Task Team NEW EMERGING TECHNOLOGIES (NET)

Meeting of ICG/IOTWMS WG-2: Tsunami Detection, Warning and Dissemination

Wahyu W. Pandoe
Chair of TT New Emerging Technologyn
National Research and Innovation Agency (BRIN)
wahyu.widodo.pandoe@brin.go.id

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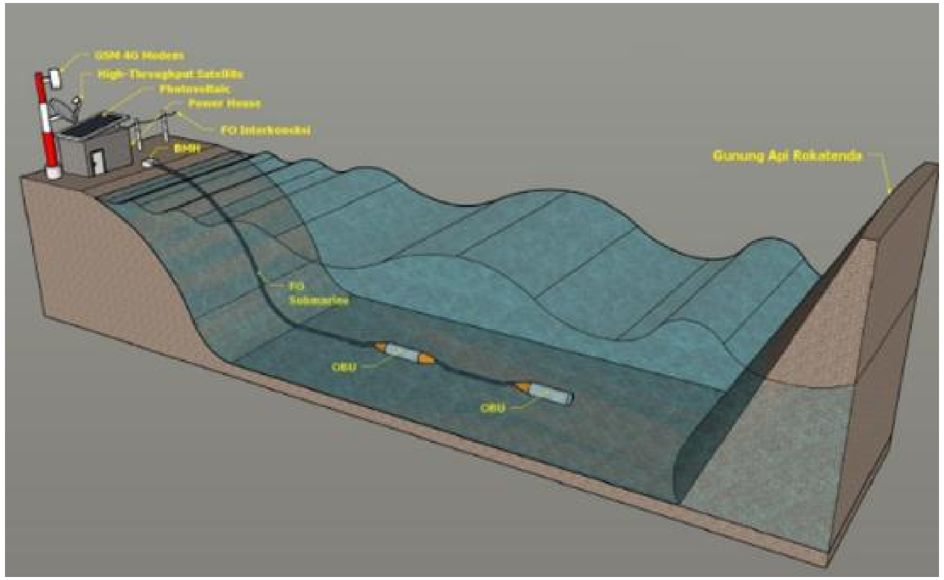
Content:

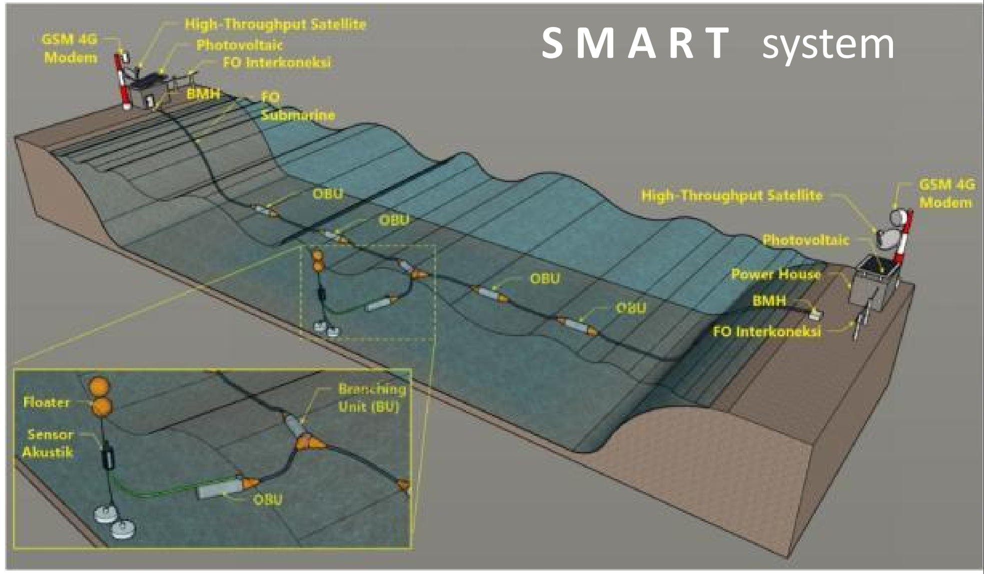
Recent (new) Technologies:

1. Ina-CBT (Indonesian Tsunami Early Warning System, stage-2)
2. SMART Cable
3. Distributed Acoustic Sensing (DAS)
4. Research on Acoustic Sensing -- "Listening Tsunami and or Disaster"
5. Hybrid system
6. Numerical Model
7. Physical Model

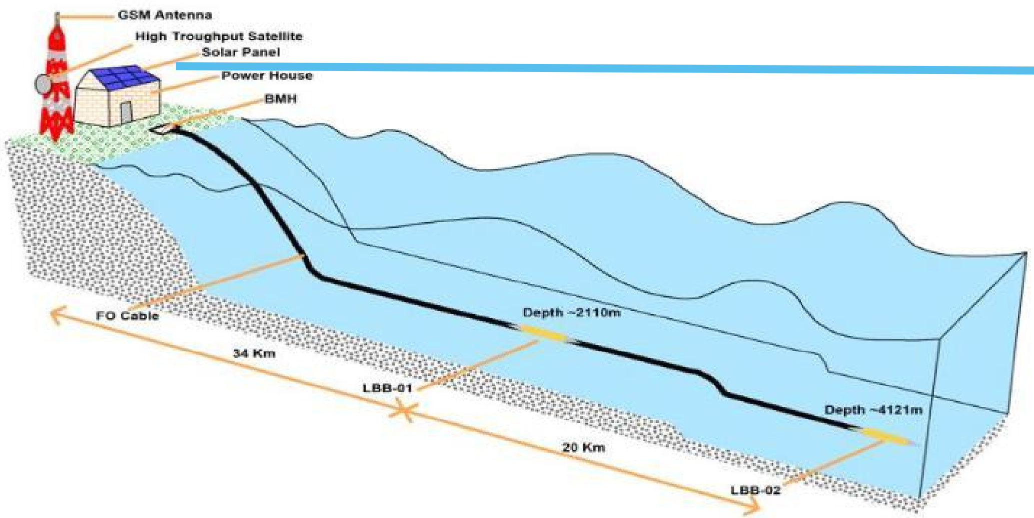
1. InaCBT : Cable-Based Tsunami sensors (CBT)



- Effective for Near Field and Atypical Tsunami
- Can be integrated with ocean bottom seismic sensors (OBS)
- High data sampling rate
- Fast data transmission
- Life time expectation > 20yrs,
- no need yearly regular maintenance except the Landing Station
- NO vandalisms
- International efforts:
  - SMART Cable System (JTF WMO-IOC-ITU)
  - Japan: S-NET, DONET
  - USA: MARS Landing System
  - Indonesia: InaCBT
  - India:: Nicobar islands



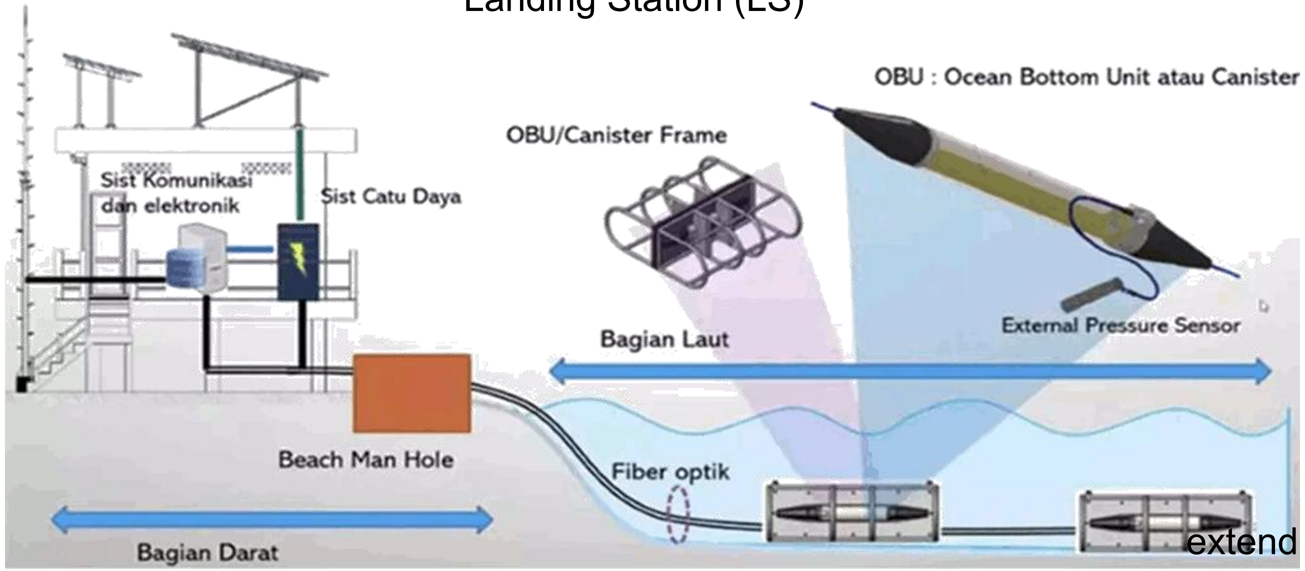
1. InaCBT



Landing Station (LS)

Location: Labuan Bajo – FLores Sea.

- Deployment: February 2022
- Operating since: February 2022
- Sensors (now):
  - ❑ Hydrostatic Precise Pressure Gauge (1Hz)
  - ❑ 3D Accelerometer (125Hz)
  - ❑ Temperature

