



Marine Strategy Framework Directive (MSFD)

Common Implementation Strategy

20th Meeting of the Marine Strategy Coordination Group (MSCG)

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The MSCG will be invited to:

- Take note of the document and disseminate as appropriate.

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**

Communication Report

April 2017

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1. Introduction & Context

In 2008, the Marine Strategy Framework Directive entered into force (MSFD: 2008/56/EC), requiring all EU Member States (MS) to reach or maintain good environmental status (GES) by 2020. European seas in good environmental status should be clean, healthy and productive. The MSFD provides eleven descriptors to further describe GES. All MS have to develop marine strategies to achieve the good environmental status of their marine waters. To define and set up good environmental status, MS have to work with criteria and methodological standards for each descriptor in their marine strategies. The Directive requires MS to work together at European and regional levels to ensure a coherent implementation of the Directive.

Descriptor 11 focuses on the energy in the marine environment, including underwater noise and describes two types of underwater sound, each with one indicator: loud, low- and mid-frequency impulsive sounds (11.1.1) and continuous low frequency sound (11.2.1), widely referred to as “low frequency ambient noise”. In 2014, the EU Technical Group on Underwater Noise¹ (TG NOISE) delivered the guidance document: *Monitoring Guidance for Underwater Noise in European Seas*.

Following this guidance, EU-funded projects and other scientific work in the field of underwater sound, TG NOISE compiled this paper to communicate the outcomes of relevant ongoing and future projects.

This report aims to be useful to experts, to policy makers, and to those who are directly or indirectly supporting Member States authorities in implementing the MSFD, in particular on monitoring and measures relevant to underwater sound.

Impulsive Sound

Regarding high intensity, low and mid-frequency impulsive sounds, the monitoring will be done in the form of a register of activities that generate such sounds. Seismic survey, pile-driving, explosives, sonars working at relevant frequencies and some acoustic deterrent devices are the most important sound-sources that should be considered for inclusion in the register. In the Baltic Sea and North-East Atlantic Ocean regions, a register for impulsive sound is now available at the International Council for the Exploration of the Sea (ICES). This has been funded by OSPAR and HELCOM. In the Mediterranean and Black Seas, efforts are also being made to establish a register for impulsive sound.

Ambient Sound

Ambient sound is caused by both natural and anthropogenic sources. Current ambient sound levels in European marine waters and their impact on the ecosystem are largely unknown. Anthropogenic activities such as shipping, military activities, construction work and oil and gas exploration lead to an increase of underwater sound. In most areas with intensive human activities, these anthropogenic sound sources tend to dominate natural sound sources at the low frequencies specified for monitoring. At other, higher frequencies, natural sounds tend to dominate. Due to the

¹ Technical groups have been assigned on technical tasks for specific emerging issues, under the common implementation strategy of MSFD, established by Member States and the European Commission.

widespread character of sound assessments, monitoring ambient sound should normally be done at the sub-regional or regional scale. For monitoring ambient sound there are opportunities emerging to set up joint monitoring programmes from the onset; one key example is the BIAS project, as well as new project initiatives that are now being developed at a regional scale.

2. Underwater Noise: Key Projects and Initiatives

A selection of key projects and initiatives and their relevant knowledge results for the implementation of Descriptor 11 – Underwater noise: impulsive sound and continuous sound (indicator 11.1.1 and 11.1.2, respectively) are presented. Their findings and outputs are made accessible and therefore available to ensure transparency and replicability.

2.1 Completed Projects & Initiatives in European marine waters

BIAS - Baltic Sea Information on the Acoustic Soundscape (2013-2016)

The BIAS project (an EU LIFE+ funded collaborative 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 ambient sound baseline.

BIAS focused exclusively on the monitoring of continuous low frequency sound (ambient 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 ships in some parts of the Baltic is one of the highest in Europe. It is estimated that about 2000 sizeable ships are at sea at any one time.

The regional approach of BIAS was important for several reasons. First, the MSFD specifies 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 and each therefore 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 compared with the alternative of multiple national approaches.

