India Sea Level Network

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Introduction:

Indian National Centre for Ocean Information Services (INCOIS) under the Ministry of Earth Sciences (MoES) works towards accomplishing "Science to Society". Its mandate is to provide multi-hazard early warnings, ocean data, information and advisory services to society, industry, the government and the scientific community through systematic and focused research by using the latest trends in ICT and marine science to emerge as a Knowledge and Information Technology Enterprise for the Oceanic realm.

After the deadly Indian Ocean tsunami on 26 December 2004, the Indian Tsunami Early Warning Centre (ITEWC) was established after the deadly Tsunami on 26 December 2004 at Indian National Centre for Ocean Information Sciences (INCOIS) Hyderabad. The centre provides tsunami advisories to India and the Indian Ocean Rim countries.

As part of the tsunami warning network, a real-time seismic monitoring facility to detect tsunamigenic earthquakes and a real-time sea-level network consisting of tide gauges and tsunami buoys were established.

Tide gauges Network:

INCOIS has established a network of state-of-the-art 36 tidal gauge stations along strategic locations of the Indian coastline to monitor the progress of tsunami waves and validate the model results. The data are transmitted in real-time through different modes of communication like INSAT and GPRS simultaneously for processing and interpretation. Tide gauges are critical to monitor the progress of tsunamis and changes in coastal sea levels. INCOIS installed three types of tide gauge sensors i.e. Radar (RAD), Pressure (PRS), and Shaft Encoders (ENC) at 21 locations (established in 2010-11) and one sensor (RAD) at 15 locations (established in 2015-16) to measure the water level heights. The details of INCOIS established tide gauges are given in Annexure-1. Data can be visualized through the link https://tsunami.incois.gov.in/TEWS/TGMap.jsp.

All sensors are connected to a data logger, which provides data logging, storage and control functions for the sensors as well as the data transmission to the tsunami warning centre. Each tide gauge measures the sea level by sampling for every one minute and transmits it for every 5 minutes (Islands stations every 3 minutes). The data are transmitted in real-time through different modes of communication like INSAT and GPRS simultaneously for processing and interpretation. INCOIS is equipped with an INSAT satellite communication hub, state-of-the-art computing hardware, and real-time data processing and visualization facilities for the reception, display, and archiving of tide gauge data.