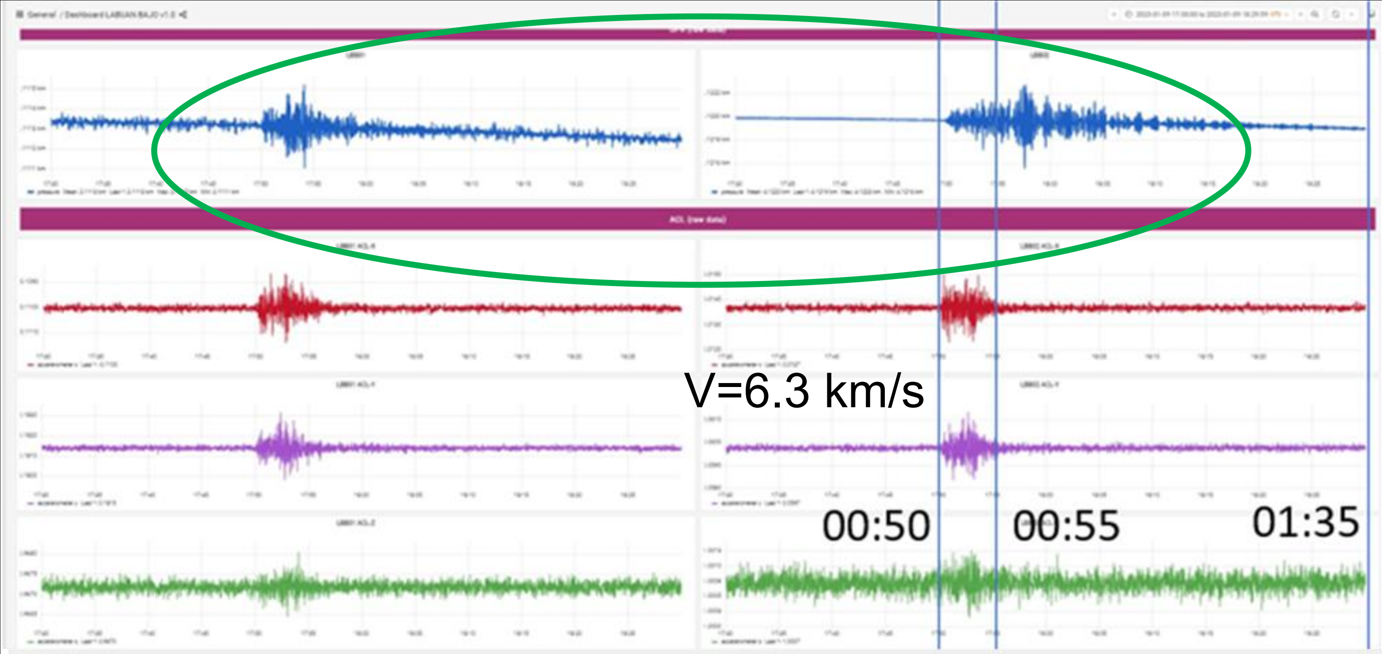


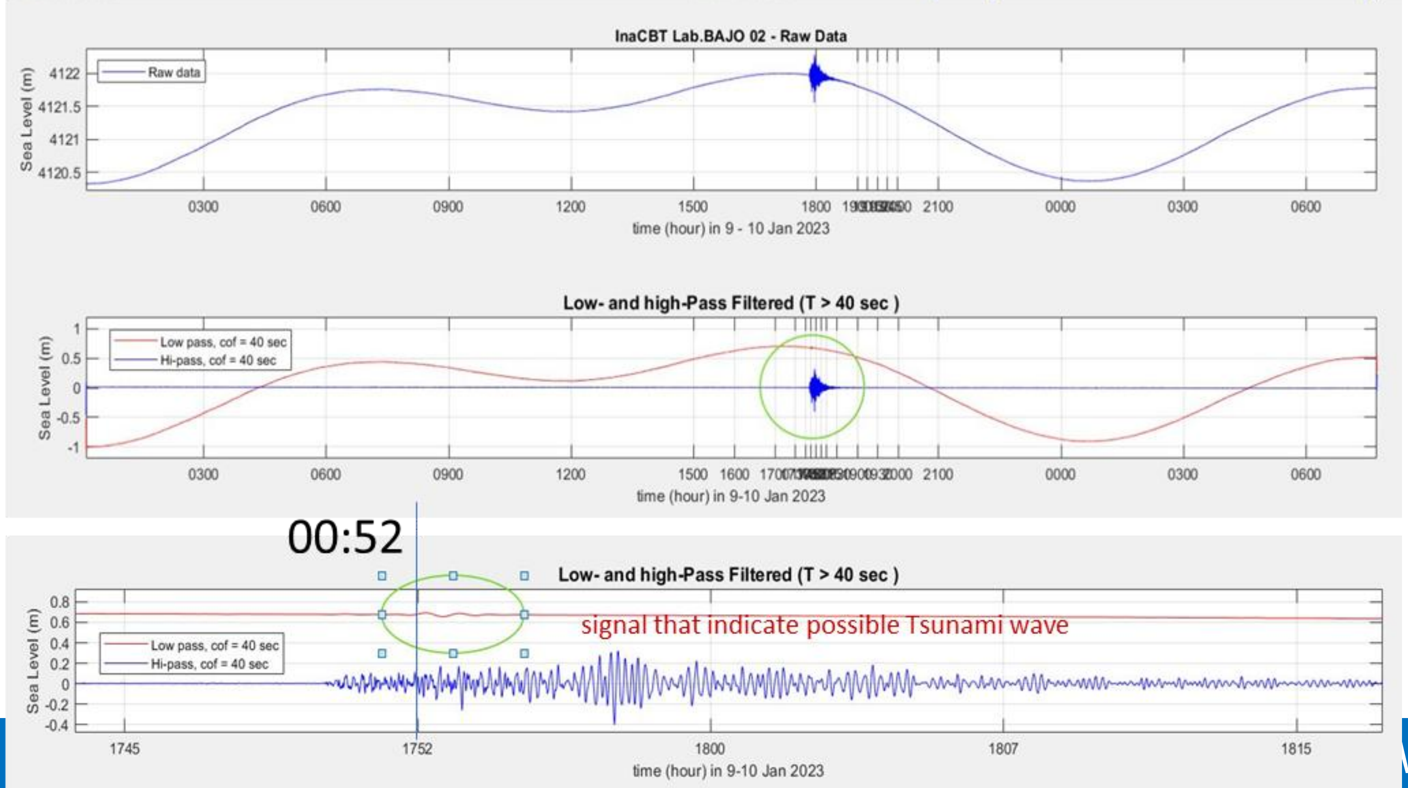
extend to 2nd LS (optional)

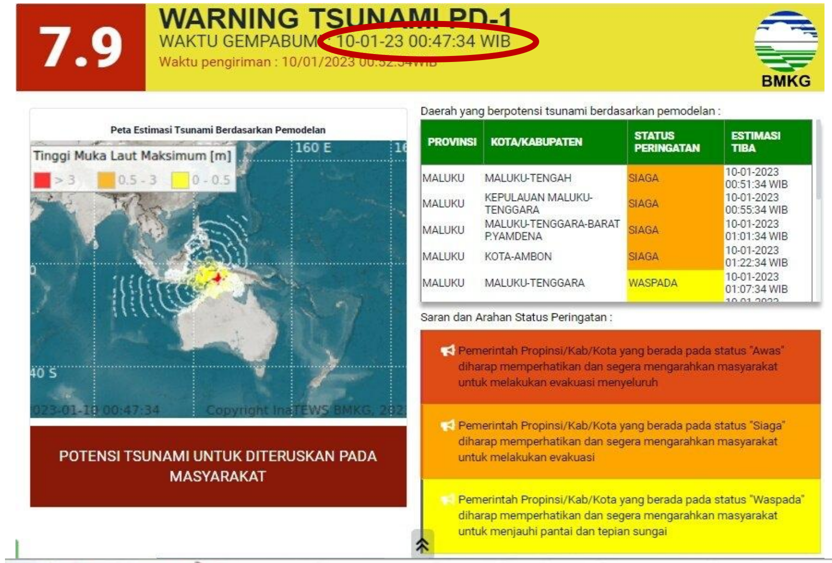
M7.9 Banda EQ

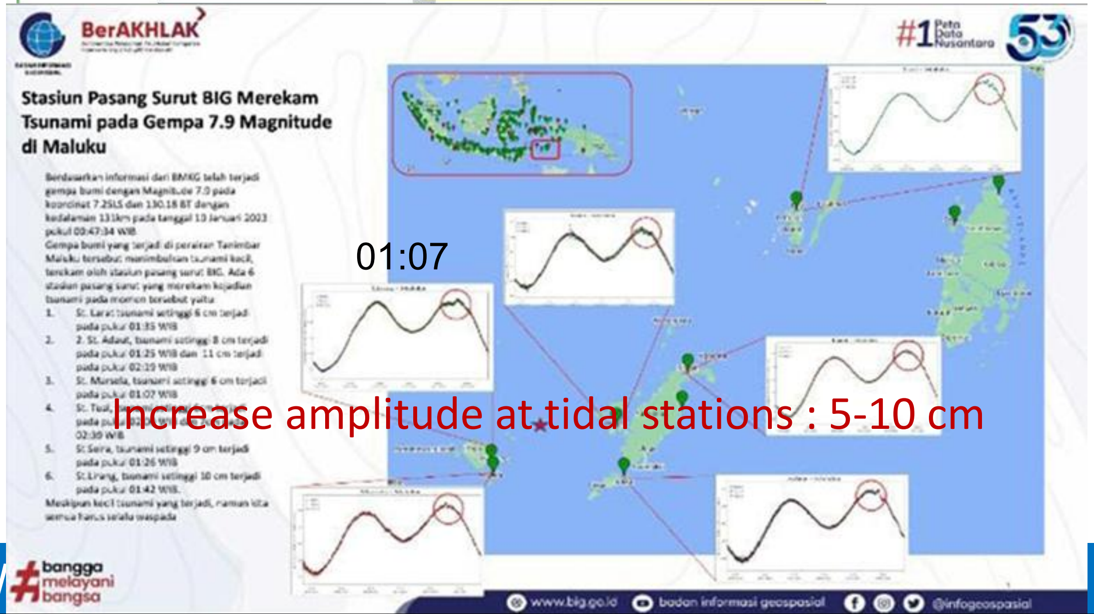
Jan 09 2023 17:47:34 UTC

Distance Epicenter – Sensor : 1130 km









M7.9 Banda EQ

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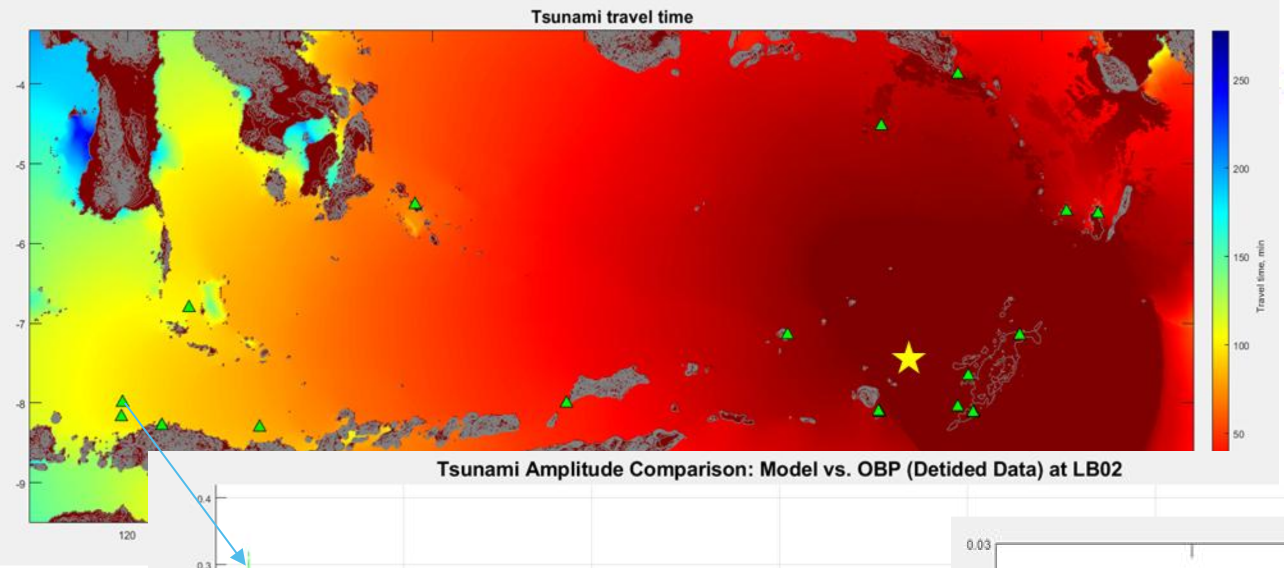