The objectives of BIAS were formulated to create the foundation for an efficient joint management of underwater sound in the Baltic Sea by elucidating, and solving, the major challenges in the monitoring of ambient noise. 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 where autonomous hydrophones were deployed at 36 locations offshore throughout the Baltic Sea in 2014. 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 level as well as to “calibrate” a numerical model of sound in the Baltic Sea. Soundscape maps were produced for the whole 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.

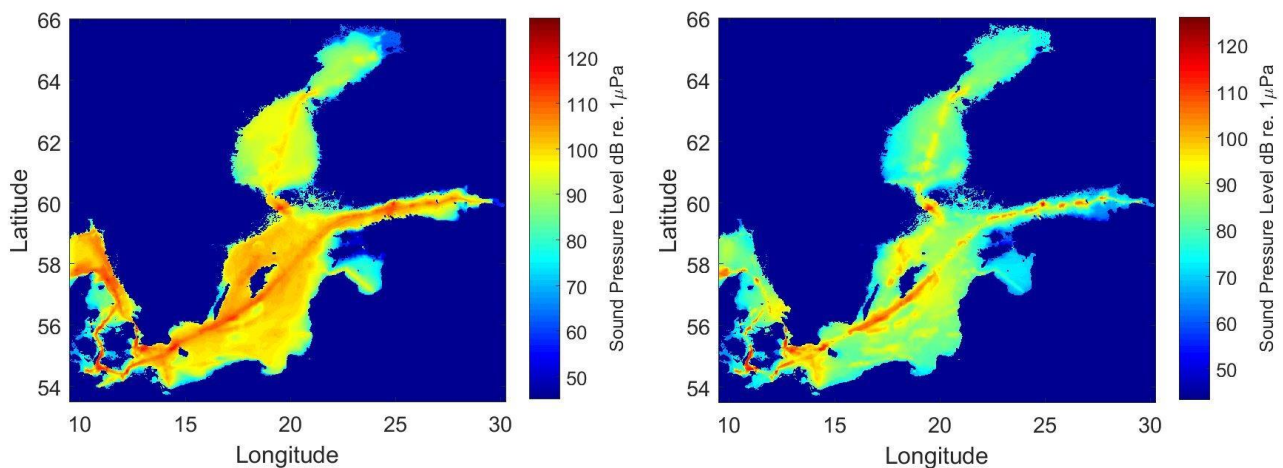


Figure 1. Soundscape maps of the monthly average sound pressure level during 2014, February (left) and August (right), for the 1/3 octave band 125 Hz, estimated over the whole water column. Color-codes denotes the decibel level in each geographical position. These sound levels occurs 25 percent of the time or more. Blue-turquoise colour shows the natural ambient noise 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 the sound from the shipping lanes, but that there are large variations in sound level both over time and space, due to variations in ship traffic and in the 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. The newly developed tool can be used to analyse the soundscape both spatially and temporally and, hence, 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 been 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.

Topics of relevance:

- ✓ 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 very 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 ambient noise. 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 available through the BIAS website (see link below).
- ✓ Implications/lessons learned for new projects: BIAS learned much during its implementation that will be 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 relevant public documents produced by BIAS are available at the project webpage

www.bias-project.eu >> Downloads >> Deliverables

AQUO - Achieve Quieter Oceans by shipping noise footprint reduction (2012-2015)

The AQUO project has provided policy makers 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 such as : Anave, Confitarma, Armateurs de France, Engie, STX France, HHI, SHI, IHC, CMA CGM, NOAA, Port of Vancouver, etc.

AQUO experts have developed tools to assess not only the current situation with regards to the anthropogenic sound from shipping at a whole basin scale, but the quantitative tools that would enable policy makers to assess scenarios with different measures in the concerned area. Those scenarios include solutions either linked to ship design (including structure and machinery, propeller

design and other sound and vibration contributors), and solutions related to shipping control and regulation.

The solution portfolio aimed at the needs of several levels of maritime industry and were addressed with consideration of cost effectiveness (ensuring both fuel efficiency and noise mitigation reductions) and of fleet applicability (new builds or existing). 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 to be able to quantify the effects on the fauna of a given scenario in a given area.

