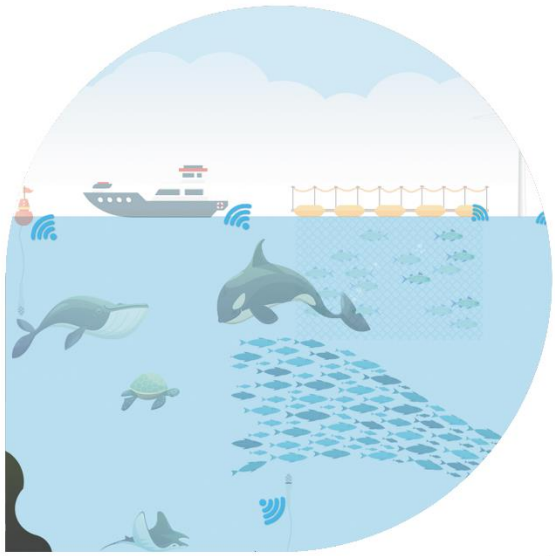
CTN



BLUE GROWTH

MONITORIZACIÓN DEL MEDIO MARINO: PROCESADO DE SEÑAL

INFORME DE VIGILANCIA TECNOLÓGICA

2019

Unión Europea

Fondo Europeo de Desarrollo Regional
"Una manera de hacer Europa"

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1. Introducción

Este informe, elaborado por el equipo del Centro Tecnológico Naval y del Mar, tiene como finalidad ofrecer al tejido empresarial una mejora en el conocimiento del entorno, que permita detectar tendencias y desarrollar estrategias adecuadas basadas en niveles superiores de certidumbre a través de la captación y divulgación de información y conocimiento de importancia estratégica en los ámbitos social, tecnológico y económico, que incidan en la detección de nuevas oportunidades de desarrollo regional.

Los contenidos de este informe están estrechamente relacionados con el desarrollo del proyecto "PAAMSY 2: Nuevas técnicas de procesado de señal embebido que permitan disponer de un sistema de monitorización de ruido submarino multi-aplicación low-cost"; financiado por el Instituto de Fomento de la Región de Murcia.

Para la realización de este informe se han aplicado técnicas de Vigilancia Tecnológica, una herramienta al servicio de las empresas y organizaciones que permite detectar oportunidades y amenazas aportándoles ventajas competitivas y fundamentos para la toma de decisiones estratégicas mediante la selección y análisis de información de diversos tipos (científica, tecnológica, comercial, de mercado, social…).

Para ello se parte de una introducción metodológica sobre las técnicas y fases de la Vigilancia Tecnológica que se han aplicado para el desarrollo del informe. A continuación se introduce el Crecimiento Azul como estrategia europea y el papel del medio marino en el marco de dicha estrategia, con el fin de dibujar un cuadro de referencia para la contextualización de los contenidos temáticos del informe. Seguidamente se realiza un análisis del estado de la técnica, noticias, patentes y literatura científica.

Por último se incluyen las fuentes que se han manejado para la realización de este informe.

2. Metodología

La vigilancia tecnológica se entiende como una "forma organizada, selectiva y permanente de captar información del exterior sobre tecnología, analizarla y convertirla en conocimiento para tomar decisiones con menor riesgo y poder anticiparse a los cambios". (AENOR, 2011) Su finalidad última es generar ventajas competitivas para la empresa ya que le proporciona datos para:

Ilustración 1. Finalidad de la Vigilancia Tecnológica

Para el desarrollo de la Vigilancia Tecnológica el primer paso el plantear los aspectos básicos (Degoul, 1992):
¿Cuál es el objeto de la vigilancia? ¿Qué debemos vigilar? ¿Qué información buscar? ¿Dónde localizarla?

Cuando el objetivo de la VT está claramente delimitado, se procede a planificar la estrategia de búsqueda. Para el despliegue de esta fase conviene tener en cuenta que la información puede presentarse de dos formas: estructurada y no estructurada. La primera es propia de las bases de datos, conjuntos de datos homogéneos, ordenados de una forma determinada, que se presenta en forma legible por ordenador (Escorsa, 2001). Su unidad es el registro –o ficha de un artículo científico o una patente- que presenta la información ordenada en campos: autor, título, fecha de publicación, titular de la patente, inventores, etc. En cambio, la información no estructurada se presenta en textos sin un formato determinado (noticias de periódicos, sitios web, blogs, correos electrónicos) cuyo tratamiento requerirá de nuevas herramientas capaces de "leer" y analizar estos textos. Estas herramientas son útiles también para analizar la información de textos completos de artículos científicos o de patentes. Hoy se considera que el texto es la mayor fuente

de información y conocimiento para las empresas. (Escorsa, Pere, Pilar Lázaro Martínez, Círculo de Innovación en Biotecnología, 2007).

Tras la selección de las palabras clave se automatiza la búsqueda en función de las diferentes tipologías de fuentes a utilizar, se lanza la misma y se filtran los resultados en términos de pertinencia, fiabilidad, relevancia, calidad y capacidad de contraste (AENOR, 2011).

Una vez comprobada la calidad de la información, los métodos de análisis han de garantizar su valor para la explotación de los mismos (F. Palop, 1995). El objetivo del análisis es transformar la información en bruto recogida en un producto con alto valor añadido. A partir de aquí, la aportación de los expertos es crítica para crear información avanzada, para generar conocimiento. Pasamos de una masa ingente de información en distintos formatos y lugares a una etapa en la que se captura la información más relevante, se organiza, indexa, almacena, filtra y, finalmente, con la opinión del experto que aporta en este punto del proceso un máximo valor añadido (CETISME, 2003).

A continuación, se incluye un esquema con las distintas fases de la metodología empleada durante la generación de este informe.

Ilustración 2. Fases de la Vigilancia Tecnológica

3. Blue Growth

El crecimiento azul es una estrategia a largo plazo de apoyo al crecimiento sostenible de los sectores marino y marítimo. Reconoce la importancia de los mares y océanos como motores de la economía europea por su gran potencial para la innovación y el crecimiento. Es la contribución de la Política Marítima Integrada (PMI) en la consecución de los objetivos de la Estrategia 2020 para un crecimiento inteligente, sostenible e integrador. La Estrategia consta de tres componentes:

a) Medidas específicas de la Política Marítima Integrada
   - Conocimiento marino para mejorar el acceso a la información sobre el mar;
   - Ordenación del espacio marítimo para garantizar una gestión eficaz y sostenible de las actividades en el mar;
   - Vigilancia marítima integrada para que las autoridades tengan una mejor apreciación de lo que pasa en el mar.

b) Estrategias de cuenca marítima que garanticen la combinación de medidas más adecuada con el fin de fomentar el crecimiento sostenible;

c) Desarrollo de las siguientes actividades específicas:
   - Acuicultura
   - Turismo marítimo, costero y de crucero
   - Biotecnología marina
   - Energía oceánica
   - Explotación minera de los fondos marinos

El informe de vigilancia tecnológica se centra en el desarrollo de plataformas multi uso como solución a varios de los temas prioritarios marcados por la estrategia europea Blue Growth.

4. Estado del arte

A continuación, se describe el estado del arte actual de cada una de las tecnologías más relevantes que componen los sistemas de monitorización acústica submarina.

1. Sistemas de adquisición de señal de ruido submarino.
2. Algoritmos de procesado de señal de ruido submarino embebido.
3. Algoritmos de compresión de datos.

4.1 Sistemas de adquisición de señal de ruido submarino

Actualmente existe en el mercado una variada oferta de tipos de equipos de grabación automatizada, sin embargo, no todos los equipos ofrecen la misma calidad de grabación. Las diferencias entre los equipos de grabación están vinculadas con varias características como, por ejemplo, en la relación señal a ruido, en la calidad y diseño de los circuitos electrónicos, la configuración, la protección del equipo a las condiciones de intemperie, frecuencia de muestreo, filtros de reducción de ruido de fondo y cronogramas de programación[1].

La MSFD[2] y la creciente necesidad de monitorizar el ruido submarino para evaluar el impacto ambiental que tienen las actividades marinas ha producido un aumento en la demanda de instrumentación multipropósito rentable. En aplicaciones marinas, aunque existen regulaciones para el ruido subacuático, como es el Descriptor 11 de la MSFD, los sensores acústicos y el procesamiento de los datos acústicos siguen siendo costosos. Esto se debe a los costos de adquisición y la necesidad de expertos en cada etapa, desde la operación del sensor hasta el procesamiento de datos.

Generalmente, los sistemas de monitorización acústica pasiva oceánicos actuales incluyen uno o varios transductores (hidrófonos), capacidad de acondicionamiento de la señal, interfaz de instrumentos con capacidad de comunicación y control y fuente de alimentación interna o externa. En plataformas independientes, los datos acústicos pasivos se suelen almacenar para su posterior recuperación y análisis, a menos que haya enlaces de RF (radiofrecuencia) a la costa. En ocasiones, estos datos se

[1] R. S. Rempel, et al., "Comparison of audio recording system performance for detecting and monitoring songbirds". Journal of Field Ornithology, vol. 84, no. 1, pp. 86–97, 2013
[2] Marine Strategy Framework Directive

transmiten a través de cableado a barcos[3] o estaciones de observación costeras[4,5]. La mayoría de las plataformas de monitorización oceánicas siguen siendo independientes con un enlace de RF de ancho de banda limitado.

Los sistemas de monitorización acústica más conocidos y ampliamente utilizados por el sector son:

- iCListen: Es un hidrófono digital inteligente, fabricado por la empresa Ocean Sonics[6] capaz de capturar la señal acústica, procesarla y ofrecer la información en unidades reales. Además, proporciona alta integridad de señal, alta capacidad de almacenamiento, bajo consumo y capacidad de procesar datos en tiempo real. Proporciona un nivel de autonomía de 8 horas en funcionamiento y 4 días en standby, así como, un rango frecuencial de 10 Hz – 200 kHz. El iCListen tiene asociado un software sencillo y funcional que permite visualizar la información en tiempo real y procesarla aplicando diferentes configuraciones de frecuencias de muestreo, resolución de bits y la señalización de eventos.
- SYLence: Es un hidrófono autónomo de bajo consumo, original de la empresa RTsys[7]. Está compuesto de un hidrófono y un sistema de grabación de bajo consumo. Es capaz de monitorizar simultáneamente diferentes tipos de sonidos, desde mamíferos hasta altos niveles de ruido. Permite frecuencias de muestreo de hasta los 192 kHz y una autonomía de hasta 45 días de datos. Además, mediante su interfaz web intuitiva se puede configurar y descargar los datos.
- ST300: El sistema Soundtrap ST300[8] es un sistema compacto de adquisición de señal acústica diseñado para trabajar en un rango de frecuencias entre los 20 Hz – 150 kHz. Su autonomía es de 13 días en modo continuo. ST300 también incluye un software que ofrece opciones flexibles de implementación de la frecuencia de muestreo, control de ganancia, filtrado y ciclo de trabajo. También incluye un mando de control remoto mediante IR que facilita las mediciones en campo ad-hoc.
- NeXOS A1 system: Este sensor inteligente, desarrollado en el proyecto NeXOS[9], consiste en un hidrófono y dos etapas de adquisición con diferentes sensibilidades para detectar, simultáneamente, niveles de

[3] J. R. Potter, et al., "The thinarray; a lightweight, ultra-thin (8 mm OD) towed array for use from small vessels of opportunity," in Underwater Technology 2000, Tokyo, Japan, June 2000, 2000.
[4] M. André, et al., "Listening to the Deep: Live monitoring of ocean noise and cetacean acoustic signals," Marine Pollution Bulletin, vol. 63, pp. 18-26. 2011
[5] M. André, et al., "Localising Cetacean Sounds for the Real-Time Mitigation and Long-Term Acoustic Monitoring of Noise, Advances in Sound Localization," D. P. Strumillo, Ed., ed: InTech, 2011
[6] http://oceansonics.com/ [20 febrero 2019]
[7] https://rtsys.eu/fr/ [20 febrero 2019]
[8] http://www.oceaninstruments.co.nz/soundtrap-300/ [20 febrero 2019]
[9] Next generation, Cost-effective, Compact, Multifunctional Web Enables Ocean Sensor Systems Empowering Marine, Maritime and Fisheries Management. (http://nexosproject.eu/)

fuentes acústicas desde los 50 dB a 180 dB referidos a micropascal. En funcionamiento consume un total de 350 mW y su rango frecuencial varía entre 1Hz a 50 kHz. El sistema A1 ha sido diseñado para sobreponerse a las limitaciones existentes en el mercado en su momento, por lo que proporciona, además de lo mencionado anteriormente, código abierto para modificación de funcionalidades, bajo consumo y capacidad de procesamiento de la señal acústica de medidas en tiempo real. Los algoritmos de procesado de señal que implementa este sistema están basados en el D11 de la MSFD, además de algoritmos para detección de clicks y silbidos.

Otros sistemas de monitorización existentes son: Pulse, ORCA Acoustic Recorder[10], TR-ORCA[11].

4.2 Algoritmos de procesado de señal de ruido submarino embebido

La motivación de la mayoría de los algoritmos de procesado de señal basados en acústica pasiva (PAM[12])desarrollados hasta el momento es, por una parte, la de mejorar el conocimiento en la monitorización de la biodiversidad marina y, por otra, cuantificar los niveles de presión sonora en el medio marino. A este concepto se le conoce en inglés como (PAM).

- Respecto a la monitorización biodiversidad marina, PAMGUARD[13] es la herramienta más conocida; es de código abierto e implementa varios de estos algoritmos. El proyecto PAMGUARD se creó con la función de proporcionar una infraestructura de software estándar mundial para la detección, localización y clasificación acústica, con objetivo de mitigar los daños a mamíferos marinos. Los algoritmos más significativos[14] que incluye PAMGUARD se pueden clasificar en detectores (detector de clicks o silbidos); clasificadores (de silbidos genérico y el conocido como "Rocca"); y localizadores (como "localizador Ishamel" o multicamino 3D).

  Hay otras aproximaciones interesantes que usan otro tipo de algoritmos, como son los de aprendizaje automático (o machine-learning en inglés), entre los que se pueden encontrar los llevados a cabo en MBARI por D. De Leon y C. College[15].

