

Sounds Fishy: Empirical Characterization of Underwater Ambient Noise in Bio-diverse Tropical Shallow Coastal Water

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Abstract

Underwater ambient noise is critical to success of naval operations. The underwater noise environment is also an important aspect of habitat for marine mammals and other organisms. Underwater noise is one of the human induced environmental threats to the ocean. Ambient noise calculations have role in the conduct of environmental-acoustic impact assessments. Documenting changes in underwater ambient noise helps in understanding the marine environment. In tropical coastal shallow waters, the acoustic environment is influenced by sea surface and bottom conditions, ship traffic and marine life. This study aims at characterizing underwater ambient noise to serve as a first reference survey of the soundscape of the site. The site is near bio-rich Grande island (15°18' N 73° 41' E) 18km off Goa, on India's western coast. Conventionally researchers use one of the three methods of noise measurements: hanging hydrophone from boat, moored hydrophone with autonomous acoustic recorder, and seabed-mounted hydrophone. In this work, we report experimental data recorded by all the three methods. Environmental parameters like sea state, wind, currents, salinity, temperature, and depth recorded to correlate with ambient noise variations. Underwater videography confirmed presence of vocal fish species at the site. Results analyzed to characterize ambient noise and identify significant contributors. At the site, the underwater ambient noise levels vary over range of 60 - 115 dB in 10 - 6400 Hz frequency band. Measurements during December 2014 – February 2016 confirm diurnal variations and that the fish chorus raised ambient noise levels by 20-30 dB in 400-1500Hz frequency range.

Keywords: *Underwater ambient noise, tropical coastal waters, marine soundscape, fish chorus, shallow water acoustics.*

I. INTRODUCTION

Underwater ambient noise is a complex phenomenon of keen interest to a diverse research community engaged in underwater acoustics, biology, ecology, meteorology and oceanography. Recreational, industrial, fishery, aquaculture, and military uses of the ocean resource require quantitative knowledge of the oceanic noise field and the influence these activities have on the environment and the marine biological systems. Estimation of noise levels is required for planning the future economic utilization of ocean resources. In addition, ambient noise has a role in the conduct of environmental-acoustic impact assessments.

Ambient noise calculations are used as naval sonar performance prediction tools. Underwater ambient noise characteristics determine acoustic properties which are of critical importance to submarine operations. Underwater acoustic conditions influence and determine operational modes of submarines and their stealth capabilities. It is extremely difficult to detect and accurately target submarines in shallow waters without the knowledge of ambient noise. A comprehensive understanding of all aspects of underwater ambient noise is critical to mission success of undersea operations. Accurate and detailed information on these areas is important for naval mission planning and operations. Coastal zones are particularly of great interest for both environmentalists as well as war strategists.

Studies showed that anthropogenic noise can cause damage to marine life and marine ecosystems. Managing underwater noise pollution has been identified as a pressing marine environments conservation issue. Many countries now require a noise impact assessment for proposed developments that may impact key marine species and the ecosystem. Particularly, there is a need to characterize the soundscapes of eco-sensitive, bio-diverse coastal/island sites.

The sources of underwater ambient noise are both natural and man-made. Ambient noise levels are highly dependent on geographic location, acoustic transmission characteristics, season of the year and weather. Shallow water noise is a combination of effects of shipping, wind, and biological noise and sea bottom topography [1]. The goal of this study is to examine the contributions of natural and anthropogenic sources of noise on the marine underwater soundscape. Ambient noise in mid frequency band (few Hz to 20kHz) is dominated by the effects of wind acting on sea surface, shipping noise, type of sea bottom and biological factors [2]. Unlike deep water, ambient noise in shallow waters have higher levels due to proximity to noise sources [3]. It is known that, soniferous (sound producing) fish, snapping shrimp, croakers, dolphins and various other ocean mammals add significantly to the noise background, especially in shallow tropical coastal waters.

High variability of ambient noise in tropical coastal shallow waters makes characterization of underwater marine environment difficult and complex. During different times of the day and seasons, the contributions by geo, bio and anthropogenic sources vary significantly. We have selected a site with unique acoustic environment with close proximity to airport, commercial shipping port, bio-diverse eco-sensitive islands and rivers flowing into the sea. Therefore, three different methods of ambient noise data measurement are used: sea-bed mounted sensors, moored vertical array hydrophones and hanging hydrophone from boat. Environmental data measured and collected at the site. Measurements of biological noise study was done by underwater videography to identify vocal fish species. Vessel traffic was studied using Automatic Identification System (AIS). Results obtained at the experimental site are analyzed, to correlate with environmental data to characterize and understand the ambient noise sources and their contributions.

The major source of ambient noise at the site is found to be bio-phonic noise. Over 800 species of fishes from 109 families worldwide are known to be vocal. Fishes produce different types of sounds using different mechanisms and for different reasons. Sounds (**vocalizations**) may be intentionally produced as signals to predators or competitors, to attract mates, or as a fright response. Sounds are also produced unintentionally including those made as a by-product of feeding or swimming. The three main ways fishes produce sounds are by using sonic muscles that are located on or near their swim bladder (**drumming**); striking or rubbing together skeletal components (**stridulation**); and by quickly changing speed and direction while swimming (**hydrodynamics**). The majority of sounds produced by fishes are of low frequency, typically around 1000 Hz. The next major contributor to underwater ambient noise at the site is wind generated noise. Contributions from commercial ships and fishing boats are third major source of ambient noise at the site during the period of measurement.

The paper is organized in six sections: Section 1 is introduction, Section 2 describes the experimental site uniqueness and Section 3 presents experimental study methods and instrumentation used. Section 4 deals with data recording and Section 5 presents results obtained and discussion. Section 6 concludes the paper.

II. SITE DESCRIPTION

The experimental site identified is located near Grande island, (15°18' 21.53" N 73°41' 27.24" E) 18 km off Goa, west coast of India, in the Arabian Sea. The acoustic characteristics of the area remain largely undiscovered. The proposed area has a unique acoustic environment due to its proximity to busy military airport also frequently used by civilian aircraft. The site is also close to Marmugaon Port (25 km) operating commercial ships, mining barges, fishing trawlers and tourist boats.



Figure-1. Site location

The Grande island is a bio-diverse eco-sensitive zone consisting of a ship wreck, corals, fish, snapping shrimps, and dolphins. Zuari and Mandovi rivers flow into the sea near the experimental site. Every year the site experiences severe monsoons (June-October), fresh water flooding of the site, and variations of seasonal salinity of water column. Also resulting in river mud deposition into seabed sediment changing acoustic properties of sea-bottom. Pikene and Grande Islands, with their marine bio-rich marine organisms make the experimental site unique and challenging for research and exploration.