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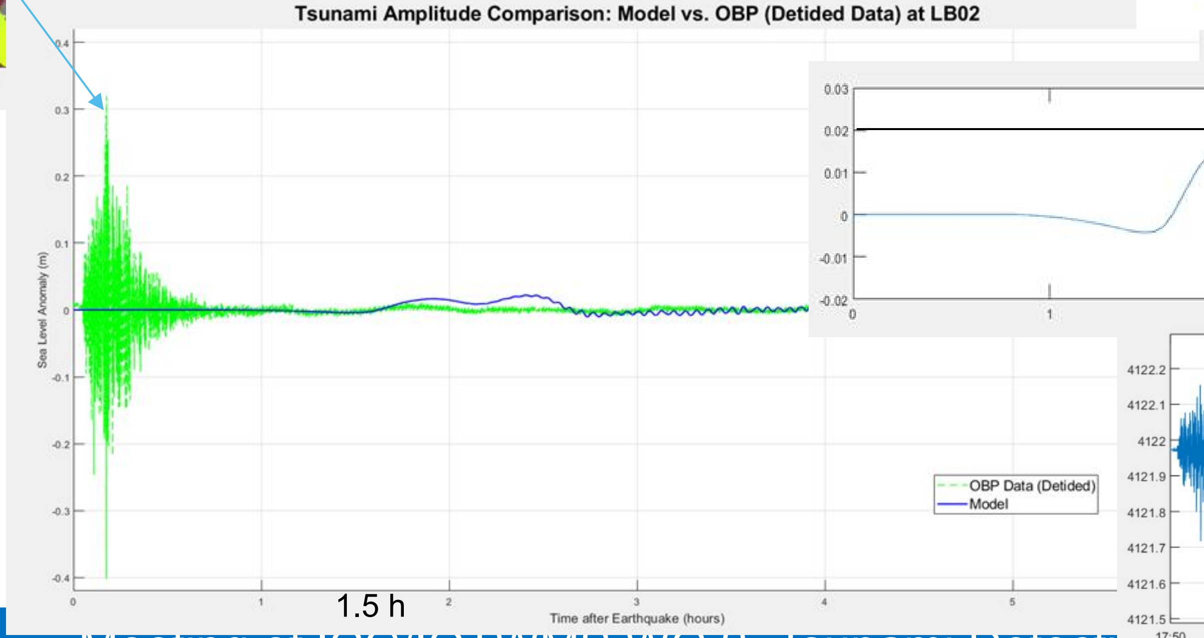
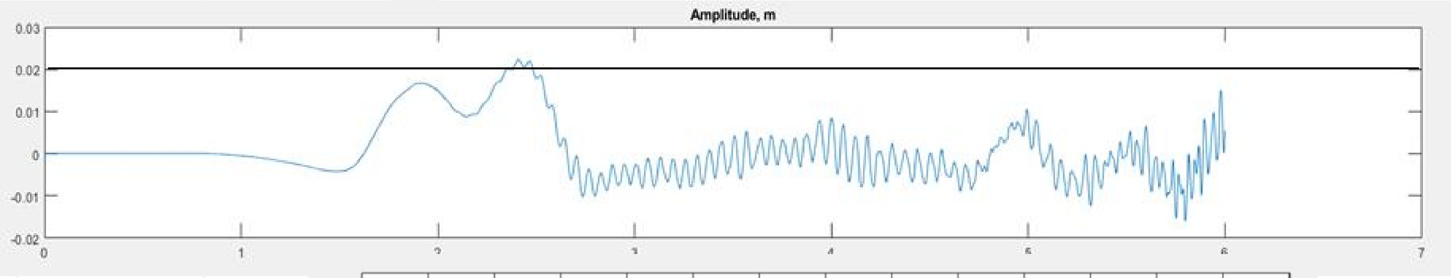
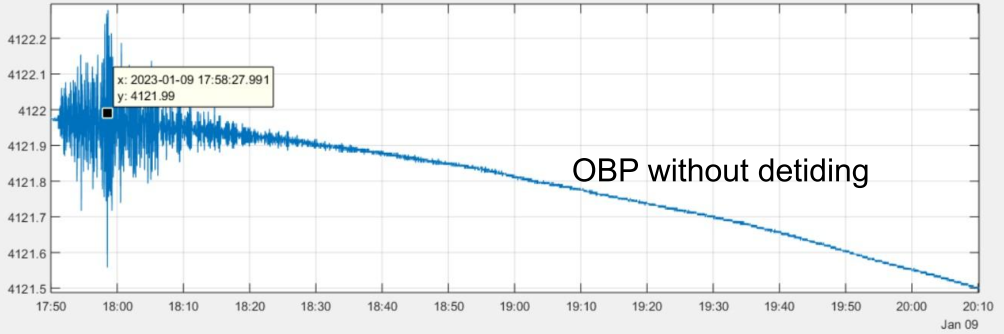
Date: 2023/ 1/ 9   Centroid Time: 17:47:47.3 GMT
Lat=  -7.19   Lon= 130.03
Depth= 92.4   Half duration=16.1
Centroid time minus hypocenter time: 12.3
Moment Tensor: Expo=27  2.680 -2.540 -0.139 -0.176 1.550 1.940
Mw = 7.6    mb = 0.0    Ms = 7.6   Scalar Moment = 3.6e+27
Fault plane:  strike=94    dip=43   slip=50
Fault plane:  strike=323    dip=59   slip=121
```







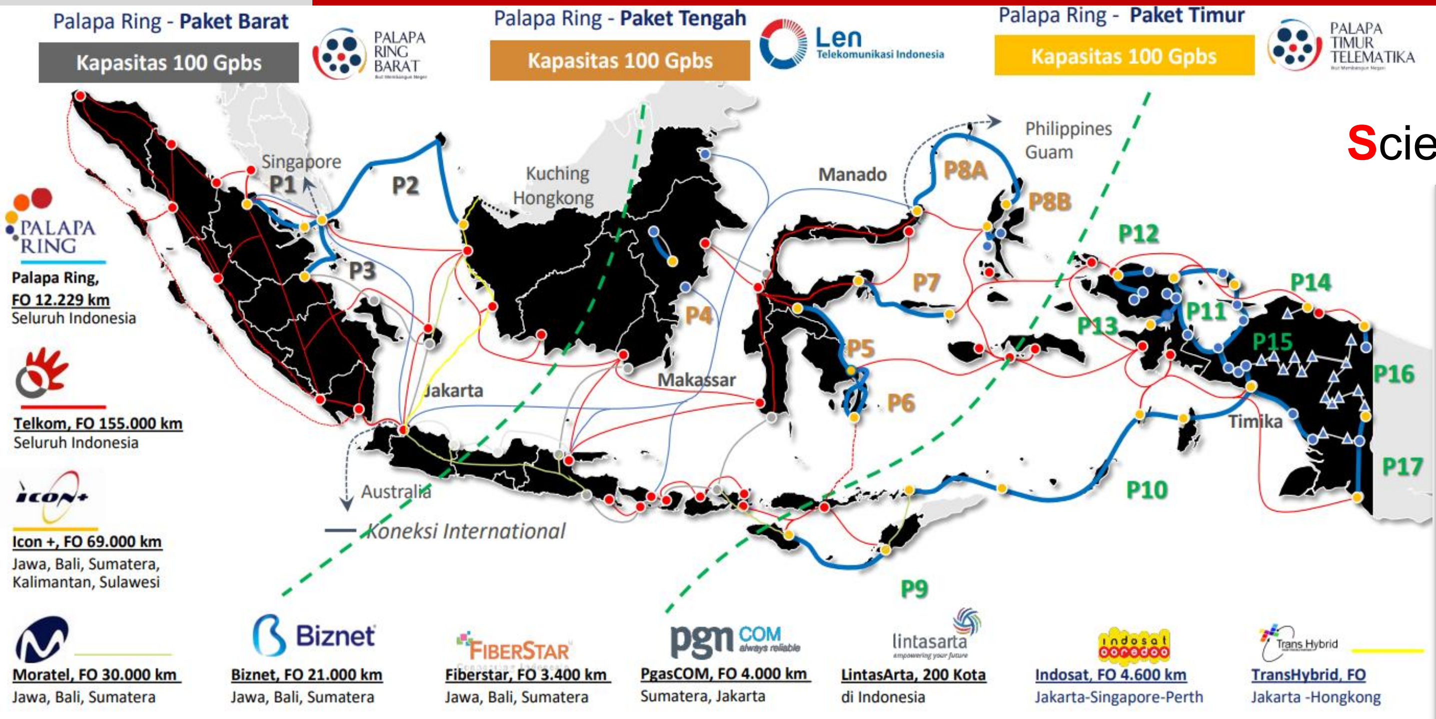
OBP without detiding

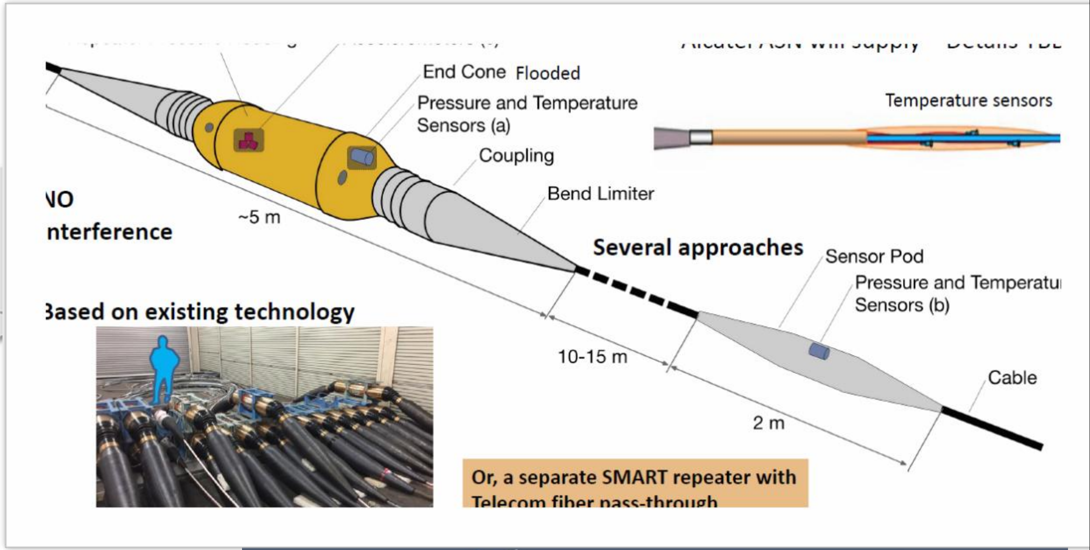
2. SMART Cable

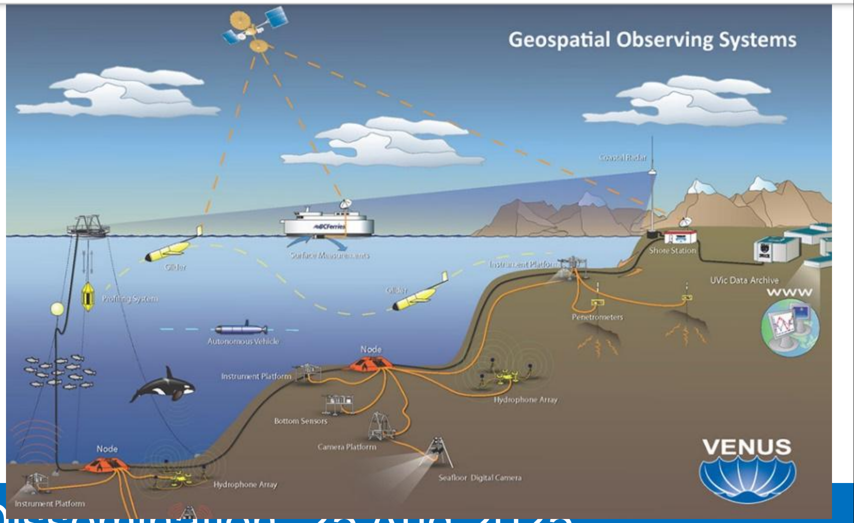
Cable-based Ocean Observation: **IOC-UNESCO, ITU**

SMART system

Scientific Monitoring and Reliable Telecommunication

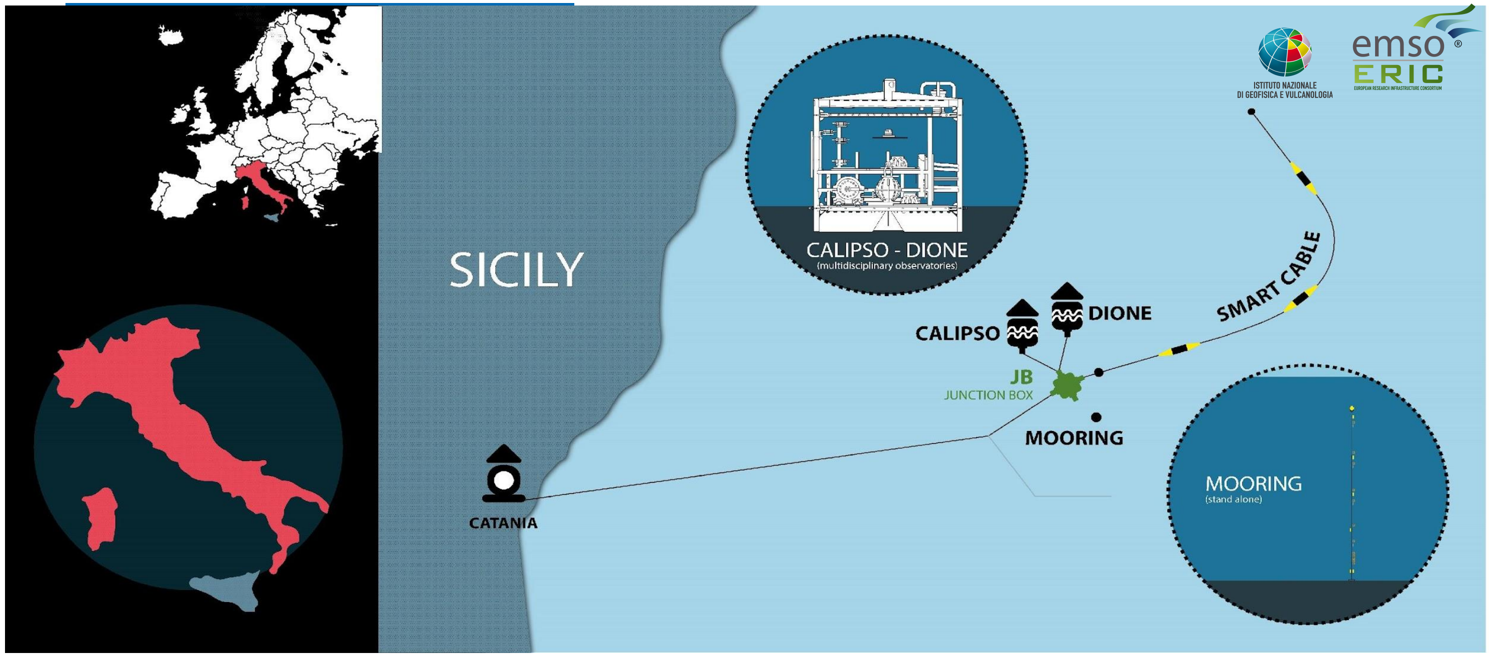






- To use the underwater (UW) telecommunication cables crossing the oceans and waters to become the network of real-time data for disaster mitigation and environment monitoring system.
- Three United Nations agencies: ITU, WMO, and IOC-UNESCO have arranged a Joint Task Force (JTF) established in 2012, aims towards incorporating environmental monitoring and tsunami sensors into trans-oceanic submarine cable systems → SMART cable system.
- No underwater telecommunications monitoring system is in place today.

InSEA wet demo SMART cable



