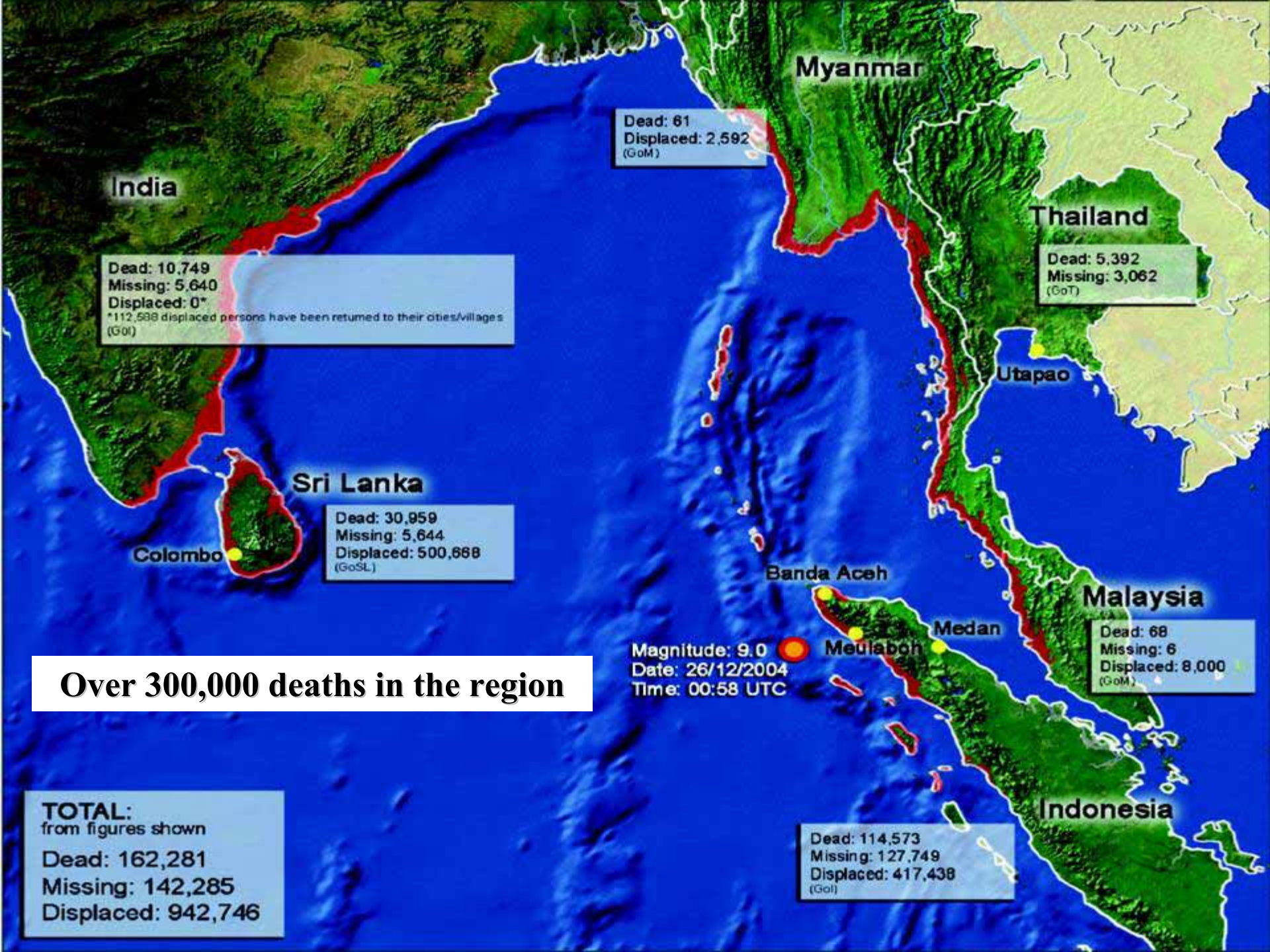
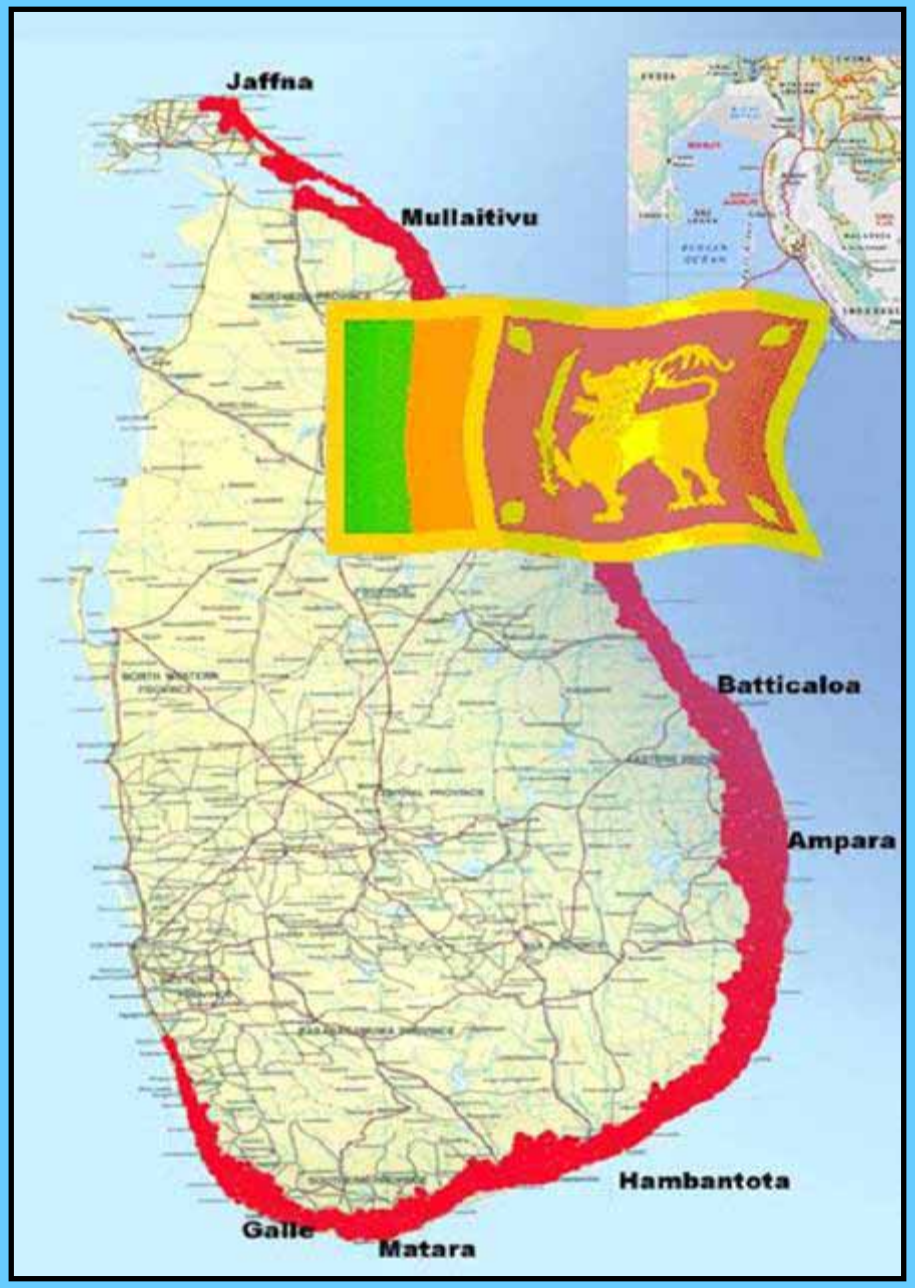
PRECAUTIONS AND STRATEGIES TO MINIMISE DAMAGE

LALITH CHANDRAPALA
DEPARTMENT OF METEOROLOGY


Myanmar
Dead: 61
Displaced: 2,592
(GoM)
India
Thailand
Dead: 5,392
Missing: 3,062
(GoT)
Dead: 10,749
Missing: 5,640
Displaced: 0*
*112,588 displaced persons have been returned to their cities/villages
(GoI)
Utapao
Sri Lanka
Dead: 30,959
Missing: 5,644
Displaced: 500,668
(GoSL)
Colombo
Banda Aceh
Malaysia
Medan
Dead: 68
Missing: 6
Displaced: 8,000
(GoM)
Magnitude: 9.0
Date: 26/12/2004
Time: 00:58 UTC
Meulaboh
Over 300,000 deaths in the region
Indonesia
Dead: 114,573
Missing: 127,749
Displaced: 417,438
(GoI)
TOTAL:
from figures shown
Dead: 162,281
Missing: 142,285
Displaced: 942,746



SRI LANKA

Number dead – 30, 959

Number missing – 5, 644

Number displaced – 500, 669

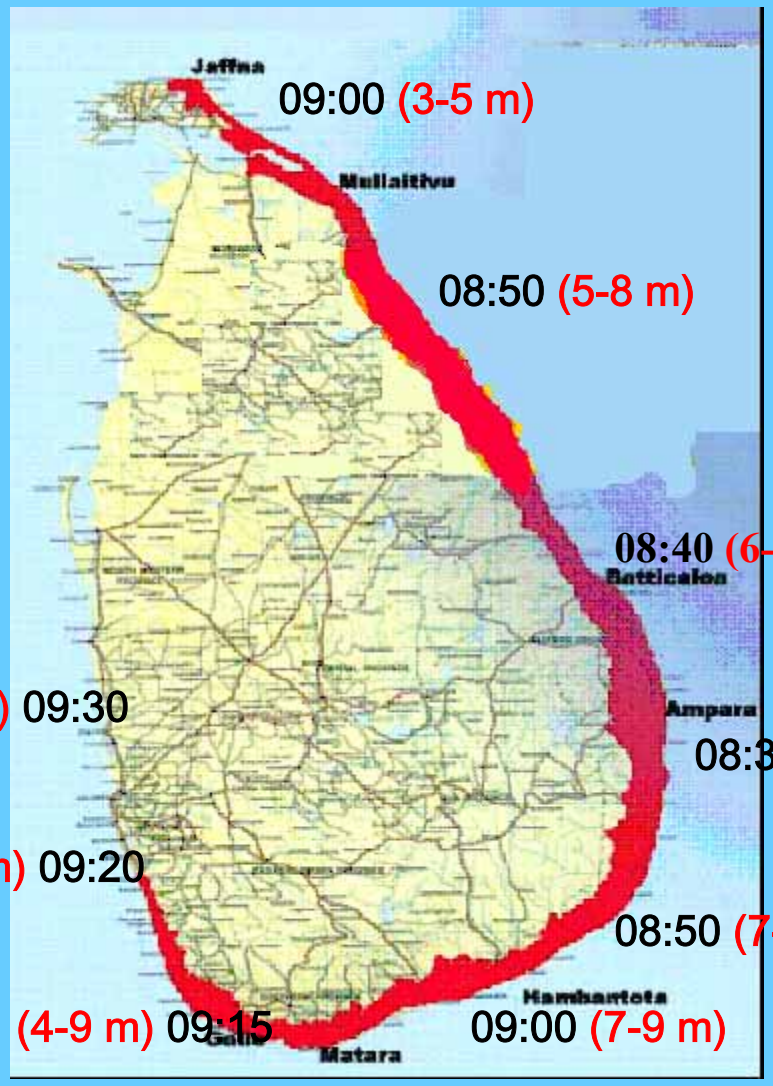
Enormous property damage

Over 900 km of coastline affected

Almost the entire coastal railway line from Colombo to Matara was severely damaged.

A Passenger train with over 1,500 passengers was washed away at Peraliya

Indian Ocean Tsunami of 26-12-2004



Note:
Earthquake
occurred at
06:58 am

Time of arrival of first wave and estimated max. wave height

Tsunami Sources:

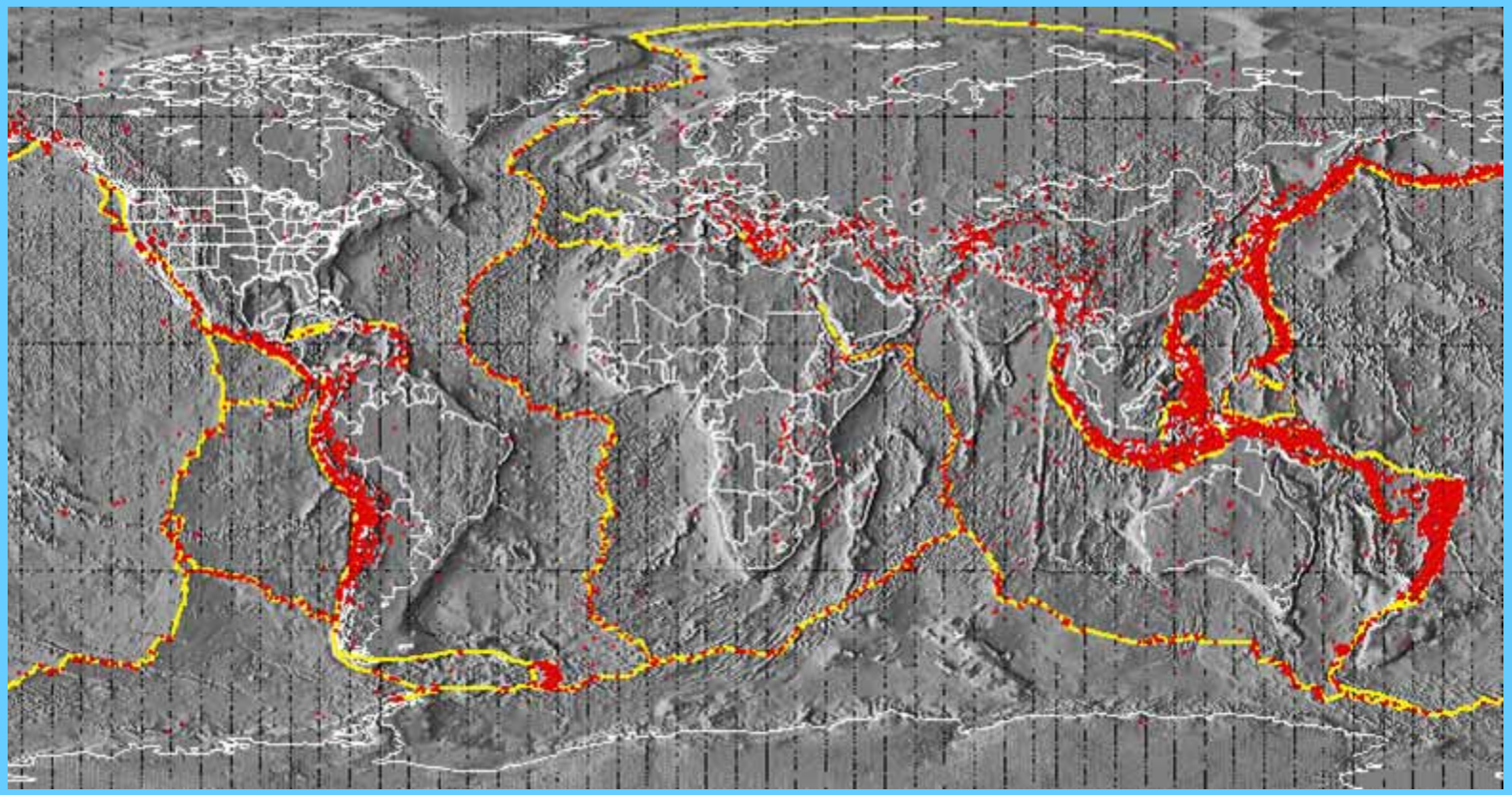
- **Generally by strong submarine earthquakes**
  e.g. Indian Ocean Tsunami, 2004

- **Less commonly by submarine landslides**
  e.g. Lithua Bay 1958

- **Infrequently by volcanic eruptions**
  e.g. Karakatoa eruption in 1883

- **Very rarely by meteorite impact**
  None in recorded history

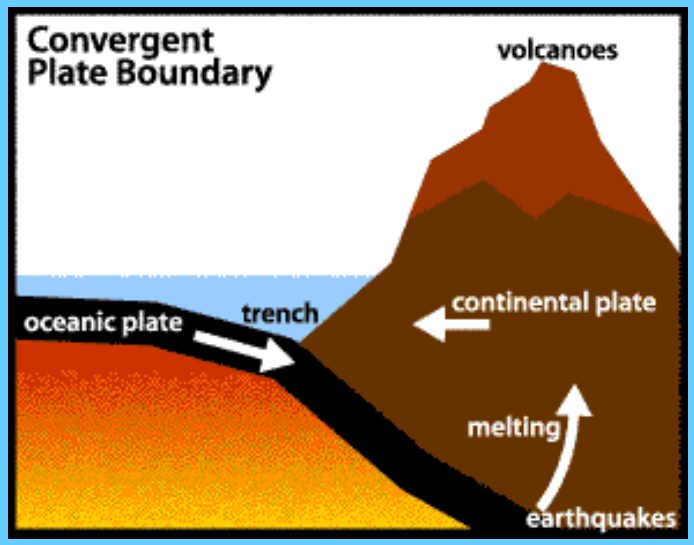
Crust of the Earth is divided into Plates



