

MSFD Common Implementation Strategy

Technical Group on Underwater Noise

TG-NOISE

**Providing research and scientific support to the
implementation of the Marine Strategy Framework Directive**

**Management and monitoring
of underwater noise in European Seas**

**Overview of main European-funded projects
and other relevant initiatives**

3rd Communication Report

March 2022

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1. Introduction & background

1.1 The Marine Strategy Framework Directive (MSFD) and the Technical Group on underwater noise (TG Noise)

The Marine Strategy Framework Directive (MSFD, 2008/56/EC) requires European Member States (MS) to develop marine strategies to achieve or maintain 'good environmental status' of EU marine waters by 2020. The Directive defines good environmental status (GES) as *"the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive"* (Article 3-5). GES means that the various uses of the marine resources are made at a sustainable level, ensuring their preservation for future generations.

The Marine Directive contains 5 main elements: the initial assessment, determination of good environmental status, establishment of environmental targets, monitoring programme (enabling the state of the marine waters concerned to be assessed on a regular basis) and the programme of measures to maintain and/or improve environmental status.

For determining good environmental status, 11 qualitative descriptors were defined, with descriptor 11 focusing on introduction of energy, including underwater noise. Underwater noise was formally defined as a pollutant in art 3(8) of the Directive. Member States are required to work together at European and regional levels to ensure a coherent implementation of the Directive.

To define and set up good environmental status, Member States are required to work with criteria and methodological standards for each descriptor in their marine strategies. In this regard, Commission Decision 2010/477/EU¹, adopted in accordance with MSFD Article 9(3), provided criteria and methodological standards to ensure consistency in the determinations of GES, and to allow for comparison between marine regions or subregions of the extent to which GES is being achieved. The 2010 Commission Decision was reviewed, and a new Commission Decision (EU)2017/848² was published in 2017, following the Commission's assessment of the marine strategies' first elements, as reported by Member States.

In the 2017 Decision, for Descriptor 11 two criteria are defined:

- The first criterion (D11C1) concerns anthropogenic impulsive sound in water and is described as follows:
"The spatial distribution, temporal extent and levels of anthropogenic impulsive sound sources do not exceed levels that adversely affect population of marine animals".
- The second criterion (D11C2) concerns anthropogenic continuous low-frequency sound in water

¹ 2010/477/EU: Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (notified under document C(2010) 5956)

² Commission Decision (EU) 2017/848 of 17 May 2017 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment and repealing Decision 2010/477/EU.

and is described as follows:

“The spatial distribution, temporal extent and levels of anthropogenic continuous low-frequency sound sources do not exceed levels that adversely affect population of marine animals”.

In both cases, Member States shall establish threshold values for these levels through cooperation at Union level, taking into account regional or subregional specificities.

In order to steer this work and advise EU Member States on the operational implementation of descriptor 11, a technical group on underwater noise ("TG Noise") was set up in 2010 to contribute to a harmonised implementation of the MSFD. It consists of nationally-nominated experts with experience in different regions and relevant scientific expertise. Back in 2010, the anthropogenic underwater sound was an emerging topic, and little was known about the levels and effects of underwater sound, and advice was needed to develop monitoring of underwater noise descriptors, as defined in the 2010 Commission Decision. In particular, proposals for methodological standards for monitoring both types of underwater noise were needed. The technical group could also provide a common platform on how to develop objectives (characteristics of GES), environmental targets, and associated indicators. Such work included the adoption of a monitoring guidance for underwater noise in the European Seas³ and the development of registers of loud impulsive noise and of a joint monitoring programme for continuous noise. Consequently, significant progress has been made in this field during the first cycle of implementation of MSFD

Since 2017 and the adoption of Commission Decision 2017/848, TG Noise is focussing on the development of thresholds in relation to the indicators developed in the framework of the MSFD. In this regard, two guidance's providing assessment frameworks for the definition of EU threshold values for impulsive and continuous noise have been adopted. Work is also ongoing to define options for such values, in line with the objectives set by the Zero Pollution Action Plan⁴ of the European Commission, under the European Green Deal.

³ Dekeling R.P.A., Tasker M.L., Van der Graaf A.J., Ainslie M.A., Andersson M.H., André M., Borsani J.F., Breusing K., Castellote M., Cronin D., Dalen J., Folegot T., Leaper R., Pajala J., Redman P., Robinson S.P., Sigray P., Sutton G., Thomsen F., Werner S., Wittekind D., Young J.V.: Monitoring Guidance for Underwater Noise in European Seas, Part II: Monitoring Guidance Specifications. JRC Scientific and Policy Report EUR 26557 EN, Publications Office of the European Union, Luxembourg,), doi: 10.2788/27158, 2014b. <http://mcc.jrc.ec.europa.eu/documents/201406241443.pdf>

⁴ EUR-Lex - 52021DC0400 - EN - EUR-Lex (europa.eu)

1.2 Monitoring of underwater sound

Sound or Noise?

In this communication report the term “noise” is used when discussing sound that has the potential to cause negative impacts on marine life.

The more neutral term “sound” is used to refer to the acoustic energy radiated from a vibrating object, with no particular reference for its function or potential effect.

“Sounds” include both meaningful signals and “noise” which may have either no particular impact or may have a range of adverse effects.

Ambient noise, continuous sound

At the time the Commission Decision of 2010 was written, the international discussion on terminology to be used to describe underwater sound was not well-developed. By now, there is an ISO standard to describe terminology (ISO 18405:2017(E)); the Commission Decision therefore uses the term continuous sound and no longer terms like ambient noise, to be consistent with the ISO standard.

Impulsive Sound

Regarding high intensity, low and mid-frequency impulsive sounds, monitoring is being done in the form of a register of activities that generate such sounds. As most of these activities are regulated in some form, much of the information on the sound sources is available with regulators or parties responsible for generating sounds. The register will also bring together the information of all these (national) sources of information. Seismic surveys, pile-driving, explosives, sonars working at relevant frequencies and some acoustic deterrent devices are the most important sound-sources to be considered for inclusion in the register. In the Baltic Sea and North-East Atlantic Ocean regions, a joint register for impulsive sound is now available and hosted at the International Council for the Exploration of the Sea (ICES). In the Mediterranean and Black Seas, efforts are also being made to establish a register for impulsive sound.

Continuous Sound

Before the MSFD required EU Member States to address underwater noise, sound levels in European marine waters and their impact on the ecosystem were not monitored. As a consequence, historical levels and trends are not known. Continuous sound is caused by both natural and anthropogenic sources. The most ubiquitous source of anthropogenic continuous sound is commercial shipping, but in some regions seismic surveys can be a notable contributor too. In areas of intensive human activity, these anthropogenic sound sources tend to dominate natural sound sources at the low frequencies. At higher frequencies, natural sounds tend to dominate. In the 2014 Monitoring Guidance TG Noise advised MS to work together in a sub-region to set up monitoring. This report describes how, in sub-regional monitoring, continuous sound has now started in joint monitoring programmes from the onset, as well as new project initiatives being developed at a regional or sub-regional scale.

1.3 The role of Regional Sea Conventions and ICES

Regional Seas Conventions (RSCs) have an important role in the Common Implementation Strategy (CIS) of the Marine Strategy Framework Directive. The directive requires EU MS to coordinate their actions on marine waters, in these regions and sub-regions, using relevant mechanisms and structures of Regional Sea Conventions, as well as other relevant international forums (Article 6 of MSFD). Making use of the experience and existing cooperation in coordinated monitoring, RSCs have played an essential role in developing joint monitoring programmes.

In the Baltic Sea, the **HELCOM Expert Group on Underwater Noise (HELCOM EG Noise, former HELCOM EN-Noise)** supports HELCOM countries in the development of a monitoring and impact assessment strategy, regarding underwater noise. Progress, built on BIAS project results as well as on other experiences, has advanced in agreeing common indicators and associated monitoring. Furthermore, the [regional monitoring sub-programme on continuous noise](#) was approved in 2018 (Outcome of HOD 54-2018, para. 4.11). In 2021, in order to implement commitments of the 2018 Ministerial Declaration related to underwater noise, the HELCOM Regional Action Plan on Underwater Noise was adopted as [HELCOM Recommendation 42-43/1](#), aiming, in the long-term, at addressing adverse effects of underwater noise on marine species identified as sensitive to noise, whilst safeguarding the potential of the Baltic Sea for sustainable human activities. The Action Plan is to be considered as the main tool to achieve the [2021 BSAP](#) objectives in connection to underwater noise: “no or minimal harm to marine life from man-made noise” (ecological objective) and “minimize noise to levels that do not adversely affect marine life” (management objective).

In the North East Atlantic, the **Intersessional Correspondence Group on Underwater Noise (ICG-Noise) working group** co-ordinates the activities of the OSPAR Contracting Parties on underwater noise. It is evaluating present pressure indicators for impulsive and continuous noise and is working on risk-of-impact indicators. OSPAR is building on the experience of the Joint Assessment and Monitoring Programme to further cover MSFD requirements. An assessment on noise has been prepared for the OSPAR Quality Status Report, to be published in 2023. Starting in 2022 the OSPAR ICG Noise will also be working on a Regional Action Plan on noise, in line with the objectives set by the [OSPAR North-East Atlantic Environment Strategy for 2030](#)⁵.

The HELCOM and OSPAR work on impulsive sound monitoring has led to a single, combined register for impulsive sound, available at the **International Council for the Exploration of the Sea (ICES)**. A combined database for continuous noise measurement data is being prepared.

⁵ Strategic objective 8 aims at reducing anthropogenic underwater noise to levels that do not adversely affect the marine environment. Operational objectives S8.O1 and S8.O2 plan the adoption of a regional action plan on underwater noise by 2025 and the development and implementation of a coordinated monitoring and modelling programme for continuous sound to support an assessment of anthropogenic underwater noise in the OSPAR maritime area.

In the Mediterranean and Black Seas, the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS) is taking forward work on underwater noise (D11) on behalf of the Convention for Protection of the Mediterranean Sea against Pollution (Barcelona Convention), and the Convention on the Protection of the Black Sea Against Pollution. In order to enhance cooperation among EU and non-EU Member States, a strong collaboration with all relevant organisations of the area is developed. [Guidelines](#) adopted by Parties, address the impact of anthropogenic noise on cetaceans in the Agreement Area, providing both general standards and noise-source specific ones. **The ACCOBAMS Joint ACCOBAMS/ASCOBANS/CMS Working Group on Noise (JNWG)** is supporting the development of the Mediterranean Strategy on Underwater Noise monitoring. It has recently prepared guidance for D11 in the framework of the UNEP/MAP EcAp initiative. The JNWG is also regularly involved in the update of an [ACCOBAMS methodological guide](#): Guidance on underwater noise mitigation measures. Moreover, the revision of impulsive noise hotspots maps in ACCOBAMS area, using the online ACCOBAMS Platform, is currently ongoing in order to identify areas of potential conflict with cetacean conservation.

TG Noise reports regularly on update on regional initiatives to ensure progress in consistency and coherence between approaches of the European legislation & Regional Seas Conventions.

2. Underwater Noise: Key Projects and Initiatives

This report presents a selection of key projects and initiatives and their relevant results, for the implementation of Descriptor 11 – introduction of energy, including underwater noise (criteria D11C1: impulsive sound sources and 11C2 – continuous low-frequency sound, respectively). It builds upon the previous compilations of 2017 and 2020, providing new information and updates regarding the main European-funded projects and other relevant initiatives since then. It thus aims to be useful to experts, policy makers, and those supporting Member States authorities in implementing the MSFD, in particular, for measures regarding underwater sound.

2.1 Completed Projects & Initiatives in European Seas

BIAS - Baltic Sea Information on the Acoustic Soundscape

Funding origin	EU LIFE+ Collaborative project
Lead organization	Swedish Defence Research Agency (Sweden)
Duration	2013 – 2016

The BIAS project was the first effort in EU waters to conduct a joint, large scale (basin wide), standardised monitoring project to measure underwater sound across national borders, with the purpose of establishing an continuous sound baseline.

BIAS focused exclusively on the monitoring of continuous low frequency sound (continuous noise). The project aimed at establishing a regional implementation plan for this sound category, with regional standards, methodologies, and tools allowing for cross-border handling of acoustic data and the associated results.

The Baltic Sea is a semi-enclosed sea bordered by nine states. It consists of 8 sub-catchment areas (basins) and numerous harbours. The density of shipping traffic in some parts of the Baltic are some of the highest in Europe. Estimates suggest that about 2000 sizeable vessels are at sea at any one time.