Topics of relevance:

The project main outcomes include:

- a shipping underwater sound footprint assessment tool using actual ship 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 radiated by ships, quantifying in situ uncertainties from onsite experiments, including both deep and shallow water conditions that 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 bioacoustic 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 at www.aquo.eu.

SONIC – Suppression of Underwater Noise Induced by Cavitation (2012-2015)

The first goal of SONIC has been to enhance the understanding of underwater radiated sound from ships and shipping. The project aimed to improve computational and measurement techniques (full scale and model scale) to determine underwater radiated noise level, to be used at the ship design phase. Subsequently these methods were applied to potential noise mitigation measures to study the effect of these design and operational measures. The resulting knowledge has been summarised in a

set of guidelines for underwater radiated sound, developed in close collaboration with the AQUO project.

A shipping sound footprint and mapping tool (NFMT) has been developed, implemented and tested for a number of benchmark scenarios. Vessel Sound Footprints and shipping sound maps have been generated to compare the effectiveness of different noise mitigation measures. Model scale experimental tools have been improved to measure the radiated propeller cavitation sound at partner test facilities. Techniques have been developed to remove the effects of background sound and reflections from the measurements. A suitable scale model test has been performed in each facility for various test conditions. Seven different approaches to the computational prediction of cavitation sound have been developed and applied to the suitable test case.

Measurements of radiated sound from a full scale test ship have been carried out using on-board sensors and off-board hydrophone arrays. These data have been used to validate the experimental and computational results. The radiated sound from a variety of larger merchant ships have been measured near a shipping lane off the Dutch coast. The measurement data are published in the SONIC public database of ship radiated sound data.

The numerical and experimental techniques to determine radiated sound have been applied to investigate the effectiveness of several noise mitigation measures. Technical measures to reduce the cavitation and machinery noise have been studied as well as operational measures. For the operational measures, it was shown that spatial planning can significantly reduce the underwater sound levels in specific marine areas.

Topics of relevance:

- the tools produced by SONIC should help to investigate and may help to mitigate the effects of underwater noise generated by shipping, both in terms of the footprint of an individual ship (a sound footprint) and of the spatial distribution (a map) of sound from many ships contributing to ambient sound.

The relevant documents and reports produced by SONIC are available at:

<https://www.dnvgl.com/maritime/research-and-development/guideline-underwater-noise.html>

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 requested 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.
- Ship owners 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 policy makers 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.

The AQUO-SONIC Guideline Document is available at http://www.aquo.eu/downloads/AQUO-SONIC%20Guidelines_v4.3.pdf

MaRVEN – Environmental Impacts of Noise, Vibrations and Electromagnetic Emissions from Marine Renewable Energy- European Commission, Directorate-General for Research and Innovation (2013-2015)

DHI group 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

Topics of relevance:

- 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.

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

Impacts of noise and use of propagation models to predict the recipient side of noise (ENV.D.2/FRA/2012/0025)

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.

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 presents the findings and roadmap are available at the [JRC / MSFD Competence Centre website](#).

Topics of relevance: The roadmap consists of the following four Actions:

1. **Agree standards for underwater sound monitoring.** It is important for GES assessment that sound levels are measured consistently by Member States. No suitable international standard exists for sound monitoring, and a general standard may in any case be incompatible with the requirements of the MSFD.
2. **Commission studies to address knowledge gaps.** Targeted studies are needed to reduce the uncertainties that constrain management decisions relating to underwater sound. There are several suitable EU funding mechanisms which could be used to address the knowledge gaps outlined above.
3. **Agree common standards for sound monitoring instruments.** There are a range of commercially available devices for monitoring underwater sound, and not all may be 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 must first be defined. There are 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 ambient noise need not be a 'hard threshold' above which GES is not attained, but could be expressed as a maximum proportion of time that sound levels can exceed a certain threshold.

