International Hydroacoustics Workshop 2015

Report of Contributions

ID: Type: **Poster**

# of IDC seismic/hydroacoutic Data to Comoro-Islands related Hazards and Assessment.

Comoros Islands, roughly in between (11-13 degrees) Latitudes and (43-45 degrees) Longitudes, are located at the Western Indian Ocean side, Along the Northern end of the Mozambique Channel, separating Madagascar from Southeastern Africa . The Indian Ocean region, mostly affected by seismic activities, experienced Hazards and effects of the most damaging wide Tsunami from under water earthquakes in reference to the Sumatra Andaman in 2004. Almost +/-6000 km distance from the source of the 9.2 Magnitude, Comoro was affected by up to 7m run-ups in 35 areas approximately surveyed. The Mid-Indian Ocean Hydroacoustic Station H08N records numerous hydroacoustic Data from local/regional under-water seismic events of Magnitudes ≥ 4 ML/mb (e.g. mb 5 on 27/08/2008; ML 4.9 on 13/03/2012, etc.). T-Phase detections from these IDC-SEL3s Data are relevant for Data investigation, characterization, Analyses and Interpretation of Oceanic seismic events. Such Phase detections are key threshold for pursuing events Magnitudes and distance estimations in regard of strong underwater seismic activities. IMS hydroacoustic Facilities are not only important in monitoring Oceans but also significant in the aspect of small Islands Disaster warning and tsunami Hazard Investigation.

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Track Classification: 1 - Civilian applications of IMS data

ID: Type: **Poster**

OF HYDROACOUSTIC TECHNOLOGY IN THE PERUVIAN SEA AND EFFECT ON BIODIVERSITY

Noise levels generated in the Peruvian marine environment resulting from the application of hydroacoustic technology in the development of civil anthropogenic activities are aimed to the rational use of fishery resources, exploitation of minerals (oil and gas exploration), infrastructure construction and maritime traffic. Main applications are: Fishery resources surveying, began in Peru (IMARPE) since the early 1970s, with the beginning of scientific sounders (120 and 38 kHz) and echointegration to estimate biomass of fish stocks; such as anchovy, sardine, horse mackerel, mackerel, hake, etc for a rational exploitation. Actually, multifrequencies scientific sounders (18, 38, 50, 70, 120, 200 and 333 kHz) are used to estimate biomass of fisheries resources. 3D seismic operations are performed frequently in the Peruvian sea. While it is true that considerations are taken to make shots and no harm marine mammals. However, the results show damage in the zooplankton, which showed deterioration in their morphological structure. Other kind use of hydroacoustic is measurements about transmission and loss propagation of sound considering two scenarios: a) noise generated by the marine environment, b) noise generated by a sound source activated by a trigger. For measuring sound intensities were used hydrophones and using the model Bellhop.

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Track Classification: 1 - Civilian applications of IMS data

ID: Type: **Oral**

/Scientific applications of IMS hydroacoustic data and products and the responsibilities of the CTBTO and member states in enforcing the treaty

The IMS uses hydroacoustic, seismic, infrasound and radionuclide technologies to monitor compliance with the CTBT. These technologies, together with data/products of the IDC, have potential civil/scientific applications which benefit states and the scientific community. IMS hydrophone and T-phase stations are able to monitor natural geophysical events (underwater seismicity and volcanism) and marine mammals. Whales have very wide range of vocalizations that can be readily detected by IMS stations. The nature of sounds, duration, pattern and frequency content, can be used to identify the whale species. Hence it is possible to obtain information on the position, populations, migration/ seasonal patterns and illegal hunting of individual whale species. Acoustic thermometry in the oceans can be used for monitoring the average, long term temperature changes, improved understanding processes and currents and an increased capability to predict weather phenomena. However, there is a need for an effective tsunami early warning system which could have saved thousands of lives on 26-12-2004 in the Indian Ocean region. Looking ahead, expert discussions need to be continued to improve the understanding of potential civil/scientific applications of verification data and technologies. Member States could increase the exchange among countries to spread technological knowledge and ease access to verification technologies.

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Track Classification: 1 - Civilian applications of IMS data

ID: Type: **Poster**

Faso NDC: challenges to use of hydroacoustic data

the government of burkina faso throught the ministry of foreign affairs in a billateral agreement with the PTS for CTBTO established a NDC in Burkina with the aim of monitoring the testing of nuclear explosions. Seismic, hydro acoustic, radionucleide and infrasound methods are used for the monitoring. The NDC was commissioned in February 2010 and currently has nearly 5 technicians who treats only the seismic data received directly from IMS. Thus to increase its resources, participate in various debates and make our contribution we are looking for these kinds of forums to enjoy the experiences of others to build our emergent NDC.