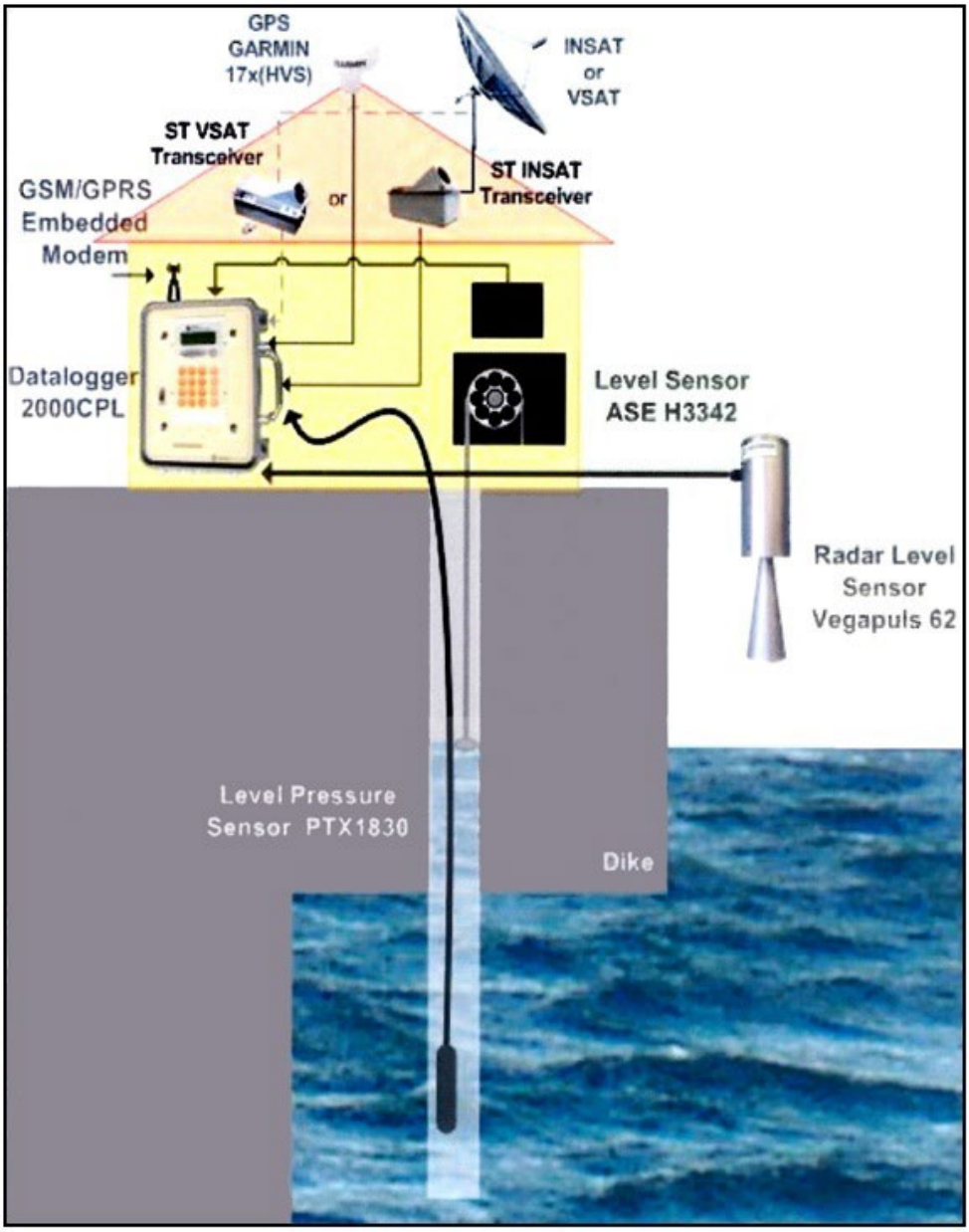

Figure 1: Schematic diagram of Tide gauge sensors

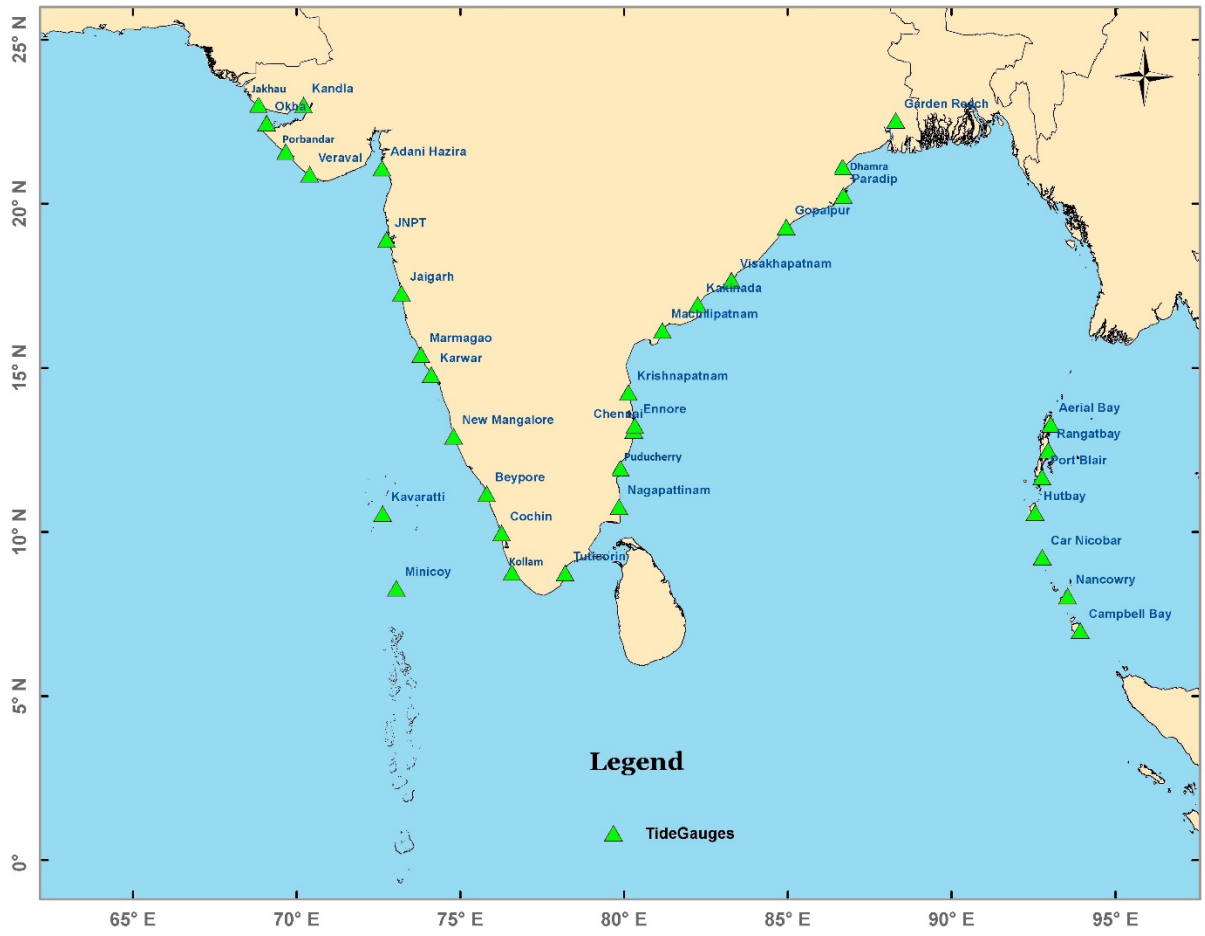

Figure 2: Indian Tide Gauges stations established by INCOIS

In India, the Survey of India (SOI) is a nodal agency for Tide gauge Observations, Benchmarking and datum corrections, etc. It is one of the oldest departments in the world, having expertise of more than 140 years in the field of tidal data collection. Since 1877, tidal data has been collected through a vast network of tie gauge stations along the Indian coastline.

Most tide gauge data is collected offline from the stations and related research by the National Tidal Data Centre, Geodetic & Research Branch, SOI, Dehradun. Survey of India is also responsible for the annual tide table publication from Suez to Singapore in the Indian Ocean region (it is a prediction of 76 ports around the world).

Tsunami Buoys Network:

As part of the Indian Tsunami Early Warning System, a real-time network of Tsunami Buoys (consisting of Bottom Pressure Recording BPR and Surface buoy) has been established by INCOIS and the National Institute of Ocean Technology (NIOT). The network is designed to detect, measure and monitor tsunamis. The network comprises 7 Tsunami Buoys (4 Indigenous Tsunami Buoys by NIOT and 3 SAIC Tsunami buoys by INCOIS) transmitting real-time data through satellite communication to INCOIS at Hyderabad and NIOT at Chennai simultaneously for processing and interpretation. Each BPR is strategically placed in the open ocean near the tsunamigenic source zones in the