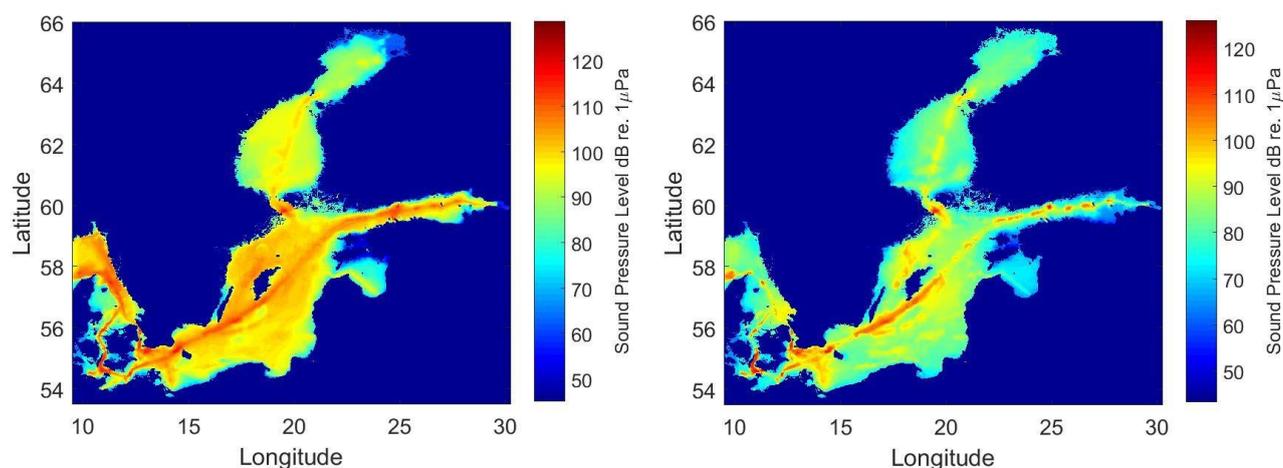
The regional approach of BIAS was important for several reasons. First, the MSFD specified a series of actions, such as monitoring and modelling of the average noise level to be carried out within the spatial division of marine regions or subregions, with the Baltic Sea constituting one of these (MSFD Article 6). Conditions, problems and needs vary between marine regions; therefore, each requires region-specific solutions. The transboundary nature of the marine environment calls for cooperation both at EU and regional levels. Underwater sound itself has a transboundary nature, especially low frequency sound that can propagate across the entire Baltic Sea. Furthermore, there are likely economic benefits from co-ordinated regional monitoring and assessment of underwater sound, as compared with the alternative of individual national approaches.

The objectives of BIAS were formulated to create the foundation for efficient joint management of underwater sound in the Baltic Sea, by elucidating and solving, the major challenges of continuous sound monitoring. During its lifetime, BIAS cooperated closely with TG NOISE.

Thereby, the work conducted within the project was based on the TG Noise monitoring guidance and specifications, which were adjusted and further developed, based on practical experience gained

through their application in the Baltic Sea region. Although the project focused on the Baltic Sea region, its outcomes are also relevant for other marine regions of the EU.

Further, the BIAS project ran a field programme in 2014, where autonomous hydrophones were deployed at 36 locations offshore throughout the Baltic Sea. The sensors were serviced every third month for maintenance and data recovery before being redeployed. The data have been used to establish monthly statistical sound levels in terms of sound pressure levels as well as to “calibrate” a numerical model for sound in the Baltic Sea. Soundscape maps were produced for the entire Baltic Sea. Monthly maps for the third octave frequency bands 63, 125 and 2000 Hz were produced for three depth intervals and for different percentiles, see figure 1 for examples of soundscape maps from the project.



Soundscape maps of the monthly average sound pressure level during 2014, February (left) and August (right), for the 1/3 octave band 125 Hz, estimated over the whole water column. Colour-codes denotes the decibel level in each geographical position. These sound levels occurs 25 percent of the time or more. Blue-turquoise colour shows the natural continuous sound levels in the water about 60 to 90 dB re 1 μ Pa and orange-red about 100 dB re 1 μ Pa which is often sound of anthropogenic origin.

The results show that the Baltic Sea soundscape is dominated by sound from shipping lanes, but there are large variations in sound level both over time and space, due to variations in shipping traffic, and in environmental factors influencing the propagation of sound.

The soundscape maps constitute the cornerstones of a web-based, soundscape, planning tool, which facilitates a user-friendly interface between results and managers. This tool can be used to analyse the soundscape, both spatially and temporally and, thus, link pressure to impact, bringing us one step closer to GES.

BIAS has successfully channelled the dissemination of results, mainly through the forums of the HELCOM Baltic Marine Environment Protection Commission (Helsinki Commission) and HELCOM Expert Network on Underwater Noise (HELCOM EN-Noise). A cooperation between BIAS and HELCOM has developed, in particular with the working groups on Pressure and State & Conservation, as well as within the BalticBOOST project. Together with the Member States, the European Commission and other Regional Conventions, HELCOM is now regarded as the target audience for the outputs of the BIAS project. However, the experience and lessons learned are definitely relevant for other marine regions. The knowledge gained by BIAS is being shared through the BIAS Implementation Plan (Nikolopoulos et al., 2016) to the Member States of the EU.

In 2018, the Heads of Delegation, the executive organ of HELCOM, decided that ICES should be the host of the data portal for the HELCOM member states, where data will be uploaded to by the member states and stored. Since 2019, ICES hosts the web-based tool, which is used to present monitoring data and soundscape maps.

Main outcomes:

- *Standards for measurement and signal processing:* The BIAS project further developed standards for monitoring methods, and for the methods needed to convert raw data into usable sound pressure products. The standards were published as two separate reports.
- *Quality Assurance guidance:* The BIAS project developed quality assurance standards for systematic measurements and data analyses, feedback loops for error prevention, and inspection routines to control and harmonize project procedures among different performers. The internal audit reports for the quality assurance actions, and a description of the inter-organisation comparisons of the data processing methods (ring-tests) are provided in the BIAS quality assurance report. The QA guidance is highly relevant and can be applied also to other initiatives.
- *Soundscape planning tool:* One of the main legacies of BIAS is a GIS-based soundscape planning tool for continuous underwater sound in the Baltic Sea, containing both the modelled soundscape maps as well as measured data. The tool was developed for managers to facilitate their evaluation of underwater continuous sound. Specific needs and requirements of the end-users were incorporated into the tool design, through surveys among the targeted national authorities, within MSFD management and HELCOM. The BIAS soundscape planning tool is now available through the ICES data portal (see link below).
- *Implications/lessons learned for new projects:* BIAS learned much during its implementation that is of use for anyone planning to implement a joint monitoring programme. New project initiatives, in particular those under preparation in the North Sea Region and in the Atlantic will build upon the lessons learned from BIAS and its recommendations (see section 2.3).

The BIAS Soundscape Planning Tool was released in 2015 but is no longer active. The BIAS soundscape maps are now available on [ICES Continuous underwater noise data portal](#).

The relevant public documents produced by BIAS are available at the project webpage www.biasproject.wordpress.com

AQUO - Achieve Quieter Oceans by shipping noise footprint reduction

Funding origin	European Commission - 7 th Framework Programme
Lead organization	DCNS, Naval Group (France)
Duration	2012 – 2015

The AQUO project has provided policymakers with practical guidelines to reduce shipping noise footprints. The practicality of the guidelines was ensured by involving shipyards and ship owners in an end-user committee of 23 major stakeholders from the maritime industry, in and beyond the borders of EU. These include: Anave, Confitarma, Armateurs de France, Engie, STX France, HHI, SHI, IHC, CMA CGM, NOAA, Port of Vancouver.

AQUO experts have developed tools to assess, not only the current situation with regards to the anthropogenic sound from shipping on a whole basin scale, but the quantitative tools that would enable policy makers to assess scenarios with different noise mitigation measures, in the concerned area. These include solutions, either linked to ship design (including structure and machinery, propeller design and other sound and vibration contributors), or solutions related to shipping control and regulation.

The solution portfolio, aimed at answering the needs of several levels of maritime industry, was addressed with consideration of cost effectiveness (ensuring both fuel efficiency and noise mitigation reductions) and of fleet applicability (new builds or existing vessels). To complement the marine engineering studies, dedicated experiments have been conducted on three species, representing the 3 main orders potentially affected by noise: invertebrates, fishes and marine mammals. Bioacoustics criteria were implemented in the methodology, so as to quantify the effects on the fauna of a given scenario, in a given area.

Main outcomes :

- a shipping underwater sound footprint assessment tool, using actual shipping traffic data and so including AIS (Automatic Identification System) data, coupled with multiparametric models and methods that predict radiated sound from ships, by addressing propeller behaviour, machinery radiation and hull hydrodynamics vibro-acoustic interactions with regards to sound;
- a standard for measuring underwater sound produced by shipping, quantifying in situ uncertainties from onsite experiments, including both deep and shallow water conditions which represent various EU waters;
- new vibro-acoustic, measurement tools and methods that can be applied to full scale experiments at sea and at model scale in test basins;
- fauna impact scaling approach to determine bioacoustics criteria and good practice for protection of marine life from underwater noise, based on analysis of available data and specific bioacoustics experiments on certain marine species,
- a list of design improvement solutions to reduce ship underwater radiated sound, without reducing fuel efficiency of the ship;
- a range of operational mitigation measures;
- practical guidelines summarising the benefits of the various scenarios (technical and operational solutions) in terms of noise and of fauna impact.

The relevant public documents produced by AQUO are available [online](#).

SONIC - Suppression Of underwater Noise Induced by Cavitation

Funding origin	European Commission - 7 th Framework Programme
Lead organization	Stichting Maritiem Research Instituut Nederland (Netherlands)
Duration	2012 – 2015

The aim of the SONIC project was to develop tools to investigate and mitigate the effects of underwater noise generated by shipping, both in terms of the footprint of an individual ship (a “noise footprint”) and of the spatial distribution of sound from a large number of ships contribution to the sound (a “noise

map”). The project’s first objective was to enhance the understanding of noise generated by a cavitating ship propeller. The second objective was to validate predictions of noise levels for individual ships, and to classify ships based on simplified noise models. SONIC’s third objective was to map the noise generated by shipping in general and to propose mitigation measures for quietening the oceans.

The SONIC project was executed in close co-operation with the AQUO project, by sharing data, organising combined workshops and dissemination activities, and by joining forces on developing guidelines for industry and regulations.

Common Guideline Document – AQUO & SONIC European Added Value

The collaborative research projects AQUO and SONIC, partly funded by the EU 7th Framework Programme 'Oceans of Tomorrow', were required to establish common, non-mandatory guidelines for the assessment and mitigation of continuous underwater sound, originating from commercial shipping. Close cooperation was achieved as both projects were developed during same time and with targeted joint workshops.

The projects jointly developed a common guideline, which presents the main findings, and conclusions of the research performed within the AQUO and SONIC projects, and summarises the consortia's recommendations on the way ahead, to help assess the environmental status of European marine waters, with respect to continuous underwater sound. The guideline document is intended to support all stakeholders of potential future regulation of underwater noise from commercial shipping:

- Policymakers and maritime authorities for further assessment and decision-making process, in particular in relation to spatial planning of shipping lanes, and for use by the International Maritime Organization (IMO).
- The shipbuilding and maritime supplier industry in finding measures combining fuel efficiency with reduced underwater sound radiation and in anticipating potential effects on the design process and vessel cost.
- Shipowners and operators in finding measures combining fuel efficiency with reduced underwater sound radiation and in anticipating potential effects on ship operation and fleet planning.

Both projects aimed at providing policymakers and maritime industry stakeholders, with the most relevant methodologies to answer to the MSFD current requirements.

The project also showed the importance of local environmental characteristics – in implementing any common strategy it is important to take account of local conditions.

Download [here](#) the AQUO-SONIC Guideline Document.

MaRVEN – Environmental Impacts of Noise, Vibrations and Electromagnetic Emissions from Marine Renewable Energy

Funding origin	European Commission, DG Research and Innovation
Lead organization	DHI A/S (Denmark)
Duration	2012 - 2015

DHI A/S led a study of the environmental impacts of noise, vibrations and electromagnetic emissions from marine renewable installations. The MaRVEN project critically reviewed the available scientific evidence and the significance of those impacts, and then recommended solutions to mitigate or resolve the identified negative impacts. The investigation comprised several tasks, including:

- provision of a historical review of the publications related to environmental impacts of marine renewable energy devices.
- an in-depth analysis of studies on the environmental impacts of noise and vibrations during installation and operation of marine renewable energy devices.
- an in-depth analysis of studies on the environmental impacts of electromagnetic emissions during the operation of marine renewable energy devices.
- an in-depth analysis of the current norms and standards related to sound, vibrations and EMF for marine renewable energy systems.
- performance of relevant on-site measurements and field experiments to validate and build on the results obtained in above studies.
- preparation of a programme for further research and development (R&D) with justified priorities.

Main outcomes :

The in-depth review of noise impacts from marine renewable energy devices (MREDs) summarises the results of peer reviewed papers, grey literature reports and Environmental Impacts Statements from the past 20 years. This provides an important information source to understand the potential contribution of MREDs to impulsive and continuous low frequency sound input into the environment.

- The in-depth analysis of studies on effects of electromagnetic emissions (EMF) provides a comprehensive summary that adds to the knowledge on input of other forms of energy into the marine environment which is of relevance to descriptor 11.
- The in-depth analysis of current norms and standards related to sound, vibrations and EMF for MREDs contains a lot of information on standardisation (for data collection and analysis) and has thus direct links to processes undertaken within TG Noise and other fora (e.g. ANSI standards).
- The on-site measurements and the results of field experiments address some open questions directly relevant to D11. These are, for example, particle motion emissions during construction activities using impact pile driving, EMF emissions during operation of wind farms, sound pressure and particle motion emissions from wave generators and sound pressure emissions from tidal energy converters.
- The programme for further research and development (R&D) identifies key issues that should

be tackled concerning sound and EMF from MREDs in the future. It is thus very relevant for the discussion of new indicators for D11.

