national warnings services through the National Meteorological Services as part of multi-hazard approach to national warning systems. [Lead partner: WMO]
3. Warning response plan for coastal regions prepared and disseminated and a national (coastal) response and evacuation exercise undertaken. [Lead partner: UN-OCHA]
4. Awareness-raising and education campaign undertaken on tsunami risks and the warning system in coastal regions. [Lead partner: IFRC]
5. Assessment of Environmental Flashpoints at subnational level for use in preparedness and spatial planning and disaster risk reduction. [Lead partner: UNEP]

6. Organizations responsible for disaster risk reduction and disaster management established to lead, monitor and coordinate the plan. [Lead partner: UNDP]
7. Intermediate and long-term plan developed for the complete and sustainable tsunami warning and response system with full costing. [Lead partner: World Bank]

Each consortium partner will take the lead for one of the targeted objectives, provide assistance for one or more of the objectives according to its expertise and experience, and assist countries to illustrate and plan for that specific capacity in preparing the action plan. The capacities offered are set out in the one-page support statements prepared by each consortium member provided as Annex D.

Plans will be initiated and driven by the country concerned, and would be tailored to the country's specific needs. For some countries, some of the objectives may already have been largely achieved, whereas for others, all seven may require a major effort. Assistance will be given for a full plan of action on the seven objectives or for just those specific components of a national system for which additional technical support is urgently required. The status of country requirements and requests to the international consortium is summarized in Tables 5-1 and 5-2.

Under Phase I, the agencies will support the preparation of each country's action plan based on the seven core objectives between April and July 2006. Updates on the national action plans will be presented at the upcoming Third Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System in Bali, Indonesia, 31 July to 2 August 2006. Under Phase II, the consortium partners will endeavour to assist in the implementation of these plans, as their existing programmes and resources allow, and to assist in fundraising efforts to support the implementation stage over the next 12 months through August 2007. Progress reviews will be conducted at the mid-year and at the end of the year.

Table 5-1: Country Status on Requests to the International Consortium

Country	National Assessment	National Plans	Expressed Interests	Official Request
Bangladesh	Done	Required	Yes	
Comores	Done	Required		
Dijbouti	2006	Required		
Indonesia	Done	Available		
Iran	2006	Required	Yes	
Kenya	Done	Required	Yes	
Madagascar	Done	Required	Yes	14 June 2006
Maldives	2006	Required	Yes	07 June 2006
Malaysia	Done	Available		
Mauritius	Done	Required	Yes	08 June 2006
Mozambique	Done	Required	Yes	11 July 2006
Myanmar	Done	Required		
Oman	Done	Required		
Pakistan	Done	Required	Yes	14 June 2006
Seychelles	Done	Required	Yes	31 May 2006
Somalia	Done	Required	Yes	04 July 2006
South Africa	2006	Required		

Table 5-1: Country Status on Requests to the International Consortium

Country	National Assessment	National Plans	Expressed Interests	Official Request
Sri Lanka	Done	Required	Yes	01 June 2006
Tanzania	Done	Required	Yes	
Thailand	Done	Required	Yes	
Timor (East)	2006	Required		
Yemen	Done	Required	Yes	

Source: Indian Ocean Consortium (2006)

Table 5-2: Support Requests made to the Indian Ocean Consortium

Support Request	Requesting Country
1. National tsunami centre established and operating as the authoritative source for tsunami advice and warnings.	
• Production of tsunami vulnerability and inundation map • 10-day training on seismology and TREMORS for 5 persons from local universities	Madagascar
• Network of seismic stations in Mauritius, Rodrigues, Agalega, and Saint Brandon • Two additional sea level stations, with modern equipment at Agalega and Saint Brandon Islands • DART System, in the middle of the Indian Ocean, off the East Coast of Rodrigues	Mauritius
• Ocean observation network and training for meteorological services on use and maintenance of new equipment and analysis and interpretation of data	Seychelles
2. Strengthening of operational 24/7 national warnings services through the National Meteorological Services as part of multi-hazard approach to national warning systems.	
• Reinforce the capacity of the Meteorology Office by establishing sea-level station data by GTS for the regional meteorology stations	Madagascar
• Access to environmental real time satellite imagery and data • Communication facilities for information and data exchange within the region	Mauritius
• To improve the current telecommunication system, this will enable TMA to collect information on a real time 24 X 7 basis from within and outside the country. • Installation of modern telecommunication equipment (GTS, Satellites etc) which will enable responsible institutions in alerting people over the pending hazards. • To establish working links with other institutions, agencies, authorities and user communities so that TMA benefit from any information available that can be of use in forecast and warnings. • To establish a reliable information dissemination system to allow rapid emergency response to vulnerable population.	Tanzania (Draft Action Plan)
3. Warning response plan for coastal regions prepared and disseminated and a national (coastal) response and evacuation exercise undertaken.	
• Train local authorities and carry out tsunami drills for all regions in Madagascar • Conduct assessment exercises	Madagascar
• Provide special frequency radios for fishers	Mauritius
• Contingency plans and early warning centres established and equipped at national and community levels	Seychelles
• Prepare handbook on development of tsunami response plan • Assist to prepare tsunami hazard maps for all coastal urban centres • Train stakeholders on preparation of response plans through pilot projects in five districts	Sri Lanka

Table 5-2: Support Requests made to the Indian Ocean Consortium

Support Request	Requesting Country
• Prepare standard procedures for conducting evacuation in schools and hospitals • Conduct evacuation drills in 20 selected schools and two hospitals • Support to conduct drills on annual basis for three consecutive years	
• Carry out situational assessment to establish Tsunami risk potential areas • Conduct seminars and workshops to create awareness to the community • Developing evacuation map which will include survey, identifying escape routes, preparation of signboard and preparation of guideline pamphlets • Identify tsunami evacuation centre along the coast • Development Warning Response Plan (Require Consultancy services) • Assessment and review the Response Plan	Tanzania (Draft Action Plan)
4. Awareness-raising and education campaign undertaken on tsunami risks and the warning system in coastal regions.	
• Conduct informal education for local leaders at village, communal and regional levels in partnership with the National Red Cross • Conduct formal education on integration of tsunami risk and other related disaster to national programme and develop manual for teachers and textbook for primary and secondary school children • Conduct vulnerability and risk mapping on tsunami and other related risks at municipal levels • Integrate disaster risk reduction into municipal development planning • Enhance the capacity of understanding of disaster risk management among Church leaders and traditional chiefs • Train media (newspapers, TVs and radios) on disaster risk reduction at national level	Madagascar
• Capacity building in developing outreach programmes and conducting public awareness campaigns	Mauritius
• Training of teachers to develop tools to integrate tsunami education in school curriculum • Capacity building in developing outreach programmes to increase knowledge and awareness on multi-hazard warning system, tsunami and other hazard prevention and mitigation and contingency plans	Seychelles
• Develop small-scale livelihood programme with community-level awareness programme • Develop hazard zoning maps for most vulnerable communities • Conduct awareness programme with livelihood component and evacuation drill • Develop indicators to monitor the effectiveness of the programme	Sri Lanka
• Integrate early warning and disaster management education into the education system.	Tanzania
• Multiply vulnerability and capacity assessment in a participatory process with communities and develop a disaster mitigation plan of action as a result of it, linking this with local authority plans.	(Draft Action Plan)