Andaman & Nicobar Islands and the Makran subduction zone. At the same time, they are far enough from the earthquake zone so that the tsunami wave signal can be clearly distinguished from the seismic Rayleigh wave. The details of NIOT and INCOIS established Tsunami buoys are given in Annexure-2. Data can be visualized through the link https://tsunami.incois.gov.in/TEWS/BprMap_include.jsp.

The Tsunami buoy system consists of a Bottom Pressure Recorder (BPR) placed on the seafloor to measure the water level height and a Surface Buoy placed on the sea surface to communicate between the BPR & satellite. The BPR collects (records) temperature and pressure values at 15-second intervals, the pressure values are corrected for temperature effects and are converted to an estimated sea-surface height by using a constant 670 mm/psia. An acoustic link transmits data from the BPR to the surface buoy. The system has two data reporting modes: normal and event mode. The system operates routinely in normal mode, in which four values are recorded at 15-minute intervals. When the internal detection software detects any changes in the water level from the expected value, the system automatically switches into event/Tsunami response mode transmission, where 15-second values are transmitted during the initial few minutes, followed by updates every 1 minute. The buoys remain in the tsunami response mode for 3 hours and automatically return to normal mode. The tsunami buoys are capable of detecting minor water-level changes of even 1 cm at water depths up to 6 km (Meinig et al).