[10] http://www.seiche.com/underwater-acoustic-products/acoustic-sensors/orca-acoustic-recorder [20/02/19]
[11] https://turbulentresearch.com/tr-orca [20 febrero 2019]
[12] Del inglés: Passive Acoustic Monitoring
[13] https://www.pamguard.org [21 febrero 2019]
[14] https://www.pamguard.org/11_PluginModules.html [21 febrero 2019]
[15] Daniel De Leon, Cabrillo College, "Passive Acoustic Monitoring of Blue and Fin Whales through Machine Learning", Mentors: Danelle Cline, Dr. John Ryan, MBARI, Summer 2017

- Respecto a la monitorización de niveles acústicos, de entre las aplicaciones de los algoritmos de procesado de señal basado en acústica pasiva destaca el descriptor 11[16] de la Estrategias Marinas (MSFD), según el cual es necesario conocer el ruido submarino, tanto continuo como impulsivo que existe en los océanos. Para esto se proponen los algoritmos D11C1 y D11C2, basados en la MSFD.

  Existen numerosas soluciones que emplean PAM (como algunas de las soluciones nombradas en el estado del arte de la etapa de adquisición), éstos suelen ser softwares privativos a los que no se puede acceder. Sin embargo, existen otros dispositivos y sistemas que también los implementan y que su acceso no está restringido, como puede ser el dispositivo desarrollado en el proyecto NeXOS.

En definitiva, el reto que supone este tipo de procesado es su implementación en sistemas embebidos, y además que sea configurable de manera que un usuario pueda seleccionar un tipo de aplicaciones y otra según sus necesidades. La dificultad se da concretamente por el hecho de que estos sistemas embebidos están limitados en capacidad de cómputo y en memoria. Por tanto, el objetivo de este proyecto reside en ser capaz de superar estas limitaciones usando para ello un sistema embebido potente y de bajo coste a la vez que se optimizan de la mejor manera posible las técnicas de procesado de señal.

4.3 Algoritmos de compresión de datos

La compresión de información ha jugado un papel fundamental en cuanto a la tecnología digital debido a su potencial de minimizar el espacio de almacenamiento de información, así como el ancho de banda necesario para su transmisión entre equipos remotos. Esta información puede ser de audio, video, texto y multimedia. Los algoritmos de compresión y descompresión de datos se diferencian en algoritmos sin pérdidas[17], que se reproducen descomprimiendo bit a bit; y los que sí tienen, que omiten parte de información.

La compresión de datos más empleada para transmisión de información inalámbrica es la compresión sin pérdidas, además la compresión resulta de vital importancia ya que consigue disminuir el consumo de potencia entre los sensores inalámbricos y poder así enviar toda la información

[16] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017D0848 [21 febrero 2019]
[17] F.A. Marengo Rodríguez, et al. "Análisis comparativo de codificadores de audio sin pérdidas", 2010.

deseada[18]. En este sentido, los algoritmos sin pérdidas más estudiados han sido los algoritmos de Huffman, Shannon-Fano y Lempel-Ziv[19]. Sin embargo, diferentes estudios han demostrado que la técnica que proporciona mejores resultados para la compresión de audio es la técnica de Huffman[20,21].

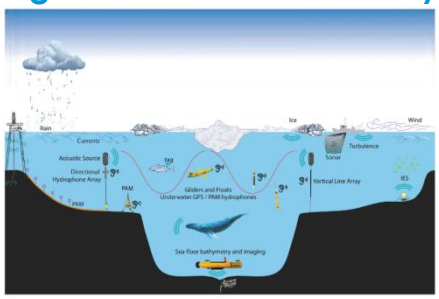
Un aspecto clave en los algoritmos de compresión de datos es encontrar un compromiso entre el rendimiento y la complejidad. Respecto al rendimiento, existen dos factores que entran en conflicto: la percepción del usuario final a la compresión (por ejemplo, la calidad de la imagen en una compresión de imagen) y la tasa de compresión de datos lograda. Por ello, es necesario alcanzar un compromiso entre ellos. La complejidad del sistema define el coste de la codificación y decodificación en los dispositivos[22].

[18] A. Khairi, B. Jambek and N. Alina. "Performance Comparison of Huffman and LZW Data Compression for Wireless Sensor Node application". American Journal of Applied Sciences. Vol. 11, Nº 1. Pp 119-126. 2014
[19] A. R. F. Quiros and R. A. Bedruz. "Comparison of Huffman ALgorithm and Lempel-Ziv Algorithm for Audio, Image and Text Compression". de *8th IEEE INternational Conference Humanoid, Nanotechnology, Information Technology*, Cebu, Philippines, 2015
[20] Shinjiro Ashida et al. "Sampled-Data Audio Signal Compression with Huffman Coding" Kyoto University, Japan
[21] Tonny Hidayat et al.. "Lossless Codign Scheeme for Data Audio 2 Channel using Huffman and Shannon-Fano." *Journal of Theoretical and Applied Information Technology,* vol. 96, nº 11, pp. 3467 - 3477, 2018
[22] M. Hosseini. "A Survey of Data Compression Algorithms and their Applications", 2012

5. Tendencias

5.1 Literatura científica

Observing the Oceans Acoustically



Autor: Howe, BM., Miksis-Olds, J., Rehm, E., Sagen, H., Worcester, P.F. & Haralabus, G.

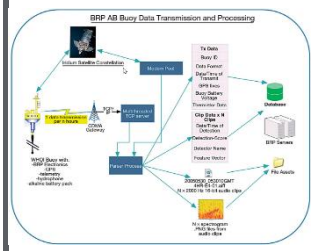
Publicado en: 2019. *Frontiers in Marine Science, 6:426.* Doi: 10.3389/fmars.2019.00426

Abstract:

Acoustics play a central role in humankind's interactions with the ocean and the life within. Passive listening to ocean "soundscapes" informs us about the physical and bio-acoustic environment from earthquakes to communication between fish. Active acoustic probing of the environment informs us about ocean topography, currents and temperature, and abundance and type of marine life vital to fisheries and biodiversity related interests. The two together in a multi-purpose network can lead to discovery and improve understanding of ocean ecosystem health and biodiversity, climate variability and change, and marine hazards and maritime safety. Passive acoustic monitoring (PAM) of sound generated and utilized by marine life as well as other natural (wind, rain, ice, seismics) and anthropogenic (shipping, surveys) sources, has dramatically increased worldwide to enhance understanding of ecological processes. Characterizing ocean soundscapes (the levels and frequency of sound over time and space, and the sources contributing to the sound field), temporal trends in ocean sound at different frequencies, distribution and abundance of marine species that vocalize, and distribution and amount of human activities that generate sound in the sea, all require passive acoustic systems. Acoustic receivers are now routinely acquiring data on a global scale, e.g., Comprehensive Nuclear-Test-Ban Treaty Organization International Monitoring System hydroacoustic arrays, various regional integrated ocean observing systems, and some profiling floats. Judiciously placed low-frequency acoustic sources transmitting to globally distributed PAM and other systems provide: (1) high temporal resolution measurements of large-scale ocean temperature/heat content variability, taking advantage of the inherent integrating nature of acoustic travel-

time data using tomography; and (2) acoustic positioning ("underwater GPS") and communication services enabling basin-scale undersea navigation and management of floats, gliders, and AUVs. This will be especially valuable in polar regions with ice cover. Routine deployment of sources during repeat global-scale hydrographic ship surveys would provide high spatial coverage snapshots of ocean temperatures. To fully exploit the PAM systems, precise timing and positioning need to be broadly implemented. Ocean sound is now a mature Global Ocean Observing System (GOOS) "essential ocean variable," which is one crucial step toward providing a fully integrated global multi-purpose ocean acoustic observing system.

Management and research applications of real-time and archival passive acoustic sensors over varying temporal and spatial scales



Autor: Van Parijs, S. M., Clark, C. W., Sousa-Lima, R. S., Parks, S. E., Rankin, S., Risch, D., & Van Opzeeland, I. C.

Publicado en: *2009. Marine Ecology Progress Series, 395, 21-36.* Doi: 10.3354/meps08123

Abstract:
Defining the appropriate scale over which to conduct a study in the marine environment is critical to achieving appropriate scientific, management, mitigation and conservation objectives. This paper focuses on applications of passive acoustic technologies over a range of spatial and temporal scales. It is divided into sections dealing with archival and real-time passive acoustic sensor applications. Each section assesses the principles behind using the respective technology and provides recent examples of research and management applications for marine mammals and fish. The section on archival sensors highlights the need for continued development of automated acoustic detectors to assess large data sets. Case studies are presented of detectors developed for determining seasonal occurrence and distribution of haddock sounds and humpback whale vocalizations. Also presented are studies of other applications using archival sensors: tracking singing humpback whales in Brazil, using vocalizations to assess the reproductive strategies of Arctic bearded seals and assessing regional variability in call patterns for North Atlantic right whales. The section on real-time passive acoustic sensors focuses on real-time buoys and towed arrays. Case studies presented include a real-time buoy system

used for monitoring endangered North Atlantic right whales and a stationary autonomous array providing real-time access to Antarctic acoustic data. The value of using towed arrays for real-time applications is also assessed, and a case study is provided on the use of towed arrays to improve abundance estimates of North Pacific cetaceans and to better understand vocalization behaviors.

Development of an Autonomous Surface Station for Underwater Passive Acoustic Observation of Marine Mammals

Autor: Arima, M., & Takeuchi, A.

Publicado en: *OCEANS 2016-Shanghai (pp. 1-4). IEEE. Doi:* 10.1109/OCEANSAP.2016.7485551

Abstract:

The purpose of this research is to develop a solar-powered autonomous surface vehicle (SASV) for the use of ocean environment monitoring and underwater passive acoustic monitoring of marine mammals. Measuring items of the logger version CTD with optical fast DO sensor are depth, temperature, conductivity, salinity, dissolved oxygen, chlorophyll and turbidity. The authors have also developed kinds of underwater passive acoustic monitoring systems (UPAMSs) for establishing a soundness index of the ocean, and contributing to preventative safety measures for collision avoidance of high-speed vessels and cetaceans. A practical application of the SASV can be watching over swarm intelligent underwater vehicles. This SASV consists of a couple of solar panels with a charge-and-discharge controller, an embedded PC, a couple of thrustors, a GPS device and a 3-axis digital compass for navigation. The SASV can be operated in autonomous control mode and manual control mode by a small game controller. Feature of this small-sized, lightweight and low-cost SASV is easy handling and long-term operation. This paper deals with its design concept, hardware components, control software, and trial run.

A Real-time Acoustic Observing System (RAOS) for Killer Whales

Autor: Matsumoto, H., Turpin, A., Haxel, J., Meinig, C., Craig, M., Tagawa, D., ... & Hanson, B.

Publicado en: *OCEANS 2016 MTS/IEEE Monterey (pp. 1-6). IEEE.*. *Doi*: 10.1109/OCEANS.2016.7761032

Abstract:

A prototype real-time, passive-acoustic observing system for killer whales was developed and tested off the coast of Newport, Oregon, USA. The system consists of two modules: 1) the passive-acoustic monitoring (PAM) module, which sits on the seafloor and continuously monitors the underwater soundscape for killer whale calls, and 2) a surface buoy, which receives information on acoustics detections from the PAM module via an underwater acoustic modem link and relays the information to shore via an Iridium (TM) satellite connection. The system was deployed in similar to 65 m deep water off Oregon in September 2015 for five days, during which the real-time detection capability was tested. A high rate of false positive detections was observed. Later analysis revealed that Dolphin clicks and impulsive sounds by invertebrate caused detection errors. During the experiment, killer whale sounds were projected with an underwater playback system to validate the detection algorithm.

Using Three Acoustic Technologies on Underwater Gliders to Survey Fish

Autor: Lembke, C., Lowerre-Barbieri, S., Mann, D., & Taylor, J. C

Publicado en: *2018. Marine Technology Society Journal, 52(6), 39-52. Doi*: 10.4031/MTSJ.52.6.1

Abstract:

Autonomous platforms and vehicles are a growing component of the ocean research fleet, producing data sets crucial to our understanding of oceanographic and fishery ecosystem processes. One emerging tool for making these measurements is underwater gliders that autonomously sample the water column for weeks to months at a time. Although originally designed to measure temperature and salinity, underwater gliders can now support a myriad of sensors. For the demonstration project described within, three complementary acoustic technologies were integrated into an underwater glider for mapping fish on the continental shelf: an acoustic telemetry receiver, a passive acoustic monitoring recorder, and a fisheries echosounder.

The demonstration project was designed to evaluate the effectiveness of each sensing technology. Sixty-one fish were implanted with acoustic tags near the Gulfstream Natural Gas pipeline in the eastern Gulf of Mexico in advance of planned underwater glider missions. The glider was deployed four times over 12 months, with all three acoustic technologies to traverse the pipeline and surrounding habitat. Glider detections were compared to detections of fish at moored acoustic tag telemetry receivers and passive acoustic recorders co-located at the tagged fish locations. All three technologies identified fish along the targeted hard-bottom pipeline habitat, as well as previously uncharted areas of hard-bottom reef. The results of this study demonstrate the utility of gliders integrated with acoustic sensors as a potential tool to identify areas that merit deeper investigation to assess fish stocks.

New compact passive digital acoustic sensor devices with embedded preprocessing

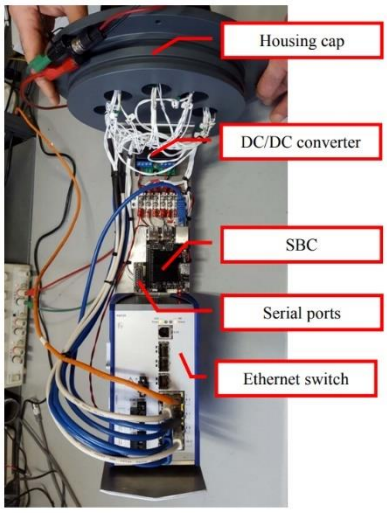


Fig. 6. *A2 Master Unit*

Autor: Delory, E., Memè, S., Cervantes, P., Ruiz, P., Casale, A., Figoli, A., ... & del Río, J.

