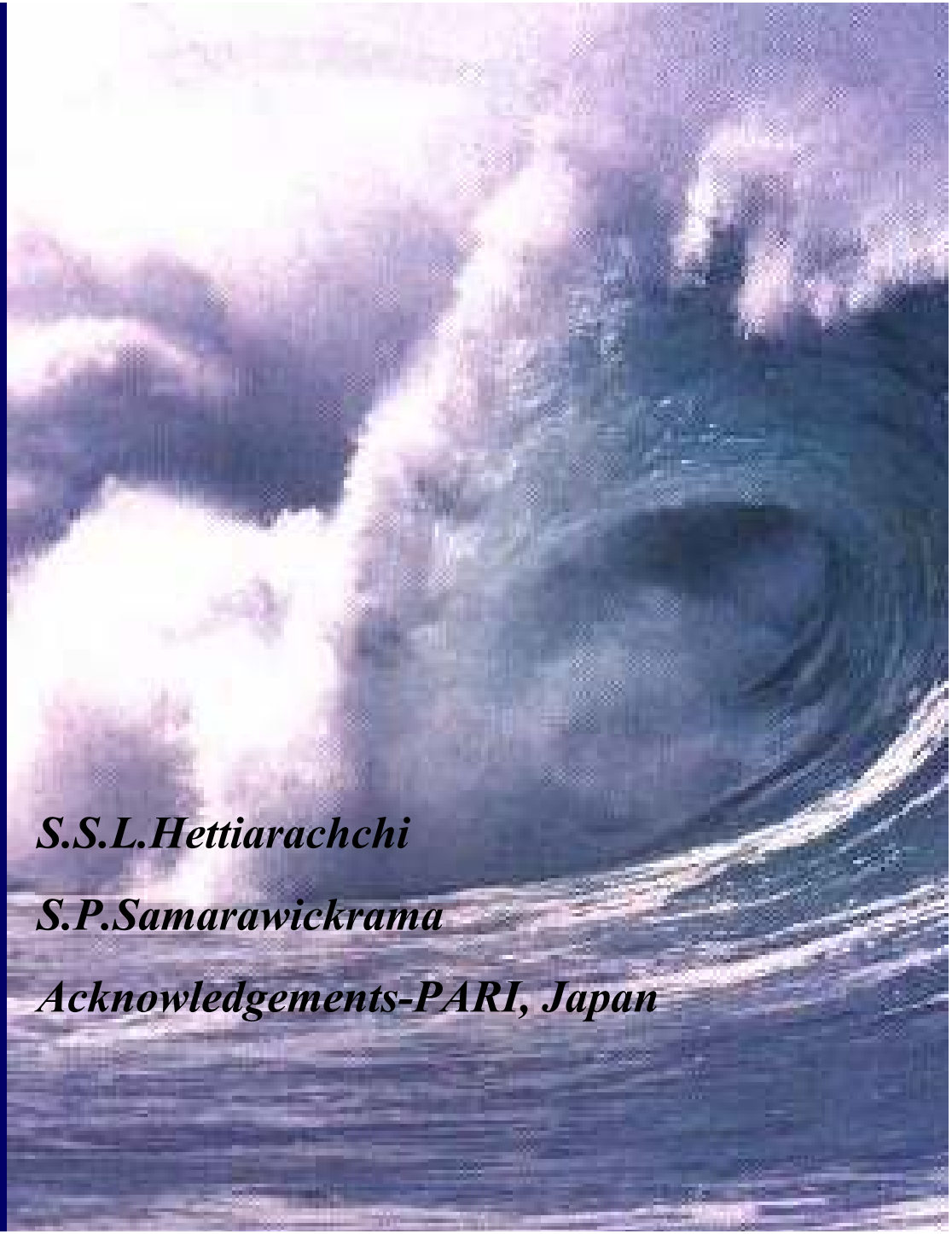
Coastal Hazards and Disaster Risk Reduction

Environmental Options for Coastal Defence

Based on Post Tsunami Research Initiatives



S.S.L.Hettiarachchi

S.P.Samarawickrama

Acknowledgements-PARI, Japan

Overall Strategic Approach

for Coastal Hazard Mitigation

using Artificial and Natural Methods

Multi Hazard Coastal Risk Assessment Framework

…. for coast conservation, protection of lives, coastal ecosystems and infrastructure

Coastal Hazards

Storm Attack

Coastal Erosion,

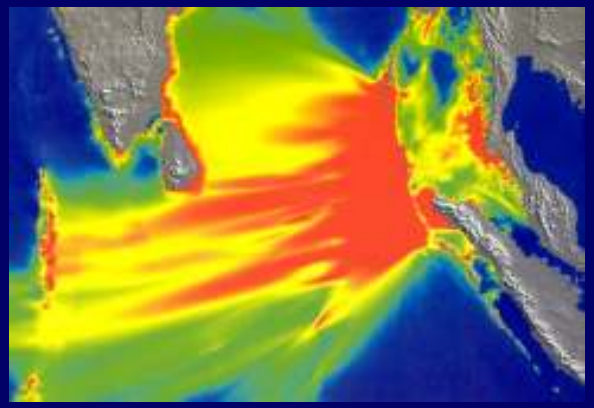
Overtopping and Flooding

Severe Storm Attack,
Cyclones and Hurricanes
(Extreme weather related events)

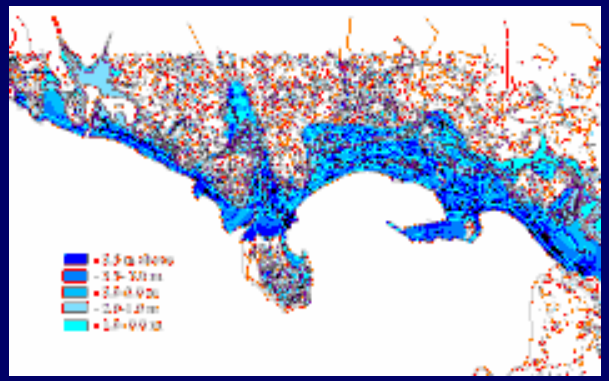
Tsunamis

Oil Spills

Hazard Sources



Regional Exposure



Local Enhanced Exposure

Vulnerability

Preparedness

Risk = Hazard x Vulnerability x Deficiencies in Preparedness

Early Warning and Countermeasures against tsunamis

Promote successful evacuation from tsunamis

- Early Warning System (Local and Regional)
- Public Warning System
- Hazard and Vulnerability Maps
- Set Back
- Evacuation Routes & Structures

Mitigate tsunamis (Mitigation Options)

- Physical Interventions (Artificial, Natural and Hybrid Methods)
- Design Guidelines for exposed infrastructure