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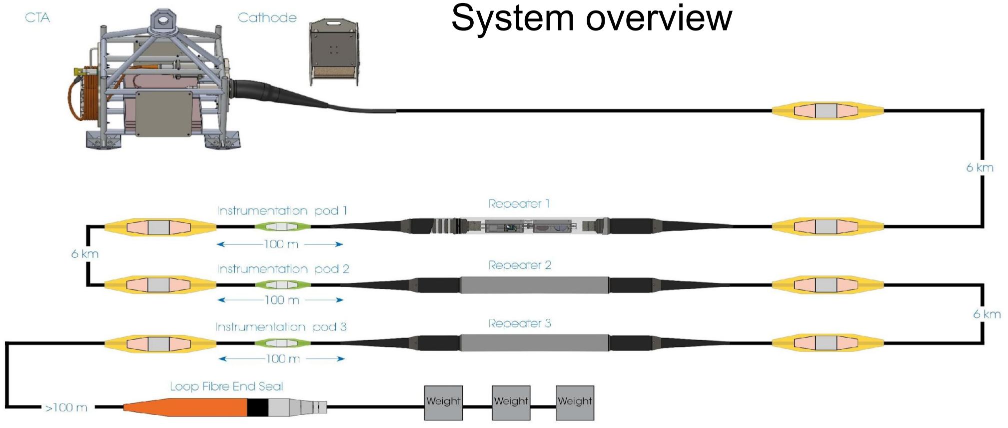
System overview



SMART Cables integrate sensors into submarine telecommunications cables to measure seafloor temperature, pressure, and seismic motion (SMART modules)

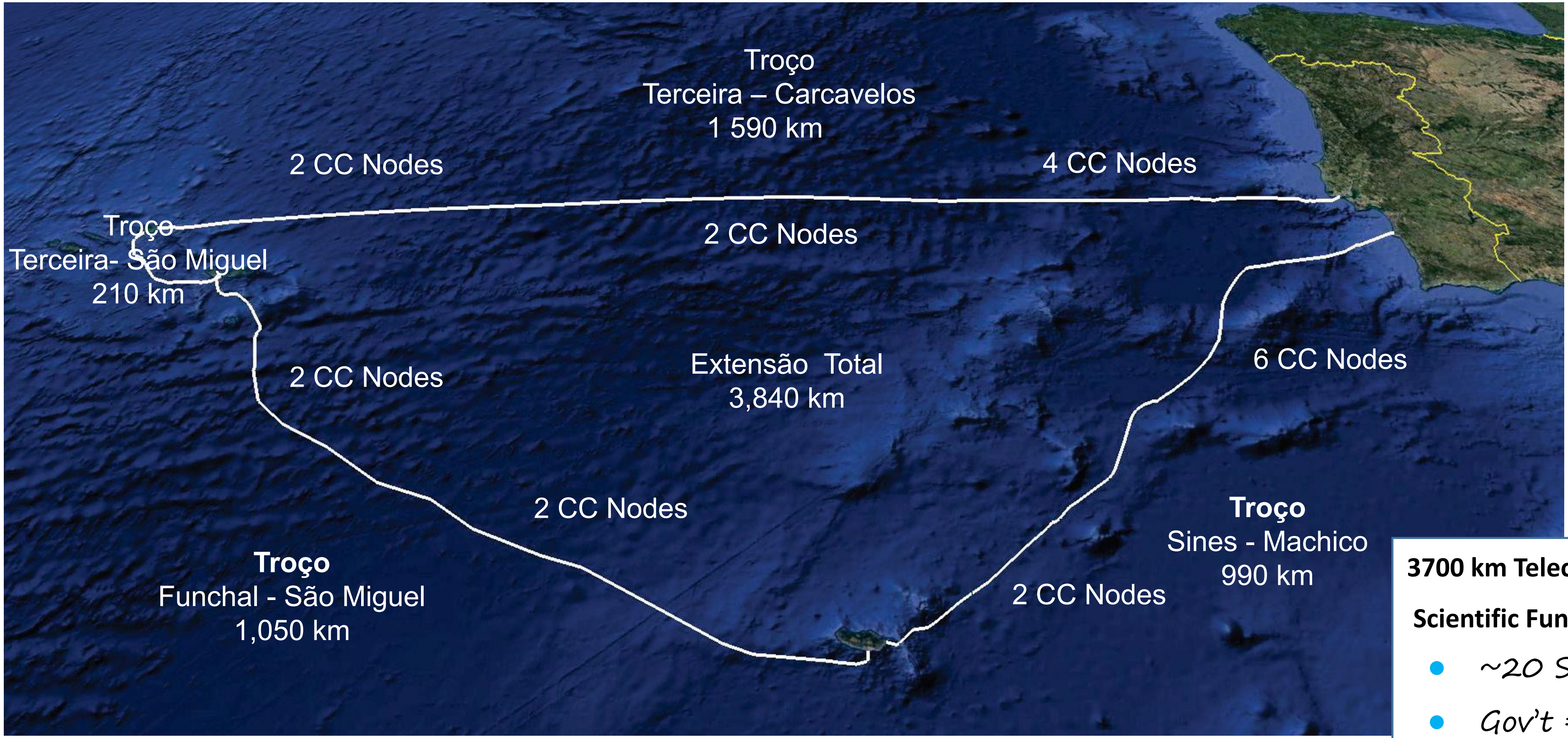
Instrument pod:

Seabird SBE 39Plus

Paroscientific 8000 Series

Infraestruturas de Portugal

Atlantic CAM
Physical Layout



3700 km Telecom Cable

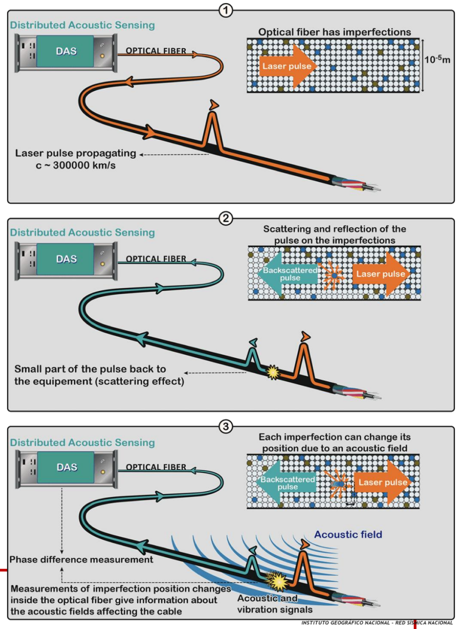
Scientific Funding :

- ~20 SMART modules
- Gov't €154M. EU support €56M
- Other sensing techniques

3. Distributed Acoustic Sensing (DAS)

Applications:

- **Earthquake and Tsunami Monitoring** → Detecting earthquakes or volcanic activity using undersea cables. Detects P-waves (fast seismic waves) before damaging S-waves arrive. Example: DAS has been used on existing submarine telecom cables to detect earthquakes in Alaska, Japan, and California.
- **Oceanography** → Monitoring ocean currents, ocean swell, internal tides, infragravity waves, storms, and interactions with the seafloor.
- **Marine Mammal Tracking** → Listening for whales and dolphins without dedicated hydrophones.
- **Traffic Monitoring** → Detecting vehicle movement near buried telecom cables.



How does it work:

- Interrogator Units send a laser pulse into an optical fiber.
- Small imperfections in the fiber cause the light to scatter back (Rayleigh Backscatter)