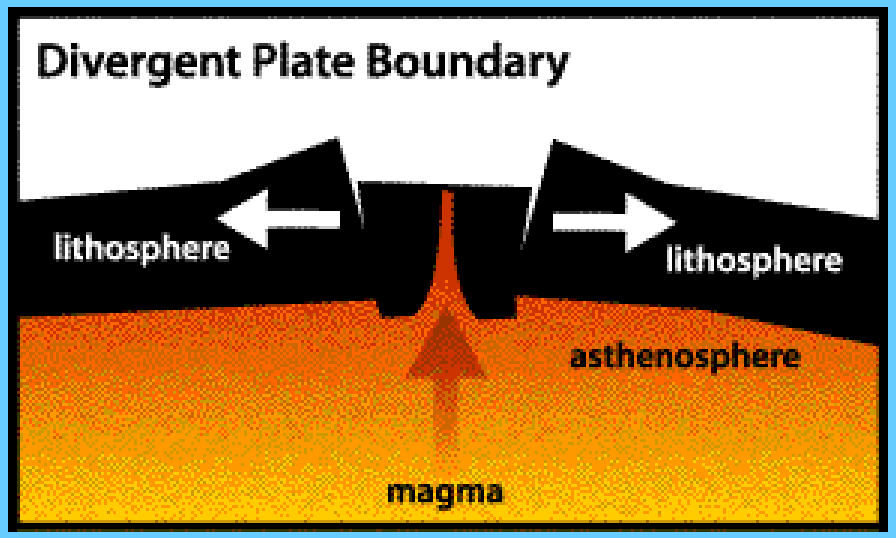
Major earthquakes usually occur at convergent plate boundaries

Three types of plate boundaries

Transform boundaries

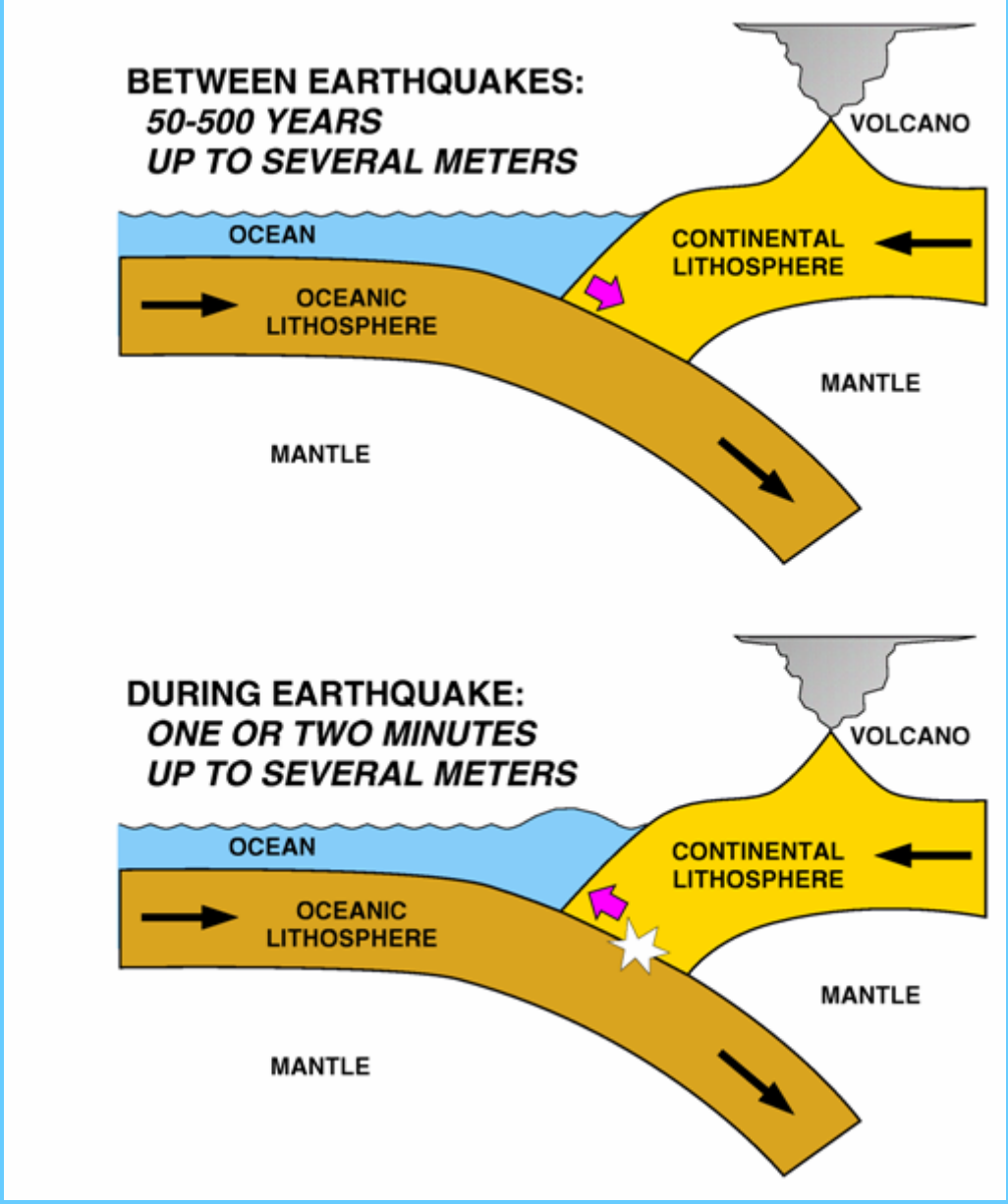


Convergent boundaries



Divergent boundaries

Tsunamis due to Earthquakes



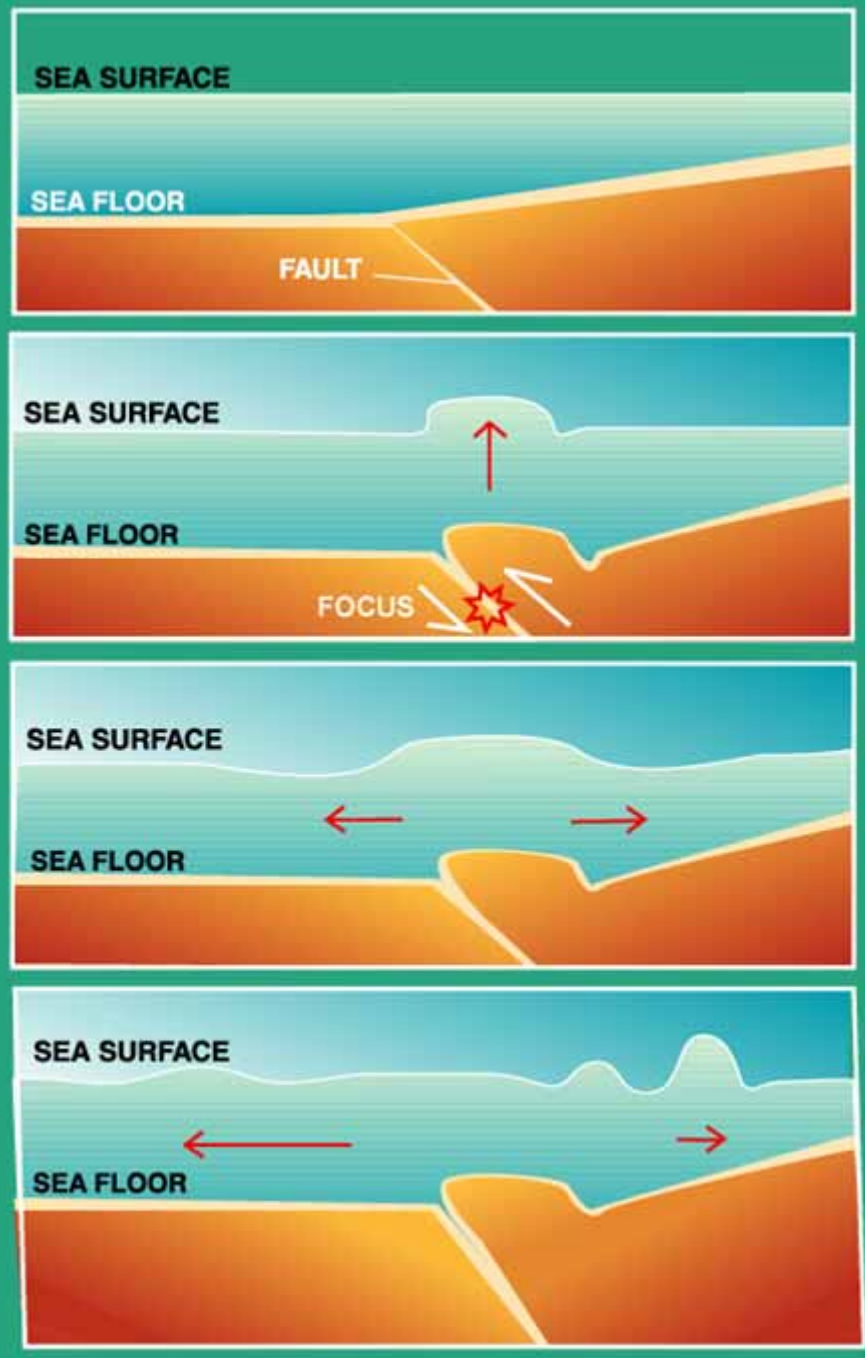
Usually at convergent plate boundaries

Oceanic plate slides underneath continental plate

Breakdown of stability

Rise of a huge column of water by several meters

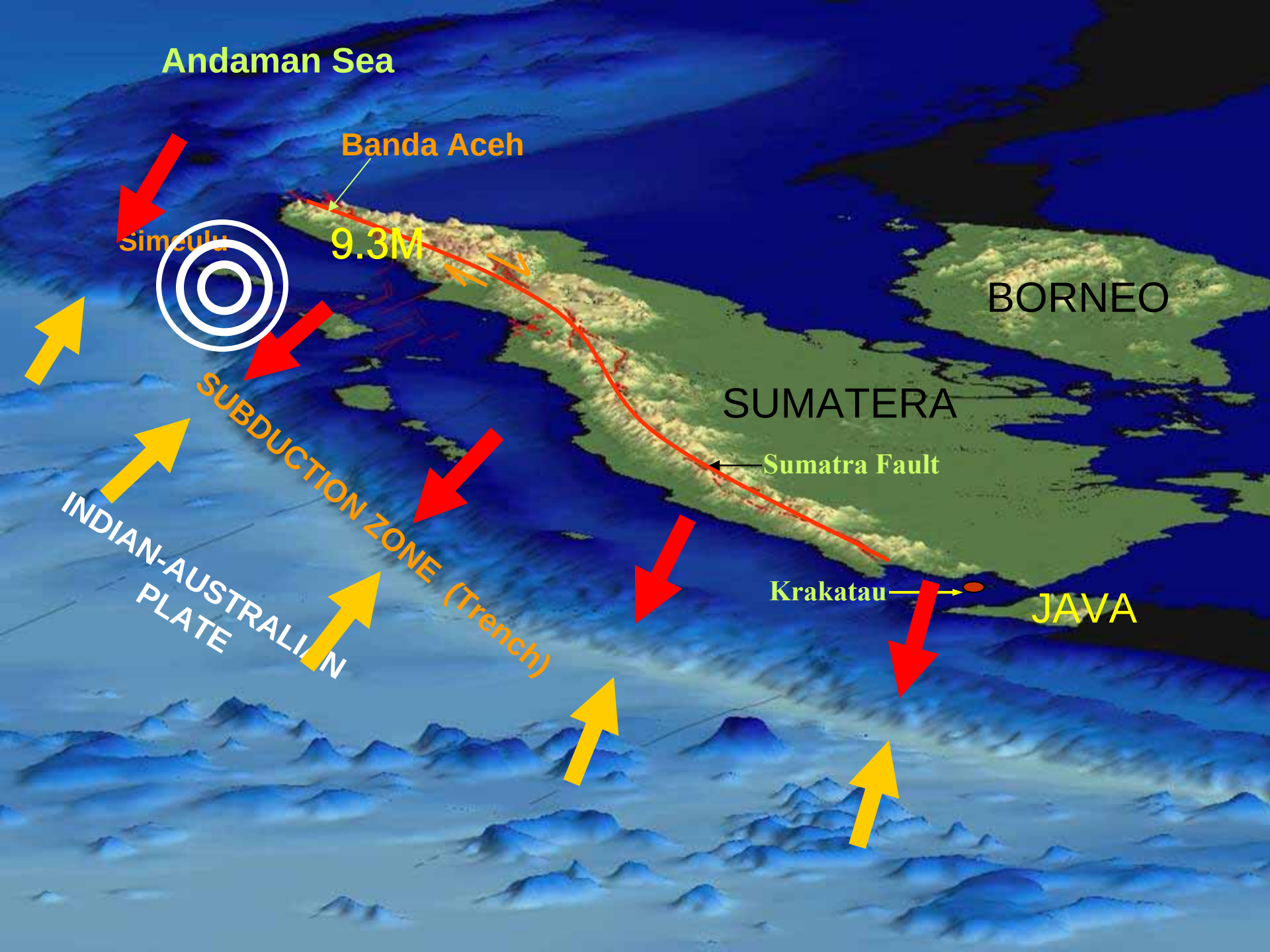
Generation of the tsunami



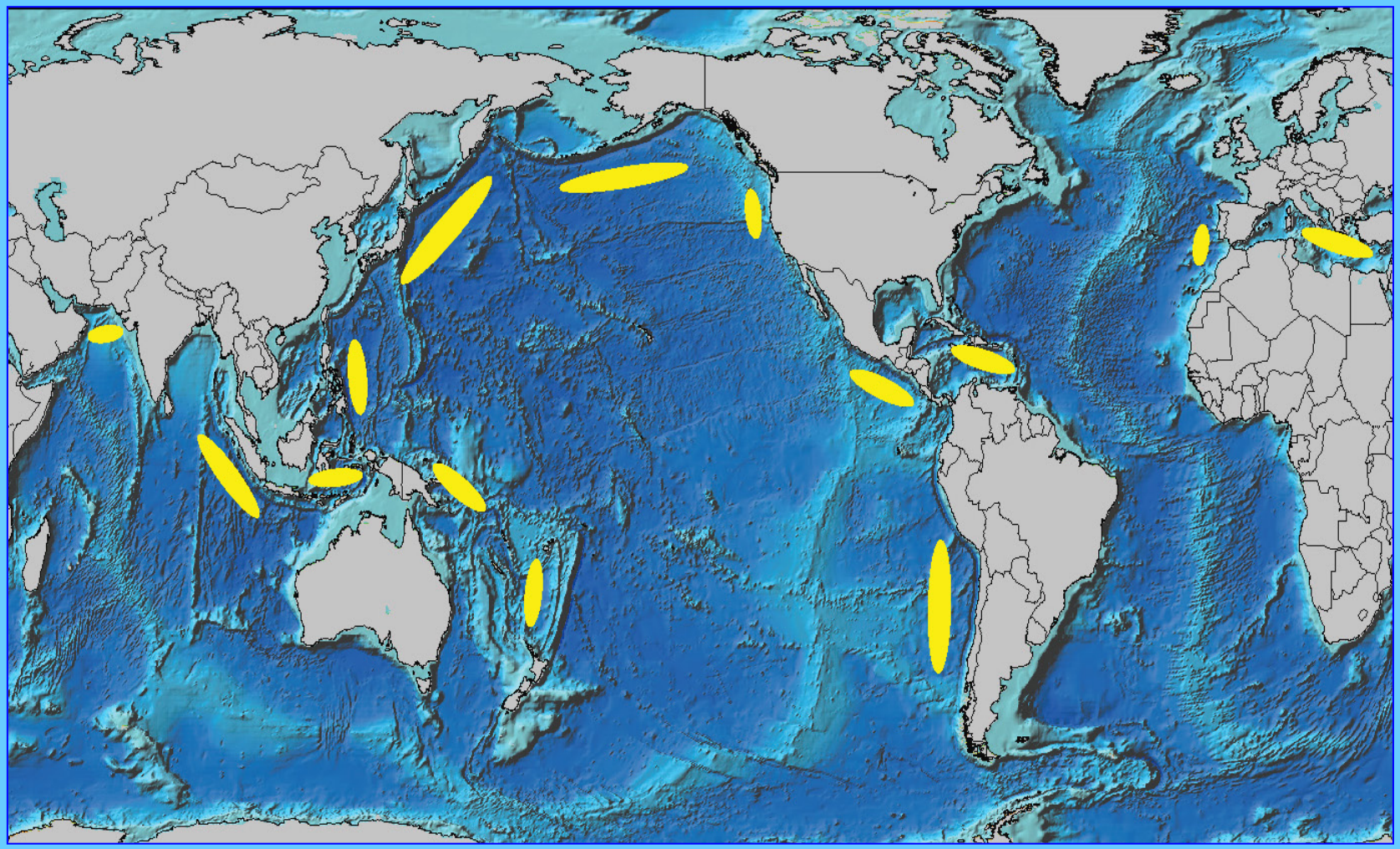
For a tsunami to be generated from an earthquake,