Publicado en: *OCEANS 2017-Aberdeen (pp. 1-6). IEEE.* Doi: 10.1109/OCEANSE.2017.8084949

Abstract:

The development of new cost-effective and compact multifunctional sensor systems for a sustainable and integrated approach to ocean monitoring is the main objective of the NeXOS project. Within this context, the company SMID Technology manufactured two passive acoustic sensor systems, A1 and A2, as a new type of small dimension, low power and innovative digital hydrophone systems. A1 is a standalone small, compact, low power, low consumption digital hydrophone with embedded pre-processing of acoustic data, suitable for mobile platforms with limited autonomy and communication capability. A2 is a compact volumetric hydrophone system, enabling real-time measurement of underwater noise and of several soundscape sources. It consists of an array of four A1 digital hydrophones with Ethernet interface and one master unit for

data processing. A2 is mainly designed to be used on fixed platforms with less limited power autonomy and/or communication capability.

Monitoring the Oceanic Environment Through Passive Underwater Acoustics

Autor: Pensieri, S., Bozzano, R., Anagnostou, M. N., Anagnostou, E. N., Bechini, R., & Nystuen, J. A.

Publicado en: *2013 MTS/IEEE OCEANS-Bergen (pp. 1-10). IEEE.* Doi: 10.1109/OCEANS-Bergen.2013.6607995

Abstract:

Underwater ambient noise plays a fundamental role in the analysis of marine acoustics as well as of acoustical oceanography since it is an integral part of the marine environment and a key parameter for improving its sustainability and preserving the ecosystem. Furthermore, the detection and quantification of wind and rainfall events on a long-term basis from underwater sound measurements could greatly improve the knowledge of these atmospheric processes in open-ocean where environmental conditions limit our ability to obtain in-situ observations through surface buoys. This paper shows results on wind, rainfall and ship passages detection and the quantification of natural sound sources from a Passive Aquatic Listener (PAL) sensor deployed in the Ligurian Sea on the W1-M3A spar buoy. Validation of the estimates from the PAL data are provided by direct comparison with in-situ wind speed and precipitation measurements collected by the meteorological sensors onboard the buoy, hourly rainfall accumulations from a C-band weather radar, and ship traffic data in the Ligurian basin.

A Review and Inventory of Fixed Autonomous Recorders for Passive Acoustic Monitoring of Marine Mammals: 2013 State-of-the-industry

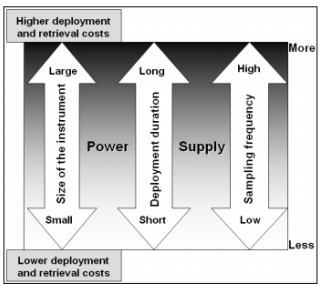


Figure 1. Schematic of the tradeoffs among power supply.

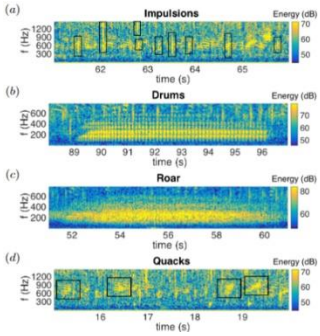
Autor: Sousa-Lima, R. S., Norris, T. F., Oswald, J. N., & Fernandes, D. P.

Publicado en: *2013 IEEE/OES Acoustics in Underwater Geosciences Symposium (pp. 1-9). IEEE.* Doi: 10.1109/RIOAcoustics.2013.6683984

Abstract:

Fixed autonomous acoustic recording devices(autonomous recorders [ARs]) are defined as any electronic recording system that acquires and stores acoustic data internally (i.e., without a cable or radio link to transmit data to a receiving station), is deployed semi-permanently underwater (via a mooring, buoy, or attached to the sea floor), and must be retrieved to access the data. More than 40 ARs were reviewed. They varied greatly in capabilities and costs, from small, hand-deployable units for detecting dolphin and porpoise clicks in shallow water to larger units that can be deployed in deep water and can record at high-frequency bandwidths for over a year. The capabilities and limitations of the systems reviewed herein are discussed in terms of their effectiveness in monitoring and studying marine mammals.

Automatic fish sounds classification



Autor: Malfante, M., Dalla Mura, M., Mars, J. I., & Gervaise, C.

Publicado en: 2016. *The Journal of the Acoustical Society of America, 139(4), 2115-2116.* Doi: 10.1121/1.5036628

Abstract:

The work presented in this paper focuses on the use of acoustic systems for passive acoustic monitoring of ocean vitality for fish populations. Specifically, it focuses on the use of acoustic systems for passive acoustic monitoring of ocean vitality for fish populations. To this end, various indicators can be used to monitor marine areas such as both the geographical and temporal evolution of fish populations. A discriminative model is built using supervised machine learning (random-forest and support-vector machines). Each acquisition is represented in a feature space, in which the patterns belonging to different semantic classes are as separable as possible. The set of features proposed for describing the acquisitions come from an extensive state of the art in various domains in which classification of acoustic signals is performed, including speech, music, and environmental acoustics. Furthermore, this study proposes to extract features from three representations of the data (time, frequency, and cepstral domains). The proposed classification

scheme is tested on real fish sounds recorded on several areas, and achieves 96.9% correct classification compared to 72.5% when using reference state of the art features as descriptors. The classification scheme is also validated on continuous underwater recordings, thereby illustrating that it can be used to both detect and classify fish sounds in operational scenarios.

Two-stage detection of north Atlantic right whale upcalls using local binary patterns and machine learning algorithms

Autor: Esfahanian, M., Erdol, N., Gerstein, E., & Zhuang, H.

Publicado en: 2017. *Applied Acoustics, 120, 158-166.* Doi: 10.1016/j.apacoust.2017.01.025

Abstract:

In this paper, we investigate the effectiveness of two-stage classification strategies in detecting north Atlantic right whale upcalls. Time-frequency measurements of data from passive acoustic monitoring devices are evaluated as images. Vocalization spectrograms are preprocessed for noise reduction and tone removal. First stage of the algorithm eliminates non-upcalls by an energy detection algorithm. In the second stage, two sets of features are extracted from the remaining signals using contour-based and texture-based methods. The former is based on-extraction of time-frequency features from upcall contours, and the latter employs a Local Binary Pattern operator to extract distinguishing texture features of the upcalls. Subsequently evaluation phase is carried out by using several classifiers to assess the effectiveness of both the contour-based and texture-based features for upcall detection. Comparing ROC curves of machine learning algorithms obtained from Cornell University's dataset reveals that LBP features improved performance accuracy up to 43% over time-frequency features. Classifiers such as the Linear Discriminant Analysis, Support Vector Machine, and TreeBagger achieve highest upcall detection rates with LBP features.

Integration of Underwater Radioactivity and Acoustic Sensors into an Open Sea Near Real-Time Multi-Parametric Observation System

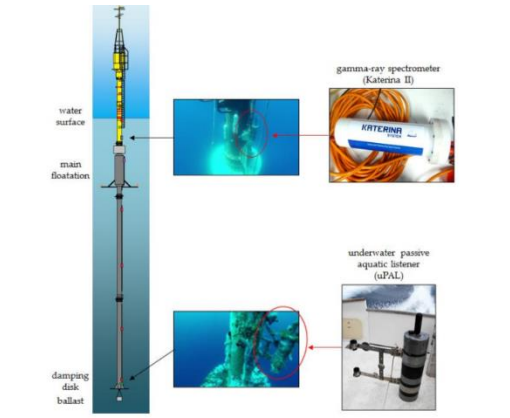


Figure 4. Sketch of the surface buoy of the W1-M3A observatory and images of the deployed sensors: the gamma-ray spectrometer at 6 m depth and the underwater passive aquatic listener close to the damping disk of the buoy at about 36 m depth.

Autor: Pensieri, S., Patiris, D., Alexakis, S., Anagnostou, M., Prospathopoulos, A., Tsabaris, C., & Bozzano, R.

Publicado en: *2018. Sensors, 18(8), 2737.* Doi: 0.3390/s18082737

Abstract:
This work deals with the installation of two smart in-situ sensors (for underwater radioactivity and underwater sound monitoring) on the Western 1-Mediterranean Moored Multisensor Array (W1-M3A) ocean observing system that is equipped with all appropriate modules for continuous, long-term and real-time operation. All necessary tasks for their integration are described such as, the upgrade of the sensors for interoperable and power-efficient operation, the conversion of data in homogeneous and standard format, the automated pre-process of the raw data, the real-time integration of data and metadata (related to data processing and calibration procedure) into the controller of the observing system, the test and debugging of the developed algorithms in the laboratory, and the obtained quality-controlled data. The integration allowed the transmission of the acquired data in near-real time along with a complete set of typical ocean and atmospheric parameters. Preliminary analysis of the data is presented, providing qualitative information during rainfall periods, and combine gamma-ray detection rates with passive acoustic data. The analysis exhibits a satisfactory identification of rainfall events by both sensors according to the estimates obtained by the rain gauge operating on the observatory and the remote observations collected by meteorological radars.

Smart embedded passive acoustic devices for real-time hydroacoustic surveys

Autor: Toma, D. M., Masmitja, I., del Río, J., Martinez, E., Artero-Delgado, C., Casale, A., ... & Memè, S.

Publicado en: 2018. *Measurement, 125, 592-605.* Doi: 10.1016/j.measurement.2018.05.030

Abstract:

This paper describes cost-efficient, innovative and interoperable ocean passive acoustics sensors systems, developed within the European FP7 project NeXOS (Next generation Low-Cost Multifunctional Web Enabled Ocean Sensor Systems Empowering Marine, Maritime and Fisheries Management) These passive acoustic sensors consist of two low power, innovative digital hydrophone systems with embedded processing of acoustic data, A1 and A2, enabling real-time measurement of the underwater soundscape. An important part of the effort is focused on achieving greater dynamic range and effortless integration on autonomous platforms, such as gliders and profilers. A1 is a small standalone, compact, low power, low consumption digital hydrophone with embedded pre-processing of acoustic data, suitable for mobile platforms with limited autonomy and communication capability. A2 consists of four A1 digital hydrophones with Ethernet interface and one master unit for data processing, enabling real-time measurement of underwater noise and soundscape sources. In this work the real-time acoustic processing algorithms implemented for A1 and A2 are described, including computational load evaluations of the algorithms. The results obtained from the real time test done with the A2 assembly at OBSEA observatory collected during the verification phase of the project are presented.

Adaptive whitening of ambient ocean noise with narrowband signal preservation

Autor: Hollmann, L. J., & Stevenson, R. L.

Publicado en: 2016. *The Journal of the Acoustical Society of America, 139(6), 3122-3133.* Doi: 10.1121/1.4953020

Abstract:

Passive underwater listening devices are often deployed to listen for narrowband signals of interest in time-varying background ocean noise. Such tonals are generated mechanically by ships, submarines, and machines, or acoustically by aquatic wildlife. Quantization of the sensor data for storage or low bit-rate transmission adds white noise which can overwhelm weak narrowband signals if the background noise is sufficiently colored. Whitening the background noise prior to quantization

can reduce the detrimental effects, but the whitening process must preserve any tonals in the signal for maximum effectiveness. Existing adaptive whitening techniques make no effort to avoid suppressing tonals in the whitening process, while existing spectral separation methods fail to whiten background noise. The proposed methods perform adaptive whitening of background ambient noise while preserving narrowband tones at their original signal-to-noise ratios. The proposed methods are shown to outperform combinations of existing partial solutions both subjectively and by evaluating the objective criteria introduced. The stability and convergence properties of the proposed algorithms match or surpass those of existing well-known adaptive algorithms.

A New Way for Underwater Acoustic Signal Analysis: The Morphological Filtering

Autor: Moreaud, U., Courmontagne, P., Chaillan, F., Mesquida, J. R., & Ouelha, S.

Publicado en: *OCEANS 2015-Genova (pp. 1-9). IEEE. Doi:* 10.1109/OCEANS-Genova.2015.7271406

Abstract:

This study presents an innovative way for underwater acoustic signal analysis. It is based on multi-directional filters implementation on time-frequency representation, where each filter is designed to enhance a given direction on the time-frequency plane. To do so, the proposed technique processes the time-frequency plane by taking into account the actual atom and its neighborhood for each direction, up to a given distance. Thus, such an approach emphases information about signal directional features into the time-frequency plane. Derivation of the technique relies first on the use of a recursive algorithm which estimates noise level. Then, after establishing filters responses for one direction, the design method is extended to all-direction, leading to the morphological filtering, which allows specific morphological feature patterns detection from the time-frequency plane. This paper finally presents experimentations on real underwater acoustic recordings to show performances obtained with this technique when objective is SNR enhancement and acoustic signature features preservation.

Energy efficient multi-objective evolutionary routing scheme for reliable data gathering in Internet of underwater acoustic sensor networks

Autor: Faheem, M., Ngadi, M. A., & Gungor, V. C.

Publicado en: 2019. *Ad Hoc Networks, 101912.* Doi: 10.1016/j.adhoc.2019.101912

Abstract:

Earth's surface is covered with two-thirds of water. The marine world covers the lakes, rivers and sea and is rich in natural resources largely unexplored by human beings. Recently, underwater wireless sensor network (UWSN) with the advancement in the Internet of underwater smart things has emerged as promising networking techniques to explore the mysteries of vastly unexplored ocean environments for several underwater applications. These applications include offshore exploration, pollution monitoring, disaster prevention, oceanographic data collection, offshore oil fields monitoring, tactical surveillance applications and several others. However, the underwater channel impairments caused by multipath effects, fading, bit errors, variable and high latency and low bandwidth severely limits the data transmission reliability for UWSNs-based applications. This results in poor quality-aware data gathering in UWSNs. Therefore, designing a quality of service (QoS)-aware data gathering protocol to monitor and explore oceans is challenging in the underwater environments. In this paper, we propose a bio-inspired multi-objective evolutionary routing protocol (called MERP) for UWSNs-based applications. The designed routing protocol exploits the features of the natural evolution of the multi-objective genetic algorithm in order to provide reliable and energy-aware information gathering in UWSNs. The extensive simulation results show that the developed protocol attains its defined goals compared to existing UWSNs-based routing protocols during monitoring and exploring underwater environments.