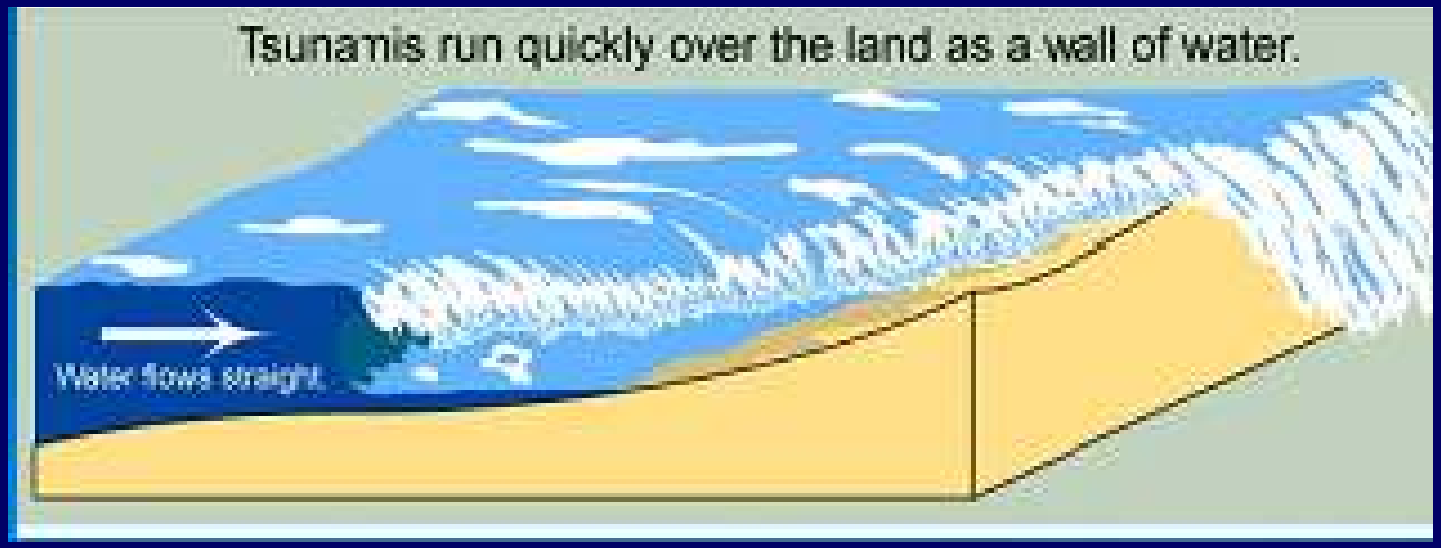
Overall Strategic Approach

Tsunami Mitigation using Artificial and Natural Methods

(1) Reduce the impacts of tsunami waves prior to reaching the shoreline (energy dissipator/ partial barrier in coastal waters)

(2) Protect the coastal zone thus preventing the inland movement of tsunami waves (full barrier on the coastline)

(3) Mitigate the severe impacts of tsunami waves on entry to the shoreline (partial barrier on the coastline)



Tsunami and Offshore Breakwaters

Reduce the impacts of tsunami waves prior to reaching the shoreline.

Revetments,Dikes (High Crest)

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

Revetments,Dikes (Low Crest)

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

/ Coral Reefs & Sand Bars

/ Sand Dunes

/Mangrove Forests

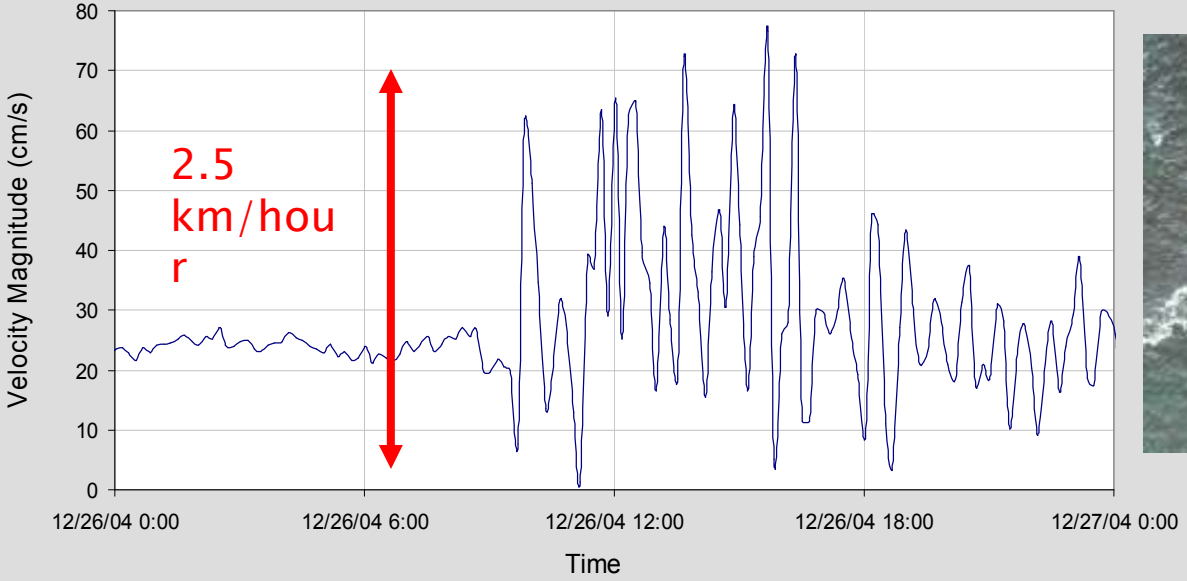
Natural Methods

-Coral Reefs & Sand Bars

-Sand Dunes

-Coastal Vegetation and Mangrove Forests

-Hybrid Solutions
Combination of Natural /Artificial Methods

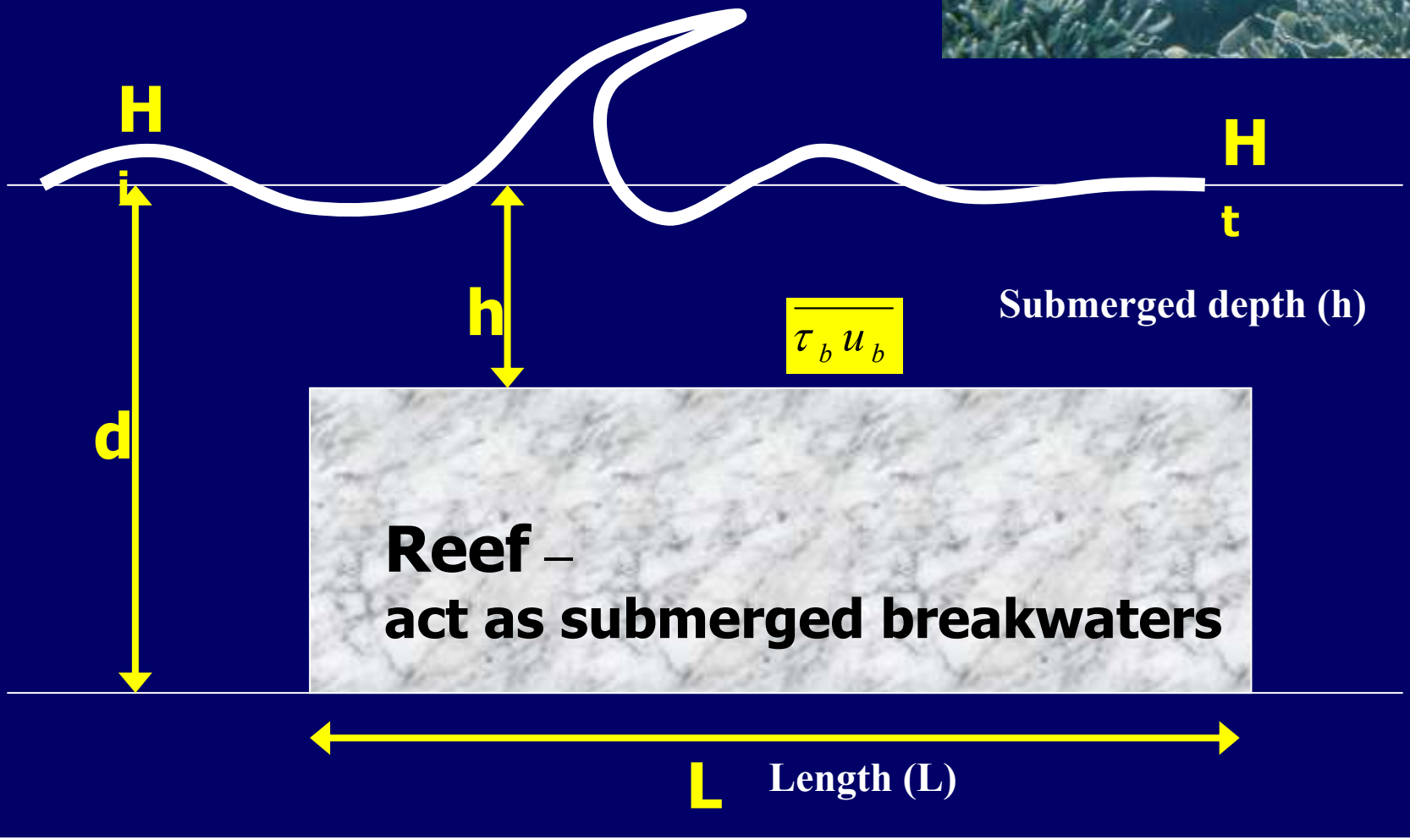


Current Speed

Coral reefs were severely affected and damaged by the debris and sand transported during the inland and shoreward movement of the tsunami wave.