III. MATERIAL AND METHODS

a) Instrumentation

The approach, including both instrumentation and analysis, is required to address these challenges in measurement of noise over a broad scale of frequency, time, and space. All instruments calibrated as per Original Equipment Manufacturer’s calibration procedure. The instrumentation used for acoustic data collection are shown in Table 1:

Table 1. List of instruments used for measurements at the site

SI	Instrument	Band width	Sensitivity	Resolution	Remarks
1	ITC8264 Hydrophone	10 Hz- 100 kHz	-175 dB re 1 micro Pa	16 bit	Sampling rate 262144 kHz
2	Songmeter SM2M+	2 Hz – 192 kHz		16 bit	2 channel recorder
3	Automated Ambient Noise Subsurface system	2kHz – 20kHz	-165 dB re 1 micro Pa		Vertical hydrophone array deployed at 15 m depth below sea surface. Sampling rate 100 kHz
4	Current meter				Sea Gaurd RCM
5	CTD meter				CC1404003

b) Measurement Methods

Measurement of ambient noise requires care to ensure that the data exclude system noise, pressure fluctuations induced by turbulence in water flow around the hydrophone and supporting cable. The measurement method is chosen to sample the sound field at appropriate points in the water column. The three main methods are:

i) Boat based hanging hydrophone measurement.

Hydrophones are deployed from a boat, with analysis and recording equipment remaining onboard. The boat is anchored or adrift. GPS system is used to record the location during each measurement. Advantage of this method is deployment can be quick and mobile and a large area can be covered. Data can be monitored as acquired, and instrument settings adjusted in real time to optimum levels ensuring high data quality. This method is prone to platform-related noise (noise from engines and echo sounders, wave slap on the vessel hull, hydrostatically induced signals due to surface wave motion).

ii) Moored static hydrophone Method.

Static systems use hydrophone-array moored to seabed with a sinker and a float on sea surface. These are suitable for longer-term deployments enabling the measured data to be sampled for a range of tidal cycles, weather conditions, operational states, etc. The data is streamed directly to shore base, either by cable, or through satellite or modem link (this is limited by transmission bandwidth). The advantage is near real-time data availability. The disadvantages are that they measure in only one location, have a higher risk of data loss and suffer from parasitic noise effects such as cable strum or flow noise.

iii) Bottom mounted hydrophone with cabled systems.

These are ideal systems with hydrophones installed on seabed, with a complex undersea cable (power and data) run from hydrophones to shore setup. The set up cannot be shifted from one location to another. The data is streamed to shore real time and data quality and control on the operation is better. There are no limitations in terms of time duration of deployment (months or years), power or data storage requirements (are provided from shore).

IV. DATA RECORDINGS

Underwater ambient noise data recorded by three methods over two square km site area over different periods covering all seasons except monsoon (June - October). Data collected using seabed-mounted hydrophones during December 2014 - March 2015; December 2015 - February 2016, hanging hydrophone from boat during May 2015, and moored vertical array hydrophones during November 2015 – January 2016. For all measurement campaigns, standard methods of ocean noise measurement [4] and good practices guide [5] were followed.

i) Hanging hydrophone from boat

Measurements were undertaken by hanging Songmeter SM2M+ hydrophone shown in Figure.2 from drifting boat with engines shut down, at site during 07 -12 May 2015. Simultaneously wind speed and direction; current speed and direction; conductivity,

temperature and depth measurements were recorded at the site. A device CTD meter, sampling at 20-sec intervals, used for recording conductivity (uS/cm), temperature (°C), and pressure (depth; m).



Figure-2. Songmeter SM2M+

ii) Moored hydrophone

An autonomous sub-surface noise measurement system was deployed at experimental site, at a depth of 32 m from 07 October 2015 - 21 January 2016. Subsurface system comprises a vertical linear array of omnidirectional hydrophones with data acquisition modules. Sampling frequency of the data acquisition system was set to 100 kHz. Sampling interval was set to 3 hours with data recording duration to be 60 seconds and eight samples of the data are acquired per day.

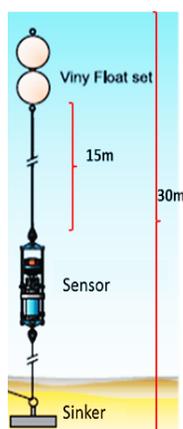


Figure-3. Noise measurement system

The hydrophone has frequency response up to 20 kHz. Array of hydrophones sense acoustic pressure fluctuations due to various sources of noise. These are converted into electrical signals and then logged by the data acquisition system. Recorded voltage is then converted into units of micropascal (μPa) by applying preamplifier gain and receiving sensitivity of the hydrophone. Wind data at the sea surface was recorded using wind data logger.

iii) Seabed-mounted hydrophones

Five ITC 8062 hydrophones were used with a 100 m separation at a depth of 30 m at the experimental site. A complex undersea cable (power and data) run from hydrophones to shore based recording and analysis equipment. Readings over a period of three months (20 December 2014 to 26 March 2015) and (01 December 2015 to 18 February 2016) were recorded. The recordings were undertaken with hourly intervals 0900 hrs to 1600 hrs. The recordings were analyzed using continuous data.

iv) Shipping traffic:

Shipping noise is one of the dominant contributor to ambient noise in shallow water areas close to shipping lanes. Shipping noise is in the 50-300 Hz frequency range. To quantify the noise due to commercial and military ships in the area, location data from the Automatic Identification System (AIS) installed at a shore station (15° 22'38" N 73°48'33" E) were used. The system transmits information via VHF, including ship identity, position, speed and course.

v) Aircraft Noise

Aircraft noise can couple through the sea surface when an aircraft flies low over the sea surface. This happens when fixed wing aircraft approach a runway located close to the coast, or a helicopter operates at low altitudes over the sea. Helicopter noise originates from the disturbance of the sea surface by the "down wash" from the blades and by coupling of blade noise directly into the sea. The down wash noise is very similar to wind noise in frequency characteristics and is greatest in the 2-20 kHz spectrum. The supersonic Figurehter aircraft operations did not add to the ambient noise levels measured due to the high altitude of the aircraft. Measurements with helicopter hovering at the site were taken with seabed sensors and the noise contribution found to be not significant. Measurements also taken coinciding the landing and taking of commercial aircraft and supersonic Figurehters and no appreciable change in the ambient noise observed due to the high altitude of aircraft operation.

vi) Biological Noise

Over 800 species of fishes from 109 families worldwide are known to be vocal. Fishes produce different types of sounds using different mechanisms and for different reasons. Sounds (**vocalizations**) may be intentionally produced as signals to predators or competitors, to attract mates, or as a fright response. Sounds are also produced unintentionally including those made as a by-product of feeding or swimming. The three main ways fishes produce sounds are by using sonic muscles that are located on or near their swim

bladder (**drumming**); striking or rubbing together skeletal components (**stridulation**); and by quickly changing speed and direction while swimming (**hydrodynamics**). The majority of sounds produced by fishes are of low frequency, typically around 1000 Hz.