A Seabed Real-Time Sensing System for In-Situ Long-Term Multi-Parameter Observation Applications

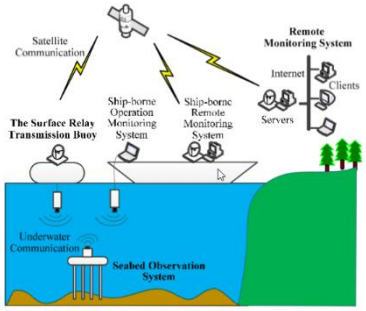


Figure 1. System structure of the seabed real-time sensing system for in-situ long-term multi-parameter observation applications (SRSS/ILMO).

Autor: Liu, L., Liao, Z., Chen, C., Chen, J., Niu, J., Jia, Y., ... & Liu, T.

Publicado en: 2019. *Sensors, 19(5), 1255.* Doi: 10.3390/s19051255

Abstract:

Aiming at the real-time observation requirements in marine science and ocean engineering, based on underwater acoustic communication and satellite communication technology, a seabed real-time sensing system for in-situ long-term multi-parameter observation applications (SRSS/ILMO) is proposed. It consists of a seabed observation system, a sea surface relay transmission buoy, and a remote monitoring system. The system communication link is implemented by underwater acoustic communication and satellite communication. The seabed observation system adopts the ARM + FPGA architecture to meet the low power consumption, scalability, and versatility design requirements. As a long-term unattended system, a two-stage anti-crash mechanism, an automatic system fault isolation design, dual-medium data storage, and improved Modbus protocol are adopted to meet the system reliability requirements. Through the remote monitoring system, users can configure the system working mode, sensor parameters and acquire observation data on demand. The seabed observation system can realize the observation of different fields by carrying different sensors such as those based on marine engineering geology, chemistry, biology, and environment. Carrying resistivity and pore pressure sensors, the SRSS/ILMO powered by seawater batteries was used for a seabed engineering geology observation. The preliminary test results based on harbor environment show the effectiveness of the developed system.

Building Novel VHF-Based Wireless Sensor Networks for the Internet of Marine Things

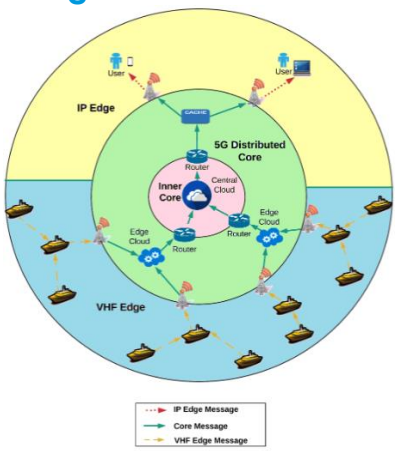


Fig. 1: The proposed IoMaT Cartography Network

Autor: Al-Zaidi, R., Woods, J. C., Al-Khalidi, M., & Hu, H.

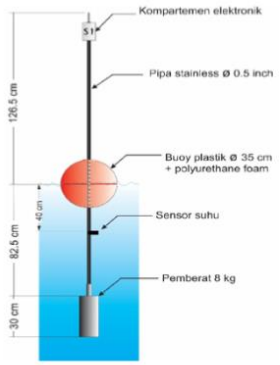
Publicado en: 2018. *IEEE Sensors Journal, 18(5), 2131-2144.* Doi: 10.1109/JSEN.2018.2791487

Abstract:

Traditional marine monitoring systems such as oceanographic and hydrographic research vessels use either wireless sensor networks with a limited coverage, or expensive satellite communication that is not suitable for small and mid-sized vessels. This paper proposes a novel Internet of Marine Things data acquisition and cartography system in the marine environment using Very High Frequency (VHF) available on the majority of ships. The proposed system is equipped with many sensors such as sea depth, temperature, wind speed and direction, and the collected data is sent to 5G edge cloudlets connected to sink/base station nodes on shore. The sensory data is ultimately aggregated at a central cloud on the internet to produce up to date cartography systems. Several observations and obstacles unique to the marine environment have been discussed and feed into the solutions presented. The impact of marine sparsity on the network is examined and a novel hybrid Mobile Ad-hoc/Delay Tolerant routing protocol is proposed to switch automatically between Mobile Ad-hoc Network and Delay Tolerant Network routing according to the network connectivity. The low rate data transmission offered by VHF radio has been investigated in terms of the network bottlenecks and the data collection rate achievable near the sinks. A data synchronization and transmission approach has also been proposed at the 5G network core using Information Centric Networks.

Wireless sensor networks buoy for coastal waters observation

Autor: Hidayat, R. R., Jaya, I., & Hestirianoto, T.



Gambar 2. Desain wahana *buoy* (Withamana, 2013).

Publicado en: 2016. *Jurnal Ilmu dan Teknologi Kelautan Tropis, 8(1), 175-185.* Doi: 0.29244/jitkt.v8i1.12714

Abstract:

The availability of data in real time and continuous is important to monitor in environmental change as early as possible. Wireless sensor networks (WSN) offer a new paradigm in the field of oceanography that can measure the parameters of complex marine environment using a moored buoy. This paper described design of a data transmission system with a moored buoy and tested the performance of WSN instrument based on ZigBee protocol radio module for monitoring coastal water environment in real time. Instruments were divided into two i.e., (1) five sensors served to measure sea surface temperature, stored the data, and transmitted the data to the base station, and (2) a coordinating instrument that placed on the bases station served to receive and record all measurement results of each sensor. The testing was done by deploying the instrument sensors in waters with depths of 2 to 5 meters and a coordinating instrument was located on the ground as a base station. Each instrument's sensor measure sea surface temperature, store, and transmit it to other nearby sensors and forward data to the next sensor and then to the next sensor send it to the base station. The Packet Delivery Ratio (PDR) value wa used as an indicator to determine the instrument performance and the values were from 89.69% up to 100% with transmission range up to 430 meter and battery endurance was up to 26 hours. The result showed that a buoy moored instrument based on WSN ZigBee radio module protocol has the potential for monitoring coastal water environment in a real time.

Hardware Design of Marine Buoy Data Communication Terminal Based on the 1st Generation Beidou Navigation Positioning System

Autor: Liu, Y., Xu, Y., Zhang, K., & Feng, Y.

Publicado en: 2019. *Journal of Coastal Research, 93(sp1), 639-645. Doi*: 10.2112/SI93-086.1

Abstract:

Aiming at the actual situation of marine buoy data monitoring and the problems of poor anti-interference performance, low fault tolerance coefficient and high energy consumption in current communication system, the hardware design of marine buoy data communication terminal based on the 1st generation Beidou navigation positioning system is proposed. Based on the marine buoy system, the overall structure of communication terminal is designed. The main components of the hardware are Beidou communication module and wireless network communication module, and the auxiliary parts are antenna and power supply module. The long-distance part uses the inherent data transmission mode of Beidou navigation system to communicate, while the short-range part uses the radio network communication protocol to complete the data transmission. There are two UART interfaces in the hardware, one is connected with the auxiliary cabin, which is responsible for receiving the related data of the auxiliary cabin, including azimuth, attitude and pressure sensing, and the other UART interface is connected with the Beidou communication module, which is responsible for receiving positioning and navigation data and transmitting remote data. The experimental results show that the design has high signal-to-noise ratio, strong fault-tolerant performance, high positioning accuracy and communication success rate, low energy consumption and perfect performance.

Low Power Wide Area Networks (LPWAN) at Sea: Performance Analysis of Offshore Data Transmission by Means of LoRaWAN Connectivity for Marine Monitoring Applications

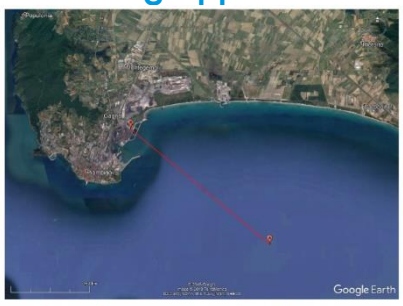


Figure 7. Map showing the positions of the end node, point A, and of the Gateways, point B along with the covered distance, red line.

Autor: Parri, L., Parrino, S., Peruzzi, G., & Pozzebon, A.

Publicado en: 2019. *Sensors, 19(14), 3239. Doi*: 10.3390/s19143239

Abstract:

In this paper the authors discuss the realization of a Long Range Wide Area Network (LoRaWAN) network infrastructure to be employed for monitoring activities

within the marine environment. In particular, transmission ranges as well as the assessment of parameters like Signal to Noise Ratio (SNR) and Received Signal Strength Indicator (RSSI) are analyzed in the specific context of an aquaculture industrial plant, setting up a transmission channel from an offshore monitoring structure provided with a LoRaWAN transmitter, to an ashore receiving device composed of two LoRaWAN Gateways. A theoretical analysis about the feasibility of the transmission is provided. The performances of the system are then measured with different network parameters (in particular the Spreading Factor-SF) as well as with two different heights for the transmitting antenna. Test results prove that efficient data transmission can be achieved at a distance of 8.33 km even using worst case network settings: this suggests the effectiveness of the system even in harsher environmental conditions, thus entailing a lower quality of the transmission channel, or for larger transmission ranges.

An underwater acoustic data compression method based on compressed sensing

Autor: Shi, Y., & Duan, R.

Publicado en: 2016. *Journal of Central South University, 23(8), 1981-1989.* Doi: 10.1007/s11771-016-3255-1

Abstract:

The use of underwater acoustic data has rapidly expanded with the application of multichannel, large-aperture underwater detection arrays. This study presents an underwater acoustic data compression method that is based on compressed sensing. Underwater acoustic signals are transformed into the sparse domain for data storage at a receiving terminal, and the improved orthogonal matching pursuit (IOMP) algorithm is used to reconstruct the original underwater acoustic signals at a data processing terminal. When an increase in sidelobe level occasionally causes a direction of arrival estimation error, the proposed compression method can achieve a 10 times stronger compression for narrowband signals and a 5 times stronger compression for wideband signals than the orthogonal matching pursuit (OMP) algorithm. The IOMP algorithm also reduces the computing time by about 20% more than the original OMP algorithm. The simulation and experimental results are discussed.

SEA-LABS: A wireless sensor network for sustained monitoring of coral reefs

Autor: Bromage, M., Obraczka, K., & Potts, D.

Publicado en: *International Conference on Research in Networking (pp. 1132-1135). Springer, Berlin, Heidelberg.* Doi: 10.1007/978-3-540-72606-7_97

Abstract:

This paper describes SEA-LABS (Sensor Exploration Apparatus utilizing Low-power Aquatic Broadcasting System), a low-cost, power-efficient Wireless Sensor Network (WSN) for sustained, real-time monitoring of shallow water coral reefs. The system is designed to operate in remote, hard-to-access areas of the world, which limits the ability to perform on-site data retrieval and periodic system maintenance (e.g., battery replacement/recharging). SEA-LABS thus provides a customized solution to shallow-water enviromnental monitoring addressing the trade-offs between power conservation and the system's functional requirements, namely data sensing and processing as well as real-time, wireless communication. We present SEA-LABS' architecture and its current implementation. Finally, we share our experience deploying SEA-LABS in the Monterey Bay.

Water ping: ICMP for the internet of underwater things

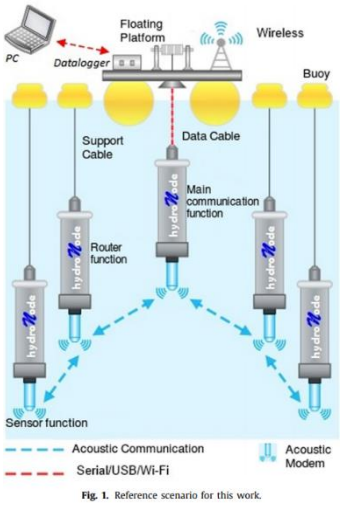


Fig. 1. Reference scenario for this work.

Autor: Lima, F. H., Vieira, L. F., Vieira, M. A., Vieira, A. B., & Nacif, J. A. M.

Publicado en: *2019. Computer Networks, 152, 54-63.* Doi: 10.1016/j.comnet.2019.01.009

Abstract:

High latency, low transmission rate and the presence of limited computational devices are characteristics present in scenarios of underwater communications. Despite the existence of concrete works on underwater wireless sensor networks (UWSNs), there is a gap in the interoperability of these networks and the traditional Internet networks. Indeed, communication solutions, routing algorithms and even data acquisition and

> analysis solutions are specifically designed to a given context or technology. In this work, we propose to turn this scenario into a ubiquitous scenario, similar to the Internet of Things, creating the Internet of Underwater Things (IoUT). More precisely, we present the Water Ping, a suppression proposal for ICMP and ICMPv6 protocol messages which will serve as a building block of the IoUT. The protocol we propose allows underwater devices to send/receive ping messages, which is one of the most widely know Internet application. Our results evidence that –now– underwater network devices can now be remotely effectively monitored through the Internet. Moreover, the suppression mechanism we propose can significantly reduce message sizes, which in turn lower the energy consumption by almost 94%

5.2 Patentes

En este apartado se realiza un análisis de patentes de boyas acústicas. El detalle de las patentes puede verse en el anexo I.

