10 Years of North Sea Soundscape Monitoring

Looking back on a four-year Interreg NSR project and looking forward to the six-year monitoring cycle

Interreg
North Sea Region
Jomopans
European Regional Development Fund

EUROPEAN UNION

End Report from the
Interreg NSR
JOMOPANS project

June 2021

Contents

Preface

The North Sea is one of the busiest seas in terms of transport and maritime industries in the world (oil and gas, renewable energy, etc.) and represents a crucial asset to North Sea countries by generating economic value and employment. Increased understanding of the economic potential of the sea means that more human activities are taking place at sea. The North Sea is an important habitat for many marine species and therefore many plants and animals are at risk of being impacted by human activity. Underwater noise is recognised as one of these threats.

For marine species, the auditory senses are very important for their survival. They use sound to orient, find food and communicate. International concern therefore increasingly focuses on the negative effects of man-made sound on marine life. These effects are still largely unknown.

The two major elements, which are needed for environmental management, are the knowledge on the effects of noise on marine life (biological knowledge) and the amount of noise and the spatial and temporal distribution of it (monitoring). The Jomopans project has focussed on the latter.

This report summarises the results of the last three and a half years.

Soundscape maps are now available and give a detailed insight in the noise distribution on the North Sea. A web-based tool is available to look and analyse these maps. Jomopans brought together the advantages of both numerical modelling and measurement at sea. The way we look at underwater noise and its impact on marine life has changed and we regard it now as a serious threat.

Underwater noise is by nature and transnational problem and needs co-operation. Sound travels over large distances and is insensitive to national boundaries. Also shipping, a major source of underwater noise, is a global industry. And last, marine animals are often very mobile.

Jomopans is an example of successful international collaboration and Rijkswaterstaat is proud on the results. We plan to continue this collaboration.

I encourage all Jomopans followers to read this interesting end report and refer to all the links for more detailed information.

Katja Portegies
Director Safety and Water, Rijkswaterstaat

The challenge

The North Sea is one of the busiest marine areas in the world in terms of transport and maritime industries (oil and gas, renewable energy, etc.). It also represents a crucial asset to North Sea countries by generating economic value and employment. Many of the human activities in the North Sea are set to expand in line with the Blue Growth strategy of the European Commission. At the same time, the North Sea is an important habitat for many marine species.

Marine managers and policy makers face a significant challenge in the coming years. Increased understanding of the economic potential of the sea means that more human activities are taking place at sea. Traditionally shipping and fisheries were the major North Sea economic activities. More recently oil and gas recovery, mining for other resources (like sand and gravel) and offshore wind energy generation have also become important economic activities. However, the sea is a valuable habitat for many species that are at risk of being impacted by human activity.

Underwater sound is recognised as one of the threats associated with human activity. Sound is omnipresent in the underwater environment and can be produced by natural (waves, weather, animals) and man-made (shipping, wind farms, oil and gas activities) sources.

For some marine animals, including species of marine mammals, fish and invertebrates, the auditory senses are very important. Underwater visibility is usually very limited in both the North Sea and elsewhere and therefore animals use sound to orient, find food, communicate with potential partners and as a warning against various threats. Man-made sound can disturb one or more of these conditions essential to animal survival. Sound is therefore directly relevant for marine life, yet the impact of man-made sound on marine life is largely unknown.

The levels of man-made sound have increased over recent decades in line with increases in human activities at sea. International concern therefore increasingly focuses on the negative effects of man-made sound on marine life. Questions regarding sound sources, sound transmission, and the distributions of vulnerable species in the North Sea must all be tackled transnationally, as required by the EU Marine Strategy Framework Directive and by the OSPAR Commission. In JOMOPANS, seven countries around the North Sea are working together in a programme to monitor underwater sound. This is the first step in the assessment of sound impacts to quantify the pressure on the ecosystem by sound. The next step relates to the animals and involves the assessment of how this pressure affects individuals and populations of animals in the North Sea.

Three years of Interreg NSR project

The JOMOPANS approach

Marine managers have to find a balance between economic interests and protection of the environment at sea. For this challenging task they require accurate information about the effects of human activities on the environment to inform their decisions. This information must be collected, analysed and processed as part of a monitoring programme. In addition, the level of accuracy of the information and the knowledge gaps relevant to the decision must be identified and presented.

JOMOPANS has developed a framework for a fully operational joint monitoring programme for ambient noise in the North Sea. The project implements the monitoring strategy outlined by the European Union Technical Group on Underwater Noise (TG-Noise) (Dekeling et al., 2013). The aim of this programme is to gather information for marine managers in relation to the MSFD. MSFD monitoring is needed to evaluate and maintain a Good Environmental Status (GES).

JOMOPANS has proposed monitoring the underwater sound in the North Sea by producing monthly maps of depth-averaged sound pressure levels to which the various marine animals are exposed. These maps will enable marine managers and policy makers to identify, for the first time, where man-made noise exceeds the natural noise to levels that could adversely affect the North Sea ecosystem.

JOMOPANS combines numerical modelling and measurements at sea to provide a full overview of the North Sea soundscape. The modelling work and measurement work have been integrated into a stepwise approach, which has been developed by OSPAR to be used for the Quality Status Report 2023.

Figure 1 expresses the relationship between the different steps of the framework. It indicates whether different steps can be progressed at the same time or are dependent on each other. This OSPAR framework will fit in to the more general framework, which is under development by the European Union's TG Noise.

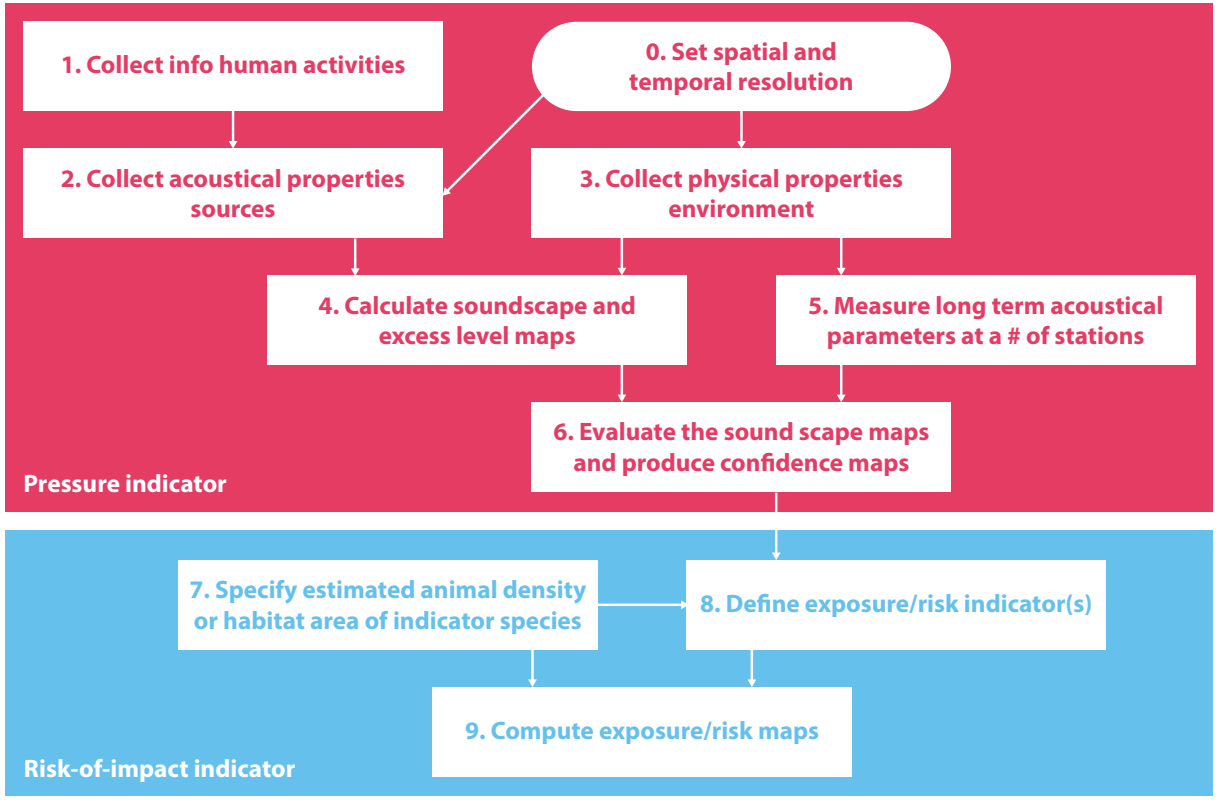


Figure 1: Framework ambient sound indicators (from Van Oostveen et al, 2020)