Download [here](#) for the final study report.

Impacts of Noise and Use of Propagation Models to Predict the Recipient Side of Noise

Funding origin	EU - Directorate-General for Environment of the European Commission
Lead organization	CEFAS (United Kingdom)
Duration	2014 - 2015

In 2014, DG Environment commissioned a study to investigate the impacts of noise, and use of propagation models, to predict the recipient side of noise. The study had the following objectives:

1. To evaluate the current knowledge of the impacts of noise on marine biota at all levels (individuals, populations, and ecosystems) and methods to assess these impacts.
2. To develop modelling techniques to predict the recipient side of noise, i.e. as it is received by marine fauna.

With the aim of developing a roadmap towards defining thresholds for good environmental status (GES), and evaluating the use of sound maps for GES assessment.

Main outcomes:

The roadmap consisted of the following four Actions:

1. **Agree to standards for underwater sound monitoring.** It was important for GES assessment that sound levels are measured consistently by the Member States. No suitable international standard existed for sound monitoring, and a general standard may, in any case, have been incompatible with the requirements of the MSFD.
2. **Commission studies to address knowledge gaps.** Targeted studies were needed to reduce the uncertainties that constrain management decisions relating to underwater sound. There were several suitable EU funding mechanisms (which could have been) used to address the knowledge gaps outlined above.
3. **Agree to common standards for sound monitoring instruments.** There were a range of commercially available devices for monitoring underwater sound, and not all were adequate to meet monitoring requirements for the MSFD
4. **Define operational GES criteria.** For Descriptor 11 to become operational, quantitative criteria for attainment of GES assessment had first to be defined. There were several unresolved questions to be addressed in addition to the particular formulation of the targets, including the metrics and spatial resolution to be used. A GES target for continuous sound was not necessary for a 'hard threshold' above which GES was not attained when it could be expressed as a maximum proportion of time when sound levels exceeded a certain threshold.

Key elements of the work developed were to convene a workshop of international experts, aimed at addressing the current knowledge gaps, and to prepare a roadmap towards defining noise limits for

GES. This final piece of work presenting the findings and roadmap is available at the [JRC / MSFD Competence Centre website](#).

Baltic BOOST

Funding origin	EU - Directorate-General for Environment of the European Commission
Lead organization	HELCOM (Baltic Marine Environment Protection Commission - Helsinki Commission)
Duration	2015 – 2016

Baltic BOOST "*Best Practices for Action Plans to Develop Integrated, Regional Monitoring Programmes, Coordinated Programmes of Measures and Addressing Data and Knowledge Gaps in Coastal and Marine Waters*" was an EU co-funded project coordinated by HELCOM (15.09.2015 – 14.12.2016).

The Baltic BOOST project was designed to boost HELCOM activities. In particular, those related to the long-term cooperation between HELCOM countries, to produce joint assessments and agreements on measures, to improve the state of the Baltic Sea. More specifically, the project developed joint assessment approaches and set up data arrangements and databases, to support indicator-based assessments of the state of the Baltic Sea. These activities focused on strengthening HELCOM work on biodiversity and hazardous substances. The project, furthermore, increased the knowledge base on impacts of pressures affecting seabed habitats, as well as impacts of underwater noise, thereby taking first steps towards the development of joint environmental targets for such pressures.

The project included a theme dedicated to underwater noise, aiming at reviewing existing knowledge on the impact of noise in the Baltic Sea, exploring the possibility of determining acceptable levels of underwater sound for marine species, and listing possible measures to manage and mitigate relevant impacts on the Baltic Sea.

Main outcomes:

- *Reporting requirements for the development of a regional registry of impulsive events:* The reporting requirements for the regional registry of impulsive events were defined in cooperation with the HELCOM EN-Noise, OSPAR and ICES (which hosts the registry). The HELCOM/OSPAR regional [registry](#) contains information on licenced events such as pile driving, controlled explosions from naval operations, and other activities that release energy from the Baltic Sea and the North East Atlantic. The registry is fully operational, and countries are in the process of reporting their national data, according to the agreed reporting format.
- *Proposal for a regional monitoring programme of continuous noise:* A proposal for a regional monitoring programme of continuous noise was drafted during the project period, which was later approved by the HELCOM Head of Delegation (2018). It proposed to combine a yearly minor assessment in 11 prioritised location stations, with a major assessment proposed every six years, over 38 stations. Further work within HELCOM (subsequent to the project's conclusion enabled the approval of the [regional monitoring sub-programme on continuous noise](#) in 2018 (Outcome of HOD 54-2018, para. 4.11).
- *Review of existing knowledge on impact of noise in the Baltic Sea:* A report on noise sensitivity of aquatic animals, in the Baltic Sea, was prepared and [published in 2019](#). It compiles and reviews the available knowledge on impact of anthropogenic noise in the Baltic Sea, in the

chapter entitled 'Impact of noise on marine animals'. It further identifies a list of priority, noise sensitive species for the Baltic Sea based on the following criteria: hearing sensitivity; the impact of noise; threat status; commercial value; and data availability. Harbour porpoise, harbour seal, ringed seal, grey seal, cod, herring, and sprat were identified as priority species. The report also compiles available, biologically important, spatial-temporal information for the identified, priority, noise sensitive species in the Baltic Sea. The report will be published in the Baltic Sea Environment Proceedings series.

- *Principles for defining levels of underwater noise consistent with GES:* The HELCOM BalticBOOST Workshop on Underwater Noise was held in Copenhagen, Denmark, on 5-6 October 2016. Based on a [draft document](#) prepared by BalticBOOST the workshop developed principles for defining levels of underwater sound consistent with GES, that have been further amended, based on recommendations by the HELCOM Pressure and Gear Groups. The principles are meant to facilitate a coherent approach among the countries, and outline what would be considered good environmental status in relation to sound. They are meant to serve as a basis for further development of guidance levels, or thresholds of sound, consistent with good environmental status for the individual species.

Decision supports trees for establishing environmental targets for impulsive sound, and continuous sound was also developed. The risk-based decision support trees is meant as a tool for identifying areas/situations where a reduction in pressure is needed.

Further work continued after the project's duration, within the regular HELCOM framework, which concluded with the agreement of the "[HELCOM input to establishment of environmental targets on underwater noise](#)" in 2018 ([Outcome of HOD 54-2018](#) para. 4.30). The HELCOM input was subsequently shared with EU TG NOISE.

- *Possible measures to manage and mitigate relevant impacts of underwater noise on the Baltic Sea:* A [document](#) compiling the reviews of internationally available, mitigation measures and country specific information (based on a questionnaire completed by Denmark, Finland, Germany, Lithuania, Russia and Sweden) was prepared by the project. It focuses on general mitigation measures as well as measures to mitigate piling, seismic surveys, shipping and recreational boating in detail, as well as some possible mitigation measures for naval sonars, high-frequency impulsive sources, marine aggregate dredging operations, and explosives. An analysis of national feedback is also provided.

All results are available on the [project website](#).

UNAC-LOW - Underwater acoustic calibration standards for frequencies below 1 kHz

Funding origin	EU H2020 EMPIR Programme
Lead organization	TUBITAK (Turkey)
Duration	2016 - 2019

The project UNAC-LOW aimed to develop the European metrological capacity in underwater acoustics, providing traceable measurement capabilities for the calibration of hydrophones and autonomous underwater acoustic recorders.

The project developed the scientific and technical research capabilities, in the field, within Europe and provide an improved metrology framework to underpin the absolute measurement of sound in the ocean, in support of regulation and EU Directives (such as the Marine Strategy Framework Directive) for which traceability is currently lacking.

Main outcomes:

- Contributions to new international guidelines, recommendations and standards, mainly with committees: EURAMET TC-AUV, BIPM CCAUV, ISO TC43 SC3, IEC TC87 WG15
- List of stakeholders` set-up, wide attendance at stakeholders` workshop with 100+ entries from research, industry and end users
- Deliverables include:
 - Documented calibration procedures for hydrophone calibration, using closed-chamber pressure methods (NPL, TUBITAK)
 - Field reports and guidelines for free-field calibration of autonomous recorders, in open-water sites (FOI, CNR, ISPRA)
 - Agreed strategies by each partner for provision of calibration services from established facilities

DEPONS - Disturbance Effects on the Harbour Porpoise Population in the North Sea

Funding origin	Six companies that work on the development of offshore wind energy: Vattenfall Wind Power Ltd, SMart Wind Ltd, Forewind, East Anglia Offshore Wind Limited, Eneco Luchterduinen and DONG Energy Wind Power A/S
Lead organization	Aarhus University (Denmark)
Duration	2012 - 2018

Harbour porpoises have been found to respond to underwater noise generated by piling of wind farm foundations at large distances. While they have also been found to return once construction activity ceases, the significance of piling noise disturbance to the survival and reproduction of harbour porpoises is not understood. The result is considerable uncertainty for the industry and governments alike in the planning of offshore wind farms.

Recognising that improved knowledge on the impacts of piling noise will be critical to be able to expand offshore wind power in a cost-effective and timely manner in balance with a long-term viable North Sea harbour porpoise population, a group of offshore wind developers funded the international research

program DEPONS. The project aimed to obtain fundamental new insights into harbour porpoise responses to underwater piling noise, as well as their small and large-scale general movement patterns.

The target group for the outcome were regulators, advisors and other stakeholders involved in offshore wind farm development. The results can also be used for the assessment of impacts of other human activities as well, and thereby contribute to an improved basis for the management and conservation of the North Sea harbour porpoise population.

The objective of the simulations model developed in DEPONS was to simulate how harbour porpoise population dynamics are affected by pile-driving noise associated with the construction of offshore wind farms. The model has been developed by DCE – National Centre for Environment and Energy at Aarhus University, Denmark with support from consulting firm Aragost.

The porpoise's survival are directly related to their energy levels, and the population dynamics are affected by noise through its impact on the animals' foraging behaviour. By ensuring that the animals' movement patterns, space use and reactions to noise are realistic, the population dynamics in the model have the same causal drivers in the model as in nature.

The model incorporates several techniques such as display of a background image, visual tracking of agents, event-based logging and simulation capture and replay in unit testing. The DEPONS 2.0 model is an important tool for assessing the impact of the construction of future wind farms before they are build.

The model has been implemented in the Repast Symphony agent-based modelling and simulation platform with support from Aragost and has been released as open source available from [GitHub](#).

Further information is available at the project website [online](#).

SHEBA - Sustainable shipping and environment of the Baltic Sea region

Funding origin	BONUS - Science for a better future of the Baltic Sea region
Lead organization	Environmental Research Institute (Sweden)
Duration	2015 - 2017

BONUS SHEBA aimed to analyse the drivers for shipping, obtain the present and future traffic volumes, and calculate a set of scenarios which will then feed into calculations of emissions into water, air, and underwater sound, using and extending the, currently, most advanced emission model, based on Automatic Identification System (AIS) ship movement data. One of the objectives of SHEBA was to conduct an impact assessment of ship-generated underwater sound, in the Baltic Sea. Further, the project provided an integrated assessment of policy options, to mitigate pressures linked to shipping, which quantifies, as far as possible, anticipated changes in ecosystem services, compared to an established baseline. This includes an analysis of trade-offs between options, as well as synergies, and the marginal changes in costs and benefits of options, to reduce environmental pressures from shipping, and support the achievement of good environmental status, as required by the Marine Strategy Framework Directive.

The methodology for predicting underwater sound emissions of individual ships was taken one step forward, based on existing empirical acoustical models for ships. The methodology links model-based sound source spectra, to specific vessels and activities, e.g. ship type, speed and AIS-information. By combining the sound source model with the Ship Traffic Emission Assessment Model (STEAM), density maps of sound sources for 2014-2015 were produced. The maps, developed in the project, facilitate a

large-scale inventory of shipping sound, which does not require any monitoring data, and could be used for minor assessment of the soundscape status (cf. BIAS project). Further, SHEBA tackled challenges in areas where the knowledge needs to be improved, in order to achieve an effective management in the future. In addition, behavioural response experiments were carried out, to improve the understanding of reaction of fish in the Baltic Sea.

Main outcomes:

- Conduct an impact assessment of ship generated, underwater sound in the Baltic Sea
- Combining a sound source model with the Ship Traffic Emission Assessment Model (STEAM), resulting in yearly density maps of sound sources.
- Studying behaviour reaction in Baltic Sea fish species, to playback ship noise.

The relevant information and public documents produced by SHEBA are available [here](#).

