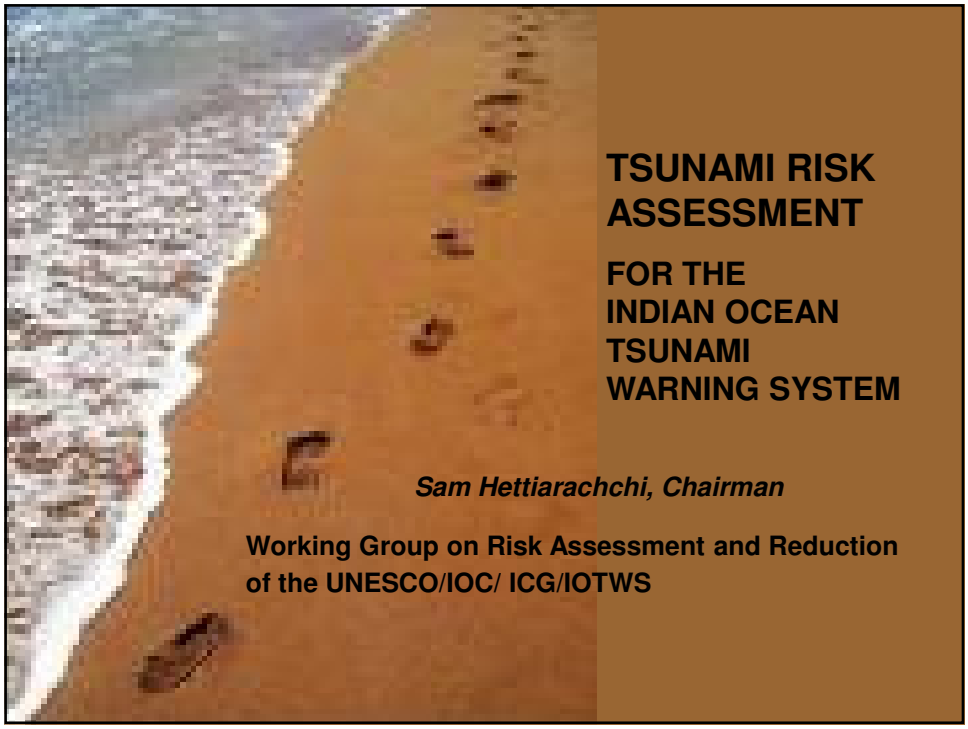


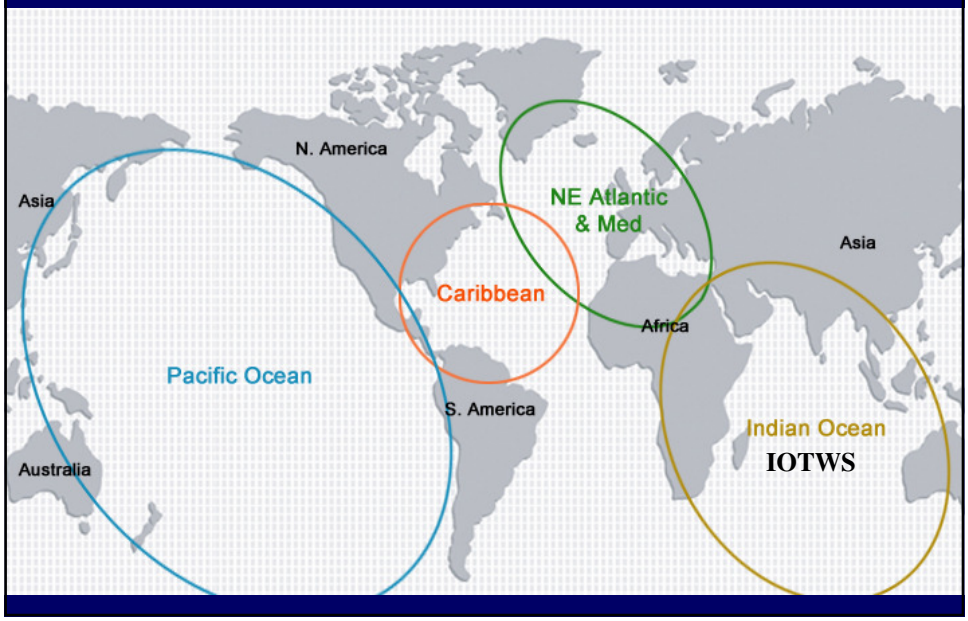
TSUNAMI RISK ASSESSMENT

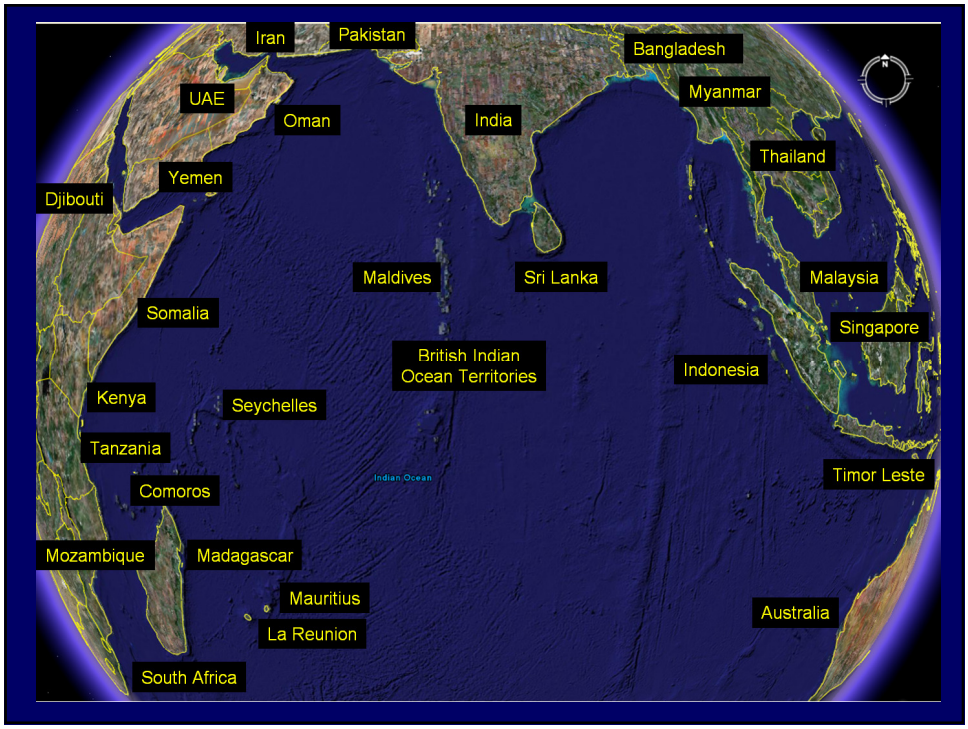
FOR THE INDIAN OCEAN TSUNAMI WARNING SYSTEM

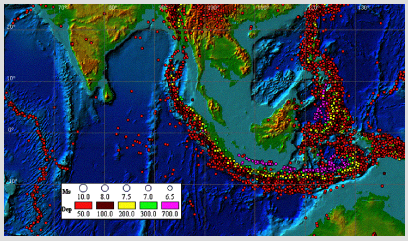
Sam Hettiarachchi, Chairman

Working Group on Risk Assessment and Reduction of the UNESCO/IOC/ ICG/IOTWS

Tsunami Warning System under UNESCO/IOC







IOTWS is developed as a coordinated network of country systems in which each country has the responsibility of identifying the hazard, assessing the risk and issuing the warning.

