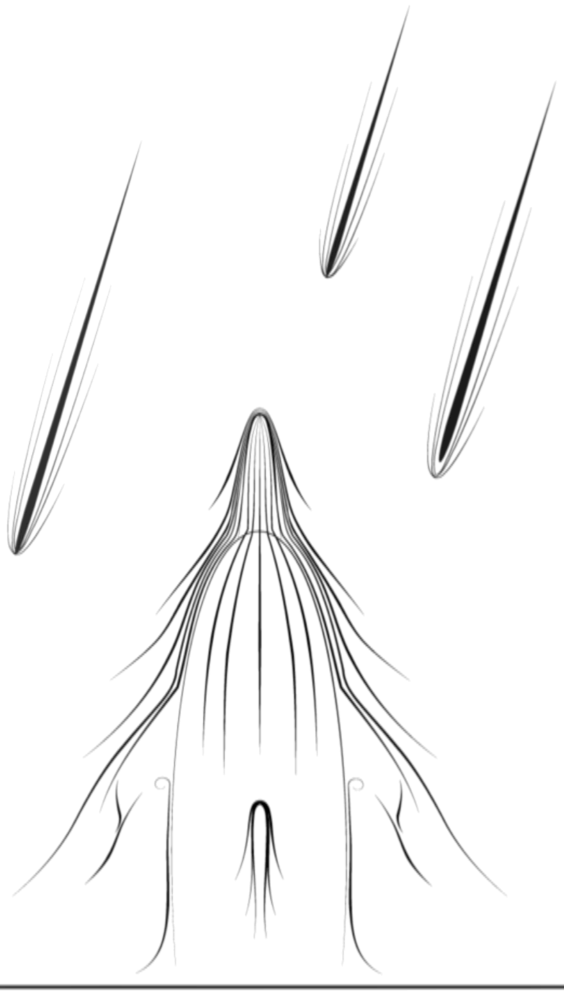
INTERNATIONAL SCHOOL OF ETHOLOGY

CETACEAN ECHOLOCATION

ETTORE MAJORANA FOUNDATION



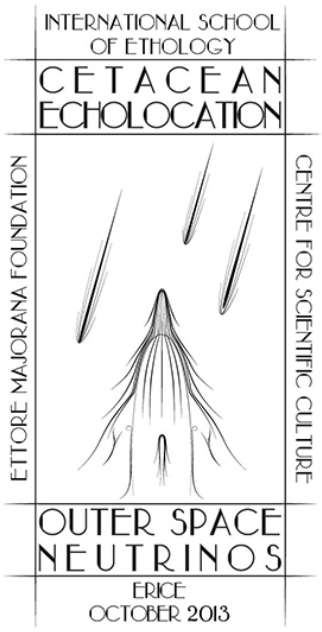
CENTRE FOR SCIENTIFIC CULTURE

OUTER SPACE NEUTRINOS

ERICE

OCTOBER 2013

PROGRAM & ABSTRACTS



Logo design by Giovanni Caltavuturo

Dolphin photo by Alessandra Passini

Ettore Majorana Foundation and Centre for Scientific Culture
International School of Ethology
30th International Workshop, Erice, October 18-21, 2013

Cetacean echolocation and outer space neutrinos: ethology and physics for an interdisciplinary approach to underwater bioacoustics and astrophysical particles detection

Program

&

Abstracts

President of the Centre

Prof. Antonio Zichichi

Directors of the School of Ethology

Prof. Danilo Mainardi
Prof. Stefano Parmigiani

Directors of the workshop

Gianni Pavan (CIBRA, Dip. Scienze della Terra e dell'Ambiente, University of Pavia, Italy)
Peter Tyack (Sea Mammal Research Unit, University of St Andrews, Scotland, UK)
Giorgio Riccobene (INFN-LNS, Catania, Italy)
William A. Barletta (Dept. of Physics, MIT, Cambridge, MA, US)

Organizing Committee

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http://www.unipv.it/cibra/erice
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Acknowledgments

Sara Pulvirenti, Giuseppina Larosa and LNS-INFN for the management of the registration website
AEST for the technical support and book editing
Giovanni Caltavuturo for the logo, Alessandra Passini for the dolphin photo

Purpose of the workshop

The development of underwater ocean observatories has stimulated new interactions between disparate disciplines to optimize their sensors and layout. One of the least predictable synergies has come from interactions between astrophysicists working to detect light and acoustic signals from neutrinos and marine biologists listening to the sounds of marine animals.
Acoustics is a particularly good tool for remote sensing in the ocean because sound propagates more efficiently than other cues. Rather than having each discipline search for their signal of interest among what is treated as random noise, it may be more effective for all of the disciplines to work together to tease apart their signals of interest from ocean acoustic sensors, helping one another to separate each desired signal from undesired ones.
The workshop is intended to join these different disciplines to promote the understanding of the underwater acoustic world and the development of common research strategies and tools. The workshop will focus on the study of the acoustic behaviour of marine mammals, on the acoustic detection of neutrinos in the sea, on the sources of sound in the ocean, on the sharing of detection technologies, and on the related technological challenges with a broad interdisciplinary approach.

Scientific Sponsors

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Day 1 - October 18th - Friday

08:30 **Registration formalities**

09:00 **Opening Ceremony**

Acoustical Oceanography
Chairman:

09:30 Henrik Schmidt (MIT, US) - Nested Autonomy: A Robust Operational Paradigm for Adaptive and Collaborative Ocean Acoustic Sensing

10:40 ***Coffee break***

Acoustic communication, vocal learning and cognition in marine mammals
Chairman:

11:00 Brandon Southall (California Univ., US) – Overview of vocal parameters and hearing abilities in pinnipeds and cetaceans

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Astrophysics with acoustics in deep sea
Chairman:

14:30 Lee Thompson (Sheffield Univ., UK) - Listening for neutrinos, Part I - from astrophysics to the deep sea
15:20 Sean Danaher (Northumbria Univ., UK) - Listening for neutrinos, Part II - acoustic neutrino detection & signal processing techniques
16:10 Francesco Simeone (INFN Roma, Italy) – NEMO and SMO Projects

16:40 ***Coffee break***

Short talks – Session I *Chairman:*

17:00 Viola S. (INFN-LNS, Italy) - SMO acoustic array: calibrations and first results
17:15 Larosa G., Viola S. (INFN-LNS, Italy) - Positioning System for neutrino telescopes: SMO and KM3NeT-Italia in Capo Passero
17:30 Pulvirenti S. (INFN-LNS, Italy) - Correlation between underwater noise level and AIS data in the Gulf of Catania (Sicily)

Day 2 - October 19th - Saturday

Submarine Multidisciplinary Observatories
Chairman:

08:30 Paolo Favali (INGV Roma, Italy) - EMSO - European Multidisciplinary Seafloor and water column Observatory
09:20 Kim Juniper (Victoria Univ., Canada) - Expansion of the Ocean Networks Canada hydrophone network and linking with AIS monitoring

10:30 **Coffee break**

10:50 Gianni Pavan (CIBRA/UNIPV, Italy) - Bioacoustic results in NEMO-SN1 ONDE and way ahead with EMSO, the European Multidisciplinary Submarine Research Infrastructure
11:40 Michel Andre (UPC, Spain) - A Global Ocean Soundscapes Monitoring Approach

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Information technology & infrastructures for acoustic data acquisition, archival and analysis
Chairman:

14:30 Lars Kindermann (AWI, Germany) – Underwater acoustics in Anctartica
15:20 Doug Gillespie (St. Andrews Univ., UK) - Looking for spaghetti in a haystack: Semiautomatic approaches to detecting marine mammals in highly variable noise environments
16:10 Alexander von Benda-Beckman (WhaleFM/TNO, Netherland) - Look who's talking – classification of whale sounds using the Whale FM Citizen Science project

17:20 **Coffee break**

Short talks – Session II *Chairman:*

17:45 Lin Tzu-hao, Yu Hsin-yi, Chen Chi-fang, Chou Lien-siang (National Univ. of Taiwan, Taiwan) - Detecting the structural variability of cetacean tonal sounds by automatic detection and classification algorithms
18:00 Vignola J., Shane G. (Catholic Univ. of America, US) - A preliminary investigation on the seismic air gun reverberant field in a shallow water Arctic environment
18:15 Vallarta J., Martin B. (JASCO, US) - Spatial prediction and interpolation effect assessment of marine mammal counter calls, ambient and anthropogenic noise
18:30 Caruso F., Sciacca V., Pavan G. (INFN-LNS, Italy) - An algorithm to measure the size of sperm whales recorded by INFN deep-sea observatories in the Ionian Sea (Eastern Sicily).
18:45 Sciacca V., Caruso F., Pavan G. (INFN-LNS, Italy) - Acoustic detection of fin whales vocalizations offshore Eastern Sicily, Ionian sea

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Day 3 - October 20th – Sunday - Full day excursion

Day 4 - October 21st – Monday

Interdisciplinary approach to Computational (Bio)Acoustics
Chairman:

08:30 Walter Zimmer (CRME, Italy) - Model-based bio-acoustics
09:20 Herve Glotin (Toulon Univ., France) - 3D multiple whale tracking

10:20 ***Coffee break***

10:40 Paul White (Southampton Univ., UK) - Tracking Algorithms in Marine Mammal Acoustics

Advanced marine research for conservation
Chairman:

11:30 Mauro Taiuti (INFN, Italy) – ARION - Systems for Coastal Dolphin Conservation in the Ligurian Sea

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14:30 Peter Tyack (St. Andrews Univ., UK) - How new technology has revolutionized the study of cetacean bioacoustics and suggestions for new directions and collaborations for the future
15:20 Hong Young Yan (Academia Sinica, Taiwan) - Impact of noise on fishes and marine mammals

16:10 ***Coffee break***

16:30 Tiago Marques (St. Andrews Univ., UK) - Cetacean density estimation from passive acoustic data
17:20 Bob Gisiner (US Navy, US) - The Sea Finds Its Voice: Changes in the Scientific Understanding of Sound and Marine Life from 1993 to 2013.