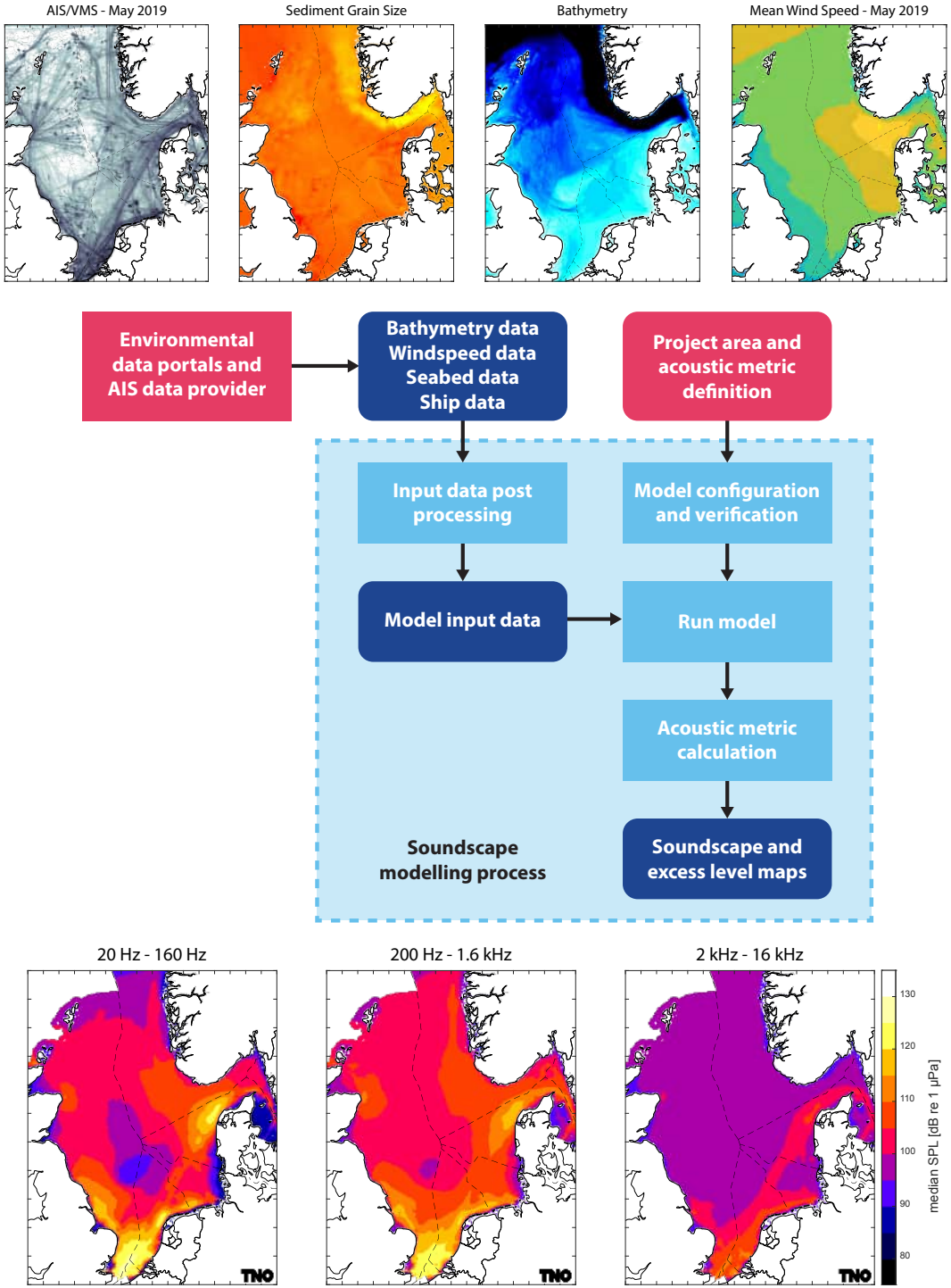
Soundscape map models

WP4

Numerical modelling is the only practical approach for monitoring underwater soundscapes at the scale of a sea basin such as the North Sea, and at sufficient temporal coverage and resolution to be able to observe trends. Numerical soundscape modelling is possible for all sound sources for data on locations and sources levels of acoustic inputs can be provided, in combination with input data for the environmental properties (such as bathymetry and sediment) that are relevant for sound propagation.

As a first step towards full soundscape modelling, JOMOPANS has built the capacity for producing maps of the sound produced by ships and wind. These are considered to be the sound sources that dominate the North Sea soundscape at many locations for a large proportion of the time. Other sound sources, such as offshore wind farms or the sound produced during offshore oil and gas exploration and production, can be added in a later stage when and where necessary. A unique semi-empirical source level model for ships has been developed on the basis of the extensive database of measurements from the ECHO programme of the Port of Vancouver and Transport Canada (MacGillivray & de Jong, 2021).

JOMOPANS proposes expressing the North Sea underwater soundscape in terms of the monthly statistics of the depth averaged sound pressure level (SPL) in selected frequency bands. The modelled soundscape maps quantify individual contributions from wind and from different ship types to the SPL statistics. This enables a comparison of (man-made) shipping noise with (natural) wind noise. The 'excess level' and 'dominance' maps in Figure 2 illustrate that the modelled shipping noise exceeds the natural wind noise for most of the month over the full North Sea area. In the Southern North Sea and in the Skagerrak the excess level is generally more than 20 dB. The 'dominance' metric provides a direct input for ambient noise assessment.



In total, JOMOPANS has produced 1248 North Sea soundscape maps for 2019, which are made available via the JOMOPANS GES tool. These maps include the 50th and 90th percentiles of the total SPL, SPL contributions of individual ship types and wind, and different versions of excess level and dominance, for six frequency bands (broadband, the two EU indicator decidecade bands and three decade bands broadly aimed at the hearing sensitivity of different animal groups) for the 12 months of 2019 and for the full year.

Based on the lessons learned from the selection of appropriate models and input data, sensitivity studies and verification and validation of the selected models, JOMOPANS has published guidelines for modelling ocean ambient noise (de Jong et al, 2021). As part of these guidelines, JOMOPANS provides two benchmark scenarios for verification of the selection of an appropriate underwater acoustic propagation model for creating shipping noise maps in shallow water, including a verification of the correct model implementation (Binnerts et al, 2019). Model-data comparisons are described in (WP6 report).

There are still many remaining issues to be solved to be able to quantify and possibly reduce uncertainties in the modelled soundscape maps. The main issues are incompleteness (missing sources), uncertainty in the input data, and uncertainties associated with the model simplifications that are required to keep the large-scale modelling manageable. Nevertheless, the JOMOPANS sound maps provide an unprecedented insight in the relevance of shipping for the North Sea sound scape.

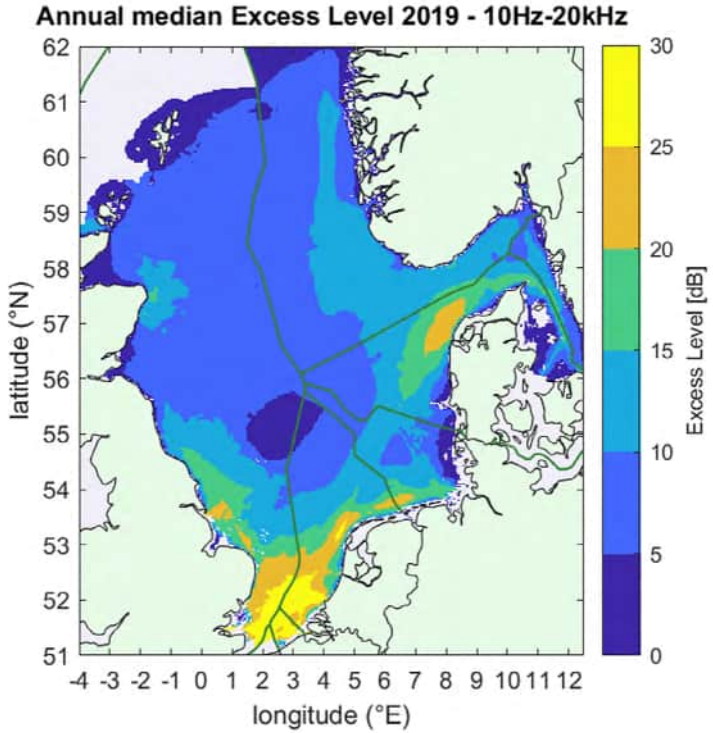
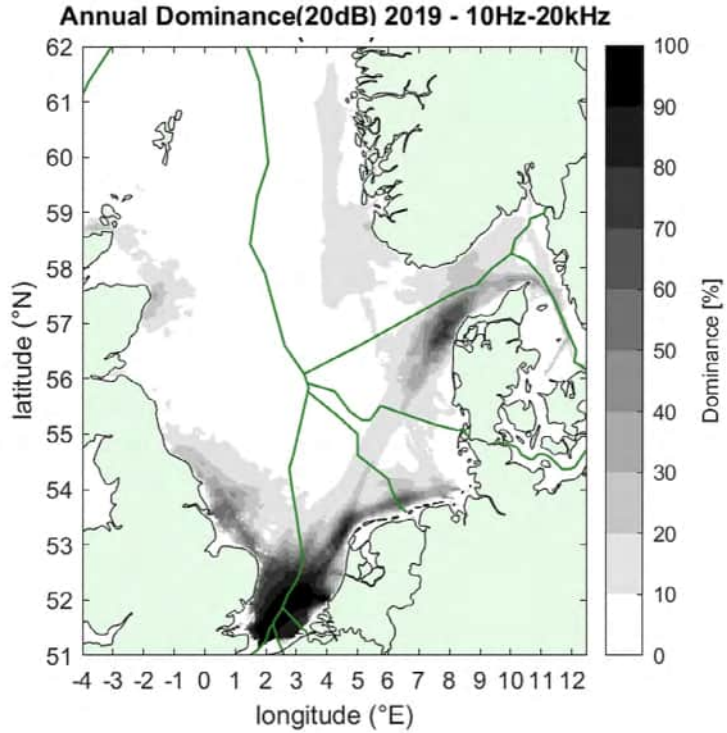


Figure 2:
Monthly median broadband excess level map, expressing the increase of underwater sound due to shipping.



Broadband dominance map, expressing the percentage of the month during which the excess level is 20 dB or more.