The BPR uses a piezoelectric pressure transducer to make 15 seconds-averaged measurements of the pressure exerted on it by the overlying water column. The tsunami detection algorithm predicts the next value of each 15-second measurement by a Newton cubic extrapolation of previous observations and is triggered when measured and predicted values differ by more than the 30 mm threshold. The tsunami buoy system has a two-way communication link and is thus able to send and receive data from the Tsunami Warning Centre. The INCOIS and NIOT were equipped with computing hardware for data reception, communication hubs, data processing, visualization and dissemination facilities.

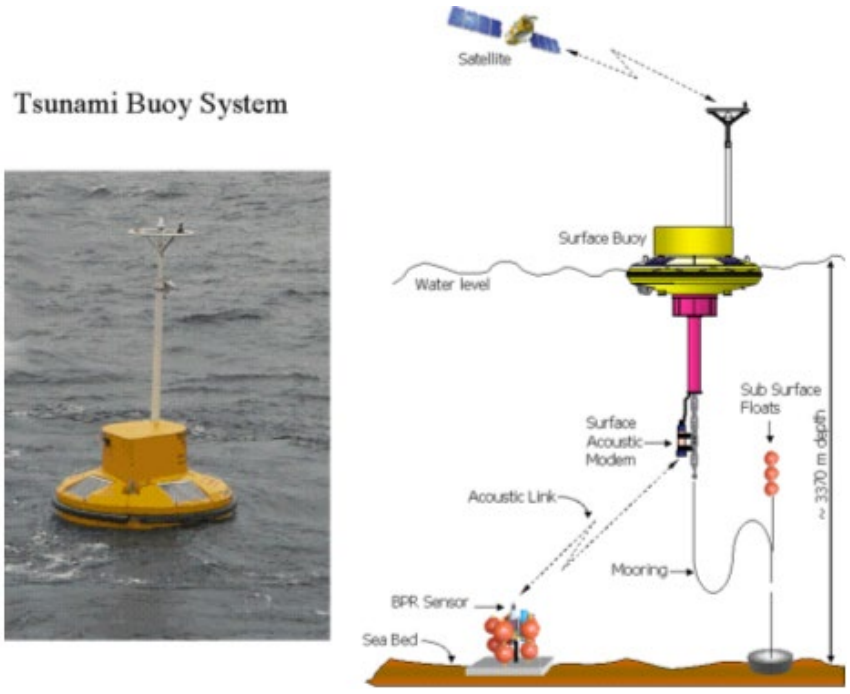

Figure 3: Schematic diagram of Tsunami Buoy System

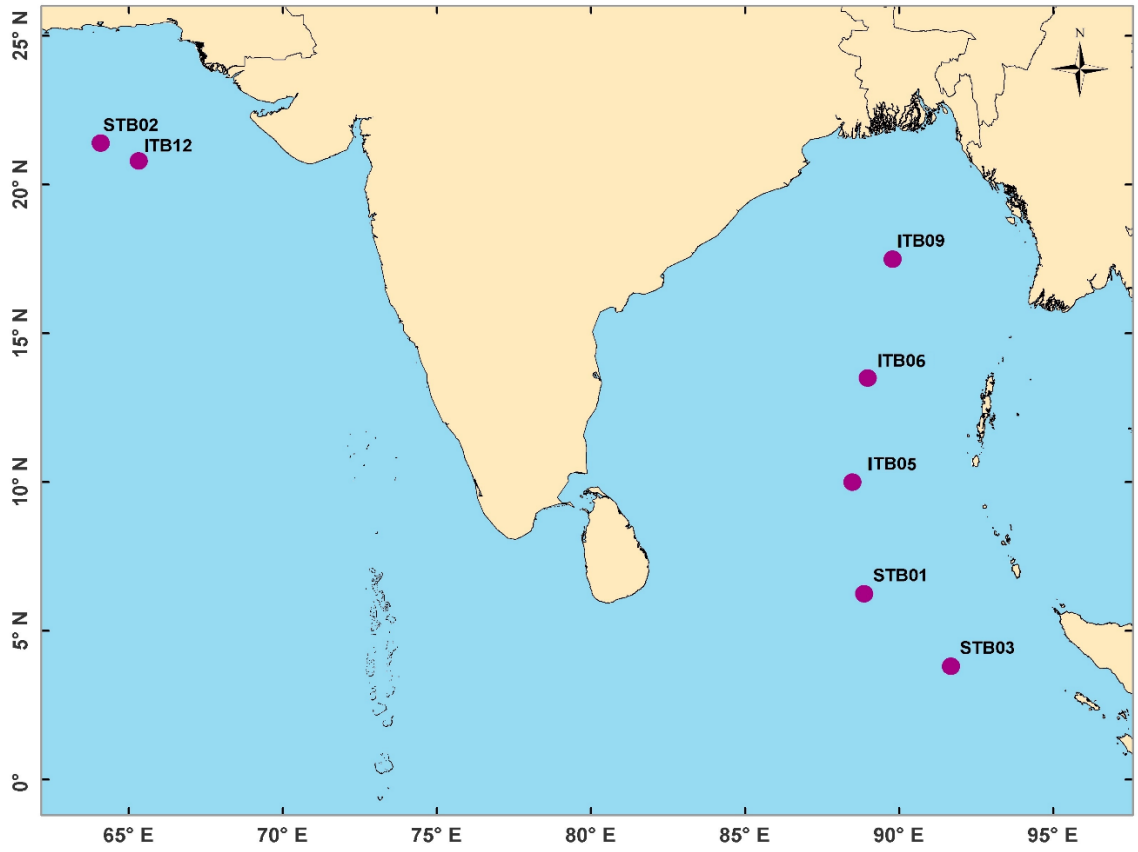

Figure 4: Tsunami Buoy network established by NIOT and INCOIS

Tide gauges and Tsunami buoys Data sharing to International Community:

INCOIS, India is sharing 8 No. of stations Tide gauge stations data, i.e. Chennai, Cochin, Nancowry, Port Blair, Visakhapatnam, Minicoy, Marmagao and Veraval, with IOC Sea level stations monitoring facility. INCOIS also shares all Tsunami buoy data deployed by India in the Bay of Bengal and Arabian Sea, a total of 7 No. of stations, i.e. ITB05, ITB06, ITB09, ITB12, STB01, STB02 and STB03 (WMO IDs 23218, 23220, 23223, 23226, 23227, 23228 and 23217, respectively) with NDBC NOAA, the same data also available at the IOC Sea level website.

Survey of India also collaborates with the international community by providing Monthly and Annual Mean Sea level data to the Permanent Service for Mean Sea Level (PSMSL), U.K. and GLOSS. It has been contributing tide gauge data to PSMSL since its inception.