Table 5-2: Support Requests made to the Indian Ocean Consortium

Support Request	Requesting Country
• Enhance training and coordination between the Red Cross and Red Crescent branches, local government authorities, NGOs, community leaders to increase awareness on risks in particular in most vulnerable areas. • Train communities and Community Disaster Response Teams in disaster preparedness and evacuation related activities to reduce their vulnerability to hazards (CBDP). • Provide training to journalists at national and rural radio level to ensure understanding of early warning and disaster management issues in support of dissemination of alert. • Promote the development of early warning information dissemination by including early warning messages in street theatres and popular radio/ TV programmes to attract attention, e.g. radio soap opera • Prepare radio and television spots on tsunami preparedness, mitigation and response • Translate and produce tsunami awareness and educational materials e.g. posters, pamphlets, flyers, leaflets, journal etc.	
5. Assessment of Environmental Flashpoints at sub-national level for use in preparedness and spatial planning and disaster risk reduction.	
• Conduct bathymetric surveys and GIS mapping by the National Institute of Cartography & Hydrography (FTM) • Develop inundation map by IOGA • Develop strategy on coast protection by the National Centre for environmental research and the National Office for environment	Madagascar
• Capacity building in the development of risk management plans, including inundation and evacuation maps • Capacity building to conduct post- event data surveys	Mauritius
• Prepare guidelines for incorporating disaster impact assessment criteria in the environmental impact assessment process • Prepare urban development plans for all urban centres along the cost • Train officials from local government on how to achieve disaster risk reduction through physical planning process • Conduct training programmes on disaster risk assessment and incorporation of disaster impact assessment into EIA process	Sri Lanka
• Training for meteorological services on tsunami hazard mapping and modeling	Seychelles
• Collect base line data on coastal biodiversity • Identify inundated coastline • Carry out spatial planning on coastal areas • Conduct awareness creation on strategic interventions to the existing national mechanisms for spatial planning • Training on environmental assessment • Development of material guideline and action plan (Need consultancy services)	Tanzania (Draft Action Plan)
6. Organizations responsible for disaster risk reduction and disaster management established to lead, monitor, and coordinate the plan.	

Table 5-2: Support Requests made to the Indian Ocean Consortium

Support Request	Requesting Country
• Develop contingency plan and emergency services on tsunami and early warning systems • Build institutional capacity in coordination	Madagascar
7. Intermediate and long-term plan developed for the complete and sustainable tsunami warning and response system with full costing.	
• Provision of materials and equipment: including speakers and sirens • Public awareness, training, development of posters and evacuation maps for communities • Training for teachers and Media • Printing of teacher's guide and textbook for school children • Installation of seismic stations (3 stations) • Installation of one tide gauge (1station) • Training of technical staff to monitor, process and interpret data and equipment maintenance • Provision of bathymetry, GIS and inundation map • Hiring of consultants to study the environmental components of the project and to identify activities to be undertaken • Drill on tsunami and other related risks and public awareness for the next 3 years • Printing of educational material for school and communities	Madagascar
• Communication systems for command center and operational training • Alert systems at community level and training in warning dissemination and procedures	Seychelles
• Conduct a detailed scientific assessment of the existing tsunami warning and response system • Improve the seismic and sea-level instrumentation • Train personnel on surge modelling and inundation mapping • Conduct an inventory of critical infrastructure and assessing the disaster management system • Develop a tsunami response plans • Develop a national tsunami warning protocol and warning dissemination mechanism to local level • Review the intermediate and long-term plans • Develop financing strategy for funding the plan and its implementation	Tanzania (Draft Action Plan)

Source: Indian Ocean Consortium (2006)

ANNEX A

Acronyms

24/7	24 hours a day, 7 days a week
ABU	Asia-Pacific Broadcasting Union (Malaysia)
ADPC	Asian Disaster Preparedness Center
ADRC	Asian Disaster Reduction Center (Japan)
BMRC	Bureau of Meteorology Research Centre (Australia)
CCR	Coastal Community Resilience
CM	Community Modelling
CNS	National Emergency Council (Madagascar)
CONOPS	National warning Centre Concept of Operations
CRED	Centre for Research on the Epidemiology of Disasters (Belguim)
CTBTO	Comprehensive Test Ban Treaty Organization
DART	Deep-ocean Assessment & Reporting of Tsunamis
EIA	Environmental Impact Assessment
FM	Frequency Modulation
GLOSS	Global Sea Level Observing System (UNESCO-IOC)
GPS	Global Positioning System
GTS	Global Telecommunications System (WMO)
HF	High Frequency
ICG	Intergovernmental Coordination Group
IFRC	International Federation of the Red Cross and Red Crescent
IO	Indian Ocean
IOC	Intergovernmental Oceanographic Commission
IOGA	Antananarivo Geophysical Institute & Observatory (Madagascar)
IOTWS	Indian Ocean Tsunami Warning and Mitigation System
IP	Implementation Plan
ISDR	(United Nations) International Strategy for Disaster Reduction
ITTI	International Tsunami Training Institute
ITU	International Telecommunication Union
JICA	Japan International Cooperation Agency
JMA	Japan Meteorological Agency
M(#)	Magnitude
NSF	National Science Foundation (USA)
NIED	National Research Institute for Earth Science and Disaster Prevention (Japan)
NGDC	NOAA National Geophysical Data Center
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration (USA)
NP/TEWRS	National Plan for a Tsunami Early Warning and Response System
NTWC	National Tsunami Warning Centres
OCHA	UN Office for the Coordination of Humanitarian Affairs
PMEL	Pacific Marine Environmental Laboratory
PPEW	Platform for the Promotion of Early Warning (ISDR)
PTWC	Pacific Tsunami Warning Center (USA)
PTWS	Pacific Tsunami Warning and Mitigation System
RANET	RAdio and interNET for the Communication of Hydro-Meteorological and Climate Related Information
RTWP	Regional Tsunami Watch Providers

TARNS	Tsunami Alert Rapid Notification System
TNC	Tsunami National Contact
TREMORS	Tsunami Risk Evaluation through seismic Moment from Real-time System
TWFP	Tsunami Warning Focal Points
TWS	Tsunami Warning and Mitigation System
UDA	Urban Development Authority (Sri Lanka)
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UN-ISDR	United Nations International Strategy for Disaster Reduction
UNU-IEHS	United Nations University – Institute for Environment and Human Security
US	United States
USAID	United States Agency for International Development
USGS	United States Geological Survey
WG	Working Group
WDC	World Data Centre
WMO	World Meteorological Organization

ANNEX B

Seismic Monitoring

Core Regional Seismic Network for the Indian Ocean

Country	Station name	Code	Data Transmission Method	Lat	Long	Height
Indonesia	Gunung Sitoli	GSI	VSAT	1.3033	97.5757	
Indonesia	Yogyakarta	YOGI	VSAT			
Indonesia	Banda Aceh	BSI	VSAT	5.4962	95.2947	
Indonesia	Padang Panjang	PPI	VSAT	-0.4568	100.397	
Indonesia	Lembang	LEM	VSAT	-6.8263	107.618	
India	Port Blair	PBA	VSAT	11.6559	92.7428	17
India	Bhuj	BHJ	VSAT	23.254	69.654	80
India	Shillong	SHL	VSAT	25.5667	91.8833	1600
India	Hyderabad	HYB	VSAT	17.4169	78.5531	510
Malaysia	Kulim	KULM KOM?	VSAT	5.2902	100.649	74
Malaysia	Kuching	KSM	VSAT	1.4733	110.308	66
Malaysia	Kota Kinabalu	KKM	VSAT	6.0443	116.215	830
Thailand	Chieng Mai	CHTO	Leased line	18.8138	98.9438	316
Thailand	Khanchanaburi	KBR	VSAT	14.0167	98.5925	173.3
Vietnam	tbd					
Myanmar	tbd					
Myanmar	tbd					
Myanmar	tbd					
Sri Lanka	Pallekele	PALK	VSAT	7.2728	80.7022	460
Pakistan	Karachi	KAR		24.9333	67.1433	34
Pakistan	Nilore	NIL	VSAT	33.65	73.2517	536
Bangladesh	Dhaka					
Bangladesh	Cox's Corner					
Maldives	Male					
Maldives	tbd					
Madagascar	Ambohimpanompo	ABPO	Internet/ VSAT	-19.017	47.227	
Madagascar	tbd					
Singapore	Bukit Timah	BTDF				
Tanzania	Dodoma					
Tanzania	Tukuyu					
Kenya	Nairobi	NAI		-1.2739	36.8037	1692
Kenya	Kilima Mbogo	KMBO	VSAT	-1.1268	37.2523	1940
Somalia	Benadir					
Somalia	Bossaso					
Seychelles	Mahe	MSEY	VSAT	-4.6737	55.4792	475
Mauritius	tbd					
Mozambique	tbd					
Comoros	tbd					
France	Le Reunion	RER		-21.159	55.746	834
France	Amsterdam Is	AIS		-37.797	77.5694	36
France	Port Alfred (Crozet Is)	CRZF		-46.43	51.8612	140
France	Port-aux-Français (Kerguelen Is)	PAF		-49.351	70.2133	17