Coral Reefs

Submerged natural breakwaters



Impact of a gap in the reef

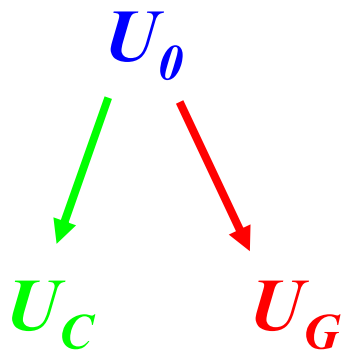
Wave Parameters (U_0, λ, a)

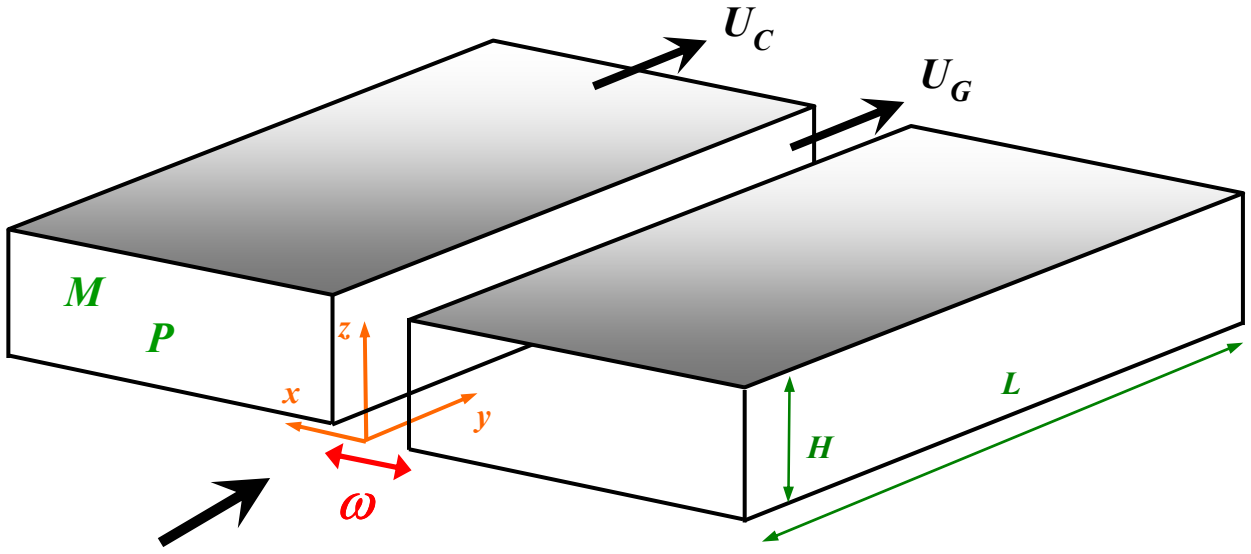
Reef Parameters (M, P, L, H)

Reef Gap (ω)

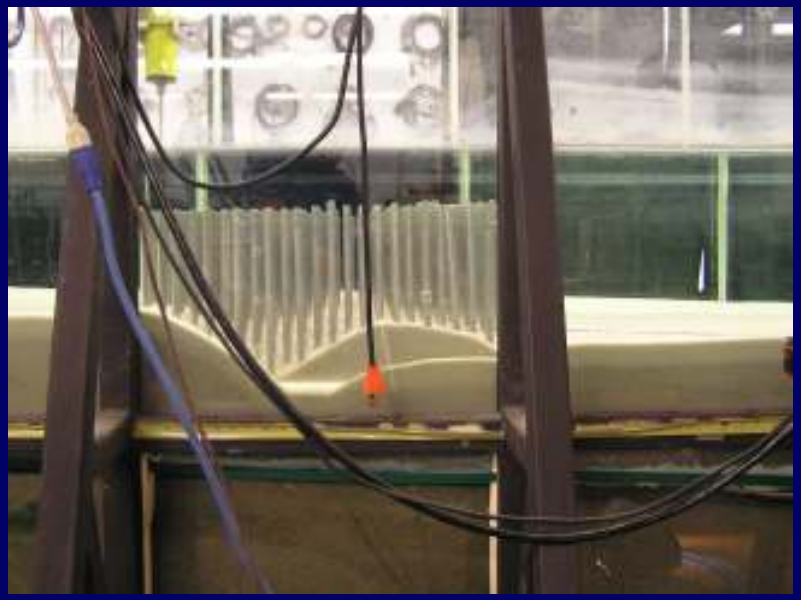
Depth of water (H_0)

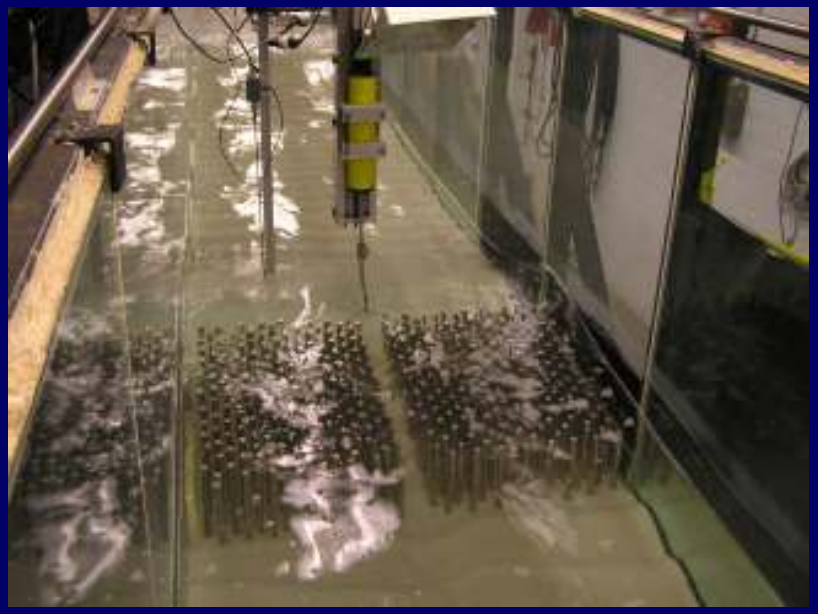
Location (x, y, z)