Copernicus Marine Environment Monitoring Service (CMEMS) and Quiet-Oceans initiative on Underwater Noise Mapping

Funding origin	Various: EU Copernicus Programme; EC 7 th FP; HORIZON2020
Lead organization	Quiet-Oceans (France)
Duration	2009 - 2017

Copernicus is a European Union Programme, aimed at developing European information services, based on satellite Earth Observation and in situ (non-space) data. The Programme is coordinated and managed by the European Commission. It is implemented in partnership with the Member States, the European Space Agency (ESA), the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the European Centre for Medium-Range Weather Forecasts (ECMWF), and the EU Agencies and Mercator Océan.

The Copernicus Marine Environment Monitoring Service (CMEMS – marine.copernicus.eu) address several areas. These services have reached different degrees of maturity. Some are already operational> Marine monitoring is currently in a pre-operational mode.

The MyOcean (2009-2012), MyOcean2 (2012-2014) and MyOcean follow-on (October 2014- March 2015) projects, funded respectively by the EU's Seventh Framework Programme for Research (FP7 2007-2013) and HORIZON 2020 (EU Research and Innovation programme 2014-2020), led the demonstration phases of the future Copernicus Marine Environment Monitoring Service (CMEMS). The MyOcean consortia were coordinated for 6 years by Mercator Ocean, the French centre for analysis and forecasting of the global ocean. In November 2016, the European Commission and Mercator Ocean signed an Agreement to implement and manage the Copernicus Marine Environment Monitoring Service.

In this framework, Mercator Ocean International and Quiet-Oceans initiated in 2017 a partnership to provide an operational service of underwater sound mapping to address the MSFD, under the umbrella of the Copernicus Marine Environment Monitoring Service. The partnership enhanced the CMEMS services, as provider of oceanographic nowcasting, and needed to provide an operational sound mapping service. The partnership focused on demonstrations of coastal and operational sound

mapping and analysis, to fulfil descriptor 11.1.2 of the MSFD.

In practice, Quiet-Oceans implemented the Quonops(c) Noise Prediction System and provided demonstrations of sound mapping services, contributing to the implementation of the MSFD, and maintaining them until the end of December 2020, as well as promoting them among National focal points, for the implementation of D11 and the Member States, currently using the CMEMS service.

Main outcomes:

- Operational online tool, to produce on-demand noise maps of continuous noise (anthropogenic and natural), that do not need a high level of expertise to use
- Live (near-real time noise mapping) and Historical (statistical noise maps for periods in the past) subscriptions available
- Coverage includes all European waters, based on Copernicus Marine Environment Monitoring Service, and EMODnet input data
- A dedicated subscription, dedicated to the MSFD (large area, 63Hz and 125Hz one-third octave mapping)

Relevant demonstrations are available [online](#), such as: *Live Ambient Noise dedicated to regulators and the EU Marine Strategy Framework Directive*. This demonstration of the capabilities of Quonops Online Services includes shipping noise and natural noise generated by ocean waves. It provides with near real-time noise maps updated every 15 minutes and daily, weekly, monthly, quarterly and annual statistical maps. The results produced by this service correspond to the regulatory requirements of the European Marine Strategy Framework Directive. They enable to monitor the noise status of marine areas of interest and contribute to characterizing their Good Environmental Status.

[Quonops Online Services](#) are available worldwide and accessible for free (with limited time, coverage and functionalities), or through [subscriptions](#).

QUIETMED – Joint programme on noise (D11) for the implementation of the Second Cycle of the MSFD in the Mediterranean Sea

Funding origin	EU - Directorate-General for Environment of the European Commission
Lead organization	CTN (Spain)
Duration	2017 - 2018

This project was co-funded under the DG ENV/MSFD Second Cycle/2016 programme and coordinated by the Marine Technology Centre (CTN) (Spain), with participants from Spain, France, Italy, Slovenia, Croatia, Greece and Malta.

The project objective was to enhance cooperation among Member States (MS) in the Mediterranean Sea, and to implement the Second Cycle of the Marine Directive and, in particular, to assist them in the preparation of their MSFD reports by 2018, through:

- promoting a common approach, at Mediterranean, level to update GES and Environmental targets related to Descriptor 11, in each MS marine strategies

- development of methodological aspects, for the implementation of ambient noise monitoring programs (indicator 11.2.1)
- development of a joint monitoring programme of impulsive noise (Indicator 11.1.1), based on a common register, including gathering and processing of available data on underwater noise.

Main outcomes:

- Creation of the “Joint impulsive noise register in the Mediterranean Region”. The register was developed in coordination with ICES, to ensure compatibility with the existing register for OSPAR/HELCOM areas. Also, it provides a tool for the calculation of the spatial distribution and the temporal extent of D11C1, according to the Commission Decision (EU) 2017/848. This register is available [online](#).
- Development of methodologies and best practices for underwater noise monitoring, in the Mediterranean Region: schemes, technologies and standardization.
- Development of three pilot projects in Spain, Malta and Greece, for ambient noise monitoring, including one modelling/mapping exercise.
- Cooperation with Barcelona Convention through the performance of two workshops, with national representatives of competent authorities and researchers from non-EU countries.

More information and reports are available at the [project website](#).

Soundscape - Soundscapes in the North Adriatic Sea (NAS)

Funding origin	EU – INTERREG V-A, Italy -Croatia CBC Programme
Lead organization	Institute of Oceanography and Fisheries (Croatia)
Duration	2019 - 2021

Soundscape - Soundscapes in the North Adriatic Sea (NAS), and their Impact on Marine Biological Resources project, is funded by 2014-2020 Interreg V-A, Italy -Croatia CBC Programme. This project is led by the Institute of Oceanography and Fisheries (IOF), in Croatia, and involves other 3 partners from Croatia (BWI, TIPH, CMEE) and 4 in Italy (CNR–ISMAR, ARPA-FVG, CF, Marche Region). The project started in January 2019 and was ended in December 2021.

The main objective of the project was to create a cross-border technical, scientific and institutional cooperation, to face together the challenge of assessing the impact of underwater environmental noise on the marine fauna, and in general on the NAS ecosystem. This cooperation aimed to ensure an efficient protection of marine biodiversity, and to develop a sustainable use of marine and coastal ecosystems and resources. The specific objectives were:

- Implementation of a framework and a shared monitoring net for a coordinated regional and transnational assessment of the underwater noise pressure in the NAS in accordance with the MSFD, specific to the soundscape ecology of the EUSAIR region
- Evaluation of the underwater noise impact on marine biological resources to protect biodiversity through the assessment of the noise habitat suitability and the vulnerability of these resources in study area (target species *Tursiops truncatus*, *Carretta carretta*)

- Development and implementation of a planning tool for management of underwater noise considering the sensitivity of natural resources, in accordance with the MSFD and MSP Directive.

During the project, anthropogenic underwater noise was continuously measured at 9 stations (frequency band 48KHz, 16 bits) set in the coastal and open waters of the northern Adriatic for 15 months (March 2020 – June 2021). In addition to different statistical processing of the measured data, the mean noise levels at 20-second intervals were calculated and used as input data to the Quonops numerical model for the purpose of its calibration. Using these and other necessary parameters (bathymetry, sediment types, sea temperature and salinity, waves) numerical modelling obtained maps of spatial-temporal values of underwater noise distribution that can be used to analyse its impact on the marine fauna of the northern Adriatic. Using the processed results of noise monitoring and maps produced, the impact on the distribution of target species was evaluated in the limited study area in Lošinj archipelago. Marine spatial planning tools were developed through identification of target areas, evaluation of current noise pressure conditions, assessment of excess noise levels and pressure indices. Highly impacted areas were identified and the catalogue of possible mitigation measures was proposed.

Main outcomes:

- Shared monitoring network and harmonized data processing set up
- Underwater noise maps, in the NAS, within the EUSAIR, area prepared
- The impact of underwater noise on target organisms, based on soundscape model estimates
- Enhanced ecological modelling tool (including noise), integrated with MSP tools, to manage co-existence of anthropogenic activities and cumulative impact, and to ensure sustainable use of the resources
- Trans-boundary collaboration for management and possible mitigation actions, to reduce the noise impact on biodiversity developed
- Methodologies and good practice transferred to stakeholders

More information and reports are available [online](#).

QUIETMED2 - Joint programme for GES assessment on D11-noise in the Mediterranean Marine Region

Funding origin	EU - Directorate-General for Environment of the European Commission
Lead organization	Marine Technology Centre (CTN) (Spain)
Duration	2019 - 2021

QUIETMED2 project aimed to support the implementation of the second cycle of the MSFD, in particular, to implement the GES Commission Decision (EU) 2017/848 of 17 May 2017). This project was funded by DG Environment of the European Commission, within the “DG ENV/MSFD 2018 call”. QUIETMED2 was coordinated by Marine Technology Centre (CTN) (Spain).

The QUIETMED2 project aimed to support Member States Competent Authorities in assessment of the extent to which GES, on Descriptor 11-Underwater noise, was achieved in the Mediterranean Region, by providing practical outcomes to implement the new GES Decision through i) a joint proposal of a

candidate, for an impulsive noise indicator, in the Mediterranean Region; ii) a common methodology for Competent Authorities, to establish threshold values on impulsive noise, in the Mediterranean region; iii) a data and information tool, to support the implementation of the monitoring programmes, of impact of impulsive noise, based on the joint impulsive noise register, developed under QUIETMED project, which was demonstrated on; iv) an operational pilot of the tool; and v) several activities to boost current regional cooperation efforts of the Barcelona Convention, developing new Mediterranean Region cooperation measures.

This project supported the cooperation needs of EU Member States' competent authorities, in the Mediterranean Marine Region, in their implementation of the next 6-year cycle of MSFD, to address it in a coherent manner.

Main outcomes:

- Joint proposal candidate impact indicator, for impulsive noise, for the Mediterranean region.
- Joint proposal of a methodology, to establish thresholds in the Mediterranean region.
- Development of data and information tool, to support the update monitoring programmes of impulsive noise impact indicator, based on the joint impulsive noise register, developed under QUIETMED.
- Implementation of an operational pilot, for an impulsive noise impact monitoring programme, to test its feasibility and operational use of the data, and information tool.
- Two training sessions for Competent Authorities from Member States, to provide technical support on: a) the implementation of the GES decision 2017/848 b) the establishment of new coordinated measures (tools, methods and results).
- Improvement of the cooperation and coordination with the EcAp process and the Barcelona Convention, through the active participation of non-EU representatives.

More information and reports are available at the [project website](#).

CeNoBS - Support MSFD implementation in the Black Sea through establishing a regional monitoring system of cetaceans (D1) and noise monitoring (D11) for achieving GES

Funding origin	EU - Directorate-General for Environment of the European Commission
Lead organization	Mare Nostrum (Romania)
Duration	2019 - 2021

The Black Sea is one of the most vulnerable regional seas, and Romania and Bulgaria are the European Member States responsible for implementation of MSFD, in close collaboration with the other non-EU countries. The two descriptors tackled by this project are : Descriptor 1 – marine mammals/cetaceans; and Descriptor 11 – underwater noise in the Black Sea, to improve the second cycle of MSFD implementation, by achieving greater consistency and coherence in determining, assessing and achieving good environmental status. The proposed activities addressed the lack of background data on the distribution/abundance of BS cetacean populations, and on bycatch pressure and the lack of

national expertise to implement effective noise monitoring. The main objectives were to assess D1 cetacean related criteria, and establishment of thresholds values, to assess and support the development of D11 monitoring in the Black Sea, and to enhance coordination among the Black Sea region, through the dissemination of the project activities, results and outcomes.

CeNoBS was a 24 month project coordinated by Mare Nostrum (NGO) and involved 10 partners from Romania and Bulgaria and Third Countries: Ukraine, Monaco, Georgia and Turkey. The project was funded by DG Environment to support the implementation of the Marine Strategy Framework Directive (MSFD) in the Black Sea.

Main outcomes:

- Initial assessments for impulsive and continuous noise were developed. Such assessments mainly include an inventory of available impulsive noise data and draw the first picture about impulsive noise generating activities in the Black Seas and on the availability and position of recordings of ambient noise in the area.
- A workshop with project partners was organised by ACCOBAMS to enhance capacities among project partners about both impulsive and continuous noise monitoring, and to disseminate information with regards to the regional Impulsive Noise Register managed by ACCOBAMS as it covers the entire ACCOBAMS Agreement area (thus including the Black Sea).
- Pilot continuous noise monitoring programs were set and produced first noise indicators for the Black Sea (Deliverable 3.3)
- A technical document addressed to competent authorities of Member-States in the Black Sea was developed containing guidance to enable the setting up of long-term monitoring programmes for impulsive and continuous sound. It also suggests a first assessment framework and draw the way forward based on recent progress on the underwater noise issue in European waters

More information and reports/deliverables are available [project website](#).

RAGES - Risk-based Approaches to Good Environmental Status with case study on D2 (non-indigenous species) and D11 (underwater noise)

Funding origin	EU - Directorate-General for Environment of the European Commission
Lead organization	University College Cork, MaREI (Ireland)
Duration	2019 - 2021

Risk-based Approaches to Good Environmental Status (RAGES) was a two-year project funded by DG Environment to support implementation of the Marine Strategy Framework Directive (MSFD). The project began in January 2019 and comprised a consortium of partners from Ireland, France, Spain and Portugal, including the competent authorities from each country. RAGES worked with the competent authorities to use international best practice in risk management (ISO 30000, ISO3010) and work toward common approaches to Risk-Based Management in implementation of MSFD. The RAGES project ended in June 2021.