The countries will be assisted by Regional Service Providers..

↓

System Integration to establish the IOTWS

Working Groups of IOTWS

Risk Assessment

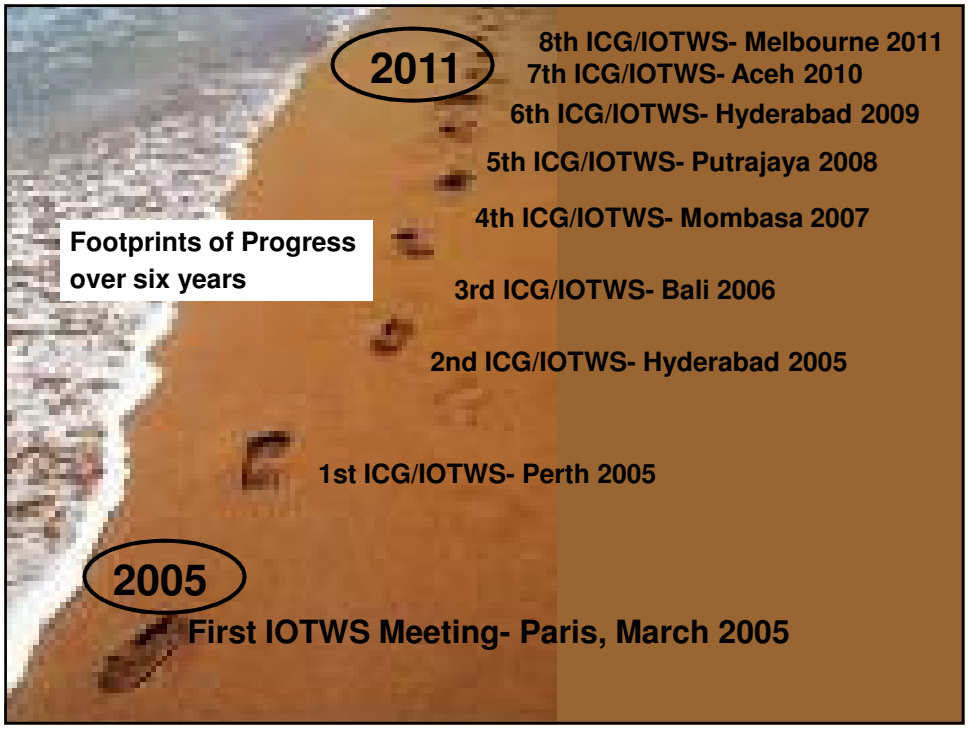
Modelling, Forecasting and Scenario Development

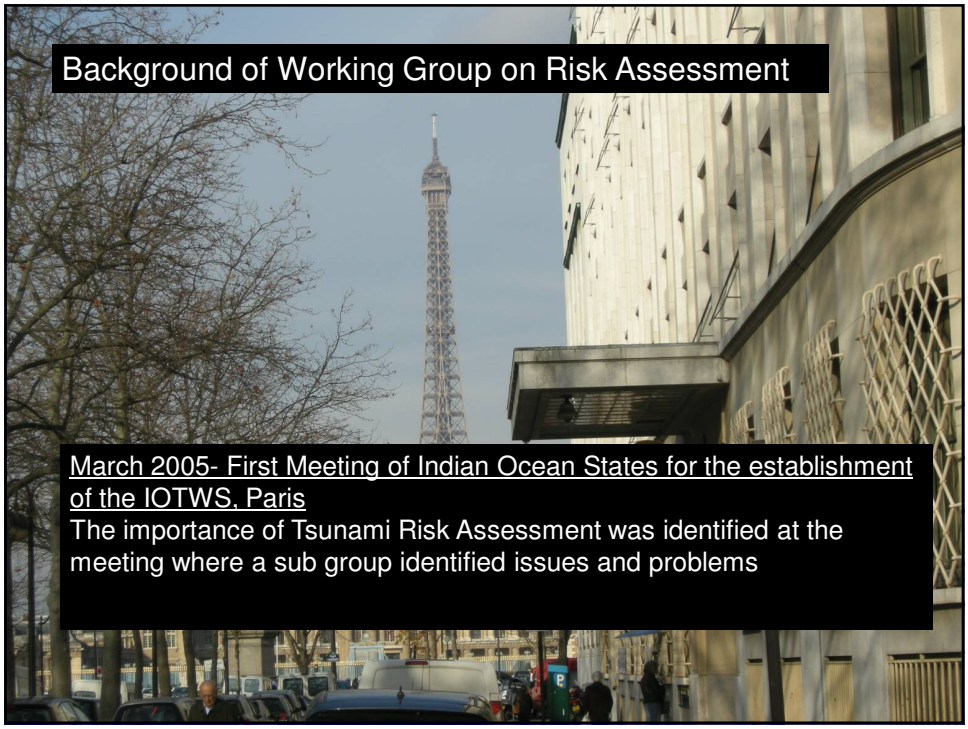
Seismic Measurement, Data Collection and Exchange

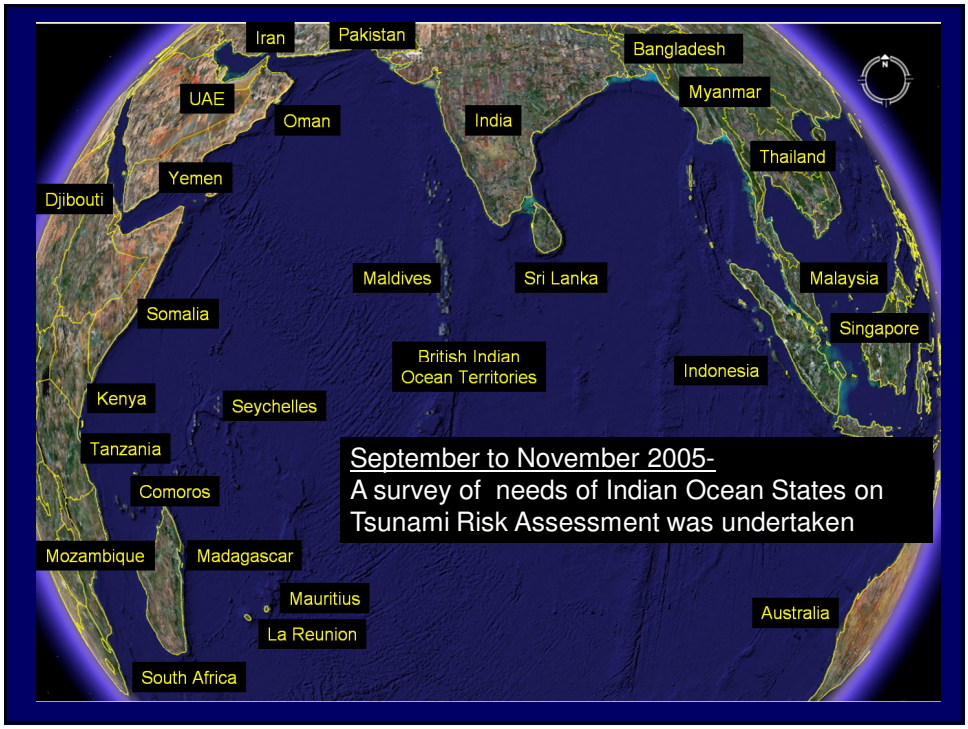
Sea Level Data Collection and Exchange

A System for Interoperable Advisory and Warning Centres

Mitigation and Preparedness- 'the last mile'