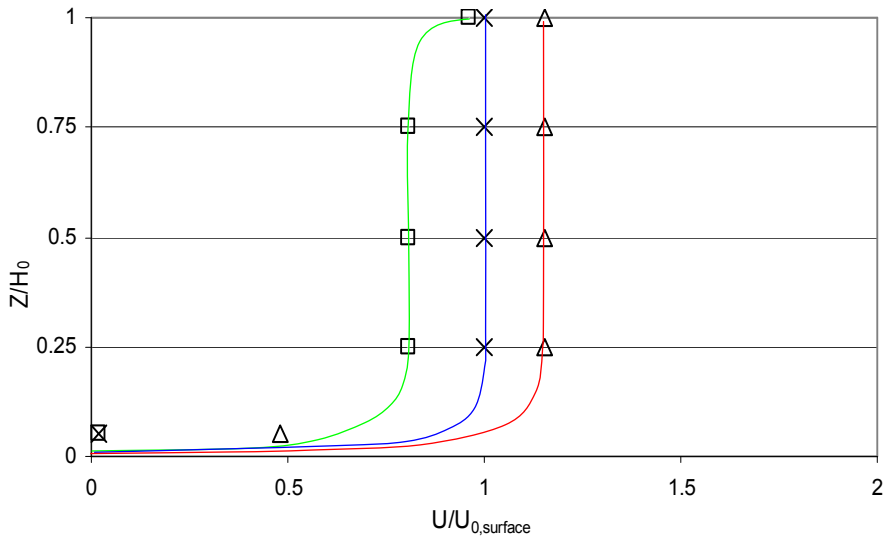


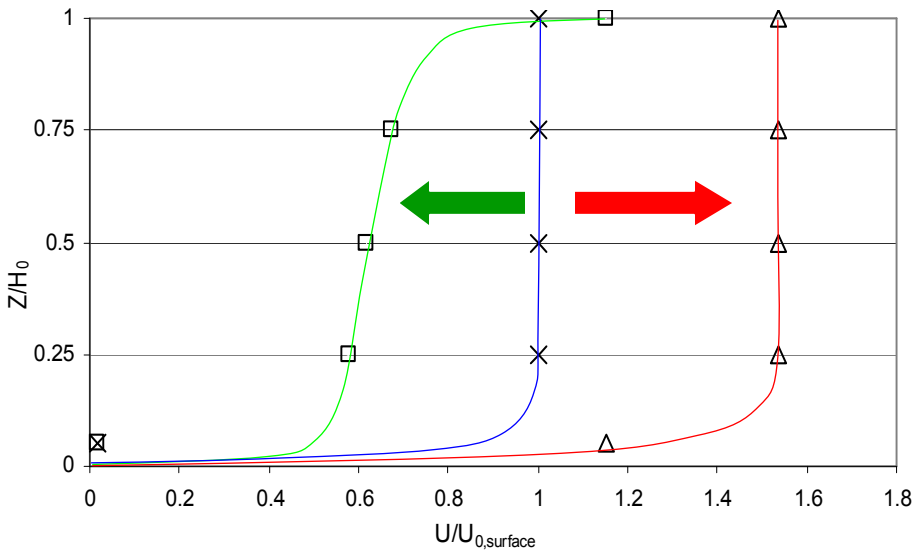


Wave Parameters U_o, λ, a









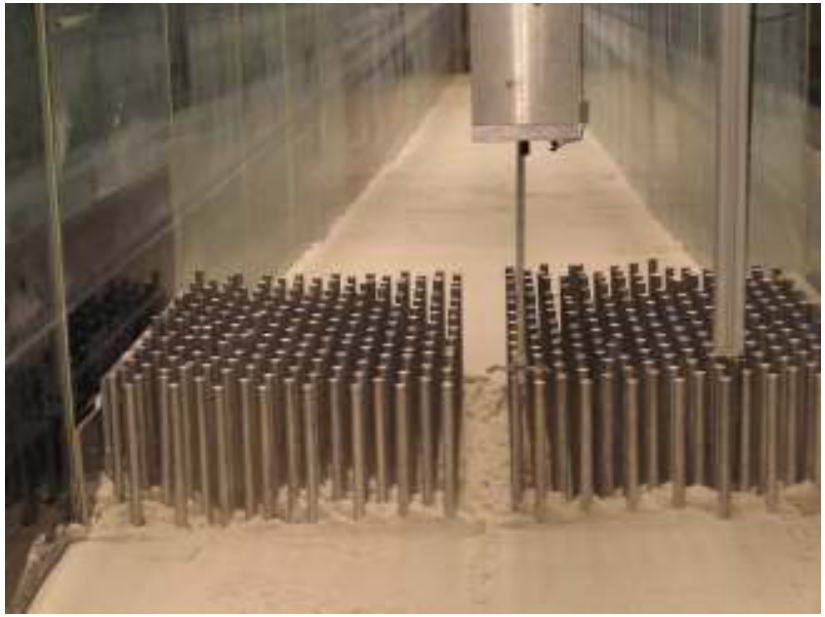
(a) 50% porosity *(b) 20% porosity*

Normalized Velocity as a function of normalized height ***2a = 30cm***

U_0 Velocity without the reef

U_C Velocity behind the reef

U_G Velocity in the reef gap

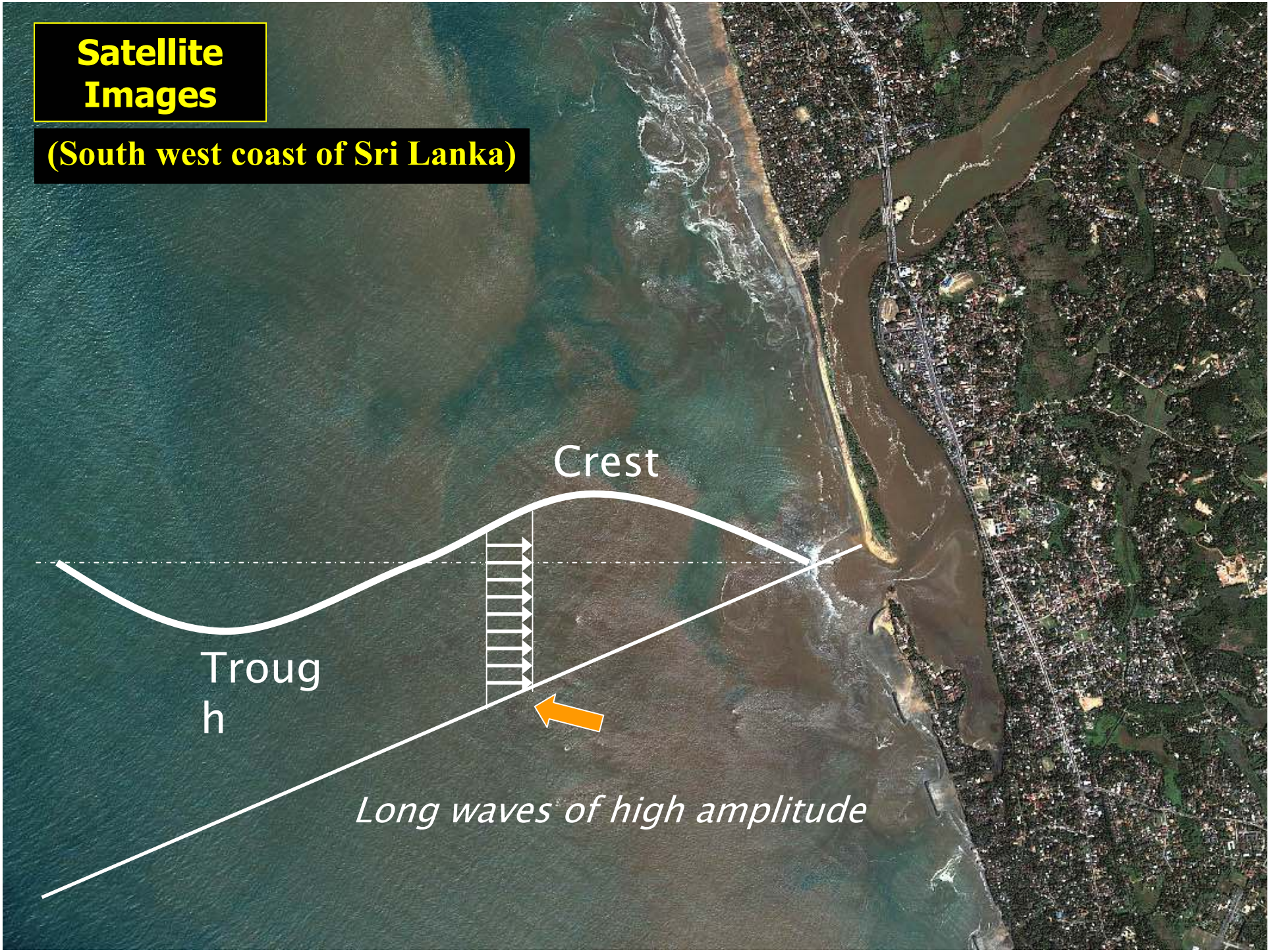


Coastal Vegetation (Mangrove Forests)- Partial Barrier

$$\Delta H = \left(H_1 + \frac{U_1^2}{2g} \right) - \left(H_2 + \frac{U_2^2}{2g} \right)$$

$$i = \frac{\Delta H}{L} = au + bu^2$$

Plant Characteristics and Resilience


Satellite Images
(South west coast of Sri Lanka)
Crest
Troug
h
Long waves of high amplitude