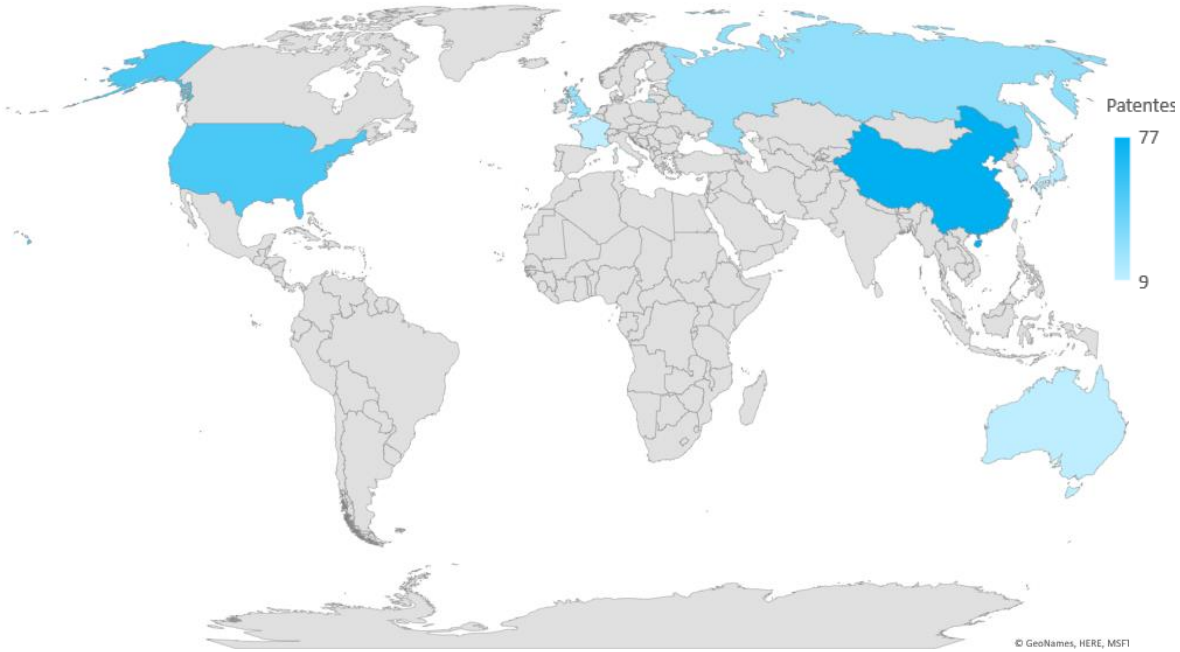


Ilustración 3. Distribución de patentes por oficinas nacionales

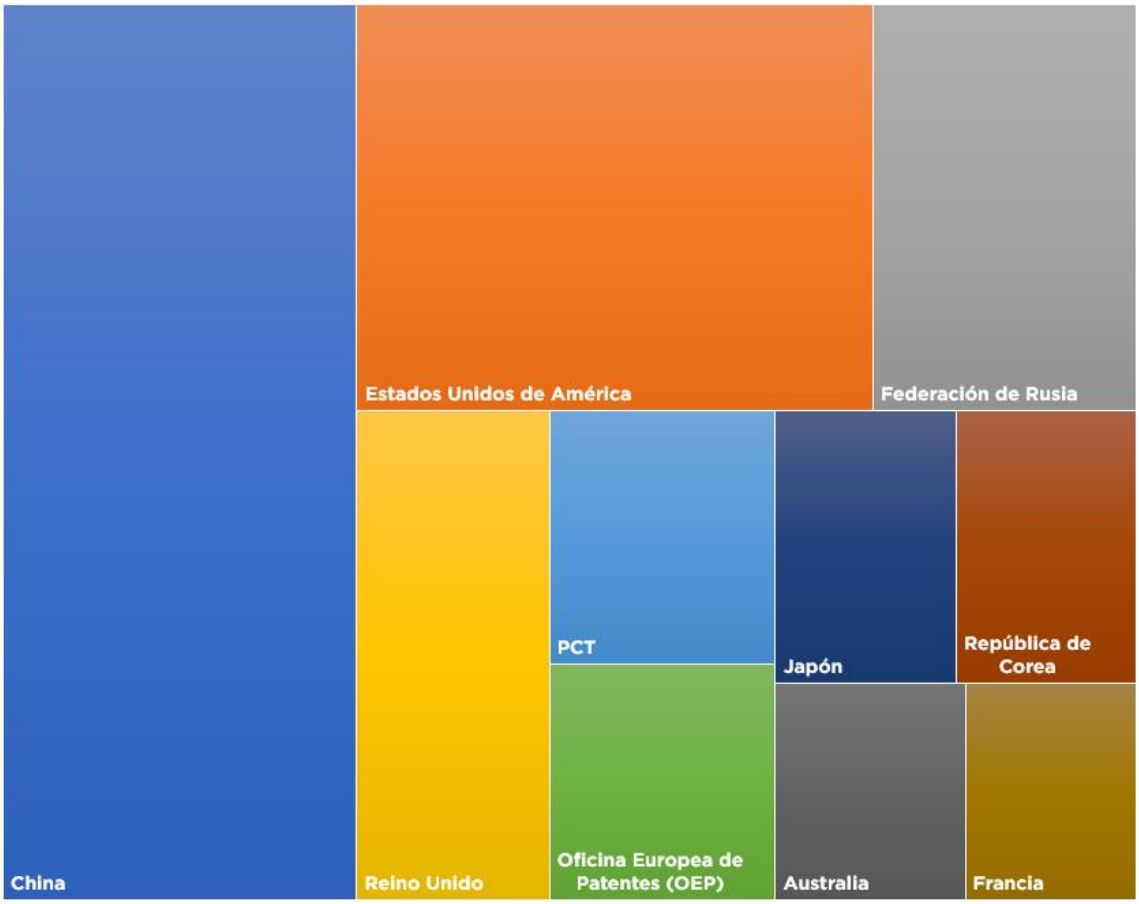


Ilustración 4. Distribución de patentes por oficinas

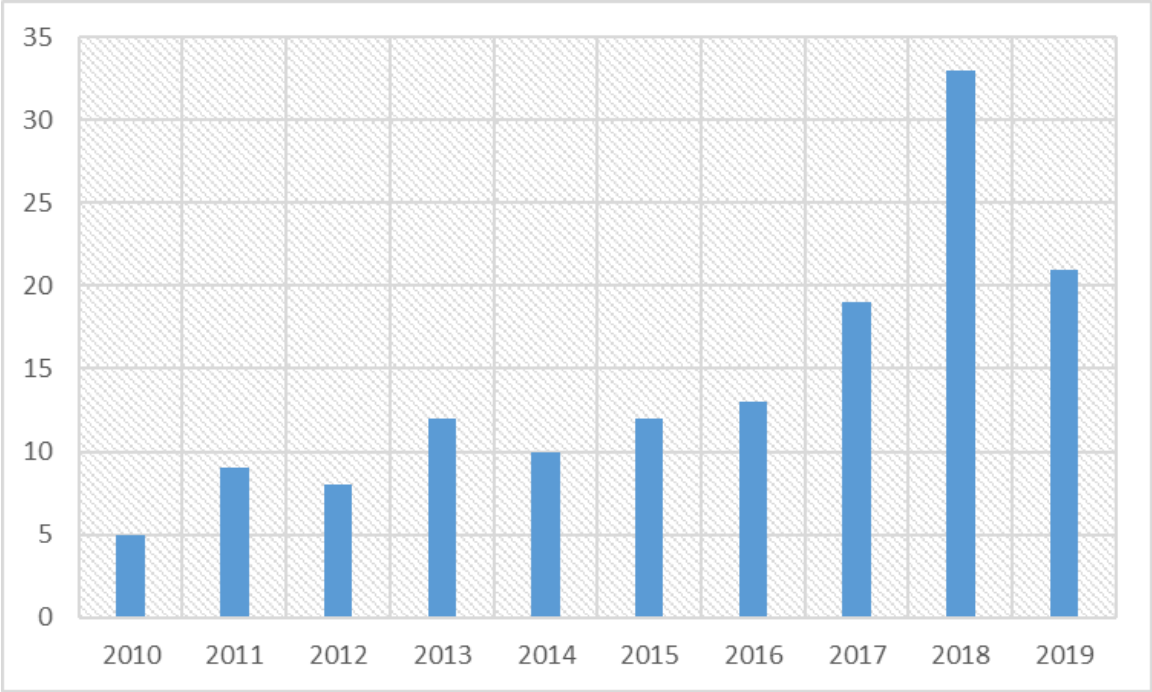


Ilustración 5. Distribución de patentes por años (a partir de 2010)

5.3 Proyectos

JONAS. Joint framework for ocean noise in the Atlantic seas

Financiado por: INTERREG ATLANTIC AREA

Periodo de financiación: 2019 –2021

+ INFO

Resumen:

Increasing human pressure on the ocean and impact on biodiversity are a major concern to policy makers, scientists and citizens. Blue growth is a major source of this: continuous and impulsive noise from shipping, offshore survey and construction, can adversely affect many marine species, threatening the oceanic environment.
JONAS addresses threats to biodiversity from underwater noise pollution on sensitive species in the North-East Atlantic by streamlining ocean noise monitoring and risk management on a transnational basis.
This project will develop and pilot a noise-monitoring platform, harmonize technical approaches to Marine Strategy Framework Directive and Maritime Spatial Planning requirements, and promote the adoption of quieter operational practices among users of the North-East Atlantic marine space.

Marine Acoustics: Marine Acoustics NERC Knowledge Exchange Innovation Placement

Financiado por: NERC

Periodo de financiación: 2018 –2019

+ INFO

Resumen:

The project involves the analysis of the passive acoustic monitoring (PAM) dataset collected by Marine Scotland Science at 10 locations along the Scottish east coast since 2013 (ECOMMAS project). These acoustic recordings provide insights into the underwater soundscape and reveal a variety of natural

(waves, rain, tidal-related sediment transport), biological (fish chorus, marine mammal vocalisations and sounds produced by crustaceans), as well as anthropogenic sounds (vessels, piling, sonar, seismic exploration).

The UK is required to monitor levels of ambient underwater noise, as it is identified by the EU as one of the Marine Strategy Framework Directive's (MSFD) Descriptors for 'Good Environmental Status'. Comprehensive baseline noise monitoring is essential to assess and mitigate impacts of noise producing activities on marine species. However, to date, such large-scale and long-term noise assessments are largely missing.

As such, the primary purpose of the secondment is the development of background noise reporting protocols through analysis of the ECOMMAS data. Additionally, a long-term integrated PAM network can provide valuable data on the occurrence and seasonality of whale, dolphin and porpoise species (collectively known as cetaceans). An increased understanding of their presence in Scottish waters will aid the assessment of the conservation status of populations, and the development of appropriate conservation measures. Furthermore, legally required environmental impact assessment for coastal developments need a better understanding of the year-round cetacean distribution and abundance. To this end, part of the ECOMMAS data will also be analysed for the presence of marine mammal vocalisations. Finally, transfer of required acoustic analysis skills to MSS staff will contribute to maintaining in-house expertise and capability to analyse broadband recordings for the presence of cetaceans and MSFD relevant ambient noise measures beyond the duration of the project.

COMPASS: Collaborative Oceanography and Monitoring for Protected Areas and Species

Financiado por: EU INTERREG VA Programme

Periodo de financiación: 2018 –2019

+ INFO

Resumen:

The COMPASS project will deliver a network of monitoring buoys across the regional seas of the Republic of Ireland, Northern

Ireland and West Scotland. It aims to develop our marine observational and data management capacity across the region.

It will integrate our network of new monitoring buoys to the existing European oceanographic monitoring stations. They will be equipped with the latest oceanographic sensors, acoustic recorders and advanced fish tracking technology.

This innovative project will build cross-border capacity for effective monitoring and management of Marine Protected Areas (MPAs).

COMPASS researchers will develop long-term monitoring strategies for highly mobile protected species such as marine mammals and salmonids. It will also provide essential infrastructure for baseline oceanographic and ambient noise monitoring.

This will help us deliver three truly regional scale environmental models, designed to support the management of a cross-border MPA network.

SYMBIOSIS: A Holistic Opto-Acoustic System for Monitoring Marine Biodiversities

Financiado por: H2020-EU.3.2.5.3. - Cross-cutting concepts and technologies enabling maritime growth

Periodo de financiación: 2017 –2020

+ INFO

Resumen:

We present the SYMBIOSIS project to provide a mature, cost effective autonomous optco-acoustic prototype for the characterization, classification, and biomass evaluation of six target pelagic fish that are important to the fishery industry and that reflect on the health of the environment. The processing will be made in a real-time fashion onsite, and the results will be sent to a shore station. The system will be completely autonomous and will withstand three month deployment without recharging. We will demonstrate the capabilities of the system and its

readiness to a TRL6 stage over three sea and ocean mooring sites.
SYMBIOSIS is devised as a blend of acoustic and optical components. The acoustic unit will include an active underwater acoustic array of 2X3 elements, to detect, classify, evaluate the biomass, and localize the predefined pelagic fish in the far field of 500m. The optical component will comprise of a fixed frame of six underwater optical cameras, and will perform machine learning-based classification and biomass evaluation in the near field of 2-3 attenuation lengths in low-light conditions. To conserve power the optical unit will be triggered upon detection from the acoustic unit, and will use the results from the acoustic localization. The system will be modular, both in term of performance and in terms of composition, and will adapt to different scenarios and cost requirements.
SYMBIOSIS will involve the university of Haifa, Israel (four groups); IMDEA Networks, Spain (two groups); Wireless and More, Italy; and EvoLogics, Germany. The academic partners have already developed all the technical components of the system, and have demonstrated preliminary results in multiple sea experiments. The industry partners have substantial experience with integrating acoustic and optical components for long-term sea development, and is a leading firm for the development of realtime underwater signal processing.

GRACE: Integrated oil spill response actions and environmental effects

Financiado por: H2020-EU.3.2. - SOCIETAL CHALLENGES - Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy.