Core Regional Seismic Network for the Indian Ocean

Country	Station name	Code	Data Transmission Method	Lat	Long	Height
Australia	Learmonth		VSAT			
Australia	Fizroy Crossing	FITZ	VSAT	-18.102	125.639	110
Australia	Christmas Island	XMIS	VSAT	-10.481	105.652	230
Australia	New Amsterdam		VSAT			
Australia	Narrogin	NWAO	VSAT	-32.927	117.234	365
China	Enshi	ENH	VSAT	30.2718	109.487	487
China	Kunming	KMI	VSAT	25.1233	102.74	1940
China	Sheshan	SSE	VSAT	31.0956	121.187	15
China	Baijiatuan (Beijing)	BJI	VSAT	40.0403	116.175	43
China	Lhasa	LSA	VSAT	29.7	91.15	3789
China	Urumqi	WMQ	VSAT	43.8211	87.695	897
China	Hailar	HIA	VSAT	49.2667	119.742	610
China	Mudanjiang	MDJ	VSAT	44.6164	129.592	250
China	Xi'an	XAN	VSAT	34.2483	108.92	395
Nepal						
Bhutan						
South Africa	Sutherland	SUR	VSAT/ Internet	-32.38	20.8117	1760
South Africa						
Philippines	Davao	DAV	VSAT	7.07	125.579	145.7
Papua New Guinea	Port Moresby	PMG	VSAT	-9.4062	147.159	65

Source: UNESCO-IOC (2005b)

ANNEX C

Sea Level Monitoring

Status of Sea Level Upgrades Based on Best Available Information (25 July 2006)

	Station Name	Country	Current Status	Plan	Current Data Sharing (min)	Funded by	Current Sample (min)	Transmission Interval	Data Transmission	WMO Header	GLOSS	Lat	Long	Core Network Station
1	Cocos Is.	Australia	2	?	60	AUSTRALIA	6	60	MTSAT DCP	SXPS90 RJTD	GLOSS	-12.11666	96.88333	
2	Rodrigues	Mauritius	1	upgraded 2005	15	IOC/NOAA	1	15	MET-5	SXXX32 EUMS	GLOSS	-19.6683	63.4183	
3	Port Louis	Mauritius	1	upgraded 2005	15	IOC/NOAA	1	15	MET-5	SXXX32 EUMS	GLOSS	-20.155	57.495	
4	Colombo	Sri Lanka	1	upgraded 2005	15	IOC/NOAA	2	15	MTSA,T DCP	SWIO40 RJTD	GLOSS	6.95	79.85	
5	Sibolga	Indonesia	1	upgraded 2005	15	IOC/NOAA	1	15	MTSAT DCP	SWIO41 RJTD	GLOSS	1.7333	98.8	
6	Padang	Indonesia	1	upgraded 2005	15	IOC	1	15	MET-5	SXXX32 EUMS	GLOSS	-0.95	100.3666	
7	Sabang	Indonesia	1	upgraded 2005	15	NOAA	1	15	MET-5	SXXX32 EUMS		-5.8877	95.2828	
8	Ko Taphao Noi	Thailand	1	2005 upgraded	15	ADPC/UNDP	1	15	MET-5	SXXX32 EUMS	GLOSS	7.83333	9843333	
9	Ko Miang	Thailand	1	2005 upgraded	15	ADPC/UNDP	1	15	MET-5	SXXX32 EUMS		8.55	97.6333	
10	Ko Tarutao	Thailand	1	2005 upgraded	NO	Thailand								
11	Ao Tap Lamu	Thailand	1	2005 upgraded	NO	Thailand								
12	Ranong	Thailand	1	newly installed	NO	Thailand								
13	Ko Surin	Thailand	1	newly installed	NO	Thailand								
14	Amphur Kuraburi	Thailand	1	newly installed	NO	Thailand								
15	Amphur sikao	Thailand	1	newly installed	NO	Thailand								
16	Ko Racha Noi	Thailand	1	newly installed	NO	Thailand								
17	Mu ko Similun	Thailand	1	newly installed	NO	Thailand								

Status of Sea Level Upgrades Based on Best Available Information (25 July 2006)

	Station Name	Country	Current Status	Plan	Current Data Sharing (min)	Funded by	Current Sample (min)	Transmission Interval	Data Transmission	WMO Header	GLOSS	Lat	Long	Core Network Station
18	Benoa	Indonesia	1	updated 1/2006	NO	IOC	1	15	MET-5	SXXX32 EUMS		-8.7666	115.2166	
19	Kuantan	Malaysia	3	installed 2005	NO	MMD	10	60	Dialup	NO GTS		3	101.4	
20	Tanjung Beras (Melaka)	Malaysia	3	installed 2005	NO	MMD	10	60	Dialup	NO GTS		2.21	102.16	
21	Bintulu	Malaysia	3	installed 2005	NO	MMD	10	60	Dialup	NO GTS		3.16	113.03	
22	Kota Kinabalu	Malaysia	3	installed 2005	NO	MMD	10	60	Dialup	NO GTS		5.98	116.06	
23	Sandakan	Malaysia	3	installed 2005	NO	MMD	10	60	Dialup	NO GTS		5.9	118.06	
24	Trincomale	Sri Lanka	2	operational		NARA/BSH	5	15	MET-5			8.1135	81.1991	
25	Kirinda	Sri Lanka	2	operational		NARA/BSH	5	15	MET-5					
26	Bali???	Indonesia	2	underway 1/2006	NO	INDONESIA								
27	Simeulue	Indonesia	2	underway 1/2006	NO	INDONESIA/ GERMANY						2.5	96.333	
28	Nias	Indonesia	2	underway 1,2/2006	NO	INDONESIA/ GERMANY						0.583	97.75	
29	Siberut	Indonesia	2	underway 1,2/2006	NO	INDONESIA/ GERMANY						-1.667	98.833	
30	Pagai	Indonesia	2	underway 1,2/2006	NO	INDONESIA/ GERMANY						-3.167	100.333	
31	Enggano	Indonesia	2	underway 1,2/2006	NO	INDONESIA/ GERMANY						-5.333	102.167	
32	Hanimaadhoo	Maldives	1	2006	60	NOAA	2	60	MET-7	SXXX32 EUMS	GLOSS	6.7667	73.1667	
33	Male/Hulhule	Maldives	1	2006	60	IOC	4	60	MET-7	SXXX32 EUMS	GLOSS	4.19	73.5267	
34	Gan	Maldives	1	2006	60	NOAA	4	60	MET-7	SXXX32 EUMS	GLOSS	0.6867	73.1517	

Status of Sea Level Upgrades Based on Best Available Information (25 July 2006)