- **Large Earthquakes, at least**
  - **> 7.5 M**
- **Shallow, close to the sea bottom, about 50 km**

Earthquake suddenly moves a great column of water upward, generating the tsunami

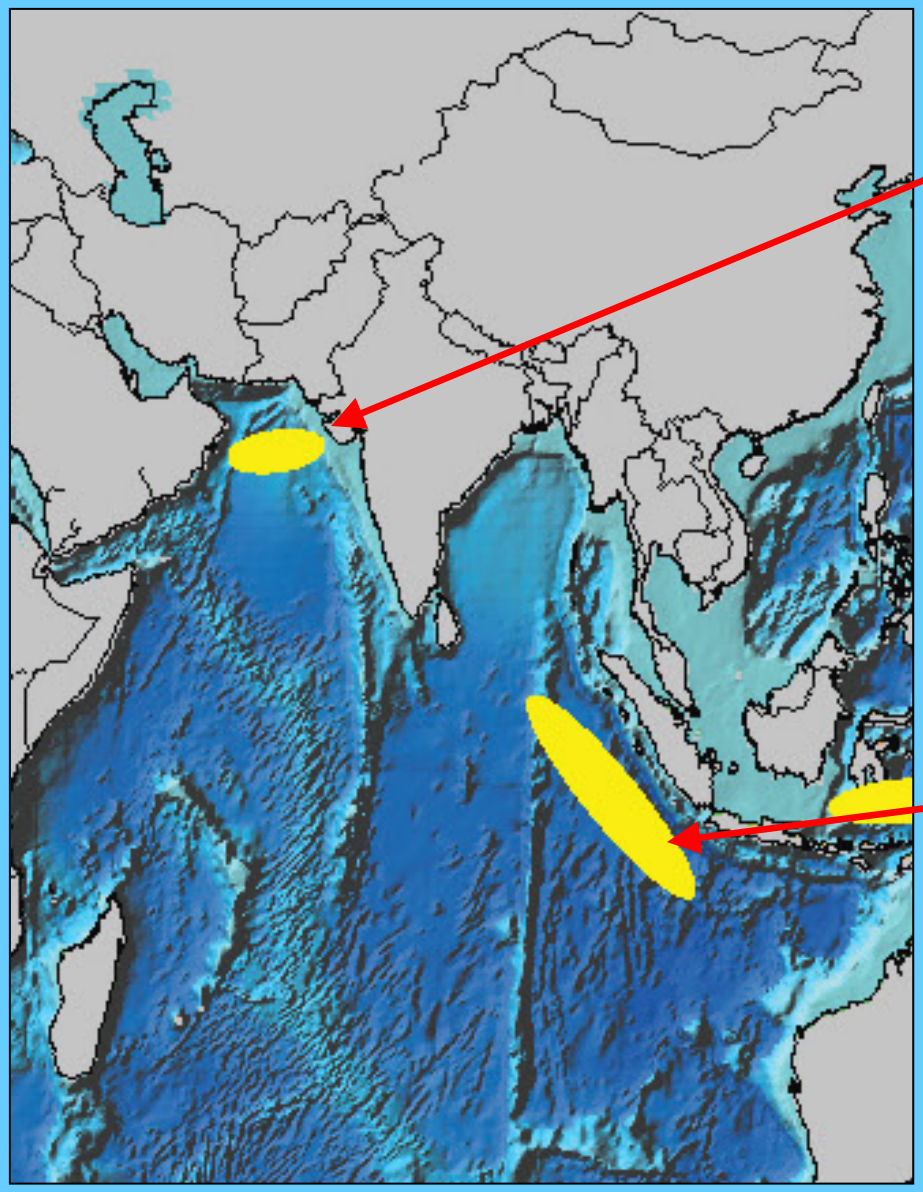

Andaman Sea
Banda Aceh
Simeulu
9.3M
BORNEO
SUMATERA
Sumatra Fault
SUBDUCTION ZONE (Trench)
INDIAN-AUSTRALIAN PLATE
Krakatau
JAVA

Tsunamigenic Regions



Large earthquakes generally occur near boundaries of tectonic plates

Tsunamigenic Regions in the Indian Ocean

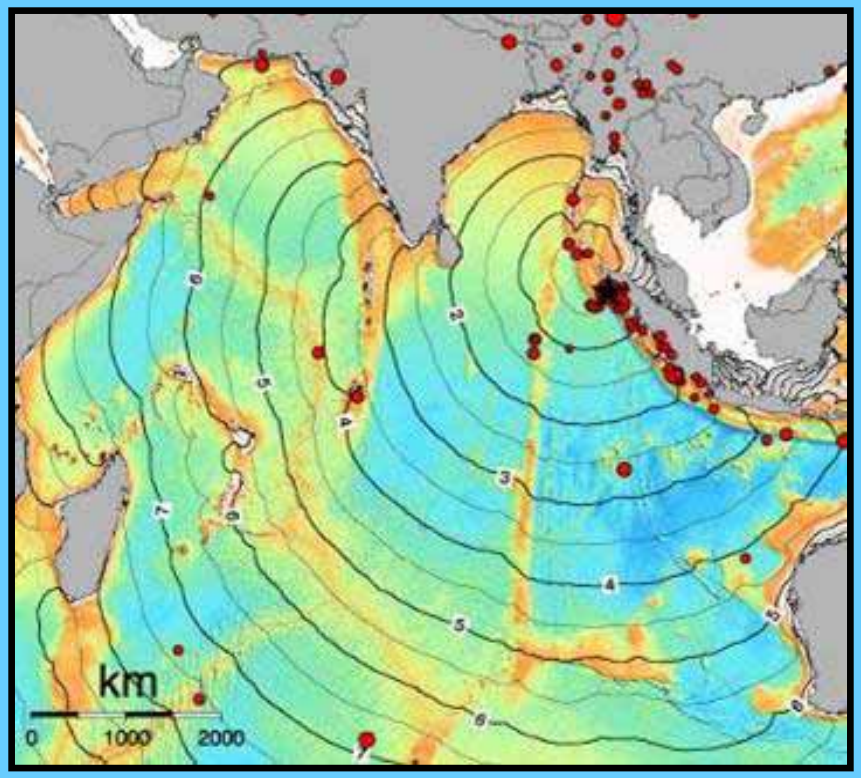


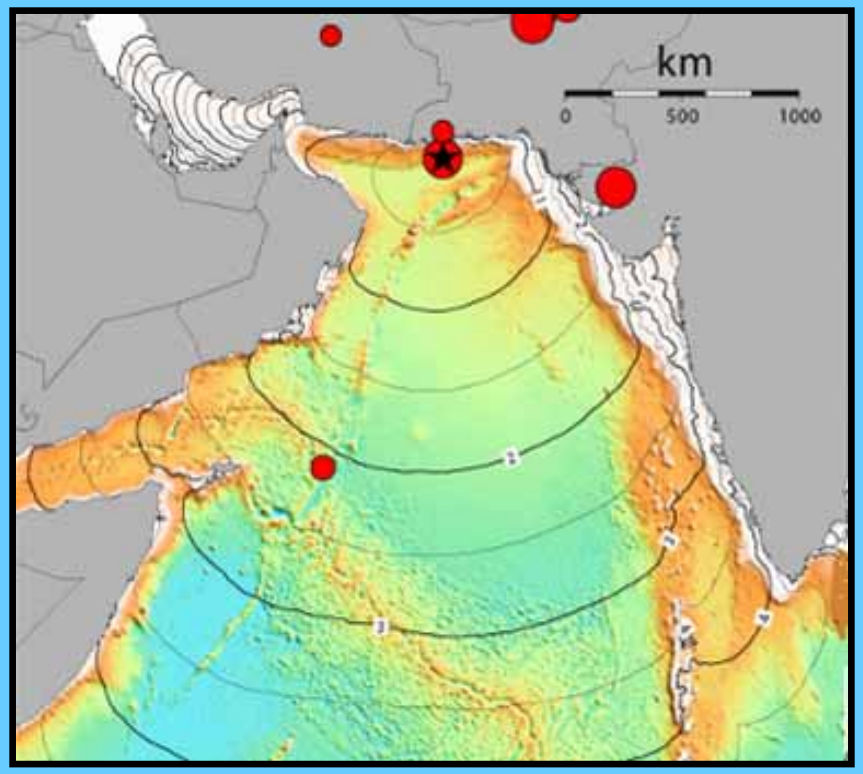
MAKRAN ZONE
(Pakistan-Iran border)

Last major Tsunami in 1945

SUMATRA-INDONESIAN ZONE - SUNDA TRENCH

Tsunamigenic areas in the indian Ocean

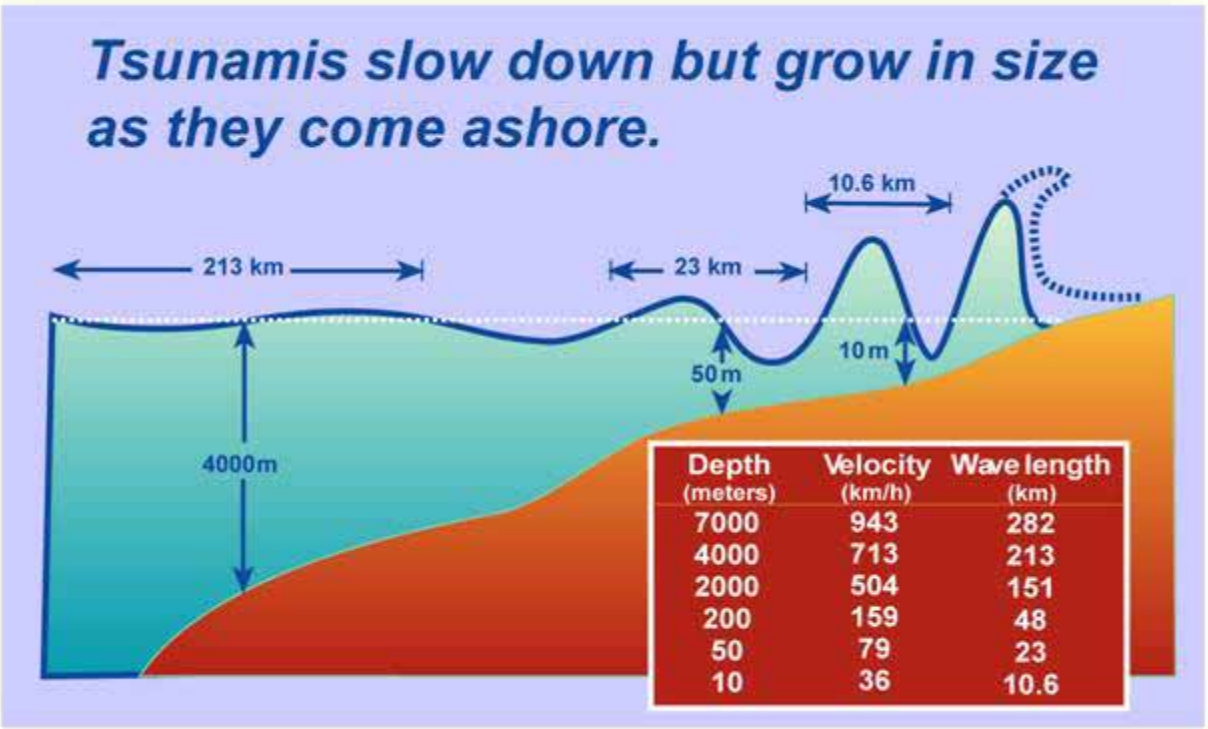




Tsunami Travel Times

- From Sumatra/Indonesia Zone – approx. 1.5 – 2.0 hours
- From Makran Zone – approx. 4.5 hours