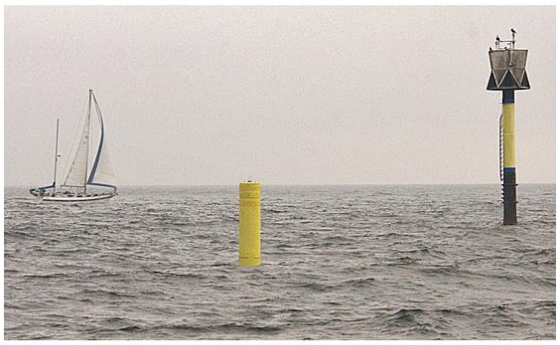
Periodo de financiación: 2016 –2019

+ INFO

Resumen:

For the first time, a smart buoy with an oil sensor is delivering data via satellite in open sea conditions in the Baltic Sea

Press release 2018-11-09 at 10:15



The yellow Smart Buoy is located south of Helsinki, but quite far out, facing the open sea, close to the main fairway to the south. © Photo: Joose Mykkänen

Objectives: 1) to improve the observation and predictions of oil spreading in the sea using novel on-line sensors on-board vessels, fixed structures or gliders, and smart data transfer into operational awareness systems; 2) to examine the true environmental impacts and benefits of a suite of marine oil spill response methods (mechanical collection in water and below ice, in situ burning, use of chemical dispersants, bioremediation, electro-kinetics, and combinations of these) in cold climate and ice-infested areas; 3) to assess the impacts on biota of naturally and chemically dispersed oil, in situ burning residues and non-collected oil using biomarker methods and to develop specific methods for the rapid detection of the effects of oil pollution; 4) to develop a strategic Net Environmental Benefit Analysis tool (sNEBA) for oil spill response strategy decision making.

A true trans-disciplinary consortium will carry out the project. Oil sensors will be applied to novel platforms such as ferry-boxes, smart buoys, and gliders. The environmental impacts of the oil spill response methods will be assessed by performing pilot tests and field experiments in the coastal waters of Greenland, as well as laboratory tests in Svalbard and the Baltic Sea with the main focus on dispersed oil, in situ burning residues and non-collected oil. The sNEBA tool will be developed to include and overarch the biological and technical knowledge obtained in the project, as well as integrate with operational assessments being based on expertise on coastal protection and shoreline response. This can be used in establishing cross-border and trans-boundary cooperation and agreements. The proposal addresses novel observation technology and integrated response methods at extreme cold temperatures and in ice. It also addresses the environmental impacts and includes a partner from Canada. The results are vital for the off-shore industry and will enhance the business of oil spill response services.

JOMOPANS: Joint Monitoring Programme for Ambient Noise North Sea

Financiado por: INTERREG NORTH SEA REGION

Periodo de financiación: 2015 –2020

+ INFO

Resumen:

The aim of this project is to develop a framework for a fully operational joint monitoring programme for ambient noise in the North Sea. Output will be the tools necessary for managers, planners and other stakeholders to incorporate the effects of ambient noise in their assessment of the environmental status of the North Sea, and to evaluate measures to improve the environment.

Sounds are omnipresent in the underwater environment and can be produced by natural (waves, weather, animals) and anthropogenic (shipping, construction) sources. International concern increasingly focusses on the potential negative effects of anthropogenic underwater noise on sensitive marine fauna. Sound sources, sound transmission, and the distributions of vulnerable species in the North Sea are all transnational questions which must be tackled transnationally, as specifically required by the Marine Strategy Framework Directive.

The project will deliver an innovative combination of modelling and high quality measurements at sea for an operational joint monitoring programme for ambient noise in the North Sea. The use of consistent measurement standards and interpretation tools will enable marine managers, planners and other stakeholders internationally to identify, for the first time, where noise may adversely affect the North Sea. Next, we will explore the effectiveness of various options for reducing these environmental impacts through coordinated management measures across the North Sea basin.

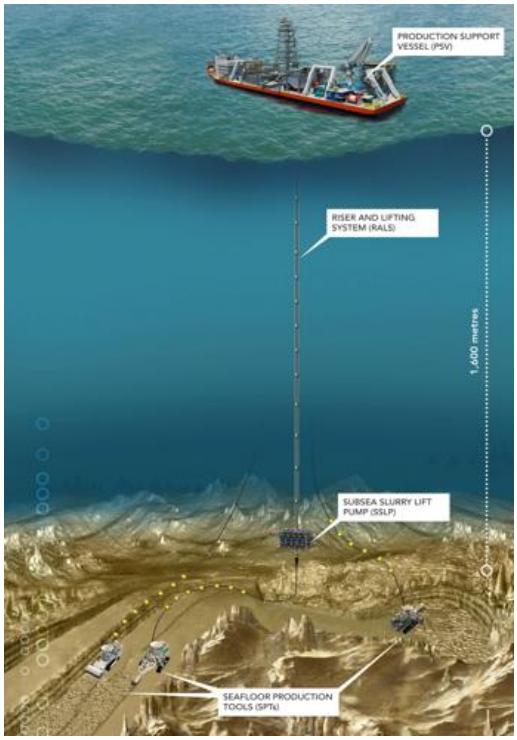
AtlantOS: Optimizing and Enhancing the Integrated Atlantic Ocean Observing System

Financiado por: H2020-EU.3.2. - SOCIETAL CHALLENGES - Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy.

Periodo de financiación: 2015 –2019

+ INFO

Resumen:



The overarching objective of AtlantOS is to achieve a transition from a loosely-coordinated set of existing ocean observing activities to a sustainable, efficient, and fit-for-purpose Integrated Atlantic Ocean Observing System (IAOOS), by defining requirements and systems design, improving the readiness of observing networks and data systems, and engaging stakeholders around the Atlantic; and leaving a legacy and strengthened contribution to the Global Ocean Observing System (GOOS) and the Global Earth Observation System of Systems (GEOSS). AtlantOS will fill existing in-situ observing system gaps and will ensure that data are readily accessible and useable. AtlantOS will demonstrate the utility of integrating in-situ and Earth observing satellite based observations towards informing a wide range of sectors using the Copernicus Marine Monitoring Services and the European Marine Observation and Data Network and connect them with similar activities around the Atlantic. AtlantOS will support activities to share, integrate and standardize in-situ observations, reduce the cost by network optimization and deployment of new technologies, and increase the competitiveness of European industries, and particularly of the small and medium enterprises of the marine sector. AtlantOS will promote innovation, documentation and exploitation of innovative observing systems. All AtlantOS work packages will strengthen the trans-Atlantic collaboration, through close interaction with partner institutions from Canada, United States, and the South Atlantic region. AtlantOS will develop a results-oriented dialogue with key stakeholders communities to enable a meaningful exchange between the products and services that IAOOS can deliver and the demands and needs of the stakeholder communities. Finally, AtlantOS will establish a structured dialogue with funding bodies, including the European

Commission, USA, Canada and other countries to ensure sustainability and adequate growth of IAOOS.

MITIGATION AND MONITORING

Financiado por: E&P SOUND & MARINE LIFE PROGRAMME

+ INFO

Resumen:

The JIP takes an active role in providing information to understand and reduce the risk of potential impacts of exploration and production sound on marine life.

The JIP has a research stream dedicated to developing monitoring and mitigation techniques, technologies and methods. For example the JIP continued the development of PAMGuard, a software system for detecting the presence of marine mammals near seismic operations. Such information enables operators to make informed decisions as whether or not to implement a mitigation action, such as to shut down a sound source to prevent any risk to marine mammals.

AREAS OF INTEREST:

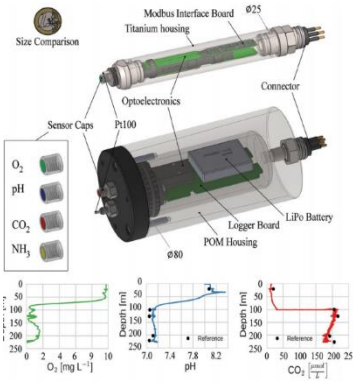
- Development of an active source for detecting whales in airgun safety zones.
- PAM: PAMGUARD III and IV software development and PAMGUARD industry field trial 2008.
- PAM software development for PAMGUARD.
- PAM: PAMGUARD maintenance and support 2008-13
- Integration and testing of an acoustic vector sensor into 3-d tracking PAM array to resolve left-right ambiguities.
- Collection and analysis of existing marine mammal observer (MMO) data.
- Density estimation for cetaceans from passive acoustic fixed sensors (DECAF).
- A review and inventory of fixed installation passive acoustic monitoring methods and technologies.

SENSEOCEAN: Marine sensors for the 21st Century

Financiado por: FP7-ENVIRONMENT - Specific Programme "Cooperation": Environment (including Climate Change)
Periodo de financiación: 2013 –2017

+ INFO

Resumen:



SenseOCEAN brings together the leading sensor developers from academia and industry across Europe to enable a quantum leap in worldwide in situ ocean biogeochemical sensor technology. It will produce fundamental innovations in analytical sciences fusing together new techniques for microfabrication, system integration, self calibration and cost-effective mass production. It will deliver a new product; an integrated multifunctional biogeochemical sensor package that is small and low-cost yet will be rugged and high performance. This product will have a major impact on the ability of EU SMEs and industry to compete in the growing market of environmental metrology and networked ecosystems. The product will measure with high precision and accuracy all of the following: the oceanic carbonate system, nutrients, the micronutrient iron, oxygen, nitrous oxide, trace metals (specifically the micronutrient iron) together with optically observed parameters including photosynthetically active radiation, particulate organic carbon, Chlorophyll a, primary production, coloured dissolved inorganic matter and transmission. As such it will quantify at scientifically relevant performance all of the major state variables in ocean biogeochemical processes. These will be observed with a new generation of sensors using lab on a chip, micro electrochemical, optode, and optical sensor technologies. Crucially the system will be small, integrated and suitable for mass production enabling it to be scaled and used on mass deployed platforms such as the profiling float array (Argo) and on many other platforms. To enable this we will develop modular interfaces. The product will be developed in line with state of the art data management practice, which we will continue to develop in collaboration with the international community. We will deliver a near real time and also a quality controlled archived data product with the outputs from our new sensor technology.

SOUNDMAR: Sound use for orientation by marine fauna, an ecosystem approach considering anthropogenic noise

Financiado por: FP7-PEOPLE

Periodo de financiación: 2010 –2013

+ INFO

Resumen:

Many marine animals use active and passive acoustics for a range of biological functions taking advantage of the low attenuation of sound in water and. Rising levels of acoustic pollution have the potential to impact negatively on groups of marine fauna, such as cetaceans, known to rely on sound to communicate and forage. There is novel and growing evidence for the use of ambient sound in orientation in other marine fauna at the base of the trophic net, particularly larval fish and crustacea searching for a settlement area. This project will extend research on the usage of passive acoustic orientation by marine fauna from different trophic levels in the marine ecosystem: fish/crustacean larvae and baleen whales. The potential negative impact of anthropogenic sound on acoustic orientation of these species will be explored as well as the possible top-down and bottom-up effects of noise in the marine ecosystem. Reference data on background noise levels in the oceans are scarce, limiting our ability to detect increases in noise levels and their potential effects in sensitive marine areas. Marine acoustic pollution is pervasive and may cross boundaries of protected areas. This project will monitor levels of broadband background noise in marine Nature 2000 sites and investigate whether the design of these sites is effective at protecting fauna from noise pollution. This multidisciplinary project involves the participartion of several international collaborators and will use state of the art technology including specialised underwater equipment for larval studies, suction-cup acoustic and orientation DTAGs to investigate whales and acoustic recording and dosimeters systems, DMONs, deployed from GPS-equipped drifting buoys, for sound field mapping of marine European Special Areas of Conservation in the Canary Islands. Results will have immediate application to EU policy on anthropogenic noise in the oceans, with implications for human fisheries and biological conservation.

5.4 Noticias

Training bats in the random forest with the confusion matrix

Publicado en: Hackaday

Fecha: 21/11/2019

When exploring the realm of Machine Learning, it's always nice to have some real and interesting data to work with. That's where the bats come in – they're fascinating animals that emit very particular ultrasonic calls that can be recorded and analysed with computer software to get a fairly good idea of what species they are. When analysed with an FFT spectogram, we can see the individual call shapes very clearly.....

Ver noticia

Asset Tracking Around the World

Publicado en: RFID Journal

Fecha: 17/11/2019

Thanks to the increased visibility provided by the Internet of Things, companies can more efficiently and cost-effectively monitor maintenance issues and the real-time status of their assets.....

Ver noticia

Listening to Nature: The Emerging Field of Bioacoustics

Publicado en: Yale Environment 360

Fecha: 05/11/2019

Researchers are increasingly placing microphones in forests and other ecosystems to monitor birds, insects, frogs, and other animals. As the technology advances and becomes less costly, proponents argue, bioacoustics is poised to become an important remote-sensing tool for conservation....

Ver noticia

Investigadores en Ingeniería Telemática desarrollan sistemas de monitorización con tecnología LoRa

Publicado en: Upct - Noticias

Fecha: 14/10/2019

Han diseñado dispositivos de sensorización de bajo coste con conexión a una infraestructura instalada en el CEDIT de la Politécnica que ofrece cobertura a todo el campo de Cartagena…

Ver noticia

Mic Drop. Researchers embed acoustic equipment in the Santa Barbara Channel to listen for whales

Publicado en: UC Santa Barbara Current

Fecha: 27/09/2019

…Members of the scientific collaboration recently dropped state-of-the-art acoustic monitoring equipment into the Santa Barbara Channel, which, when coupled with artificial intelligence, could signal the presence of these creatures in the heavily trafficked corridor. Once post-deployment adjustments are made and bugs fixed, the equipment will take data and measurements at regular intervals…

Ver noticia

Four ways Google is using AI to solve problems too complex for humans

Publicado en: 9News

Fecha: 21/07/2019

…To give the at-risk marine species a better chance for survival, Google has partnered with National Oceanic and Atmospheric Administration (NOAA) to create a solution.
The bio-acoustics project used 19 years worth of underwater audio data collected by NOAA to train Google's neural network to identify the call of a humpback whale.…

Ver noticia

How Many Manatees Are There? There's an Algorithm for That

Publicado en: Scientific American

Fecha: 01/01/2019

Biologists and computers scientists team up to create a census of animal populations.
Biologists trying to count endangered Antillean manatees in Costa Rica and Panama face a major challenge: the animals live in murky waters, making them virtually impossible to see…

Ver noticia

The Raven-X Software Package. A scalable high-performance computing framework in Matlab for the analysis of large bioacoustic sound archives.