18:10 **Conclusion and Concluding**

Posters

Acoustic data acquisition systems (AcouDAQ) for the SMO, KM3NeT and SN1 experiments
Pellegrino C.

Click and burst pulse proprieties of wild bottlenose dolphin in the Central Mediterranean Sea
Buscaino G., Alonge G., Buffa G., Filiciotto F., Maccarrone V., Di Stefano V., Mazzola S.

A Calibrator for UHE neutrino acoustic detection in underwater telescopes
Adrian Martinez S., Ardid M., Bou M., Felis I., Llorens C., Martinez-Mora, J.A., Saldana M.

A smart platform for monitoring underwater noise
Barker P., Lepper P.

Acoustically derived growth rates of sperm whales (Physeter macrocephalus) around Ischia and Ventotene Islands (Italy): preliminary results
Pace D. S., Miragliuolo A., Dernowski R., Vivaldi C., Mussi B.

First results on underwater acoustic background in SMO - NEMO Phase II
Grasso R.

What does a small, shy cetacean which vocalises 6 times above a human's hearing range do underwater? Challenges in localising harbour porpoises.
Macaulay J., Gillespie D., Northridge S., Gordon J.

WaveShark – a compact multifunctional multichannel high sampling rate recorder
Pelicella I., Balsamo F., Pavan G.

An Inter-frequency attenuation model for estimation of click distance
Doh Y., Glotin H., Razik J., Paris S.

Biomechanical Evidence of Low to Infrasonic Hearing in Mysticetes: Implications for Impacts
Ketten D., Arruda J., Cramer S., Zosuls A., Mountain D.

Abstracts

Talks

Nested Autonomy: A Robust Operational Paradigm for Adaptive and Collaborative Ocean Acoustic Sensing

Friday 18 Oct 2013 at 09:30 (01h00')

Abstract

Underwater acoustic sensing and monitoring is currently transitioning from the traditional platform-centric, human-controlled sensing, processing and interpretation, toward distributed sensing concepts using networks of autonomous underwater vehicles. However, being dependent on acoustic communication with a channel capacity many orders of magnitude smaller than the air and land-based equivalents, the operation of such new distributed undersea observation systems require a much higher level of autonomous, distributed data processing and control than land- and air-based equivalents. Nested Autonomy is a new command and control paradigm, inherently suited for the layered communication infrastructure provided by the low-bandwidth underwater acoustic communication and the intermittent RF connectivity. Implemented using the open-source MOOS-IvP behavior-based, autonomous command and control architecture, it provides the fully integrated sensing, modeling and control that allows each platform to autonomously detect, classify, localize and track episodic acoustic events in the ocean, without depending on any operator command and control. The core enabler of the new undersea sensing paradigm is a multi-objective optimization algorithm HelmIvP which allows the sensing platforms to adapt to changes in the environment and the event being tracked, without any need for operator intervention. The prosecution of an event, such as the detection and tracking of a marine mammal or other sources of sound, may be initiated by the operators or entirely autonomously by an onboard detection capability. The event information collected by each node in the network is reported back to the operators by transmitting an event report, using a dedicated command and control language. Collaborative processing and control is exploited when the communication channel allows, e.g. for collaborative tracking of a coastal front, or the tracking of marine mammals. Examples will be given from several recent field deployments involving several autonomous underwater and surface vehicles for acoustic and oceanographic undersea sensing and monitoring [Work supported by the Office of Naval Research and the NATO Undersea Research Centre].

Author : SCHMIDT, Henrik (MIT, US)

Session : Acoustical Oceanography
Type : Invited Lecture

Notes

Overview of vocal parameters and hearing abilities in pinnipeds and cetaceans

Friday 18 Oct 2013 at 11:00 (01h00')

Abstract

Sound is centrally important in the lives of marine mammals. We know they make sounds in social interactions and to find objects and their way around. We know they listen for conspecific animals to facilitate breeding, rearing, and other social dynamics. We also believe they listen to avoid predators and environmental sounds to facilitate spatial orientation. Among the 125+ species of marine mammals there is a tremendous diversity in sound production that mirrors the varied speciation and adaptations of these marine predators. The large baleen whales produce typically long-duration (seconds to tens of seconds) low frequency (tens of Hz to ~10 kHz) sounds that may be detected over tens to hundreds of miles and primarily facilitate social interactions. The related odontocete cetaceans (dolphins and porpoises) have a more varied sound communication strategy that includes both moderate duration (seconds), medium frequency (~5-20 kHz) whistles and other conspecific communication signals as well as transient, impulsive (milliseconds), high frequency (tens to over 100 kHz) echolocation clicks used for detecting prey objects and in precise spatial orientation. The pinnipeds (seals, sea lions, and walruses) produce moderate duration (seconds), typically low to moderate (tens of Hz to 10 kHz) sounds used in social interactions and spatial orientation. The pinnipeds and baleen whales lack the specialized high-frequency echolocation signals of odontocetes cetaceans, but rely nonetheless on sound production and communication in critical social and predator avoidance and navigation contexts. Each species group is known or expected to have sound detection capabilities that roughly (but not exactly) relate to frequency ranges of sound production systems. Passive detection of marine mammals with ocean observing systems offers innovative new ways of remotely sensing large areas of the oceans to better understand and conserve marine mammals by improving the spatial and temporal sampling of marine mammal presence and (increasingly) estimates of abundance.

Author : SOUTHALL, Brandon (Southall Environmental Associates, Inc., US)

Session : Acoustic communication, vocal learning and cognition in marine mammals
Type : Invited Lecture

Notes

Listening for neutrinos - from astrophysics to the deep sea - Part I

Friday 18 Oct 2013 at 14:30 (00h50')

Abstract

The use of acoustic methods for the detection of high energy neutrinos is one of a number of techniques that can be used to record these relativistic fundamental particles. This presentation will briefly justify the interest in high and ultra-high energy neutrinos as well as briefly discuss other techniques currently in use to detect them. The presentation will then turn to the acoustic detection of neutrinos, explaining the physical mechanisms involved and highlighting the unique physical characteristics of the expected signals. The presentation will conclude with a historical overview of earlier, pioneering activities in the field that will put the later presentations on current activities into a suitable perspective.

Author : THOMPSON, Lee (Sheffield Univ., UK)

Session : Astrophysics with acoustics in deep sea
Type : Invited Lecture

Notes

Listening for neutrinos - from astrophysics to the deep sea - Part II

Friday 18 Oct 2013 at 15:20 (00h50')

Abstract

This lecture will discuss both the hardware and software needed to acoustically detect neutrinos and will cover topics such as Hydrophone structure, Analogue to digital converters, Fourier Transforms, matched filtering, spectral analysis and the Hilbert Transform for envelope detection. Although the topics covered are in general very mathematical the talk will be very descriptive and have any examples and illustrations rather than detailed mathematical workings and will be geared towards a general scientific audience.

Author : DANAHER, Sean (Northumbria University)

Session : Astrophysics with acoustics in deep sea
Type : Invited Lecture

Notes

NEMO and SMO Projects

Friday 18 Oct 2013 at 16:10 (00h30')

Abstract

In recent years the astro-particle community is involved in the realization of experimental apparatuses for the detection of high energy neutrinos, originated in cosmic sources or produced in the interaction of cosmic rays with the cosmic microwave background. For neutrino energies in the TeV-PeV range, the underwater optical Cherenkov technique is considered as optimal. For higher energies, the detection of acoustic waves, originated by neutrino interactions in acoustically transparent mediums, is under study. Cherenkov detectors measure the visible photons originated by charged particles, produced in the neutrino interaction and propagating at velocities greater than the speed of light through a transparent medium. This kind of detectors consists of array of photomultipliers in a volume of several km3; this topology requires the ability to acquire physics information in different places of the detector and correlate them, using the occurrence time, with a sub-ns precision. The km3net-italia collaboration has successfully deployed a prototype tower of a Cherenkov detector at a depth of about 3000 m in the Capo Passero site, 100 km off the Sicily coast, on march of 2013. The underwater detector sample signals from photomultipliers and hydrophones, acquire slow-control data, both from oceanographic instruments and dedicated sensors, and send the whole data to the laboratory through a fully bi-directional fiber optic link, providing a real-time data transport layer, synchronous and phased with the GPS clock, between the onshore laboratory and the underwater detector. The SMO collaboration has contributed to design, build and integrate, 14 large bandwidth hydrophones, for multi-disciplinary use, onboard the NEMO detector. This detector will be used to perform long term and real-time monitoring of sounds and environmental parameters, identification and full tracking of cetaceans and to test neutrino acoustic detection techniques. An overview of the NEMO-SMO experiment will be given and its first results will be summarized.

Author : SIMEONE, Francesco (INFN Roma, I)

Session : Astrophysics with acoustics in deep sea
Type : Invited Lecture

Notes

SMO acoustic array: calibrations and first results

Friday 18 Oct 2013 at 17:00 (00h15')

Abstract

The SMO (Submarine Multidisciplinary Observatory) project consists of a 3D array of 14 broad-band (10 Hz - 70 kHz) hydrophones, installed on board the NEMO Phase-II detector, a prototype of a detection unit for an underwater neutrino telescope. Thanks to very low noise acquisition electronics and broadband hydrophones, SMO is suitable for both studies of astrophysical neutrino detection and identification of biological signals (namely mammals' sounds). Dedicated tests carried out at the water-pool facility of CNR-IDASC and NATO-URC laboratories allowed full characterization of the detector and in particular its sensitivity as a function of pressure. These measurements, also, shown that acoustic data can be effectively time- stamped underwater with a known and measurable latency (time delay) with respect to the GPS absolute time provided by the shore station master clock. In view of a km3-scale neutrino telescope (KM3NeT), this feature allows to perform preliminary studies on acoustic neutrino detection searching for acoustic impulsive signals in coincidence with the optical events reconstructed by the Cherenkov detector. In this work the tests carried out to measure the performances of the SMO acoustic array are described and first results are reported.