Propagation of Tsunami Waves



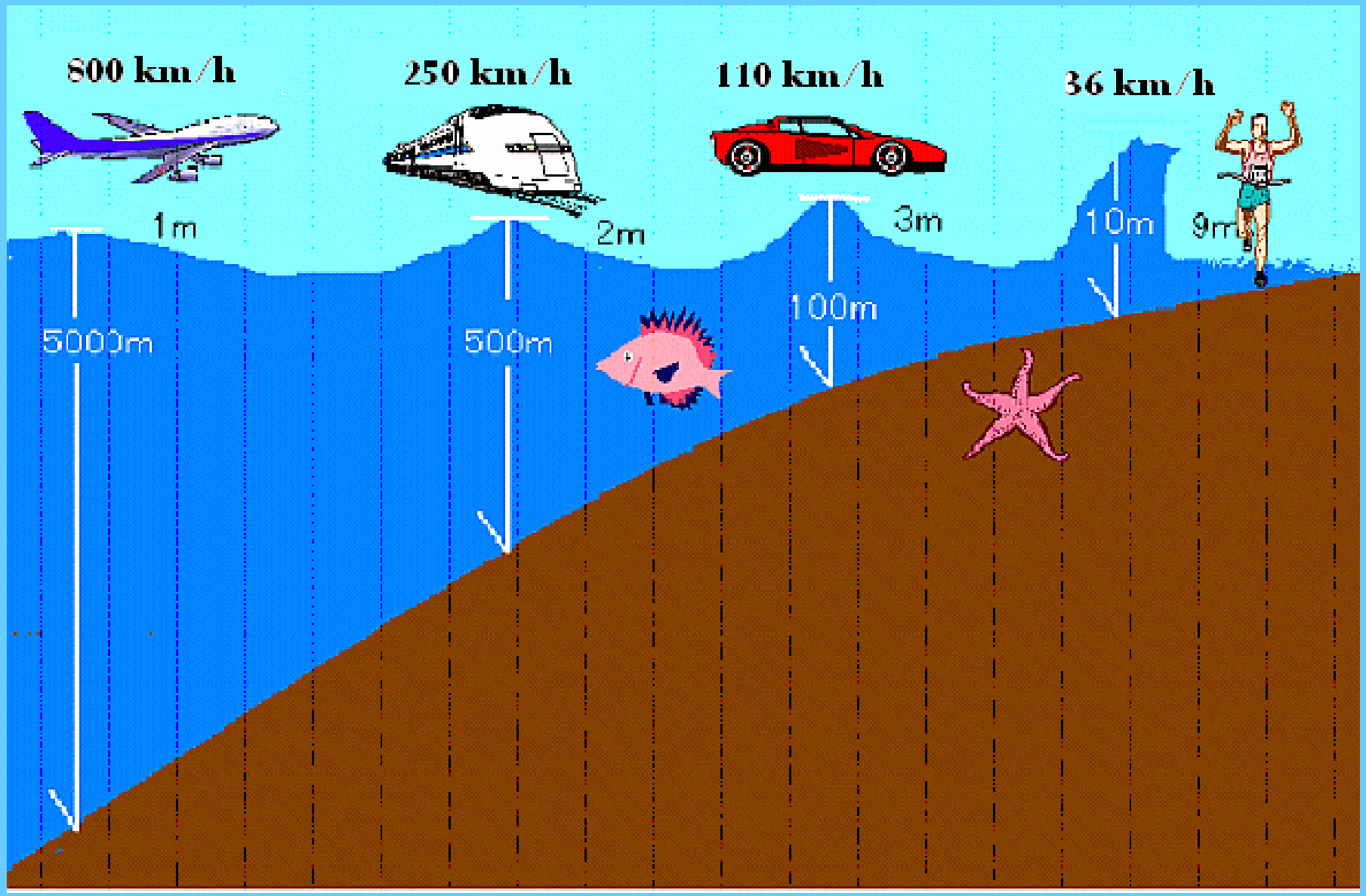
Wave Speed α (h) ½

Where h *is the depth of sea*

Propagate at high speed in deep sea

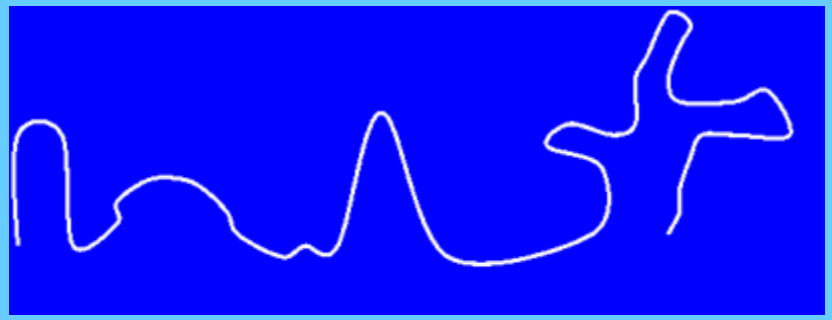
Speed slows down near coastline

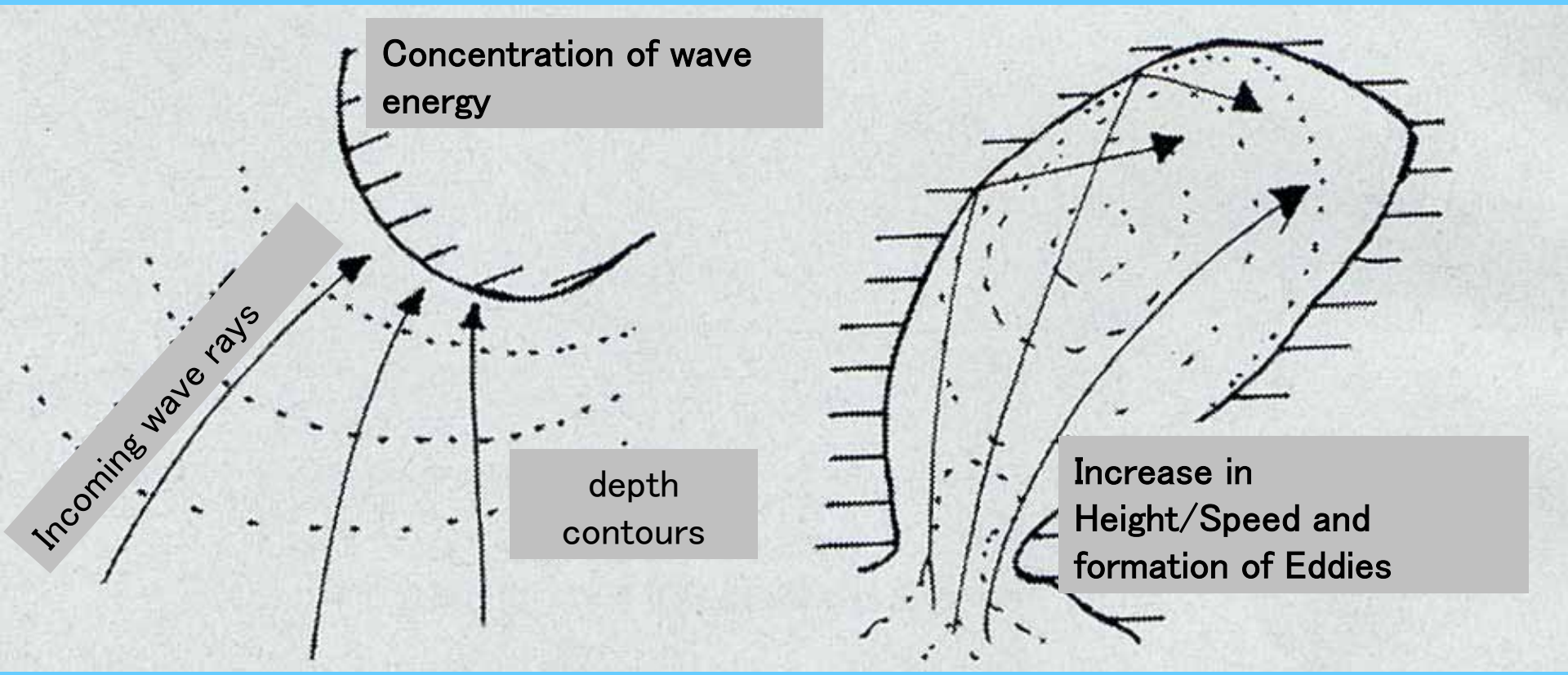
Tsunami Propagation Speed



Characteristics influenced by the shape and geometry

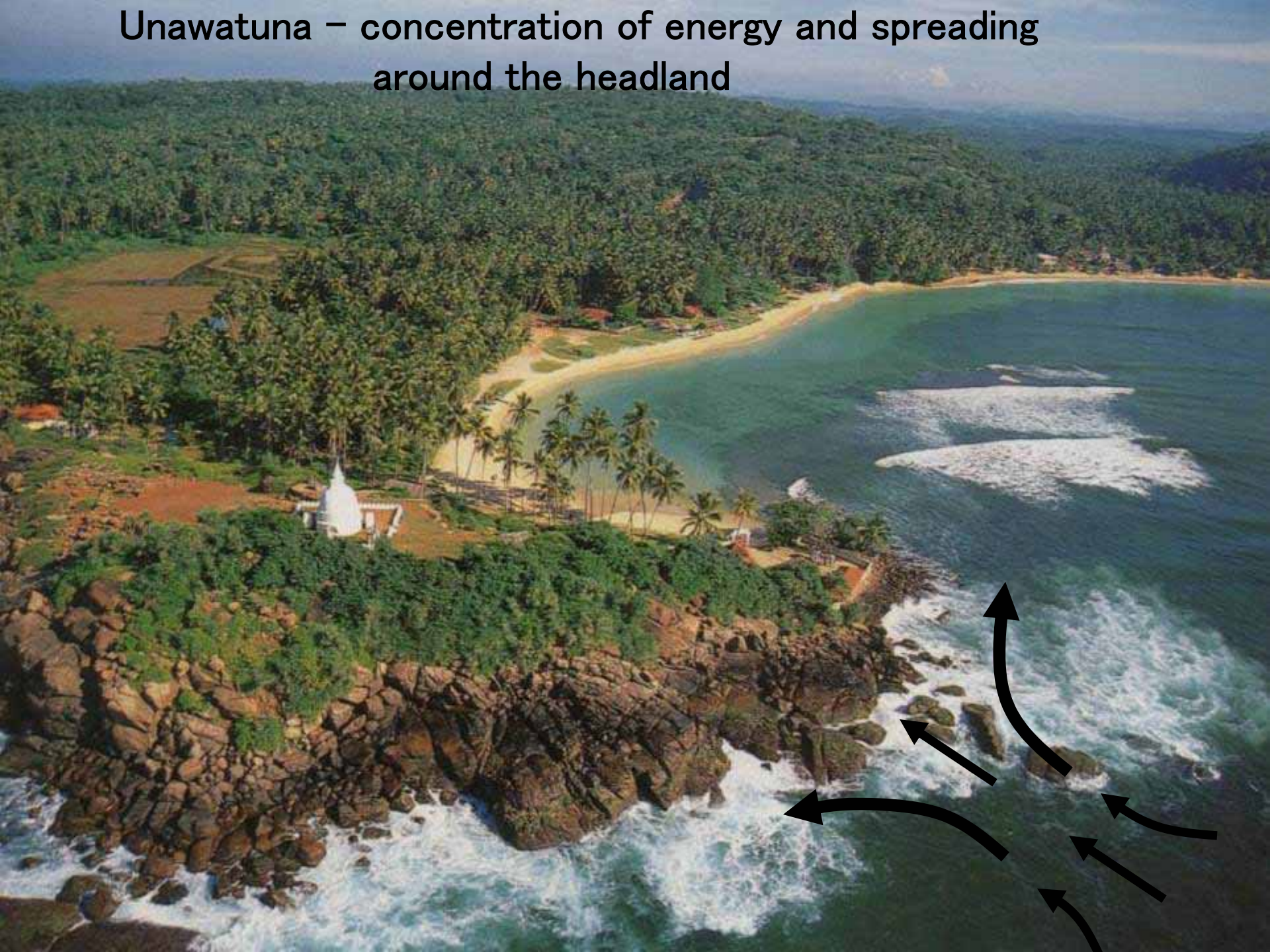
Energy concentration at headlands and in bays





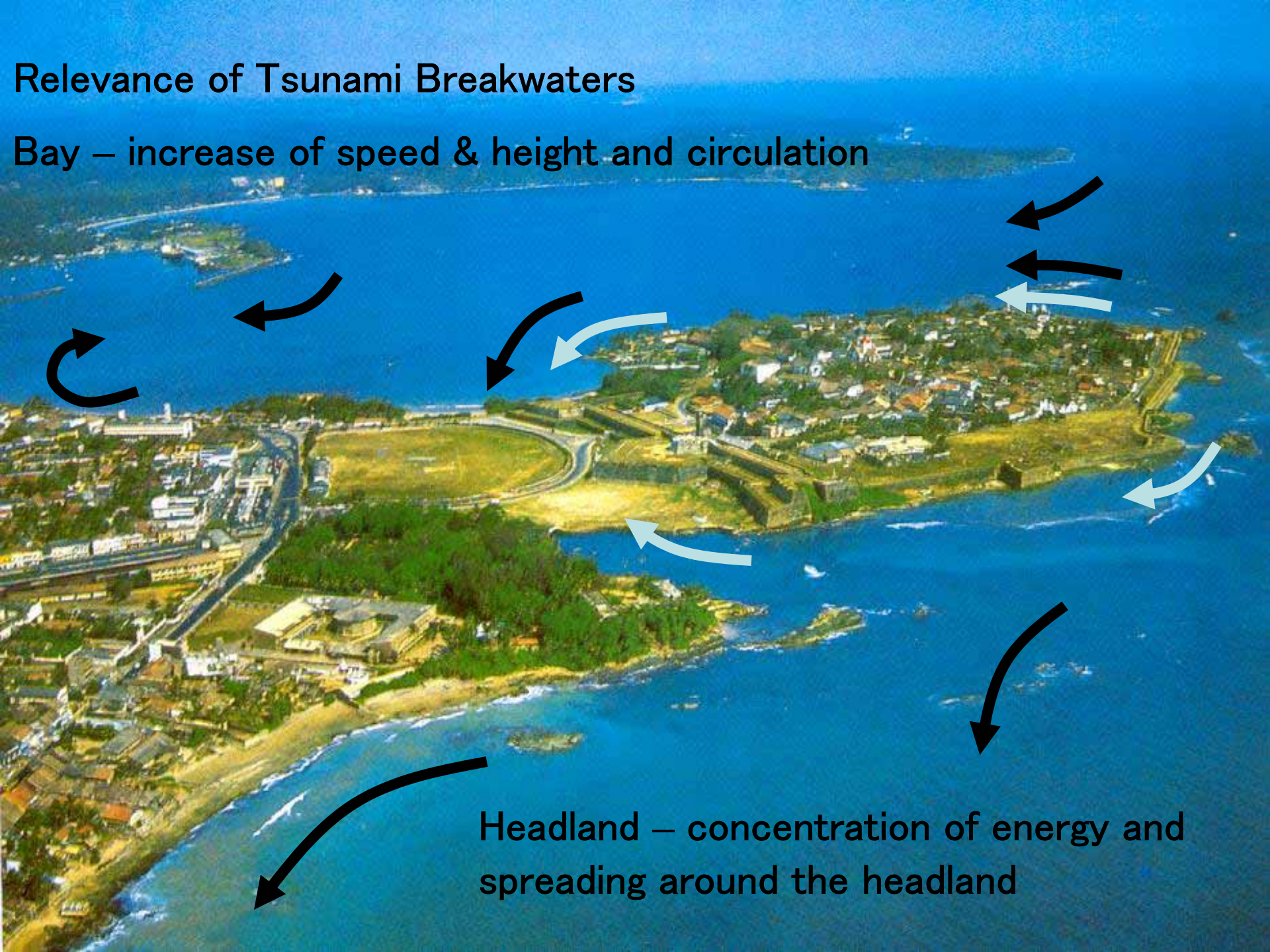
Bay – Increase of Speed & Height

Unawatuna – concentration of energy and spreading around the headland



Relevance of Tsunami Breakwaters

Bay – increase of speed & height and circulation



Headland – concentration of energy and spreading around the headland

Identification of Tsunami over deep sea impossible !

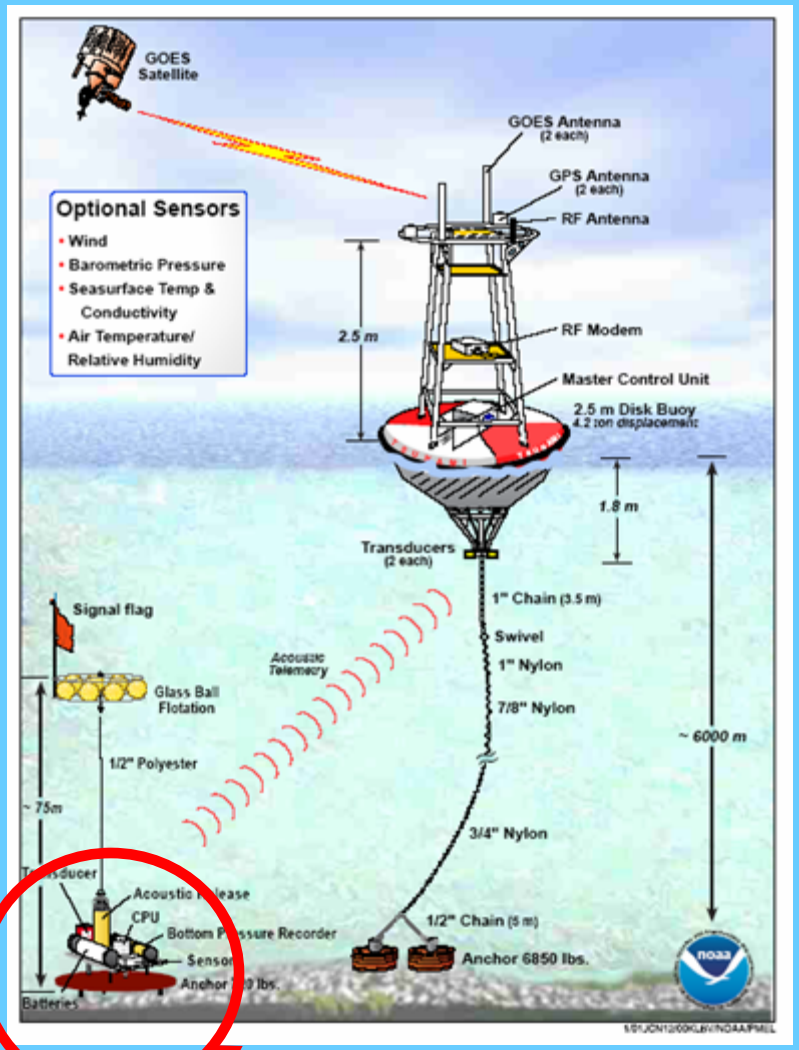
Over deep sea, the vertical displacement of tsunami waves is small; only a few tens of centimeters.

Hence, the identification of tsunami waves in deep sea is not possible with ships, boats or aircrafts.