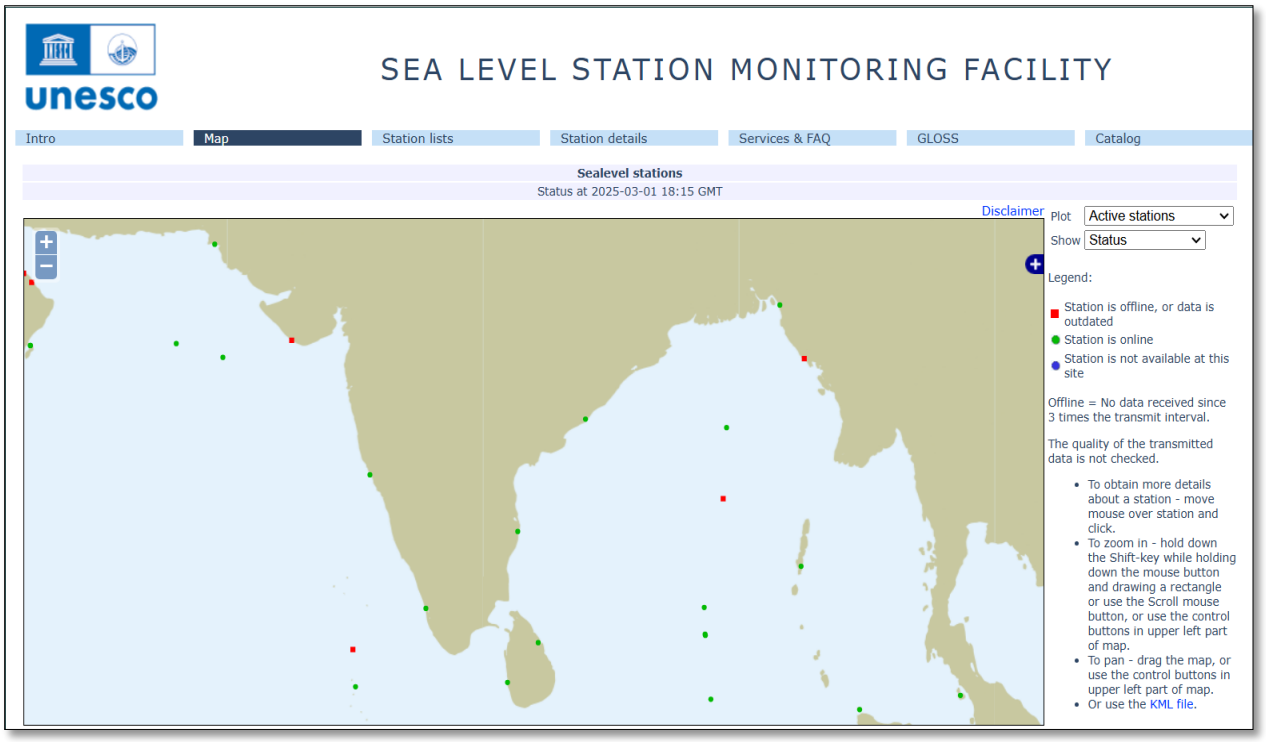

Figure 5: INCOIS, Indian Tide gauges and Tsunami Buoys real-time data sharing to IOC Sea level website

dni7		India	DART Bay of Bengal	web		2709.09	2024-02-08 08:00	387d	6h	[open]
dni4		India	DART Bay of Bengal	web		2334.51	15:00	3h	6h	[open]
dni6		India	DART Bay of Bengal IN4	web		3319.4	04:00	14h	6h	[open]
marm	281	India	Marmagao	ftp	43195	6.12	18:02	9'	10'	[open]
coch	32	India	Cochin	ftp	43357	1.48	18:03	8'	10'	[open]
nanc		India	Nancowry	ftp	43383	0.16	09:05	9h	10'	[open]
ptbl	38	India	Port Blair	ftp	43332	1.3	18:02	9'	10'	[open]
vish	35	India	Visakhapatnam	ftp	43151	1.46	17:59	12'	10'	[open]
dara		India	DART Arabian Sea	web		2789.76	12:00	6h	6h	[open]
dni2		India	DART Bay of Bengal	web		3801.39	12:00	6h	6h	[open]
dar2		India	DART Arabian Sea	web		2824.4	17:00	1h	6h	[open]
mini	29	India	Minicoy	ftp	43370	0.01	14:05	4h	10'	[open]
verav	31	India	Veeraval	ftp	42910	7.32	2024-05-10 06:03	296d	10'	[open]
chenn	34	India	Chennai	ftp	43280	0.92	18:03	8'	10'	[open]

Table 1: Indian Tide gauges and Tsunami Buoys real-time data sharing to IOC Sea level website and NOAA NDBC (Tsunami Buoys)