Sediment Transport by the 2004 tsunami at Sri Lanka

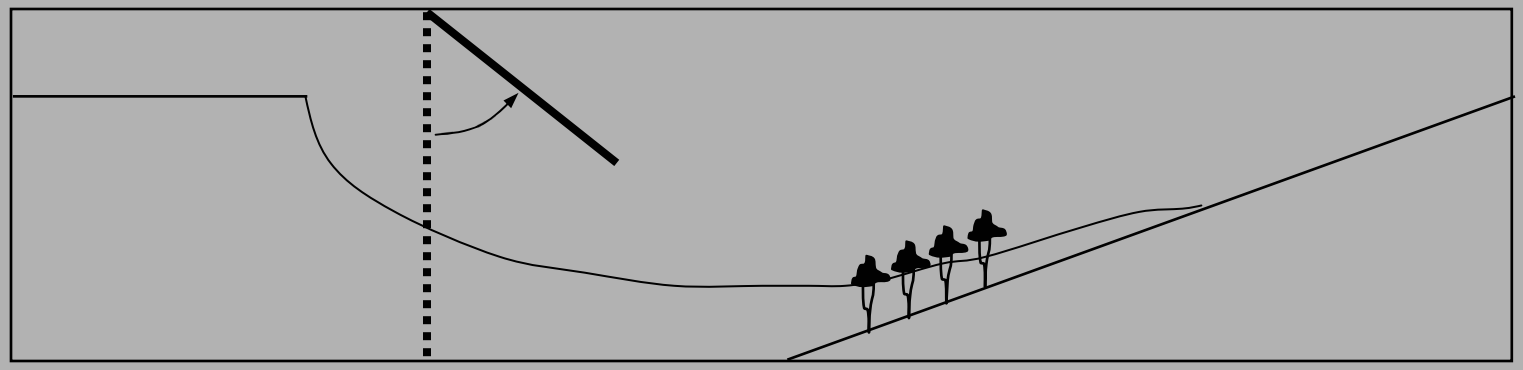
Ongoing Study (Tohoku University)

Sounding surveys were conducted before (December 2004) and after (December

Before Tsunami (2004 Nov - 2004 Dec)

After Tsunami (2005 Nov - 2006 Jan)

Investigations on Coastal Vegetation as Partial Barriers

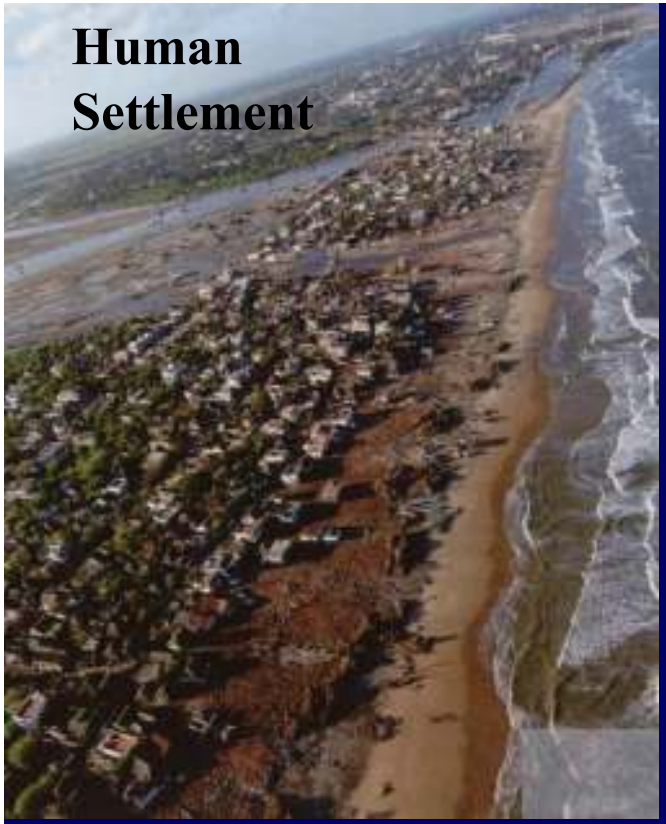


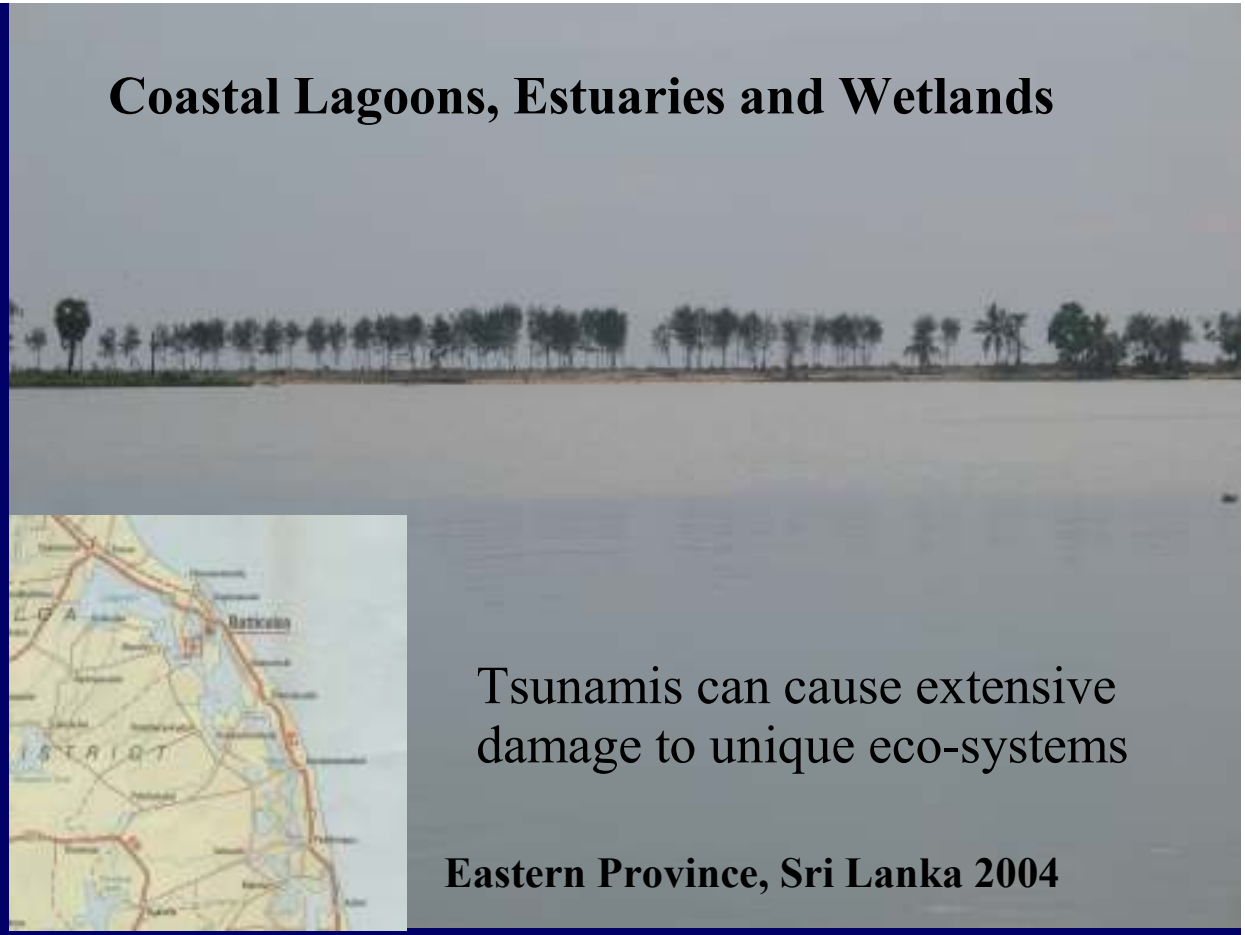
Failure of Rock armoured revetments and movement of rock boulders.