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"

Baltic BOOST was an EU co-funded project coordinated by HELCOM. The project has recently finished (15.09.2015 – 14.12.2016) being its final report under consideration by the European Commission. Once this process is concluded the results of the project will be available at the project website (<http://www.helcom.fi/helcom-at-work/projects/baltic-boost>).

The BalticBOOST 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 has 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 have focused on strengthening HELCOM work on biodiversity and hazardous substances. The project has 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 includes 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.

Topics of relevance:

- *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 (who is hosting 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. It proposes to combine a yearly minor assessment in a few prioritised locations (11 stations) and a major assessment every e.g. six years (38 stations). Further work in HELCOM on the regional monitoring programme is envisaged for 2017-2018 including i.e. final agreement on location of stations, as part of the Work Plan for State & Conservation Working Group for 2017-2018.
- *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. It compiles and reviews the available knowledge on impact of anthropogenic noise in the Baltic Sea in the dedicated 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, 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 spatio-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. When agreed by HELCOM, the principles will be shared with other groups e.g. OSPAR and EU TG NOISE. In addition, the international framework provided by the IMO (in relation to continuous sound) could be built upon when utilising the proposed principles for further work.

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

Continued work on these principles and decision support trees will be taken forward by the HELCOM EN-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 filled in 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 and 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.

2.2 European Ongoing & New Initiatives

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

The project, funded by EU H2020 EMPIR programme, aims to develop the European metrological capacity in underwater acoustics, providing traceable measurement capabilities for calibration of hydrophones and autonomous underwater acoustic recorders.

The project will develop 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.

The project started mid 2016 for 36 months and information will be made available at <http://empir-unaclow.com/>

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

Harbour porpoises are affected by a wide range of anthropogenic disturbances such as noise from the installation of wind farms and from ships, and are often by-caught in gillnet fisheries. These factors have a direct impact on individual porpoises, but until recently their cumulative impact on a porpoise population had never been investigated. In a recent study Nabe-Nielsen et al. (2011) demonstrated how the population consequences of anthropogenic disturbances could be analysed using an individual-based simulation model, where the population size emerged from the individuals' responses to environmental variations.

The project started in November 2015. The results of the project shall be delivered to the DEPONS steering group in the form of a submission ready manuscript for a peer-reviewed scientific journal by June 2017. After the submission, the simulation framework will be updated to take advantage of the new input data; the model will be re-parameterized based on the new information, and it will be investigated how sensitive it is to variations in the size and spatial distribution of prey patches. The project will end by June 2018.

Relevant information is available at <http://depons.au.dk/currently>

LIDO – Listening to the Deep-Ocean Environment

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 (<http://antares.in2p3.fr/>) neutrino observatory, the OBSEA, Spain (<http://www.obsea.es>) shallow water test site, the NEPTUNE Canada (<http://www.neptunecanada.ca/>) observatory, the JAMSTEC, Japan (<http://www.jamstec.go.jp/e/>) network of underwater observatories and at the NEMO, Sicily (<http://nemoweb.lns.infn.it/>) site after the observatory has been redeployed. Part of the system is being tested for suitability on autonomous gliders and towed arrays in collaboration with the NURC (NATO Undersea Research Center, <http://www.nurc.nato.int/>) 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, <http://www.ctbto.org/>) 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 between 10Hz and 10 kHz, assessed using either sound energy over time (Sound Exposure Level SEL) or peak sound level of the sound source, while the Descriptor 11.2 addresses background noise without distinguishable sources that can lead to masking of biological 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, detection, classification 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 at <http://listentothedeep.com>

SHEBA - Sustainable shipping and environment of the Baltic Sea region

BONUS SHEBA aims 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 to water, to air, and of 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 is to conduct an impact assessment of ship generated underwater sound in the Baltic Sea. Further, the project will provide an integrated assessment of policy options to mitigate pressures linked to shipping, quantifying as far as possible anticipated changes in ecosystem services compared to an established baseline. This will include 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 will be developed further 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. This approach will be refined with the existing sound footprints of the Baltic Sea fleet collected in previous projects dealing with underwater sound (e.g. BIAS). By combining the sound source spectra with the Ship Traffic Emission Assessment Model (STEAM), sound source maps will be produced. These maps will be produced both for 2014 and 2015. The sound source maps will be used in studies of underwater sound propagation in two sub-regions of the Baltic Sea. The maps developed in the project will facilitate large-scale inventories of shipping sound, which will be used to assess the impact of underwater sound to the marine environment. Further, SHEBA will tackle 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 will be carried out to improve the understanding of reaction of fish in the Baltic Sea. The project runs until March 2018.