Author : VIOLA, Salvatore (LNS) Co-authors

Session : Short talks - Session I
Type : Short talk

Notes

Positioning System for neutrino telescopes: SMO and KM3NeT-Italia in Capo Passero

Friday 18 Oct 2013 at 17:15 (00h15')

Abstract

The KM3NeT-Italia project, leaded by the INFN, is building the first block of the forthcoming KM3NeT underwater neutrino telescope (www.km3net.org). A prototype detection unit has been deployed the 23rd March 2013. It consists of a vertical sequence of 8 horizontal structures called floors, kept vertical by appropriate buoyancy on the top and follows the tower layout. The tower has been installed at a depth of 3500 m, about 90 km offshore the village of Capo Passero (Sicily), where the KM3NeT telescope will be installed. The unit hosts the SMO detector an array of 12 acoustic sensors continuously sampled underwater at 192kHz /24 bit and transmitted to shore. The array permits real-time study of acoustic biological sounds and acoustic background monitoring. However the main goal of SMO is provide, acoustically, the position of the mechanical unit underwater. The underwater acoustic positioning is performed also through a Long Base Line (LBL) of acoustic beacons anchored on sea- floor at about 400 m from the tower. The acoustic signals emitted by the beacons are acquired by the SMO array and sent to shore through electro-optical cable. All SMO receivers are phased and synchronized by a common master clock and data are time- stamped underwater with GPS time. The results of the underwater acoustic positioning will be presented. SMO is also a test-bench for sensors and electronics technologies for acoustic systems of the future KM3NeT telescope.

Author : LAROSA, Giuseppina (LNS)
Co-authors : VIOLA, Salvatore (LNS)

Session : Short talks - Session I
Type : Short talk

Notes

Correlation between underwater noise level and AIS data in the Gulf of Catania (Sicily)

Friday 18 Oct 2013 at 17:30 (00h15')

Abstract

NEMO-SN1 is a sea-floor multidisciplinary observatory, managed by INGV and INFN and connected to shore by an electro-optical cable. It is located at a distance of 25 km from the Eastern Sicily Coast, off-shore Catania, at an operative depth of 2100 m. SN1 is equipped with geophysical and oceanographic sensors that acquire data since June 2012. An array of hydrophones is also installed on NEMO-SN1 detector tower within the SMO project; goals are the long term, real-time monitoring of the acoustic and seismic environmental activity in the deep sea. The acoustic array will monitor anthropogenic underwater noise variation and, in particular, the component due ship traffic, that has substantially increased over the years in the Mediterranean Sea. The peculiar location of NEMO-SN1, few km off the port of Catania, is optimal to study the correlation between underwater acoustic noise and ship traffic. Using AIS (Automatic Identification System) we obtained information on vessel characteristics and movements details in the area of the Gulf of Catania. AIS data were correlated with acoustic data acquired from the hydrophone array installed on board the NEMO-SN1 station. Results of this study will be presented.

Author : PULVIRENTI, Sara Rita (LNS)

Session : Short talks - Session I
Type : Short talk

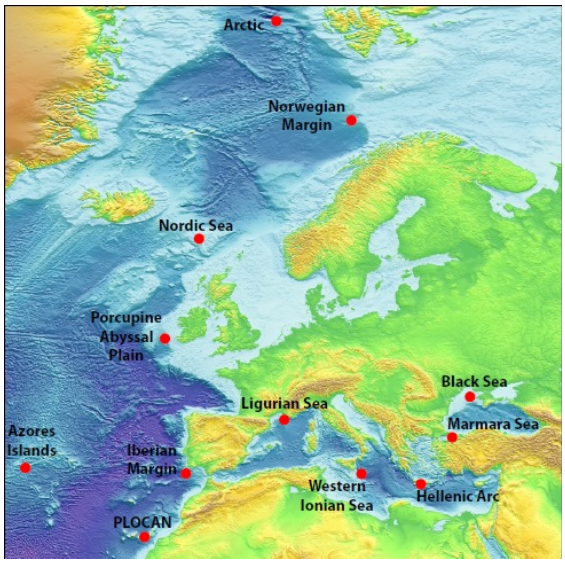
Notes

EMSO - European Multidisciplinary Seafloor and water column Observatory

Saturday 19 Oct 2013 at 08:30 (00h50')

Abstract

EMSO (http://www.emso-eu.org) is a large-scale European Research Infrastructure (RI) of the ESFRI roadmap composed of fixed-point, seafloor and water-column observatories with the basic scientific objective of near- and real-time, long-term monitoring of environmental processes related to the interaction between the geosphere, biosphere, and hydrosphere. It is geographically distributed in key sites of European waters, spanning from the Arctic, through the Atlantic and Mediterranean Sea to the Black Sea. EMSO will be the sub-sea segment of the COPERNICUS (former GMES-Global Monitoring for Environment and Security) initiative and will significantly enhance the observational capabilities of European Member States. EMSO is the European counterpart of many similar worldwide programmes, such as ONC-NEPTUNE in Canada, NSF- OOI In US, JAMSTEC-DONET in Japan or IMOS in Australia. The picture below shows the location of the EMSO sites presently targeted to establish permanent, fixed-point observatories. EMSO ended its Preparatory Phase project in 2012 and now is in the Interim phase to arrive, along with the respective Funding Agencies representatives, to the legal entity managing the infrastructure, the European Research Infrastructure Consortium (hereinafter “ERIC”). A phased implementation will characterize EMSO sites extension, construction and operation. The overall duration of the first phase of EMSO implementation will be 5 years from the ERIC foundation, with a review point scheduled at year 3. From the technological point of view, the most striking characteristic of observatory design is its ability to address interdisciplinary objectives simultaneously across scales. Data will be collected from the surface ocean, through the water column, the benthos, and the sub-seafloor. Depending on the application, in situ infrastructures can either be attached to a cable, which provides power and enables data transfer, or they operate as independent benthic and moored instruments. Data, also in the latter case, can be transmitted through acoustic networks that are connected to a satellite- linked buoy. Cabled infrastructures provide important benefits such as real-time data transfer, when a processing of huge amount of data (as for bioacoustics) or a real-time integration with land-based networks (as for the seismology), as well as a rapid geo-hazard early warning system, are needed. Selected case studies of data series collected at various EMSO sites, showing the technological challenges to be faced and the potential for answering important scientific questions.



Author : FAVALI, Paolo (Istituto Nazionale di Geofisica e Vulcanologia)

Session : Submarine Multidisciplinary Observatories
Type : Invited Lecture

Expansion of the Ocean Networks Canada hydrophone network and linking with AIS monitoring

Saturday 19 Oct 2013 at 09:20 (01h10')

Abstract

Ocean Networks Canada operates major cabled undersea observatories in the northeast Pacific Ocean, and a cabled mini-observatory in the Arctic Ocean. These observatories support a variety of underwater instruments ranging from seismometers to chemical sensors and cameras. Access to all data collected on our networks is open to all researchers and free of charge. After experimenting with several types of hydrophones, we are now expanding our hydrophone network in both inshore and offshore waters. We have also initiated a program to link hydrophone data to vessel traffic information provided by Automatic Identification System (AIS) receivers, in inshore waters of British Columbia, and in the Arctic Ocean near Cambridge Bay, Nunavut. Our goal in linking AIS and hydrophone data in a single database is to permit documentation of underwater noise generated by different vessel types, and the study of cetacean responses to vessel traffic. This presentation will describe the distribution of our hydrophone network, operational challenges and recent research results.

Author : JUNIPER, Kim (Ocean Networks Canada, University of Victoria)
Co-authors : MCLEAN, Scott (Ocean Networks Canada, University of Victoria); DAKIN, Tom (Ocean Networks Canada, University of Victoria); DEWEY, Richard (Ocean Networks Canada, University of Victoria); PIRENNE, Benoit

Session : Submarine Multidisciplinary Observatories
Type : Invited Lecture

Notes

Bioacoustic results in NEMO-SN1 ONDE and way ahead with EMSO, the European Multidisciplinary Submarine Research Infrastructure

Saturday 19 Oct 2013 at 10:50 (00h50')

Abstract

Within the EMSO and KM3NeT Italia framework INFN and INGV develop and run deep sea infrastructures and instruments for a wide range of scientific research developed by a network of institutional partners.
The marine bioacoustic research began in 2005 with the NEMO-OnDE platform deployed at 2000m depth 25 km off Catania (Sicily), connected to the INFN-LNS laboratory in Catania by fiber optic cables. Wideband acoustic data collected during 2 years of operations (2005-2006) revealed an unexpected presence of sperm whales in the Ionian Sea and demonstrated the importance of continuous acoustic monitoring of the deep marine environment.
This pilot project led to the deployement in 2012 of the new NEMO-SN1 observatory, funded under the LIDO Demonstration Mission of ESONeT (FP6) and the development of the Submarine Multidisciplinary Observatory (SMO) program, a FIRB project granted by the Italian Ministry of the University and Research, hosted by INFN-LNS (http://web.infn.it/smo).
The seafloor installations now available in the gulf of Catania e and off Capo Passero open new research and monitoring perspectives, however new challenges emerge, mostly related to the processing and storage of huge data streams. These monitoring platforms can fill the gaps linked to traditional surface surveys, usually concentrated during the good season and anyway rarely covering wide areas and long time windows.
These new stations provide wide band acquisition for sperm whales and other odontocetes as well as for low frequency fin whales' calls and marine noise. The goal of the research is to confirm the sperm whales' presence and seasonality, to assess the size of detected whales, to map the presence of fin whales, and to measure the low frequency background noise that may have an impact on these animals. AIS data, collected by dedicated receivers in Catania and Capo Passero, allows to link measured noise levels to the ship traffic in the area, to identify the most noisy ships, to model the impact on marine mammals and consequently to develop mitigation plans.
The long term observation is functional to the implementation of the MSFD (EC/2008/56) – monitoring of biodiversity and noise - and to provide feedback about conservation policies.