Main outcomes:

- Development of a **risk-based approach** to support the coordinated **regional and sub-regional implementation of the MSFD** based on the commission decision on GES, and
- Providing a replicable, transparent and standardised decision processes based on **international best practice for risk management**.
- **Two main outputs** were developed in separate case study areas **considering the shipping density data and sound maps based on 2019 AIS** navigation data.

RAGES focused on the waters under national jurisdiction of Ireland, Portugal and the Atlantic parts of the French and Spanish waters under national jurisdiction. Combined these make up the majority of European waters under national jurisdiction within the North East Atlantic Region. The study area included three sub-regions: The Celtic Seas, the Bay of Biscay and Iberian Coasts and Macaronesia.

More information and final outputs are available [online](#).

EUROPEAN MARINE BOARD

Funding origin	Independent, self-funding (through contributions from its member organizations and related European projects)
Lead organization	EMB - Expert Working Group on Underwater Noise
Duration	2020 - 2021

In 2020, the European Marine Board conveyed an Expert Working Group on Underwater Noise which was led by Frank Thomsen (DHI) and Sonia Mendes (JNCC) and comprising 13 scientists with complementary expertise on topics such regulation, marine life biology, bioacoustics and underwater acoustics. The task for the group was to produce a Future Science Brief (FSB) which presents an update on the previous EMB publication on underwater noise, Position Paper N° 13 on “The effects of anthropogenic sound on marine mammals: A draft research strategy”. The FSB No 7 ‘Addressing underwater noise in Europe: Current state of knowledge and future priorities’ was published by EMB in October 2021. The FSB expands the scope of the discussion beyond marine mammals to fishes and invertebrates and outlines key developments that have taken place since the Position Paper’s publication. The main chapters of the document focus on:

- the advances in our knowledge on anthropogenic underwater sound in the Ocean;
- the new knowledge that has been developed on the effects of noise on marine organisms; and
- the measures that have been taken to address the issue of underwater noise.

The key section of the document then presents outstanding issues and highlights priority actions for addressing them.

Main outcomes:

The FSB - [Future Science Brief N°7 Addressing underwater noise in Europe](#): Current state of knowledge and future priorities’ is very relevant to TG noise as the FSB points out the relevant actions that need

to be taken in order to ensure that a solid scientific basis is available to inform ecosystem and precautionary-based legislation on underwater noise.

More information about the EMB working group on underwater noise is available [online](#) as well as the latest report [factsheet](#).

French National Underwater Noise Guidance

Lead organization	Ministère de la Transition écologique et solidaire, France
Duration	2018-2021

The French Ministry of Ecological and Inclusive Transition has recently published a guide of recommendations intended for central and decentralized State services to limit the impacts of anthropogenic acoustic emissions on marine fauna. This methodological guide should constitute reference documentation on the systems, tools and good practices available.

The guide *Recommendations to limit the impacts of manmade underwater acoustic emissions on marine wildlife* consists of 4 parts:

- Part 1 provides an overview of the activities and the different types of underwater noise emissions they trigger;
- Part 2 focus on the presentation of the impacts on marine fauna according to the types of emission according to the species and their noise tolerance threshold;
- Part 3 is the inventory and analysis of the various procedures and technologies available and how they limit and reduce the impact of emissions on marine fauna, and
- Part 4 is the main practical output consisting of a set of summary sheets with one entry per activity

The publication of this guide allows the implementation of the M021-NAT2 measure “*Define recommendations to limit the impacts of acoustic emissions of anthropogenic origin*” of the first cycle implementation of the French Plan of Measures (2016) of the MSFD.

Both FR and EN versions of the report can be downloaded [online](#).

2.2 Ongoing projects and initiatives in European seas

Joint Monitoring Programme for Ambient Noise North Sea - JOMOPANS

Funding origin	EU – INTERREG North Sea Region Programme
Lead organization	Rijkswaterstaat (The Netherlands)
Duration	2018 – 2022

In early 2018, the three-year project “Joint Monitoring Programme for Ambient Noise in the North Sea” (EU Interreg North Region Programme) ‘JOMOPANS’ started. In 2021, an extension till June 2022 has been granted. International concern focused, increasingly, on the potential negative effects of anthropogenic underwater noise, on sensitive marine fauna. Questions regarding sound sources, sound transmission, and the distributions of vulnerable species, in the North Sea, must all be tackled transnationally, as specifically required by the EU Marine Strategy Framework Directive, and by the

OSPAR Convention. JOMOPANS aims at developing a framework for a fully operational joint monitoring programme, for continuous sound, for the North Sea region. The project delivers the tools necessary for managers, planners and other stakeholders, to incorporate the effects of continuous sound, into their assessments of the environmental status of the North Sea, and to evaluate measures to improve the environment.

Expected outcomes:

- In the Implementation Plan an operational joint monitoring programme is outlined. At this moment JOMOPANS discusses the working arrangement with the marine managers of the North Sea countries.
- The project develops soundscape maps for the North Sea. The relative importance to the soundscape of different sound sources (such as ships and wind) will be determined, together with the variation in continuous sound pressure levels and sources, in different parts of the North Sea. Originally maps for 2019 were made, but during the project extension also maps for 2020 are planned.
- In total 14 measurement stations around the North Sea are now employed and gather long term sound data. These data will be combined with modelling, to obtain validated soundscape maps of the North Sea.
- A GES management tool was developed, which combines distribution maps of sensitive species, with the soundscape maps. Marine policy makers will be able to use this information to evaluate Good Environmental Status (GES), in relation to underwater sound. This tool will in the future also allow managers to design and assess appropriate measures, to reduce the risk of environmental impacts of underwater sound.
- The GES Tool of the JOMOPANS project is designed to be part of ODIMS (OSPAR Data and Information Management System). It has not been integrated into ODIMS yet. In the transition period the integration can take place with help of the OSPAR staff.
- JOMOPANS contributed to standardisation of underwater sound, by developing and publishing project standards on terminology, measurements, calibration and modelling. These standards are meant to be transferred to the rest of the underwater acoustics community. The documents are available on the website, but ISO working groups on underwater acoustics can use them to develop ISO standards.
- In the transition period the outcomes of the project will be presented at various occasions and work on the harmonisation will continue.

More information, publications and reports are available [online](#).

Joint programme for Ocean Noise in the Atlantic Seas - JONAS

Funding origin	EU – INTERREG Atlantic area Programme
Lead organization	University College Cork, MaREI (Ireland)
Duration	2019 – 2022

JONAS aims to address the risks of acoustic pressures on biodiversity, focusing on sensitive receptor species in the NE Atlantic, by streamlining ocean noise monitoring and risk prediction. Cost effective, risk-based approaches to monitoring and modelling noise, across the maritime territories of the Atlantic

Arc countries (France, Ireland, Portugal Spain and the UK) will be developed. These will be appropriate to the scale of the area, the levels of anthropogenic pressure, and the susceptibility of receptor species. JONAS draws on the outcomes of the BIAS Life+ project, adapting and generalising methods and standards from the Baltic, to reflect the scale and complex oceanography of the NE Atlantic region. JONAS cooperates closely with the JOMOPANS project, which is currently addressing underwater noise in the adjoining North Sea Area, and with QUIETMED in the Mediterranean.

Expected outcomes:

- JONAS addresses real-time noise management at local scale, particularly in sensitive areas, and support policy partners to develop regional-scale approaches, that benefit vulnerable biodiversity and supporting MSFD implementation.
- Practical implementation of the methodology and the results in various parts of the NE Atlantic Area: six high-resolution areas are covered in the JONAS project (Irish Sea, Brittany, Bay of Biscay, Gibraltar, Azores and Canary Islands) and for each of them monthly, quarterly and annual sound maps (ship noise) have been produced in 2020.
- Broad scale noise maps for NE Atlantic have been completed. The work on validation against in-situ data towards the definition and mapping of confidence metrics continue in 2022.
- Pam2Py developed by the project is an open source tool that facilitates and encourages exchange of acoustic data by enabling the extraction of essential statistical quantities from raw acoustic data and packaging these along with contextual metadata using uniform standard output exchange formats. Download and further information [here](#).
- Investigation of impacts of seismic surveying off the Portuguese coast on dolphin communities based on habitat suitability modelling and ground truthed sound propagation maps.
- New technical guide released on techniques and practices for harmonised underwater noise monitoring.
- An interactive web interface is under development to define pressure indicators, based on the information provided (e.g., MRU, key species, etc.) and the noise maps. Some parameters are defined by the users (e.g., thresholds and effects). After that, also scenarios can be defined by the user, based on the species presence/habitats in the MRU. It is also possible to obtain maps showing the percentage of time exceeding a certain threshold (set by user) or getting a single number ('surface-below-the-curve') rather than distribution curves as an output. The interface also nicely shows that differences in impacts among different areas are well reflected in the indicators (e.g., constant indicator for one area, while fluctuating for another area with same parameters used). Finally, different effects can be investigated, such as disturbance and masking (loss of communication), with the tool.
- Completion of requirements analysis for data products and Virtual Research Environment functionalities. The online platform provides a useful way to implement pressure indicators based on statistical sound maps. It is also flexible to adapt to local conditions (parameters such as MRU, key species, effects of concern and thresholds can be decided by the user). The web interface has successfully been tested for several MRU and types of effects and the obtained pressure indicators are sufficiently sensitive to describe different 'states' of the case studies. The tool is operational and can help in decision-making related to the setting of GES.
- Ocean Soundscapes Infographic produced in collaboration with European Marine Board for use in their 2021 report (see the section of European Marine Board).

More information and reports are available [online](#).

PIAQUO: Practical implementation of AQUO

Funding origin	EU – LIFE Programme
Lead organization	Naval Group (France)
Duration	2019 - 2022

Levels of underwater noise have massively increased over the past 50 years, mainly due to marine shipping, with negative impacts on marine wildlife. LIFE-PIAQUO (Underwater noise impact reduction of the maritime traffic, and real-time adaptation to ecosystems), headed by the French state-owned Naval Group, will develop measures to reduce this noise pollution. These include optimising propeller design to limit cavitation, which reduces bubble formation, and conducting ship speed reduction trials in vulnerable areas, based on real-time underwater noise readings.

Expected outcomes:

- Reduction of 50 to 100% of the cavitation volume, which should result in a reduction of URN by an order of 5 to 15 dB (representing a 3 to 33-fold reduction of the acoustic energy dispersed). In parallel the optimisation should generate a fuel economy saving of 1 to 3%;
- The project targets an accuracy of the estimation of the ship's noise of +/- 6 dB. On the large ferry where it will be tested, partners expect an average speed reduction of 10%, resulting in a 10dB reduction of URN and a decrease up to 20% on fuel consumption;
- Record the vessel acoustic signatures of 500 vessels (10% of the vessels that cruise in the area of the Pelagos sanctuary). At least 100 vessels will receive their Noise Ship Index scores and at least one harbour will set up incentives;

Thanks to MPAs voluntary mitigation policies, a reduction of ambient noise of 10 dB is targeted; and 5- provide a 24/7 online broadcasting system that delivers acoustic and biological mapping and information (live, historical and predictive) with the related business model.

More information is available [online](#).

AGESCIC – Achieve Good Environmental Status for Coastal Infrastructure Construction

Funding origin	EU – LIFE Programme
Lead organization	Naval Group (France)
Duration	2019 - 2023

With more than 400 projects per year in the EU, coastal constructions are an important source of water pollution, with turbidity and underwater noise. These cause severe damage on biodiversity, especially benthic fauna, fish, mammals, cephalopod, microalgae and seagrass.

The AGESCIC project, a EU Life funded project, aimed at bringing new technology solutions, to reduce the marine environmental impacts of coastal works, especially for both underwater noise and turbidity impacts, on marine fauna and ecosystems. AGESCIC is related to the new European ocean protection strategy, through the Marine Strategy Framework Directive (MSFD) 2008/56 / CE (descriptors 6 and 7 for turbidity and 11 for underwater noise), to reach Good Environmental Status for oceans. The project has been extended until 2023.

Expected outcomes :

In practice, AGESCIC's innovation is made of a suite of three complementary technology solutions, dedicated for coastal infrastructure construction that will mitigate the pressure, monitor pressure and receptors, and restore the ecosystem.

- The first stone of the complete solution is the SubSea Quieter® (SSQ), an innovative underwater noise and turbidity containment system, made of an air-filled membrane. To report on the efficiency of the SSQ, and to continuously ensure compliance with the regulation during operations, the solution is also made of SmartPAM+. Based on Quiet-Oceans' and UPC existing SmartPAM passive acoustic monitoring buoy, SmartPAM+ is a smart connected buoy that monitors, in real time, the levels of turbidity, the levels of underwater noise and the presence of marine mammals, to give a comprehensive monitoring board. Finally, the AVOREST system, based on sound attraction device and an artificial habitat for fish and larvae, is added to reduce the impact on fish, and recover the ecological functions of the work area.