	Station Name	Country	Current Status	Plan	Current Data Sharing (min)	Funded by	Current Sample (min)	Transmission Interval	Data Transmission	WMO Header	GLOSS	Lat	Long	Core Network Station
35	Cilacap	Indonesia	2	2006	NO	IOC					GLOSS	-7.56666	108.98333	
36	Benoa	Indonesia	1	2006	NO	IOC					GLOSS	-8.73333	115.2	
37	Masirah	Oman	1	2006	NO	IOC	4	60	MET-7	SXXX33 EUMS		20.68667	87.1667	
38	Salalah	Oman	2	2006	currently no data transmission	IOC	4	60	MET-7	SXXX33 EUMS	GLOSS	16.935	54.0067	
39	Pengkalan	Malaysia	2	2006	NO	IOC								
40	Diego Garcia	UK	2	2006	NO	IOC	6	60	MET-7	SXXX33 EUMS	GLOSS	-7.28333	72.4	
41	Pointe La Rue	Seychelles	2	upgrading 2006	60	IOC	4	60	MET-7	SXXX32 EUMS	GLOSS	-4.68333	55.51666	
42	Moulmein	Myanmar	2	underway 92006	NO	IOC					GLOSS	16.48333	97.61666	
43	Akyab	Myanmar	2	underway 9/2006	NO	IOC					GLOSS	20.15	92.9	
44	Lamu	Kenya	2	upgrading 7/2006	60	IOC	4	60	MET-7	SXXX33 EUMS		-2.2667	40.9	
45	Zanzibar	Tanzania	2	upgrading 7/2006	60	IOC	4	60	MET-7	SXXX33 EUMS	GLOSS	-6.15	39.1833	
46	Pemba	Mozambique	2	upgrading underway 2006	120 or more	IOC			Orbcomm; will be changed to Met-7	website	GLOSS	-12.96666	40.48333	
47	Inhambane	Mozambique	2	upgrading under way 2006	120 or more	IOC			Orbcomm; will be changed to Met-7					
48	Darwin	Australia	2	2006	1440	AUSTRALIA	6	1440	Dialup	NO GTS	GLOSS	-12.46666	130.85	
49	Broome	Australia	2	2006	1440	AUSTRALIA	6	1440	Dialup	NO GTS	GLOSS	-18	122.21666	
50	Port Hedland	Australia			1440	AUSTRALIA	5	1440	Dialup	NO GTS	GLOSS	-20.31666	118.5666	

Status of Sea Level Upgrades Based on Best Available Information (25 July 2006)

	Station Name	Country	Current Status	Plan	Current Data Sharing (min)	Funded by	Current Sample (min)	Transmission Interval	Data Transmission	WMO Header	GLOSS	Lat	Long	Core Network Station
51	Carnarvon	Australia			1440	AUSTRALIA	5	1440	Dialup	NO GTS	GLOSS	-24.9	113.65	
52	Fremantle	Australia			1440	AUSTRALIA	5	1440	Dialup	NO GTS	GLOSS	-32.05	115.73333	
53	Hilarys	Australia	2	2006		AUSTRALIA								
54	Esperance	Australia	2	2006		AUSTRALIA								
55	Thevenard	Australia	2	2006		AUSTRALIA								
56	Christmas Is.	Australia	2	?	1440	AUSTRALIA	15	1440	Dialup	NO GTS	GLOSS	-10.41666	105.66666	
57	Nicobar	India	2	?		INDIA					GLOSS	7	93.83333	
58	Port Blair	India	2	?		INDIA					GLOSS	11.68333	92.76666	
59	Vishakhapatnam	India	2	?		INDIA					GLOSS	17.68333	83.28333	
60	Madras	India	2	?		INDIA					GLOSS	13.1	80.3	
61	Cochin	India	2	?		INDIA					GLOSS	9.96666	76.26666	
62	Minicoy	India	2	?		NOAA					GLOSS	8.28333	73.05	
63	Marmagao	India	2	?		INDIA					GLOSS	15.41666	73.8	
64	Veraval	India	2	?		INDIA					GLOSS	20.9	70.36666	
65	Chittagong	Bangladesh	3	2006?		IOC					GLOSS	22.3333	91.8333	
66	Coco Is.	Myanmar	2	site survey 2006		ADPC								
67	West Coast	Philippines	2	site survey completed		ADPC								
68	East Coast	Vietnam	2	site survey completed		ADPC								
69	Reunion Is.	France	2	2007		FRANCE					GLOSS	-20.93333	55.3	
70	Karachi	Pakistan	2	2006		IOC					GLOSS	24.8	66.96666	

Status of Sea Level Upgrades Based on Best Available Information (25 July 2006)

	Station Name	Country	Current Status	Plan	Current Data Sharing (min)	Funded by	Current Sample (min)	Transmission Interval	Data Transmission	WMO Header	GLOSS	Lat	Long	Core Network Station
71	Djibouti	Djibouti	2	2006		ODINAFRICA					GLOSS	11.6	43.15	
72	Mombasa	Kenya	2	7/2006		NOAA					GLOSS	-4.05	39.66666	
73	Dzaoudzi		2	2007		FRANCE					GLOSS	-12.78333	45.25	
74	Nosy Be	Madagascar	3	unknown		ODINAFRICA					GLOSS	-13.4	48.28333	
75	Fort Dauphin	Madagascar				Uncommitted					GLOSS	-25.01666	47	
76	Durban	South Africa	2	2006		IOC					GLOSS	-29.88333	31.03333	
77	Port Elizabeth	South Africa	2	2006		IOC					GLOSS	-33.96666	25.63333	
78	Kerguelen	France	2	2006		FRANCE	1	1 day			GLOSS	-49.345	70.22	
	26 additional stations	Indonesia	2	by Dec 2006		INDONESIA								
79	Kupang	Indonesia	2	2007		NOAA					GLOSS	-10.16666	125.58333	
80	Prigi	Indonesia	2	2007		NOAA								
81	Lembar	Indonesia	2	2007		NOAA								
82	Tamatave	Madagascar		2007?		FRANCE								
83	Aden	Yemen		unknown		IOC					GLOSS	12.78333	44.98333	
84	Marion Is.	South Africa		2006?		GERMANY					GLOSS	-46.8666	37.8666	
85	Syowa (Antarctica)	Japan					5	1 day			GLOSS	-69	39.5666	
86	Gwadar	Pakistan		unknown		uncommitted					GLOSS	25.11666	62.33333	
87	Mogadishu	Somalia		unknown		uncommitted					GLOSS	2.01666	45.33333	
88	Mtwara	Tanzania		unknown		uncommitted					GLOSS	-10.28333	40.18333	
89	St. Paul	France		unknown		uncommitted					GLOSS	-38.71166	77.53833	
90	Crozet	France		unknown		uncommitted					GLOSS	-46.425	51.87	

Notes:
Current Status: 1 - Upgrade completed; 2 - Upgrade underway, 3 - Requires upgrade
Blank: no description in GLOSS Handbook

ANNEX D

Indian Ocean Consortium
Technical Assistance Areas

Basic Capacity 1: National tsunami centre established and operating as the authoritative source for tsunami advice and warnings.

Support agency: Intergovernmental Oceanographic Commission (IOC) of UNESCO

Main contact person: Patricio Bernal
Assistant Director General and
Executive Secretary for IOC
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Short description of the capacity: The national tsunami centre is a technical facility that is staffed by a small cadre of well-trained tsunami experts and technicians and operates on a 24 hour a day, 7 days a week basis, supported by a network of seismic and oceanic observing systems and by highly reliable data analysis and communications systems. The centre acts as the national focal point for regional and international interactions.

Main organizations involved: Disaster management office, civil protection departments, government scientific organizations, ocean science institutes, national meteorological and hydrological agency, and the telecommunications authorities.

Main tasks required: Building a Tsunami Warning and Mitigation System means the establishment of a comprehensive Tsunami Warning System (TWS) infrastructure and people based knowledge level that is designed to save lives and reduce property damage from the approach of a tsunami. In order to build such a system there is a number of requirements:

- The TWS infrastructure uses technology to disseminate tsunami warnings. This technology needs to be adopted by all stakeholders in the system.
- Emergency management officials must translate the warnings into public evacuation actions.
- A team of experts by area of expertise and stakeholders needs to be established and funded within government to form "Tsunami Warning and Mitigation Committees."
- Ideally, such committees can be established at all levels of government including the national, provincial, and local jurisdictions.
- Strategic country planning and resource commitment can take place at the national and provincial levels.
- Formulation and implementation of community specific strategies is best conducted at the local levels.