Study carried out by GB Sreekanth et al [6] to monitor the fish communities of Grande Island through underwater visual census (UVC). The major coastal island ecosystems of Goa include Grande Island and Sao Jorge Island near to the mouth of Zuari estuary off Vasco De Gama in South Goa. These ecosystems include habitats like natural coral reef patches, shipwrecks, submerged rocky zones covered of corals and sandy bottoms all around the islands. Hence, they provide conducive habitats with respect to breeding, feeding and shelter for a variety of aquatic fish and shellfish species. A total of 85 species from 35 families was recorded during the study at the site.



Figure. 4 (a) Indian Mackerel, (*Rastrelliger Kanagurta*) soniferous fish found at experimental site (b) School of fish making chorus (c) Aquamap showing habitat map of *Rastrelliger Kanagurta*

In tropical shallow coastal bio-diverse waters, the contribution of biological noise is very significant [7]. The major source of ambient noise at the site is found to be biophonic noise made by Terapontidae and planktivorous fish chorus. Underwater videography confirmed vocal fish presence at the site. The analyses carried out reveals fish chorus belonging to the family “Terapontidae” which is found in South east Arabian Sea (SEAS) [8] is also found in abundance near the Goa test site. William Fernandez et al [9] of NIO and NIOT, who carried out recording of noise made by fish near Grande island, reported similar results. Efforts made to identify noise making fish off Goa coast in consultation with Department of Fisheries, and Indian Council of Agricultural Research (ICAR), Central Marine Fisheries Research Institute (CMFRI), NIO, Goa and local fishermen communities. Diving operations conducted and underwater videography undertaken on 12 April 2015 to ascertain the type of vocal fish species available at the site. It was observed that the experimental site has a diverse range of noise-making fish species. The major source of ambient noise at the site is found to be biophonic noise made by Terapontidae and planktivorous fish chorus. The Indian mackerel (*Rastrelliger kanagurta*) which is Planktivorous fish is a species of mackerel in the scombridae family of order Perciformes[10]. Underwater videography confirmed this vocal fish presence at the site. The details of fish and its habitat are shown in Figure. 4.

vii) Environmental Parameters

It is known that, sea surface, sea bottom and the water column between the two, significantly influence the ambient noise in shallow coastal tropical waters. Environmental parameters like wind speed/direction, salinity, bathymetry and sound speed profile were measured at location. Wind speed and direction data was also collected from Indian Navy weather station located at ~5km from the site.

V. RESULTS AND DISCUSSION

The underwater ambient noise in marine environment is measured by three methods: (i) portable hydrophones from boat (ii) moored autonomous acoustic vertical array and (iii) sensors placed on sea bed. The measurements taken up at the site and the results obtained are discussed in detail.

a) Wind

Wind-dependent noise results from the oscillation of bubbles formed by air entrainment as waves break and this is more dependent on the forcing by the wind. The dependence of noise on wind speed provides a simple way of predicting and forecasting the noise from weather forecasts, and if wind speed is measured together with measurements of ambient noise, this component can be separated from other components. Noise generated by wind has a distinctive shape with the frequency range up to 0.5-8 kHz. The noise level fluctuation is higher in the lower frequency and lower in the higher frequency. Figure. 5(a) shows the ambient noise observed at different wind speeds. Figure. 5(b) shows ambient noise measured during the same wind speed conditions.

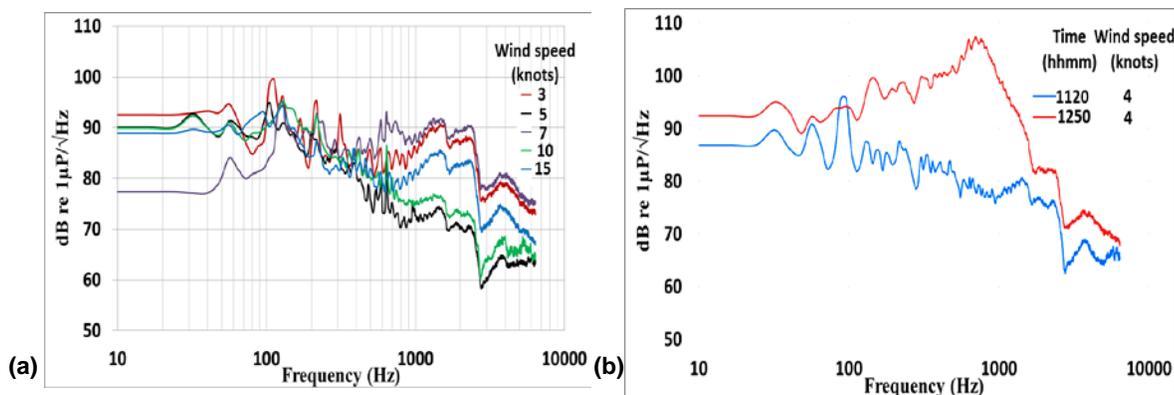


Figure.5 Measurement of the ambient noise on 27 and 28 January 2015 (a) at different wind speeds (b) at same wind speed and different times.

Ambient noise level variations observed from 60-100 dB at different frequencies 10Hz-10kHz. with wind speeds 3-15 knots (1.54 - 7.72m/s).When the wind speed was consistent at 4 knots the peak noise level increased by 25 dB at 1000 Hz frequency during time period 1120 hrs to 1250 hrs. It is observed that wind is not significantly responsible for increase in ambient noise from 1200 hrs –

2300 hrs at the site. This increase in ambient noise cannot be attributed to wind variations. It can be by other sources like biophonic and/or anthropogenic sources (shipping).

b) Velocity profile

The cast away conductivity-temperature-depth (CTD) instrument was deployed from boat and various parameters recorded to determine the effect of sound velocity profiling, temperature, conductivity, density and salinity on ambient noise at the site. Figure. 6