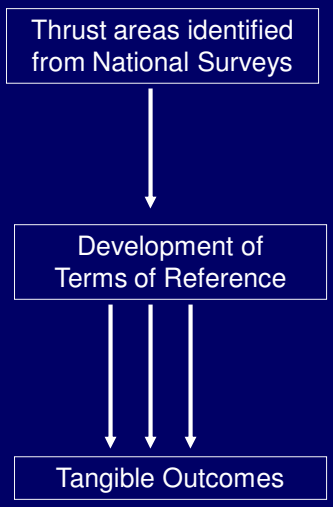

Background of Working Group on Risk Assessment
March 2005- First Meeting of Indian Ocean States for the establishment of the IOTWS, Paris
The importance of Tsunami Risk Assessment was identified at the meeting where a sub group identified issues and problems


Iran
Pakistan
Bangladesh
UAE
Oman
India
Myanmar
Thailand
Yemen
Djibouti
Maldives
Sri Lanka
Malaysia
Somalia
Singapore
British Indian Ocean Territories
Indonesia
Kenya
Seychelles
Tanzania
Comoros
Mozambique
Madagascar
Mauritius
La Reunion
Australia
South Africa
September to November 2005-
A survey of needs of Indian Ocean States on Tsunami Risk Assessment was undertaken

Thrust Areas in the Terms of Reference,
based on review of Regional Capability in Risk Assessment

1. Initiate Investigative Studies on Tsunami Hazard Sources and Data Collection
2. Prepare Integrated Regional Tsunami Hazard Map /Risk Model to enhance understanding of the Tsunami Hazard
3. Develop Uniform Guidelines for Tsunami Risk Assessment based on the wide experience available among the member countries
4. Provide Guidance on Tsunami Hazard Mitigation
5. Strengthen the Capabilities of IO States in the field of Tsunami Risk Assessment and Mitigation

APPROACH



APPROACH

Thrust areas identified from National Surveys

Development of Terms of Reference

Tangible Outcomes

Strategic Partnerships

Strategic Partnerships

1. With Geoscience, Australia to develop the Indian Ocean Tsunami Hazard Map based on Probabilistic Tsunami Hazard Modelling

2. With Working Group on Modelling, Forecasting and Scenario Development to develop capability in Deterministic Tsunami Hazard Modelling for Risk Assessment

3. With UNU- Bonn to develop an understanding on Assessing Vulnerability required for Risk Assessment

4. With USAID-IOTWS **Project** on aspects relating to Risk Assessment and Community Resilience

Strategic Partnerships

5. With WAPMERR, Dubai to assist the Working Group on Hazard Assessment and Developing Risk Assessment Capability

6. With UNDP Bangkok to Develop the Tsunami Risk Assessment Guideline and Promote Risk Assessment Capability in the region

7. With IO-COAST MAP Project under UNESCO/IOC to Promote an Integrated Approach towards GIS based Coastal Mapping, Inundation Modelling and Risk Assessment **(CoMMRA)**

8. With UN-ISDR, Geneva to Share Information and Develop a Strategic Approach towards Disaster Risk Reduction in coastal zones

Strategic Partnerships

9. With Ports and Airport Research Institute (PARI), Japan, on sharing results from

   ---large scale laboratory investigations on tsunami impact on infrastructure and humans and

   ---mathematical modelling of tsunami wave propagation and inundation

Successful links, networks and partnerships

Footprints of Progress

Development of Tools and Methods for Risk Assessment and Reduction

Regional Training on Risk Assessment

Initiate Geologic Assessment of the Makran Tsunami Hazards

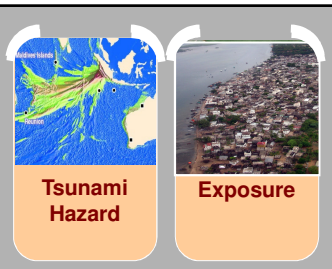
Laying the foundation for a Platform for Tsunami Risk Assessment

Footprints of Progress

Development of Tools and Methods for Risk Assessment and Reduction

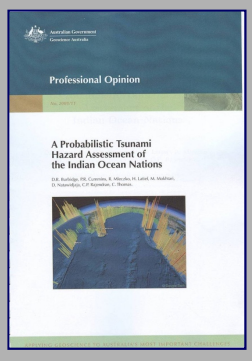
Tools and Methods on Risk Assessment and Reduction

--developed by the Working Group
--to which the Working Group contributed
--adopted for RA studies



John Schneider and Phil Cummins led the hazard group within the Working Group

Documents from Working Group on Risk Assessment of IOTWS



A Probabilistic Tsunami Hazard Assessment of the Indian Ocean Nations

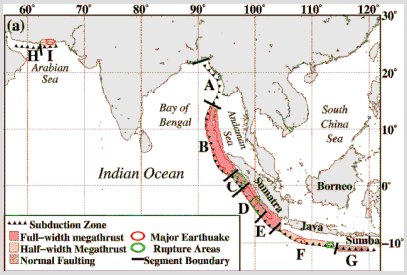
Implemented by Geo Science Australia as an activity of Working Group

September 2009

-Only subduction zone earthquake sources of tsunami considered
-Hazard expressed as offshore tsunami amplitude
-Two hazard zonations identified.
-Difference expresses uncertainty, with actual hazard lying between the two end members

Low-Hazard Source Zonation

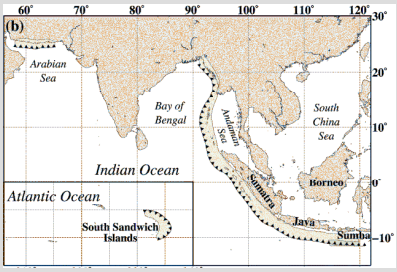
based on only those earthquake sources of tsunami for which there is definite evidence



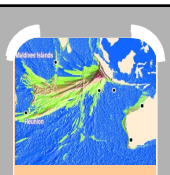
Each subduction zone source characterized by historical tsunamigenic earthquake occurrence only

High-Hazard Source Zonation

based on all potential subduction zone earthquake sources, including hypothetical ones for which there is no historical or geological evidence



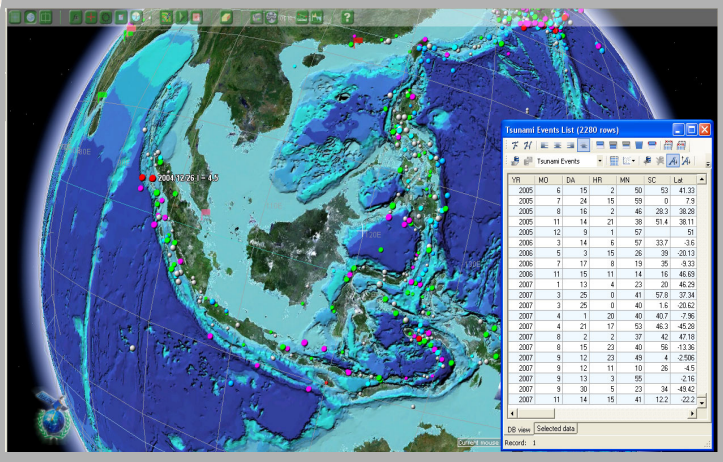
All potential subduction zones can rupture at full width, limited by lesser of magnitude 9.5 events or full subduction zone length

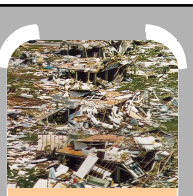


Tsunami Hazard

Historical Tsunami Database

A complete historical tsunami database is being maintained by NTL-WAPMERR.
Database contains 2270 historical events for the period from 2000 BC to present.