Author : PAVAN, Gianni (University of Pavia - Centro Interdisciplinare di Bioacustica e Ricerche Ambientali)

Session : Submarine Multidisciplinary Observatories
Type : Invited Lecture

Notes

Listening to the Deep-Ocean: A global underwater noise monitoring initiative

Saturday 19 Oct 2013 at 11:40 (00h50')

Abstract

The growing scientific and societal concern about the effects of underwater sound on marine ecosystems has been recently recognized through the introduction of several international initiatives aiming at measuring the environmental impact of ocean noise on large spatial and temporal scales. From a regulatory perspective, the European Marine Strategy Framework Directive includes noise as one of eleven descriptors to determine Good Environmental Status of the oceans. The Directive specifically requires Member States to provide a measure of annually averaged noise. LIDO (Listening to the Deep-Ocean Environment) has developed a software package that measures sound levels and monitors acoustic sources in real-time; this software is now operating to provide industry with an environmentally responsible approach. The system is currently operating worldwide from several wired and radio-linked underwater observatories. Recently, through a zero-cost contract with the CTBTO (Preparatory Commission for the Comprehensive nuclear-Test Ban Treaty Organization), years of data from hydroacoustic stations were analysed to look for background noise trends and to detect cetacean presence. Here, we present the analysis of four CTBTO platforms, each covering 42 months of data, focussing especially on the estimation of background noise levels and the measurement of noise contributions from anthropogenic sources. Continuous monitoring of background noise will indeed help to understand whether long-term exposures to noise, in areas with intense shipping or seismic campaigns, for instance, might alter animal natural behaviour and may be used in the future to assess the effects of ocean noise on marine life.

Author : ANDRÉ, Michel (Laboratori d'Aplicacions Bioacústiques, Universitat Politècnica de Catalunya (UPC))
Co-authors : VAN DER SCHAAR, Mile (LAB, UPC); HOUÉGNIGAN, Ludwig (LAB, UPC); CASTELL, Joan (LAB, UPC); SÀNCHEZ, Antonio M. (LAB, UPC)

Session : Submarine Multidisciplinary Observatories
Type : Invited Lecture

Notes

Underwater acoustics in Antarctica

Saturday 19 Oct 2013 at 14:30 (00h50')

Abstract

The Southern Ocean is one of the most diverse soundscapes of earth. The dynamics of the cryosphere i.e. sea ice, glaciers and icebergs create unique acoustic conditions. During polar winter the snow covered sea ice shields the ocean from atmospheric influences, suppresses the creation of waves and resembles an almost perfect acoustic absorber, thus creating one of the quietest environments of all oceans. On the other hand, large table icebergs calved from the enormous ice sheet of the Antarctic continent are the largest moving objects on earth and can accumulate kinetic energy in the terajoule range when driven by circumpolar currents. This energy is eventually released when these giants collide with the continental or ice shelves - events that create some of the loudest sounds in the sea which can be detected thousands of kilometers away. However, these are singular events which occur only few times per year. Typically the acoustic environment is dominated by the vocalizations of marine mammals. Most remarkable, the chorus of blue whales represents the spectral peak of the acoustic spectrum, audible almost during every single minute of the year despite the remaining population of blue whales in the Southern Ocean is just 2300 animals – compared to about 350.000 in the pre whaling area 100 years ago. The second largest source of acoustic energy are Antarctic Minke whales - the main target of today's scientific whaling. The relation between these animals and a sound of formerly unknown origin was just recently identified in 2013. Long term acoustic monitoring of this ecosystem thus can yield easy indicators for the population development of these animals. In 2005 we set up the autonomous PALAOA observatory on the Eckström ice shelf, an acoustic array deployed through bore holes into the ocean under a 100m thick ice sheet. In 2009 we started to add long term deep water acoustic recorders to most of the oceanographic moorings that are deployed throughout the Weddell Sea, creating a basin wide acoustic array with 20 nodes at the moment. An international project will extend this to a circum- Antarctic installation during the next years, aiming to infer the complete spatio-temporal distribution of the Antarctic great whales. While the long term recorders are typically recovered every three years and their data are analyzed offline, the PALAOA data is streamed live via satellite to the lab and the public internet. This allows to direct field parties immediately to the seaside when interesting acoustic events are detected. Additional sensors provide related information that helps to interpret the acoustics. An AIS receiver monitors all ship traffic in the area to analyze human impacts. A CTD probe delivers oceanographic data. Meteorology and webcams make local weather and ice conditions accessible. Relating the acoustics to the medium and large scale ice situation is possible through high resolution ASAR images, provided by several satellites. All this data is collected in a database at the Alfred Wegener Institute and published in the PANGAEA data center. Live audio stream and historical data are available via www.awi.de/palaoa

Author : KINDERMANN, Lars (AWI, D)

Session : Information technology & infrastructures for acoustic data acquisition, archival and analysis
Type : Invited Lecture

Notes

Looking for spaghetti in a haystack: Semiautomatic approaches to detecting marine mammals in highly variable noise environments

Saturday 19 Oct 2013 at 15:20 (00h50')

Abstract

The wide variety of sounds produced by marine mammals are for the most part well documented. While some of these sounds, such as fin whale moans and the clicks of harbour porpoise and beaked whales are highly stereotyped, others, such as humpback song and dolphin whistles are highly variable both at the individual and at the population level. Even the more stereotyped sounds can become highly variable at the receiving instrument due to changes in the emitting animals orientation relative to the receiver and changes in sound propagation conditions. As well as a highly variable sound source, detection systems also have to deal with variable background noise, with interference from other natural sources (e.g. other animals, wind and waves, natural seismic activity) as well as anthropogenic sources (e.g. vessel noise, sonars, piling, oil and gas exploration). While humans are generally excellent at differentiating signals of interest from noise, automatic detection is essential for the analysis of large continuous datasets. Developing automatic detectors for poorly defined signals in unknown noise is however a near impossible task. An effective solution is often semi-automatic detection in which automatic detectors reduce the amount of data that has to be viewed by a human to a manageable quantity. The level of automation that can be applied to a specific data set depends heavily on the type of signal, the types of noise encountered, and also the level of detail required in the information that is to be extracted from the data. In certain circumstances, detection can be close to 100% automatic, with the human doing little more than reject a small number of false alarms, in other circumstances, a high level of operator input is required.

Author : GILLESPIE, Doug (St. Andrews Univ., UK)

Session : Information technology & infrastructures for acoustic data acquisition, archival and analysis
Type : Invited Lecture

Notes

Look who's talking – classification of whale sounds using the Whale FM Citizen Science project

Saturday 19 Oct 2013 at 16:10 (00h50')

Abstract

Long term acoustic monitoring, which is required for assessing impact of anthropogenic activities on marine mammals, leads to increasingly large acoustic datasets that need to be classified. Although significant improvements have been made in applying automated methods to categorize marine mammal calls, scientists often still have to rely on human judgment to classify calls into call categories, which is challenging especially for vocal species. The Whale FM project was launched in November 2011 to investigate the feasibility of Citizen Science for classifying large acoustic datasets. The aim of the project is to establish the call repertoire of vocally active marine mammal species, such as killer whales and pilot whales, using Citizen Science. The Whale FM project builds on previous successes of Citizen Science in the fields of astronomy, and is a first interdisciplinary attempt to apply this approach to the field of bioacoustics on a large scale. The Whale FM dataset contains approximately 15,000 recorded calls of vocally active whale species: Norwegian and Icelandic killer whales and Norwegian long- and Bahamas short-finned pilot whales. To date, approximately 14,000 volunteers have matched calls almost 217,000 times in the Whale FM project, demonstrating the capacity of Citizen Science to handle large acoustic datasets. I will present initial results of the Whale FM dataset, and discuss the benefits and challenges of applying Citizen Science to classification of marine mammal calls.

Author : VON BENDA-BECKMANN, Sander (TNO)
Co-authors : SIMPSON, R.; SMITH, A.; SHAMIR, L.; TYACK, P.L.T.

Session : Information technology & infrastructures for acoustic data acquisition, archival and analysis
Type : Invited Lecture

Notes

Detecting the structural variability of cetacean tonal sounds by automatic detection and classification algorithms

Saturday 19 Oct 2013 at 17:45 (00h15')

Abstract

In recent years, long-term acoustic recorders have been extensively employed to examine the temporal variation of cetacean occurrences. However, the interpretation of cetacean behavior based on their vocal usage remains difficult. The temporal variation of behaviors can only be detected through the variability of vocal usage. Tonal sounds are believed to play an important role in cetacean communication and the changes in repertoire complexity can be indicative of behavioral changes. Burst- pulses are frequently detected in the terminal phase of feeding event, thus can be seen as the indication of foraging behavior. In this study, automatic detection and classification algorithms were applied to examine the usage pattern of tonal sounds, in terms of frequency modulation and structural complexity. A bandwidth detector was employed on long-term recordings from the marine cable hosted observatory (MACHO) off Northeastern Taiwan to collect cetacean tonal sounds and burst-pulses. The instantaneous frequency bandwidth of tonal sound was applied as a detection parameter so that it can effectively extract the representative frequencies of tonal sound. The representative frequencies of burst pulse, fundamental frequency, and harmonic were separated and used to analyze the temporal variation of tonal sound frequency modulation. Individual contours were then tracked from the representative frequencies of fundamental frequency. Different types of contour were classified through an unsupervised method to examine the repertoire composition without subjective determination. The structural complexity of tonal sound repertoire was quantified using the information theory. Through the current framework, the variability of tonal sound usage among the diel cycle and seasonal cycle can be analyzed. It also provides intuitive parameters for the structural variability of tonal sound usage, which can facilitate the species recognition and the examination of cetacean habitat use.