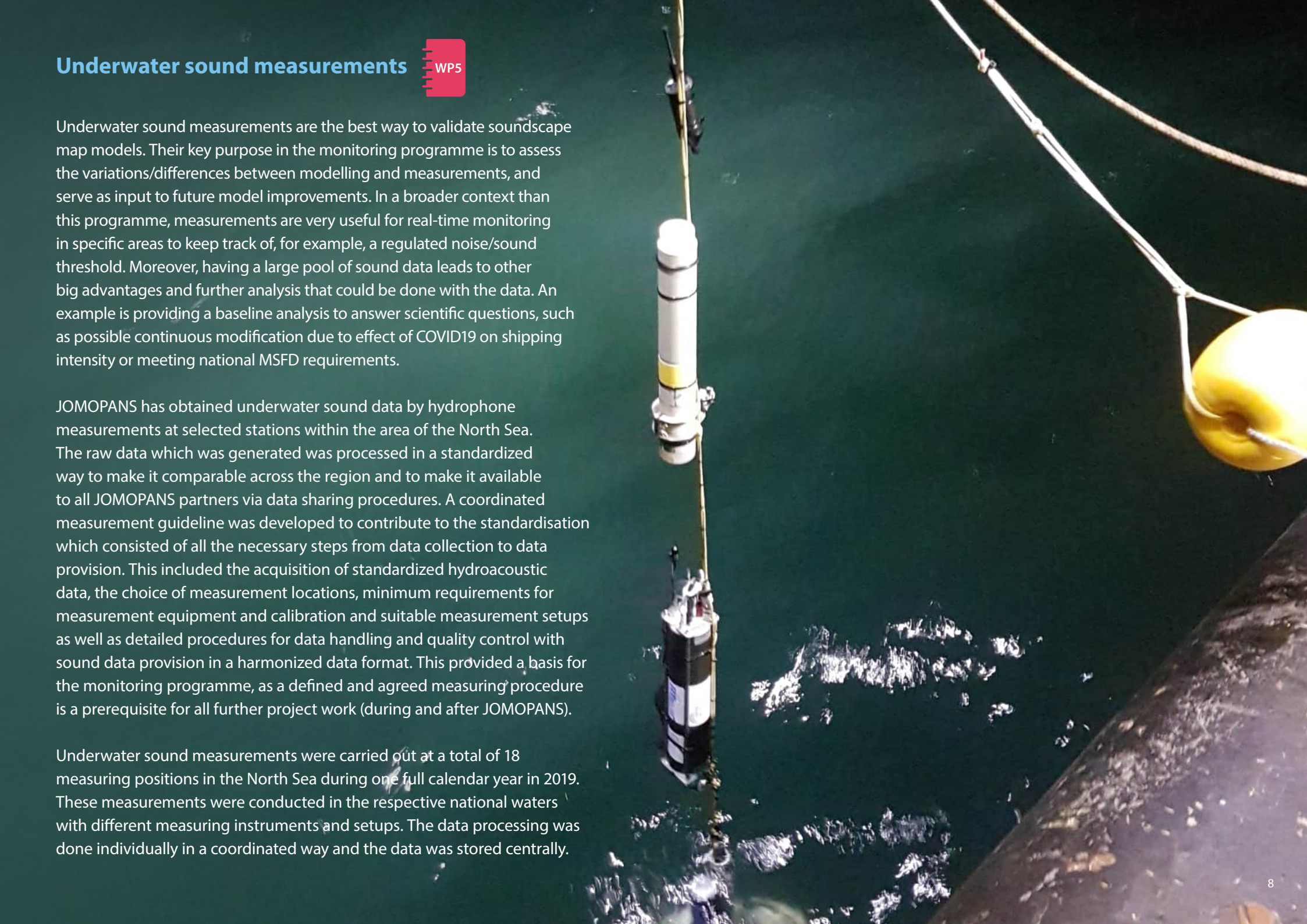
Underwater sound measurements

WP5

Underwater sound measurements are the best way to validate soundscape map models. Their key purpose in the monitoring programme is to assess the variations/differences between modelling and measurements, and serve as input to future model improvements. In a broader context than this programme, measurements are very useful for real-time monitoring in specific areas to keep track of, for example, a regulated noise/sound threshold. Moreover, having a large pool of sound data leads to other big advantages and further analysis that could be done with the data. An example is providing a baseline analysis to answer scientific questions, such as possible continuous modification due to effect of COVID19 on shipping intensity or meeting national MSFD requirements.

JOMOPANS has obtained underwater sound data by hydrophone measurements at selected stations within the area of the North Sea. The raw data which was generated was processed in a standardized way to make it comparable across the region and to make it available to all JOMOPANS partners via data sharing procedures. A coordinated measurement guideline was developed to contribute to the standardisation which consisted of all the necessary steps from data collection to data provision. This included the acquisition of standardized hydroacoustic data, the choice of measurement locations, minimum requirements for measurement equipment and calibration and suitable measurement setups as well as detailed procedures for data handling and quality control with sound data provision in a harmonized data format. This provided a basis for the monitoring programme, as a defined and agreed measuring procedure is a prerequisite for all further project work (during and after JOMOPANS).

Underwater sound measurements were carried out at a total of 18 measuring positions in the North Sea during one full calendar year in 2019. These measurements were conducted in the respective national waters with different measuring instruments and setups. The data processing was done individually in a coordinated way and the data was stored centrally.



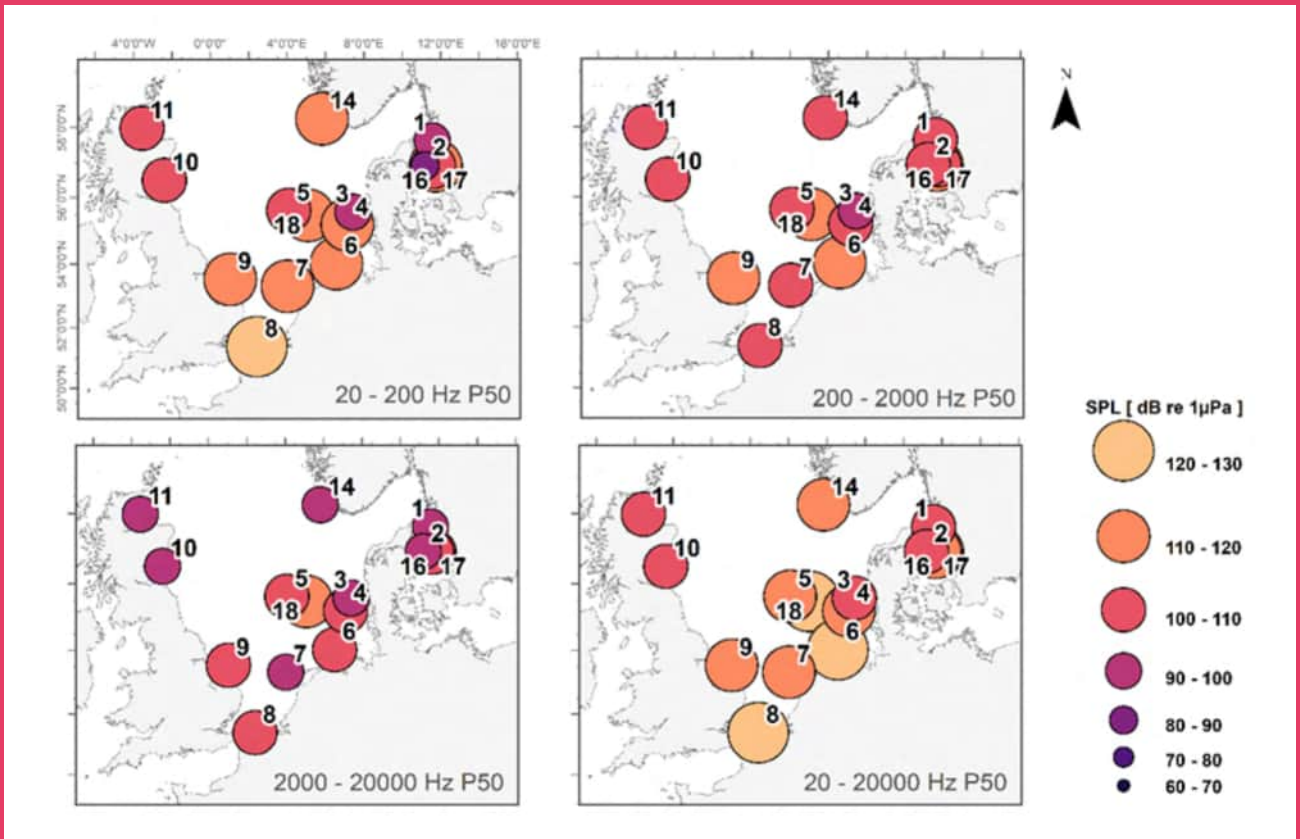


Figure 3: Sound pressure level [SPL (dB re 1 µPa)] for the 18 JOMOPANS passive acoustic monitoring stations. Each plot shows the yearly P50 value for frequencies between 20 – 200 Hz (top left), 200 – 2000 Hz (top right), 2000 – 20000 Hz (bottom left) and 20 – 20000 Hz (bottom right)

Through the JOMOPANS project a unique set of reliable and essential data has been successfully measured collectively and processed and quality controlled in a standardised way, which is not only essential for this project work, but will also be made available to the broader community after the project ends.

Considerable insight was gained from the difficulties and risks associated with installing monitoring stations at sea (rough offshore conditions can often lead to system failures) and data losses as that were experienced at some stations due to storms or fishing activities (although some were found again), or recovery delays due to weather or ship time restrictions. Furthermore, the analysis of the acquired data provided the insight that the quality evaluation methods need further harmonisation and attention to ensure the appropriate comparison against the modelled results. In particular, the identification and segmentation of source contributions (such as wind, rain, ships, but also artificial flow noise and electrical induced noise) is identified to be of key importance to learn from the vast amount of acquired data.

Validation of the soundscape maps

WP6

The soundscape maps will be used to underpin policy and regulatory decisions, which aim to reduce the impacts of underwater noise pollution on marine life. To ensure confidence in the use of these maps, it is therefore critical that they are properly ground-truthed with in situ field measurements and that the uncertainties in the maps are quantified. JOMOPANS has provided an independent validation of the noise maps produced by the modelling work, using the field data gathered within the measurement work.

The independent validation was conducted on the final soundscape maps, covering the year 2019 and using 15 JOMOPANS field monitoring stations, providing a large temporal and spatial range. Monthly percentiles of the measured and modelled data were compared within third octave frequency bands from 10 - 20,000 Hz, in decidecade frequency bands, and as broadband sound levels.

The general pattern of uncertainty showed that the model predicted sound pressure levels were lower than the measurements at low frequencies (< 1 kHz), while the model more closely agreed with the measurements at higher frequencies (> 1 kHz). The validation results highlight the difficulty of accurately predicting low-frenquency ambient noise levels, due to multiple uncertainties.

These uncertainties include the quality of AIS coverage, and the accuracy of low-frequency propagation loss estimation in shallow water, which is strongly influenced by the quality of sediment property data. Noise sources that were not included in the model also add to the uncertainty in the noise maps at low frequencies (< 1 kHz), such as:

- Vessels without active AIS transponders (mainly smaller vessels such as fishing and recreational vessels)
- Seismic surveys
- Wind farm operational noise, construction noise and service vessels
- Generator/ platform noise

The validation process highlighted limitations in both the field measurements and the acoustic modelling, both of which could be improved upon. At some sites, tidal flow noise contaminated the recordings at low frequencies, rendering parts of the recordings unusable. The limitations in modelling included shortcomings in the input data, particularly suspected gaps in the AIS ship tracking coverage and the availability of suitable sediment data, but also the inclusion of other sources of noise, such as small vessels. Overall, the analysis did not identify consistent uncertainties in noise maps; rather, uncertainties may be caused by a complex combination of factors.