Low Crest Revetments and Dikes

Interlocking concrete units

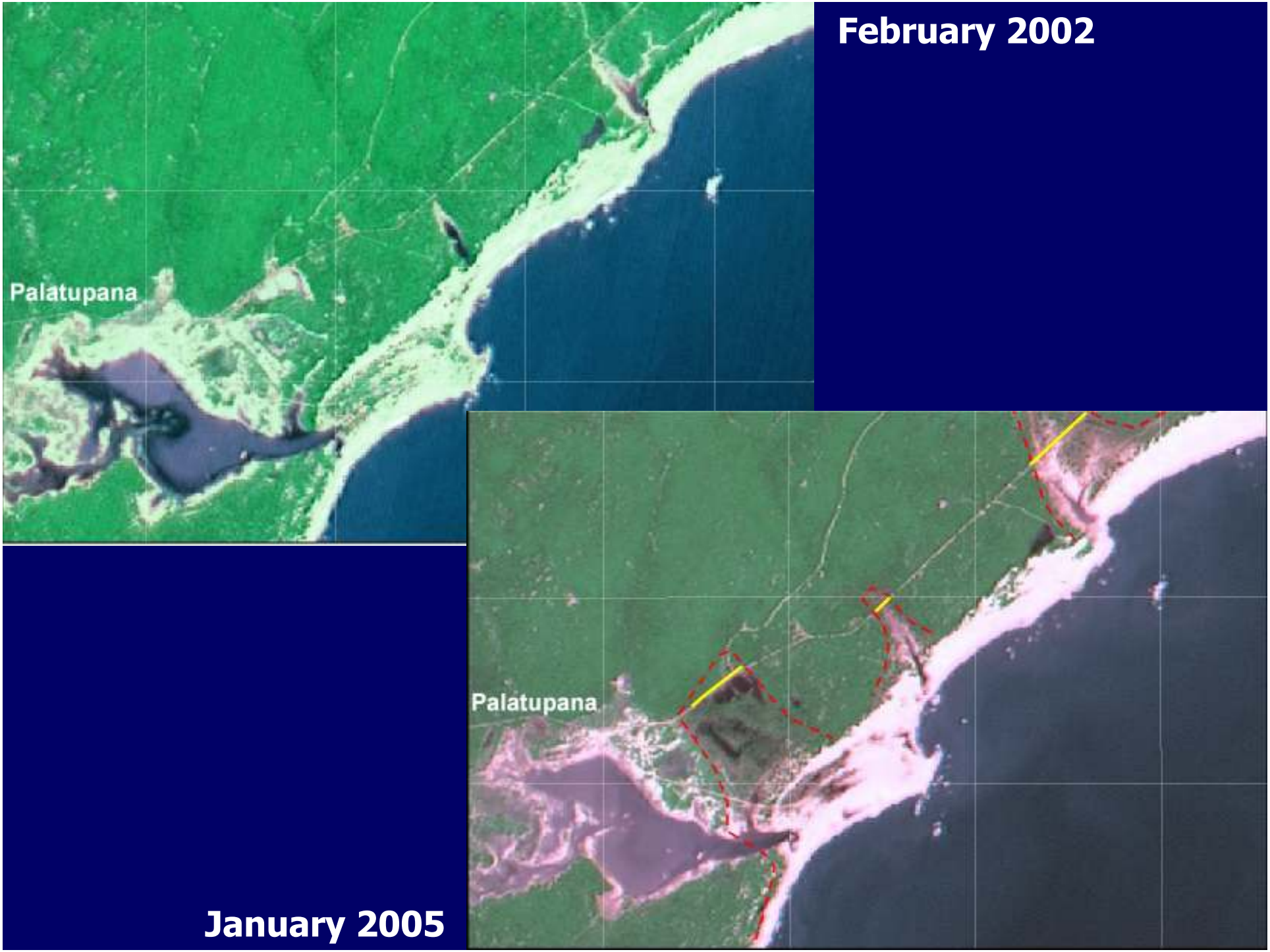
Sand Dunes (High Crest Natural Dikes)





Sand Dunes can be used effectively to protect land, life, ecosystems and infrastructure from excessive overtopping and damage

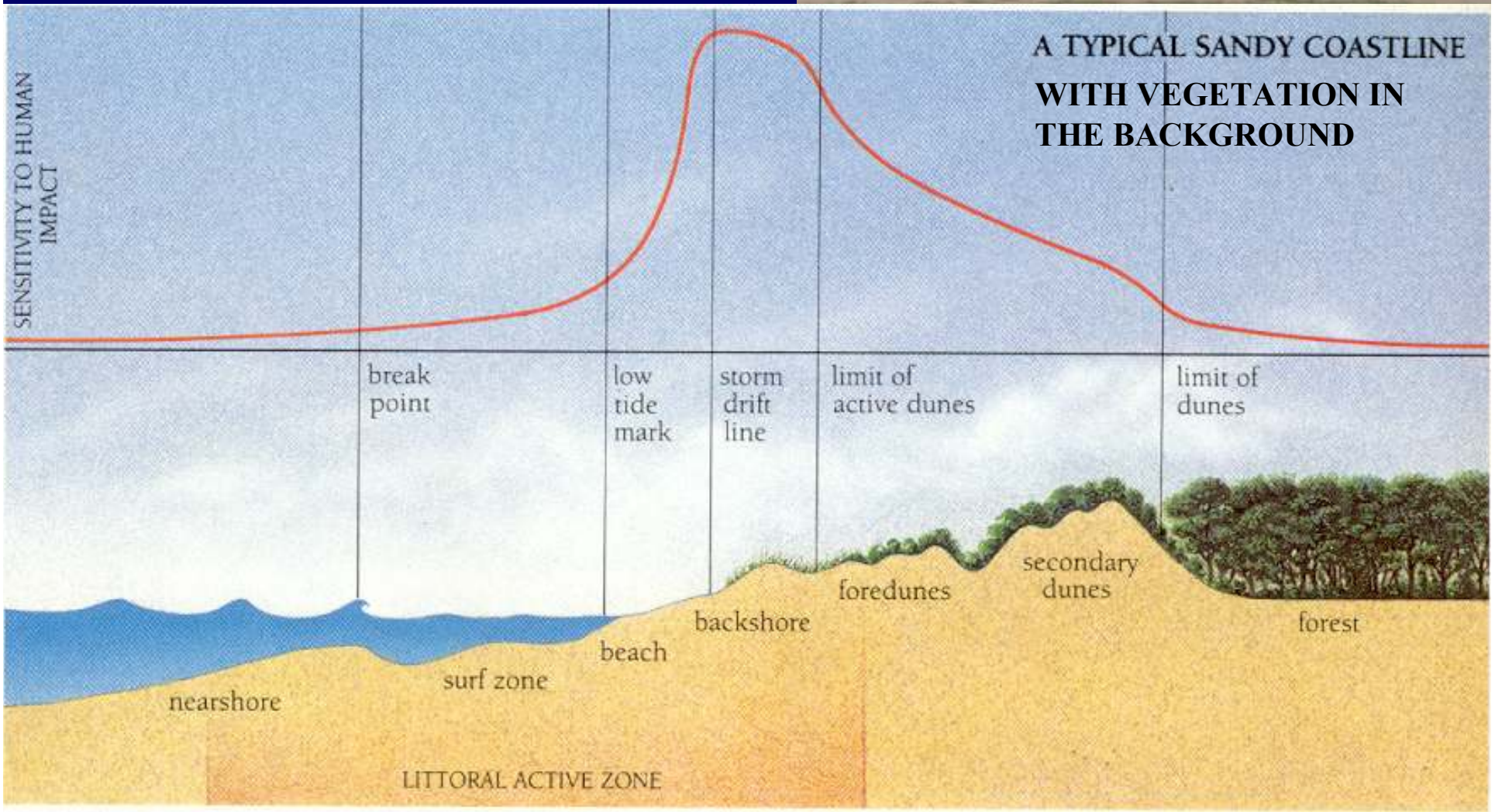
- **Dynamic behaviour of sand dunes (Dune Erosion/Degradation)**
- **Dune Rehabilitation, Construction and Maintenance**