(a) shows the variation of

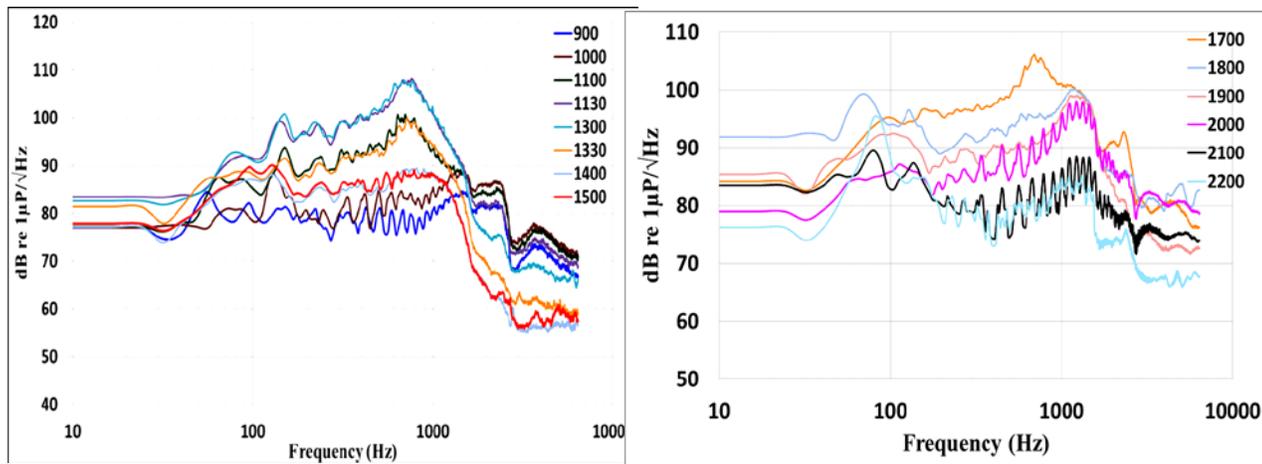


Figure.6 Ambient noise levels recorded at the site on 13 February 2015 (a) from 0900-1500 hrs and (b) from 1700-2200 hrs

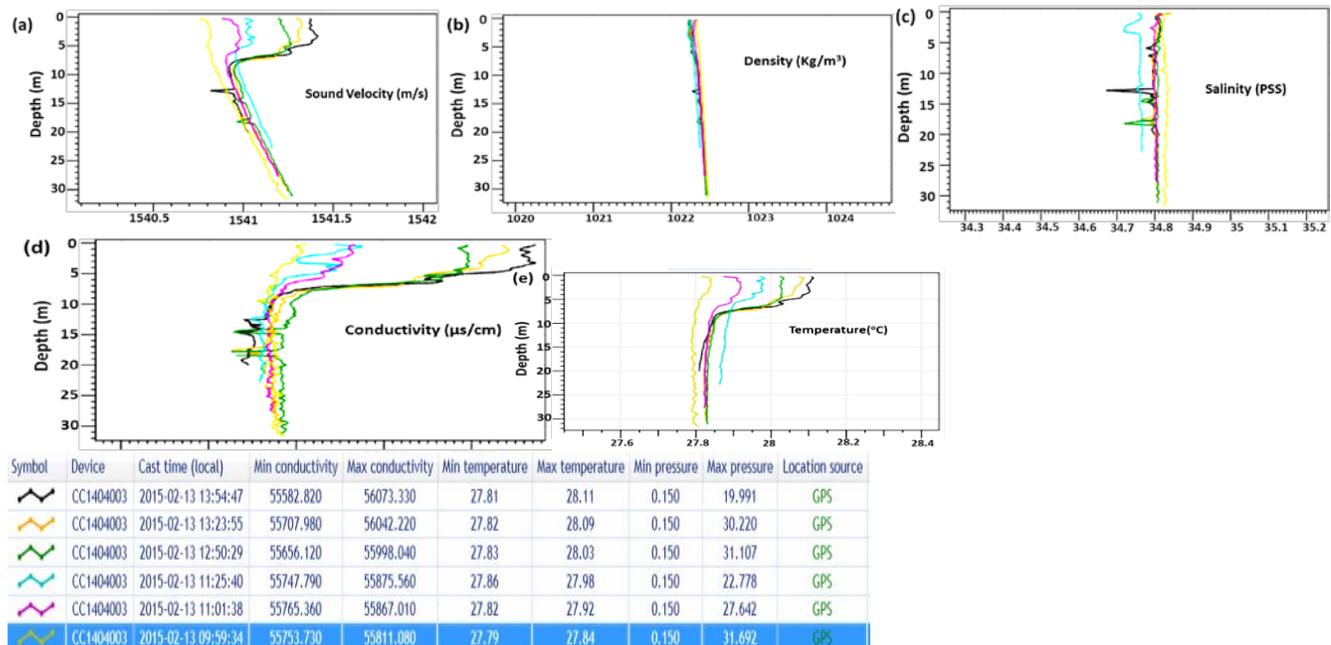


Figure.7 Environmental parameter measurements on 13 Feb 15 from 1000 to 1400 hrs by using a CTD (conductivity depth temperature). (a) Sound velocity profile (b) Density (c) Salinity (d) Conductivity and (e) Temperature and device log details with color code.