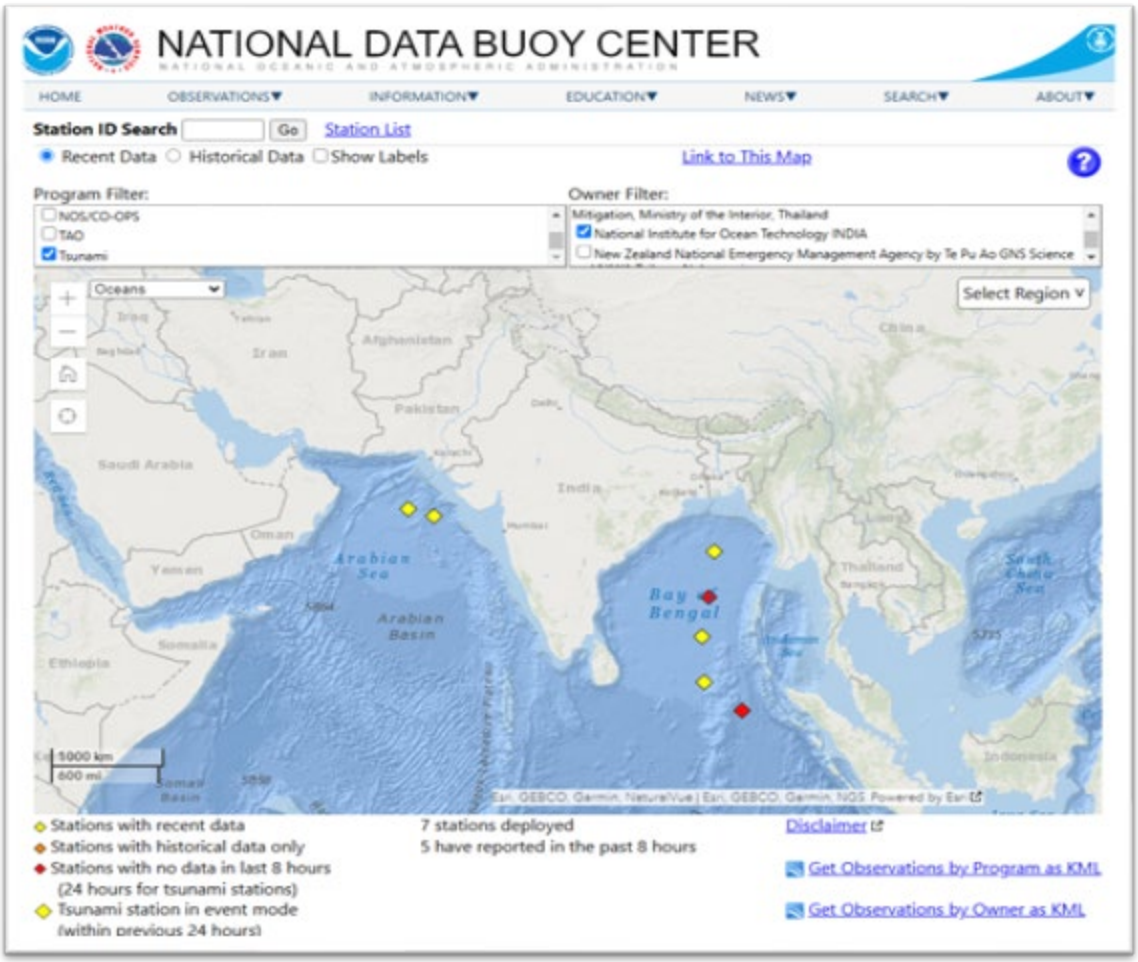

Figure 6: Indian Tsunami Buoys real time data sharing to NDBC, NOAA website

Annexure-1

List of Tide gauges stations established by INCOIS

S. No.	Station Name	Latitude (N)	Longitude (E)	Establishment in	Sensors
1	Aerial Bay	13° 17' 0.01"	93° 1' 31.238"	Aug 2010	RAD, PRS, ENC
2	Campbell Bay	7° 0' 1.39"	93° 55' 53.915"	Oct 2010	RAD, PRS, ENC
3	Chennai	13° 4' 16.536"	80° 17' 7.138"	July 2010	RAD, PRS, ENC
4	Cochin	9° 58' 11''	76° 15' 29''	Mar 2011	RAD, PRS, ENC
5	Ennore	13° 15' 0"	80° 19' 58.8"	Jul 2010	RAD, PRS, ENC
6	Garden Reach	22° 32' 54.287"	88° 19' 5.142"	Jul 2010	RAD, PRS, ENC
7	JNPT	18° 57' 07.3''	72° 56' 47.6''	Nov 2010	RAD, PRS, ENC
8	Kakinada	16° 56' 28.644''	82° 16' 9.372''	Oct 2011	RAD, PRS, ENC
9	Kandla	23° 1' 6.812''	70° 13' 15.254''	Aug 2010	RAD, PRS, ENC
10	Karwar	14° 48' 10.685"	74° 6' 51.696"	Aug 2010	RAD, PRS, ENC
11	Kavaratti	10° 34 '1.2"	72° 37' 58.8"	Sep 2010	RAD, PRS, ENC
12	Krishnapatnam	14° 15' 18.032"	80° 6' 40.129"	Aug 2010	RAD, PRS, ENC
13	Minicoy	8° 16' 58.8"	73° 3' 0"	Sep 2010	RAD, PRS, ENC
14	Nagapattinam	10° 45' 42''	79° 50' 57''	Jul 2010	RAD, PRS, ENC
15	Nancowry	8° 2' 9.265"	93° 32' 35.844"	Sep 2010	RAD, PRS, ENC
16	New Mangalore	12° 54' 58.928"	74° 48' 54.148"	Aug 2010	RAD, PRS, ENC
17	Okha	22° 28' 1.2''	69° 04' 58''	Aug 2010	RAD, PRS, ENC
18	Paradip	20°16'6.017"	86° 40' 0.059"	Jul 2010	RAD, PRS, ENC