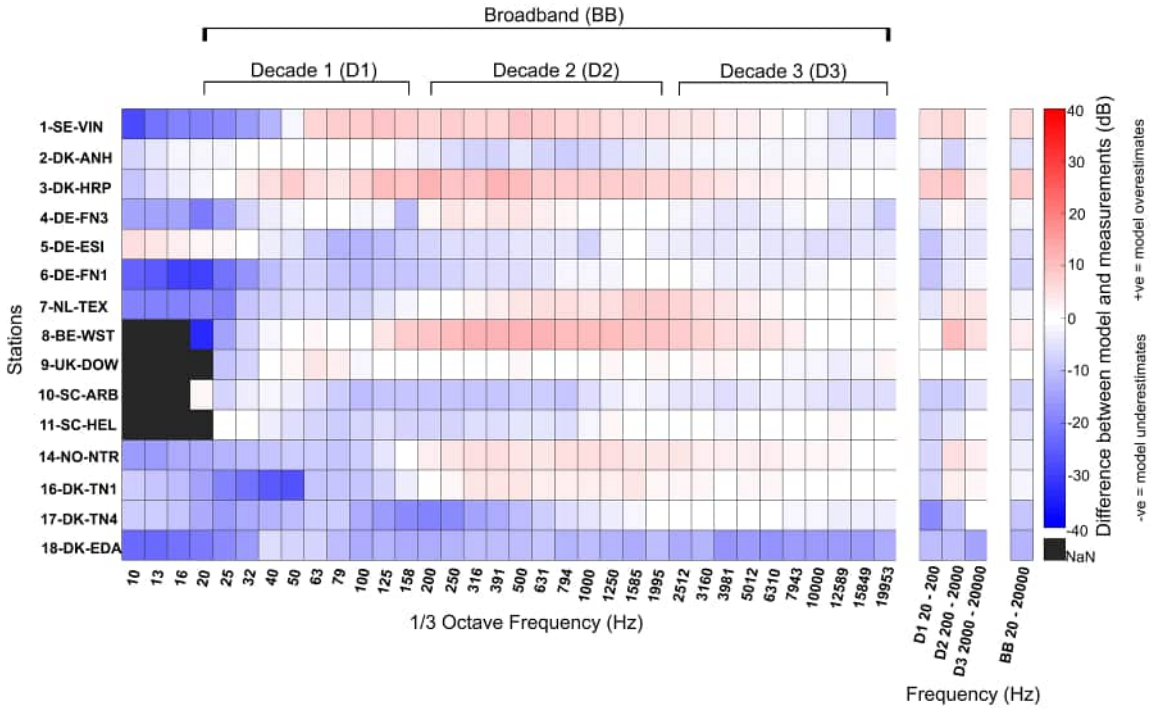


Figure 4:
P50 difference between model and measurement noise levels [dB] in 2019 for all JOMOPANS stations and frequencies (1/3 octave frequency bands, 20-200 Hz, 200 – 2000 Hz, 2000 – 20000 Hz and 20-20000 Hz). Negative values (blue) indicate measurement data was larger than model predictions and vice versa

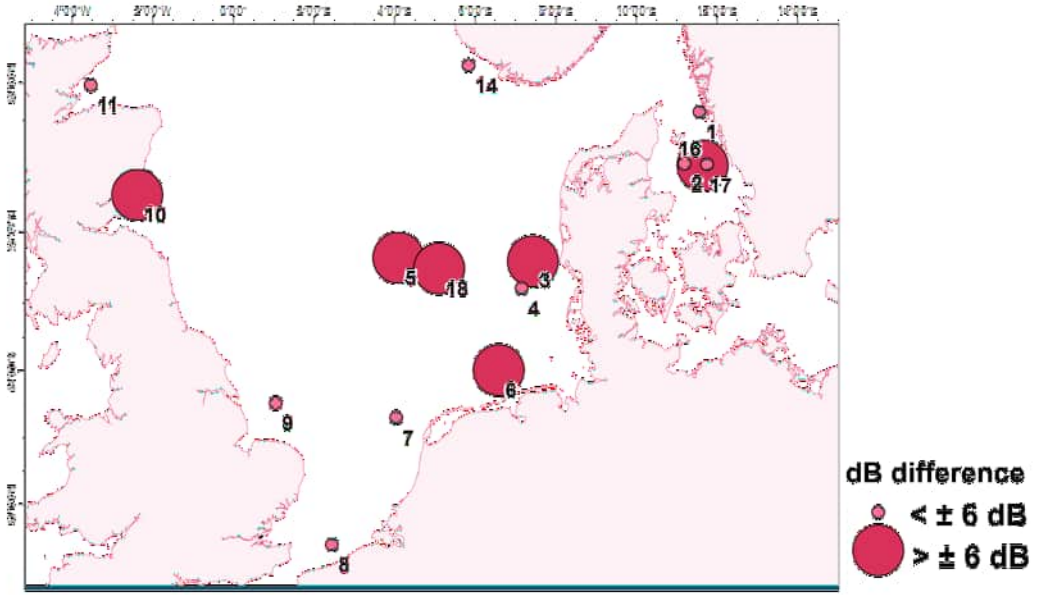


Figure 5:
dB difference for broadband frequency (20 – 20000 Hz) comparing P50 yearly measurement and model data. Possible reasons for uncertainty at individual stations: 3; proximity to an oil rig, 5; generator at platform, 6: offshore wind farm noise, 10; non AIS fishing vessels, 17; sediment uncertainty in the Kattegat, 18; seismic survey present and proximity to oil rig.

Assessment of the environmental status

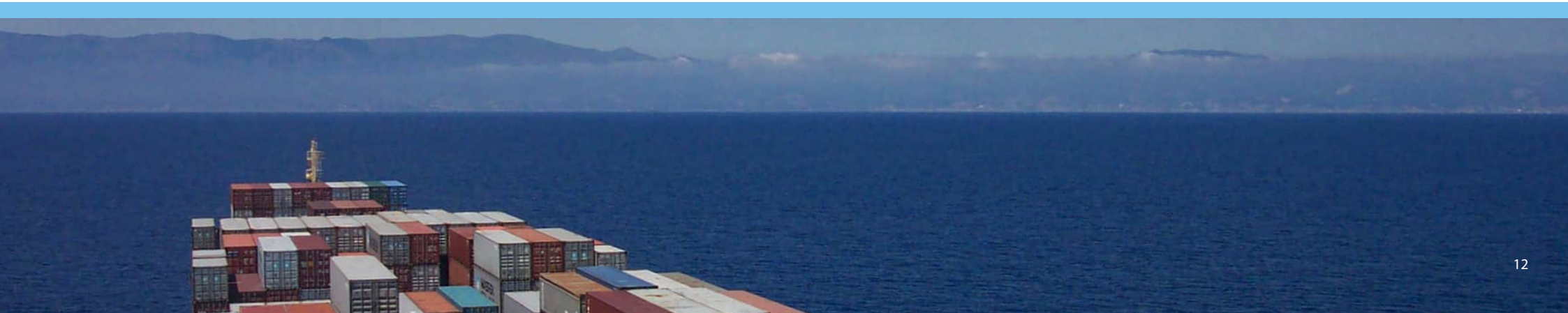
WP7

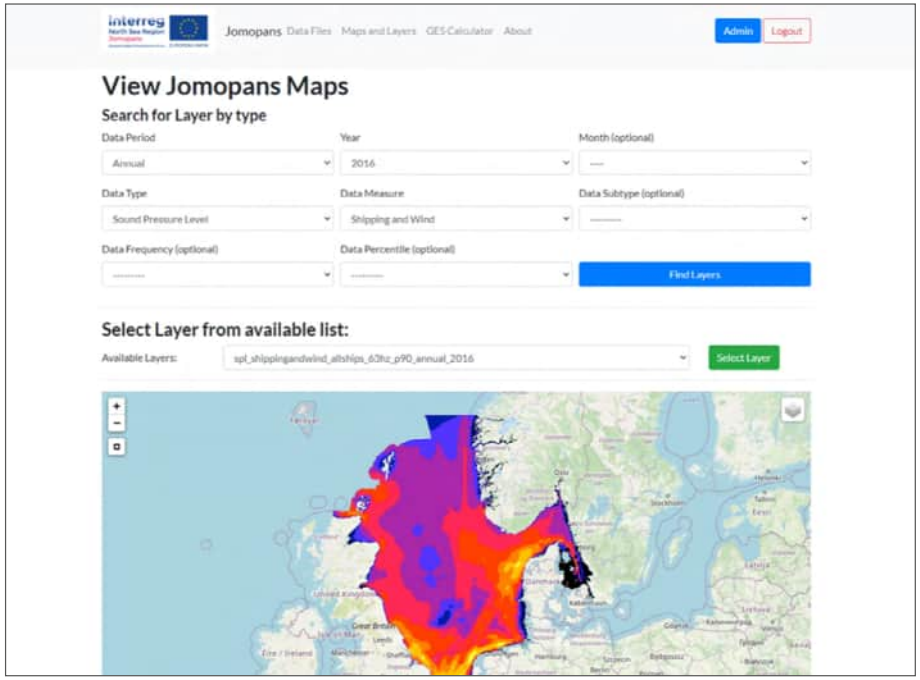
Underwater sound, both from natural and man-made sources, varies in time and space. The same is the case for animals, which may move over sometimes very large distances and show pronounced variation in abundance and distribution. This makes it challenging to assess the possible impact of man-made noise on animals: if the noise occurs in the same areas and at the same time as the animals, there is a higher risk of impact than if the noise and animals are separated in time and/or space. To address this, a core task of JOMOPANS has been to develop a tool (the so-called GES-tool) to assess spatiotemporal variation in the noise itself and to allow the noise metrics to be combined with information about animal distribution in assessment of the degree to which GES has been achieved.

Impact from underwater sound on marine animals can occur in different ways: impede detection of other sounds (masking), disturbance of behaviour, effects on stress hormone levels and ultimately acute injury to hearing organs or other biological tissue. JOMOPANS has a focus on ship noise and the principal concern in this respect is masking of communication and other sounds of importance to the animals. Masking is inherently linked to signal-to-noise ratio, i.e. the power of the signal of relevance related to the power of the noise in the relevant frequency range. If the signal-to-noise ratio is high, the receiver can easily hear the signal, but as the signal-to-noise ratio decreases, the signal gradually disappears into the noise and becomes increasingly difficult to hear. This has the consequence that for a given sound source (e.g. a whale or a fish) the maximum distance at which the sound can be heard (by another whale, fish etc.) depends on the noise level. If noise from ships in the area around the sound source is so high that the total noise level is elevated, the signal-to-noise ratio will decrease and the result is that the maximum distance at which the sound can be heard decreases as well.

Excess level, as defined in JOMOPANS, is a measure of this deterioration in maximum communication distance by noise from ships, because it expresses the elevation of the ambient noise caused by the presence of the ships. If excess is low (approaching zero when no ships are present), communication among animals is limited by their own hearing and the natural ambient noise, whereas if excess increases, communication becomes increasingly limited by the ship noise rather than the natural ambient noise.