(a) Sound

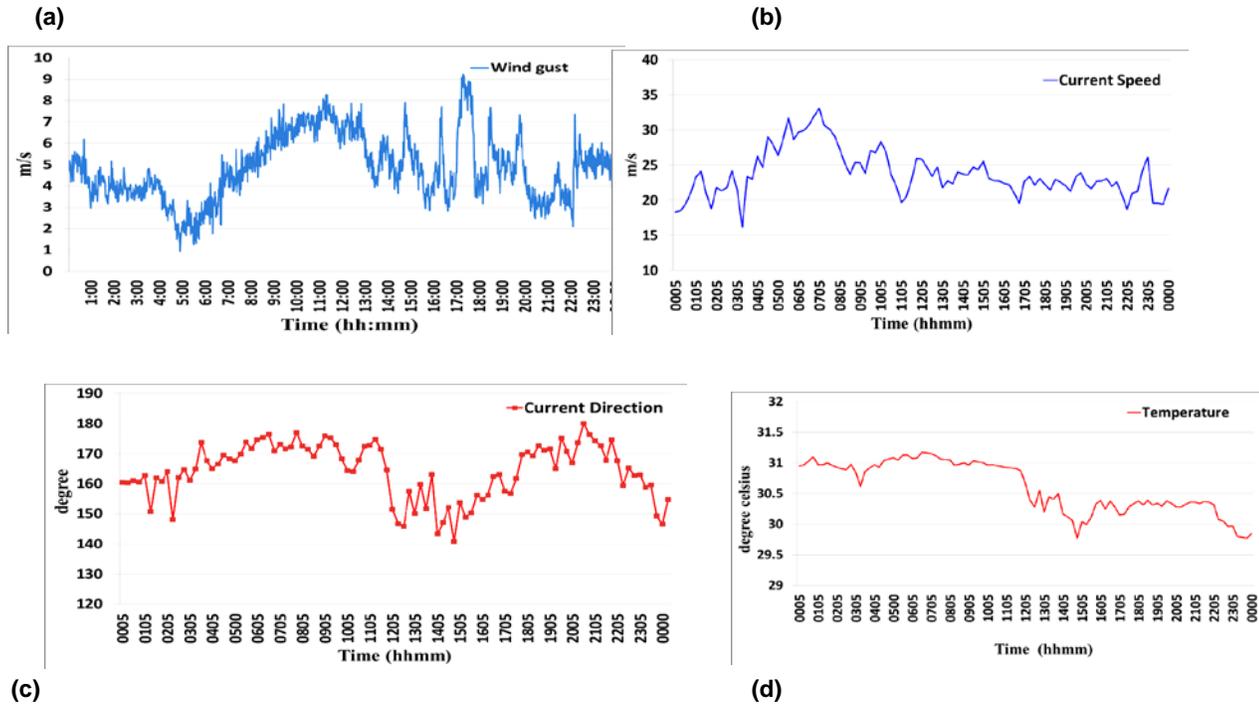


Figure. 8 Weather parameter measurements at site a) Wind gust b) Current speed c) Current direction and d) Temperature of sea water

ambient noise from 0900-1500 hrs and Figure. 6 (b) shows ambient noise variations from 1700-2200 hrs on 13 February 2015. As seen from Figure.6 (a) and (b), the ambient noise level was low at 0900 hrs around 70-80 dB. Noise level started to increase from 1130 hrs and peaked at 1700 hrs (85-105 dB). The noise level was observed to decrease to 70-80 dB range at 2200 hrs. The increase is correlated to changes in sound velocity profile, current speed/direction, wind speed/direction and sea water temperature, conductivity as seen from Figures 7 and 8.

c) Noise Measurements using hanging hydrophone from boat

Noise measurements using Songmeter SM2M+ from boat with engine shutdown were taken at the site on 10 and 11 May 2015. The results are shown below. The ambient noise spectrum is plotted against frequency upto 6400 Hz for narrow band analysis.

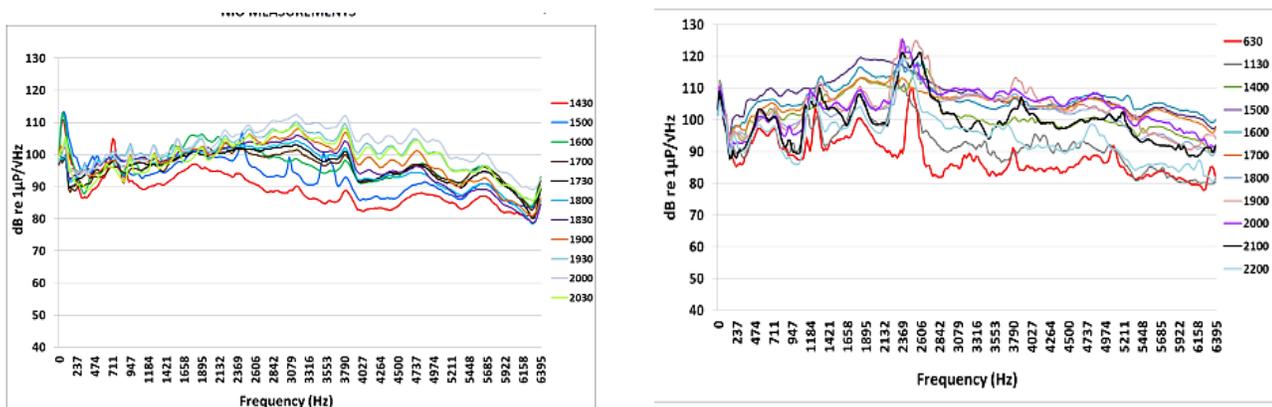


Figure 9 (a) shows the

(a) (b)

Figure 9. Ambient noise levels measured by hanging hydrophone from boat a) 10 May 2015 and b) 11 May 2015

levels recorded at half-hourly basis at different times of the day starting 14:30 hrs to 20:30 hrs on 10 May 2015. There is a consistent increase in noise levels through out the frequency range. Figure 9 (b) shows the recorded noise levels from 06:30 hrs to 22:00 hrs on 11 May 2015. The noise levels consistently increased with time and few peaks observed at frequencies 1000-2800 Hz. The variations are pronounced in this graph as the recordings presented are from 06:30 hrs where the ambient noise levels are at minimum and increased steadily throughout the day and night.

d) Comparison of ambient Noise data recorded from seabed sensors and hanging hydrophone from boat

Figure 10 shows the comparison of the ambient noise level spectrum measured on 10 and 11 May 2015 with hanging hydrophone from boat (a) and (c) and seabed mounted hydrophones (b) and (d). The noise levels measured by both methods follow a similar spectral distribution. The noise levels measured on 10 May 2015 by hanging hydrophone from boat are in the range of 80-110 dB over a frequency band of 0-6395 Hz. The noise levels measured by hanging hydrophones are 20-30 dB higher than the seabed mounted hydrophone measured noise levels (50-90 dB) over the same frequency range on the same day.