- If the fiber is disturbed (e.g., by sound, vibration, movement, or pressure changes), the backscattered signal changes.
- By analyzing these changes, it's possible to measure vibrations along the fiber in real time

3. Distributed Acoustic Sensing (DAS)

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Feature	DAS (using fiber)	Recent Seismometers/ Hydrophones
Coverage	100s of km	Point-based
Installation cost	Low (uses existing cables)	High (new sensors + maintenance)
Data density	Very high (every few meters)	Sparse grid
Power requirement	Only at one end (interrogator)	Each sensor needs power
Applications	Multi-variables	Usually single-purpose

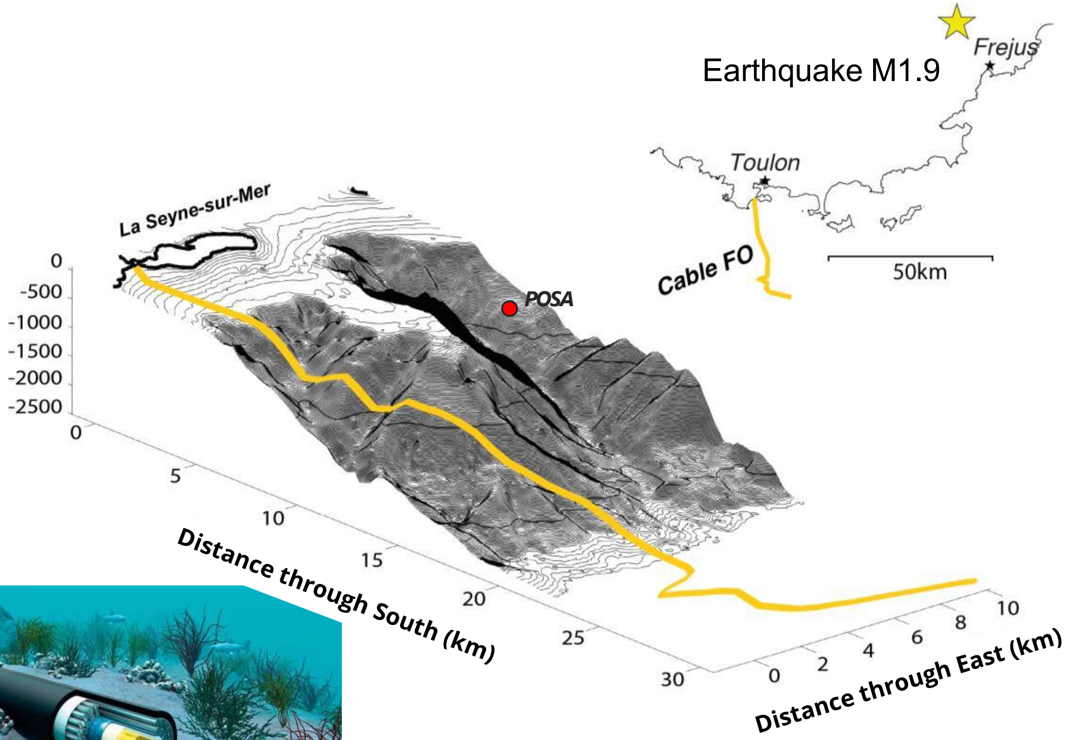
Seismic monitoring in Mediterranean sea (Toulon)

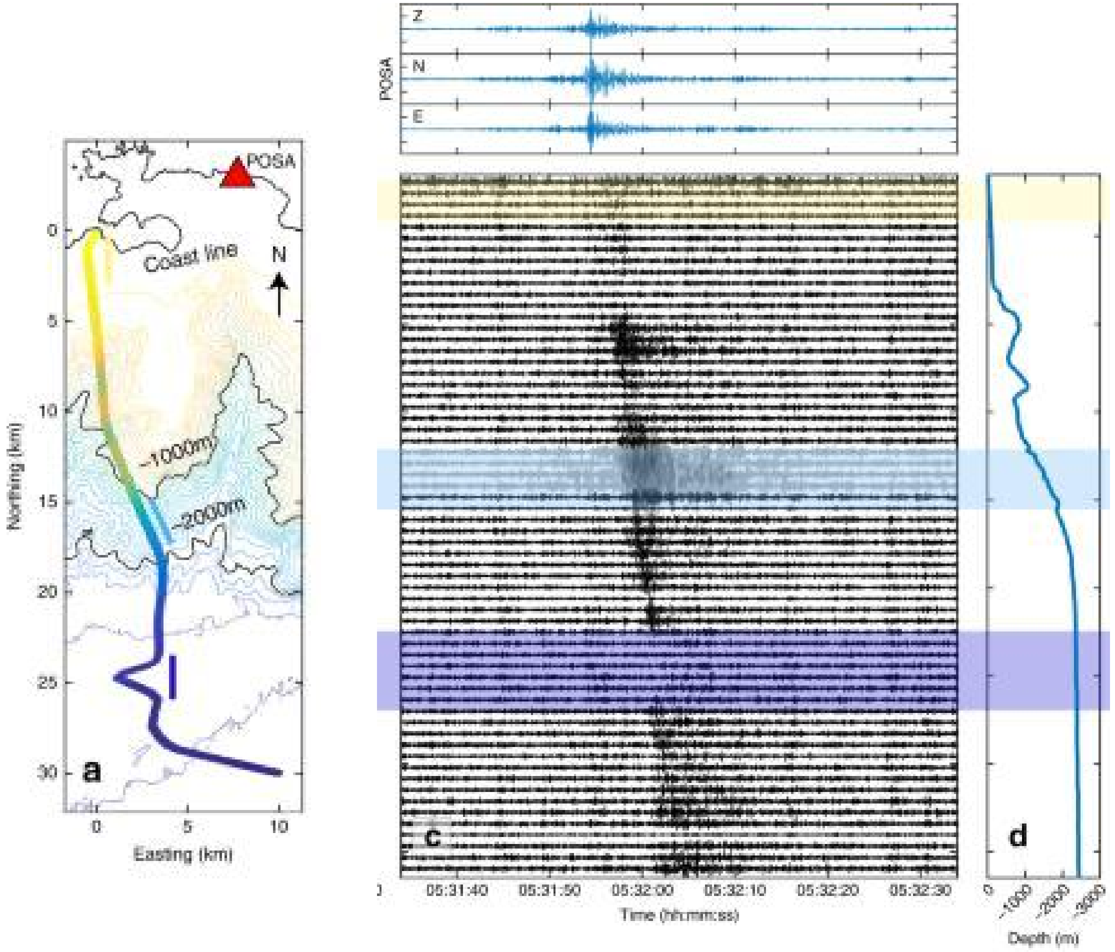
https://doi.org/10.1038/s41467-019-13793-z

OPEN

Distributed sensing of earthquakes and ocean-solid Earth interactions on seafloor telecom cables

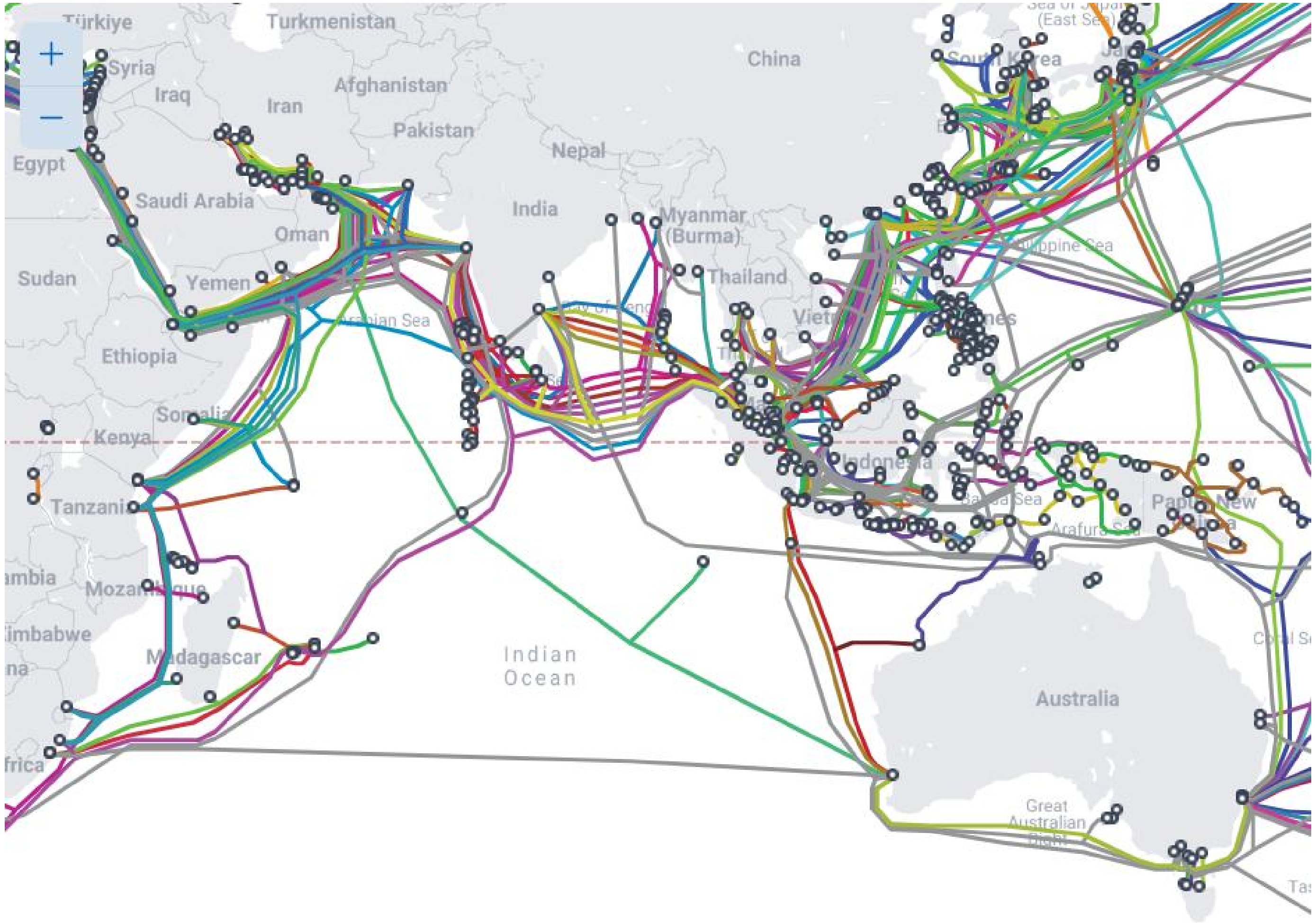
A. Sladen [1*], D. Rivet[1], J. P Ampuero[1], L. De Barros [1], Y. Hello [1], G. Calbris [2] & P. Lamare [3]





3. Distributed Acoustic Sensing (DAS)

Existing cables over the Indian Ocean



4. Listening an Earthquake (Acoustic Sensing)

Occur in Tropical Sea Water

Reseach collaboration BRIN-Indonesia with UPHF France 2025 – 2029