As well, the system requires to:

- Look at desired outcomes (e.g. human evacuation actions, mitigation strategies that reduce exposure to tsunamis).
- Determine programs and systems that will reach these desired outcomes in an "end to end" approach.
- Development an assessment of the organizations and expertise that is available for Hazard Assessment; Warning Guidance; and Preparedness / Mitigation.

The specific critical tasks required are the following:

- Establish legislative mandate, administrative rules or any form of delegated authority for providing warnings;
- Establish offices to house staff and equipment; procure and install equipment; identify and direct personnel; train personnel;
- Establish observation networks and communications networks; obtain and establish manuals, protocols, operating plans;
- Establish working links with user communities (government officers, police, disaster managers, media, etc); build linkages with regional and international coordination mechanisms; undertake periodic tests and trials of all systems used.

Assistance offered to support the development of plans for this capacity:

UNESCO/IOC will provide for:

- A permanent Secretariat for the ICG/IOTWS based in Perth to support all the intergovernmental coordination required for the IOTWS.
- A Tsunami Coordination Unit, composed of 9 experts, located in HQs, in the ITIC Office and in the ICG/IOTWS Secretariat that will technically back-stop the IOTWS. Through this unit, IOC is ready to offer technical assistance to countries requesting it to setup their National Tsunami Warning Centers, in the form of:
    1. Training of personnel for handling and processing Earthquake and Tsunami relevant data.
    2. Training and assistance to produce coastal inundation maps,
    3. Technical Assistance for defining, installing, and monitoring seismic and oceanographic equipments
    4. Technical Assistance to prepare Terms of Reference for provision of personnel services or equipments.
    5. Technical Assistance for developing manuals, protocols and operating plans, in partnership with JMA, PTWC,
    6. Technical Assistance for defining mandates and delegation of authority.
- Connect national facilities to the core regional system, including the recently upgraded 23 sea-level stations.
- Delivering tsunami-resistant new equipment to selected countries, facilitating communication channels, and providing maintenance and training support.
- Support the upgrading of the seismographic network around the Indian Ocean Basin, concentrating mainly in the Indian Ocean Islands, East Africa and other selected countries (Sri Lanka). Equipment and training will be provided

Information resources support that can be provided: IOC will establish a Tsunami Information Centre in Jakarta, Indonesia, to act as a clearinghouse for transferring emergency preparedness material. Backstopping will be provided through its International Tsunami Information Center (ITIC) based in Hawaii, USA. Comprehensive communication and training package as the "Tsunami Teacher" will be provided.

Other capacities or partners than can be engaged to help: Through its capabilities in Education and Public Awareness for Tsunami (ITIC) and Coastal Zone Management (ICAM Programme) UNESCO/IOC is able to cooperate with OCHA for Objective 3, IFRC for Objective 4, UNEP for Objective 5 and WB for Objective 7.

WMO and ISDR cooperation will be requested for Objective 1.

Logistics and contingency issues if any: Not applicable

Basic Capacity 2: Strengthening of operational 24/7 national warnings services through the National Meteorological Services as part of multi-hazard approach to national warning systems.

Support agency: World Meteorological Organization (WMO)

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Chief, Natural Disaster Prevention and Mitigation Programme
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Email: mgolnaraghi@wmo.int

Short description of the capacity: Every country requires a basic operational capability for 24/7 warning services to be able to monitor hazards, develop and disseminate forecasts and warnings within a multi-hazard approach, in support of preventive, preparedness and emergency response measures. In certain countries, this capability is attached to the National Meteorological and Hydrological Services (NMHS), which require for this purpose effective observing networks, trained professional staff, access to state of the art computers, data archiving and management equipment, efficient telecommunication equipment and access to networks, ability to develop and disseminate specific forecasts, warnings and data products to government authorities and other stake holders in support of various stages of disaster risk management from prevention to preparedness to emergency response and recovery.

Warning services should be available for all hazards posing risk to the country and span various time-scales. Hazards connected with very short warning lead-time are for example tsunami, flash floods, and tornadoes, hazards with longer warning lead-times of 24 hours to several days are for example tropical cyclones and storm surges, and droughts have a warning lead-time of months). However, organizational capacities of the NMHSs vary significantly from country to country in serving their mandate for development and/or issuance of warnings. In many countries in this region, there is an urgent need for upgrading and strengthening the technical and operational capacities of NMHSs to meet the minimum requirements as operational 24/7 warning services. Furthermore, the role and responsibilities of NMHSs as agencies responsible for providing warning within a multi-hazard approach and their interaction with other key agencies involved in disaster risk reductions must be clearly identifiable and be an integral part of national disaster plans of the countries.

Main organizations involved: Disaster management office, Ministries under which NMHS operate, National Meteorological and Hydrological Agencies, other government scientific organizations such as ocean science institutes, civil protection departments, national and regional tsunami centres, telecommunications authorities, media, WMO Regional Specialized Meteorological Centers, UNDP, WB, IFRC, OCHA and other international agencies.

Main tasks required:

- Establish a national disaster plan in which the role and responsibilities of the NMHS and their interactions with other agencies involved in different aspect of disaster risk management planning and response are identified for tsunami and hydro-meteorological hazards posing risk to the country.

- Ensure through legislation, the NMHSs mandates are clear. Identify minimum requirements for operational 24/7 NMHSs to be able to effectively serve their mandate in support of preventive, preparedness and emergency response measures.
- Determine gaps and needs for strengthening of NMHSs capacities with respect to observation networks, computers and data management systems, telecommunication equipment and access to networks, technical training and capacity building, joint training and educational programmes with media, National Disaster Management Agencies (NDMOs), Red Cross and Red Crescent Societies for providing useful and understandable warnings, professional staff needs to operate the forecasting and warning services, needs for manuals, protocols, operating plans, etc.
- Establish working links with other agencies, authorities and user communities (government officers, police, disaster managers, media, etc) as determined the official mandate.
- Strengthening of linkages with regional tsunami alert providers, national tsunami centre (if different from the NMHSs), and WMO's Regional Specialized Meteorological Centres to benefit from forecasts, alerts and other information that can be critical for development of national forecasts and warnings.

Assistance offered to support the development of plans for this capacity:

- Over the next four months (April –July 2006), WMO offers travel support and up to three weeks of experts' time in the countries supporting governments and partners in the development of national plans, role of NMHSs and requirements for the NMHSs to serve their mandate, followed by 2-3 days support from the WMO Headquarters per country for NMHSs plan development.
- Beyond July 2006, for the following 8 months, (August 2006 – March 2007) WMO offers additional 6 weeks of experts' time in the countries followed by 2-3 days of support from the WMO Headquarters per country for the NMHSs plan developments.

Information resources support that can be provided: Furthermore, WMO Secretariat, through its Natural Disaster Prevention and Mitigation Programme has launched two major surveys (country-level, and regional-level) to assess in detail the current technical and operational observing, monitoring, forecasting and warning capabilities, as well as major gaps and needs in support of preventive, preparedness and emergency response measures. The Country-level survey is distributed to all 187 WMO Members including all Indian Ocean countries. The regional survey is conducted in six regions including Africa, Asia, Pacific, Caribbean, Central and North America, South America and Europe, thus will include the Indian ocean in its entirety. A detailed database of country-level and regional-level capacities gaps and needs within the multi-hazard approach is underdevelopment by WMO and will be used to assist countries and the NMHSs to develop their plans.

Other capacities or partners than can be engaged to help: Experts from leading NMHSs and WMO Specialized Regional Meteorological Centers will be invited by WMO to work at the national level with the governments and other partners for development of the plans.