More information is available at the [project website](#).

LIDO – Listening to the Deep-Ocean Environment

Funding origin	Various funds
Lead organization	Technical University of Catalonia, Barcelona Tech (UPC) (Spain)
Duration	2007 - ongoing

Originated in the European Sea-Floor Observatory Network of Excellence (ESONET), in 2007, the Laboratory of Applied Bioacoustics (LAB), from the Technical University of Catalonia, Barcelona Tech (UPC) is currently leading an international project titled "Listen to the Deep Ocean Environment (LIDO), and is extending existing techniques for sound measurement, and passive acoustic monitoring to cabled deep sea platforms and moored stations. The software framework, called SONS-DCL, is currently active at the [ANTARES](#), France neutrino observatory, the [OBSEA](#), Spain shallow water test site, the [NEPTUNE](#) Canada observatory, the [JAMSTEC](#), Japan network of underwater observatories and at the [NEMO](#), Sicily site after the observatory has been redeployed, in Chile for [the Blue Boat Initiative](#), and is used for data processing under [JONAS](#). Part of the system is being tested for suitability on autonomous gliders and towed arrays, in collaboration with the [NURC](#) (NATO Undersea Research Center), and is implemented in several autonomous radio-linked buoys. It is also currently analysing all the [CTBTO](#) (Preparative Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization) data files, from 11 hydroacoustics stations in the Southern Hemisphere. The software contains several independent modules to process real-time data streams. Among these, there are dedicated modules for sound assessment, detection, classification and localization of cetaceans, and other acoustic events.

The sound measurement module computes statistics on fixed length intervals, especially following the recommendations of the European Marine Strategy Framework Directive (2008/56/EC), as well as sound trends over large time series. In particular, the Descriptor 11.1 (Tasker et al. 2011) focuses on high amplitude impulsive anthropogenic sound, within a frequency band of 10Hz and 10 kHz, assessed using either sound energy over time (Sound Exposure Level SEL), or peak sound level of the sound source. Meanwhile, the Descriptor 11.2 addresses background noise without distinguishable sources, which can lead to masking of biologically relevant signals, alter communication signals of marine mammals, and through chronic exposure, may permanently impair important biological functions. This latter indicator requires a set of sound observatories, to enable trends in anthropogenic background

sound to be followed (sound within the 1/3 octave bands 63 and 125 Hz, centre frequency).

It also displays real-time acoustic maps that are constructed in collaboration with Quiet-Oceans, as well as alerts on different acoustic events for mitigation.

The development and implementation of the real-time component of SONS-DCL (the software package behind LIDO), in existing observatories, has offered a unique opportunity to monitor sound, at a spatial and temporal scale, never previously realised. Access to the continuous flow of data has allowed the development of an exclusive database of sound sources, that are permanently updated, and used to calibrate the algorithms. These are applicable to almost any scenario, sea state, geographical location and sound level.

The system can be implemented on cabled observatories, autonomous radio-linked buoys, moored antennas, autonomous vehicles (including gliders), towed arrays and existing data sets.

The software package contains several independent modules to process real-time data streams. Among these, there are dedicated modules for sound assessment, evaluation of bioacoustics indicators, detection, classification (with optional use of TensorFlow Lite models), and localization of acoustic events, including marine mammals and fish vocalizations. To summarise the LIDO system, it takes, as input, an acoustic data stream and produces, as output, the characterisation of the acoustic events that were detected in the data (written to an XML file), spectrograms for quick visualisation and compressed audio. These outputs are then made available on the Internet where they can be viewed with a specific application. A custom alert service is also available, warning the user of the presence of acoustically sensitive species, in the vicinity of the activity. SONS-DCL is designed to be modular and dynamic (allowing the choice of detectors/classifiers), depending on the objectives and geographical areas. SONS-DCL is conceived for ease of operation (non-expert) and provides a monitoring system that automatically operates 24/7, without the need of post processing.

Relevant information is available [online](#).

JPI Oceans Action – Munition in the Sea

Funding origin	European Research Area; JPI Member States funds transnational research and innovation and multinational funding opportunities
Lead organization	JPI-OCEANS Secretariat (Italy)
Duration	Nov. 2015 – Jan. 2023

The JPI Oceans Action on munition in the sea was proposed by the Strategic Advisory Board, in April 2014, and approved by the JPI Oceans Management Board in November 2015. The Knowledge Hub aims to share scientific and technological expert knowledge and work towards a knowledge exchange platform that enables participating countries an efficient handling of problematic underwater munitions.

The objectives are to deliver a knowledge exchange platform that enables operators and responsible authorities in the participating countries an efficient handling of problematic underwater munitions. The Knowledge Hub will provide accessible information on scientific results, practices and technologies.

The Knowledge Hub will deliver services and products on four different focus topics:

1. Management of underwater munition;
2. Mapping and evaluation of underwater munition;

3. Environmental pathways, impact and toxicity and
4. Remediation methods.

Expected outcomes:

- **Science Support: provision of services to support operators and provide risk-assessment, through:** use of 3D numerical models to provide meaningful data for the risks effect of shallow/deep water explosions, chemical leakage, diver visibility, sediment transport; impacts of blast waves and underwater sounds generated from controlled and spontaneous detonations; estimate of corrosion phenomena and consequences; recognition and identification of munition, increasing the accuracy and efficiency in the post-processing of sonar and visual data.
- **Technology Transfer: technology transfer and development of new technologies for:** high-resolution seabed mapping, acoustic, magnetic and visual, measure sea conditions and marine ecosystems; mitigate effects of blast waves and underwater sounds from controlled detonations on marine life and infrastructure; autonomous and robotic systems, chemical sensors for aquatic systems and assessment of the health of marine ecosystems; safety conditions for operations on the sea floor along with confirmed procedures to monitor the release of toxic compounds; protect current infrastructure and improve safety for new infrastructure; avoid the introduction of potentially harmful chemicals into the human food web via aquaculture facilities; improving defence and national security.
- **Exchange of Practices and Knowledge:** Science-to-policy transfer, with knowledge support to select best options; improvement of existing knowledge base, method standardization, and intercalibration; exchange of practices, standardization of guidelines; improvement of personal skills of experts.

More information is available at JPI Oceans Action - Munition in the Sea [online](#).

QUIETSEAS

Funding origin	European Union - Directorate-General for Environment of the European Commission
Lead organization	Marine Technology Centre (CTN) (Spain)
Duration	2021 - 2023

QUIETSEAS is a project funded by the DG Environment of the European Commission within the call “DG ENV/MSFD 2020” Marine Strategy Framework Directive (MSFD). This project supports the 2nd phase of MSFD implementation and builds upon the work developed by the QUIETMED (2017-2019) and QUIETMED2 (2019-2021) projects. The project has a duration of 24 months and started in February of 2021.

The QUIETSEAS project is organised around 4 thematic blocks (TB), developed through 9 different activities, as follows:

1. **Indicators and thresholds:** Indicators will be defined to propose a methodology for assessing the risk of impact due to underwater noise and establish threshold values. Once the

methodologies are defined, its applicability will be tested in the Mediterranean and Black Sea Regions through the first exercise of GES assessment for impulsive and continuous noise in both regions.

- 2. Coordinated (sub)regional assessments:** Management tools will be developed to a) facilitate Competent Authorities the noise management, b) support the management, harmonisation, data sharing and reporting of continuous noise data, c) support the implementation of the monitoring programmes d) enable the preliminary assessment of the risk of impact on biodiversity by continuous noise sources, in particular marine traffic.
- 3. Measures:** A practical exercise will be performed based on two cases studies to assess and quantify the effectiveness of corresponding potential joint measures that address the transboundary pressure caused by continuous underwater noise. One of them will be a multi-scenario of vessel speed slowdown. The other one will be the opportunistic activity-dependent scenario of traffic reduction created by the COVID-19 lockdown.
- 4. Subregional cooperation:** the QUIETSEAS project will continue reinforcing links among Sea Regions by performing specific capacity building events, training sessions and networking activities. It will pay special attention to the cooperation in the Mediterranean Sea and Black Sea Regions, fostering cooperation between EU and non-EU Member States.

Expected outcomes:

- Definition of particularities for risk-based GES assessment in the Mediterranean Sea (MED) and Black Sea (BS) regions.
- Recommendations on acoustic propagation modelling for continuous sound assessment in MED and BS regions.
- Data gathering (D11C1, D11C2 and D1).
- Proposal of a methodology to establish thresholds values for D11C2 in the MED and BS regions in agreement with TG Noise work.
- Initial GES assessment of D11 underwater noise (D11C1 and 11C2) in the MED and BS regions.
- Management tools for harmonization, reporting and assessment of D11 (D11C1 and D11C2).
- Quantification of the effect of potential mitigation measures to reduce shipping noise: vessel speed slowdown and traffic reduction.
- Training session for Competent Authorities and experts from EU and non-EU countries.
- Networking activities (other projects and initiatives).

More information is available [online](#).

SATURN

Funding origin	European Union's Horizon 2020 research and innovation programme
Lead organization	MaREI, University College Cork
Duration	2021 - 2024

SATURN (Solutions At Underwater Radiated Noise) is an €8.96 million Horizon 2020 funded project that brings together 20 partners (19+1 linked) from 9 EU countries ranging from a variety of disciplines and

expertise backgrounds. SATURN addresses the adverse effects of underwater radiated noise on individual marine species and whole populations and seeks to develop technologies and measures to reduce and mitigate the negative impact of underwater noise.

The project will apply a risk-based conceptual approach (5 steps): to quantify ship underwater noise; to quantify sound exposure; to quantify individual animal response; to quantify population animal response, and to develop and assess noise mitigation measures.

Expected outcomes:

- **Develop Standards & Methods:** SATURN will define standards for terminology, methodology, tools, and metrics to measure, assess, and compare the impacts of noise from shipping and boats.
- **Quantify Ship Underwater Radiated Noise:** Quantifying the URN from individual vessels is an essential first step towards quantifying the dose and frequency range of noise to which animals can be exposed.
- **Quantify Sound Exposure:** URN from ships and boats propagates through the underwater environment to locations where animals are exposed to it/ Quantifying sound exposure will involve the use of state-of-the-art miniature tags attached to marine mammals, which will give us a better understanding of where, when, and how wild animals are exposed to ship noise.
- **Quantify Individual & Population-level Responses:** Standards, methods, and standardized test signals will be used within SATURN to assess the impact of URN on representative aquatic species, including invertebrates, migratory fish, and three species of marine mammals. Both acute and cumulative effects will be measured.
- **Develop & Assess Mitigation Solutions:** Having identified the most harmful aspects of the source level of ship and vessel sound, the project will evaluate which of the existing and novel solutions are the most feasible and effective to mitigate these effects.
- **Engage Stakeholders & Raise Awareness:** SATURN will establish a stakeholder group across a range of disciplines (e.g. shipping, research, policy, and NGOs) and ensure their engagement in all stages of the project, including the development of standards and methodologies.

More information and project updates are available [online](#).

HARMONIZE

Funding origin	European Union - Directorate-General for Environment of the European Commission
Lead organization	BSH
Duration	2021 - 2022

The HARMONIZE (*Towards the cross regional unification and harmonization of applicable assessment approaches for D11 in regard of special requirements from EU Subregions*) project, started in February 2021 and has a duration of 18 months. BSH is the lead partner of a consortium of 3 partners (KTH and ISPRA), one main contractor (MBBM) and two activity specific contractors (Quiet Oceans and Scopeland Technology).

The aim of HARMONIZE is to harmonize assessment approaches for good environmental status (GES) for impulsive sound within the EU based on scientifically valid approaches as well as field-tested

experiences and standardization of procedures.

This will be achieved by: i) identifying existing best practices, ii) considering specific regional requirements, and iii) defining common criteria and boundary conditions.

Key activities of HARMONIZE concern the acquisition of assessment data, best available practices and regional and sub-regional requirements as important foundation of harmonization. Exemplary regional case studies are considered for a data driven evaluation of regional requirements and of the applicability of harmonized methodologies within specific regional areas.

Expected outcomes:

- standardized common procedures, which are applicable to the purpose of determining GES,
- practicable across the EU regions, and
- affordable regarding the national resources needed to implement them.

Project results obtained in 2021 have been published in the [Interim Report](#) and more information and project updates are available [online](#).

HELCOM BLUES

Funding origin	EU - Directorate-General for Environment of the European Commission
Lead organization	HELCOM (Baltic Marine Environment Protection Commission - Helsinki Commission)
Duration	25.1.2021 – 24.1.2023

Good environmental status (GES), and a Baltic Sea in a healthy state are at the core of the “*HELCOM Biodiversity, Litter, Underwater noise and Effective regional measures for the Baltic Sea*” (HELCOM BLUES) project. Co-funded by the European Union and led by HELCOM, started in February 2021 will run through 2023, for a total period of two years.

HELCOM Blues is a sister project of HARMONIZE and in contrast to other projects, underwater noise (Activity 4) is only one part of the project. Activity 4 is dedicated to the support for, and harmonisation of, regional work on MSFD Descriptor 11 (underwater noise) and is led by the Tallinn University of Technology (TalTech), Estonia.