A Tertiary wave (or T-wave) is the acoustic signal from these earthquakes. A T-wave typically has frequencies ranging from 4 to 50Hz. T-waves propagate efficiently in the ocean compared to seismic waves through the earth and can be detected at great distances.

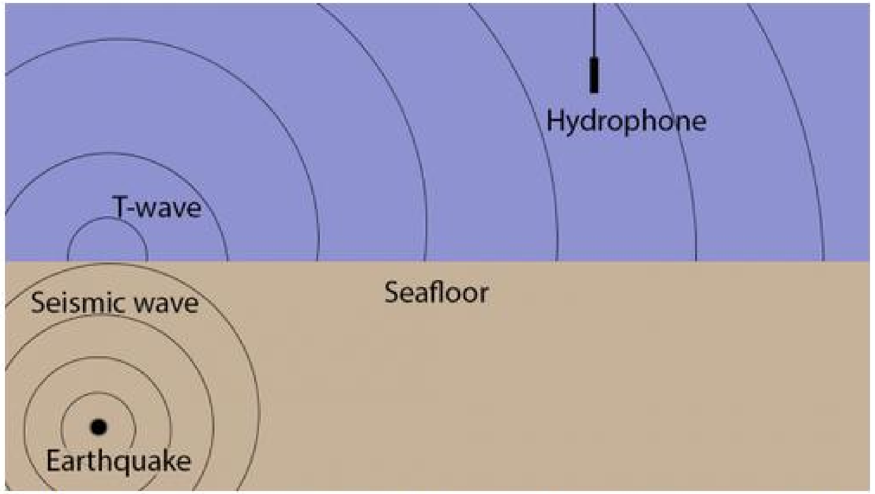
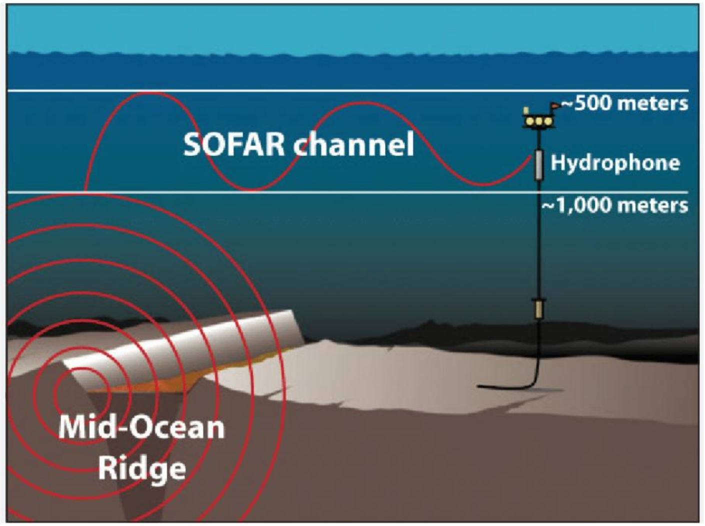


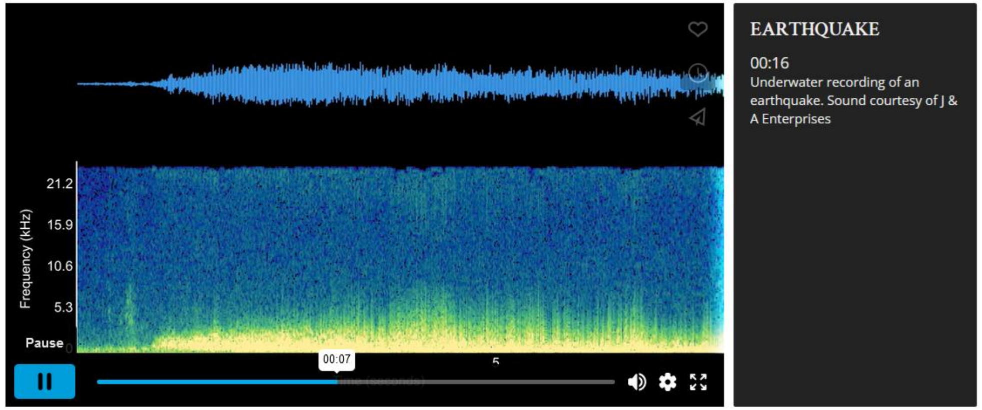
Diagram showing the creation of T-waves from seismic waves and detection by a hydrophone. Image credit URI

https://dosits.org/people-and-sound/examine-the-earth/earthquakes/

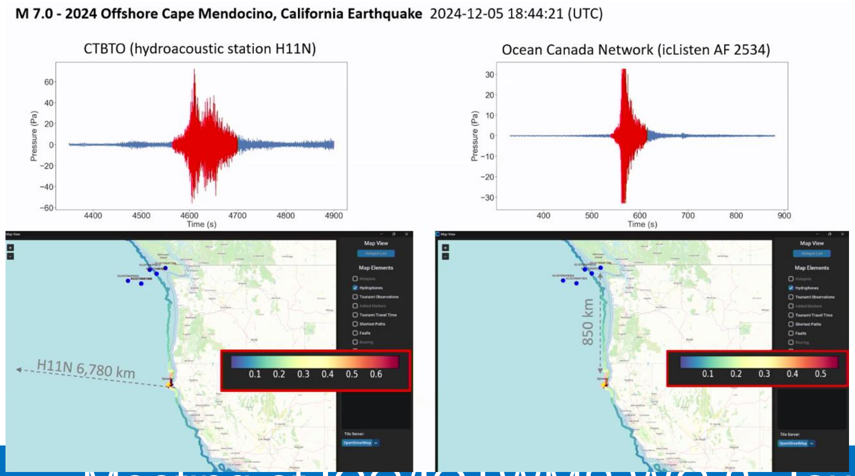


Example of how a hydrophone deployed in the ocean sound channel

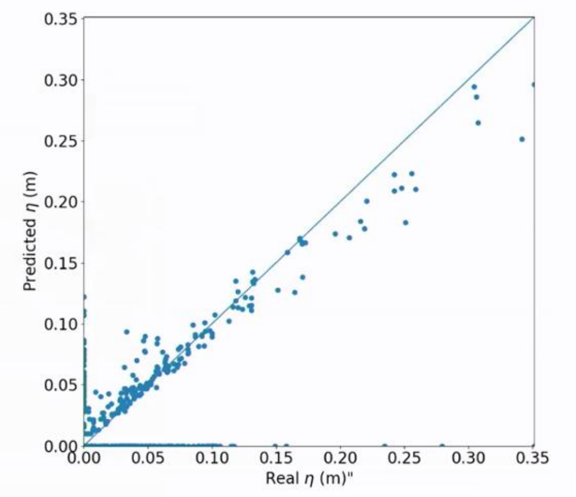
Listening an Earthquake

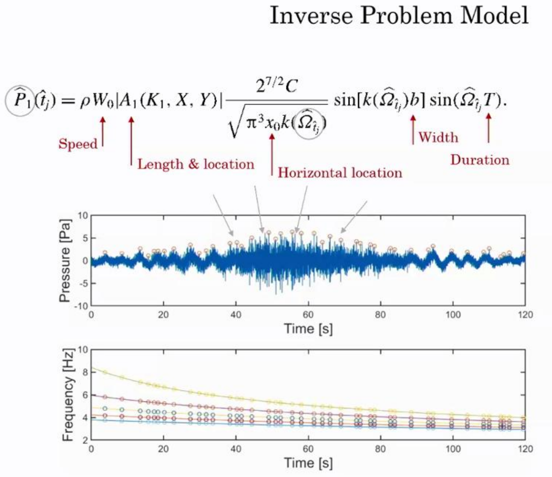


In the Pacific Ocean, sounds from a volcanic eruption have been heard thousands of miles away. Hydrophones located around the Pacific Ocean monitor the ocean for sounds of seismic events. Earthquakes produce acoustic signals known as T-waves



Reseach at Cardiff University Tsunami Center UK :





Machine Learning Model Predict Surface Elevation of Tsunami from Earthquake Acoustic signal

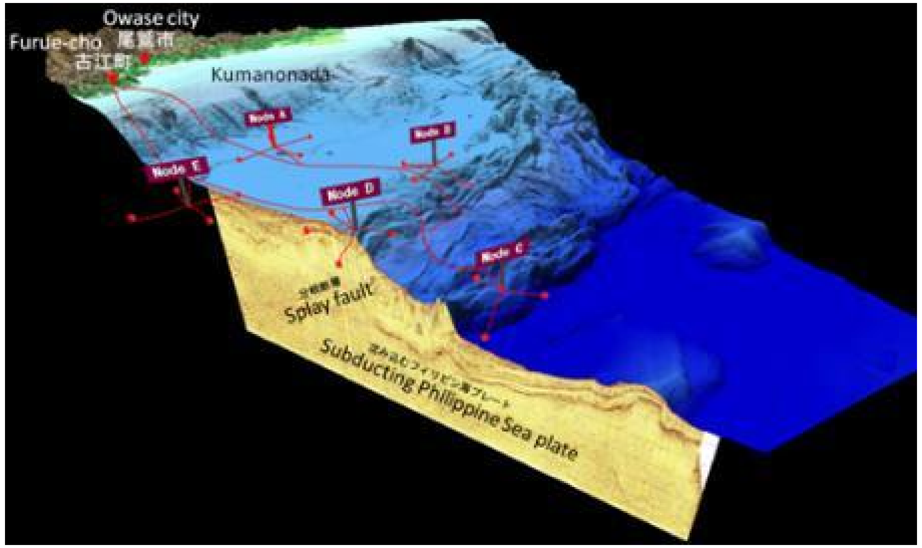
Inverse Problem Model

5. Hybrid System: Cable and Acoustic system

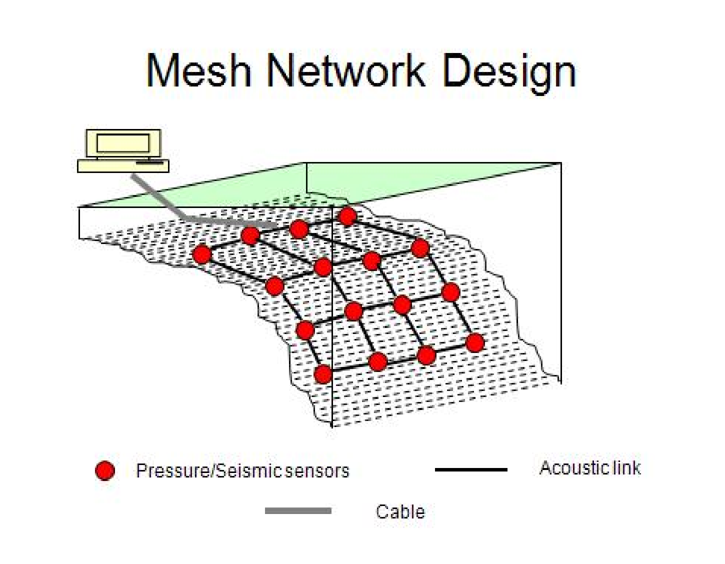
Occur in Tropical Sea Water

DEEP SEA RESEARCH
UNDER WATER CABLES FOR OCEAN OBSERVATION

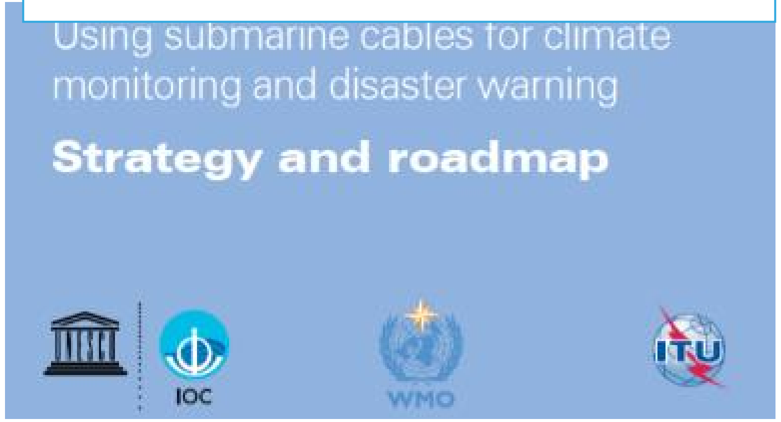