Logistics and contingency issues if any: Not applicable

Basic Capacity 3: **Warning response plan for coastal regions prepared and disseminated and a national (coastal) response and evacuation exercise undertaken.**

Support agency: UN Office for the Coordination of Humanitarian Affairs (OCHA)

Main contact person: Terje Skavdal
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Short description of the capacity: Based on technical information available (e.g. tsunami hazard maps, highly vulnerable areas) and operation of tsunami alert systems, warning response plans for selected coastal regions will be prepared and disseminated. A highly participatory approach involving community leaders at the local level will be utilised. Once the plan is adopted, an evacuation drill will be conducted. This activity will include public education and awareness programmes.

Main organizations involved: Disaster management office, civil protection departments, government scientific organizations, ocean science institutes, national meteorological and hydrological agency, telecommunications authorities, municipal authorities, NGOs, Red Cross Movement; community based organisations, private sector; the media.

Main tasks required: Create minimum standard guidelines for a community to follow for adequate tsunami readiness; Establish a standard format and methodological guidelines for the formulation of warning response plans; prepare a cadre of trainers; obtain tsunami hazard maps and select most vulnerable coastal areas; obtain the buy-in from municipal authorities; establish working links with user communities (government officers, police, disaster managers, media, etc); formulate the plan; define evacuation routes and safety zones; post evacuation signs; adequate facilities for temporary shelter; define alert system; prepare table-top simulation exercise to test the plan; formulate and disseminate evacuation plans; design and disseminate public information materials; conduct evacuation drill; undertake periodic tests and trials of all systems used.

Assistance that can be supplied to support the development of plans for this capacity:

- Technical support through OCHA Regional Office in Bangkok
- Short-term consultancies (national officers)
- Review of successful emergency planning experiences and evacuation exercises supported by OCHA.

Other capacities or partners than can be engaged to help: IFRC, local Red Cross/Crescent Society, NGOs, PVOs.

Logistics and contingency issues if any: The implementation of this capacity depends on the existence of technical information (mainly tsunami hazard maps) and the existence of alert systems already in place in the selected coastal communities.

Basic Capacity 4: **Awareness-raising and education campaign under-taken on tsunami risks and the warning system in coastal regions.**

Support agency: International Federation for Red Cross and Red Crescent Societies

Main contact person: Johan Schaar,
Special Representative for the Tsunami Operation
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Short description of the capacity: National Red Cross and Red Crescent Societies are present in 183 countries. In each of the countries[1] in the Indian Ocean region, National Societies – as auxiliary to the public authorities – are active in disaster management. In terms of the structure, National Societies have their headquarters in the capital and the branches at provincial, city or district levels. All levels are supported by a network of staff and volunteers.

Apart from the National Societies, the International Federation of Red Cross and Red Crescent Societies' country offices and regional delegations[2] have extensive experience in disaster preparedness and risk reduction which includes early warning. Through sharing knowledge and experience and working with National Societies, they have the mission to strengthen the institutional capacity and organisation for disaster management, for instance its work in cyclone early warning in Bangladesh and flood related early warning in Cambodia.

They are also part of regional bodies and networks helping to ensure a more coordinated approach in disaster management. With its permanent observer status at the United Nations, the International Federation of Red Cross Red Crescent Societies also works with the United Nations, international organisations, Inter-governmental and non-governmental international organisations in moving forward policy and practice in early warning.

Within the Indian Ocean region a number of national Red Cross and Red Crescent Societies, with their programmes in disaster preparedness, have supported and run activities in awareness raising and education for more than 10 years.

Main organizations involved: At country level it involves the local and partner Red Cross / Red Crescent National Societies, Ministry of development and its disaster management offices, Ministry of education, civil protection departments, universities, scientific organizations, ocean science institutes, national meteorological and hydrological services and telecommunications authorities. The programmes will also seek support from other interested parties such as government developmental organisations and NGOs.

Main tasks required:

At schools:

- Integrate early warning and disaster management education into the education system.

[1] The exception is the Maldives where the National Society is currently in formation

[2] International Federation of Red Cross and Red Crescent Societies regional delegations and country offices are mandated to support and strengthen National Societies

- Increase knowledge of risks and identify vulnerable areas.
- Develop disaster response plans for safer schools.
- Promote the development of an Early Warning Day to be held at schools that brings together all actors of the community and those involved in early warning and disaster management.
- Produce educational materials, i.e. board games, to reach out to children.

At community level:

- To increase awareness of early warning issues and share cost effective good practises at community level, a National Early Warning Fair will be established to support building networks and to exchange information between the various actors.
- Raise awareness of risks and actions to take through National Societies' settings and other community based organisations, such as Youth Red Cross / Red Crescent and Mother's Club.
- Multiply vulnerability and capacity assessment in a participatory process with communities and develop a plan of action as a result of it, linking this with local authority plans.
- Enhance training and coordination between the Red Cross and Red Crescent branches, local government authorities, NGOs, community leaders to increase awareness on risks in particular in most vulnerable areas.
- Communities will be trained in disaster preparedness and evacuation related activities to reduce their vulnerability to hazards.
- Train Community Disaster Response Teams. Well informed communities save more lives as they are trained in early warning, know about the risks, understand the danger signals and respond to disasters.

With the media:

- Provide training of journalists at national and rural radio level to ensure understanding of early warning and disaster management issues in support of dissemination of alert.
- Promote the development of early warning information dissemination by including early warning messages in street theatres and popular radio/ TV programmes to attract attention, e.g. radio soap opera.

Assistance that can be supplied to support the development of plans: Over the next four months the International Federation of Red Cross and Red Crescent Societies will involve of National Societies in setting up this long-term plan and establish coordination with Governments and partners. Support can be provided through its National Societies through its country and regional delegations as well as through its Geneva secretariat. This activity will extend beyond July 2006 to March 2007.

Information resources support that can be provided: The International Federation of Red Cross and Red Crescent Societies offers to share knowledge such as guidelines, case histories and reports on disaster awareness, disaster multi-risk reduction (including tsunamis), emergency response and early warning at community level.

Other capacities or partners than can be engaged to help: The International Federation of Red and Cross Red Crescent Societies expects to build on its partnerships and work closely at country level with local authorities, WMO, UNDP, ISDR, UNESCO, WB and other international and local organisations.

Logistics and contingency issues if any: Not applicable

Basic Capacity 5: **Assessment of Environmental Flashpoints at sub-national level for use in preparedness and spatial planning and disaster risk reduction**

Support agency: United Nations Environment Programme (UNEP)

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Short description of the capacity: Sub-national assessments of environmental flashpoints, developed in cooperation with national and international partners, would draw attention to critical environmental concerns that affect risk and vulnerability to coastal hazards. Assessments would be fully integrated with preparedness planning for the Indian Ocean Warning System and for use in identifying strategic interventions through existing national mechanisms for spatial planning, early warning and disaster risk reduction.

Main organizations involved: National and sub-national environmental management authorities, disaster management agencies, coastal zone management authorities, planning agencies, mapping agencies, scientific and technical institutions

Main tasks required: Assessments of environmental flashpoints would be developed based on an instrument designed by UNEP and cooperating technical experts and would include identification of critical parameters, data and information needs. The instrument will be adapted to national needs based on consultations with national authorities and technical experts which would include those national partners expected to use the analyses for decision making purposes. The assessment will be carried out by trained national partners with technical support from UNEP. A final review of the assessment will include development of an action plan and guidelines for integrating the assessment findings in national and sub-national planning processes.

Assistance that can be supplied to support the development of plans for this capacity: Technical guidance, environmental assessment methodologies, training, delivery of assessments

Information resources support that can be provided: national and (sub) regional scale environmental and select disaster related information; (sub)national and (sub)regional scale data sets for select locations.