The spatio-temporal variation in the excess level is handled in the GES-tool by the pressure function, which describes how often and how widely ship noise dominates over natural ambient noise. These curves provide a condensed summary of the ship contribution to noise in the assessment area and allows for comparisons among subareas and frequency bands. Furthermore, maps of habitat suitability for indicator species can weight the pressure curve, whereby an exposure function is obtained. The exposure function is a measure of risk of impact, as it will increase with increasing spatio-temporal overlap between high ship noise and high habitat suitability for the species in question.





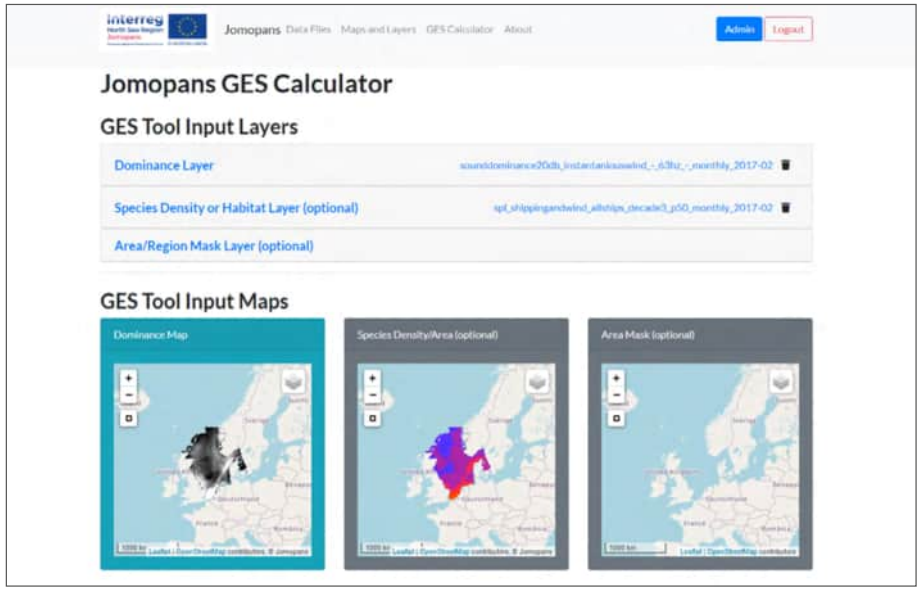


Figure 6:
Example screenshots from the JOMOPANS online GES-tool. The tool allows browsing and displaying the maps created in JOMOPANS, download of layers and calculation of GES indicators for different subparts of the North Sea, different frequency bands and optionally also to weight the indicators by animal distribution ranges or habitat suitability.

Results of the assessment

For the assessment one or more assessment areas have to be chosen. In this example we show the pressure functions for five sub regions: Northern North Sea, Southern, North Sea, Dogger Bank, Norwegian Trench and Skagerrak. The choice of assessment areas can be made on various grounds and needs further discussion. Other possible choices can be based on national boundaries or marine protected areas.

The pressure curves show the percentage of time versus the percentage of area for which the cut-off level is exceeded and are displayed in Figure 7. The pressure curves for the selected sub regions illustrate two important features. The red for the Southern North Sea (SNS) has a pronounced 'bump' in the upper left corner. This indicates areas with chronic exposure: about 10% of the sub region has a dominance close to 100%. This is the influence of the very intense shipping in the English Channel and along the coast of Belgium. The orange curve for the Northern North Sea (NNS) has a similar 'bump', but in the lower right corner. This indicates that the pressure is widespread: 90% of the area has a dominance of 10% or more, but only about 10% of the area has a dominance of more than 50%. The shape of the curve and the degree of asymmetry around the positive diagonal therefore carries additional information about the spatio-temporal characteristics of the anthropogenic noise in the sub region.

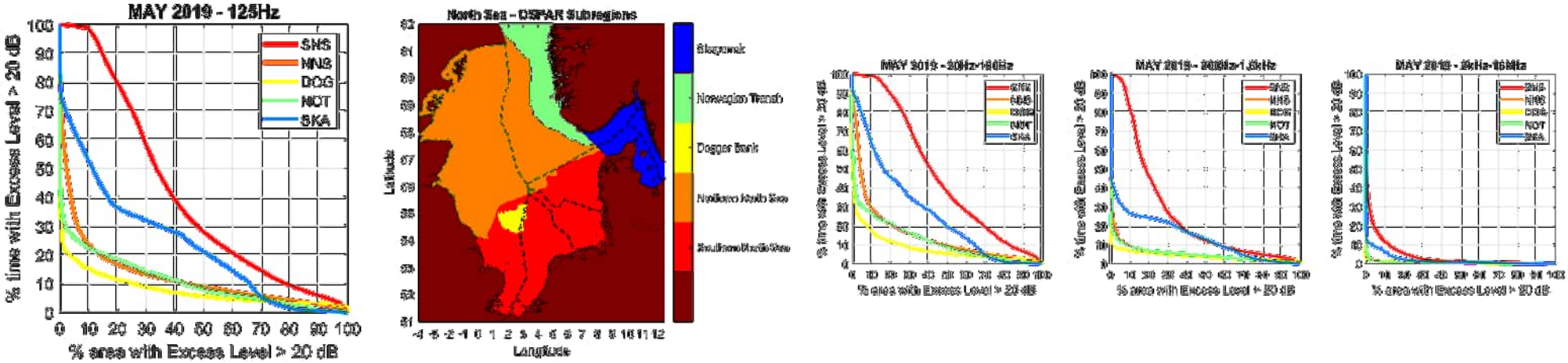


Figure 7:
Example calculation of for sub regions of the North Sea, calculated for the 125 Hz third-octave band. The contribution from ships is higher in three regions (southern North Sea, Norwegian Trench and Skagerrak) than the remaining three (Northern North Sea, Dogger Bank and Kattegat), indicated by the larger area below the curves.

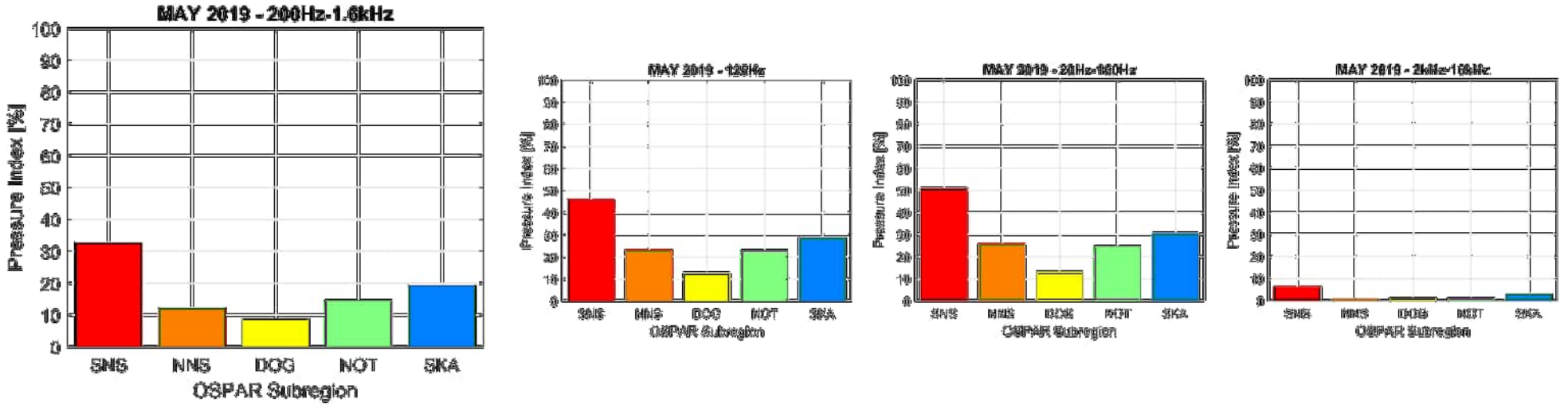


Figure 8:
Pressure indices for the selected subregions and various frequency bands.

Standardisation WP3

JOMOPANS has developed the standard procedures necessary for monitoring MSFD Indicator 11.2.1 in the North Sea so that all partners used a common approach and all data were comparable. Before JOMOPANS, there were no international standards for monitoring ambient noise, and one our aims was to lay the foundation for such standards with the procedures and protocols developed in the project. In total, we developed standard procedures for:

- Terminology (building on existing standards such as ISO 18405);
- Performance, calibration and deployment of instrumentation (including frequency response, dynamic range, in-situ calibration checks, calibration and traceability, uncertainties, deployment of the equipment, rigging and anchoring, mitigation of non-acoustic artefacts, quality assurance, recording of auxiliary data);
- Data analysis of the acoustic data obtained (including calculation of key metrics, provision of benchmarking with standardised data sets for validation of partner analysis algorithms);
- And in conjunction with WP4, for acoustic modelling of underwater the sound field (model inputs, spatial, temporal/spectral averaging, model choice, source description, and provision of benchmarked test scenarios to demonstrate fitness for purpose).

JOMOPANS standard procedures, shown in Figure 1, have built upon existing guidance (eg from ISO, EU TG Noise, NPL and the EU BIAS project). Close co-operation was maintained with the ADEON project in the USA with regard to terminology so as to ensure international coherence. Calibration was recognised as an important issue during the project, and this motivated a calibration workshop, which was held at NPL and included a “round-robin” comparison of calibrations to assess the equivalence of the calibrations of partners. To assess the equivalence of the data analysis undertaken by the partners, standardised data sets were provided by NPL for analysis by each partner.

The four standard procedures developed within JOMOPANS are a valuable set of protocols describing the methodology for ocean noise monitoring. They will now form important input documents to international standards to be developed by ISO TC43 SC3. In this committee, a new work item proposal has been submitted in 2021 on standardisation of ocean sound monitoring. The impact and influence of JOMOPANS is reflected in the fact that several key members of the ISO committee (including the Chair of the committee and the work item leader) are project partners. The influence on the ISO work will ensure the project has lasting impact and legacy in the field of standardisation.

Communication and harmonisation

JOMOPANS did not work in isolation, but has been throughout the project period, active in communicating the progress and results to a broad audience, including scientists, policy makers and the public. Not only the progress and results were disseminated, but also the topic of underwater noise pollution was highlighted to a large audience. Various stakeholders were addressed separately: policy makers participated in a Policy Advisory Board that has met five times and the scientific community was addressed at conferences and through scientific papers. Special meetings with NGO's were held and a large public was reached through the radio, television and the JOMOPANS website.