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Track Classification: 1 - Civilian applications of IMS data

ID: Type: **Oral**

the Global Ocean Soundscape Over Time

Measurements of ocean sound ocean have been made in many locations at many times since hydrophones were first deployed in the 1950s, and measurements in the North Pacific Ocean and some other regions show that sound has increased over this period. This increase has significant implications for organisms that live in the ocean and use sound for life functions. Much ocean acoustic data are available from scientific measurements, ocean observing systems, observations by national navies, and energy companies. The Comprehensive Nuclear Test Ban Treaty Organization International Monitoring System (CTBTO IMS) records hydroacoustic information at 6 locations throughout the world ocean to monitor for nuclear signatures. Although the CTBTO IMS was designed for a specific purpose related to adherence to the treaty, the data obtained are useful for a wealth of scientific purposes. To create a global ocean soundscape and determine how sound in the ocean is changing over time, coordination of available acoustic observations, intercalibration of observing systems, and sharing of data needs to be improved. This presentation describes a new international research project called the International Quiet Ocean Experiment, which is designed to characterize ocean soundscapes, improve observations of ocean sound, and study how sound affects marine organisms.

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Track Classification: 1 - Civilian applications of IMS data

ID: Type: **Poster**

AND USAGE OF IMS HYDROACOUSTIC DATA BY STATE PARTIES IN AFRICA

The IMS hydroacoustic network do detects signals from underwater explosions, military activities, anti-submarine exercises, marine seismic surveys and blast fishing. This study investigated access and usage to IMS hydroacoustic data. The population of the study was State Parties in the Africa region. Source of data was primary and were collected through structured questionnaire which was distributed to State Parties selected at random. Data were analyzed with the aid of SPSS. The result showed that in human capital there are inadequate skilled personnel in hydroacoustic data analysis; also few educational institutions in offer courses in ocean studies. On structural capital there is poor power supply, inadequate computing equipment and poor funding to support human development in hydroacoustic data analysis. In terms of social capital poor networking of professionals in hydroacoustic data analysis within the State Parties was noted in the study also noted were poor communication with CTBTO in the area of training needs and lack of government commitment to ocean studies. To strengthen the State Parties ability to deploy CTBT verification technologies civil and scientific purposes there is the need to increase the period allocated for hydroacoustic data analysis during CTBTO trainings and exercises.

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Track Classification: 1 - Civilian applications of IMS data

ID: Type: **Oral**

ocean sound trends and whale density from CTBTO data

While deep water ambient sound level increases have been documented in the eastern North Pacific Ocean over the past 60 years, it remains unclear whether this trend increasing is observed globally. Data from the Comprehensive Nuclear-Test-Ban Treaty Organization International Monitoring System (CTBTO IMS) was used to examine the rate and direction of low frequency change over the past decade in the Indian, South Atlantic, and Equatorial Pacific Oceans. Similar to observed increases in the NE Pacific, increases in the ambient sound floor were also observed in the Indian Ocean at Diego Garcia. Sound levels over the past 5-6 years in the Equatorial Pacific, however, decreased. Decreases were also observed for specific sound level parameters and frequency bands in the South Atlantic Ocean. Based on these observations, it does not appear that low frequency sound levels are increasing globally; however, great variability in the soundscape was observed over time scales ranging from hours to seasons. Follow-on work examined the impact of the dynamic soundscape and selected sound level parameters on estimates of signal detection range, which is a critical parameter for current work in estimating blue and fin whale density from CTBTO IMS data.

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Track Classification: 1 - Civilian applications of IMS data

ID: Type: **not specified**

OF THE NATIONAL DATA CENTRE IN GHANA

The National Data Centre (NDC) in Ghana is part of a global network of capacity building under the auspices of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO). The Data Centre has technical expertise in the monitoring and verification technologies of the Comprehensive Nuclear-Test-Ban Treaty and provides technical advice and support on issues pertaining to the verification of the treaty. The goals of the data centre include the following: collating of seismic, hydroacoustic, infrasound and radionuclide data for monitoring nuclear explosions and in the case of seismic data for seismic hazard assessment and disaster reduction. The Centre has access to certified data as well as transfer of technology and global communications systems from the CTBTO. The Centre provides information on earthquake safety measures to assist government agencies develop land and building policies for the nation as well as provide technical advice and support to our stakeholders. The NDC is complementing the efforts of the Geological Survey Department of Ghana in monitoring seismic activities in the country, with the data it receives from the International Data Centre. Ghana is pleased to be part of this very important global agenda. Monitoring the testing of nuclear explosions to ensure global security and peace.