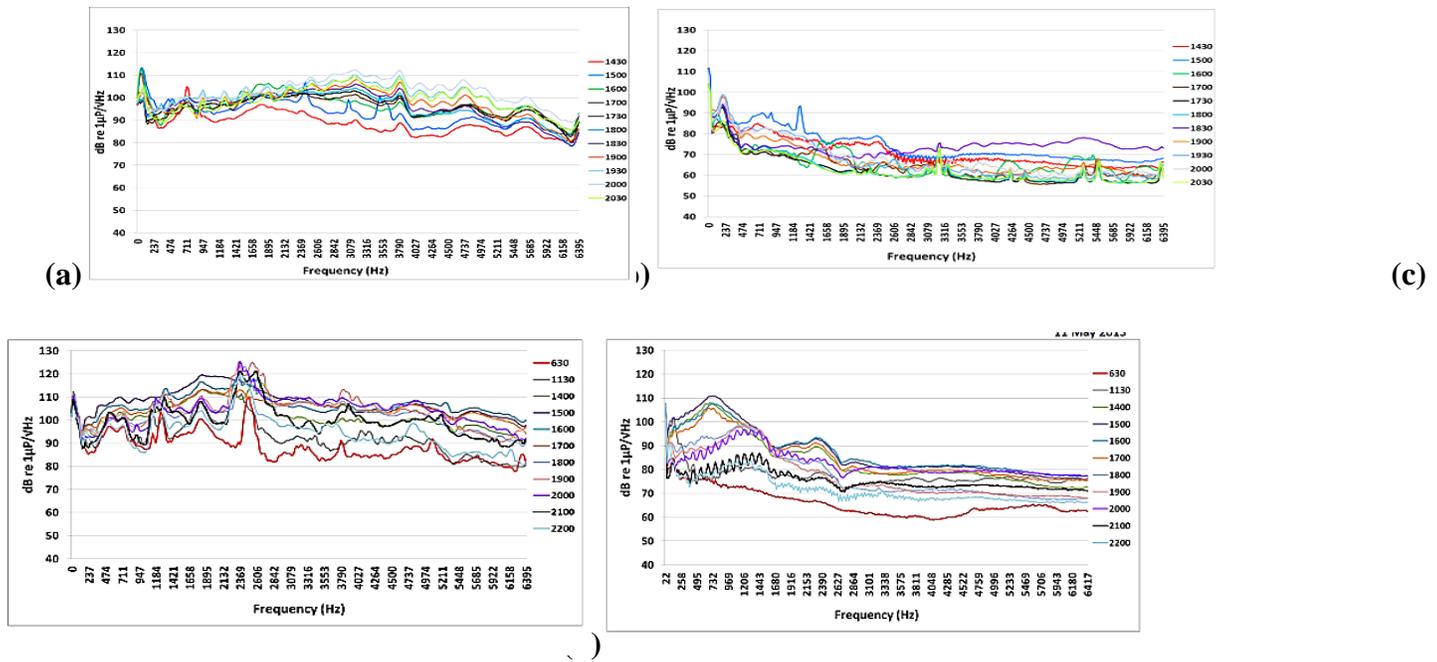


Figure.10 Ambient noise measurements 10 May 2015 with (a) hanging hydrophone from boat (b) seabed mounted hydrophones: 11 May 2015 with (c) hanging hydrophone from boat (d) seabed mounted hydrophones

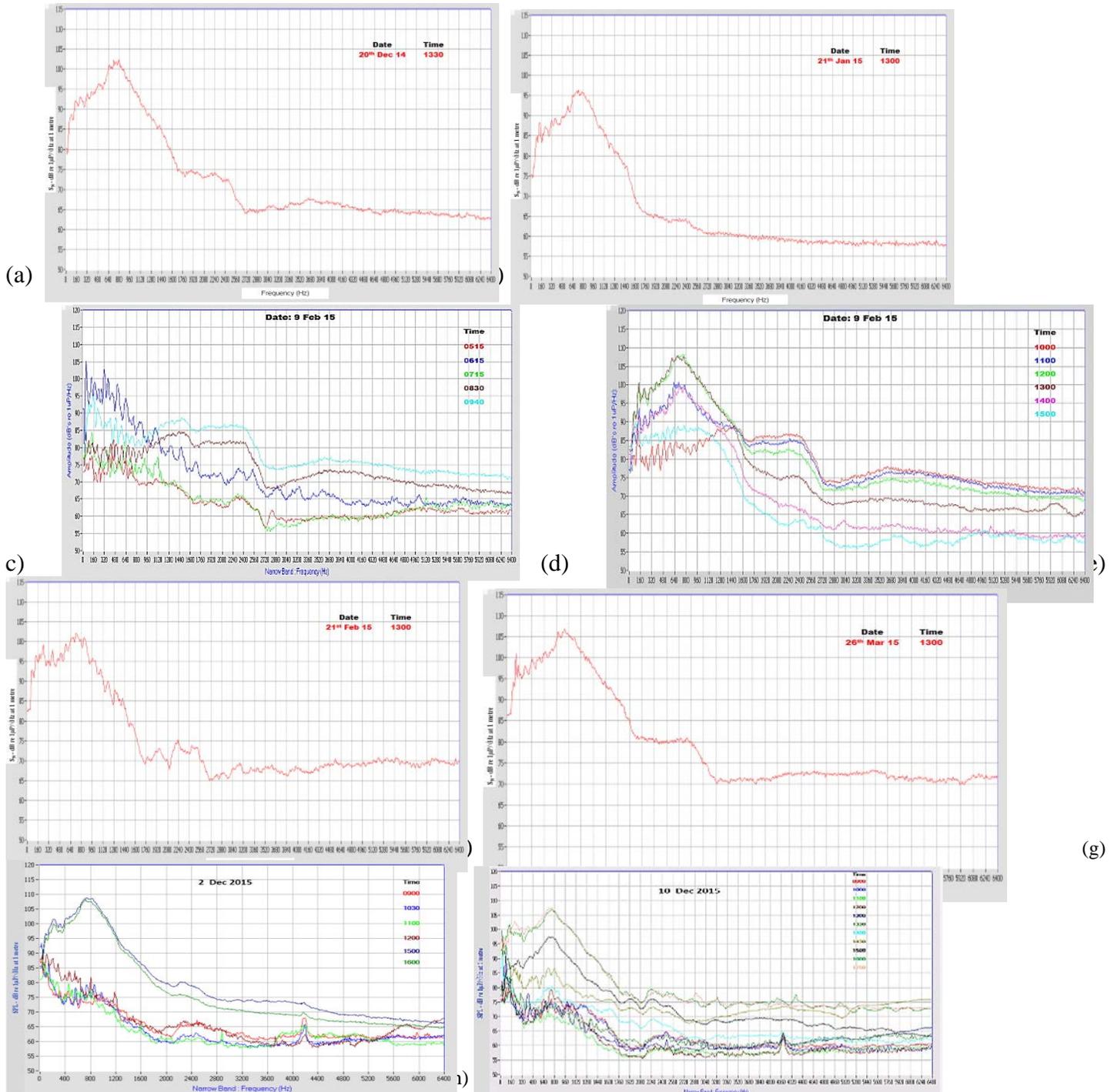
The noise levels measured on 11 May 2015 by hanging hydrophone from boat are in the range of 80-125 dB over a frequency band of 0-6395 Hz. However, there is a peak power level of 110-125 dB over frequency range of 1000-2600 Hz. The noise levels measured by seabed mounted hydrophone are 60-110 dB with peak power levels of 100-110 dB over frequency range of 500-1500 Hz. The noise levels measured by hanging hydrophone are 20-30 dB higher than the seabed mounted hydrophones.