Through harmonisation with past, on-going and new projects, the project has been inspired to develop a monitoring programme with broad utility and replicability. Moreover, JOMOPANS has contributed to the application of coherent measurements and modelling standards across the North Sea.

Media attention

Project members has appeared in various media reaching from national television, radio, printed and online newspapers and websites. Below are only a few listed.

- Netherlands National television, the project coordinator Niels Kinneging, was interviewed and the need for this project for defining proper measures by marine managers was highlighted. Estimated viewers 1 million.
- Swedish national radio, FOIs Mathias Andersson talks about underwater noise and impact on the marine environment. Estimated listeners 1.5 million.
- Multimedia comic - Underwater sound illustrated in a different way. In 2019, design and media student Philine Dorenbusch accompanied scientists of the JOMOPANS project on a field trip to the North Sea. The aim was to create a multimedia report covering various aspects of underwater sound from a more artistic point of view.

Meetings and conferences

- **2019-12-07 World Marine Mammal Conference, Barcelona, Spain**. JOMOPANS had a joint booth at the conference with the EU Interreg project Jonas and the project results was also presented in various posters. The conference had more than 2700 attendees.
- **2020-02-21 Ocean Sciences Meeting, San Diego, USA**. JOMOPANS was presented at the meeting in the soundscape session and raised a lot of interest. In addition, special discussions were held with NOAA, IQOE and organisations represented at the exhibition. The meeting as a whole had about 6000 attendees.
- **2020-06-02 TG Noise meeting, online**. TG Noise is a committee under the Common Implementation Strategy of the MSFD. TG Noise addresses all issues related to D11 of the MSFD. JOMOPANS was presented at the meeting.

Furthermore, in the discussions during the meeting, references were made to the JOMOPANS work. JOMOPANS results have been an important input to the expert groups work in the development of the assessment framework for threshold values for continuous sound and later meetings (Ref DL3).

- **2020-06-06 ICG Noise meeting, online**. ICG Noise is a sub-committee of EIHA of OSPAR and co-ordinates the activities of various projects on underwater sound. The progress of JOMOPANS was presented and a discussion was held on various aspects of the project. Based on JOMOPANS results also a draft indicator for ambient noise was presented. JOMOPANS results will be used to update this draft for submission to EIHA.

Website

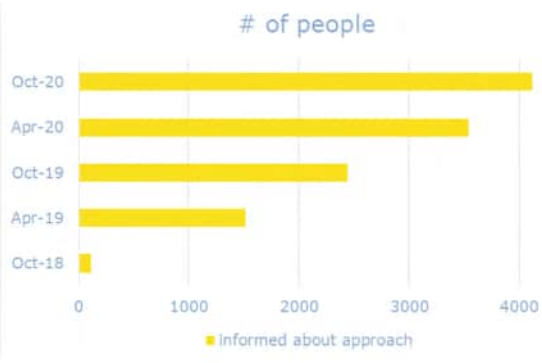
The website was up and running on January 2018. The site is routinely updated with short news articles, newsletters and published reports. Throughout the project time, the website had on avarage 500 visitors per month.

Newsletter

The project has published regular newsletters describing the progress and results. People that have signed up for the newsletter received it by email (311 subscriptions) but the newsletters are also available on the web site and are printed out and shared at events.

Workshop

To discuss the requirements for data management and ways to find practical solutions, the JOMOPANS project organized a workshop 13 July 2019 in The Hague on the topic **Monitoring continuous underwater sound – beyond acquisition** in co-operation with IQOE. The workshop's objective was to discuss the requirements for data management, trying to find ways to make the monitoring data available to scientists, policy makers and the public in order to find solutions for best possible harmonisation. At the workshop, nine large scale and long term monitoring projects and programs where presented from three continent (North America, Europe and Australia which were conducted in the time period from 2008 to the present day. Experiences and results was shared and a common declaration was agreed on: *"Monitoring continuous underwater sound: beyond acquisition" state that the sharing of knowledge and data in the field of underwater acoustics is essential to progress in the scientific field as well as on the management of underwater sound. International co-operation needs to be established and supported in order to realize a facility for sharing and disseminating acoustical data from monitoring programmes."*



Mid-term event

Half way into the projected, a mid-term event was organised on the 8 October 2019 at the Royal Society in London. The projects progress and first results were shared in presentations and a poster session. There was a broad audience present, including scientists, managers and NGOs. A policy brief was presented and handed over to mangers of the marine environment. The attendees were engaged in discussions on underwater noise and the challenges for the future. The list of topics that emerged from the discussions will keep scientists involved in the assessment of the environmental status busy for a long time ahead.

Next six years of joint monitoring

Joint monitoring programme

Noise pollution is by nature a transnational phenomenon. Not only does sound propagate across borders, sound sources (ships) also move across borders. Commercial shipping is a major source of low-frequency underwater noise. As international law grants extensive rights to other nation's ships in terms of access to international and territorial waters, any regulation of the sources must be international (in practice through the International Maritime Organisation, IMO).

The monitoring programme proposed by JOMOPANS is more than simply the sum of seven national programmes. The major product of the programme is a (set of) common regional soundscape map(s). These maps give a seamless picture of the noise distribution on the North Sea and show no discontinuities along national boundaries. Measurements remain a national responsibility, but the geographical distribution of measurement stations provides a coordinated coverage for the North Sea.

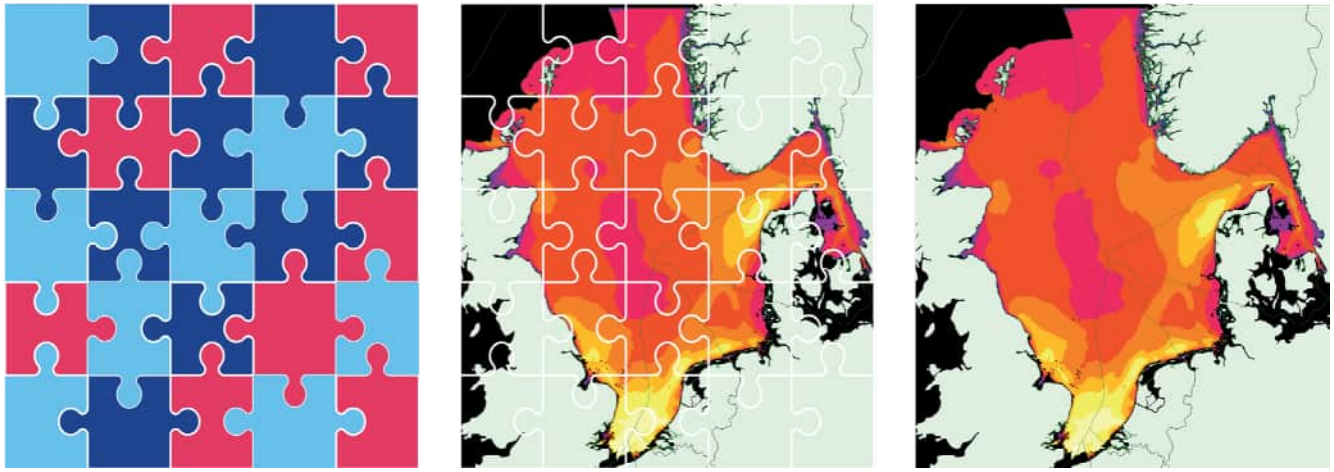


Figure 9:
From jigsaw puzzle to a common set of maps of underwater noise without 'seams'

The idea of joint monitoring is that tasks are undertaken by those parties that are best equipped to do so. Thus, the scarce knowledge and expertise on underwater noise is used most effectively and the programme supports the strong community of experts in this field. Other advantages can be found in efficiency, cost reduction and process harmonisation. On the other hand, the central coordination of the joint monitoring programme comes at the cost of a loss of national influence on decision making. The central coordination role should preferably be limited, finding a good balance in distributing the tasks among the participating countries with all countries having an ability to influence the programme.

These advantages and disadvantages should be considered in setting the ambition level for the joint monitoring programme. Joint monitoring can involve different levels of commitment. The (proposed) ambition level for the joint monitoring programme for ambient sound in the North Sea is best represented by a 'coordinated network'. This is because the coordination role is limited at this integration level, with the participants sharing resources (e.g. money or staffing). The participants are still working apart on the relevant tasks, although there might be some division of tasks (to exploit one another's expertise).

Organisation of the programme

An organisational structure is required for the joint monitoring of ambient noise. There is strong wish to implement such a structure under de OSPAR Convention. At this moment there are no examples of joint monitoring under OSPAR. There is now work in progress to set up joint monitoring for eutrofication using satellite measurements of chlorofyll as a result of the JMP-Eunosat project.

Most monitoring for OSPAR is using a coordination through the Common Environmental Monitoring Programme (CEMP). The coordination is performed by Intersessional Correspondence Groups (ICGs), like ICG Noise. The benefit of this approach is that no new organisations have to be installed, but usually the output products of the monitoring of the Contracting Parties is combined into one assessment. Jomopans showed how all countries can work together to produce common output products, but the OSPAR working groups EIHA and ICG Noise can best implement this closer form of cooperation.