Vulnerability

Juan Carlos Villagran led the vulnerability group within the Working Group

Vulnerability

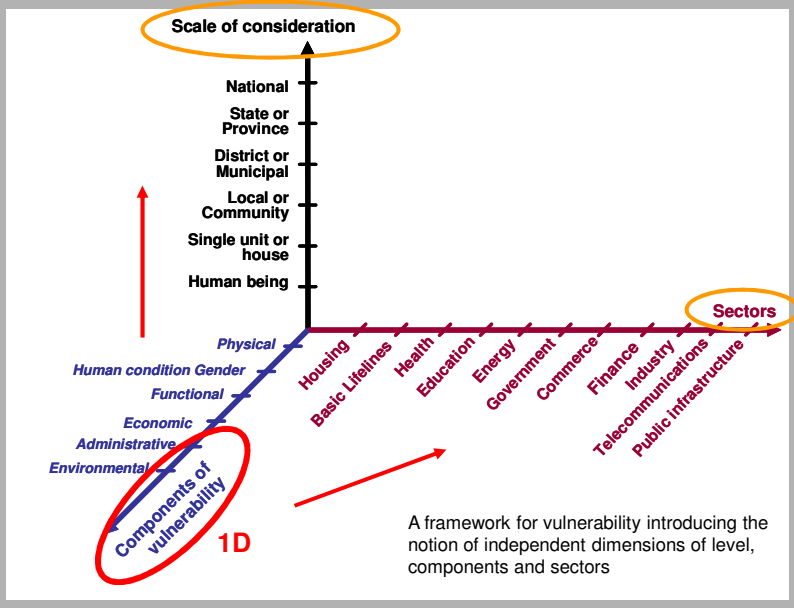
A Conceptual and Methodological Review

Juan Carlos Villagran De Leon

SOURCE- UNU EHS

N0.4/2006

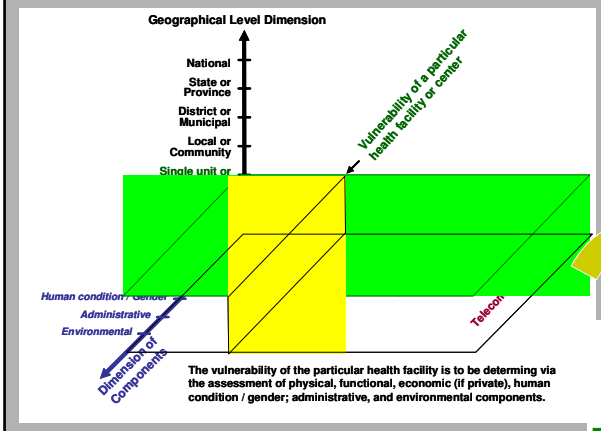
The Sector Approach (3D approach)

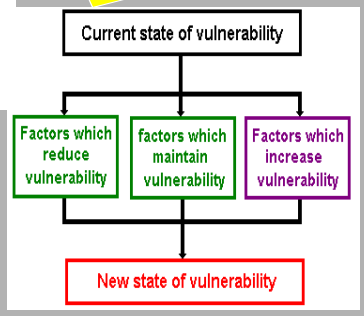


A framework for vulnerability introducing the notion of independent dimensions of level, components and sectors

after Juan Carlos Villagran

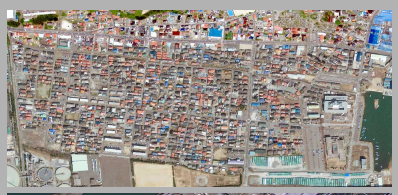
Vulnerability - The Sector Approach

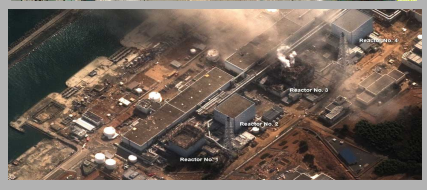




after Juan Carlos Villagran

Vulnerability - The Sector Approach

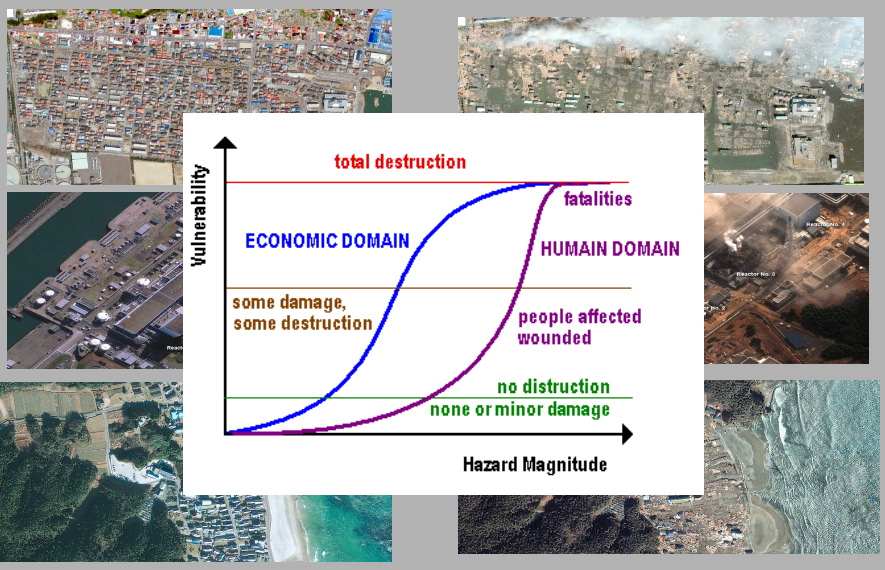




Risk Management

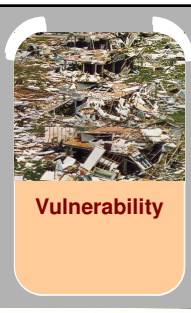
Disaster Management

Vulnerability - The Sector Approach

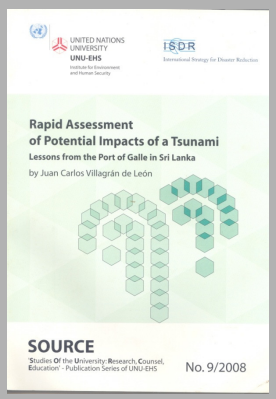


Risk Management

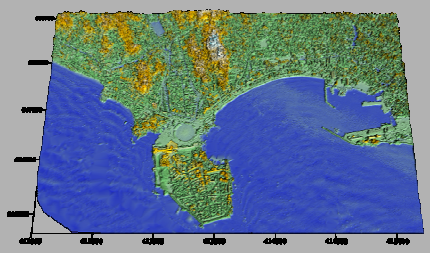
Disaster Management



Vulnerability



Case Study on the Sector Approach



Rapid Assessment of Potential Impacts of a Tsunami

Lessons from the Port of Galle in Sri Lanka

Juan Carlos Villagran de Leon

SOURCE- UNU EHS

9/2008

Documents from Working Group on Risk Assessment of IOTWS

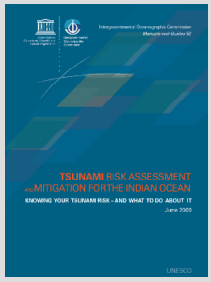
Guideline on Tsunami Risk Assessment and Mitigation for the Indian Ocean

Knowing your Tsunami Risk and what to do about it

UNESCO/IOC Manual and Guideline 52 prepared by Working Group with the support of UNDP Bangkok and WAPMERR, Dubai.