This phenomenon is due to the fact that hanging hydrophone is closer to the sea surface (5-10 m below sea surface) and the noise making sources (wind, ships, and fishing boats) than the seabed mounted hydrophones (30 m below sea surface). The spreading (spherical), propagation, refraction/reflection and absorption losses account for the difference in ambient noise power levels near the surface and near the bottom of the sea in shallow water waveguide like scenario.

e) Noise measurement using seabed mounted hydrophones

Ambient noise measurements carried out from 20 December 2014 to 08 Feb 2016 except monsoon period of June-October. Figure 11 shows noise power spectrum levels during typical days throughout the measurement cycle. The noise level variations at 1330hrs on 20 Dec 2014 and at 1300 hrs 21 Jan 2015 show a similar pattern with lower peak power (by 6 dB) on 21 Jan 2015. On 09 February 2015 the noise levels in the morning and noon sessions are shown at Figure.11 (c) and (d) respectively. The gradual increase in the ambient noise power levels over a frequency band of 0-6400 Hz with time of the day can be clearly seen. Most of the noise power is concentrated in the lower frequency zone with clear peak power level of 107 dB at frequency range of 600-800 Hz near noon

time and decaying and leveling with increase in frequency. The power levels recorded at 1300 hrs on 21 Feb 2015 and 26 Mar 2015 (e) and (f) are almost same and the pattern is identical. Typical pattern is also observed on 02-10 December 2015 (g) and (h) at different times increasing from morning till late evening with peaks at 800-1000 Hz frequency range. During 01-06 January 2016 (i) and (j) the results are same with high power peaks at lower frequency and power levels increasing as the day progresses. On 02-08 Feb 2016 (k) and (l) the same phenomenon occurs with typical power levels indicating a typical pattern recorded by seabed mounted hydrophones.



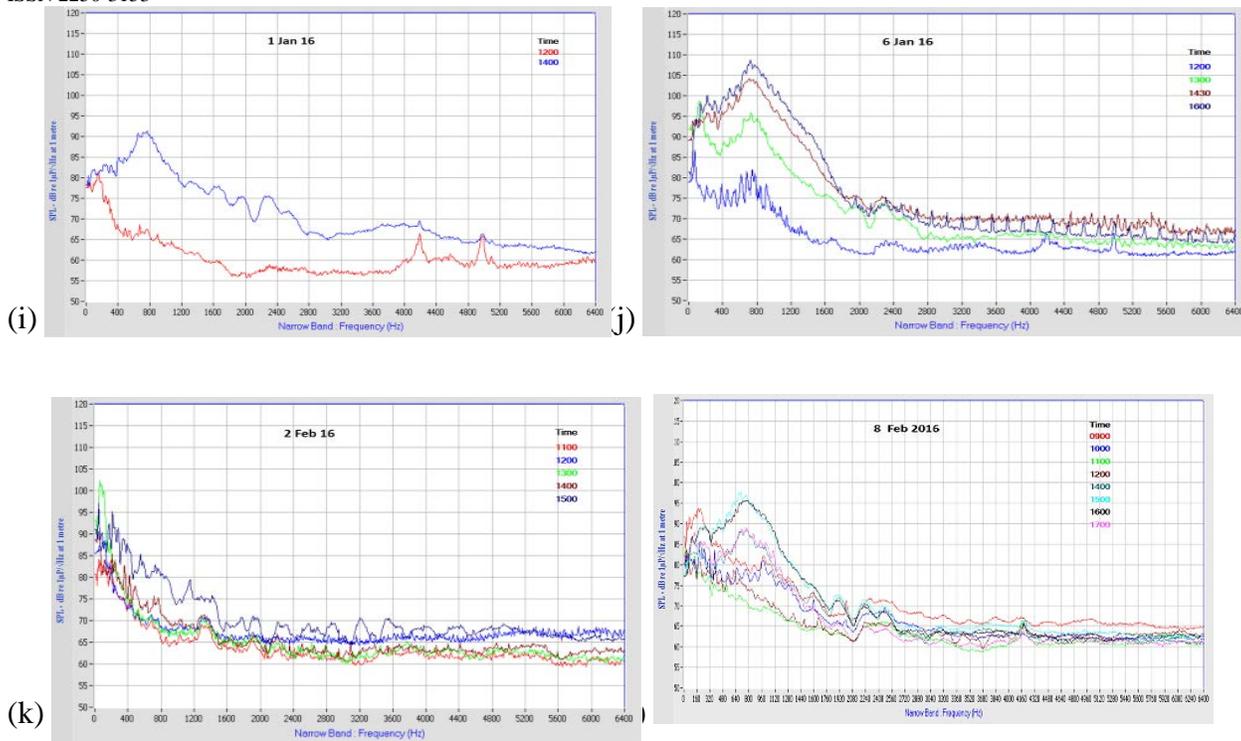
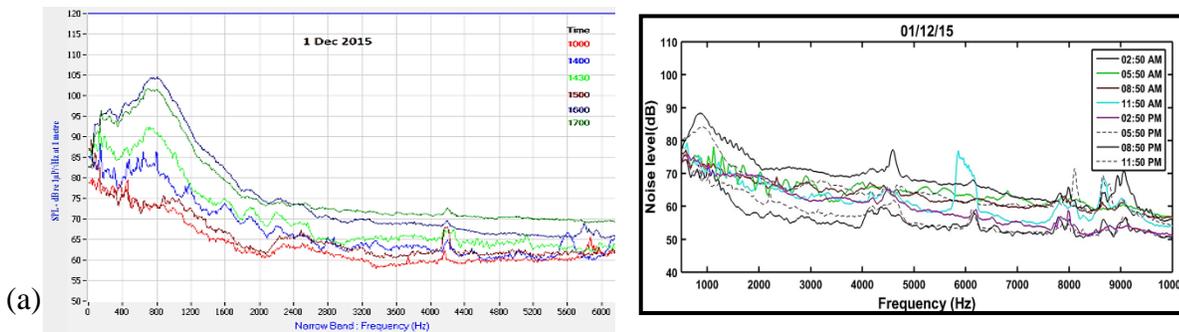


Figure.11 underwater ambient noise spectrum levels recorded by seabed mounted hydrophones on (a) 20 Dec 2014 and (b) 21 January 2015; 09 February 2015 (c) 0515 – 0940 hrs and (d) 1000-1500 hrs; (e) 21 February 2015 and (f) 26 March 2015; (g) 02 December 2015 and (h) 10 December 2015; (i) 01 January 2016 and (j) 06 January 2016; (k) 02 February 2016 and (l) 08 February 2016

f) Comparison of ambient noise measured by Seabed hydrophone vs moored hydrophone

Passive acoustic datasets were collected using moored hydrophones and seabed mounted hydrophones concurrently, during December 2015 and January 2016 at the site. The results shown in Figure 12 (a), (b) and (c) are the noise levels recorded on 01 Dec, 10 Dec 2015 and 06 Jan 2016 respectively. Left hand side is seabed mounted hydrophone recorded data and right hand side is moored hydrophone data .