19	Port Blair	11° 41' 18.622"	92° 43' 19.902"	Aug 2010	RAD, PRS, ENC
20	Tuticorin	8° 45' 1.8'' N	78° 12' 3''	Jul 2010	RAD, PRS, ENC
21	Visakhapatnam	17° 41' 18.622''	83° 17' 16.775''	Jul 2010	RAD, PRS, ENC
22	Adani Hazira	21° 6' 0"	72° 36' 57.6"	Dec 2015	RAD
23	Beypore	11° 10' 15.6"	75° 48' 28.8"	Dec 2015	RAD
24	Car Nicobar	9° 14' 2.4"	92° 46' 33.6"	Dec 2015	RAD
25	Hutbay	10° 35' 27.6"	92° 33' 43.2"	Dec 2015	RAD
26	Jaigarh	17° 16' 51.6"	73° 12' 28.8"	Dec 2015	RAD
27	Machilipatnam	16° 8' 42"	81° 10' 40.8"	Dec 2015	RAD
28	Marmagao	15° 24' 32.4"	73° 48' 0"	Dec 2015	RAD
29	Rangatbay	12° 29' 16.8"	92° 57' 21.6"	Dec 2015	RAD
30	Veraval	20° 54' 43.2"	70° 24' 28.8"	Jan 2016	RAD
31	Gopalpur	19° 17' 20.1"	84° 56' 54.13"	Jul 2016	RAD
32	Puducherry	11° 55' 48"	79° 50' 6"	Dec 2016	RAD
33	Kollam	8° 51' 50.4"	76° 36' 10.8"	Feb 2017	RAD
34	Porbandar	21° 37' 15.6"	69° 31' 19.2"	Apr 2017	RAD
35	Jakhau	23° 14' 34.8"	68° 36' 21.6"	Jun 2017	RAD
36	Dhamra	20° 47' 6.36"	86° 57' 20.16"	Feb 2019	RAD

Annexure-2

List of Tsunami Buoys established by NIOT and INCOIS

S. No.	Station Name	Latitude (N°)	Longitude (E°)	Location	Maintained by
1	STB01	06.2	88.8	Bay of Bengal	INCOIS
2	STB02	20.8	65.3	Arabian Sea	INCOIS
3	STB03	03.8	91.7	Bay of Bengal	INCOIS
4	ITB05	10.2	88.5	Bay of Bengal	NIOT
5	ITB06	13.5	89.0	Bay of Bengal	NIOT
6	ITB09	17.7	89.6	Bay of Bengal	NIOT
7	ITB12	19.9	67.0	Arabian Sea	NIOT