June 2009

Table of Contents



A. Introduction

A1. Tsunamis-are you prepared for them?

A2. Guide to readers

B. Assessing the tsunami risk

B1. Is your coast prone to tsunamis? **HAZARD**

B2. Are your communities vulnerable? **VULNERABILITY**

B3. Are your communities properly prepared? **PREPAREDNESS**

B4. What is the tsunami risk to your communities? **RISK ASSESSMENT**

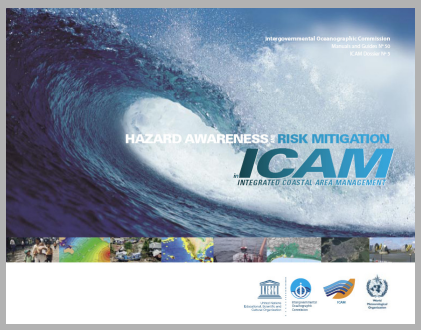
C. Managing the tsunami risk **RISK MANAGEMENT**

C1. How to improve your preparedness for tsunamis

C2. How to mitigate the tsunami risk

Hazard Awareness Mitigation

Documents from UNESCO /IOC

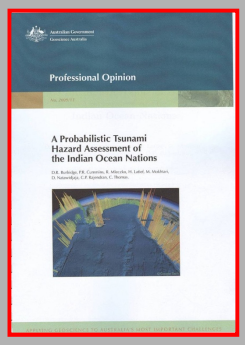


Hazard Awareness and Risk Mitigation in Integrated Coastal Area Management

UNESCO/IOC Manual and Guideline No 50

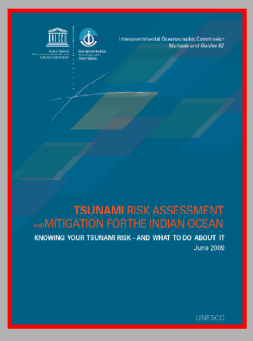
June 2009

HAZARD AWARENESS AND MITIGATION UNESCO / IOC



HAZARD-Geo-Science / IOTWS

VULNERABILITY-UNU-Bonn



RISK ASSESSMENT-IOTWS

Footprints of Progress

Regional Training on Risk Assessment

- Sharing of knowledge and Training during the Preparation of the Tsunami Hazard Map and the Tsunami Risk Assessment Guideline
- Development of Course Structure and Materials for training programmes in Risk Assessment and Management
- Training on Tsunami Risk Assessment Guideline
- Assisting nations to develop country specific guidelines

A journey of sharing knowledge, transfer of technology and training

Colombo- June 06

Bandung- July 07

Oman-May 2008

The Indian Ocean Tsunami Hazard Map

Dubai- Oct 07

Bangkok- Sep 08

Bali- Nov 08

Tsunami Risk Assessment Guidelines

Bangkok- Aug 09

Bangkok- Nov 09

Kandy (SL)- June 09

Jakarta- Nov 09

Risk Assessment Training

A journey of sharing knowledge, transfer of technology and training



The Indian Ocean Tsunami Hazard Map



Tsunami Risk Assessment Guidelines




Risk Assessment Training

Dissemination of Risk Assessment Guidelines via Regional Training Programme 2009

Regional Design Workshop for Preparation of Course Structure and Teaching Materials and for the Organization of Regional Workshop

Bangkok -Aug 09
Sponsor and Host UNDP, Bangkok

First Regional Seminar and Training Workshop on Risk Assessment Guidelines

Bangkok- 3-9 Nov 09
Organized by ICG/IOTWS , UNDP, Bangkok and IO-COAST MAP Collaborative event with Working Group on Awareness & Response

Risk Assessment Workshops in Sri Lanka and Indonesia in 2010

The WG on Risk Assessment in partnership with Working Group on Awareness and Response and UNDP, Bangkok conducted two Workshops on Tsunami Risk Assessment in Sri Lanka and Indonesia.

UNDP, Bangkok obtained funding from UN-ESCAP Fund

Outcome-Enhance national capacity and of relevant professionals in the field of Tsunami Risk Assessment

Kandy, Sri Lanka, June 2010

Jakarta, Indonesia, Nov 2010

WORKSHOP CONTENTS

Introduction to Risk Assessment

Sea Level Rise
Storm Surges
Coastal erosion
Tsunami Hazard
Oil Spill Hazard

Multi hazard approach → Hazards and Modelling

Coastal Mapping → Mapping

Vulnerability → Vulnerability

Risk Management

Risk Assessment Case Studies → Risk Assessment and Management

Capacity Building for Preparedness and Reconstruction, Risk and Resilience → Resilience

Developing Tsunami Resilient Infrastructure → Hazard Resilient Infrastructure

Footprints of Progress

Initiate Geologic Assessment of the Makran Tsunami Hazards

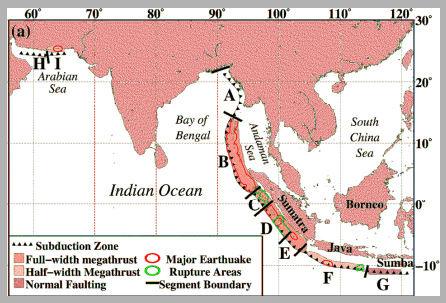
Geologic Assessment of the Makran Tsunami Hazards

The ICG/IOTWS Secretariat and the WG continued activities on the Makran Palaeotsunami project which commenced in 2008

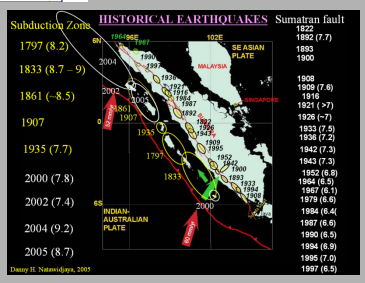
Funding received from UNESCAP for further studies

Outcome-Enhance knowledge base on critical tsunami hazard source

Geologic Assessment of the Makran Tsunami Hazards



800 kilometers across the North Arabian sea
Occurrence of Mw 8.1 earthquake in 1945 near Pasni



Workshops conducted in 2010

Preparedness and Awareness Workshop
1-5 May, Tehran, Iran
(30 local participants from institutions in Iran)

Preparedness and Awareness Workshop
19-23 July Karachi, Pakistan
(50-60 participants attended from institutions in Pakistan)

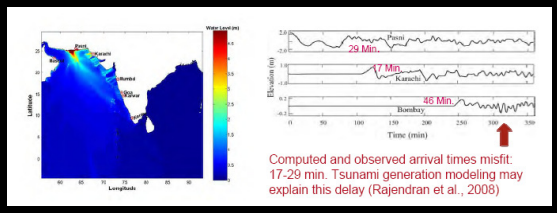
Field Workshop on Assessment and Awareness of Makran Hazard
9-19 October, Hormozgon Province, Iran
(5 trainers and 17 participants attended the workshop

Training Workshop will be held in Banda Aceh in due course

ISSUES RELATED TO MAKRAN SOURCE

C.P Rajendra, Indian Institute of Science, Bangalore

- Active sources other than 1945
- Activity and capability of the western Makran to generate large earthquakes
- Nature of tsunami hazard from the Makran subduction zone
- Submarine slides may be an underestimated hazard
- Was the 1945 tsunami generated by earthquake triggered submarine slumps
- Need to re-evaluate historic data
- Evidence which may lead to a potential large earthquake