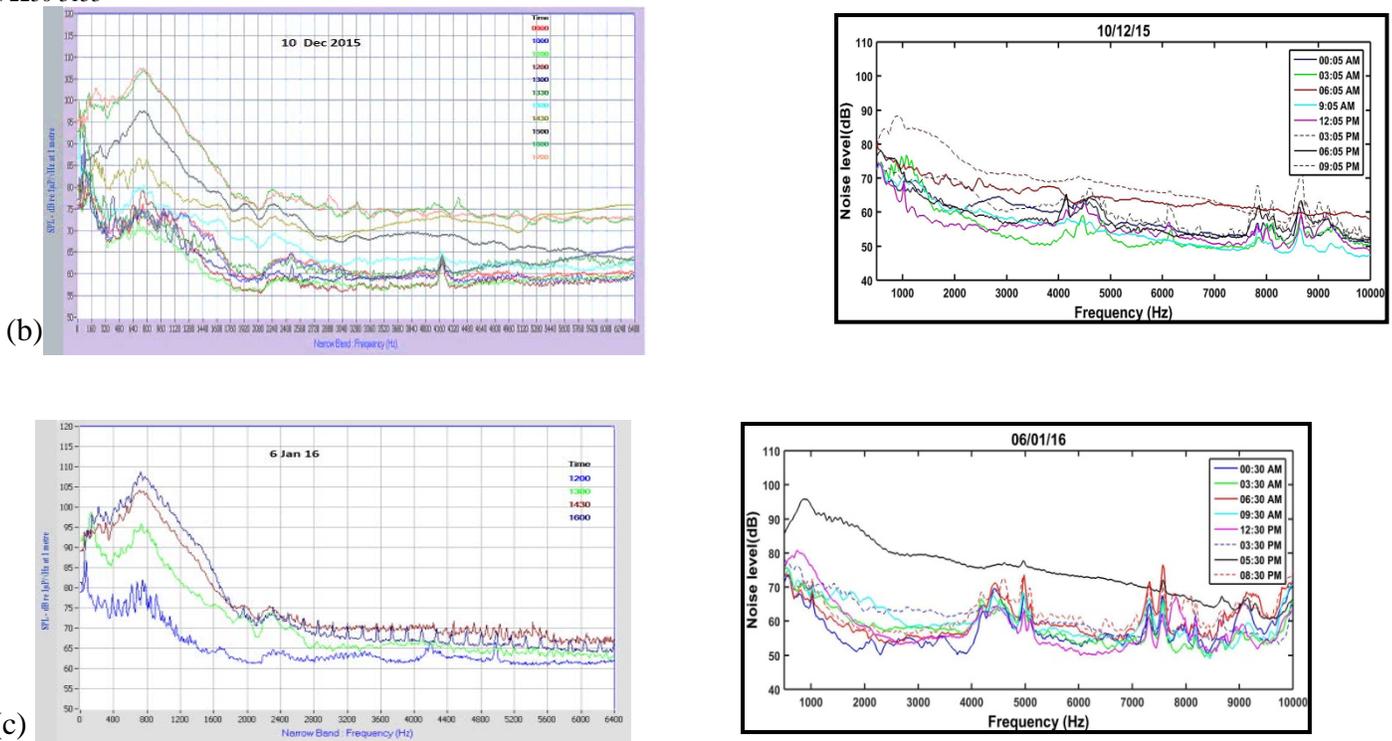


Figure 12 Ambient noise level data recorded by seabed hydrophone (left) and moored hydrophone (right) on (a) 01 December 2015 (b) 10 December 2015 and (c) 06 January 2016

The seabed sensors data is presented in power spectrum density level vs frequency (0-6400Hz) whereas the autonomous recorder data is presented sound pressure level vs frequency (0-10000Hz). However, the shape of both ambient noise curves show the same varying pattern. The area is dominated by the noise due to geophonic and biophonic as well as anthroponic sources. Noise generated by wind has a distinctive shape with the frequency range up to 0.5-8 kHz. The noise level fluctuation is higher in the lower frequency spectrum.

VI. CONCLUSIONS

In this study, an attempt is made to empirically characterize the underwater ambient noise in coastal tropical shallow waters of Goa coast. Three methods of underwater ambient noise measurement used for recording data at experimental site to cover the entire water column and the results compared. It is observed that seabed mounted hydrophones cabled to the shore measurement method is better suited for shallow coastal underwater ambient noise measurements. This method gives accurate results compared to moored hydrophone autonomous recorder or hanging hydrophone method. The underwater ambient noise levels and variations measured simultaneously during December 2015 – January 2016 by using seabed hydrophones and moored autonomous recorder with vertical array of hydrophones, at the site, gave almost similar results. Effect of different environmental factors such as ocean currents,

wind, temperature, conductivity, density of seawater, velocity profiling, shipping and air traffic and biological noise were determined for the increase in ambient noise at the site.

The underwater noise levels varied in the range 60-115 dB corresponding to 10-6400 Hz frequency band. The major source of ambient noise at the site is found to be bio-phonic noise made by Indian mackerel (*Rastrelliger kanagurta*) which is Planktivorous fish is a species of mackerel in the scombridae family of order Perciformes. Measurements confirm that fish chorus raised the ambient noise level by 20-30 dB. The fish chorus noise started at 1200 Hrs and reduced by 2300 Hrs during most of the period of measurement from December 2014 - February 2016. The results clearly show that second-largest contribution to ambient noise is wind. Contributions from ships and fishing boats are occasional and is observed to be the third major source of ambient noise at the site. The wind speed during the period of observation varies from 1 to 7 m/s, and the increase in noise level with wind speed is observed in the noise records. Shipping noise and chirp signals were observed during the first week of December 2015. Analysis revealed the highest underwater ambient noise levels occurring in Mar-May 2015 (105 ± 0.6 dB_{rms} ref 1 μ Pa) and December 2015-February 2016 (108 ± 0.6 dB_{rms} ref 1 μ Pa) at the site. There was significant temporal variation over a 24 h period in measured sound levels, with higher sound levels generally occurring at dawn. Spectral analysis revealed a rise in spectral power in the 0.5–4 kHz bandwidths during afternoon periods within the site.

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