Special instruments are required to identify tsunami waves in deep sea

Deep Sea Pressure Sensors (Buoys)

Deep Sea BUOYS



Pressure sensor

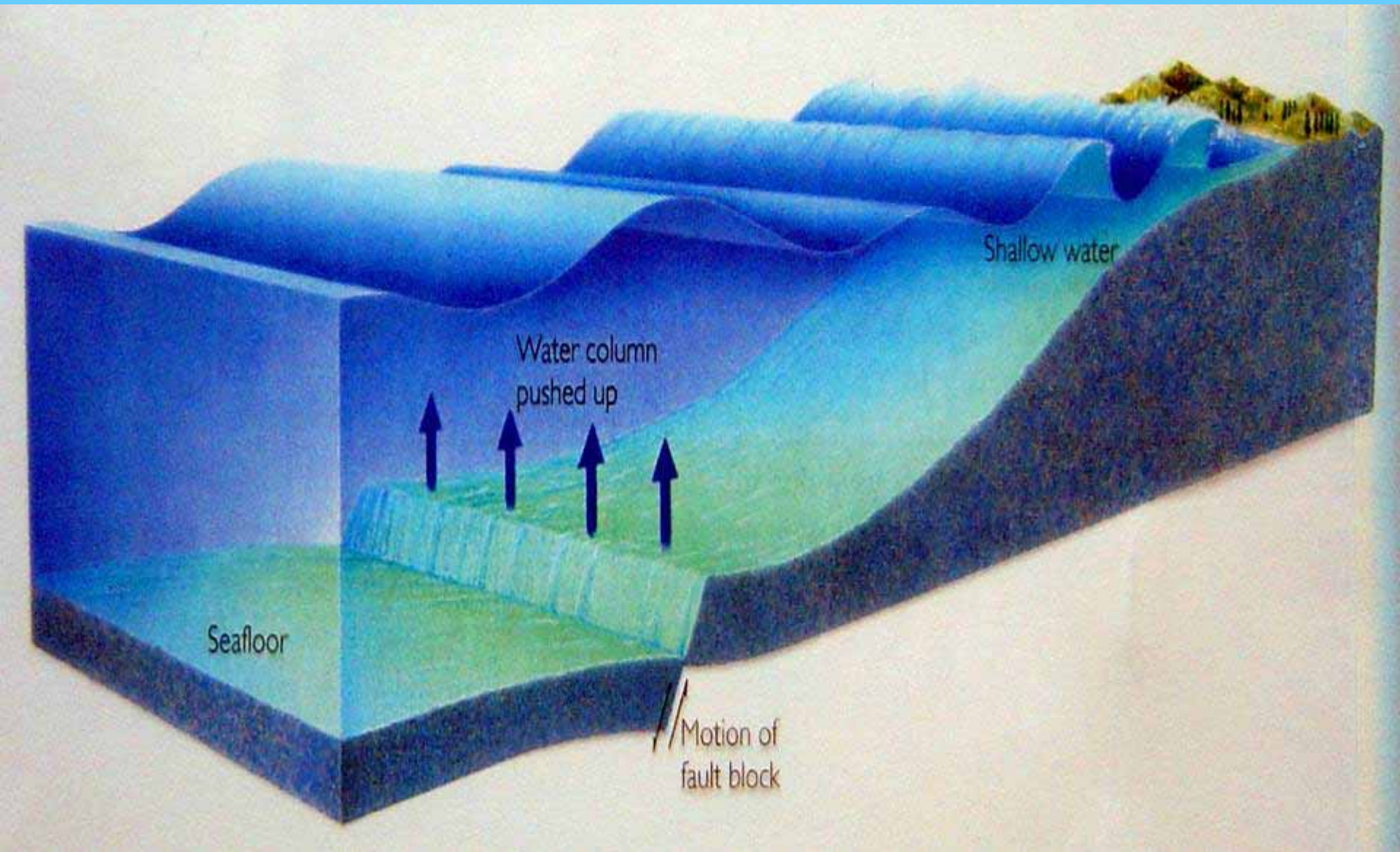
[How the Buoys detect Tsunami Waves]

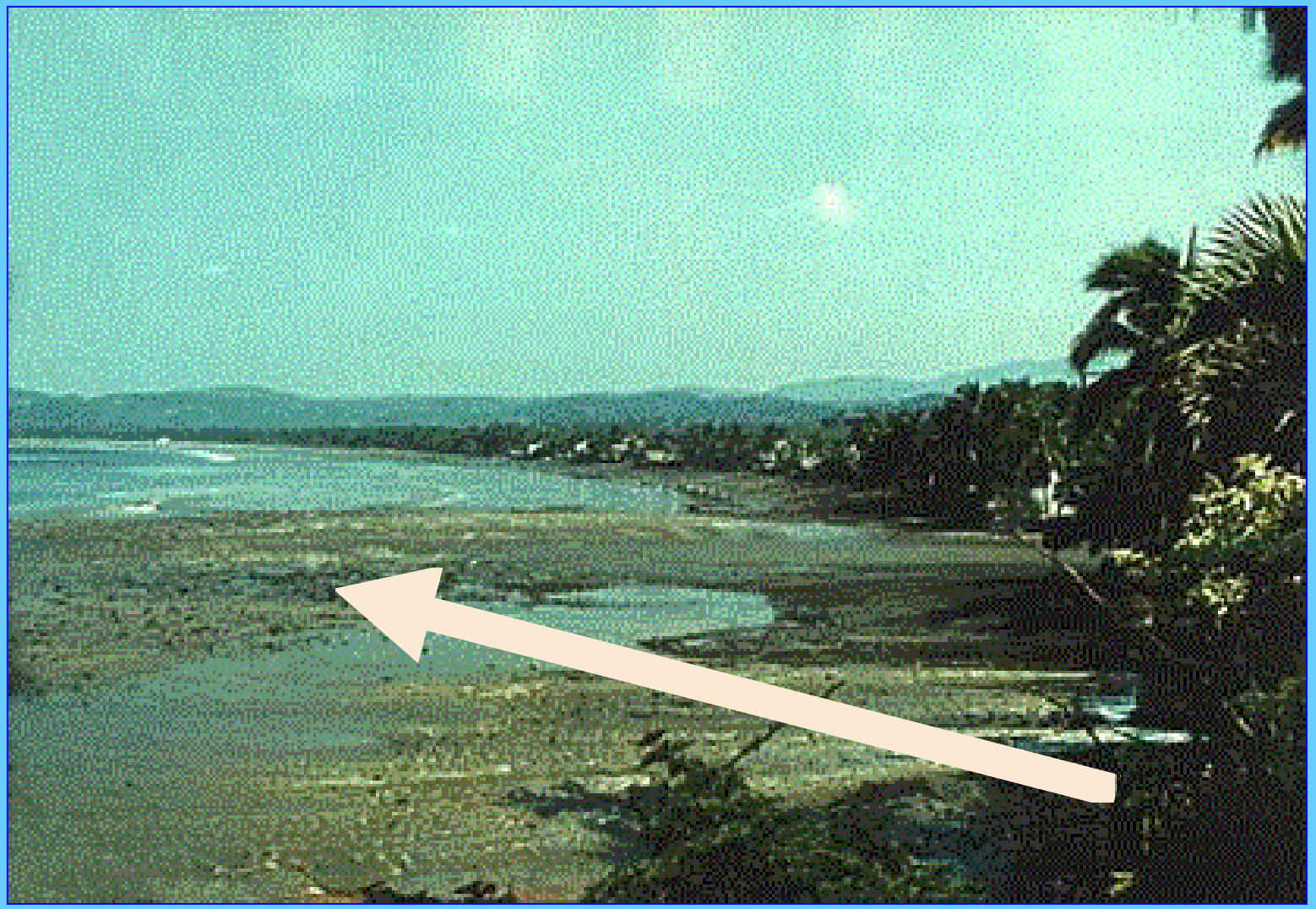
Very expensive instrument

Costly to maintain

None in operation in the Indian Ocean

TSUNAMI GENERATED BY AN EARTHQUAKE





The first wave can be a receding wave

Receding waters at Kalutara

On 26th December 2004,

No agency in Sri Lanka was responsible for monitoring Tsunami

No Early Warning System existed in the Indian Ocean

No country in the region was prepared

Public awareness was non existent

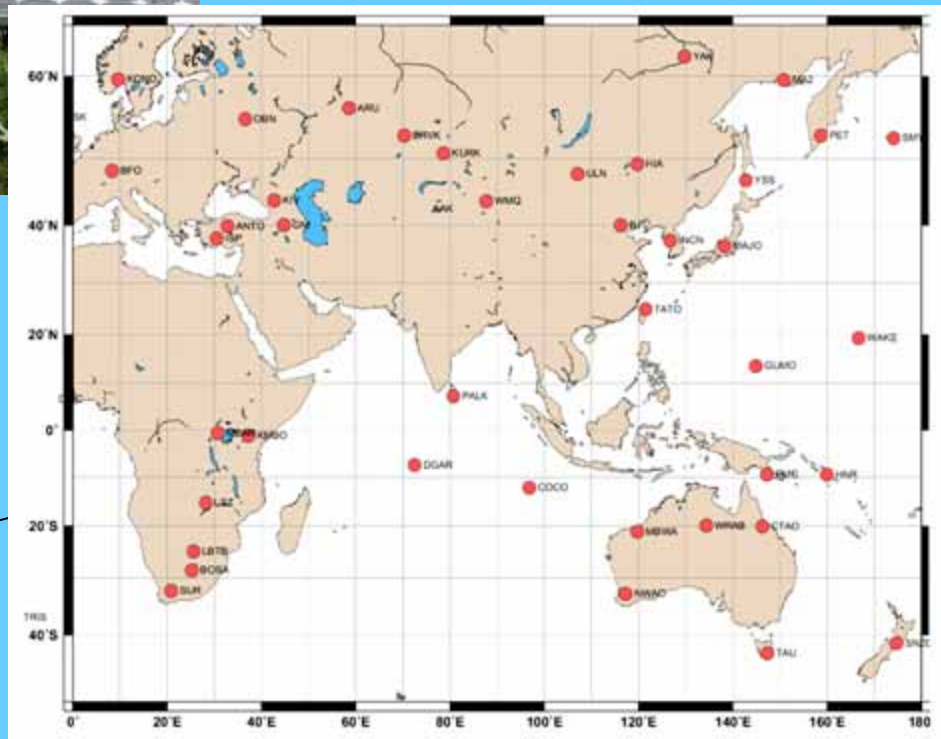
From March, 2005 Department of Meteorology is functioning as the Tsunami Early Warning Centre

Working on 24 x 7 basis

Linked with other centres in the region

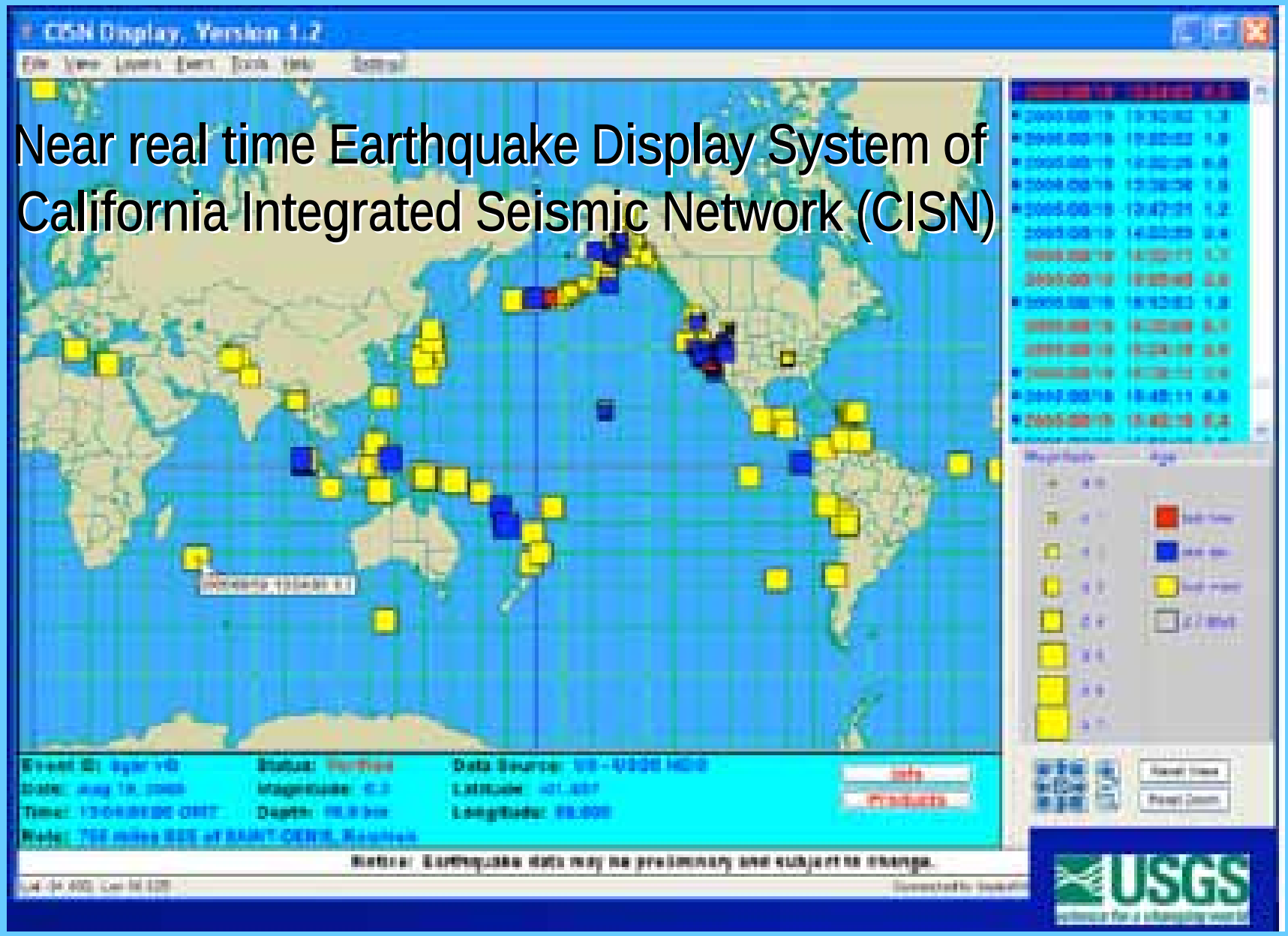
- Linked with Intergovernmental Oceanographic Commission's (IOC) Tsunami Warning System
- Information regarding major earthquakes in the region are received from Pacific Tsunami Warning Centre (PTWC), Hawaii and Japan Meteorological Administration (JMA)

Seismic Station at Pallekele



Pallekele (PALK)

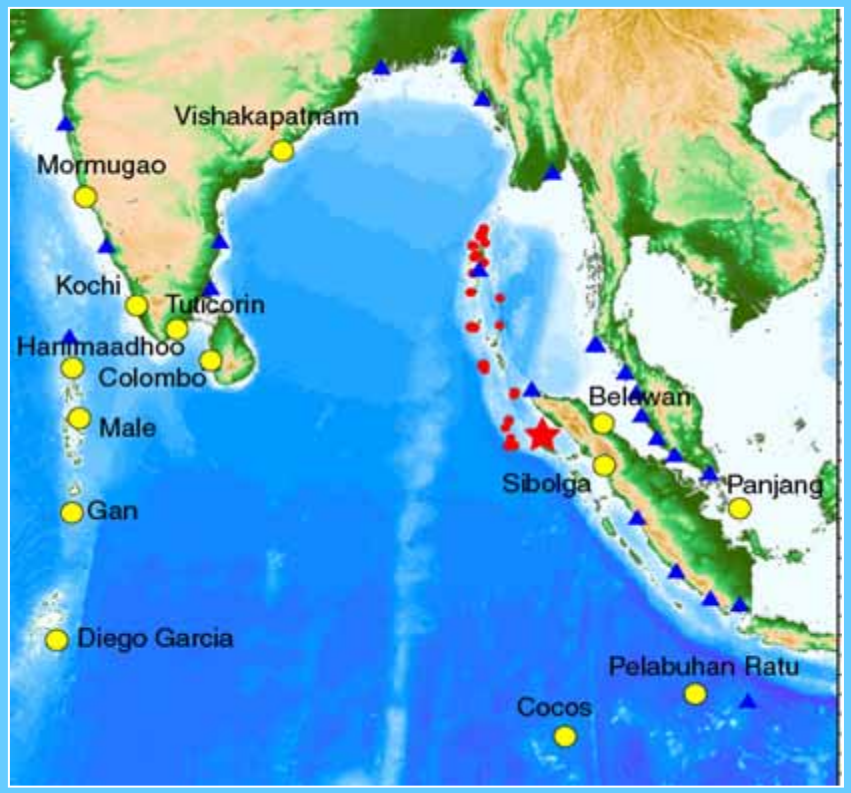
Geological Survey and Mines Bureau

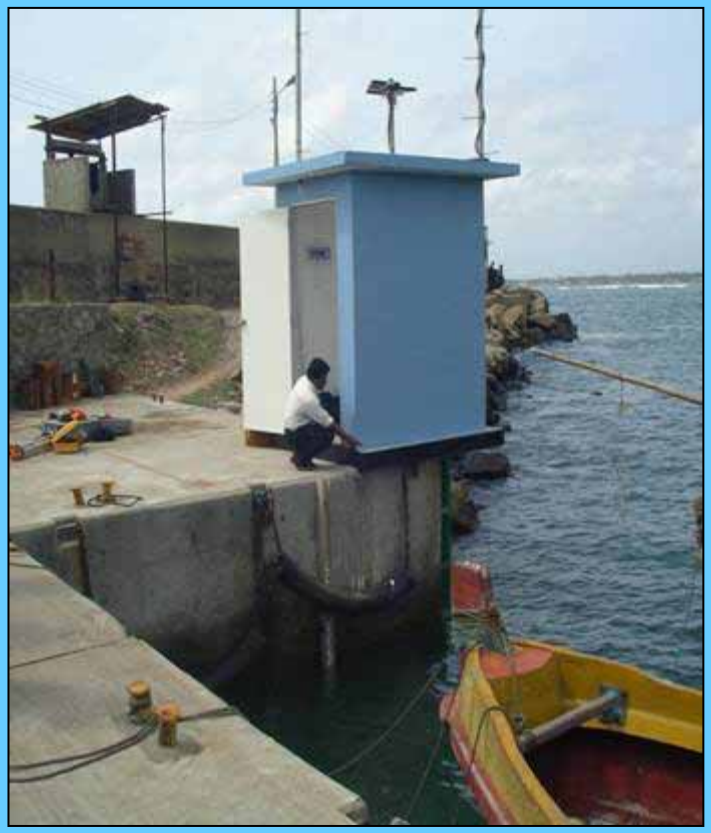


In addition, Tsunami Early Warning Centre receives earthquake information from California Integrated Seismic Network (CISN) and from USGS