Author : LIN, Tzu-Hao (Institute of Ecology and Evolutionary Biology, National Taiwan University)
Co-authors : YU, Hsin-yi ((Institute of Ecology and Evolutionary Biology, National Taiwan University)); CHEN, Chi-Fang ((Department of Engineering Science and Ocean Engineering, National Taiwan University)); CHOU, Lien-Siang ((Institute of Ecology and Evolutionary Biology, National Taiwan University))

Session : Short talks - Session II
Type : Short talk

Notes

A preliminary investigation on the seismic air gun reverberant field in a shallow water Arctic environment

Saturday 19 Oct 2013 at 18:00 (00h15')

Abstract

Offshore oil and gas exploration as well as geophysical research activities using seismic airgun arrays are known to generate intense underwater impulses that could impact marine mammals by causing hearing impairment and/or behavioral modification. However, few studies have investigated the resulting multipath propagation and reverberation from the airgun impulses, which could affect long distance communication and result in acoustic masking for marine mammals. In this study we report our initial findings on elevated overall background sound levels by the multipath propagation and reverberations between airgun impulses during a low-level open-water seismic survey in a shallow water environment in the U.S. Arctic. The research uses continuous acoustic recordings collected from three bottom-mounted hydrophones deployed in the U.S. Beaufort Sea between August and early September 2012. Two quantitative methods are employed to characterize the background sound field. The first is based on a Hilbert transform to extract and quantify the amplitude of the reverberant field in the period between impulses. The second is a statistical examination of the RMS noise levels during the same intervals between pulses and its dependence on source range. Preliminary results show that a significant portion of the sound field between seismic impulses raises above nominal ambient noise levels reported in the Arctic, and at least certain portions of the sound field were above 120 dB re 1 μPa, a benchmark used by U.S. regulators as a threshold for marine mammal behavioral harassment by non-impulse sound. Further, the duration of the reverberation field was found to be related to the source range, with significantly longer decay time measured on hydrophones that are farther away from the source. This effective increase of the ambient noise field has the potential to effects marine mammals in ways that differ from short higher amplitude, shorter duration impulsive levels seen in regions closer to the source.

Author : VIGNOLA, Joseph (The Catholic University of America)
Co-authors : SHANE, Guan (NOAA/NMFS Office of Protected Resources)

Session : Short talks - Session II
Type : Short talk

Notes

Spatial prediction and interpolation effect assessment of marine mammal counter calls, ambient and anthropogenic noise

Saturday 19 Oct 2013 at 18:15 (00h15')

Abstract

Spatial prediction methods were used to produce contour surface maps in order to document baseline ambient and anthropogenic noise conditions, and to examine the spatial and temporal distribution of marine mammals based on acoustic detections of their vocalizations. Contour surface maps are created with two main groups of interpolation techniques: deterministic which is based on the degree of smoothing, and geostatistical, which is based on the statistical properties of the measured points. Mean-absolute-error and root-mean-square-error were used to assess how accurate these two techniques are at generating a contour surface map that represents empirical reality.
We found Radial basis function (RBF) suitable to represent the spatial and temporal distribution of bowhead whale (*Balaena mysticetus*) counter calls in the Chukchi Sea. Based on the assumption that the interpolating surfaces are influenced by a function of their radial distance from a grid point and that the surface must pass through each measured sample value, RBF was chosen as a deterministic interpolation technique to calculate predictions from the measured points.
Ordinary Kriging, a geostatistical interpolation technique that relies on both statistical and mathematical methods to create contour surface maps and assess the uncertainty of predictions, was chosen to represent predicted ambient and anthropogenic noise conditions in larger study areas. Unlike RBF, Ordinary Kriging requires the complete specification of the spatial process in terms of a variogram model. Because the variogram model is not known in advance, we estimated the variogram model using an approach based on a geostatistical model. The appropriate model was then fit to the empirical values by matching the shape of the curve from the experimental variogram to the shape of the curve from the mathematical function.

Author : VALLARTA, Jonathan (Jasco Applied Sciences)
Co-authors : MARTIN, Bruce (Jasco Applied Sciences)

Session : Short talks - Session II
Type : Short talk

Notes

An algorithm to measure the size of sperm whales recorded by INFN deep-sea observatories in the Ionian Sea (Eastern Sicily)

Saturday 19 Oct 2013 at 18:30 (00h15')

Abstract

The Sperm whale continuously produces short acoustic signals, defined as “clicks”, to recognize the environment, to find food and to facilitate intraspecies communication. Each click has a multi-pulse structure, with a first variable pulse and a series of equally spaced pulses originating from multiple reflections inside the head of the whale. The measurement of the stable Inter Pulse Interval allows to acoustically assess the size of the animals. This work stemmed from the idea to automatically estimate the stable IPI through the average of cepstra computed on a large number of clicks. A new algorithm was developed to identify and extract the clicks and to carry out the analysis. Finally, the software searches for the peaks in the averaged cepstra and confirms the results with an automatic evaluation of reliability. The first results were produced analysing the dataset acquired during the years 2005-2006 by the NEMO OnDE (Ocean noise Detection Experiment) station. This was an INFN-LNS project, in cooperation with CIBRA, and consisted in an acoustic antenna, made of four large bandwidth hydrophones (30Hz < f < 42kHz), in operation at 2100 m of depth and connected in real-time to shore, through a submarine electro-optical cable. OnDE represented the first experiment performing acoustic noise monitoring in real-time over a long time in the Mediterranean deep sea. Using this automatic software tool, we processed the huge dataset acquired with OnDE and we now analyse new data coming from the SMO (Submarine Multidisciplinary Observatory) acoustic sensors, with minimal supervision. The developed software allows assessing the dimensional distribution of the specie, to hypothesize the sex, the maturity stage and to identify single whales present in consecutive recordings. Continuous data collection in real time will support an ecological study on sperm whales population structure in a strategic area of the Mediterranean Sea.

Author : CARUSO, Francesco (University of Messina / INFN - LNS)
Co-authors : PAVAN, Gianni (University of Pavia - Centro Interdisciplinare di Bioacustica e Ricerche Ambientali); SCIACCA, Virginia (University of Messina / INFN - LNS)

Session : Short talks - Session II
Type : Short talk

Notes

Acoustic detection of fin whales vocalizations offshore Eastern Sicily, Ionian sea

Saturday 19 Oct 2013 at 18:45 (00h15')

Abstract

The fin whale (Balaenoptera physalus) is considered to be the only mysticete common and constantly present into the Mediterranean Sea, representing a genetically isolated population and being distributed all over the basin. Although the increased number of surveys in recent years confirmed its presence in highly productive areas of the Mediterranean Sea, still very little is known about the trends this population follows seasonally and, particularly, in the Ionian area. Previous monitoring actions evidenced fin whales occurrence during late winter - early spring months in the area of Lampedusa (Strait of Sicily) and during summer months in the Strait of Messina and off East Sicily coast. This lets us consider the Ionian Sea as a possible major route through a seasonal migration of the species. To investigate this issue we started from the assumption that sound represents an essential tool for fin whales and their biological functions, producing two types of low frequency signals (around 20 Hz) to communicate over long distances with low transmission loss. In June 2012 the real- time deep sea multidisciplinary observatory NEMO–SN1, was deployed and connected 25 km off the port of Catania, East Sicily, at a depth of 2100 m. Four large bandwidth hydrophones (10 Hz < f < 70 kHz) and one low bandwidth seismic hydrophone (1 Hz < f < 1 kHz) allow us to monitor acoustically fin whales traveling across the region. Fin whales vocalizations have been detected using NEMO-SN1 data. Data have been analyzed to study animals' occurrence and the characteristic calls patterns that are thought to be used for communication purposes. In this work we will show preliminary results demonstrating the importance of this long-term monitoring project to better understand the presence of the species in the study area.

Author : SCIACCA, Virginia (University of Messina / INFN - LNS)
Co-authors : CARUSO, Francesco (University of Messina / INFN - LNS); PAVAN, Gianni (University of Pavia - Centro Interdisciplinare di Bioacustica e Ricerche Ambientali)

Session : Short talks - Session II
Type : Short talk

Notes

Model-based bio-acoustics

Monday 21 Oct 2013 at 08:30 (00h50')

Abstract

Fourier noted in his book on Théorie analytique de la chaleur that while the ultimate causes for the surrounding world are hidden to us, all natural processes follow simple and unchangeable laws that may be discovered through observations. While Fourier was interested in the understanding of a physical phenomenon (heat), it seems appropriate to consider also complex biological processes as a synthesis of simple laws and to try to learn about the biological reality by searching for the simple relationships of the underlying biological processes. The set of such simple, mostly mathematical relationships constitute a biological model. Model-based bio- acoustics is, in this sense, an attempt to explain the observations, that is, acoustic observations of deep diving cetaceans, by a set of simple rules, that is, by a model. Deep diving cetaceans are known to produce short sound pulses and it is generally accepted that these sound pulses are emitted for foraging purposes. Following the echolocation paradigm of bats, the common assumption is that echolocating whales use sound to search for, approach and capture their prey items. Using data from tagged sperm whales and a simple foraging model, I will show that the classical 'search, approach, capture' hypothesis for echolocation does not necessarily hold for deep diving sperm whales. In particular, the sperm whale echolocation data may be better described by an 'overview and intercept' model. As such, functional models are fundamental to the understanding of reality, I will discuss the consequences of the presented echolocation model for the foraging ecology of sperm whales.