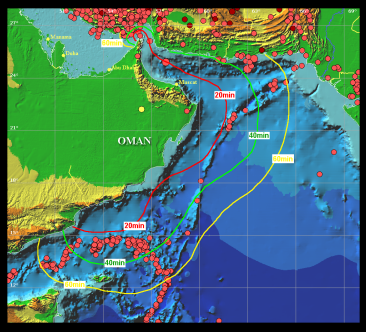
Computed and observed arrival times misfit: 17-29 min. Tsunami generation modeling may explain this delay (Rajendran et al., 2008)

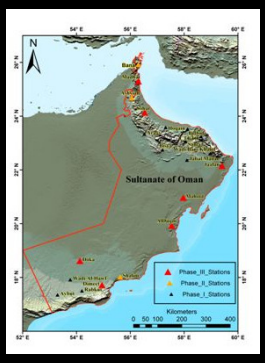
Government of Oman will initiate detailed Risk Assessment Studies

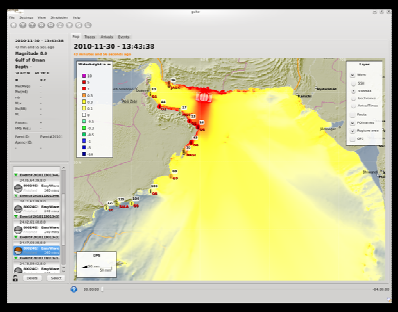
The studies will comprise
-Overall risk assessment along the coast of Oman

-Detailed risk assessment of selected coastal cities

The assessment will cover the city boundaries and a minimum distance of 15-20 km on either side along the coast.







Project will cover

- Hazard Source Identification and Assessment
- Scenario Modelling
- Vulnerability
- Risk Assessment and Management

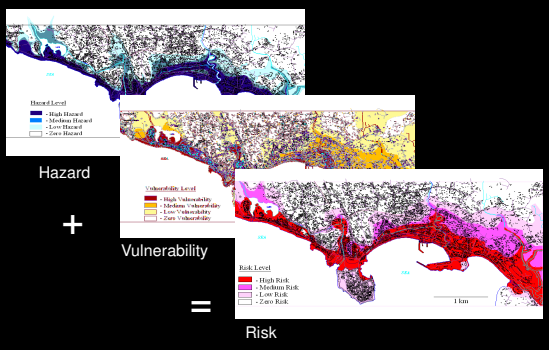
Footprints of Progress

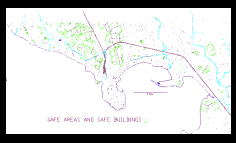
Laying the foundation for a
Platform for Tsunami Risk Assessment

Risk Assessment Case Studies from the region

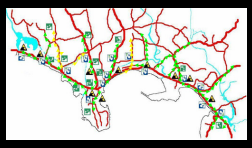
Working Group is initiating the implementation of Case Studies on Tsunami Risk Assessment in Indian Ocean States

Outcome-Enhance knowledge base of professionals and sharing of experience

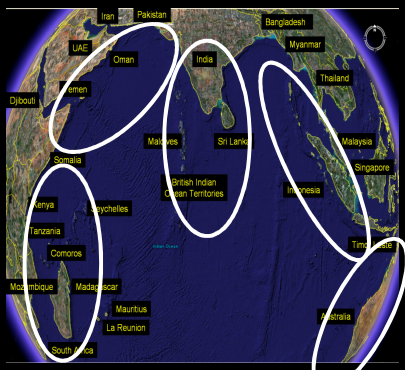


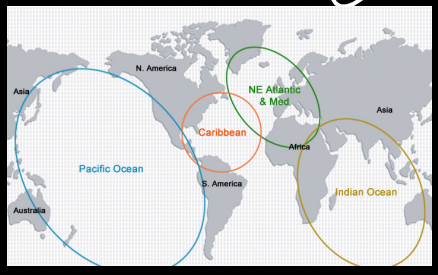


Evacuation Places



Evacuation Routes



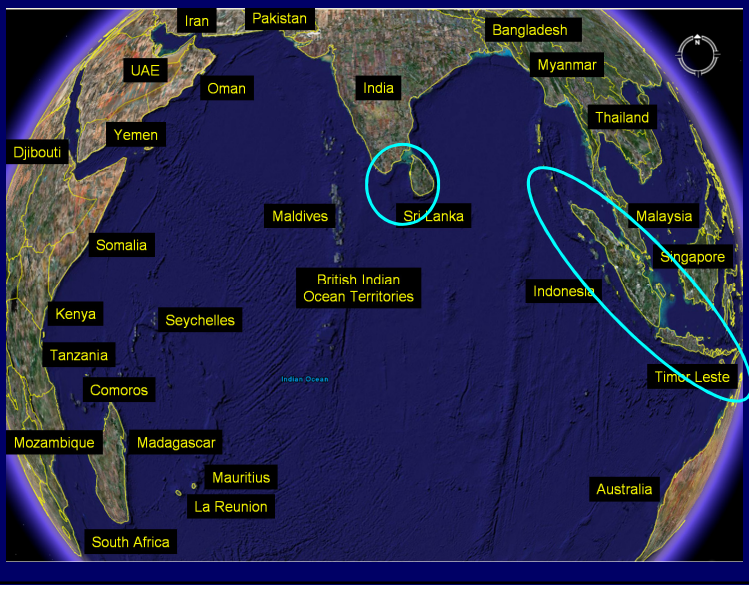


The overall goal

To implement at least 5 Case Studies on Risk Assessment, spread across the Indian Ocean, using the RA Guidelines or respective national guidelines

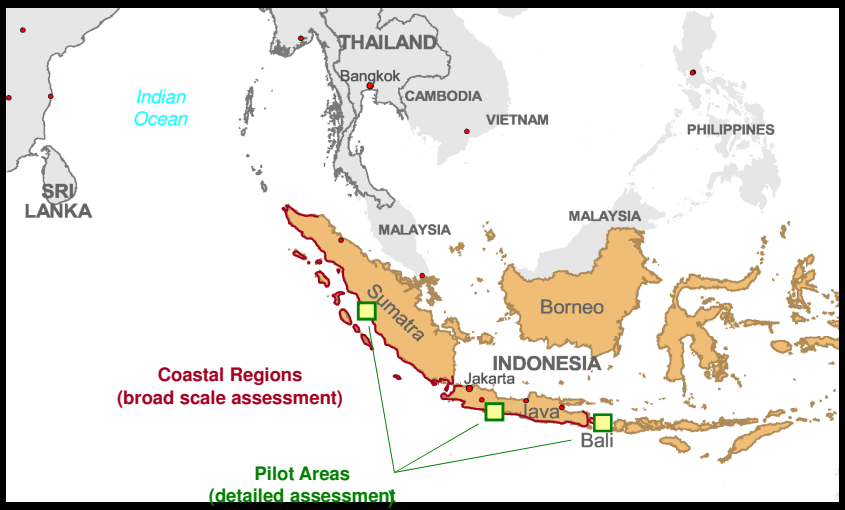
To work in collaboration with other warning systems to record at least 1 Case Study on Risk Assessment from the other ocean basins prone to tsunami hazards