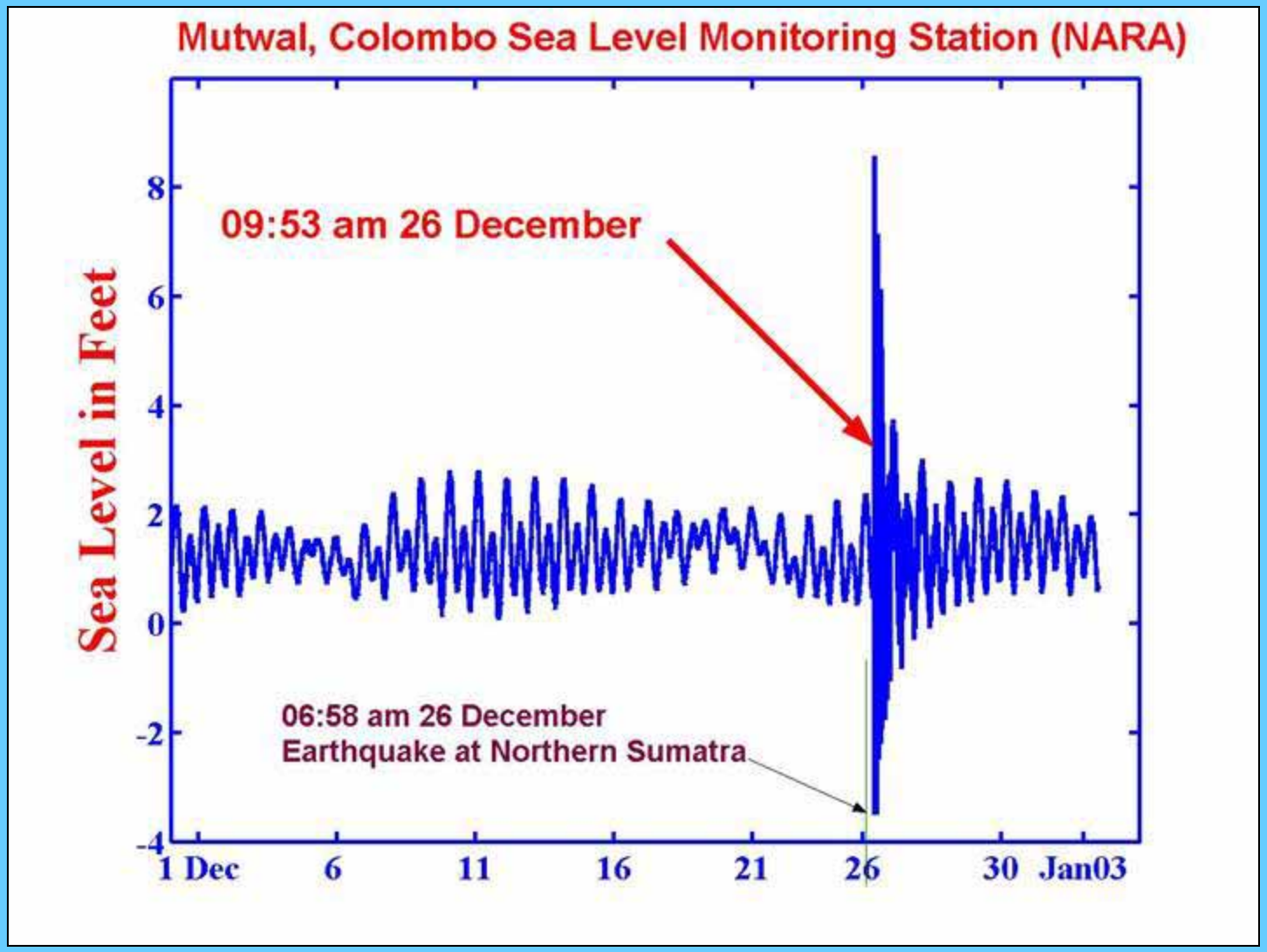
Oceanic Data:

As no buoys are still operational in the Indian Ocean, information from tide gauges are used to identify sea level changes.





Three tide gauges are in continuous operation at Colombo (Mutwal), Trincomalee and Kirinda. Realtime data from these data are available through internet



How the tide gauge at Mutwal recorded the Tsunami

TSUNAMI BULLETIN NUMBER 001
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 0117Z 11 APR 2005

THIS BULLETIN IS FOR ALL AREAS OF THE INDIAN OCEAN.

... TSUNAMI INFORMATION BULLETIN ...

THIS MESSAGE IS FOR INFORMATION ONLY.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME - 0100Z 11 APR 2005
COORDINATES - 1.3 NORTH 97.5 EAST
LOCATION - NORTHERN SUMATERA INDONESIA
MAGNITUDE - 6.7

EVALUATION

A DESTRUCTIVE WIDESPREAD TSUNAMI THREAT DOES NOT EXIST BASED ON HISTORICAL EARTHQUAKE AND TSUNAMI DATA.

HOWEVER - THERE IS A VERY SMALL POSSIBILITY OF A LOCAL TSUNAMI THAT COULD AFFECT COASTS LOCATED USUALLY NO MORE THAN A HUNDRED KILOMETERS FROM THE EARTHQUAKE EPICENTER. AUTHORITIES IN THE REGION NEAR THE EPICENTER SHOULD BE MADE AWARE OF THIS POSSIBILITY.

THIS WILL BE THE ONLY BULLETIN ISSUED BY THE PACIFIC TSUNAMI WARNING CENTER FOR THIS EVENT UNLESS ADDITIONAL INFORMATION BECOMES AVAILABLE.

THE JAPAN METEOROLOGICAL AGENCY MAY ISSUE ADDITIONAL INFORMATION FOR THIS EVENT.

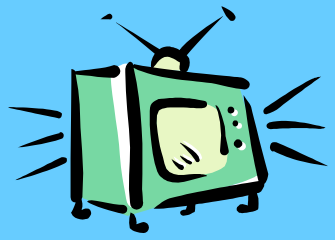
PTWC is providing guidance to national agencies during emergency situations

A Sample of a Tsunami Bulletin issued by the Pacific Tsunami Warning Centre, Hawaii for National Focal Agencies in the Indian Ocean

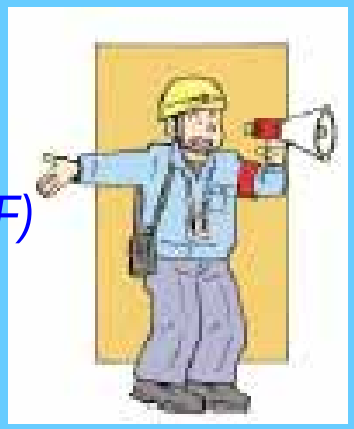
Warning Dissemination

- Through Mass Media – Radio and Television

  (message passed through telephone)



- Through Local Police Stations



  (message passed through telephone to Mirihana and thereafter HF)

- Through Communication systems of Armed Forces

  (Telephone/Telefax)

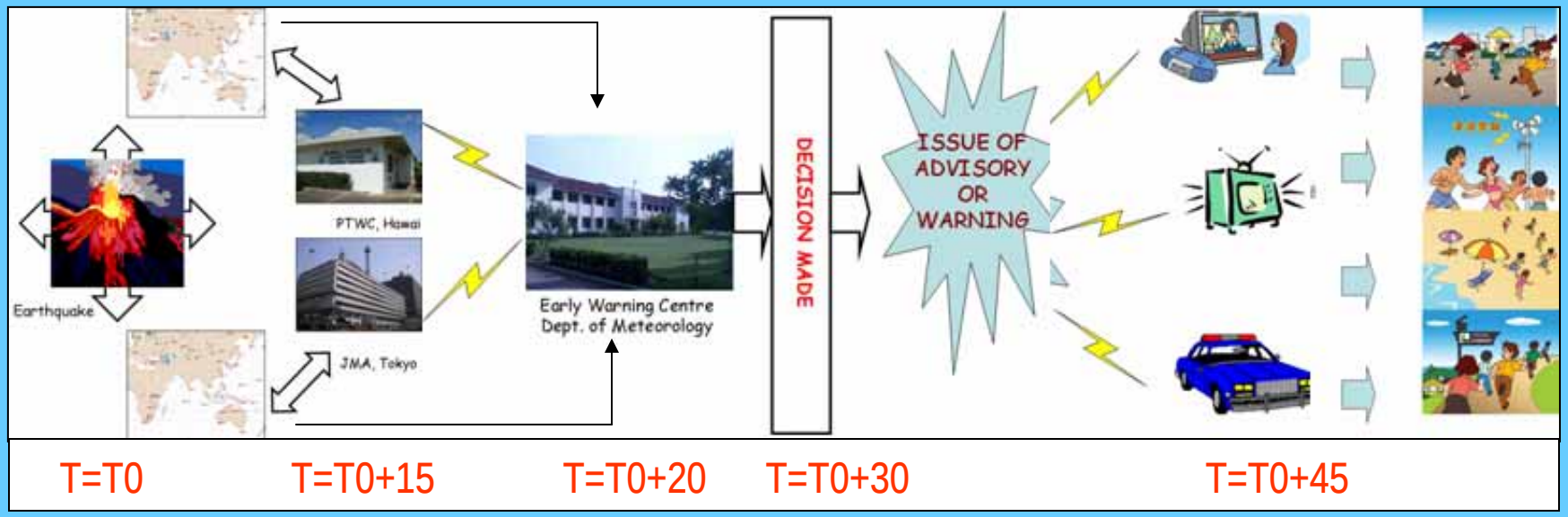
- Through District Units of DMC

  (Telephone/Telefax)

Planned:

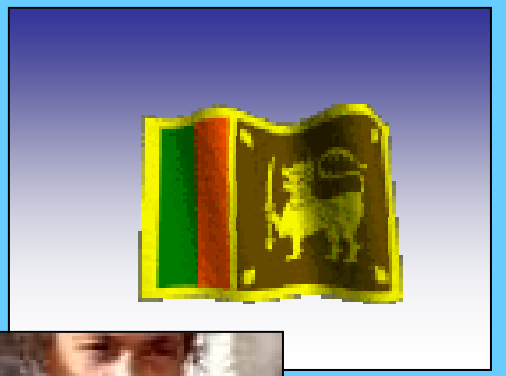
SMS dissemination

Warning Generation and Dissemination



- Issue of the Advisory/Warning within 30 mnts of the earthquake
- If the warning reaches the vulnerable communities within 45 mnts.,
  then, for Indonesian earthquake 45 minutes
  for Makran earthquake 3 hours 45 minutes leadtime.

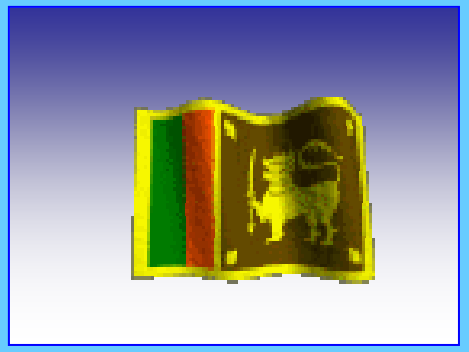
The Tsunami devastation resulted in the recognition of the need for comprehensive disaster risk management, rather than post disaster relief or better response



Some of the major

Post-Tsunami Developments in Sri Lanka

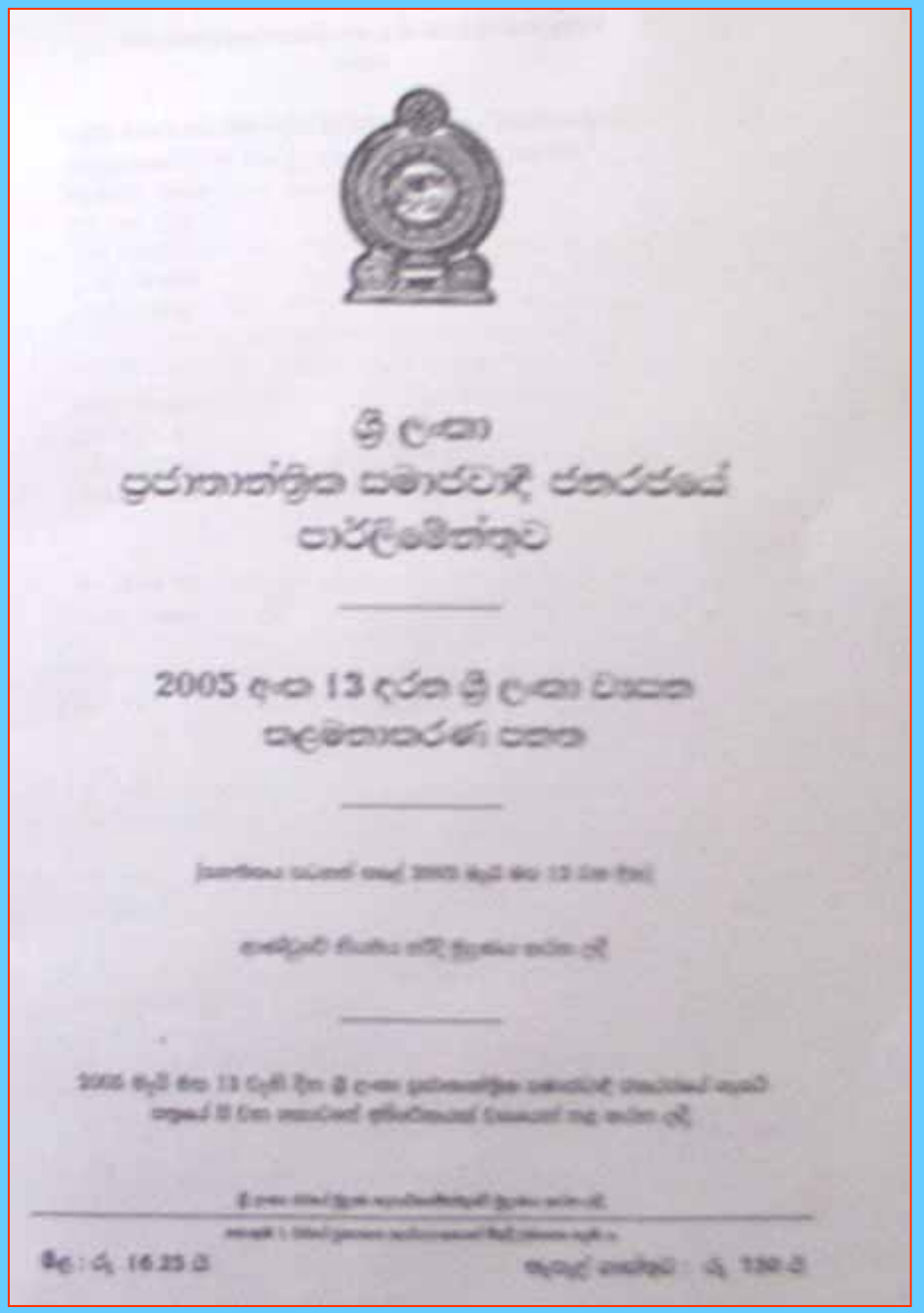
- Disaster Management Act No. 13 of 2005 enacted
- National Council for Disaster Management (NCDM)
- Disaster Management Centre
- Ministry of Disaster Management and Human Rights



Disaster Management Act No. 13 of 2005

Enacted on 13th May 2005

A legal basis for disaster management . . .