Author : ZIMMER, Walter (CRME, I)

Session : Interdisciplinary approach to Computational (Bio)Acoustics
Type : Invited Lecture

Notes

3D multiple whale tracking

Monday 21 Oct 2013 at 09:20 (01h00')

Abstract

First we present our real-time multiple whale tracking on large or short hydrophones array. Our algorithm is based on the transitivity of the Time Delay of Arrival (TDOA) computed from correlation of each couple of hydrophones [Glotin et al. 2008, 2009, patent USA,EU]. It results a high precision track without false alarm (online demonstrations at http://www.youtube.com/watch?v=0Szo3gdiTRk, http://sabiod.org/tv : real fine tracking results computed on the widely spaced hydrophones of DCL 2005 Monaco challenge, record from Bahamas AUTEC). The TDOAs were computed after Teager-Kaiser or Stochastic Matching Filter which was more efficient [Benard 2010, 2011]. The shape of the track demonstrates some interesting observation and predation behaviours of the whale. Second we show that our algorithm is compatible with short spaced hydrophones base (2 meters square) as demonstrated using the Nemo Onde data (from INFN, CIBRA and the NEMO, data distributed within the 2009 DCL challenge by G. Pavan). In this purpose we firstly detect each click on each channel. A first static method consists in computing the position of each target, relative to the platform, using directly TDOA estimates, resolving the acoustic model with a maximum likelihood estimator for example. In parallel, we proposed a more dynamic tracking system base on particle filtering in presence of false alarms and an unknown and varying number of targets. This takes into account the problem of data association and is called the Rao-Blackwellized Monte Carlo data association (RBMCDA) algorithm. Thus, we trajectography the whales and we can increase the state dimension to estimate other features such as speed. We compute the Cramér-Rao Lower Bound (CRLB) for the given array geometry and the confidence ellipses. This method allows us to locate several sperm whales with a reasonable accuracy [Benard and al. 2011]. This method opens new perspectives for compact military or civil whale monitoring and various behavior feature extractions. Third we show how sparse coding allow efficient TDOA estimation without knowledge on the pattern of the target. We demonstrate simple cosine metrics results on couple of hydrophone of the Mink whale data set (Hawaii) distributed at DCL 2011, and we discuss on the advantages of this approach for scaled tracking methods (Glotin with Razik, ASA ICA Montreal proceeding 2013).
This work was supported by the inter-institute MASTODONS CNRS project Scaled Acoustic Biodiversity http://sabiod.org & Institut Universitaire de France. Universitaire de France.

Author : GLOTIN, Herve (Toulon Univ., F)

Session : Interdisciplinary approach to Computational (Bio)Acoustics
Type : Invited Lecture

Notes

Tracking Algorithms in Marine Mammal Acoustics

Monday 21 Oct 2013 at 10:40 (00h50')

Abstract

The problems associated with detecting, classifying and localising marine mammals using acoustic methods have been widely studied. These represent challenging tasks when applied to individual animals and become even more burdensome when groups are encountered, as is frequently the case in practice. Here we shall consider an aspect of such acoustic processing systems that is the focus of less attention, namely the issue of tracking. Many automated acoustic systems yield detections made over short, sliding, temporal windows, resulting in sequences of, potentially multiple, detections. Tracking allows one to link together detections through time and by doing so provides a more complete picture of the acoustic environment. The use of tracking techniques has some benefits when applied to situations where a single animal is present; for example they allow optimal estimation of position based on a sequence of measurements, effectively reducing noise on location estimations. However, arguably, there is much greater potential in scenarios where many animals are vocalising simultaneously. In those instances tracking methods offer the potential to link together (associate) detections from individuals to form tracks and hence solve the problem of which vocalisation came from which animal. This paper will review the principles underlying tracking methods and outline the panoply of existing techniques. Two prototypical tracking problems encountered in the acoustic analysis of odontocetes will be used to illustrate the issues, these are: the spatial tracking of sperm whales using a towed array and dolphin whistle tracking (contour extraction).

Author : WHITE, Paul (Southampton Univ., UK)

Session : Interdisciplinary approach to Computational (Bio)Acoustics
Type : Invited Lecture

Notes

ARION - Systems for Coastal Dolphin Conservation in the Ligurian Sea

Monday 21 Oct 2013 at 11:30 (00h30')

Abstract

ARION "Systems for Coastal Dolphin Conservation in the Ligurian Sea" - LIFE09 NAT/IT/000190. The bottlenose dolphin (Tursiops truncatus) is a Mediterranean cetacean listed as “vulnerable” in IUCN Red List. It is estimated that 200-300 individuals live in the project area. As a coastal species, bottle nose dolphins are the most threatened by habitat degradation and loss. The main threats come from coastal urbanisation, port construction, boat traffic, shipping, pollution by industrial and agriculture activities, overfishing and overexploitation. The Ligurian Sea and the Portofino coastal area are subject to intensive boat traffic, especially during the summer season, which significantly increases underwater noise pollution. This kind of impact represents a serious threat for cetaceans as they communicate and orient by underwater sonar-waves. Moreover, human interaction with bottlenose dolphins has to be regulated during the summer season when newborns and calves are present with adult individuals. The main objective of the project is the improvement of the conservation status of the bottlenose dolphin in the MPA of Portofino. To this end, an acoustic monitoring system has been designed to detect and track the species. A network of hydrophones, communicating with an on-shore computer centre, has been installed at the boundaries of the Portofino MPA to identify and follow dolphins in real time. Human activities and underwater noise are being recorded as well. A description of the system as well as the summary of the first three months of activity will be presented.

Author : TAIUTI, Mauro Gino (GE)

Session : Advanced marine research for conservation
Type : Invited Lecture

Notes

How new technology has revolutionized the study of cetacean bioacoustics and suggestions for new directions and collaborations for the future

Monday 21 Oct 2013 at 14:30 (00h50')

Abstract

Our human sense of audition is adapted for hearing in air, so we need to rely upon electronic apparatus to hear well underwater, to localize sounds, and to broadcast them. After modest development in the first 40 years of the twentieth century, WWII brought rapid development of excellent gear for listening, locating, and broadcasting sound underwater. Unfortunately for civilians interested in this topic, most of this military equipment was very expensive, was so large as to require large ships, and often its use was restricted by military security. When Roger Payne and Doug Webb proposed in 1973 that baleen whale calls might be audible over ranges of hundreds of km, many biologists rejected this as implausible, not knowing that navies used networks of hydrophones to routinely track whales and other sound sources at these ranges. While the methods became more openly available by the end of the 1980s and the end of the Cold War, their expense limited their use for marine bioacoustics. The increasing power and miniaturization of digital electronics through the 1990s finally opened the door to allow normal biological projects access to sophisticated signal processing for bioacoustics in the field. Finally a graduate student could build an array of hydrophones, program a personal computer to process the data for beamforming, and put it all on the small boats typically used by field biologists. By 2000, the miniaturization of digital electronics made it possible to put a recording system directly onto a whale. These developments turned marine bioacoustics from the realm of expensive cruises on large research vessels to a tool that could be used by field biologists. This has led to an explosion of research in this area, promoting the use of bioacoustics tools to answer questions from behavior to estimating population size. These relatively cheap small-scale devices also have shown great value in combination with large expensive research programs. When a tag recording the vocalizations and orientation of a calling whale is combined with measurements from acoustic arrays, either towed from a ship or mounted on the seafloor, it becomes possible to measure the three dimensional beam pattern of the animal's sound production. Similar tags can monitor behavioral and physiological reactions to potential sources of disturbance such as naval sonar, yielding functions relating acoustic dosage to behavioral response. These dose-response functions are essential for managing the risk of disturbance. As we recognize that sound may affect marine life globally, and that acoustic methods can help us to track the distribution and abundance of vocal species such as marine mammals and fish, this suggests future needs for developing bioacoustics methods that work over longer spatial and temporal scales than ever before. Current acoustic recording tags only last a day or so. This is not long enough to sample much behavior and physiology, nor to monitor the effects of seismic surveys or sonar exercises. These data needs argue for acoustic tags that last several weeks to months. The development of long-term global ocean observatories offers the promise for supporting these needs, but the acoustic components of current plans need to be greatly strengthened. I hope that if communities such as marine biologists and particle physicists who use sound in the ocean, can work together with one voice, we may be more successful in adding the critical acoustic capabilities to ocean observatories.