The relevant information and public documents produced by SHEBA are available from the project webpage: www.sheba-project.eu

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

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, respectively funded 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 have signed an Agreement to implement and manage the Copernicus Marine Environment Monitoring Service.

In this framework, Mercator Ocean and Quiet-Oceans have 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 will enhance the CMEMS services as provider of oceanographic nowcasting needed to provide an operational sound mapping service. The partnership will focus on demonstrations of coastal and operational sound mapping and analysis to fullfit descriptor 11.1.2 of the MSFD. In practice, Quiet-Oceans will implement the Quonops(c) Noise Prediction System and provide demonstrations of sound mapping services contributing to the implementation of the MSFD, maintain them until the end of December 2020, and promote them among National focal point for the implementation of D11 and Member States currently using the CMEMS service.

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

This project was co-funded under the DG ENV/MSFD Second Cycle/2016 programme. This project is coordinated by Centro Tecnológico Naval y del Mar (CTN) (Spain), with participants from Spain, France, Italy, Slovenia, Croatia, Greece and Malta; this project started in January 2017 and will run until the end of 2018.

The project objective is to enhance cooperation among Member States (MS) in the Mediterranean Sea 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.

More information will be available at the project website www.quietmed-project.eu.

New project initiatives: Joint Monitoring Programmes for Ambient Sound

Two complementary project initiatives have been recently submitted for funding under INTERREG for the Atlantic Area and the North Sea Region. These initiatives build upon the experience and lessons learned from the BIAS initiative in the Baltic Sea.

- ***Joint programme for Ocean Noise in the Atlantic Seas - JONAS*** (Interreg Atlantic Area) proposal submitted in December 2016. This project initiative aims to set up a joint monitoring programme in the Atlantic area and to use the data from the monitoring to produce tools for management or policy purposes in the Atlantic Area. The project coordination is currently by MAREI in Ireland with representation of all Atlantic region countries;
- ***Joint Monitoring Programme for Ambient Noise North Sea - JOMOPANS*** (Interreg North Sea Programme) project proposal submitted in February 2017 includes representatives from all countries around the North Sea. The aim of this project is to develop a framework for a fully operational joint monitoring programme for ambient sound in the North Sea. Output will be the tools needed by managers, planners and other stakeholders to incorporate the effects of ambient noise into assessments of the environmental status of the North Sea, and to evaluate measures to improve the environment.

2.3 Other ongoing and new international initiatives

US Atlantic Deepwater Ecosystem Observatory Network (ADEON) initiative

The Atlantic Deepwater Ecosystem Observatory Network (ADEON) for the U.S. Mid- and South Atlantic Outer Continental Shelf (OCS) is currently being developed and is anticipated to be deployed in the summer of 2017. This observatory network will generate 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 will provide further a mechanistic understanding of the cumulative impacts these factors have 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.

More information and reports available at website: <https://adeon.unh.edu/>

The International Quiet Ocean Experiment (IQOE) initiative

The International Quiet Ocean Experiment (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. Terms of reference and membership are being developed for the following groups:

Working Group 1: Standardisation

IQOE WG 1 will recommend best practices for experiments, observation, reporting, and other means to ensure that results are comparable and can be integrated to standardise data across large spatial and long-time scales.

Working Group 2: Data Management and Access

The IQOE aims to notably increase the openly available and easily accessible acoustic observations, including long time series, and related biological and experimental results. IQOE WG 2 will develop data management and data access policies for scientists and data centres involved in the programme.