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Track Classification: 1 - Civilian applications of IMS data

ID: Type: **Oral**

computation of three-dimensional (3D) long-range acoustic propagation for improved localisation methods

Three-dimensional acoustic propagation in the open ocean for low frequency sound is an observed phenomenon (Heaney and Murray, JASA 2008), and is known to lead to biases in the localisation of long-range sources (Munk et. al., JASA, 1988). In this paper, a high-fidelity fully 3D global acoustic Parabolic Equation model is applied to the problem to demonstrate the impact of 3D acoustic propagation due both to bathymetric diffraction/refraction and to mesoscale oceanographic variability. The mesoscale/seasonal angle-of-arrival variability (for an open water path) for a 10,000 km source/receiver range through dynamic oceanography is shown to be on the order of 2 degrees over the annual cycle. For regions with traditional bathymetric blockage, 3D propagation exhibits significant diffraction, leading to a large area of the ocean that is covered by the hydroacoustic network, but is currently considered shadowed. Three-dimensional back-propagation from each hydroacoustic station can be computed and used as a look-up table to directly improve the localisation accuracy of hydro-acoustic only detections. Inclusion of these maps in the Bayesian localisation approach used at CTBTO should lead to significant reduction in the area of uncertainty associated with hydro-only detections and localisations, permitting a significant improvement in the sensor networks overall detection/classification/localisation capability.

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Track Classification: 2 - Signal processing techniques for hydroacoustic event detection and evaluation via different types of sensors

ID: Type: **Oral**

calibration of CTBTO hydrophone arrays using long-term ambient noise records

When using a hydroacoustic array to determine the bearing of a source, errors in the sensor positions severely reduce the accuracy of any bearing measurements. This issue is particularly problematic for three sensor arrays, designed to work in two dimensions, because of the lack of redundancy built into the array. This paper presents a method for correcting errors in sensor positions. It is mathematically straightforward to determine the bearing of a far-field impulsive signal by determining the time difference of arrival between sensors by cross-correlation. These time delays can also be used to estimate the sound speed in the vicinity of the array. In an isotropic acoustic medium, the local sound speed is expected to be independent of the source bearing. If the sensor positions used to determine the sound speed and bearing are incorrect, the resulting sound speed measurements will be bearing-dependent. Using an analytically derived function, the correct array shape (with only translational and rotational ambiguity) can be backed out from the directional sound speed distribution. This method will be demonstrated using long-term ambient noise records from the CTBTO's hydrophone arrays.

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Track Classification: 2 - Signal processing techniques for hydroacoustic event detection and evaluation via different types of sensors

ID: Type: **Poster**

GSN Seismometers as Temporary Replacements for Hydrophone Stations

The requirement for essential maintenance to be carried out on the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) hydrophones means that data from some of these stations may be unavailable for substantial periods of time. In this study we examine the possibility of using seismometer stations located on nearby islands as temporary replacements. To do this, hydrophone station recordings of T-phases for seismic disturbances published in the Reviewed Event Bulletin are compared with the recordings at nearby seismometer stations. A comparison of the signal-to-noise ratios (SNRs) for these data from a five-year period shows that many of the T-phases recorded on the CTBTO hydrophones are detected in the 2-6 Hz passband at seismometers located on Ascension Island and Diego Garcia. At higher frequencies the detection capability at Ascension Island is hindered by the presence of high frequency noise, while at Diego Garcia signals above 8 Hz are rarely detected. The absence of high frequencies suggests that while T-phases recorded on nearby seismometers may potentially be used to detect and locate seismic sources when nearby hydrophones are unavailable, source identification by observation of the bubble pulse or high frequency signals diagnostic of an underwater explosion will not be possible.

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Track Classification: 2 - Signal processing techniques for hydroacoustic event detection and evaluation via different types of sensors

ID: Type: **not specified**

analysis of T-wave observed in Ulleungdo of South Korea

Ulleungdo is an island located in the East sea of Korea. Korea Institute Geoscience and Mineral Resources (KIGAM) has operated a seismic array station called ULDAR composed of four CMG-40T sensors and four Q330 digitizers since December, 2007. This study is about the T-wave recorded by ULDAR. The ULDAR recorded various noises and signals different from those recorded at inland stations. We observed a number of events such as earthquakes, underwater explosions and so on. T-wave was generated from some events. For example, from the second and third underground nuclear tests of North Korea, T-wave was observed. The distance between the test site and ULDAR is about 445km. Group velocity is 1.5km/s in good fit with T-wave speed. We classified the T-wave generated by events in the East Sea including the North Korean nuclear tests to understand its features.