Author : TYACK, Peter (St. Andrews Univ.)
Session : Advanced marine research for conservation
Type : Invited Lecture

Impact of noise on fishes and marine mammals

Monday 21 Oct 2013 at 15:20 (00h50')

Abstract

Sound travels efficiently underwater, therefore, it could impact large areas of water body where fish and marine mammals live. Underwater anthropogenic sounds are ubiquitous due to extensive human activities into the aquatic environments. Many studies have documented deleterious effects of underwater noise on fishes and mammals which include: temporary or permanent hearing threshold shift, deafness, loss of vestibular function, changes in: vocalizations, respiration, swim speed, diving, foraging behaviors; displacement, shifts in migration path, stress, strandings, changes in social behaviors, reduced communication and echolocation efficiency, hampered avoidance of anthropogenic threats, hampered parental care or bonding, chronic effects (e.g., stressed-related physiological changes) or indirect effects (e.g., reduced prey availability due to responses of prey to sound effect). The underlying mechanisms of acoustic trauma is largely results from mechanical damages to sensory hair cells or biochemical damages due to oxidative stresses caused by the production of reactive oxygen species (ROS). ROS production disrupts neuronal transmission promotes oxidative DNA injury, and contributes to peroxidative damage to membrane lipids of the cochlae. Conversely, decreased ROS formation, increased ROS scavenging capabilities, or increased antioxidant levels are associated with a reduction in threshold shifts after noise exposure. Thus, oxidative damage is a consequence of increased oxidative stress, decreased antioxidant potential, or the combination of the two. In contrast with mammals, the ears of fish (sharks, rays and bony fish) can produce hair cells throughout life and therefore any damage to the hair cells caused by acoustic trauma has the chance to recover but this is not the case in marine mammals. Hence effective mitigation measures are even more important for marine mammals. The establishment of “safe” noise exposure levels, reduction of noise at off-shore construction sites, reducing noise levels from biological important areas and creation of marine protected areas are all tangible mitigation methods.

Author : YAN, Hong Young (Taiwan)

Session : Advanced marine research for conservation
Type : Invited Lecture

Notes

Cetacean density estimation from passive acoustic data

Monday 21 Oct 2013 at 16:30 (00h50')

Abstract

The estimation of density (and abundance) of cetaceans is a key step towards their management and conservation. Currently, the most widely used methods for obtaining density estimates are distance sampling or capture-recapture methods, usually involving visual detections and/or marking (even if only conceptual, e.g. photo ID). However, many cetacean species are difficult to sight, and cannot be easily marked or recaptured. Some of these species produce readily identifiable sounds, opening the door to use passive acoustic data to estimate animal density. Automated acoustic data collection means that surveys can occur at times and in places where it would be too expensive or dangerous for human observers. While the methods are also applicable to other aquatic and terrestrial sound-producing taxa, most applications to date have involved cetaceans and sensors at fixed locations. We present an overview of cetacean density estimation using passive acoustic data, reviewing the types of data and methodological approaches currently available to researchers, noting primary methods are based on distance sampling and spatially explicit capture-recapture concepts. We provide a framework for acoustics-based density estimation, illustrated with examples from real-world case studies. We also mention a number of possible research areas that might help the field of passive acoustic density estimation to develop further.

Author : MARQUES, Tiago (University of St Andrews / CREEM)
Co-authors : HARRIS, Danielle; THOMAS, Len

Session : Advanced marine research for conservation
Type : Invited Lecture

Notes

The Sea Finds Its Voice: Changes in the Scientific Understanding of Sound and Marine Life from 1993 to 2013.

Monday 21 Oct 2013 at 17:20 (00h50')

Abstract

Over the past twenty years societal concern about the effects of manmade underwater sound on marine life has grown. The increased concern has been reflected in increased funding for scientific research. Numerous studies of the hearing and behavior of marine life, especially studies of marine mammals, have been conducted to determine the risks to marine life from sound. Of particular note are anatomical models of hearing for species too large to easily test by traditional methods, development of frequency weighting thresholds corresponding to human A weighting functions, and open ocean field studies of behavioral responses to sound. Collectively, these data have been synthesized into models of sound exposure and risk, like the Effects of Sound on the Marine Environment (ESME) model. One of the most difficult remaining questions is "What is the significance of the effects we observe?"; in other words, when does disturbance by manmade sound rise to a level that places marine life at risk? One model for structuring thought about such questions is the Population Consequences of Acoustic Disturbance (PCAD) model, which develops energetic or condition-based metrics to translate observed individual effects to the population level via consequences for life history parameters like growth, survival and reproduction. Another dramatic positive benefit of research on the effects of manmade sound has been the advancement of acoustic monitoring equipment and animal tag technologies which offer tremendous scientific and conservation benefits; not only for assessing and mitigating the effects of manmade noise, but for overall monitoring and beneficial management of our precious ocean resources.

Author : GISINER, Robert (U.S. Navy)

Session : Advanced marine research for conservation
Type : Invited Lecture

Notes

Abstracts

Posters

An Inter-frequency attenuation model for estimation of click distance

Abstract

In the last 10 years, the knowledge of marine mammals behaviour, their trajectory and density estimation has been enhanced by using passive acoustics techniques. Whale detection and precise localization is often achieved by expensive and heavy hardware such as hydrophone arrays and bottom mounted hydrophones. However, the frequent use of light and single hydrophone devices, which are quick to deploy, requires methods of analysis. In the past, the first steps in the realization of an estimator of the propagation distance between the acoustic source and the receiver were proposed. In this paper, the theoretical expression of this propagation distance estimation is presented with the necessary simplifying assumptions in the case of odontocete wideband signals. It is called Inter-Frequency Attenuation (IFA) model as it is based on the inter-band signal's attenuation laws. This model is evaluated on sperm whale range estimation on recordings of 25 min on four hydrophones. The range prediction is compared to a precise ground truth available from previous studies. The mean relative absolute range error of the direct theoritical IFA model is 15 \%, but a statistical IFA regression yields to 6 \%. We also discuss the dependencies between IFA and the source orientation."

Author : DOH, Yann (LSIS/DYNI)
Co-authors : GLOTIN, Hervé (Université de Toulon et Insitut Universitaire de France); RAZIK, Joseph; PARIS, Sebastienne

Type : Poster

Notes

First results on underwater acoustic background in SMO – NEMO Phase II

Abstract

In recent years the Italian legislation is conforming itself to protect marine ecosystems which requires the study and the subsequent monitoring of the physical and chemical characteristics of the underwater environment that is affected and changed by the increasing human activities. The Submarine Multidisciplinary Observatory (SMO) is an underwater acoustic antenna installed onboard the NEMO-KM3NeT tower at 3500 m water depth and 100 km offshore Capo Passero (Sicily) and founded by Italian Ministry of Research, University and Education. It consists of 12 high sensitivity and broadband (sensitivity: -172±3 dB re 1V/μPa, bandwidth: 10Hz ÷ 70kHz) acoustic sensors (hydrophones) and environmental probes (two Conductivity-Temperature-Depth probes to measure sound velocity at the site). The SMO antenna performs real-time monitoring of acoustic signals in deep-sea and, in particular, bio-acoustic sounds (marine mammals). Hydrophone signals are sampled at 192 kHz/24 bit and analyzed in real-time on shore. In this contribution we present the first results of the analysis of underwater acoustic background measured by the SMO antenna, operating since end of March 2013. Ambient sound in the whole bandwidth, and in particular impulsive sounds measured over the frequency band 10 Hz to 10 kHz and continuous low frequency sounds will be presented.

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Type : Poster

Notes

Acoustic data acquisition systems (AcouDAQ) for the SMO, KM3NeT and SN1 experiments

Abstract

The SMO team has successfully deployed two deep-sea acoustic antennas, permanently connected to shore by means of electro-optical cables. Both observatories are real- time operating since their deployment. The first one is hosted aboard the NEMO-SN1 multiparameter observatory (managed by INGV and INFN) installed at the INFN-LNS "Catania Test Site" located ~25km off the Catania harbour at a depth of ~2100m. The other one is aboard the KM3NeT-SMO detector, mainly devoted to neutrino detection, deployed at ~100km off the Portopalo di Capo Passero (SR) at a depth of ~3500m. The two antennas are equipped with arrays of hydrophones, 4 on the NEMO-SN1 and 14 on KM3NeT-SMO, that are acquired in real time using a common clock derived from the GPS. All data are GPS-time stamped underwater: thus forming the first sparse underwater hydrophones array (the distance between the two installations is about 200km) synchronous and phased with the GPS. Data collected by the two acoustic arrays are sampled and digitized in EBU/AES audio standard data format (24bit - 96 or 192kHz) by the off-shore electronics and sent, through optical cable, to the shore laboratories of Catania and Portopalo. In each on-shore laboratory an Acoustic Data Acquisition system was installed, running on a dedicated computer farm. The system installed on the farms permits to run parallel real-time data analysis software, which can be remotely controlled at run-time, over the whole data flow. The data acquisition architecture will be presented and its scalability to the expected size of the future KM3NeT acoustic array will be discussed.

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Notes

WaveShark – a compact multifunctional multichannel high sampling rate recorder

Abstract

Multichannel high speed recording systems had always required an ADC acquisition card, a personal computer, a dedicated software, a power supply and often additional external filters and preamplifiers. This implied huge and expensive instrumentation not well suited for field work. WaveShark comes from a strong request to have a compact, lightweight and autonomous high speed multichannel recording system. To fulfill these requirements we have used one of the latest very low power 32 bit ARM® CORTEX® processor and designed a dedicated acquisition interface based on a simultaneous ADC able to convert 8 channels simultaneously at 500 kHz with 16 bit resolution. The analogic section uses high quality amplifiers and a power down supply to disconnect unused channels. Four SD card slots allow a total max capacity of 256 Gbytes in FAT32 mode. The integrated firmware allows to program the recording system in continuous mode, triggered mode, or timer mode. An integrated GPS unit provides accurate timestamping and georeferencing of any recording. A simple menu makes possible to change all the setting in few steps via a small low power LCD and 6 command buttons. With accurate GPS timestamping it is possible to synchronize multiple units (in post processing). A high speed USB interface provides direct connection to a laptop or tablet PC for easy setting or for real-time signal processing and display with the SeaPro software.