Activity 4 supports the implementation of GES assessment methodology according to Descriptor 11 of the EU Marine Strategy Framework Directive (MSFD). This will be achieved by updating the soundscape maps and by using the latest available regional information on noise sensitive species and estimating their exposure to the pressure of anthropogenic noise. The modelled soundscape maps will be calibrated by the monitoring data uploaded to the ICES hosted continuous underwater noise database by HELCOM countries. Harmonisation of the measurement data through the standardization of calibration is of particular importance, in order to establish a solid foundation for successful underwater sound propagation modelling.

Impulsive noise is addressed through the further improvement of the [HELCOM registry on impulsive events](#) to increase its accuracy and allow for estimate of the effect of mitigation measures.

Expected outcomes:

- New soundscape maps
- Quantitative continuous noise assessment for HOLAS 3
- Improve calibration standards for monitoring of continuous noise
- Quantitative impulsive noise assessment for HOLAS 3

Furthermore, Activity 4 leads a quantitative assessment of continuous and impulsive noise in the Baltic Sea, building on previous work within the BalticBOOST and Life+ BIAS, EU co-financed projects as well as on the knowledge gained in the frame of HELCOM EN-Noise.

More information and project updates are available [online](#).

Navis Sonus (NAVISON)

Funding origin	European Maritime Safety Agency (EMSA)
Lead organization	JASCO Applied Sciences (Germany)
Duration	2022-2023

The Navis Sonus (NAVISON) project started in January 2022. Its objectives are to develop advanced vessel source level, acoustic propagation and sound mapping methodology and to produce sound map layers using this methodology for a wide set of vessel classes in European seas, including variants in design and operational specifications, enabling both hindcasts and forecasts. The main acoustic frequencies are 63 and 125 Hz, with a third frequency of 5000 Hz under consideration. Future variants in ship design and operations will facilitate forecasts from the present to 2050.

Expected outcomes:

- to develop advanced vessel source level, acoustic propagation and sound mapping methodology
- to produce sound map layers using this methodology for a wide set of vessel classes in European seas, including variants in design and operational specifications, for past, present and future scenarios.

JPI Oceans Action – Underwater Noise in the Marine Environment

Funding origin	Participating Member States national funds or own resources (cash or in-kind)
Lead organization	JPI-OCEANS Secretariat (Germany - Italy)
Duration	May 2020 – Dec 2025

The Joint Action Underwater Noise in the Marine Environment was adopted on 6th of May 2020 by the JPI Oceans Management Board with the purpose of promoting a pan-European, cross-disciplinary partnership, for the integration of different sectors of the scientific research community. The overarching objective of this Action is to decrease the high level of uncertainty about the impact of noise through the promotion of specific lines of scientific research, which contributes also to the implementation of the MSFD at regional sub-basin scale. It focuses on biological and interlinked implications from genes to ecosystems.

The action was initiated with two scoping workshops organized in Brussels in 2019 and in Rome in 2020. The main output of the workshops was the identification of priorities, research gaps and needs on the state of impacts, technology, sound propagation, and measurements. This preparatory work led to the launch of a [joint call](#) for proposals in December 2021. The call provides an opportunity to address a systemic approach to ocean challenges, support policy and governance, and support experimental research activities on the emerging issue of the acoustic pollution of oceans and seas. It is endorsed as a contribution to the UN Decade of Ocean Science for Sustainable Development, which means that selected projects will be endorsed as Decade Actions. The participating countries (providing national funds) are Belgium, Germany*, Ireland, Italy, Norway, Poland, Romania* and Spain (*participation subject to national approval), while UN Ocean Decade, BANOS CSA, BlueMed CSA and NOAA are external partners.

The call addresses two main challenges in the field through activities that may focus on:

- **Theme 1: Effects of anthropogenic noise pollution on marine ecosystems**
All acoustical environment components (source – medium – receiver) need to be understood for measurements and modelling. The most important anthropogenic noise sources are sonar, seismic exploration, offshore wind farms, detonations and shipping. The risk for animal populations from acoustic disturbance is a function of acoustic signal characteristics (including particle motion), biological species identity, and the ambient environmental conditions. To account for the complexity, a coordinated system approach is desirable. The evaluation of impacts should be considered in an ecological framework considering the effects on the full trophic network that connects invertebrates such as zooplankton to top predators (fish and marine mammals) and establish links to fishery activities.
- **Theme 2: Innovative seismic sources as an option for quieter and effective alternatives to conventional marine geophysical exploration**
Industry and researchers should work closely together to address the challenge of developing alternative more quiet acoustic sources for geophysical exploration of comparable efficiency, which, at the same time, cause a lower impact on marine fauna. Experimental scientific research is needed to evaluate the efficiency and impact of alternative acoustic sources, such as industrial scale marine

vibrators and other methods for acoustic energy spread-out, in comparison to existing seismic airguns.

Expected impacts:

- Improved knowledge of soundscapes at regional level, population effects, physiological diagnostics, and cumulative effects of anthropogenic noise on marine wildlife.
- Synergies between academic and industrial stakeholders in developing reasonable and efficient alternative sound sources, and comparative evaluation of impacts on marine ecosystems (e.g. marine vibrators and alternative sources for geophysical exploration).
- Improvements in the development of a regulatory framework at a sub-basin scale, shared among transnational administrations.

More information available at JPI Oceans Action [online](#).

2.3 Other relevant international initiatives

US Atlantic Deepwater Ecosystem Observatory Network (ADEON) initiative

Funding origin	US Department of the Interior- Bureau of Ocean Energy Management, US Department of Commerce- National Oceanic and Atmospheric Administration, US Office of Naval Research, US National Oceanographic Partnership Program.
Lead organization	University of New Hampshire (USA)
Duration	2016 - 2021

The Atlantic Deepwater Ecosystem Observatory Network (ADEON), for the U.S. Mid- and South Atlantic Outer Continental Shelf (OCS), was deployed in November 2017. This observatory network generated long-term measurements of both the natural and human factors active in this region, thus informing the ecology and soundscape of the OCS. These data provided a mechanistic understanding of the cumulative impacts of these factors on marine resources and provide insight for ecosystem-based management efforts. Long-term observations of living marine resources and marine sound will assist Federal agencies, including the U.S. Bureau of Ocean Energy Management, Office of Naval Research, and National Oceanic and Atmospheric Administration, in complying with mandates in the Endangered Species Act, Marine Mammal Protection Act, and Sustainable Fisheries Act.

ADEON Objectives:

1. Establish an ecosystem observation network.
2. Develop standardised measurement, processing, and visualisation metrics, for comparing ADEON observations with data from other monitoring networks.
3. Assess baseline soundscape and ecosystem conditions in support of predictive environmental modelling and trend analyses in the planning areas.
 - How do soundscape and ecosystem components vary with water depth across the OCS?
 - How do the soundscape and ecosystem components vary with latitude along the OCS?
 - Where are the hot spots of human activity for consideration in ecosystem impacts?

4. Assess the spatial and temporal distribution of the soundscape and biological scatterers with distance from the mooring locations.
 - What are the environmental factors that define and constrain the horizontal range of appropriate extrapolation of observations measured at the stationary mooring sites?
5. Develop and apply new methods for the effective visualization of 5D soundscape data to interactive analysis tools that enable users to explore, analyse, and integrate ancillary ecosystem data with the 5D soundscape.
6. Develop a robust data management system that archives and provides public access to multiple data streams to encourage future development of ecological models.

ADEON Progress in 2020-2021:

The project was completed successfully in September 2021. The final project standards are available from the project website and from the following DOI links:

TITLE	CITATION
ADEON Hardware Specification	Martin B, C.A. Hillis, J. Miksis-Olds, M.A. Ainslie, J. Warren, and K.D. Heaney (2018). ADEON Hardware Specification. Document 01412, Version 2.3. Technical report by JASCO Applied Sciences for ADEON. https://doi.org/10.6084/m9.figshare.6809711
ADEON Underwater Soundscape and Modeling Metadata Standard	Ainslie, M.A., Miksis-Olds, J.L., Martin, B., Heaney, K., de Jong, C.A.F., von Benda-Beckmann, A.M., and Lyons, A.P. 2018. ADEON Underwater Soundscape and Modeling Metadata Standard. Version 1.0. Technical report by JASCO Applied Sciences for ADEON Prime Contract No. M16PC00003. https://doi.org/10.6084/m9.figshare.6792359.v2
ADEON Calibration and Deployment Good Practice Guide	Warren, J.D., Ainslie, M.A., Miksis-Olds, J.L., Martin, B., and Heaney, K.D. (2018). ADEON Calibration and Deployment Good Practice Guide. Version 1.0. Technical report by Stony Brook University for ADEON Prime Contract No. M16PC00003. https://doi.org/10.6084/m9.figshare.6793745
ADEON Data Processing Specification	Heaney, K., Martin, B., Miksis-Olds, J., Ainslie, M., Moore, T., and Warren, J. 2020. ADEON Data Processing Specification, Version 1.0 FINAL. Technical report by Applied Ocean Sciences for Prime Contract No. M16PC00003. https://doi.org/10.6084/m9.figshare.12412610.v1
ADEON Project Dictionary: Terminology Standard.	Ainslie, M.A., C.A.F. de Jong, S.B. Martin, J.L. Miksis-Olds, J.D. Warren, K.D. Heaney, C.A. Hillis, and A.O. MacGillivray. 2020. ADEON Project Dictionary: Terminology Standard. Document 02075, Version 1.0. Technical report by JASCO Applied Sciences for ADEON. https://doi.org/10.6084/m9.figshare.12436199.v2

More information and reports available at [website](#).

The International Quiet Ocean Experiment (IQOE) initiative

Funding origin	Alfred P. Sloan Foundation provided funding for the development of IQOE. SCOR and POGO are contributing additional resources for implementation.
Lead organization	Scientific Committee on Oceanic Research (SCOR) and the Partnership for Observation of the Global Oceans (POGO)
Duration	2011 - ongoing

The International Quiet Ocean Experiment (IQOE) is an international scientific program to promote research, observations, and modelling to improve understanding of ocean soundscapes and effects of sound on marine organisms. The IQOE was started as initiative of the Scientific Committee on Ocean Research (SCOR), USA, as (one of the) first initiatives to bring together scientists who study sound in the ocean at a large scale. IQOE will use a variety of approaches to implement the project, including working groups.

In 2021 the IQOE co-ordinated the efforts to bring together various investigations into the effects of the Covid-19 pandemic (via shipping) on underwater noise. The IQOE website gives access to a number of papers on this topic.

The following working groups have been established:

Acoustic Measurement of Ocean Biodiversity Hotspots

Several types of ocean environments have high biodiversity, such as coral and deep-water reefs, mangrove forests, and kelp forests. These areas are important to human society and for functioning of ocean ecosystems, but are endangered by local, regional, and global changes. Assessment of the biodiversity of ocean areas is hindered by the requirement for frequent observations by human divers. However, many organisms in these areas make sounds that can be measured continuously. This working group aims to develop the potential to monitor sound high-diversity ocean areas continuously to help characterize and understand biodiversity.

Arctic Acoustic Environment

The Arctic Ocean remains relatively pristine acoustically. However, the warming and decrease in ice cover across its basins will change its acoustic properties. Meanwhile, oil and gas exploration, shipping, tourism, and other sound-producing activities may increase. This working group aims to produce an acoustic baseline against which future sound increases can be compared.

Data Management and Access

A goal of the IQOE is to create time series of acoustic data in key locations of the global ocean to document how sound in the ocean has changed over time. The IQOE aims to notably increase the openly available and easily accessible acoustic observations and related biological and experimental results. This working group will develop data management and data access policies for scientists and data centres involved in the program.

POGO Working Group

This working group of the Partnership for Observation of the Global Oceans (POGO) implemented specific elements of the IQOE Science Plan related to capabilities of POGO member institutions. This working group (1) led an effort to create an Essential Ocean Variable

(EOV) related to sound, for use by the Global Ocean Observing System; and (2) revised the list of passive acoustic observing assets first presented in Appendix 2 of the IQOE Science Plan and made this updatable online.

Standardization

Standardization of experimental protocols and observational techniques and calibration of instrumentation (such as acoustic recorders) enable comparison of results. This working group will recommend best practices for experiments, observation, reporting, and other means to ensure that results are comparable and can be integrated to standardize data across large spatial and long-time scales.

Marine Bioacoustical Standardization

Observations and experiments related to sound production and sensing by marine organisms use a variety of methods and measures, making it difficult to compare results from different locations. This working group has been developed to make bioacoustic measurements more comparable.

Relevant information and public documents are available [online](#).