Publicado en: Zenodo

Fecha: 19/04/2018

Raven-X is a software package designed for scalable high-performance computing. The software framework is written in Matlab and uses parallel-distributed computing for the analysis of large bioacoustic sound archives. This application contains various algorithms used for marine mammal sound detection. The various algorithms are available as sub-modules…

Ver noticia

6. Legislación y normativa

6.1 La Directiva Marco sobre la Estrategia Marina - MSFD

La Directiva Marco (Marine Strategy Framework Directive-MSFD) es el principal marco legislativo sobre el medio ambiente marino para todos los Estados Miembros de la Unión Europea. Se publicó en 2008 y tiene como principal objetivo que los mares y océanos alcancen o mantengan un Buen Estado Ambiental (BEA) para el año 2020.

La Directiva Marina es un marco de acción común para mantener la biodiversidad y preservar la diversidad y el dinamismo de unos océanos y mares que sean limpios, sanos y productivos, cuyo aprovechamiento sea sostenible. En ella se establecen once descriptores cualitativos para determinar el buen estado ambiental entre los que se encuentra el "Descriptor 11(D11)".

6.1.1. El descriptor 11

El Descriptor 11 se define como "La introducción de energía, incluido el ruido subacuático, se sitúa en niveles que no afectan de manera adversa al medio marino". Por su relevancia, en esta fase de implementación de la Directiva se le ha dado prioridad al ruido submarino frente a otras fuentes de energía.

Para abordar este descriptor la Decisión (UE) 2017/848 de la Comisión establece dos criterios resumidos en la siguiente tabla:

Elementos de los criterios	Criterios	Normas metodológicas
Sonido impulsivo antropogénico en el agua.	D11C1 — Primario: La distribución espacial, la extensión temporal y los niveles de las fuentes de sonido impulsivo antropogénico no superan los niveles que puedan afectar adversamente a las poblaciones de animales marinos. Los Estados miembros establecerán los valores umbral correspondientes a estos niveles mediante la cooperación al nivel de la Unión, atendiendo a las especificidades regionales o subregionales.	*Escala de evaluación* Región, subregión o subdivisiones. *Uso de los criterios:* La medida en que se haya logrado el buen estado medioambiental se expresará para cada zona evaluada de la siguiente forma: a) para el criterio D11C1, la duración por año civil de las fuentes de sonido impulsivo, su distribución a lo largo del año y espacialmente en el área de evaluación, y si se han alcanzado los valores umbral fijados; b) para el criterio D11C2, la media anual del nivel de sonido, u otra métrica temporal adecuada acordada al nivel regional o subregional, por unidad de superficie y su distribución espacial en el área de evaluación, así como la extensión (%, km2) del área de evaluación en la que se
Sonido continuo antropogénico de baja frecuencia en el agua	D11C2 — Primario: La distribución espacial, la extensión temporal y los niveles de sonido continuo antropogénico de baja frecuencia no superan los niveles que puedan afectar adversamente a las poblaciones de animales marinos.	

Elementos de los criterios	Criterios	Normas metodológicas
	Los Estados miembroshan superado los valores umbral establecerán los valores umbralfijados. correspondientes a estos nivelesEl uso de los criterios D11C1, D11C2 mediante la cooperación al nivelen la evaluación del buen estado de la Unión, atendiendo a lasmedioambiental en relación con el especificidades regionales odescriptor 11 deberá acordarse al subregionales.	nivel de la Unión. Los resultados de estos criterios contribuirán asimismo a las evaluaciones en el ámbito del descriptor 1.

Tabla 1. Especificaciones y métodos normalizados para el seguimiento y la evaluación

1. Para el seguimiento relativo al criterio D11C1:
   a. Resolución espacial: ubicaciones geográficas cuya forma y superficie deberán determinarse al nivel regional o subregional atendiendo, por ejemplo, a las actividades enumeradas en el anexo III de la Directiva 2008/56/CE.
   b. El sonido impulsivo descrito como nivel sonoro de la fuente de energía monopolar en unidades de dB re 1µPa (1) s, o como variación del nivel sonoro desde cero hasta el nivel máximo de la fuente monopolar en unidades de dB re 1µPa m, ambos por encima de la banda de frecuencias de 10 Hz a 10 kHz. Los Estados miembros podrán tener en cuenta otras fuentes específicas con bandas de frecuencias más elevadas si los efectos a larga distancia se consideran relevantes.

2. Para el seguimiento relativo al criterio D11C2: La media anual, u otra métrica adecuada acordada al nivel regional o subregional, de la presión sonora al cuadrado en cada una de dos bandas de tercio de octava, una centrada en 63 Hz y la otra en 125 Hz, expresadas como nivel sonoro en decibelios, en unidades de dB re 1µPa, con una resolución espacial adecuada en relación con la presión. Este valor se podrá medir directamente, o bien deducirse de un modelo utilizado para interpolar entre mediciones, o por extrapolación de las mediciones. Los Estados miembros podrán decidir, asimismo, al nivel regional o subregional, hacer un seguimiento de otras bandas de frecuencias.

6.1.2. Recomendaciones

MSFD: **Recomendaciones del TGNOISE** para campañas de medición:

- Part I - Executive Summary.
- Part II: Monitoring Guidance Specifications.
- Part III: Background Information and Annexes.

6.2 Normativa

A continuación se incluye un listado de los comités nacionales y homólogos internacionales identificados hasta hoy en el ámbito de las tecnologías que abarca este informe[23]:

6.3 CTN 116 Sistemas Industriales Automatizados

Comité español de normalización de los sistemas de automatización industrial e integración relacionados con la fabricación de componentes discretos, abarcando la aplicación de múltiples tecnologías, como por ejemplo: sistemas de información y control, máquinas y equipos y sus componentes.

Normalización en el ámbito de la fabricación aditiva (Additive Manufacturing) en relación con los procesos, términos y definiciones, sistemas de fabricación (materiales, hardware y software), procedimientos de ensayo, parámetros de calidad, contratos de servicio y cualquier otro tipo de fundamentos.

Con exclusión de: La seguridad eléctrica de los equipos y los componentes eléctricos y electrónicos.

6.3.1. Comités Internacionales.

- ISO/TC 184 Automation systems and integration
- CEN/TC 310 Advanced automation technologies and their applications

6.4 CTN 71/SC 6 Telecomunicaciones e Intercambio de Información entre Sistemas

Comité español de normalización en el ámbito de las telecomunicaciones que trata del intercambio de información entre sistemas abiertos, incluidas las funciones, los procedimientos y los parámetros del sistema, así como las condiciones para su utilización. Esta normalización abarca protocolos y servicios de capas inferiores, incluidos los físicos, de enlace de datos, de red y de transporte, así como los de capas superiores, incluidos, entre otros, Directory y ASN.1: MFAN, NFC, PLC, Future Networks y OID.

[23] Extraído de **Fuente especificada no válida.**

6.4.1. Comités Internacionales.

ISO/IEC JTC 1/SC 6 Telecommunications and information exchange between systems.

6.4.2. Normas publicadas.

- **ISO/IEC 21228:2019**. Information technology. Telecommunications and information exchange between systems. Coexistence mechanism for broadband powerline communication technologies.
- **Serie ISO/IEC 29181.** Information technology. Future networks. Problem statement and requirements.

6.5 CTN 71/SC 42 Inteligencia Artificial y Big Data

Este es un órgano nacional que está en proceso de creación. Su campo de actividad será la norrnalizaci6n en el campo de la Inteligencia Artificial y Big Data, además de:

- Servir de foco y proponente del programa de norrnalizaci6n intencional en todo lo relacionado con la inteligencia artificial, de forma que se tengan en cuenta l as prioridades nacionales.
- Proporcionar orientad6n a otros comités técnicos que desarrollen aplicaciones relacionadas con la inteligencia artificial.

6.5.1. Comités Internacionales.

- ISO/IEC JTC 1/SC 42 Artificial intelligence
- IEC SEG 10 Ethics in Autonomous and Artificial Intelligence Applications
- CEN/CENELEC Focus Group on Artificial Intelligence

6.5.2. Normas publicadas.

- **ISO/IEC 20546:2019**. Information technology. Big data. Overview and vocabulary.
- **ISO/IEC TR 20547-2:2018**. Information technology. Big data reference architecture. Part 2: Use cases and derived requirements.
- **ISO/IEC TR 2054 7 -5:2018.** Information technology. Big data reference architecture. Part 5: Standards roadmap.

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Anexo I. Patentes

Application Id	Application Date	Publication Number	Publication Date	Country	Title	Applicants
GB135688799	25.04.1977	1519577	02.08.1978	GB	ACOUSTIC BUOY	CIT ALCATEL
CN190134213	30.08.2016	106218816	14.12.2016	CN	Multifunctional marine acoustic buoy	TIANJIN TENYN OCEAN TECHNOLOGY DEVELOPMENT CO., LTD.
JP65673214	10.02.1997	10221430	21.08.1998	JP	MULTI-FREQUENCY ACOUSTIC BUOY	NEC CORP
CN231390366	11.02.2018	207889941	21.09.2018	CN	Underwater acoustic is release for buoy	BEIJING GREAT WALL ELECTRONIC EQUIPMENT CO., LTD.; 北京长城电子装备有限责任公司
CN202674922	18.05.2017	106965905	21.07.2017	CN	Marine acoustic surveying buoy system	NATIONAL OCEAN TECHNOLOGY CENTER; 国家海洋技术中心
US36991753	29.04.1977	4065821	03.01.1978	US	Acoustic buoy	Compagnie Industrielle des Telecommunications Cit-Alcatel
US73709325	30.09.2008	07924654	12.04.2011	US	System for beamforming acoustic buoy fields	The United States of America as represented by the Secretary of the Navy
CN250405506	14.03.2019	110081963	02.08.2019	CN	Mobile co-vibrating type vector detection underwater acoustic buoy	HARBIN ENGINEERING UNIVERSITY; 哈尔滨工程大学
WO2007001191	29.06.2006	WO/2007/001191	04.01.2007	WO	ACOUSTIC BUOY	ABYSSUS MARINE SERVICES AS; TJØM, Kyrre J.

Application Id	Application Date	Publication Number	Publication Date	Country	Title	Applicants
CN83540351	29.06.2006	101351380	21.01.2009	CN	Acoustic buoy	Abyssus Marine Services AS; 阿比苏斯海运服务公司
MX172867	07.01.2008	MX/a/2008/000021	21.07.2008	MX	BOYA ACUSTICA	ABYSSUS MARINE SERVICES AS
IN211439910	29.01.2008	817/DELNP/2008	04.07.2008	IN	ACOUSTIC BUOY	ABYSSUS MARINE SERVICES AS
CN225540278	29.05.2018	108414982	17.08.2018	CN	Communication buoy for underwater acoustic positioning and networking thereof	INSTITUTE OF ACOUSTICS, CHINESE ACADEMY OF SCIENCES; 中国科学院声学研究所
AU181385013	29.06.2006	2006262996	21.02.2008	AU	Acoustic buoy	Abyssus Marine Services AS
EP14898218	29.06.2006	1907275	09.04.2008	EP	AKUSTISCHE BOJE	ABYSSUS MARINE SERVICES AS
EA95412336	29.06.2006	200800158	30.06.2008	EA	ACOUSTIC BUOY	АБИССУС МАРИН СЕРВИСЕЗ АС null; ABYSSUS MARINE SERVICES AS null
CN242273315	25.01.2019	109720508	07.05.2019	CN	Compensating type transverse mooring very-low frequency vector acoustic horizontal submersible buoy	HARBIN ENGINEERING UNIVERSITY; 哈尔滨工程大学
CN145441281	03.04.2015	104764519	08.07.2015	CN	Submerged buoy type acoustic signal acquisition and storage system	UNIT 91388 OF PLA
CN224410223	31.12.2017	108298025	20.07.2018	CN	Automatic inflatable airbag device for underwater acoustic communication buoy	BEIJING GREAT WALL ELECTRONIC EQUIPMENT CO., LTD.; 北京长城电子装备有限责任公司
RU223811835	13.06.2017	0002659347	29.06.2018	RU	RADIO-ACOUSTIC BUOY ON MICROCONTROLLERS	
CN82978035	07.12.2004	1786733	14.06.2006	CN	System for automatic searching buoy and locating of submerged buoy	Inst. of Oceanology, CAS; 中国科学院海洋研究所

Application Id	Application Date	Publication Number	Publication Date	Country	Title	Applicants
CN220087844	30.01.2018	108116621	05.06.2018	CN	Marine acoustic real-time observation buoy system	NATIONAL OCEAN TECHNOLOGY CENTER; 国家海洋技术中心
FR186478933	10.10.1985	2588523	17.04.1987	FR	Improvements to energy generators which can be primed with sea water for acoustic buoy and acoustic buoy equipped with such a generator	FRANCE ETAT ARMEMENT
CN248608408	26.12.2017	109959914	02.07.2019	CN	Retractable buoy type acoustic array structure	750 TESTING GROUND OF CHINA SHIPBUILDING INDUSTRY CORPORATION; 中国船舶重工集团公司七五〇试验场
EP177121934	13.09.2011	3058872	24.08.2016	EP	SELBSTGETRIEBENE BOJE ZUR ÜBERWACHUNG VON UNTER WASSER BEFINDLICHEN OBJEKTEN	INCUBE LABS LLC
KR4138646	12.04.2007	100855298*	25.08.2008	KR	ACOUSTIC DOPPLER CURRENT PROFILER AND A METHOD OF COLLECTING THE SAME, ALLOWING A BUOY TO EMERGE ONLY AT POST-PROBING SITES	GEOSYSTEM RESEARCH CORPORATION
CN231927277	09.05.2018	108631885	09.10.2018	CN	Wireless real-time communication system and method of subsurface buoy	INSTITUTE OF ACOUSTICS, CHINESE ACADEMY OF SCIENCES; 中国科学院声学研究所
CN217878714	29.12.2017	108008145	08.05.2018	CN	Deep-sea subsurface buoy wireless real-time system	INSTITUTE OF OCEANOLOGY, CHINESE ACADEMY OF SCIENCES; 中国科学院海洋研究所
KR212582322	31.05.2017	1018277420000*	12.02.2018	KR	AUTONOMOUS SURFACE VEHICLE (ASV) FOR EXAMINATION OF	한국해양과학기술원