National Council for Disaster Management (NCDM)

Chairperson – H.E. the President

Vice Chairperson – Hon. Prime Minister

Leader of the Opposition

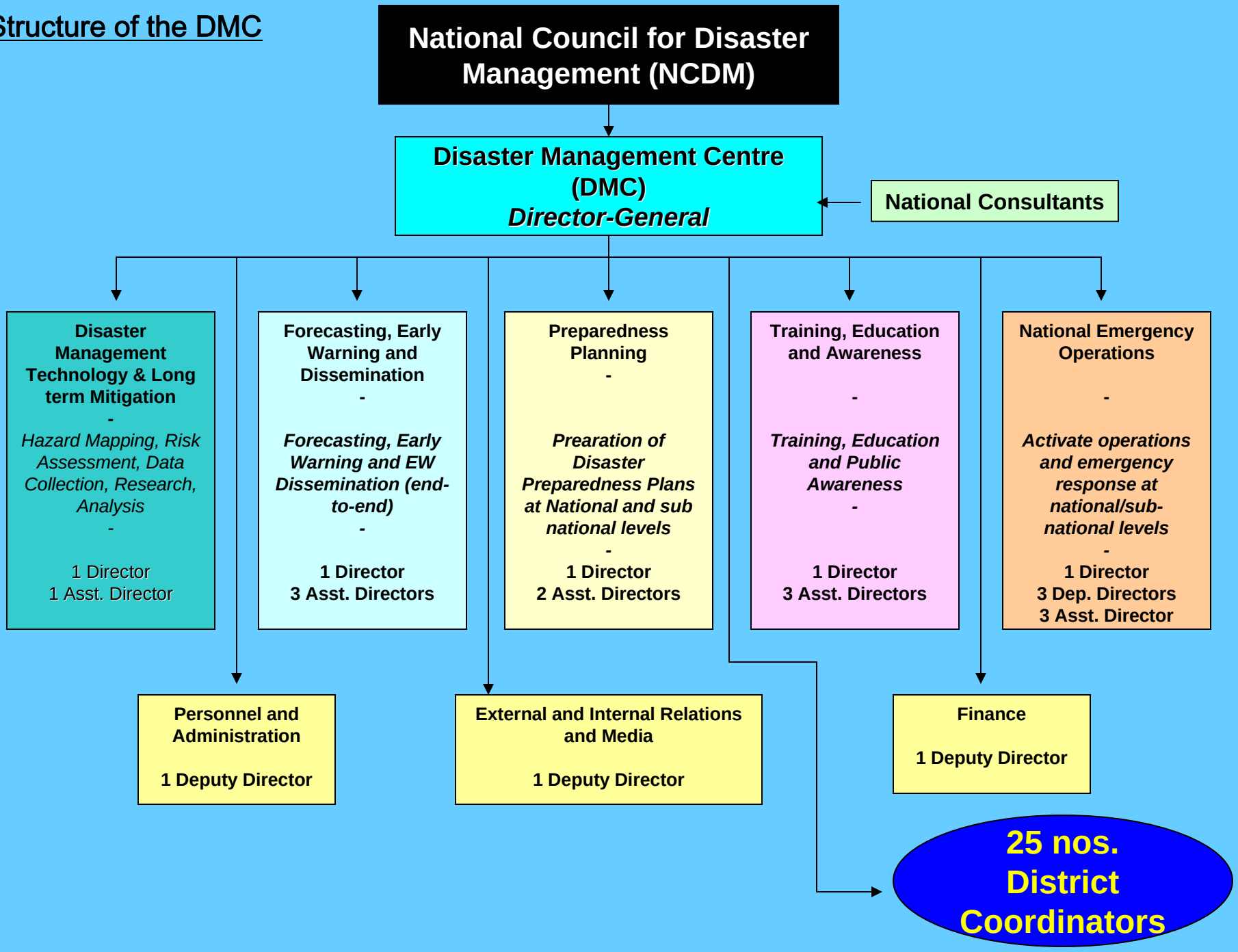
Ministers in-charge of the following subject areas:

Social Welfare	Rehabilitation and Reconstruction
Environment	Home Affairs
Health	Science and Technology
Housing	Coast Conservation
Irrigation	Electricity
Defence	Police
Finance	Land
Fisheries and Aq. Res.	Foreign Affairs
Water Supply	Urban Development
Education	Highways

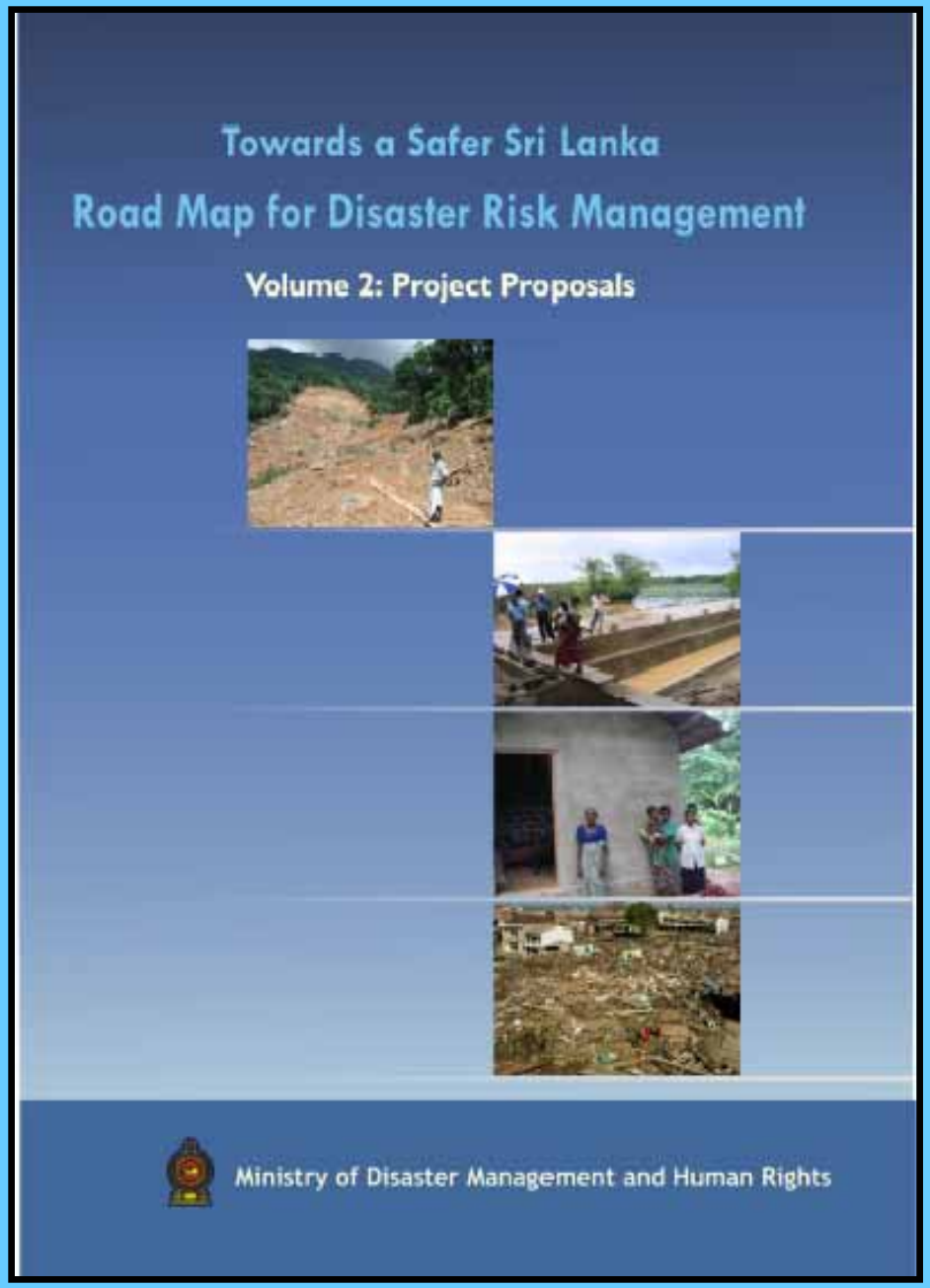
Chief Ministers of all Provincial Councils

05 Opposition Members from Parliament

Structure of the DMC



During this period public institutions, NGOs, INGOs and many international agencies were involved in reconstruction and introducing systems for disaster risk management towards sustained risk reduction in Sri Lanka



Towards a Safer Sri Lanka

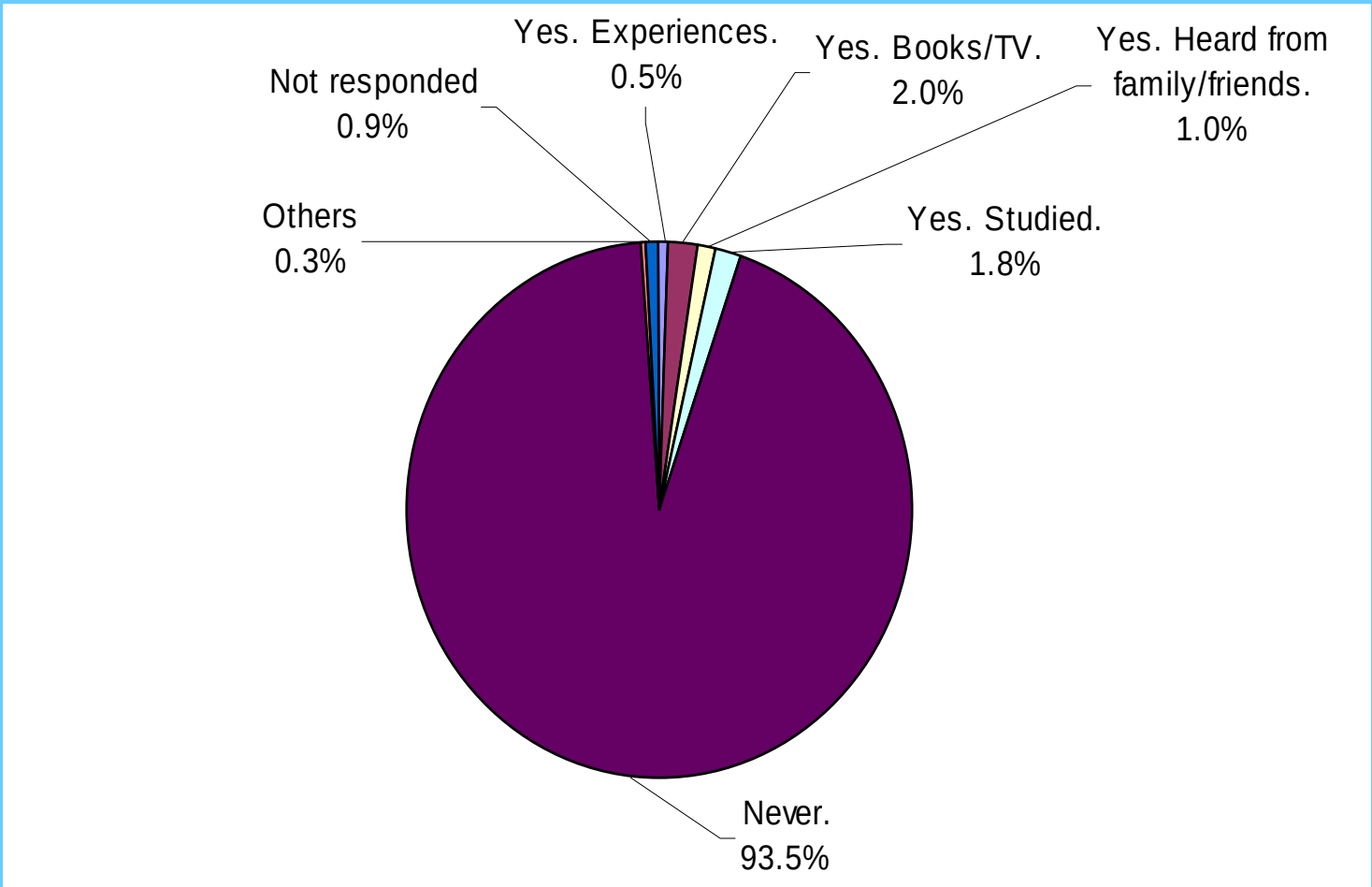
Road Map for Disaster Risk Management

- **A holistic strategy towards building a Safer Sri Lanka**
- **Developed through a consultative process**
- **Priority areas for immediate action identified**
- **Focused on seven (7) thematic components**
- **Consistent with Hyogo Framework for Action 2005-2015**
- **Government of Sri Lanka committed to implement within the next decade**

Components of **Road Map for Disaster Risk**

1. Policy, Institutional Mandates and Institutional Development
2. Hazard, Vulnerability and Risk Assessment
3. Tsunami and Multi Hazard Early Warning System
4. Preparedness and Response Plans
5. Mitigation and Integration of Disaster Risk reduction into Development Planning
6. Community based Disaster Risk Management
7. Public Awareness, Education and Training

Question: Had you heard about Tsunami prior to 26-12 ?



Answer: 93.5 % of the people knew nothing about tsunami

*** Results of a survey conducted in Sri Lanka in Jan 2005 by ADPC*

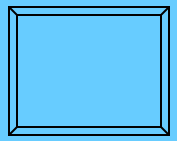
To reduce damage from natural disasters – Public Awareness is important

To create awareness among vulnerable communities, a large number of seminars, workshops conducted

Evacuation drills for vulnerable communities

Tsunami Drill @ Balapitiya

Programs for School Children



C W W Kannangara Vidyalaya, Galle

Similar programs are continuing in vulnerable coastal regions
Under the supervision of District Disaster Management Coordinators
to ensure effective response to hazard impact