NOAA/NPS Ocean Noise Reference Station Network

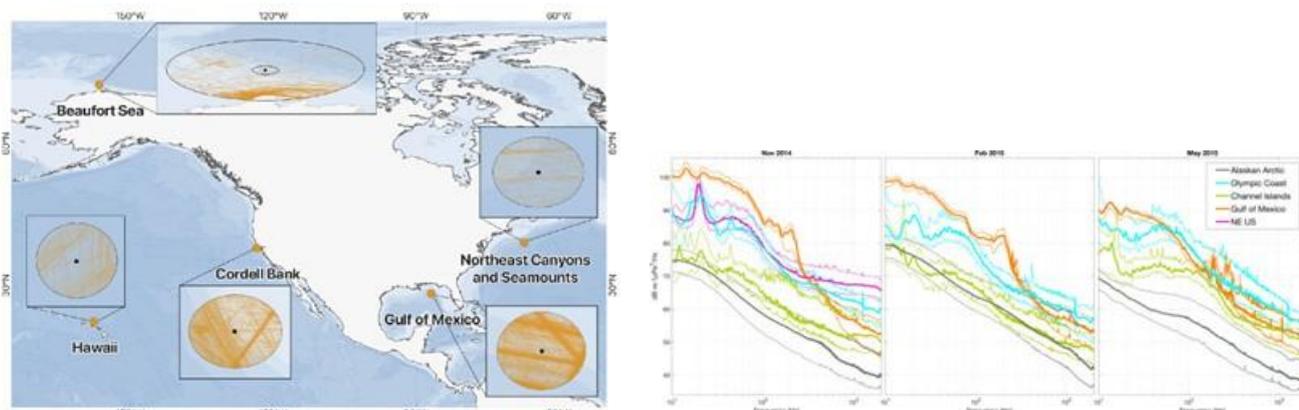
This network of hydrophones is a collaborative effort between the Office of Oceanic and Atmospheric Research (OAR) of the Pacific Marine Environmental Laboratory (PMEL), all National Marine Fisheries Science Centers, the NOAA's National Ocean Service National Marine Sanctuary System, and the U.S. National Park Service to establish and collect consistent and comparable long-term acoustic data sets covering all major regions of the U.S. A.



Network of permanent hydrophones in U.S. Exclusive Economic Zone designated as NOAA/NPS Ocean Noise Reference Stations. Source : <https://www.pmel.noaa.gov/acoustics/noaanps-ocean-noise-reference-station-network>

This network of reference stations is used to detect and characterize: (1) sounds produced and used by living marine resources (e.g., endangered marine mammals); (2) natural sources of noise from physical oceanographic processes; and (3) anthropogenic noise sources that contribute to the overall ocean noise environment. The overall objective is to monitor long-term changes and trends in the underwater ambient sound field.

All data from the NRS network are available from NOAA's National Centers for Environmental Information [Passive Acoustic Archive](#). Two recent publications focused on an assessment of [shipping-influenced ambient levels in U.S. waters](#) ranging from Arctic (less impacted) to the Gulf of Mexico (more impacted) and highlighting the role of [centralized data management](#) to support sound level attribute comparison across wide-ranging longer term monitoring assets.



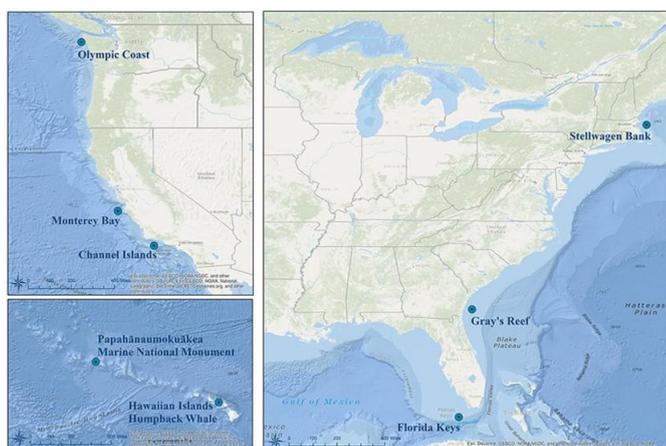
Have et al 2021 Large Vessel Activity and Low-Frequency Underwater Sound Benchmarks in United States Waters

More details are available [online](#).

Sanctuary Soundscape Monitoring Program

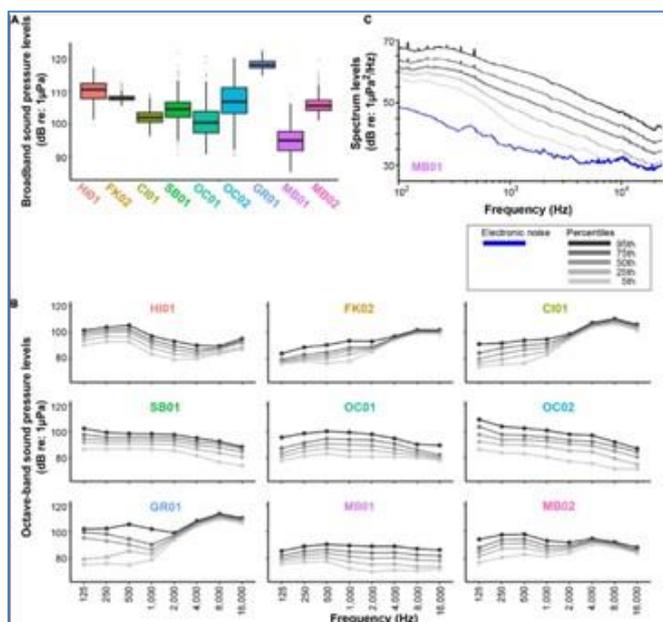
SanctSound is a four-year project, managed by NOAA and the U.S. Navy, to better understand underwater sound within national marine sanctuaries. Between all of 2018, and spring of 2022, the agencies are working with over 50 scientific partners from over 20 institutions to study sound within seven national marine sanctuaries and one marine national monument, in waters off Hawaii and the East and West coasts.

Standardized measurements are extracted to assess sounds produced by marine animals, physical processes (e.g., wind and waves), and human activities. Collectively, this information will help NOAA and the Navy measure sound levels and baseline acoustic conditions in sanctuaries. This work is a continuation of ongoing [Navy](#) and [NOAA](#) monitoring and research, including efforts by [NOAA's Office of National Marine Sanctuaries](#).



U. S. National Marine Sanctuaries participating in the Sanctuary Soundscape Monitoring Program. Upper left: (West Coast) Olympic Coast, Monterey Bay, and Channel Islands national marine sanctuaries; lower left: (Pacific Islands Region) Hawaiian Islands Humpback Whale National Marine Sanctuary and Papahānaumokuākea Marine National Monument; right: (East Coast) Stellwagen Bank, Gray's Reef, Florida Keys national marine sanctuaries. Source: NOAA.

Recent publications based on SanctSound data have highlighted [national scale comparison of sound level results as well as interpretation complexities](#) for shallow water natural resource managers and opportunities for new approaches.



McKenna et al. 2021. Advancing the Interpretation of Shallow Water Marine Soundscapes. This work was also highlighted in a [news story](#) published by NOAA.

SanctSound recordings are available for download through NOAA’s National Centers for Environmental Information [Passive Acoustic Archive](#). The project will culminate in spring 2022 with public release of a data portal through NOAA’s [Integrated Ocean Observing System](#), providing explanation, exploration and download capability for all data products, ranging from sound levels to detections to sound clips. Additional contextual data assets will also be explorable through the portal, including vessel tracking summaries and sound propagation modelling results.

The project has presented a [web-based series of new stories](#) showcasing the application of its results to questions of importance to natural resource managers at individual sanctuaries and for the sanctuary system as a whole. In addition, a [StoryMap](#) provides an overview of the project.

More details are available [online](#).

UN Ocean Decade Endorsed Programme: Ocean Decade Research Programme on the Maritime Acoustic Environment (UN-MAE)

Led by the US Interagency Working Group for Ocean Sound and Marine Life, the programme aims to begin in January 2022 to support international partnership on underwater sound characterization and application of a global growth in knowledge and training to improved human relationship to the sea.

Sound is a persistent yet dynamic component of the maritime environment reflecting both physical and biological properties and phenomenology that define oceanography. Understanding sound in the ocean is critical to support users of, and life within, the ocean. The UN Research Programme on the Maritime Acoustic Environment will establish a comprehensive science-based program aimed at measuring and

objectively characterizing underwater acoustic environments – the physical, biological and anthropogenic – at regional to global scales. It will foster new scientific knowledge, technologies, approaches to data collection and dissemination that facilitate the use of sound for analyzing, evaluating and predicting ocean-life systems.

MAMP – Marine Animal Movement Portal

Funding origin	PETROMAKS2 — program petroleum
Lead organization	DHI (Norway)
Duration	2016 - ongoing

To support better environmental management, DHI created the Marine Animal Movement Portal (MAMP). This web-based tool allows accessing state-of-the art data on the movements of fish, seabirds and marine mammals and model their response to stressors like underwater noise and oil spills. The portal uses a combination of advanced dynamic habitat and agent-based modelling to provide a comprehensive description of the presence and movement of vulnerable species. creates better understanding and reduced the uncertainty of the environmental studies. This can lead to swifter permitting while simultaneously protecting marine life.

The first MAMP module is covering the Barents Sea. Further modules covering the North Sea and other areas are under development. To learn more visit: [MAMP](#)

ISO TC 43/SC 3/WG 5 Underwater acoustics — measurement of underwater ambient sound

Funding origin	Multiple sponsors
Working Group Convenor	Michael Ainslie, JASCO Applied Sciences
Duration	2021 - 2024

Worldwide there is an increasing awareness and concern for possible effects of noise-related impacts from the addition of anthropogenic underwater sound in marine environments.

For example, in the EU, the Marine Strategy Framework Directive requires Member States to achieve or maintain Good Environmental Status (GES) by the year 2020. GES has 11 Descriptors, of which one, Descriptor 11, (“Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment”) relates to underwater noise. As a result of a European Commission Decision in 2010, Member States must monitor trends in ‘Continuous low frequency sound’ and they must do so at a regional level, requiring international collaboration and standardization of monitoring methods.

The U.S. National Oceanic and Atmospheric Administration (NOAA) has published a forward looking Ocean Noise Strategy to provide long term direction to NOAA’s management of Ocean Noise. A framework for ocean noise monitoring has been developed in U.S. waters in which methods and techniques have been outlined for characterizing and monitoring marine soundscapes.

Australia has developed an Integrated Marine Observing System (IMOS), with three moored acoustic observatories. These observatories can be moved, and are currently placed on the east coast, north of Sydney, on the south coast, near Victoria, and on the south west coast, close to Perth. The purpose of IMOS is to understand background noise (noise in absence of identifiable sources) and then deal with identifiable sources separately.

Fisheries and Oceans Canada (DFO) has published a discussion document ‘Ocean Noise Strategy for Canada’, with broadly ranging objectives covering science research and technology development, impact assessment and management, and outreach and communication.

Recognizing the need for international compatibility between national observation systems, the International Organization of Standardization (ISO) is developing an international standard to measure ambient sound. A Draft International Standard (DIS) is scheduled for May 2023, with the publication of the standard itself planned for July 2024.

Information about the ISO working groups developing standards in underwater acoustics is available [online](#).

3. Acronyms

ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea, the Mediterranean Sea and the contiguous Atlantic area
ADEON	Atlantic Deepwater Ecosystem Observatory Network
AGESCIC	Achieve Good Environmental Status for Coastal Infrastructure Construction
AQUO	Achieve Quieter Oceans by shipping noise footprint reduction
Baltic BOOST	Best Practices for Action Plans to Develop Integrated, Regional Monitoring Programmes, Coordinated Programmes of Measures and Addressing Data and Knowledge Gaps in Coastal and Marine Waters
BIAS	Baltic Sea Information on the Acoustic Soundscape
CMEMS	Copernicus Marine Environment Monitoring Service
DEPONS	Disturbance Effects on the Harbour Porpoise Population in the North Sea
EMODnet	European Marine Observation and Data Network
GES	Good Environmental Status
LIDO	Listening to the Deep-Ocean Environment
MSFD	Marine Strategy Framework Directive
MarVEN	Environmental Impacts of Noise, Vibrations and Electromagnetic Emissions from Marine Renewable Energy
NOAA	National Oceanographic and Atmospheric Administration (US)
HELCOM	Baltic Marine Environment Protection Commission - Helsinki Commission
HELCOM EN-Noise	HELCOM Expert Network on Underwater Noise
ICES	International Council for the Exploration of the Sea
ICG-Noise	Intersessional Correspondence Group on Underwater Noise (ICG-Noise)
IQOE	International Quiet Ocean Experiment
JRC	Joint Research Centre
JOMOPANS	Joint Monitoring Programme for Ambient Noise North Sea
JONAS	Joint programme for Ocean Noise in the Atlantic Seas
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PIAQUO	Practical Implementation of AQUO
QUIETMED	Joint programme on noise (D11) for the implementation of the Second Cycle of the MSFD in the Mediterranean Sea
QUIETSEAS	Assisting (sub) regional cooperation for the practical implementation of the MSFD second cycle by providing methods and tools for D11 (underwater noise)

SATURN	Developing solutions to underwater radiated noise
SHEBA	Sustainable shipping and environment of the Baltic Sea region
SONIC	Suppression of Underwater Noise Induced by Cavitation
TG NOISE	Technical Group on Underwater Noise
UNAC-LOW	Underwater acoustic calibration standards for frequencies below 1 kHz
URN	Underwater Radiated Noise

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