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Track Classification: 2 - Signal processing techniques for hydroacoustic event detection and evaluation via different types of sensors

ID: Type: **Oral**

# of an extremely shallow underwater explosion of the ROKS Cheonan sinking using seismic, hydroacoustic and infrasound waves including boundary element method

We estimated the detonation depth and net explosive weight for a very shallow underwater explosion using cutoff frequencies and spectral analysis of seismic and hydroacoustic waves. With detonation depth and a bubble pulse the net explosive weight for a shallow underwater explosion could simply be determined. The ray trace modeling confirms the detonation depth as a source of the hydroacoustic wave propagation in a shallow channel. We found cutoff frequencies of the reflection off the ocean bottom to be 8.5 Hz, 25 Hz, and 43 Hz while the cutoff frequency of the reflection off the free surface to be 45 Hz including 1.01 Hz for the bubble pulse, and also found the cutoff frequency of surface reflection to well fit the ray-trace modeling. We also attempted to corroborate our findings using a 3D bubble shape modeling and boundary element method (BEM) and infrasound signals. Our findings led us to the net explosive weight of the underwater explosion for the ROKS Cheonan sinking to be approximately 136 kg TNT at a depth of about 8 m within an ocean depth of around 44 m off the coast of Baengnyeong Island in the Yellow Sea on March 26, 2010.

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Track Classification: 2 - Signal processing techniques for hydroacoustic event detection and evaluation via different types of sensors

ID: Type: **Oral**

-time monitoring data for early tsunami detection and prediction studies for disaster mitigation from earthquakes and tsunamis

DONET 1 and DONET 2 are ocean floor observatories designed for real time earthquake and tsunami warning. They include 51 observation points to cover the Nankai trough seismogenic zone SW in Japan. Their observation capability is based on a variety of sensors, such as accelerometer, broadband seismometer, pressure gauges, thermometers and ocean floor hydrophones. Although their construction is expected to be fully completed by March 2016, they already provide real time monitoring capabilities. In 2011, during the Tohoku earthquake 10 observation points from DONET 1 was operational and provided useful data. These data identify the tsunami process in a more definite manner than those obtained from nearly tide gauges. Pertinent databases are created to facilitate quick initial response and appropriate tsunami evacuation processes.

Further studies focus on the identification of tsunami precursors in hydro-acoustic data from DONET. This approach could be used of the detection of non-seismogenic tsunamis and other disasters which cannot be cannot be detected by the seismic network. Recently, a Nature article provided real data evidence on ambient seafloor noise excited by earthquakes in the Nankai subduction zone. In conclusion, real-time monitoring data from ocean observatories are indispensable both for ocean sciences and for disaster mitigation.

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Track Classification: 4 - Upcoming acoustic/seismic trends in Ocean Observatories

ID: Type: **Oral**

- a State-of-the-Art Cabled Undersea Observatory

In 2013 and 2014, the University of Washington deployed RSN (Regional Scale Nodes), a state-of-the-art cabled ocean observatory. RSN was designed and constructed by the Applied Physics Lab-UW for a 25 year service life. Powered from shore by an 860 km backbone of high-bandwidth, telecom grade electro-optical cable, RSN supports 14 seafloor instrument platforms operating at depths of 80 to 2900 m. The instrument platforms are located on sediment in the offshore littoral zone and at the base of the continental shelf, and on pillow basalt in the caldera of an active undersea volcano 480 km offshore. Also deployed are three large and complex subsurface moorings that host APL-designed winched profilers, as well as APL-upgraded McLane Moored Profilers on separate moorings. The moorings are anchored at depths of 600 to 2900 m. In all, 100 commercial and custom academic instruments are connected to this observatory, including nine hydrophones and 13 seismometers. The observatory is highly modular and flexible, utilizing many hybrid and electrical wet-mate connectors for efficient installation and servicing by ROV.

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Track Classification: 4 - Upcoming acoustic/seismic trends in Ocean Observatories

ID: Type: **Oral**

-dynamic pressure recorded by the in-situ measurement at tsunamigenic earthquakes

Offshore observations make it possible to detect tsunamis in advance prior to their arrivals at the shoreline. For this purpose, bottom pressure gauges are traditionally used. However, in near- or intermediate-fields, ocean bottom pressure records usually exhibit a complicated interference of signals related not only to gravitational wave, but also to hydro-acoustic and seismic waves. Network of offshore observatories recently developed and deployed in Japan provide high sampling records of ocean bottom pressure and seismic (acceleration and velocity) signals. In the present study, by taking advantage of simultaneous in-situ measurements of pressure and seismic signals that were recorded during some recent tsunamigenic earthquakes, we reveal particular features of these signals and develop a practical method for selecting tsunami signal from ocean bottom pressure records. The present data processing has been done based on frequency dependencies among hydro-acoustic, forced, and gravitational waves.