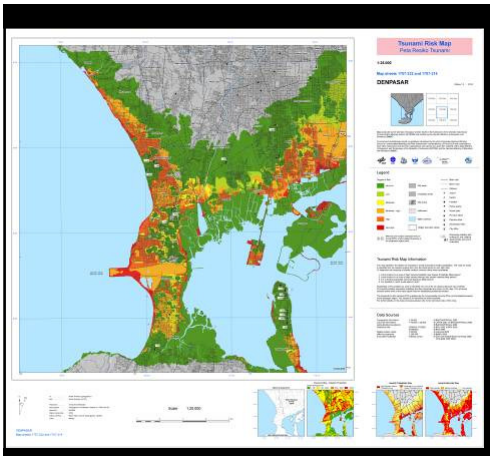
Case study reports from Indonesia and Sri Lanka have been completed



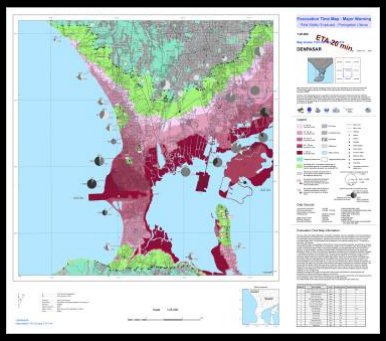
Tsunami Risk assessment for Coastal Areas in Indonesia

(Led by Guenter Strunz and Jochim Post for German Aerospace Centre as part of Indonesian/German Tsunami Warning System)





Risk Map for Bali

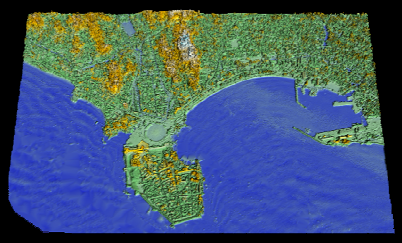


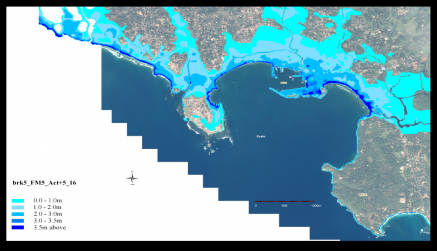
Evacuation Time Map for Bali

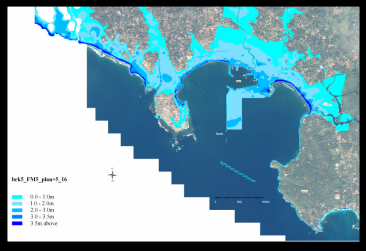
<u>Risk Assessment and Mitigation for Tsunami Hazard</u>

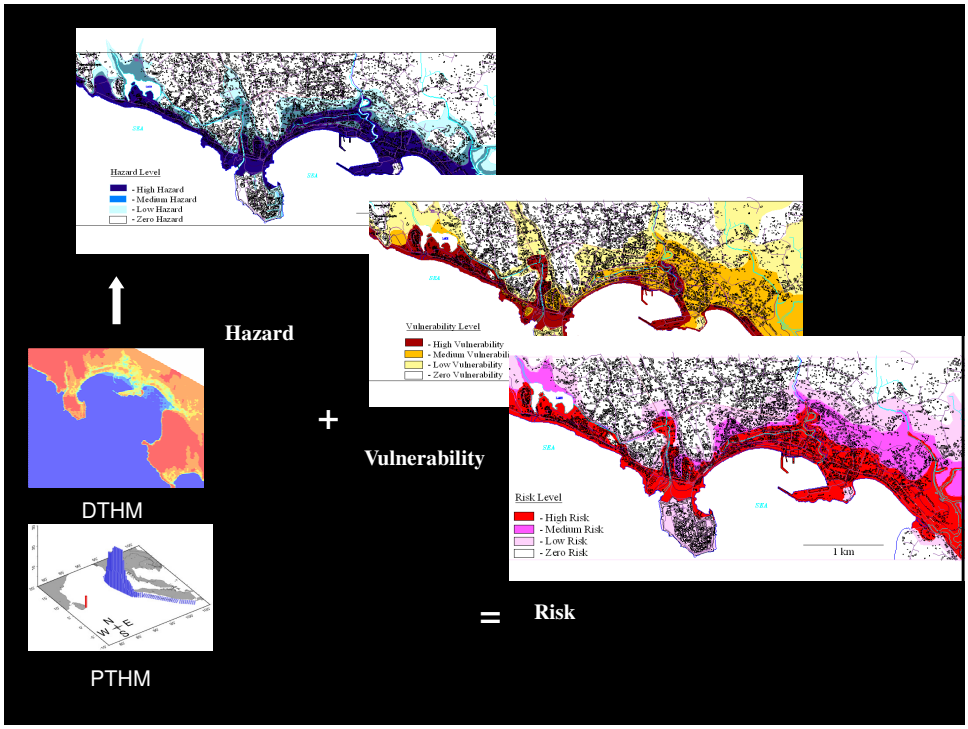
Case Study for the Port City of Galle

(Led by Sam Hettiarachchi with the assistance of UNDP)









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Dynamic Hazard Map of Inundation of IOT for Galle- PARI, Japan

based on Deterministic Tsunami Hazard Modelling

Revisions of Guidelines and New publications

Revision of Tsunami Risk Assessment Guideline to incorporate recent developments and demands

Outcome-Enhance national and regional capacity and knowledge base

Important issues for the revision

•Impacts on marine infrastructure and focus on tsunamis that generate ocean currents and rips not necessarily heavy inundation

•Tsunami Hazard Mitigation

•Early Warning Systems and associated risks

•Risk Management

Risk Management

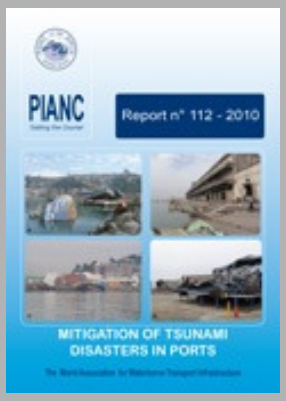
Mitigate the impact of the hazard (Mitigation Options)

-Mitigate exposure and vulnerability to the hazard

-Promote successful evacuation from hazard where necessary

Prepare Guidelines on Tsunami Hazard Mitigation-
Physical Interventions both artificial, natural and hybrid within a Multi Hazard Coastal Assessment Framework.

Mitigation



Mitigation of Tsunami Disasters in Ports

International Working Group convened by the Maritime Navigation Commission (MarCom)