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Notes

A Calibrator for UHE neutrino acoustic detection in underwater telescopes

Abstract

Underwater neutrino telescopes require in situ acoustic calibration in order to assure the optimal performance of sensors dedicated for the acoustic detection of ultra-high energy neutrinos. Moreover, sensor calibration is necessary to evaluate the acoustic detection and the efficiency of the entire detection. A first prototype of a compact acoustic array able to mimic the acoustic neutrino signal, this is a transient bipolar signal with 'pancake' directivity, is presented. Parametric acoustic source technique has been used to reproduce the neutrino signal with those characteristics. The compact array developed has practical features such as easy handling and operation, and versatile functionality. In the latter sense, the transmitter is able to work in different frequency ranges for different application modes, and thus to carry out several tasks related to acoustics in underwater neutrino telescopes: emission of neutrino-like signals, calibration of sensor sensitivities and responses, emission of signals for positioning, etc. The design process, construction and characterization of the prototype are detailed. A theoretical study is also discussed, where experimental signals were propagated over distances in the kilometre range. A test plan is proposed for testing the device in a Sea Campaign.

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Type : Poster

Notes

Click and burst pulse proprieties of wild bottlenose dolphin in the Central Mediterranean Sea

Abstract

In this study we describe the impulsive signals from bottlenose dolphin of the Central Mediterranean sea. Data were collected during 2011 and 2012 year during 27 survey in the Sicilian Channel (ranged from 1 to 25 nautical miles from the coast, included Lampedusa island) in which were sighted 144 specimens. It was used a digital acquisition system that allow to obtain calibrated signals in the range 0.01-150 kHz at 16 bit. Based mainly on the pulse repetition rate, the signals were grouped in a) LF click (single clicks without a regular pulse rate), click train (click with a median inter-click interval of 60 ms), burst (with a median inter-click interval of 2.2 ms) and HF click (with a median inter-click interval of 2.7 ms). The considered measured parameters were: SPLpk (dB re 1microPa peak), duration, 1°, 2° and, 3° peak of frequency, number of peak frequency, bandwidth, centroid frequency, 10%, 25%, 75% and 90% percentiles of the power spectrum distribution. Most of all parameters were significantly different between the different groups types reflecting the different functions of these signals. LF clicks showed a lower peak frequency and longer duration and could be used to explore wider area without a focal target. Otherwise the click train type showed a higher SPLpk, peak frequency and lower duration and number of peak frequency showing a better resolution to investigate a specific target. In the click train there is a positive correlation between the SPLpk and the quartile of the power spectrum distribution.

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Notes

Acoustically derived growth rates of sperm whales (*Physeter macrocephalus*) around Ischia and Ventotene Islands (Italy): preliminary results

Abstract

Measuring the size of individuals and quantifying their growth are fundamental to answering many ecological questions. Acoustic methods for estimate the size of sperm whales (*Physeter macrocephalus*) by measuring the inter-pulse interval (IPI) of their clicks have been applied in some different studies; however, very few data on the growth rate of sperm whale individuals in the Mediterranean Sea is available to date. We recently started to apply this method to recordings made around Ischia and Ventotene Island (Tyrrhenian Sea), Italy, in order to estimate the size and the growth of sperm whales that have been photo-identified and recorded at least two times in two different years between 2004 and 2012. This dataset includes 20 whales of different sex and age class. Two individuals - one of unknown sex named 'Norma' and one immature male named ' Brunone' - were the first whales that we analysed over three years (2004-2005-2006). IPIs were manually derived (using Rainbow Click Software) from a limited number of clicks (out of a total of 283.932 clicks) selected through a simple random sampling. Body lengths were estimated using different formulas (Clarke, 1978; Gordon, 1991; Goold, 1996; Growcott, 2011). Unconcernedly from the applied formula, both whales showed: a) a similar length in 2004; b) an increasing IPI over time, with an estimated growth rate between 0 and 0,227; c) a quicker growth rate between 2005-2006 than 2004-2005. Furthermore, the immature male Brunone seems to grow up significantly faster than the other whale Norma. To proceed with the analysis of the other individuals of the dataset, we will use automatic methods to generate IPIs in order to match results with our manually derived preliminary findings.

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Type : Poster

Notes

A smart platform for monitoring underwater noise

Abstract

In light of recent concerns about the effects of both acute and chronic noise exposure on the marine environment, it is desirable to implement long-term, continuous monitoring of underwater noise levels in key locations. This monitoring may be used to provide impact assessment for specific anthropogenic noise sources as well as to provide insights into long-term trends in underwater noise levels. However, the potential volume of data produced during such monitoring is vast due to broad bandwidths and long timescales. Even with modern technologies, continuous direct storage or transmission of such data for prolonged periods may not be cost effective. An underwater noise monitoring system is presented which addresses this problem by performing real-time analysis on acoustic data as it is acquired to compute third- octave sound exposure levels (SELs), peak pressures and other statistics for both continuous and impulsive noise. The results of this analysis have a significantly lower bit rate than that of the unprocessed acoustic data and so provide a more efficient format for data storage or transmission. They also provide a simple pathway to real-time impact assessment of underwater noise. The presented system consists of a hardware platform and a software application. The hardware platform (UDAQ system) is a battery-powered embedded computer system with hydrophone input in a pressure housing suitable for underwater deployment. The software is designed for unattended operation, can be ran on both the UDAQ system and general-purpose computers and is to be released under an open-source license to facilitate standardisation of analysis and automated impact assessment methods.

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Notes

What does a small, shy cetacean which vocalises 6 times above a human's hearing range do underwater? Challenges in localising harbour porpoises.

Abstract

Using passive acoustics to track the movements of animals underwater is well established in cetacean research. However as animals get smaller, their vocalisations tend to get higher in frequency and less dispersed hydrophone arrays are required in order to determine a location. As arrays get smaller, errors in the estimated position of hydrophones and sound speed become much greater in proportion to the received time delays. In reverberant environments high vocalisation rates can result in problems matching detections on different hydrophone elements further complicating matters. For harbour porpoises, which vocalise at 130kHz with a highly directional bio-sonar and can produce upwards of 600 indistinguishable clicks per second, these challenges are particular acute. However the harbour porpoise is a protected species and one of Europe's most abundant cetaceans, hence it is vital tools are created to better understand their use of certain habitats, especially with rapid expansion of the marine renewable energy industry. We have trialled a practical free floating hydrophone system which can be deployed in challenging habitats, such as tidal areas, to track the 3D movements of harbour porpoises underwater. Markov chain Monte Carlo (MCMC) techniques were employed to localise positions of porpoises and effectively propagate errors, such as sound speed fluctuations, individual hydrophone element positions and cross correlation of narrow band signals, into final position estimates. Echoes and detection matching problems were addressed by localising all possible combinations of detections over all hydrophone elements and determining the combination which best fits the MCMC localisation algorithm. This 'brute force' approach has proved highly effective in trials using a simulated porpoise clicker deployed at different depths and ranges and has the ability to localise any number of vocalising animals simultaneously. We will show how MCMC localisation compares against more traditional techniques, such as direct hyperbolic methods and present data on calibration experiments to the check accuracy of this system in the field. We will conclude with some examples of wild porpoise and dolphin tracks from survey data collected over the last two years.

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Notes

Biomechanical Evidence of Low to Infrasonic Hearing in Mysticetes: Implications for Impacts

Abstract

An important concept in neuroethology is the Umwelt; i.e., that an animal's perceived world depends upon the capacity and filter characteristics of species-specific, evolutionarily tuned, sensory modules. Biomechanical modeling deconstructs these blocks for insights into commonalities and specializations of sensory systems across species. Knowing the hearing abilities of marine mammals is fundamental to understanding noise impacts, but we have audiograms for fewer than 25 species, mostly from smaller high frequency (HF) odontocetes (toothed whales) with poor low frequency (LF) hearing. We have no direct hearing measures for any mysticete (baleen whales). Based on vocalizations, mysticetes are likely to have acute LF hearing and thus are potentially the taxa most liable to harm from anthropogenic sources. To address this data gap, we analyzed the anatomy and material properties of dolphin, whale, and land mammal ears to determine whether, like elephants, mysticetes have ears adapted for acute IF/LF hearing.
The analyses demonstrated three key specializations in mysticetes vs MF/HF adapted mammals: magnitude lower basilar membrane apical ratios (0.0009 vs 0.013); middle ear transfer functions (METF) two magnitudes less (0.0032 mm/Pa-s vs 0.25 mm/Pa-s); and cochlear radii ratios >8.
Mysticete basilar membrane ratios correlate with decreased apical stiffness optimized for LF frequency transduction. The METF is consistent with peak sensitivities <3 kHz. High radii ratios imply logarithmic spirals that redistribute LF wave energy towards the cochlear spiral's lateral wall, a biologic equivalent of a "Whispering Gallery" that enhances intracochlear LF penetration. By contrast, odontocete cochleae approximate tightly curved Archimedean spirals with basal radii ratios <5 and a narrow, double basal hook that may minimize LF energy transfer to the inner ear. Consequently, there are significant questions about the ability of MF/HF adapted species response measures to represent the impact of sounds on IF/LF adapted ears.

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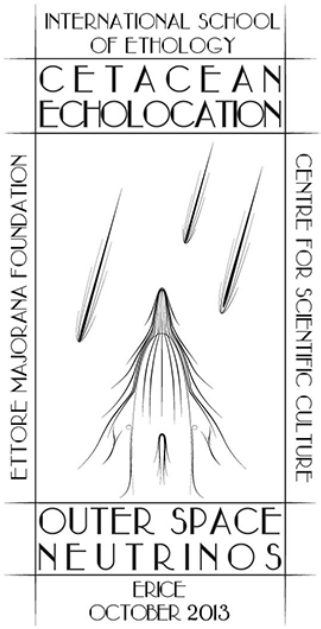
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