Other capacities or partners than can be engaged to help: UNDP, UNISDR, bilateral and multilateral donors, NGO's

Logistics and contingency issues if any: Administrative and logistical support through UNDP country offices; full engagement of relevant government agencies; availability of financial and technical resources to meet the volume of requests.

Basic Capacity 6: **Organizations responsible for disaster risk reduction and disaster management established to lead, monitor and coordinate the plan.**

Support agency: United Nations Development Programme (UNDP)

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Pablo Torrealba, Regional Risk Reduction Specialist
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Short description of the capacity: The multi-faceted nature of effective early warning systems requires that plans to develop and implement them are undertaken with input from multiple stakeholders. The primary responsibility and leadership of a multi-stakeholder process for designing and implementing early warning system plans under the current initiative is expected to rest with national governments. The role of international agencies is to support national governments and the other stakeholders in the planning process.

The basic capacity needed for ensuring that organizations responsible for disaster risk reduction and disaster management are established to lead, monitor and coordinate the plan therefore has two dimensions: 1) that governments identify and convene or involve the appropriate mix of stakeholders needed to design effective early warning systems, and 2) coordination of support for the planning process by international agencies.

Main organizations involved: Early warning systems consist of linked sub-systems:

- A warning sub-system, in which hazards are monitored and forecasted, at the international, national and local levels. In these, scientific information about impending hazards is produced and communicated to national authorities responsible for disaster management.
- A risk information sub-system, which can enable disaster management authorities to generate risk scenarios. These should indicate the potential impact of an impending hazard event on specific vulnerable groups and sectors of the society.
- A preparedness sub-system, in which disaster preparedness strategies are developed that indicate actions required to reduce the loss and damage expected from an impending hazard event
- A communication sub-system, which allows the communication of timely information on impending hazard events, potential risk scenarios and preparedness strategies to vulnerable groups, so that they may take appropriate mitigation measures.

The design and implementation of each sub-system involves multiple actors and institutions. The particular authorities and other stakeholders needed for the design and functioning of the entire system differ from one context and geographic location to the next. One of the most important stakeholder groups is the public who will receive, and who will be expected to act on, early warning information.

With respect to international support for the current initiative, effective engagement with national level actors requires a permanent presence in each country. The primary responsibility for ensuring a coordinated approach among UN agencies in support of member states lies with the Resident Coordinator, who chairs UN Country Teams. Resident Coordinators can encourage non UN agencies, such as International Finance Institutions, regional organizations and NGOs to actively join relevant agencies from the UN Country Teams to support the planning process.

The UN Resident Coordinator is usually also the UNDP Resident Representative in the country. Within UNDP, Resident Representatives are supported by the Bureau for Crisis Prevention and Recovery and its Disaster Reduction Unit. This Bureau and Unit have a Regional Program for tsunami recovery. The Program is backstopped by a Bureau for Crisis Prevention and Recovery office in Delhi and Disaster Reduction Unit staff in Geneva. UNDP works closely with many national and international partners, including those supporting the current initiative.

In approximately 60 countries worldwide, UNDP and the government implement substantial disaster risk reduction programs. For example, large country-level programs were implemented or expanded in affected countries following the 2004 Indian Ocean tsunami. In countries with on-going disaster risk reduction programs there is typically a national focal point in charge of the program who could also assist with supporting the current initiative. Details on the programs in countries affected by the 2004 tsunami are below.

Main tasks required: Design of early warning system plans under the current initiative involves work by two interfacing sets of institutional structures:

1) Each country desiring to participate can so indicate and identify the organizations responsible for disaster risk reduction and disaster management that have been, or will be, established to lead, monitor and coordinate development of early warning system plans.

2) Upon being notified of a country's desire to participate in the initiative, UNDP will facilitate coordination among international partners involved in the current plan as requested, through the institutional mechanisms described above.

The substantive dimensions of the plans in each country will be elaborated through the resulting collaborative process. It will also be important to compare plans across countries in order to share knowledge being generated by the planning process.

Assistance offered to support the development of plans for this capacity: The UNDP national disaster focal points, tsunami recovery Regional Program, Disaster Reduction Unit, Bureau for Crisis Prevention and Recovery, and UNDP in general work with national and local authorities to promote the formation of national systems for comprehensive management of disaster risks. Areas of particular focus include capacity development and promotion of an enabling institutional and legislative policy environment. In the tsunami-affected countries, as in others, early warning systems are an important component of a national risk management system.

UNDP has assisted countries directly affected by the December 2004 tsunami with putting programs in place to reduce disaster risks associated with tsunamis and other hazards. Situations differ from one country to the next. In the countries affected by the 2004 tsunami,

these programs provide potential vehicles for supporting the current initiative Support for additional countries would depend upon availability of resources.

By way of example, short summaries of current tsunami-related UNDP assistance follow. These descriptions provide background for how the planning process could be undertaken in each case as part of the current initiative:

Sri Lanka: The Government of Sri Lanka and UNDP implement an on-going $4M Disaster Risk Management Programme consisting of four separately funded initiatives. Aided by UNDP, the government has enacted a new legislation (May 2005) which accords disaster reduction a higher level of priority than previously at least within the national government. Leadership for disaster reduction has moved from a Department within a Ministry into a new Ministry of Disaster Management headed by the Prime Minister and an executive agency (Disaster Management Centre) headed by a Director General. In December 2005, after intensive consultation process, the GoSL completed the "Road Map for Disaster Management" which seeks to address disaster reduction and emergency response in a coordinated function. The Road Map underscores the importance of EWS and multi hazard risk assessment. UNDP shall focus in supporting the implementation of the Road Map. The EWS and multi hazard assessment components are already planned to be elaborated into a project proposal/implementation plan working with the relevant authorities.

Maldives: In the Maldives there is a $1M Disaster Risk Management Programme which is a national initiative. The Government is focused on installing state of the art equipment for receiving international warnings and has been very active in adopting international protocols for information exchange. The President recently decreed that the Ministry of Defence is the focal organization for disaster management. The UN Country Office has started supporting the Ministry through basic disaster management training. An important issue to be urgently addressed is the development of an enabling policy and legislative framework and subsequently a national disaster reduction plan. The plan should be generated with the involvement of officials from the atoll and island levels and the key economic and social sectors of Maldives. UNDP will provide support by collecting information on disaster risk management from other Island States, and support the initial process of drafting a Disaster Risk Management policy for Maldives, that will emphasize relevant aspects of early warning systems (such as risk identification, warning issuing and appropriate islands response).

Thailand: The Government of Thailand and UNDP implement a $6M tsunami recovery program. Of that $.4M is designated for establishment and strengthening of early warning systems. The Prime Minister has decreed the creation of a National Early Warning Centre in charge of coordinating the early warning system of the country. The Centre is still forming its human resource capability and coordination arrangements with other institutions particularly the local administration are still under development. Consequently, clarity in institutional roles and responsibilities particularly in relation with established NDMO (the Department of Disaster Prevention and Mitigation), the Meteorology Department and other warning agencies still require support. UNDP proposes that the entry point is to start a dialogue with the National Early Warning Centre to identify possible cooperation and initial identification of support requirements.

Indonesia: The Research and Technology Agency is responsible for coordinating a people-centred EWS Master Plan with three elements: 1) scientific research, monitoring, and prediction, to be lead by the BMG, 2) public awareness and preparedness, to be lead by LIPI,

and 3) government response from national down to the district and village level to be led by BAKORNAS PBP. This process is still ongoing. UNDP proposes to assist BAKORNAS PBP in engaging a short term in country consultant who would assist in forming and developing the component assigned to them in developing the Master Plan for people-centered EWS that includes risk identification and public information. UNDP proposes to assist BAKORNAS PBP in engaging a short term in country consultant who would assist in forming and developing the component assigned to them in developing the Master Plan for people-centered EWS that includes risk identification and public information. This effort can be supported through a planned program that is currently pending government approval. To date US $2M has been pledged by one donor, to which UNDP has proposed to provide up to US $.5M in additional funding.