PIANC Report No 112

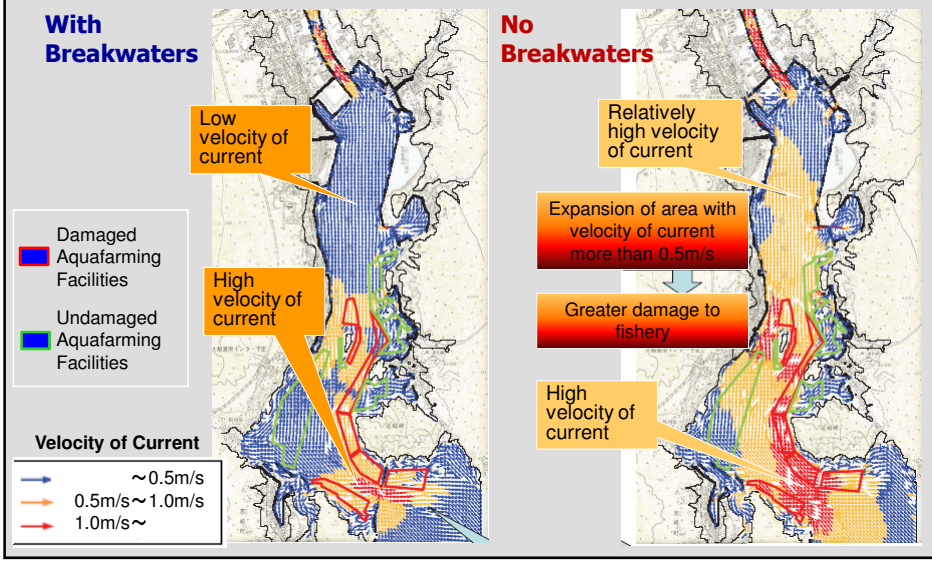
June 2010

PIANC Guideline of Mitigation of Tsunami Disasters in Ports

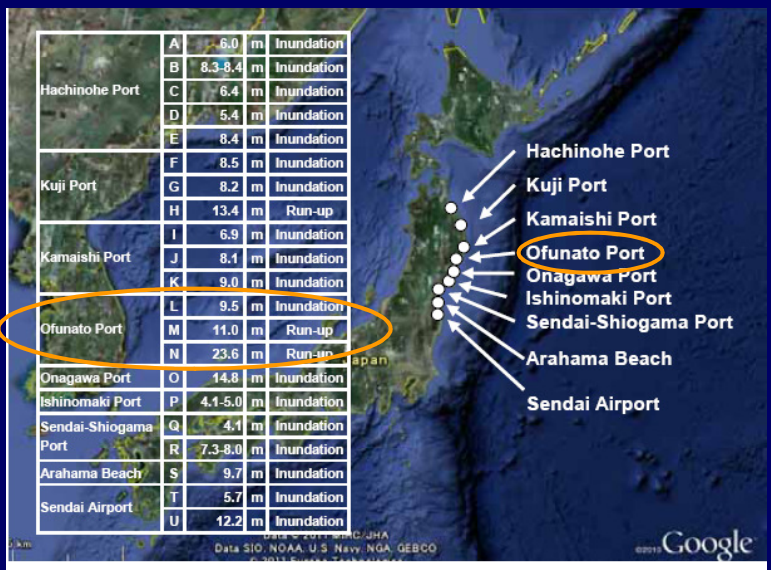
Photos- IFRC and PARI Japan and Sri Lanka

Influence of Tsunami Breakwater (Hiromi KADO, Ports and Harbors Bureau, Japan)

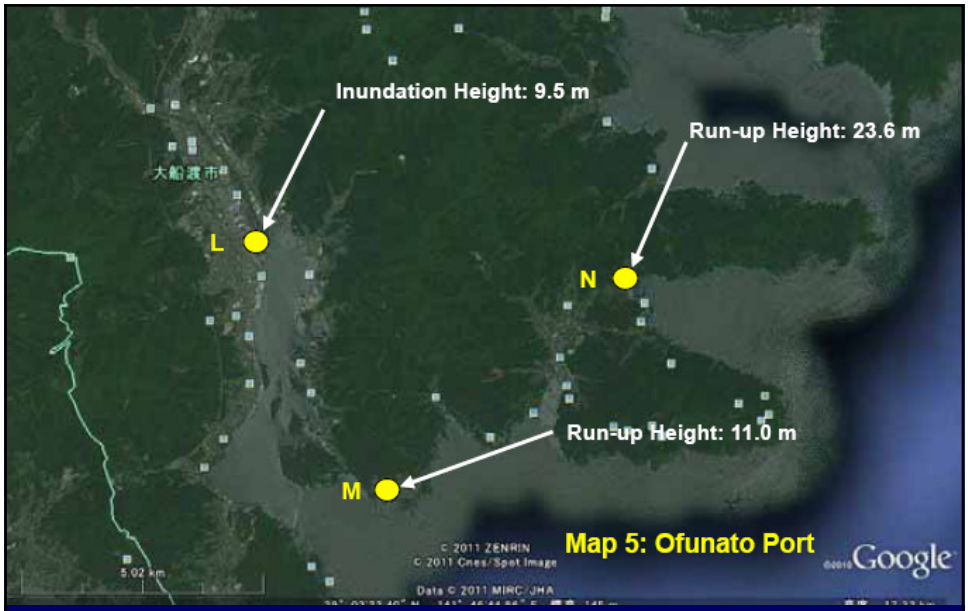
Chile Earthquake in February, 2010.
Reduction of tsunami damage by Tsunami breakwaters in Ofunato Port.



Japanese Tsunami March 2011-Surveys by PARI Japan



Map 1: Location of Surveyed Ports



Japanese Tsunami March 2011

Tsunami Hazard Mitigation using Artificial and Natural Methods

Tsunami Breakwaters

Revetments,Dikes (High Crest)

Revetments,Dikes (Low Crest)

Coral Reefs and Sand Bars

Sand Dunes

Coastal Vegetation

Sea Walls

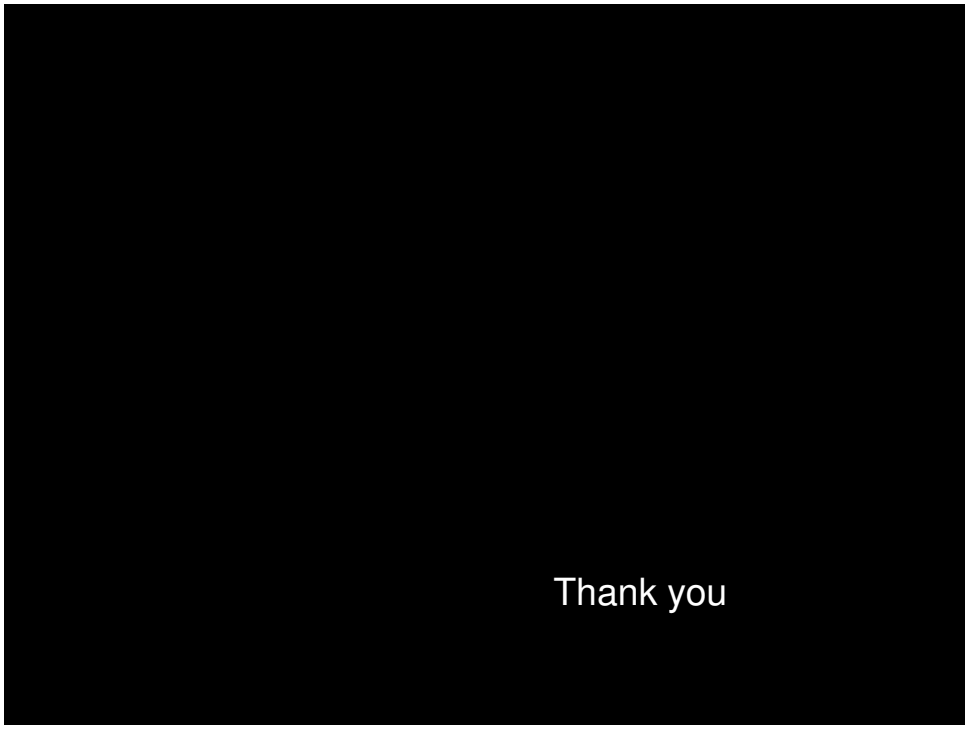
Earthquake caused structural damage

Tsunami overtopping seawall in Iwate Pref.
(Chile Earthquake in 1960)

Breakwater damaged by typhoon in 2005 at Higashinohama Port, Kagoshima Pref.

(Images supplied by Hiromi KADO, Ports and Harbors Bureau, Japan)

M Tsunami attack on Concrete Wall Collaboration with PARI, Japan


Thank you