Application Id	Application Date	Publication Number	Publication Date	Country	Title	Applicants
					SHALLOW SEA HAVING MOVEMENT AND HORIZON MAINTAINING FUNCTION USING DRONE	
CN231375189	04.07.2018	108563176	21.09.2018	CN	Buoy microsystem for ocean exploration	HARBIN INSTITUTE OF TECHNOLOGY; 哈尔滨工业大学
US41215713	26.01.2004	20050162977	28.07.2005	US	Buoy-to-sailboat distance indicator system	Reifer Michael H.
JP23623489	05.07.2007	2009017241	22.01.2009	JP	HIGHLY FUNCTIONAL BUOY INCORPORATING GPS	JAPAN RADIO CO LTD; 日本無線株式会社
US37017349	01.10.1976	4081784	28.03.1978	US	Omnidirectional monitor buoy	The United States of America as represented by the Secretary of the Navy
RU29277018	19.05.1995	95108170	20.02.1997	RU	NEUTRAL BUOYANCY BUOY	Vojskovaja chast' 60130; Войсковая часть 60130
RU260702479	09.01.2019	0002703406	16.10.2019	RU	RADIO-HYDROACOUSTIC BUOY ON MICROCONTROLLER WITH ACOUSTIC UNDERWATER COMMUNICATION UNIT	
US40769187	21.01.2003	6711095	23.03.2004	US	Expenable/recoverable voice and data communications system buoy	The United States of America as represented by the Secretary of the Navy
DE102849303	07.12.1990	000004039031	11.06.1992	DE	Unterwasser-Schallboje	HONEYWELL ELAC NAUTIK GMBH
US36829121	09.01.1974	3889307	17.06.1975	US	REMOTE?CONTROLLED UNDERWATER BUOY	SCHLUMBERGER TECHNOLOGY CORPORATION
CN243473759	30.01.2019	109781382	21.05.2019	CN	Vector sensor-based cable subsurface buoy ocean internal wave monitoring system	HANGZHOU DIANZI UNIVERSITY; 杭州电子科技大学
CN83165571	01.12.2006	1971649	30.05.2007	CN	Positioning and communicating integral buoy	Harbin Engineering University; 哈尔滨工程大学

Application Id	Application Date	Publication Number	Publication Date	Country	Title	Applicants
JP67460790	15.05.2001	2002341007	27.11.2002	JP	WATER DEPTH AUTOMATIC SETTING TYPE ACOUSTIC MEASURING BUOY	NEC CORP; 日本電気株式会社; 東京都港区芝五丁目７番１号
US38373943	26.04.1993	5331602	19.07.1994	US	Acoustic navigation and diving information system and method	Hughes Aircraft Company
JP66173205	18.05.1998	11326501	26.11.1999	JP	UNDERWATER DEPTH MULTIPLE-STAGE ACOUSTIC MEASUREMENT BUOY	NEC CORP
FR187121740	21.07.1995	2947914	14.01.2011	FR	Wire guided torpedo combating method for boat, involves providing shape including zero directivity to radiation diagram of acoustic masking signal, and orienting zero directivity for reducing jamming of sonar of boat through buoy	THOMSON CSF
GB241260545	23.10.2017	2567584	17.04.2019	GB	A buoy assembly	POLARCUS DMCC; ERIK GODOY
GB137526129	02.08.2012	2493452	12.09.2012	GB	Method and system of a controllable tail buoy	PGS GEOPHYSICAL AS
CN97970474	11.09.2013	103466046	25.12.2013	CN	Anchoring-buoy-based vertical section current observing device	中国科学院海洋研究所
WO2018080314	23.10.2017	WO/2018/080314	03.05.2018	WO	A BUOY ASSEMBLY	POLARCUS DMCC; GODØY, Erik
AU181555375	13.09.2011	2011302166	18.04.2013	AU	Self-propelled buoy for monitoring underwater objects	Incube Labs, LLC
CN210849411	18.05.2017	206826877	02.01.2018	CN	Marine acoustics measurement buoy system	NATIONAL OCEAN TECHNOLOGY CENTER
WO2012037174	13.09.2011	WO/2012/037174	22.03.2012	WO	SELF-PROPELLED BUOY FOR MONITORING UNDERWATER OBJECTS	INCUBE LABS, LLC; IMRAN, Mir

Application Id	Application Date	Publication Number	Publication Date	Country	Title	Applicants
EP90214449	13.09.2011	2616317	24.07.2013	EP	SELBSTGETRIEBENE BOJE ZUR ÜBERWACHUNG VON UNTER WASSER BEFINDLICHEN OBJEKTEN	INCUBE LABS LLC
AU194142764	15.10.2015	2015243046	29.10.2015	AU	SELF-PROPELLED BUOY FOR MONITORING UNDERWATER OBJECTS	Incube Labs, LLC
AU205636505	05.10.2017	2017239545	26.10.2017	AU	SELF-PROPELLED BUOY FOR MONITORING UNDERWATER OBJECTS	InCube Labs, LLC
US154138306	15.07.2015	20160009347	14.01.2016	US	Self-propelled buoy for monitoring underwater objects	InCube Labs, LLC
JP65952465	21.10.1997	11125667	11.05.1999	JP	BUOY TYPE ACOUSTIC POSITION MEASURING DEVICE	TECH RES & DEV INST OF JAPAN DEF AGENCY; 防衛庁技術研究本部長; MITSUBISHI HEAVY IND LTD
CN178184203	21.04.2016	205554536	07.09.2016	CN	Intelligence life buoy	DING LI
US130176714	17.07.2014	20150003192	01.01.2015	US	Self-propelled buoy for monitoring underwater objects	InCube Labs, LLC
US73510488	13.09.2011	20120063262	15.03.2012	US	Self-propelled buoy for monitoring underwater objects	Imran Mir; InCube Labs, LLC
EP105638182	18.01.2013	2748647	02.07.2014	EP	AUF BOJEN BASIERENDES MEERESBEBENERFASSUNGSSYSTEM UND -VERFAHREN	CGG SERVICES SA
CN84740198	16.12.2010	102167136	31.08.2011	CN	Ocean lifting submerged buoy system	No. 710 Research Institute of China Shipbuilding Industry Corporation; 中国船舶重工集团公司第七一〇研究所
CN226077101	07.12.2017	207809689	04.09.2018	CN	Oceanographic buoy based on monitoring platform	NANTONG SEA AREA UTILIZATION DYNAMIC MONITORING CENTER (NANTONG OCEAN

Application Id	Application Date	Publication Number	Publication Date	Country	Title	Applicants
						INFORMATION CENTER, NANTONG SEA AREA RESERVE CENTER); **南通市海域使用**动态监管中心（南通市海洋信息中心、南通市海域储备中心）
WO2013107869	18.01.2013	WO/2013/107869	25.07.2013	WO	BUOY BASED MARINE SEISMIC SURVEY SYSTEM AND METHOD	CGG SERVICES SA
CN179524147	05.05.2016	105974363	28.09.2016	CN	Underwater enhanced positioning method based on acoustic measurement error correlation	HARBIN ENGINEERING UNIVERSITY; **哈**尔滨工程大**学**
RU233941057	12.02.2018	0002672830	19.11.2018	RU	NAVIGATION BUOY WITH COMPLEX ENERGY INSTALLATION	
EP105443747	07.08.2012	2744704	25.06.2014	EP	KOMMUNIKATIONSBOJE UND EINSATZVERFAHREN DAFÜR	ATLAS ELEKTRONIK UK LTD
AU194235371	07.08.2012	2012296711	06.03.2014	AU	Communication buoy and method of deployment	ATLAS ELEKTRONIK UK Ltd
US36770498	26.12.1973	3858166	31.12.1974	US	RECOVERABLE UNDERWATER ACOUSTIC BEACON	BRIDDELL, CHARLES D. D/B/A C.D.B. COMPANY
IN211623263	13.03.2014	540/KOLNP/2014	09.05.2014	IN	COMMUNICATION BUOY AND METHOD OF DEPLOYMENT	ATLAS ELEKTRONIK UK LTD
CA96778914		2845265	21.02.2013	CA	COMMUNICATION BUOY AND METHOD OF DEPLOYMENT	ATLAS ELEKTRONIK UK LTD
US37432738	11.02.1982	4486869	04.12.1984	US	Underwater acoustic devices	The Secretary of State for Defence in Her Britannic Majesty's Government of the United Kingdom of Gr
US90225338	08.01.2013	20130188451	25.07.2013	US	Buoy based marine seismic survey system and method	CGGVeritas Services SA

Application Id	Application Date	Publication Number	Publication Date	Country	Title	Applicants
US95991038	18.01.2013	20140056100	27.02.2014	US	Buoy based marine seismic survey system and method	CGG SERVICES SA
GB137505221	18.08.2011	2493912	05.10.2011	GB	Communication buoy with underwater deployment	ATLAS ELEKTRONIK UK LTD
WO2013024258	07.08.2012	WO/2013/024258	21.02.2013	WO	COMMUNICATION BUOY AND METHOD OF DEPLOYMENT	ATLAS ELEKTRONIK UK LTD; POINTER, Stephen; PURNELL, Daryl
CN199379881	23.01.2017	106828783	13.06.2017	CN	Buoyancy-driven intelligent self-lifting communication subsurface buoy system	INSTITUTE OF DEEP-SEA SCIENCE AND ENGINEERING, CHINESE ACADEMY OF SCIENCES; 中国科学院深海科学与工程研究所
GB135944114	22.02.1982	2094101	08.09.1982	GB	UNDERWATER ACOUSTIC DEVICES	SECR DEFENCE
CN214223092	02.11.2017	107817806	20.03.2018	CN	Horizontal route resolving method for AUV to autonomously get in butt joint with submerged buoy	NO.705 RESEARCH INSTITUTE OF CHINA SHIPBUILDING INDUSTRY CORPORATION; 中国船舶重工集团公司第七0五研究所
FR187447831	30.08.1983	2551020	01.03.1985	FR	Device for auto-releasable buoy	NEVEU ANDRE; SALAUN GERARD
KR192649985	09.07.2015	101686962*	15.12.2016	KR	MICRO BUOY ROBOT HAVING ATTITUDE CONTROL SYSTEM	동명대학교산학협력단
US38508547	11.10.1994	5452262	19.09.1995	US	Radio telemetry buoy for long-range communication	The United States of America as represented by the Secretary of the Navy
CN195383070	06.09.2016	206087244	12.04.2017	CN	Equipment of searching for aning rescue under water based on underwater acoustic	NANJING UNIVERSITY OF INFORMATION SCIENCE & TECHNOLOGY
CN238918914	26.11.2018	109367705	22.02.2019	CN	Quasi-real-time communication subsurface buoy for seasonal ice zone of polar region	THE FIRST INSTITUTE OF OCEANOGRAPHY; 国家海洋局第一海洋研究所

Application Id	Application Date	Publication Number	Publication Date	Country	Title	Applicants
CN225103145	29.12.2017	207717803	10.08.2018	CN	Real time implementation system that deep sea subsurface buoy is wireless	INSTITUTE OF OCEANOLOGY, CHINESE ACADEMY OF SCIENCES; 中国科学院海洋研究所
CN205200835	06.07.2017	107187549	22.09.2017	CN	Whole-bottom-material bottom-resting seabed submarine buoy and measuring system thereof	GUANGZHOU MARINE GEOLOGICAL SURVEY
RU223812339	26.09.2017	0002660174	05.07.2018	RU	ACOUSTIC DEVICE	
CN212984641	06.07.2017	207000763	13.02.2018	CN	End formula seabed subsurface buoy is sat to full substrate and measurement system thereof	GUANGZHOU MARINE GEOLOGICAL SURVEY
CN223874215	30.10.2017	207580095	06.07.2018	CN	Real time implementation surface of water buoy system that deep sea subsurface buoy is wireless	INSTITUTE OF OCEANOLOGY, CHINESE ACADEMY OF SCIENCES; 中国科学院海洋研究所
FR187915383	26.06.1975	2315434	21.01.1977	FR	Impact release mechanism for acoustic buoy dropped by parachute - has pin spring biased in sleeve with retainer balls knocked into grooves	CIT ALCATEL
CN212143574	30.10.2017	107651118	02.02.2018	CN	Deep sea subsurface buoy wireless real-time water surface buoy system and implementation method thereof	INSTITUTE OF OCEANOLOGY, CHINESE ACADEMY OF SCIENCES
IN211589697	24.10.2011	3649/CHE/2011	14.06.2013	IN	SYSTEM AND METHOD FOR ACOUSTIC TRACKING AND IDENTIFICATION OF NOISE SOURCES IN A WATER BODY	COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
RU75732389	07.06.2010	0002424151	20.07.2011	RU	HYDRO ACOUSTIC MEASUREMENT HARDWARE COMPLEX CARRIER	

Application Id	Application Date	Publication Number	Publication Date	Country	Title	Applicants
CN84079736	09.04.2010	101888266	17.11.2010	CN	Radio communication method of distributed acoustic positioning system	Harbin Engineering University; 哈尔滨工程大学
FR188444062	26.06.1975	2315428	21.01.1977	FR	Listening buoy launched from aircraft - has float and sinker connected by cable, and releasable casing	CIT ALCATEL
JP22651395	11.03.2005	2006250830	21.09.2006	JP	AZIMUTH MEASURING METHOD AND SYSTEM, AND UNDERWATER ACOUSTIC MEASURING BUOY	日本電気株式会社
CN177633515	07.06.2016	105911552	31.08.2016	CN	Anti-submarine sonar buoy based on Big Dipper short message function	Southeast University
US39466582	12.06.2000	6254445	03.07.2001	US	Inflatable chemical foam injected buoy	The United States of America as represented by the Secretary of the Navy
CN196117022	09.11.2016	106568496	19.04.2017	CN	Real-time transmission multivariate vector hydrophone array subsurface buoy system	HARBIN ENGINEERING UNIVERSITY
US40914574	18.03.2004	20050206560	22.09.2005	US	Integrated maritime portable acoustic scoring and simulator control and improvements	The United States of America as represented by the Secretary of the Navy
RU29501094	25.07.2007	02344962	27.01.2009	RU	SELF-CONTAINED NEAR-BOTTOM BUOY STATION	

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