India: The Government of India and UNDP implement a $34M Disaster Risk Management Programme which was expanded with an additional $15M to cover the tsunami-affected states of Tamil Nadu, Kerala and Pondicherry. Strengthening of EWS is being done through established mechanisms. The focus had been in mobilizing additional resources and implementing local level disaster preparedness. A study on EWS and risk assessment will be started, focusing on those existing in the Tsunami-affected states.

Information resources support that can be provided: UNDP and partners are in a position to supply a variety of information resources and support information and knowledge sharing under the current initiative:

1) Early warning best practices, particularly in the areas of risk information, preparedness and communication.

2) Sharing of planning results among countries through the Regional Program.

Other capacities or partners than can be engaged to help: At the country level, coordination in support of the current initiative is expected to take place among national stakeholders and international supporting agencies. Coordination between national and international stakeholders, and among international agencies involved in the current initiative, will be the primary vehicles for mobilizing and harmonizing the contributions of additional stakeholders.

Logistics and contingency issues if any: Not applicable

Basic Capacity 7: **Intermediate and long-term plan developed for an end-to-end system with components' cost to develop and operate a sustainable tsunami warning and response system.**

Support agency: The World Bank (WB)

Main contact person: Country Directors, The World Bank Group country offices Washington: Hazard Risk Management Team, The World Bank Group, Washington DC 20433, USA. Tel: +1-202-458-2726; Fax:+1-202-522-3227;
Email: **sjha1@worldbank.org**

Short description of the capacity: National Plan for Tsunami Warning and Response System outlines the objectives and strategies for a sustainable tsunami warning and response system. The Plan, following a multi-hazard approach, integrates policy and management issues and includes all requirements of an end-to-end system including instrumentation requirements, communication infrastructure, emergency preparedness and response, contingency planning, risk assessments, and preparedness, awareness and education, and training and capacity building programs. The Plan provides for benchmarking of the status of early warning and response systems, intermediate and long term goals, implementation strategies, financial arrangements and indicators to measure the progress in the implementation of the plan.

Main organizations involved: National Disaster management office, National Finance and Planning Ministries, civil protection departments, government scientific organizations including national meteorological and hydrological services, ocean science institutes, national meteorological and hydrological agency, telecommunications authorities, civil society organizations, WMO and other UN agencies.

Main tasks required: Based on its expertise in design and implementation of large community-driven development programs and critical infrastructure projects including strengthening of hydro meteorological services in client countries, development of intermediate and long-term plan for tsunami warning and response systems will require the following steps:

- Undertake detailed scientific assessment of existing tsunami warning and response system and identify the gaps in policy, legal and organization framework;
- Requirements for improvements in seismic and sea-level instrumentation and network development, data transmission and archiving, data reduction and analysis methodol
- for training, software and hardware for surge modelling to develop inundation maps;
- Undertake vulnerability and risk mapping for tsunami hazard prone areas;
- Technology transfer and capacity building for operating the system;
- Assessment of disaster management system and critical infrastructure;
- Developing tsunami response plans including establishment of command, control and coordination, incident management teams, standard operating procedures;
- Developing tsunami warning protocols and warning dissemination mechanism from national to local levels;

- Develop an intermediate and long term plan to develop and operate a robust tsunami warning and response system;
- Develop financing strategy for funding the plan and its implementation;

Assistance that can be supplied to support the development of plans for this capacity: The World Bank is prepared to provide financial assistance (IBRD loans, IDA credits or grants, depending on countries' IDA grant eligibility) for projects that reduce vulnerability to disasters, including tsunami early warning systems. As part of preparation of such projects (or separately, where programmed in the Country Assistance Strategy), the Bank can also provide analytical and advisory assistance for an assessment of existing capacity and needs, and development of an intermediate and long term plan for tsunami warning and response system. One such project in India for Cyclone Risk Mitigation with a proposed investment of $ 250 million is in pipeline.

Information resources support that can be provided: The World Bank, in collaboration with IOC and its members, offers to facilitate access to global and regional information resources on best practices in multi-hazard risk reduction in general and developing and operating a tsunami warning and response system in particular.

Other capacities or partners than can be engaged to help: IOC, UNESCO, UNDP, WMO, IFRC, NOAA, USGS, JRC, and other

Logistics and contingency issues if any: Not applicable

ANNEX E

IOTWS Points of Contact

Contact
ICG/IOTWS Secretariat c/o Bureau of Meteorology P.O. Box 1370, West Perth WA 6872 Australia ph: 61 8 9226 0191 or 61 8 9321 9976 Fax: 61 8 9263 2211 Email: t.elliott@unesco.org , j.cunneen@unesco.org
UNESCO-IOC 1, rue Miollis 75732 Paris Cedex 15, France Tel: +33 1 45 68 39 83 Fax: +33 1 45 68 58 12 Website: http://ioc.unesco.org Email: p.koltermann@unesco.org

The Communiqué of the Paris Meeting stated: "*Welcome that, in addition to the steps taken, or to be taken, by countries of the Indian Ocean, the UNESCO/IOC and ISDR for interim tsunami warning, the Pacific Tsunami Warning Center and the Japan Meteorological Agency have agreed to provide, if requested, reliable interim tsunami advisory information to authorized contacts in the Indian Ocean states. Member States are requested to provide to UNESCO/IOC their official 24x7 contact information (prime and alternate) for receiving this information by 1 April 2005*;"

Changes and modifications to the list should be communicated formally through either the Minister of Foreign Affairs, its equivalent or the UNESCO Permanent Delegation of the country.

Member States bordering the Indian Ocean have provided the following information:

Australia [Dr. R. Canterford, Bureau of Meteorology]
Bangladesh [Mr. Begum Arjumand Hablb, Bangladesh Meteorological Department]
Comores [Mr. Amir Mohamed Karihila]
East Timor [Mr. Francisco do Rosario]
France [Director, Météo France, Reunion Island]
India [Dr. K. Radhakrishnan, INCOIS]
Indonesia [Dr. P.J. Prih, Meteorological and Geophysical Agency]
Islamic Republic of Iran [Dr. V. Chegini, INCO]
Kenya [Dr. Joseph Mukabana]
Madagascar [Pr Rambolamanana Gérard, and Mrs. Sahondraarilala Raveloarisoa]
Malaysia [Mr. Jailan B. Simon, Duty Forecaster, Central Forecast Office]
Maldives [Mr. Abdullahi Majeed, Ministry of Environment, Energy and Water and Mr. Abdulla Algeen, Department of Meteorology]
Mauritius [Mr. Suresh Chandra Seeballuck, Mr. Ballah]
Mozambique [Mr Mustafa Mussa, Instituto Nacional de Meteorologia]
Myanmar [Dr. San Hla Thaw, Department of Meteorology and Hydrology]
Oman [Mr. Ahmed Hamood Al-Harthi, Meteorology Department]
Pakistan [Mr Qamar-uz-Zaman Chaudhry]
Saudi Arabia [NOT AVAILABLE]
Seychelles [Mr. Wills Agricole, Mr. Denis Change-Seng]
Singapore [Duty forecaster]
Somalia [NOT AVAILABLE]

South Africa [Mr. Lance Williams, Executive Manager: Disaster Management]
Sri Lanka [Mr. G.H.P. Dharmaratna, Department of Meteorology]
United Arab Emirates [NOT AVAILABLE]
Tanzania [Dr. M. S. Mhita, Tanzania Meteorological Agency (TMA)]
Thailand [Executive Director, National Disaster Warning Center Office]
United Kingdom [British Representative, HQBF BIOT]
Yemen [M. Eng. Abdulkhaleq Y Al-Ghaberi, DG of Environmental Emergency, Ministry of Water & Environment]

Full information is available from the ICG/IOTWS Secretariat.

ANNEX F

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