February 2002
Palatupana
Palatupana
January 2005


Safe crest level ?
Breached Depth
Panama – Sand Dunes

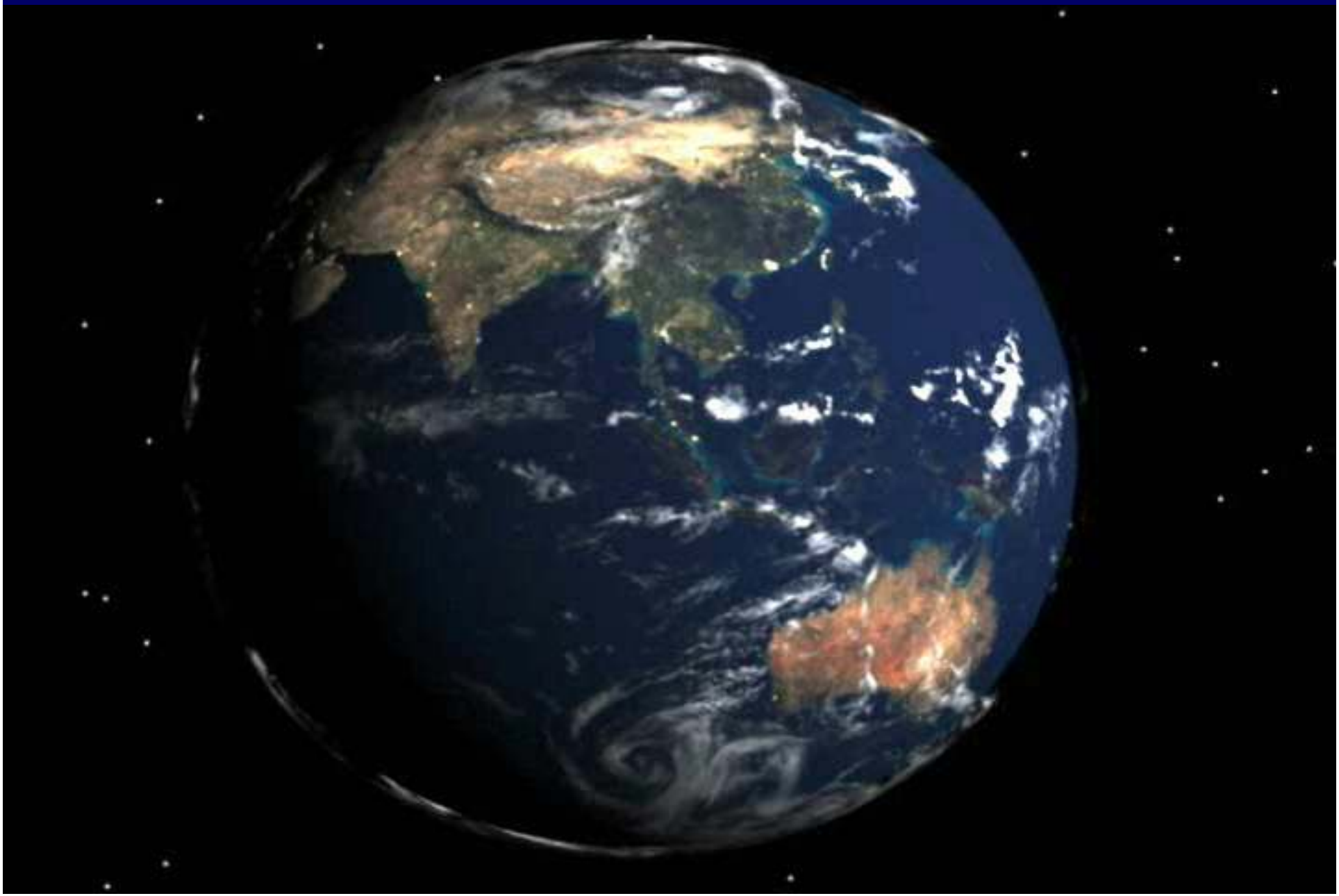
Hybrid Solutions

Sand dunes and Coastal vegetation

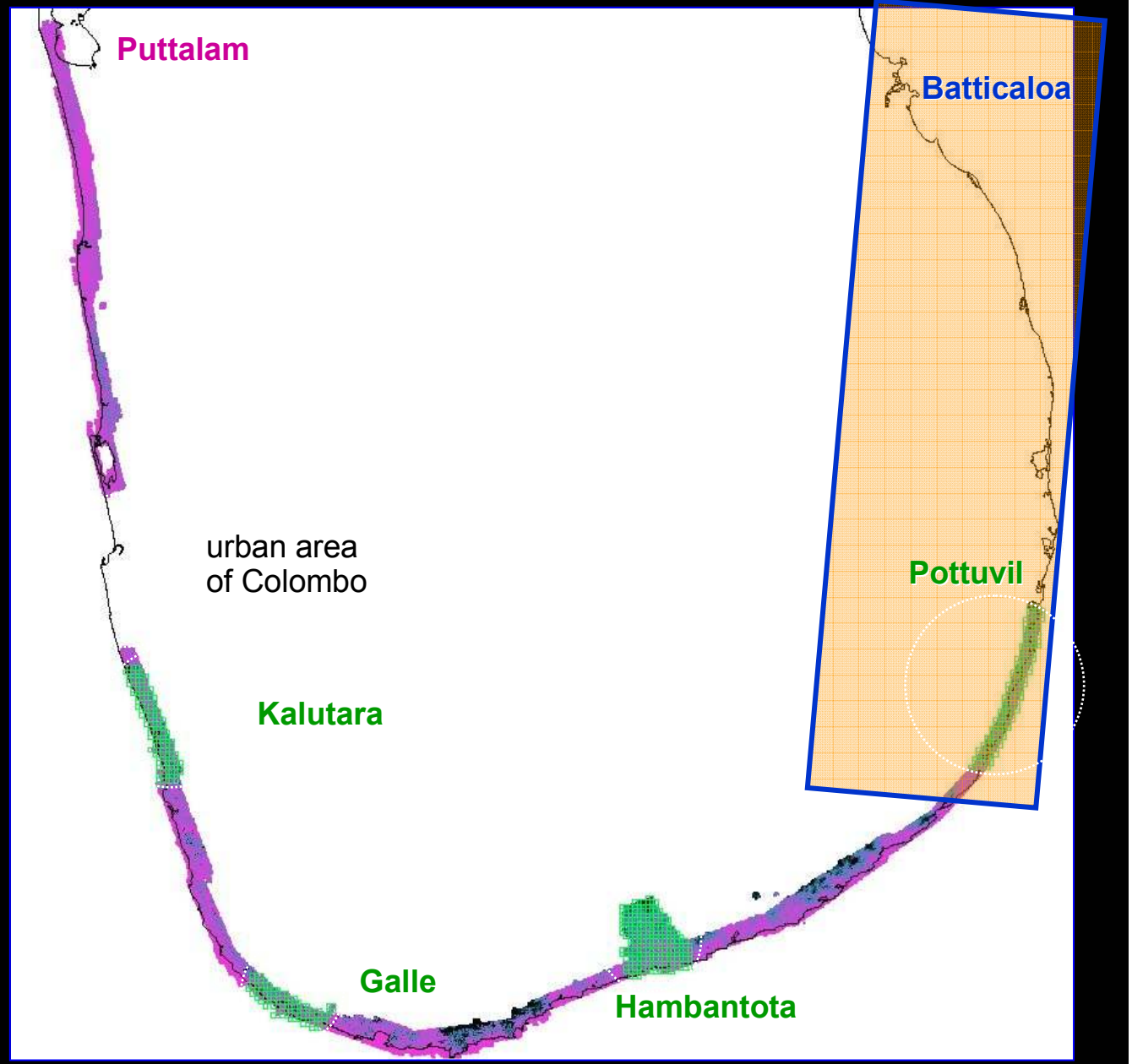



TRINCOMALEE
ANURADHAPURA
POLONNARUWA
KURUNEGALA
DAMBULLA
KANDY
NEGOMBO
COLOMBO
KALUTARA
RATNAPURA
GALLE

Tsunami Simulation- City of Galle- from PARI Japan



"HyperDEM"