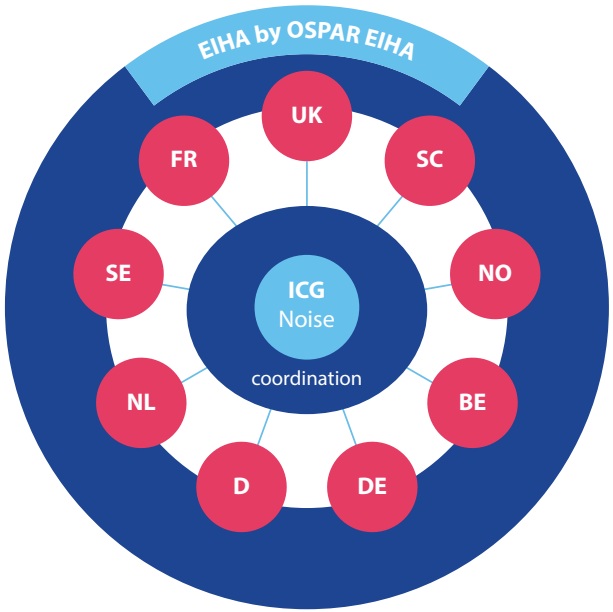
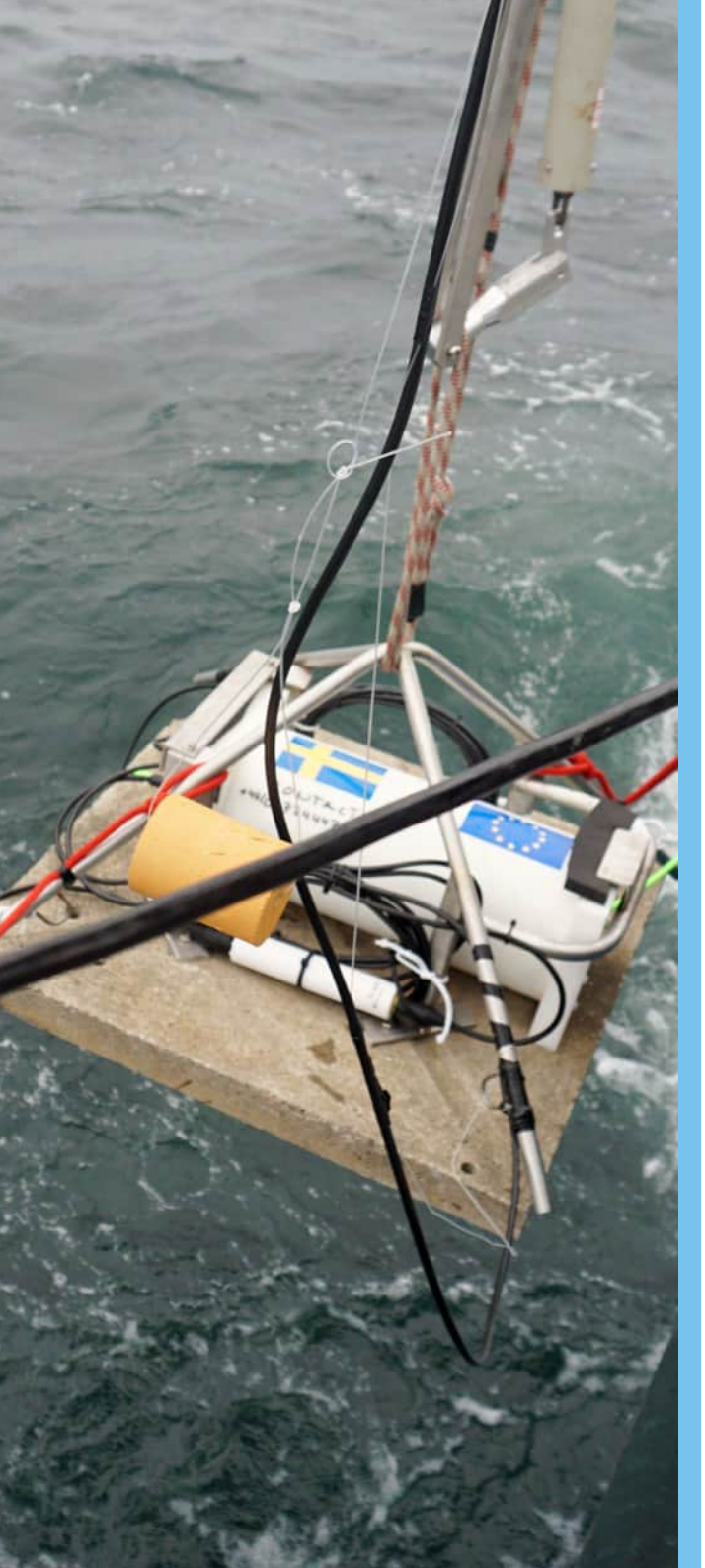


Figure 10:
Organisational structure for coordination of the monitoring programme. ICG Noise acts as a coordinating committee for the programme, where the OSPAR Contracting Parties work together. OSPAR EIHA is the Steering Committee for the monitoring programme

EIHA (OSPAR Committee on Environmental Impact of Human Activities)
The EIHA Committee is the main decision-making body of the monitoring programme. All OSPAR countries are represented in EIHA. EIHA decides on the programme plan and needs to approve the yearly reports. EIHA meets at least once per year. EIHA effectively acts as the steering committee for the programme.

ICG Noise (OSPAR Intersessional Correspondence Group on Underwater Noise)
The existing OSPAR working group ICG Noise acts as the programme team for the monitoring programme. Most of the members of ICG Noise are already involved in the implementation of underwater noise monitoring.

These roles for EIHA and ICG Noise could well fit into the general OSPAR operations. It is a concern that the workload for the shared tasks in the future monitoring programme for ambient noise will exceed the resources available for ICG Noise today. OSPAR contracting parties usually allocate a certain amount of time to members of the committees. If a contracting party volunteers for certain tasks (e.g. co-convenor) the amount of time needs to be increased. At this moment, the major work for ICG Noise is performed by the co-convenors.



Timeline of the programme

The MSFD has a six-year cycle. Every six years an assessment has to be reported to the European Commission based on the result of the monitoring programme. The OSPAR reporting cycle tries to align with the MSFD such that the OSPAR assessments can be used for the MSFD as well.

The MSFD requires monitoring of the 'trend'. This implies that it is necessary to have a regular monitoring frequency. This need is addressed in JOMOPANS by using modelled soundscape maps. JOMOPANS proposes to do yearly sound modelling for the North Sea area, supported by local measurements, where deemed necessary.

It is not necessary to carry out a full measurement of underwater noise every year. Only a basic measurement effort should be done each year to have a continuous 'health check' on ambient noise in the North Sea. Certain changes in the data can be detected from these measurements as well as the effect of certain events. Once every six years an extended measurement effort will be performed with stations covering the whole North Sea. This cycle should be aligned with the cycles of OSPAR and the MSFD.

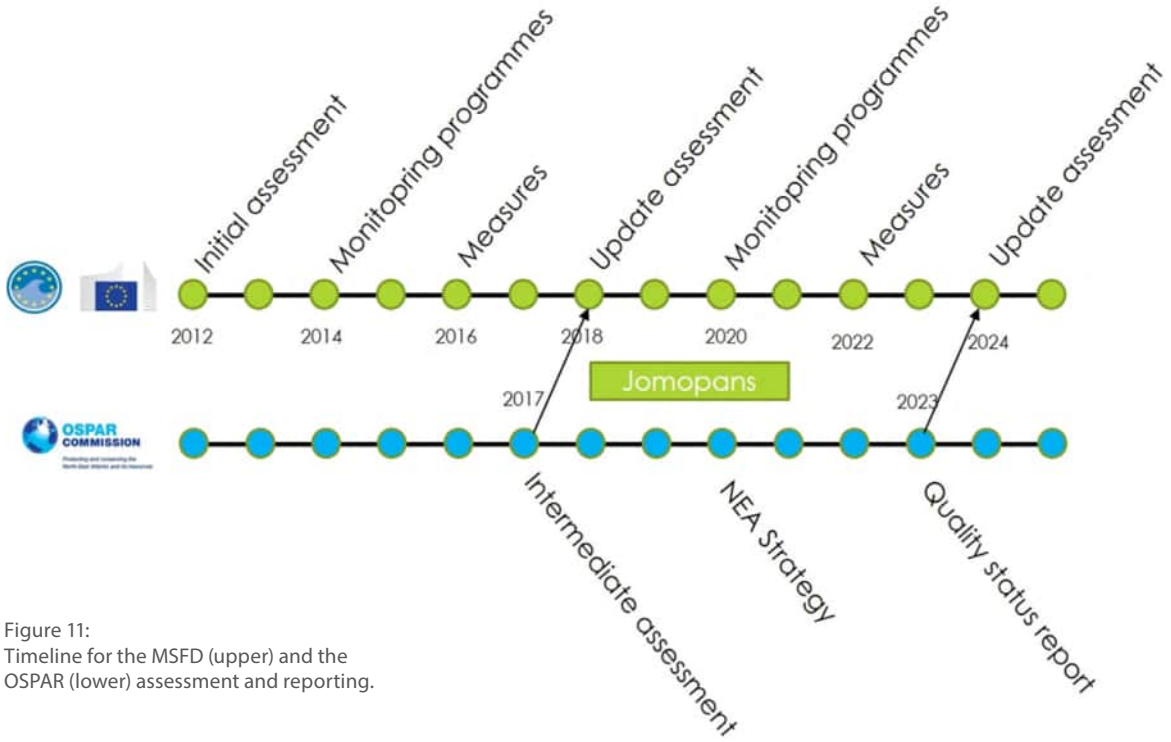


Figure 11:
Timeline for the MSFD (upper) and the OSPAR (lower) assessment and reporting.

Costs of the programme

Figure 12 gives an estimate of the total costs for the monitoring programme. In this the different intensity of the activities in a six-year cycle has been accounted for. Year four is the year of a major measurement effort and year one is the target year for the assessment. Modelling and AIS analysis are done every year. The impact assessment is done in years three and six. It should be noted that the measurements remain a national responsibility and the costs for measurements as well. The arrangements for measurements can vary much depending on the national choices on the use and utility.