Working Group 3: 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. IQOE WG 3 aims to produce an acoustic baseline against which future sound increases can be compared.

Working Group 4: Acoustic Measurement of Biodiversity on Coral Reefs

IQOE WG 4 aims to develop the potential to monitor sound on coral reefs continuously to help characterise reef biodiversity.

Working Group 5: Stakeholder Relations

QOE WG 6 will help the IQOE keep the range of stakeholders informed, engage them as partners as appropriate, and assure fair consideration of concerns.

POGO Working Group

This complementary WG of the Partnership for Observation of the Global Oceans aims to implement specific elements of the IQOE Science Plan related to capabilities of POGO member institutions, including approaches to assess the impact of noise exposure and acoustic monitoring methods and means to implement and improve these approaches, as well as better understanding of broad-scale issues related to ocean sound and human influences

Relevant information and public documents are available at <http://www.scor-int.org/IQOE.htm>

3. Regional Sea Conventions, International Agreements, ICES and MSFD Competence Centre

Regional Seas Conventions (RSCs) have an important role in the common implementation strategy of the Marine Strategy Framework Directive. The directive requires EU MS to coordinate their actions on marine waters in the same region and sub-regions using relevant mechanisms and structures of Regional Sea Conventions, and other relevant international forums (Article 6 of MSFD). As there is experience in coordinated monitoring, RSCs should have an important role in ensuring comparability in the monitoring programmes of EU Member States, also contracting parties of RSCs. Monitoring of underwater sound has been or is being developed in joint monitoring programmes.

In the Baltic Sea, the **HELCOM Expert Network on Underwater Noise (HELCOM EN-Noise)** supports the contracting parties in the development of a monitoring and impact assessment strategy regarding underwater noise. Progress, built on BIAS project results, is advanced in agreeing common indicators and associated monitoring.

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 and work has started to evaluate what could be the best way forward to develop impact indicators. OSPAR is building on the experience of the Joint Assessment and Monitoring Programme to further cover MSFD requirements.

The HELCOM and OSPAR work on impulsive sound monitoring has led to one combined register for impulsive sound available at the **International Council for the Exploration of the Sea (ICES)**.

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. **The ACCOBAMS Joint ACCOBAMS/ASCOBANS/CMS Working Group on Noise** 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.

TG NOISE reports regularly on update on regional initiatives to ensure progress in consistency and coherency between approaches European & Regional Seas Conventions.

The **MSFD Competence Centre** (<http://mcc.jrc.ec.europa.eu>) provides the main relevant scientific references for MSFD and includes a section on Descriptor D11. This science-policy interface facilitates cooperation and information exchange between EU countries for MSFD implementation. On this European Union site information is available on activities of the European Commission related to assessment of monitoring programmes and on work done for the revision of the Decision 2010/477/EU laying down criteria, methods and standards on good environmental status of marine waters. The revised GES decision aims to help Member States in characterising the good environmental status and in monitoring, assessing state and pressure of marine waters in a consistent and coherent way at the European scale and at regional level.

4. Main Conclusions

In the progress report sent by TG NOISE to the Marine Directors in November 2014, TG NOISE recommended that starting of monitoring of the existing indicators should be the highest priority for Member States. Since then, significant progress has been made with implementation of monitoring of underwater sound. The combined HELCOM and OSPAR Impulsive Noise Registry has become operational at ICES, the BIAS project has been completed, and concrete initiatives in the Mediterranean Sea, the North Sea and the Atlantic area are in different stages of planning and these initiatives will further expand the areas where monitoring of underwater sound is implemented.

At this stage, it has become clear that:

- 1) Monitoring programmes as these can and will deliver relevant information on underwater sound levels,

and
- 2) Joint Monitoring Programmes for underwater sound are realistic, effective and provide information for Member States that cannot be obtained by individual monitoring campaigns.

5.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
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
DEPONS	Disturbance Effects on the Harbour Porpoise Population in the North Sea
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
QUIETMED	Joint programme on noise (D11) for the implementation of the Second Cycle of the MSFD in the Mediterranean Sea
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

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