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Track Classification: 4 - Upcoming acoustic/seismic trends in Ocean Observatories

ID: Type: **not specified**

Range and Observatory technology for IMS systems

Technology advancements in Ocean science observatories particularly in the area of power and data transport and wet matable power and data connection, provide new opportunity for IMS and other similar systems to be upgraded and maintained. An example of a modern operational observatory is the Regional Scale Nodes (RSN) observatory. The system is currently operational and sending real time data to researchers around the globe. Naval Maritime Ranges and other defense related cabled systems also offer connectivity options for repair, expansion and modernization. Maritime ranges typically rely on a large trunk cable to fixed junction boxes, at the junction box, the division of power and data for the separate systems is provided. Observatory technology similar to RSN in addition to the use of offshore junction boxes allows proven opportunities for; maintenance, expansion or use of emergent sensor systems in a plug and play manner. This paper provides an overview for implementation of an ocean observatory and training range technology and how these technologies can provide for IMS sustainability and improvement.

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Track Classification: 4 - Upcoming acoustic/seismic trends in Ocean Observatories

ID: Type: **Poster**

experiment results of long-range time reversal communication in deep water.

In our research program, a project to develop a long cruising autonomous underwater vehicle (AUV) is planned. Researches to realize communication with such AUV using time reversal have been conducted. By time reversal, multipath waves are converged so that signal-to-noise ratio (SNR) is improved and intersymbol interferences (ISI) are removed. Recently, communication at data rates of 100 and 400 bps at the range of 1000 and 600 km, respectively, in deep water were performed. Additionally, at-sea experiments for multiuser communication by time reversal under Doppler effect due to source movement were demonstrated. Results of such experiments are described in this paper.

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Track Classification: 4 - Upcoming acoustic/seismic trends in Ocean Observatories

ID: Type: **Oral**

Concepts for the Next generation IMS Hydroacoustic stations

A study was conducted to review advances in undersea technology with an emphasis on the applicability of a modularized approach to the next generation IMS Hydroacoustic Stations. The primary objective of the study was improving station maintainability. In the past 10 to 20 years, significant technological developments in undersea connectivity have been made driven by the emergence of ocean observatories and Oil & Gas applications. These developments were considered for their suitability to the hydroacoustic component of the IMS network. The study presents different design concepts and highlights their advantages and disadvantages. The study concluded that different modular design options based on a Hub and Spoke configuration provided greater deployment flexibility, easier maintainability and a marked advantage for fault tolerance in the hydrophone triplet. Analysis of aggression scenarios identified that the overall system reliability is dominated by trunk cable aggression which could, in some instances, be improved by a configuration that implemented a cross connection between the North and South triplets of IMS's hydrophone hydroacoustic stations. Regarding underwater equipment improvements, the study noted that adoption of integrated digital hydrophones versus the current analog system would improve the signal path data quality.

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Track Classification: 4 - Upcoming acoustic/seismic trends in Ocean Observatories

ID: Type: **Oral**

cabled seismic network above the Japan Trench seismo-tsunamigenic zone

The Japan Trench, off northeast Japan, is one of the most destructive tectonic plate boundaries. The 2011 Tohoku earthquake (Mw9.0) generated there huge tsunamis that caused severe destruction along the Pacific coastline. A seafloor cabled system with 3 seismometers and 2 tsunami gages had been working above the rupture area since 1996. The system recorded the seismic waves, and the two gages caught 5 m height tsunamis before they reached the coast. The system, however, stopped just after the waves reached the coastline because the landing station was washed out, whereas the seafloor instruments and cables in marine still work after the strong seismic waves and the huge tsunamis. We restarted it in April 2015 and are going to install another new system which consists of 3 observatories in September 2015. Each of the new 2 observatories is equipped with a seismometer and a pressure gauge. The other has a seismometer and an auxiliary port which passes electronic power with data. Currently, NIED is constructing a large-scale seafloor cabled network with 150 stations and 5,700 km of cable in total, to monitor earthquakes and tsunamis around the Japan Trench, named S-net. Our two systems with the adjacent S-net stations will work as a 20-km spacing network.

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Track Classification: 4 - Upcoming acoustic/seismic trends in Ocean Observatories