ITU, 2012



DONET: Dense Oceanfloor Network System for Earthquakes and Tsunamis (JAMSTEC, proposed for Southern West Java)



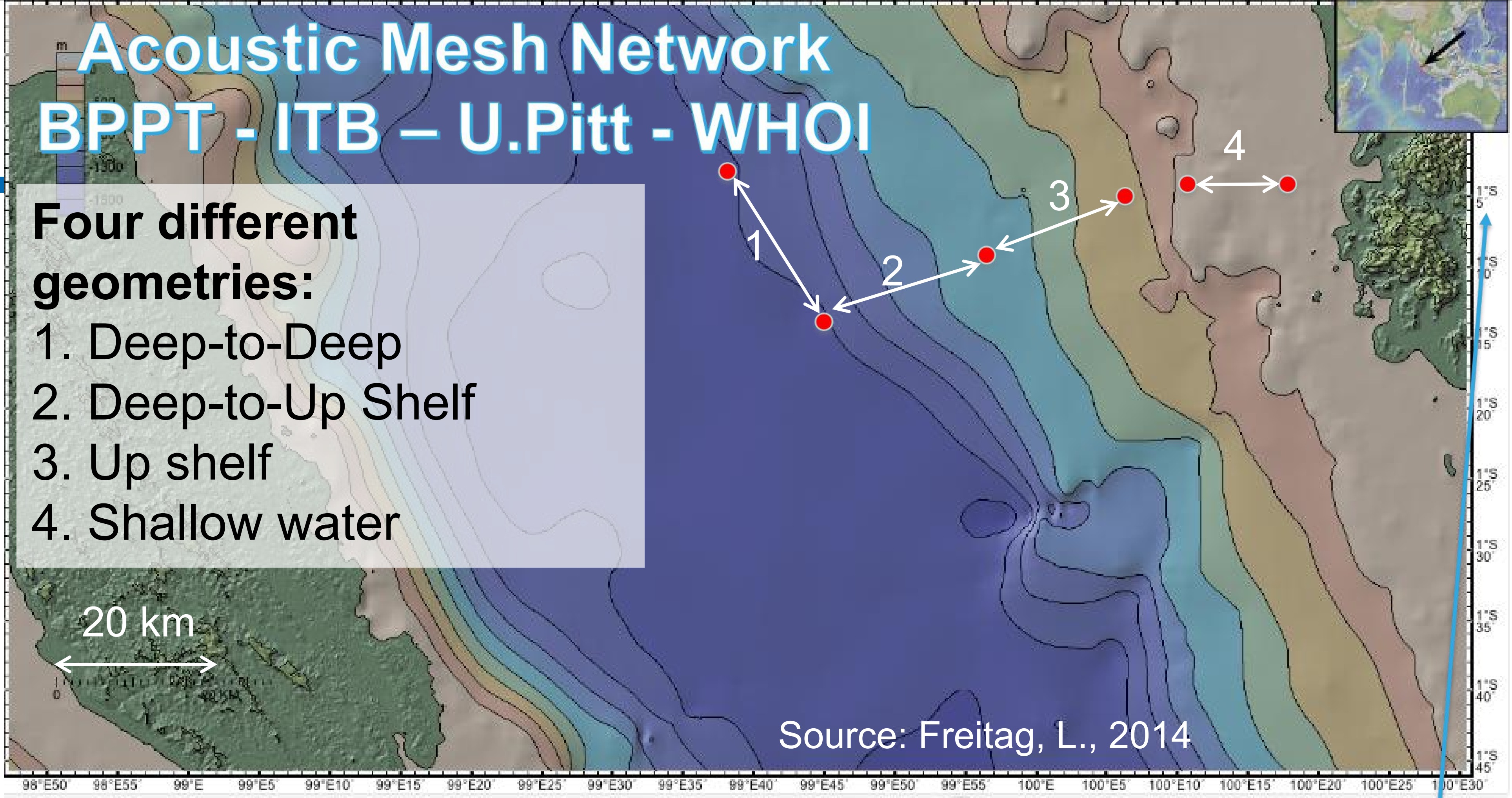
NSF Project for Padang: Underwater acoustic network connected to FO cable (Upitt, BPPT, ITB) for Padang Waters



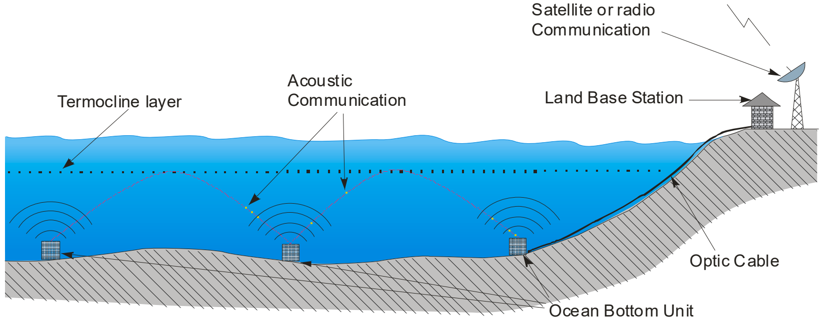
Acoustic Mesh Network
BPPT - ITB – U.Pitt - WHOI

Four different geometries:

1. Deep-to-Deep
2. Deep-to-Up Shelf
3. Up shelf
4. Shallow water



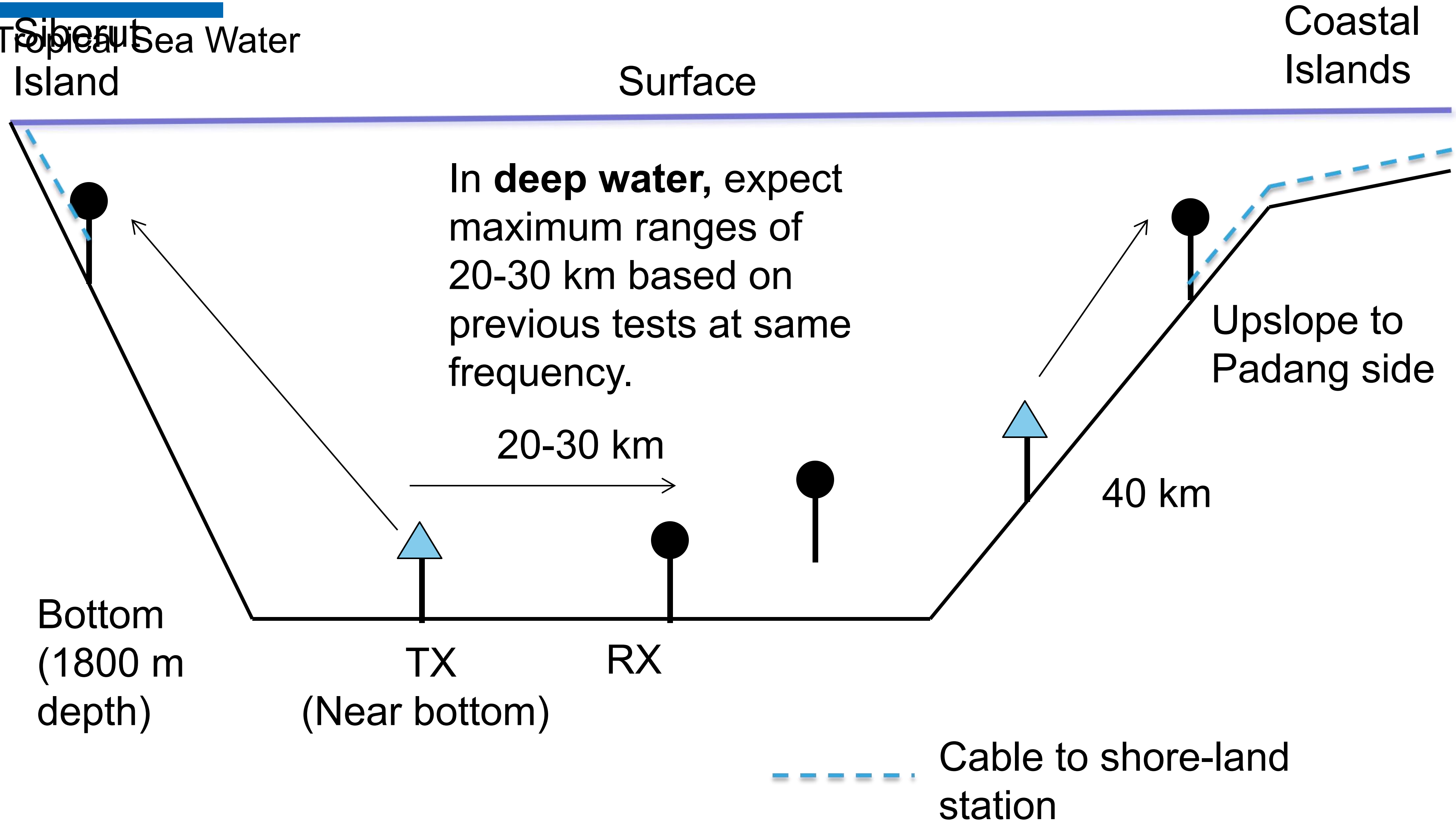
Link 4, shallow water, may not be needed if the cable is terminated at an off-shore island



Sumber: Lee Freitag, WHOI, Aug 2015

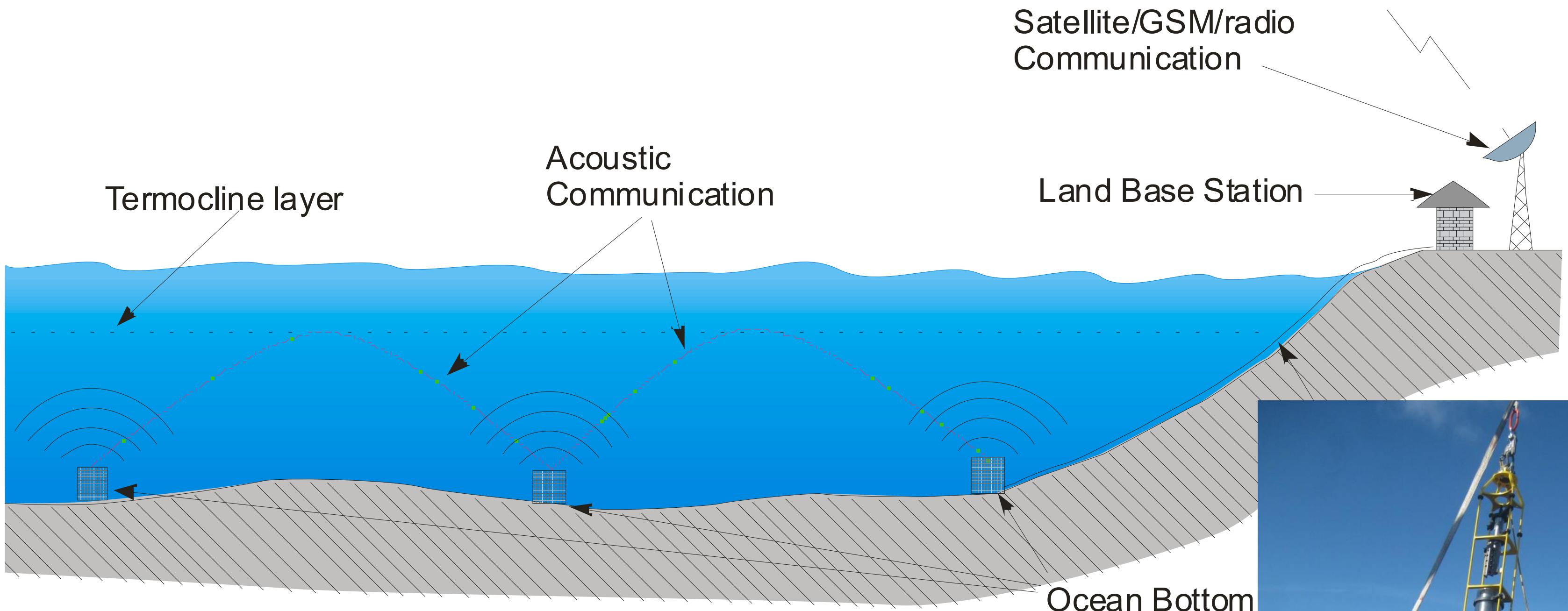
5. Hybrid System: Cable and Acoustic system

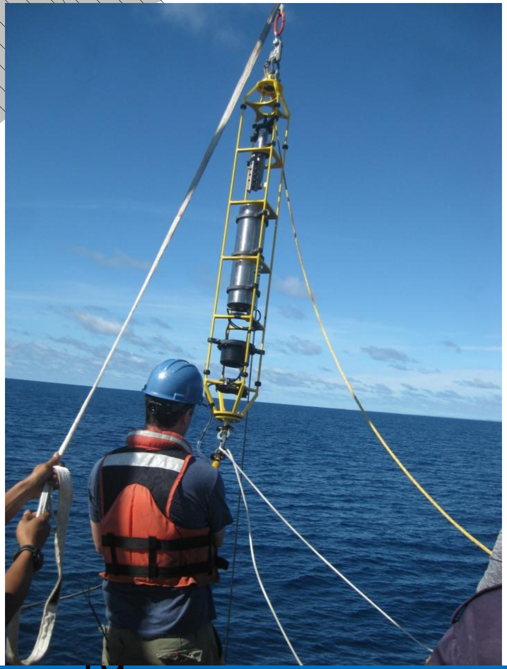
Occur in Tropical Sea Water



Sumber/modified from: Lee Freitag, WHOI, Aug 2015

5. Hybrid System: Cable and Acoustic system





Buoy Tsunami Indonesia 19

6. Country/Institutions Tsunami Numerical Model

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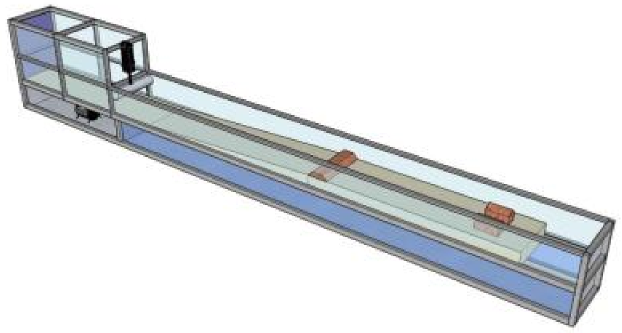
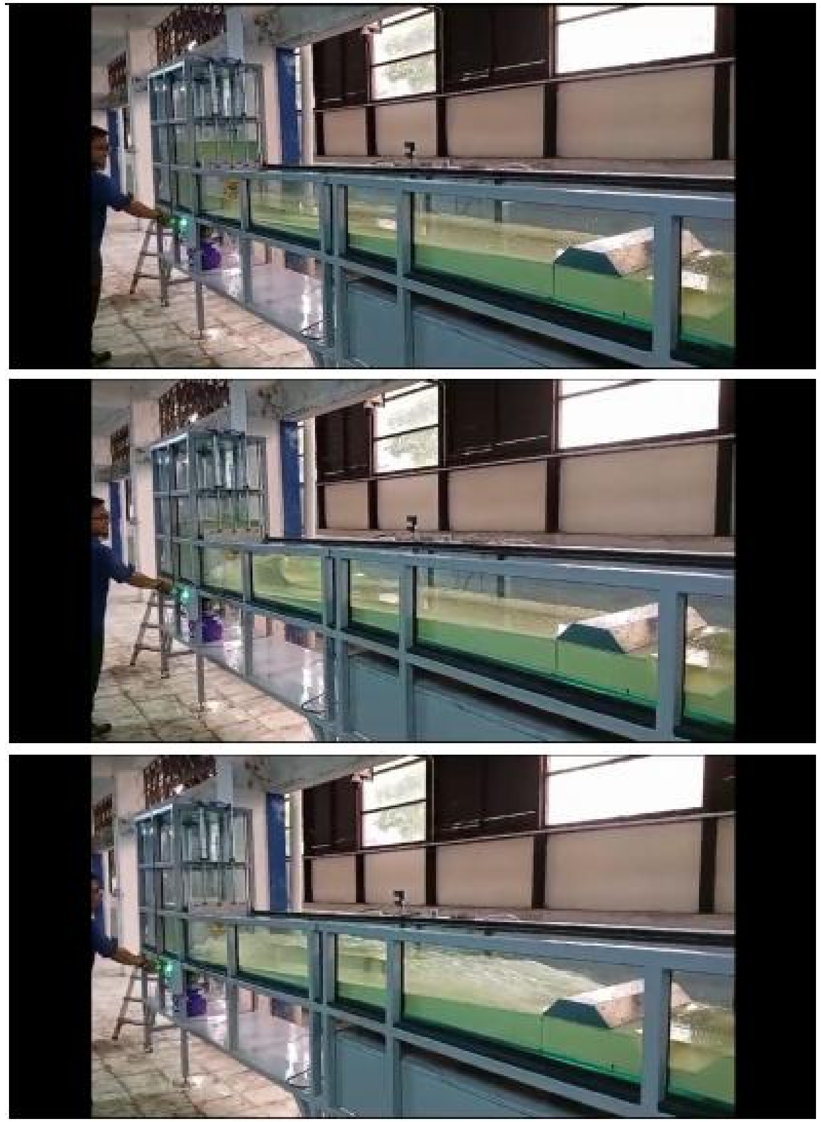
Negara / Institusi	Model Numerik	Keterangan Utama
Global (NOAA, UNESCO)	COMCOT, MOST, Tsunami-HySEA	Model propagasi dan genangan berbasis NSWE.
AS (NOAA)	MOST, SIFT	Forecast real-time dan asimilasi buoy.
Jepang (JMA, NIED)	JAGURS, TUNAMI-N2	Model resolusi tinggi untuk prediksi lokal.