Airborne campaign (ready)

Airborne campaign (in progress)

Satellite campaign (acquisition in progress)

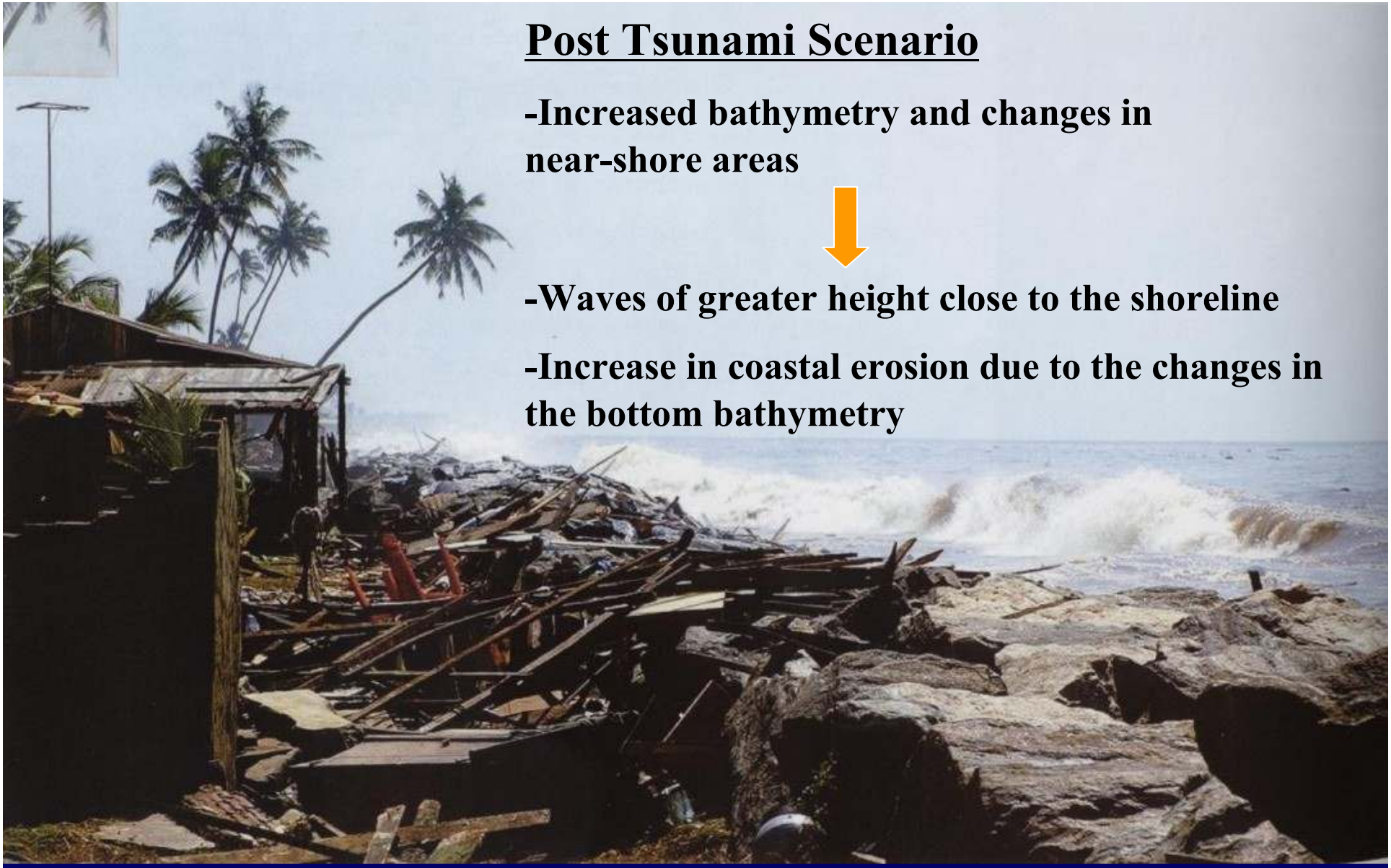
Project “HyperDEM”

Galle (Sri Lanka)

Full 3-D reconstruction of the urban area of Galle. In foreview, the Dutch Fort

Tsunami attack on wooden house and impact on people

Tsunami attack on house and impact on people
Collaboration with PARI, Japan



Post Tsunami Scenario

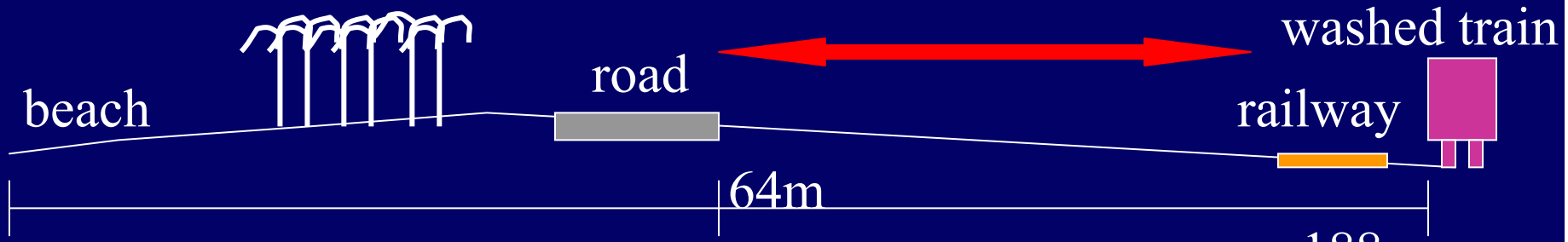
-Increased bathymetry and changes in near-shore areas

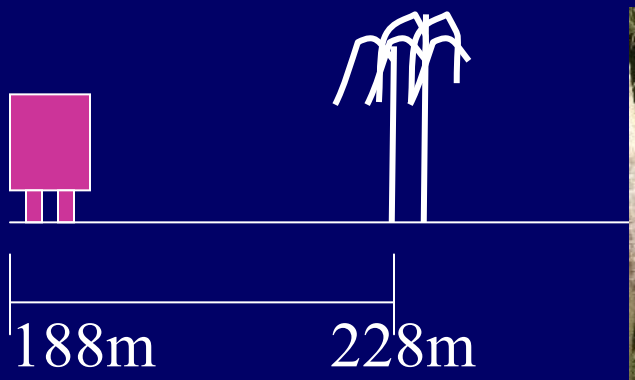
-Waves of greater height close to the shoreline

-Increase in coastal erosion due to the changes in the bottom bathymetry

Issue- **Sloping surface**

Hikkaduwa






Hikkaduwa Train Tragedy
Source: Port and Airport Research Institute, Japan

- Increase in velocity
  - 20% - 50%
- Increase in Impulsive Bore Pressure
  - 100% - 150%
- Increase in Sustainable Pressure
  - more than 100%
- Water tends to stay longer