For highly vulnerable areas

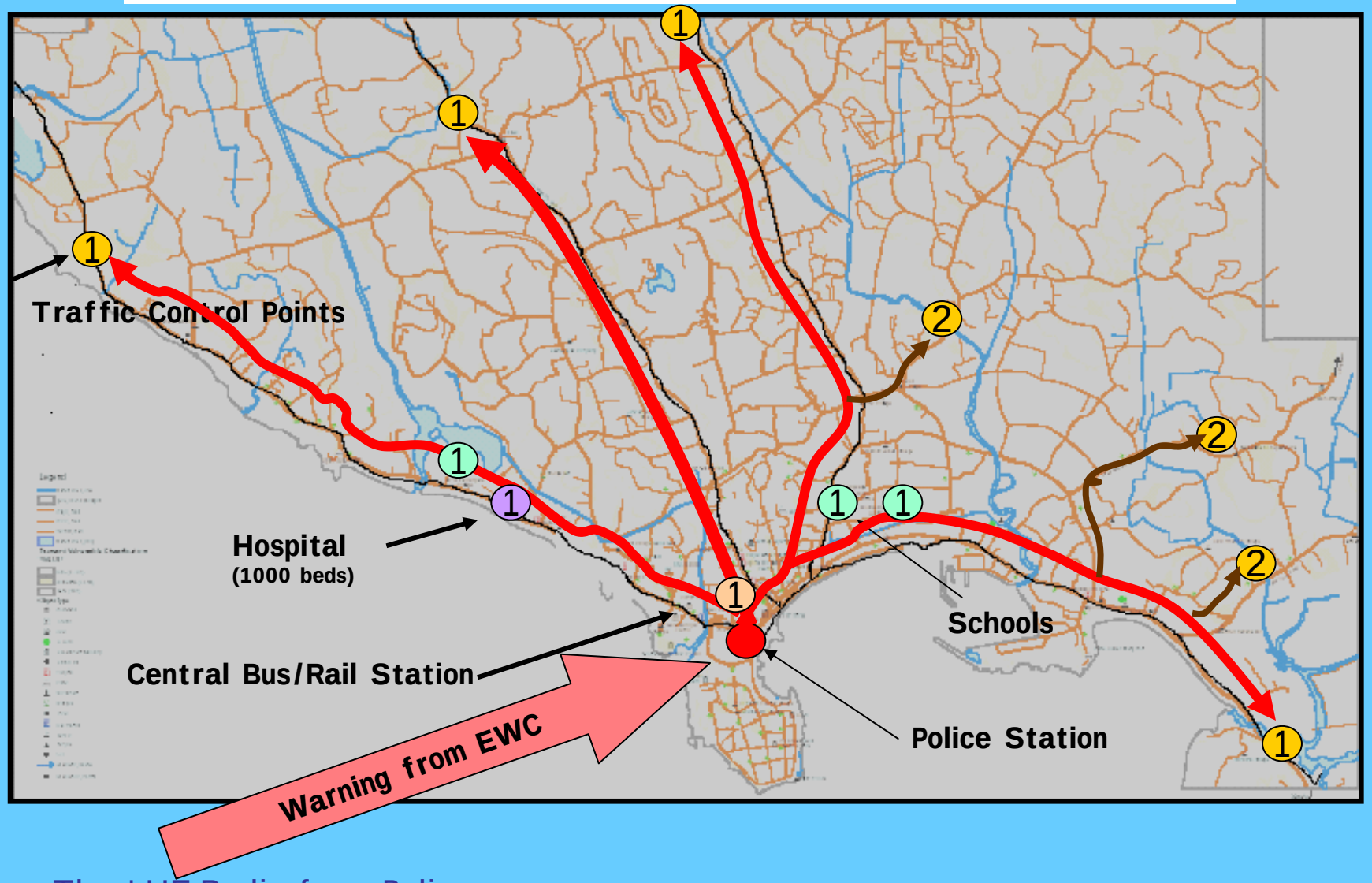
- ✓ Vulnerability maps
- ✓ Evacuation maps with safe areas clearly marked
- ✓ Mobilization plans for Police

are developed

TSUNAMI EVACUATION MAP FOR CITY OF GALLE


TSUNAMI EVACUATION PLAN FOR UNAWATUNA TOURIST VILLAGE
N 91000
N 90000
E 141000
E 142000
N
EVACUATION ROUTE
NO EVACUATION ROUTE
PROPOSED TSUNAMI REFUGE FOR TOURISTS
RECENT TSUNAMI INUNDATION ZONE
ELEVATION HIGHER THAN 5m
ELEVATION HIGHER THAN 10 m
HOTEL/ RESTAURANT GUEST HOUSE
PROPOSED EVACUATION RUTE
SECONDARY ROAD
MAIN ROAD
GALLETOWN
FLOWER GARDEN
CALM
BLUE SWAN INN
VIHAR REST
SHANGRILLA
ZIMMER RESTAURANT
SUNNY MOOD
SRIDHARA
VEGETATION FOOD REST
NEW HOTEL
RANGA REST
UNAWATUNA BEACH RESORT
TEMPLE
LUCKY TUNA
3 STORY HOUSE
ANMAS
NEW HOTEL
HOTEL DANMINA
NEPTUNE BAY
HAPPY BANANA
SUNNY BEACH
LA TANTALIZA
SANDY LAKE
FULL MOON REST
SURFING TURF
THE VILLA HOTEL
HOT ROCK
UPUL RESTAURANT
HARD ROCK RESTAURANT
TRAK RESTAURANT
KINGFISHER RESTAURANT
PEACOCK RESTAURANT
BLUE EYES DIVING SCHOOL
BANANA GARDEN HOTEL
OCEANWELL
HAPPY LIGHT
SUN-N-SEA
CONNARAN BEACH HOTEL
SEA HORSE
ETTONA GUEST HOUSE
MILION
TAMBAPANNI RETREAT
AMARASINGHE INTERNATIONAL BUDDHIST CENTRE
DREAM HOUSE
HEAVEN ON EARTH
ROCK HOUSE
HIGHLAND GUEST HOUSE
LOTUS HOUSE
SADHANA BIRD HOUSE
STRAND HERITAGE
PRIMROSE GUEST HOUSE
PASANVILLA
SUNIL GARDEN
OCEAN BAY
HOTEL GOLDEN ENTE
DRINK HOUSE
SEA VIEW RESTAURANT
3 STORY HOUSE
MARSHY LAND
WOW VILLA
SUNSET POINT
LANDS END
UNAWATUNA BAY HOTEL
BLOWHOLE RESTAURANT
WALE DEVALE TEMPLE
SEA
250 m

POLICE EMERGENCY MOBILISATION PLAN FOR CITY OF GALLE

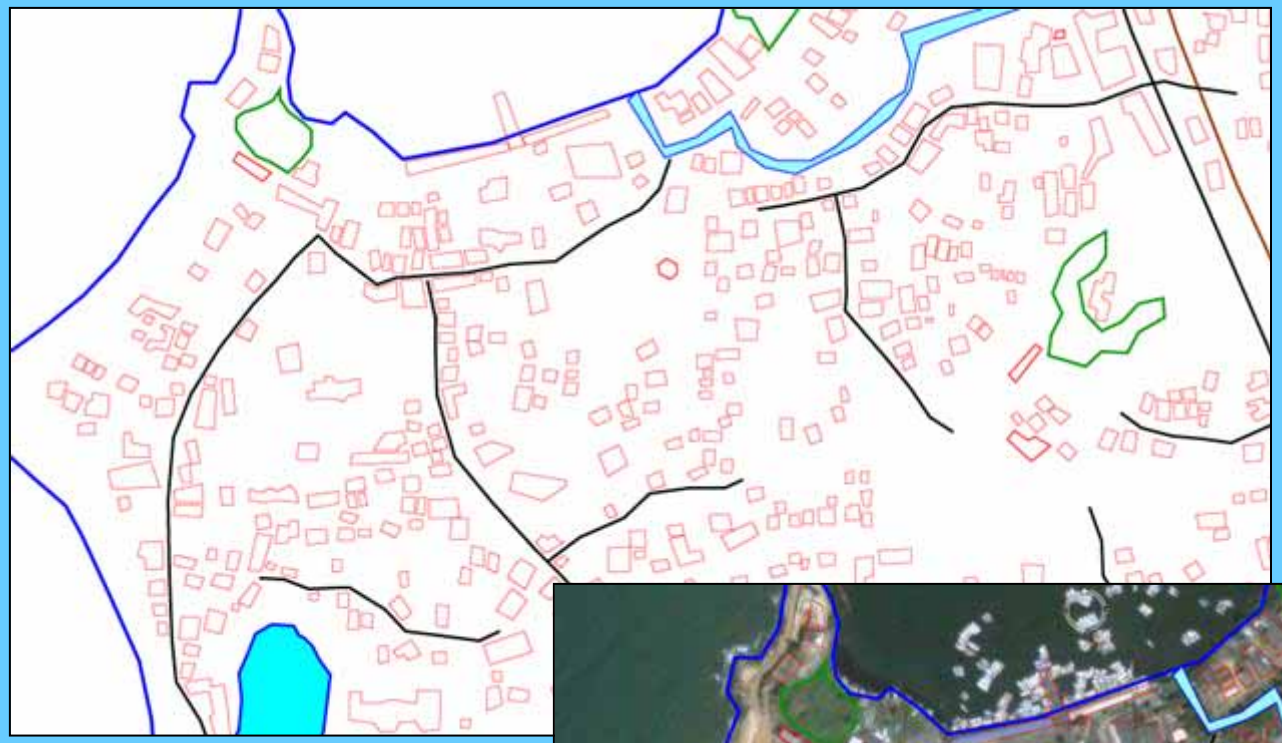



TSUNAMI ZONE


TSUNAMI ZONE


EVACUATION ROUTE
ආරක්ෂිත ගමන් මග
காலிசெய்யும் வழி


TSUNAMI MODEL VILLAGE
No 1 BALAPITIYA
Ministry of Environmental and Natural Resources
In
Association with



Vulnerability map

under development

for Bentota-Beruwala

Interventions for Tsunami Mitigation using

Artificial and Natural Methods

Overall Strategic Approach

(1) Reduce the impacts of tsunami waves prior to reaching the shoreline.

Tsunami Breakwaters / ***Coral Reefs***
Offshore Breakwaters / ***Submerged Sand Barriers***

(2) Protect the coastal zone thus preventing the inland movement of tsunami waves.

Dikes / ***Sand Dunes***

(3) Mitigate the severe impacts of tsunami waves on entry to the shoreline.

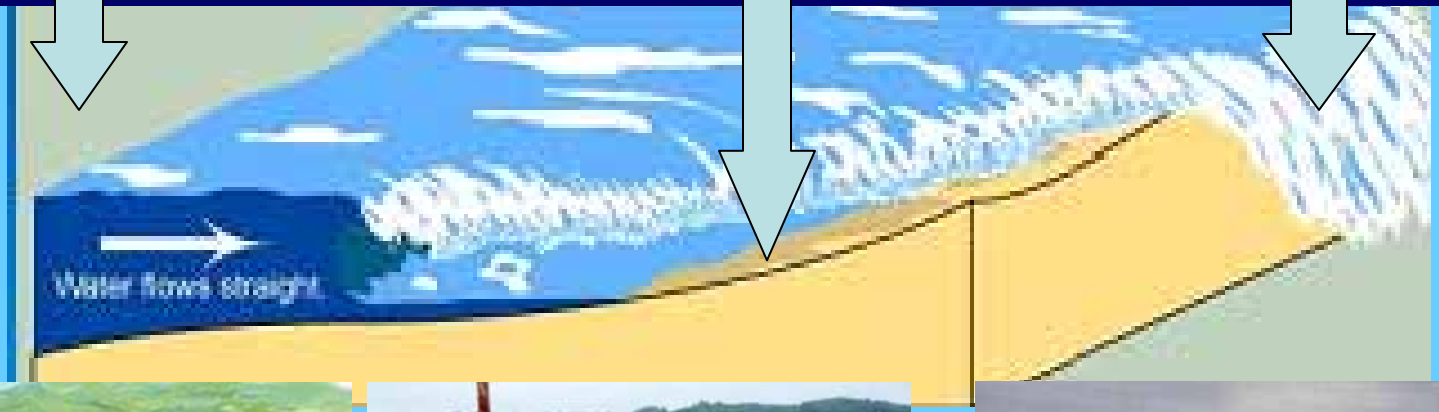
Revetments / ***Mangrove Forests***

ARTIFICIAL METHODS:

Reduce the impacts of tsunami waves prior to reaching the shoreline

Protect the coastal zone thus preventing the inland movement of tsunami waves

Mitigate the severe impacts of tsunami waves on entry to the shoreline

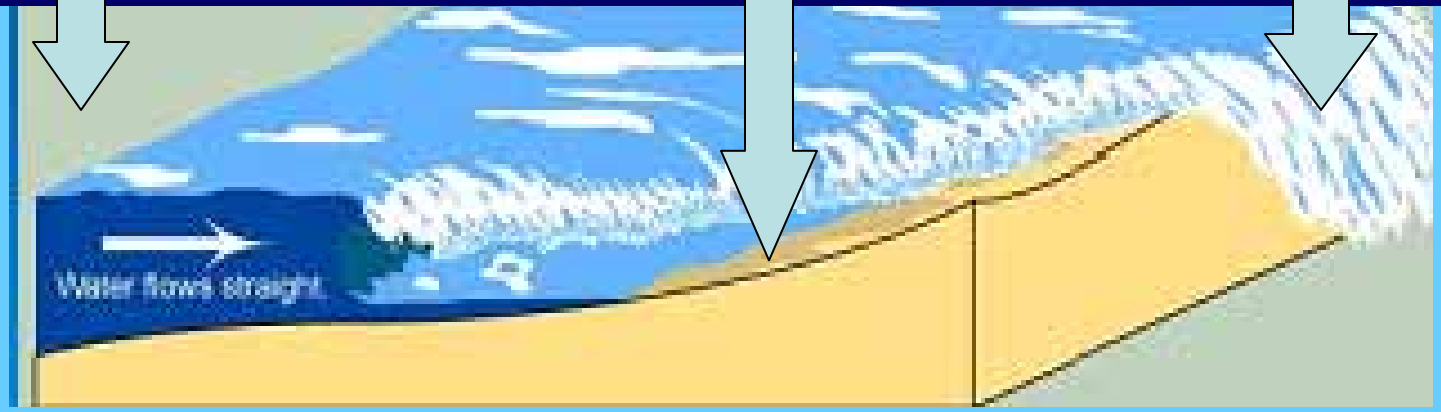


NATURAL METHODS:

Reduce the impacts of tsunami waves prior to reaching the shoreline

Protect the coastal zone thus preventing the inland movement of tsunami waves

Mitigate the severe impacts of tsunami waves on entry to the shoreline

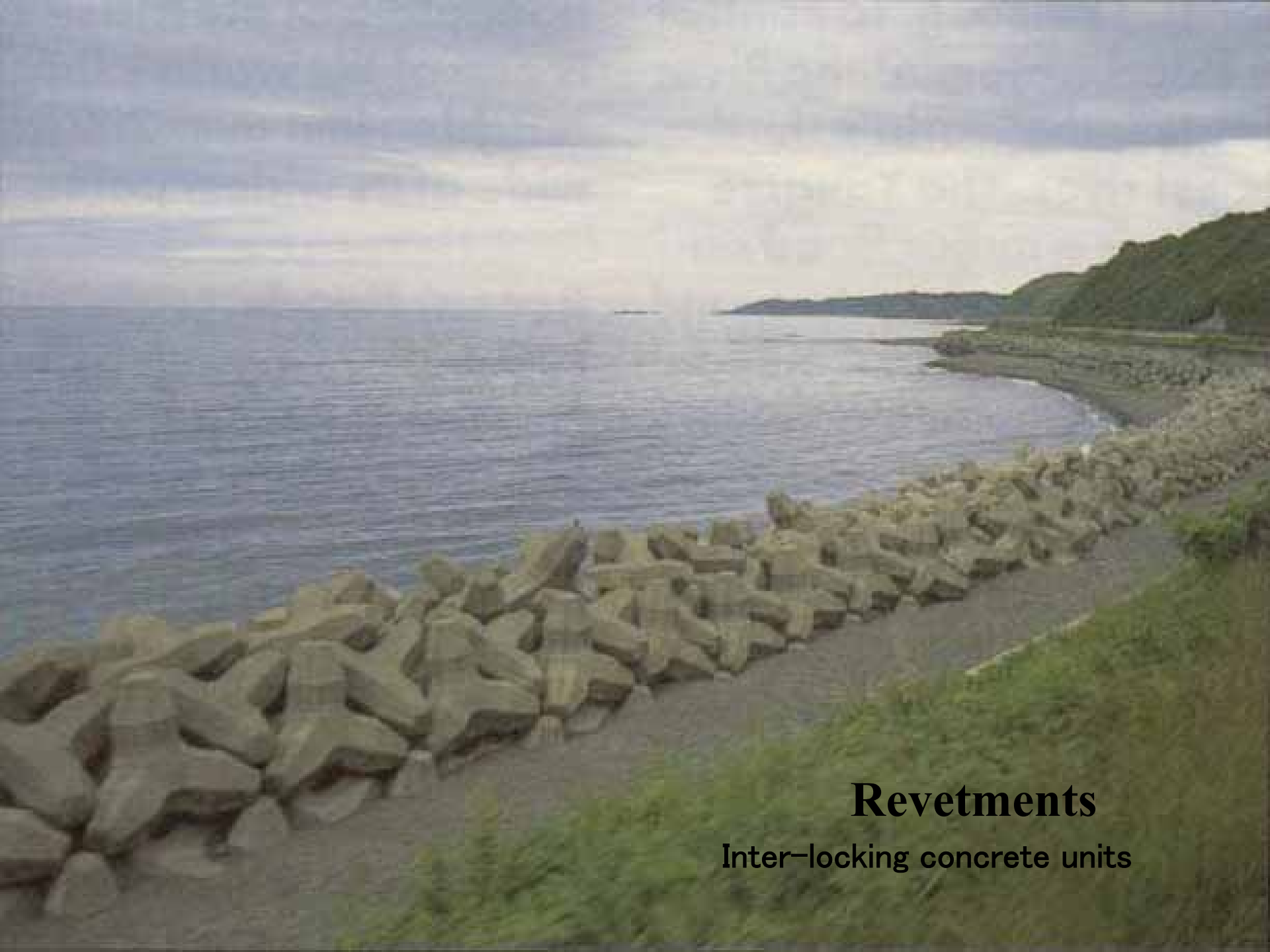



Submerged sandbars/coral reefs


Sand dunes


Mangroves

Tsunami Dike and Tsunami Gate in Japan


Revetments
Inter-locking concrete units


Off-shore Breakwaters


Rock armoured revetments

Sand Dunes – Natural Dikes


Submerged Offshore Sandbars


THANK YOU