Indonesia (BMKG, BRIN)	COMCOT, TUNAMI-N2, HySEA	Simulasi propagasi dan genangan dengan validasi buoy.
Australia (Geoscience)	ANUGA	Open-source, 2D finite-volume.
India (INCOIS)	TUNAMI-N2	Custom model berbasis TUNAMI.
Eropa (JRC, INGV)	Tsunami-HySEA, SELFE, TeLEMAC	GPU-based, semi-implicit models.
Peru (IGP)	COMCOT, NAMI-DANCE	Prediksi tsunami Pasifik Selatan.
Thailand	COMCOT, MIKE21, TUNAMI-N2	Pasca tsunami 2004.
Karibia (CTIC)	Tsunami-HySEA	Simulasi pelatihan dan skenario.

7. Physical Model : Tsunami Modeling Device

Alat Pemodelan Tsunami yang dimaksud adalah alat Pemodelan simulasi pembangkitan tsunami dengan skala ≥ 1:50 dengan sistem *dambreak*. Alat ini akan membangkitkan gelombang tunggal dengan periode yang panjang dan bisa diatur periode dan tinggi gelombang tsunami. Pembangkitan tsunami atau gelombang panjang diatur dengan memvariasikan volume air (elevasi dan panjang) di tangki, Pemodelan tsunami dibangkitkan dengan membuka pintu tangki air yang terdapat diujung saluran uji. Pintu air dilengkapi dengan actuator dengan sistem *pneumatic* sehingga pintu air bisa dibuk secara otomatis secara cepat untuk menPemodelankan tsunami. Alat Pemodelan Tsunami ini dapat digunakan sebagai wahana pembelajaran untuk mengetahui pola dan pengaruh tinggi dan panjang gelombang tsunami terhadap model uji berupa tanggul pantai, vegetasi laut (mangrove dll) dan perumahan di area pesisir.

Perspektif





THANK YOU