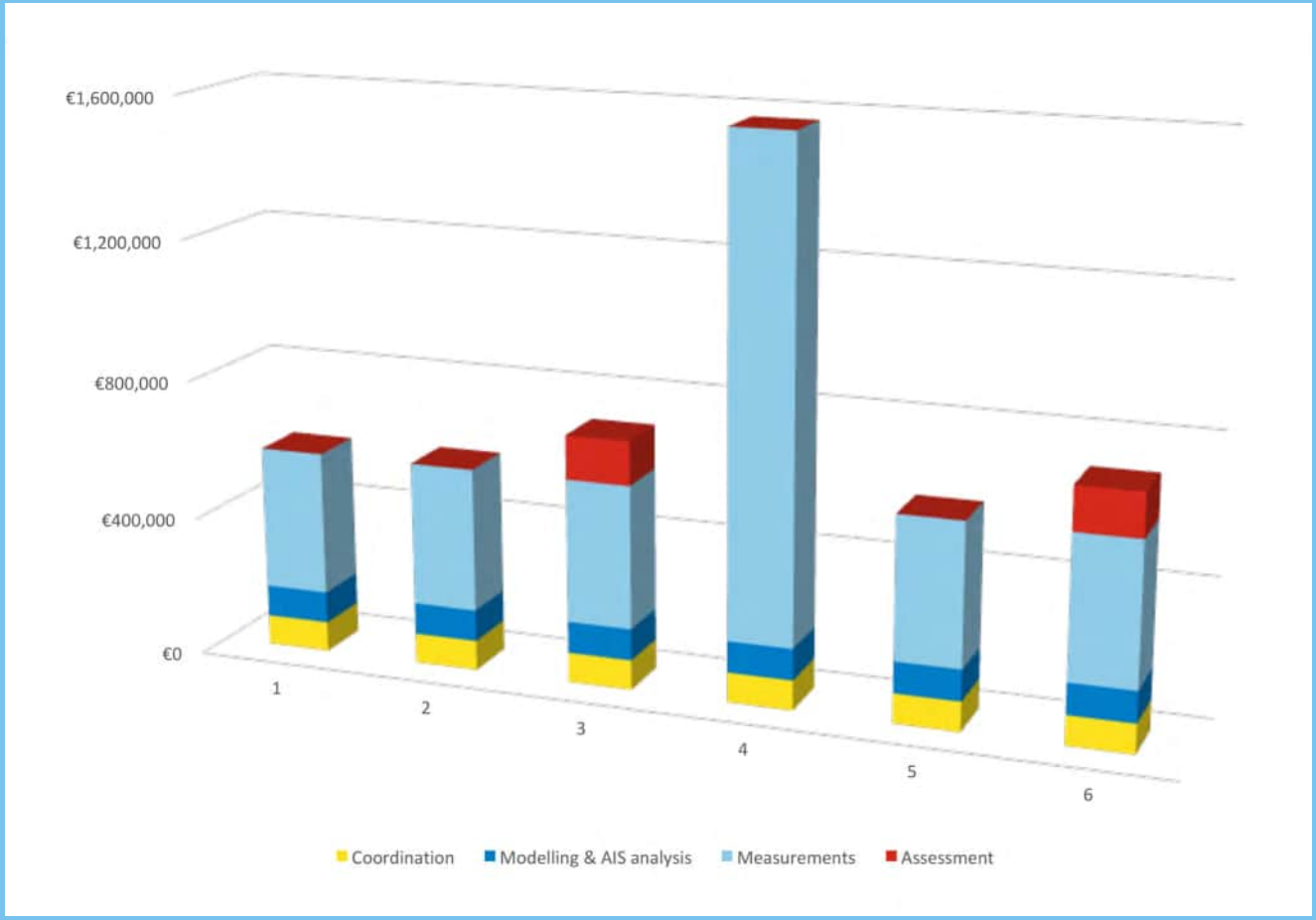


Figure 12:
Yearly costs along the six-year monitoring cycle

Cost sharing mechanism

Another concern is a shared budget. At this moment ICG Noise has no budget available which means that any task to be subcontracted is currently volunteered by one of the contracting parties.

It is anticipated that once every three years the amount of shared work will be high and in the other two years low. This is related to the preparation of an assessment, similar to the three-year assessment on impulsive noise. The work for ambient noise is more labour intense, especially related to the production of the soundscape maps. There are a few options to organise these activities under ICG Noise.

The current way of working will also be adopted for ambient noise monitoring. This implies that each nation has a responsibility for the measurements and that one or more nations volunteer to contract out the shared activities needed for the modelling part of the monitoring. The nations that act as contracting parties should increase the amount of time and budget available to their representatives in ICG Noise.

One year of transition into practice

At the end of the JOMOPANS project, the monitoring programme for ambient noise will not yet be operational. This implementation plan was produced as advice to OSPAR on the outlines of such a programme,and the OSPAR EIHA committee will eventually decide on the implementation.

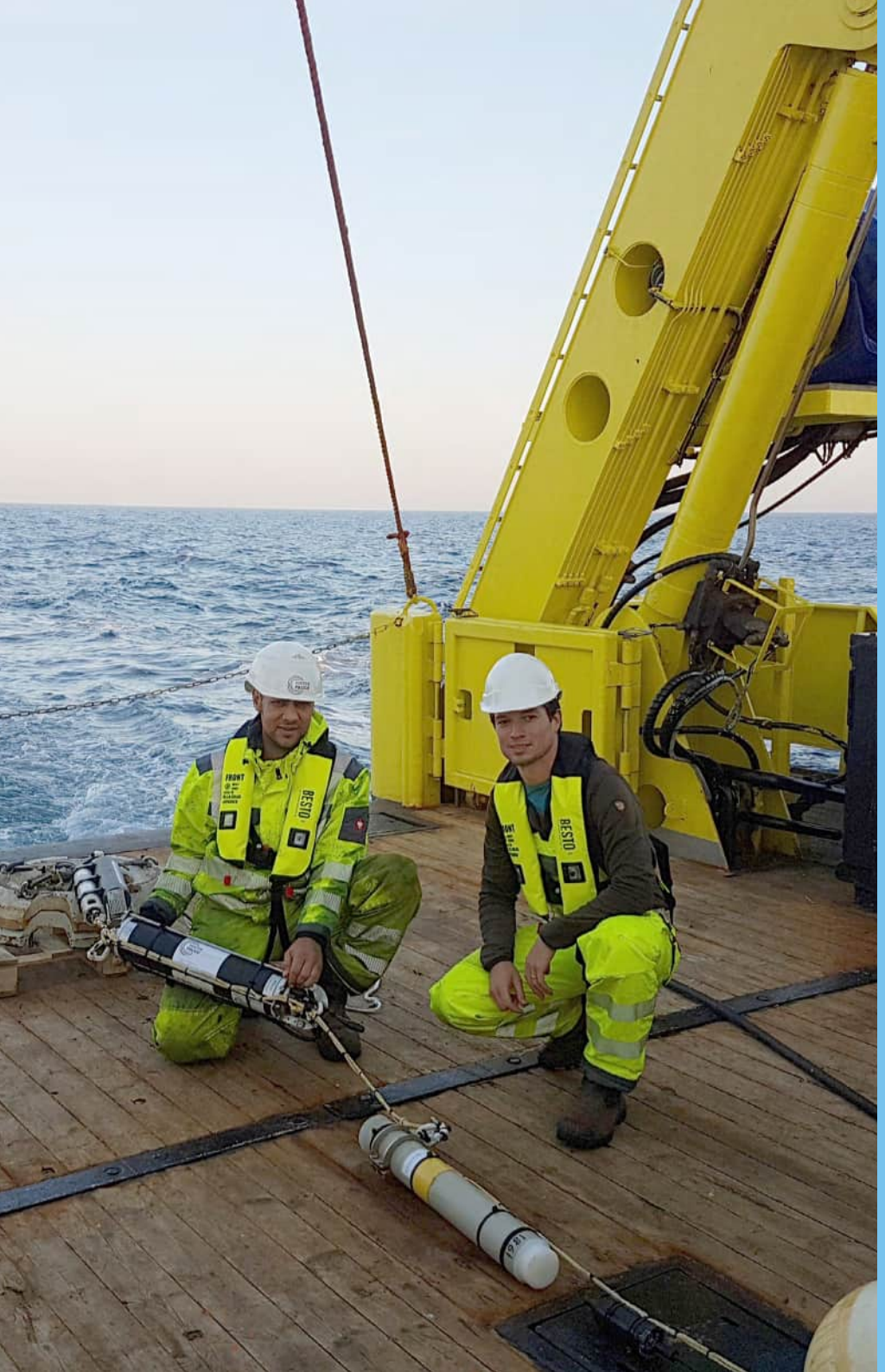
Various elements of the monitoring programme have been developed and used in the JOMOPANS project and it would be counterproductive not to continue this, therefore, it is recommended that a transition phase is entered into at the end of the project. This phase must be used to discuss and agree on the operational monitoring programme and also to continue monitoring activities that started during the JOMOPANS project. The transition phase can also be used to safeguard and communicate the outcome of the JOMOPANS project (the 'legacy').

Agreement on monitoring programme
In this report an operational joint monitoring programme is described, requiring a light organisational structure be created by dividing the tasks for the programme amongst the North Sea countries. The countries must agree on the size of the programme and on the input and resource they are willing to invest on behalf of the whole programme with an overriding aim to balance the different contributions.

Continuing activities
Over the past three years the JOMOPANS team has worked together with increasing enthusiasm and some major questions on ambient noise (monitoring) have benefitted hugely from the peer-to-peer discussions that JOMOPANS facilitates. It is therefore recommended that the team remains together to continue this success.

JOMOPANS legacy
During the transition period valuable results from the JOMOPANS project need to be safeguarded. It needs effort to do so:

- JOMOPANS is a successful project and attracted a lot of attention around the world. In the transition period the successes of the project will be presented at various occasions and work on the harmonisation will continue.
- JOMOPANS has formulated standards. These standards are meant to be transferred to the rest of the underwater acoustics community. The documents will be available on the website, but ISO working groups on underwater acoustics can use them to develop ISO standards.
- 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.



Knowledge and information gaps

In the JOMOPANS project a number of knowledge gaps were identified, that should be addressed in the proposed coordinated joint monitoring program which will succeed JOMOPANS or in dedicated research projects.

- The knowledge on the effects of ambient noise on marine animals should improve such that science based threshold values can be determined.
- The quality of the input data to the models is the main source of uncertainty observed in the model-data comparison. The possibilities for improving the quality of the input data must be investigated:
    - Incomplete AIS
    - Ships without AIS
    - Incomplete and uncertain information about acoustic properties of the sea floor
- The contribution of sources of ambient noise needs to be evaluated, particularly also for other sources than ships.
- Distribution and sensitivity of marine animals is needed to make an assessment of (risk of) impact possible
- Evaluation of various options for mitigating measures to reduce the negative effects of ambient noise.

Contact

Project leader

Niels Kinneging - **niels.kinneging@rws.nl**

Work Package leads

Communication and harmonisation:
Mathias Andersson - **mathias.andersson@foi.se**

Standardisation:
Stephen Robinson - **stephen.robinson@npl.co.uk**

Modelling:
Christ de Jong - **christ.dejong@tno.nl**

Measurements and Data management:
Jens Fischer - **jens.fischer@bsh.de**

Combination Modelling and Measurements:
Nathan Merchant - **nathan.merchant@cefas.co.uk**

GES Tool
Jakob Tougaard - **jat@bios.au.dk**

More detail, including technical reports, can be found on the JOMOPANS project website:
https://northsearegion.eu/jomopans

WP reports

- WP3
- WP4
- WP5
- WP6
- WP7

Partnership

The following organisations participate in the JOMOPANS project:

Rijkswaterstaat
Ministerie van Infrastructuur en Waterstaat

Institute of Marine Research

TNO innovation for life

Scottish Government
Riaghaltas na h-Alba
gov.scot
marinescotland

Institut royal des Sciences naturelles de Belgique
museum

AARHUS UNIVERSITY

FFI Forsvarets forskningsinstitutt
Norwegian Defence Research Establishment

NPL National Physical Laboratory

BSH Bundesamt für Seeschiffahrt und Hydrographie

Cefas

FOI