Joint Monitoring Programme for Ambient Noise North Sea

2018 – 2021

Jomopans Implementation plan

WP 7

Deliverable/Task: T7.2

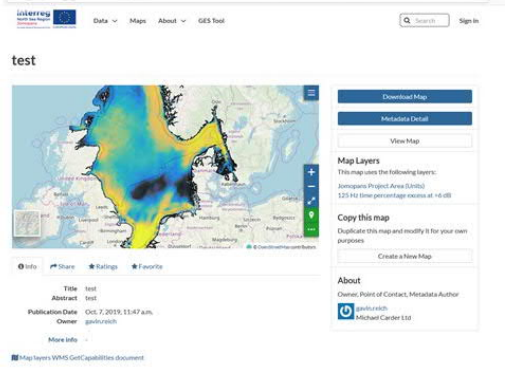

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Table of Content

Executive summary

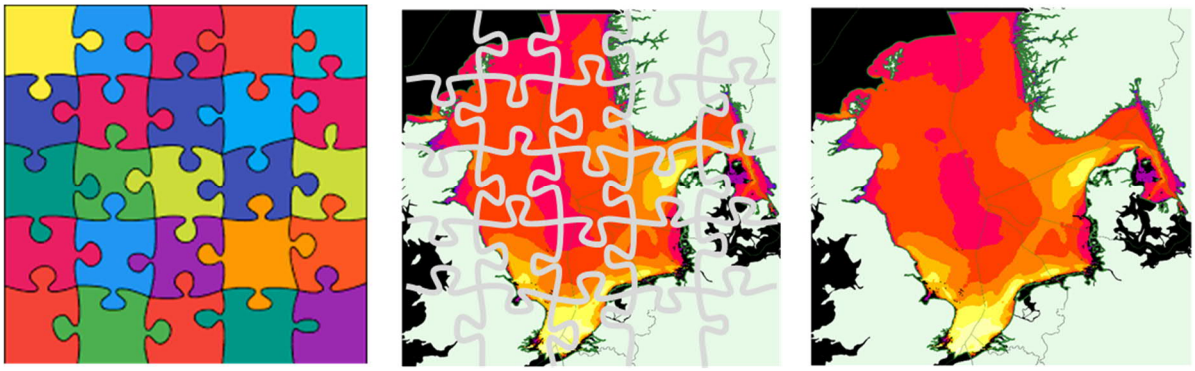
The Jomopans project started in January 2018 and ends in June 2021. An important deliverable of the Jomopans project is an Implementation Plan. This plan is an advice of the Jomopans consortium to the marine managers of the North Sea countries on how to implement regular monitoring of ambient noise. This is needed to supply the key information to OSPAR products like the Quality Status Report and/or Intermediate Assessment. The advice is based on the experience of the Jomopans project.

Monitoring as a joint effort

End result of joint monitoring (one map)
Noise pollution is by nature a transnational phenomenon. Not only does sound propagate across borders, sources (ships) also move across borders. Commercial shipping is the 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 proposed monitoring programme 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 shows no discontinuities along national boundaries. Measurements remain a national responsibility, but the geographical distribution of stations is chosen to give the best coverage for the North Sea.

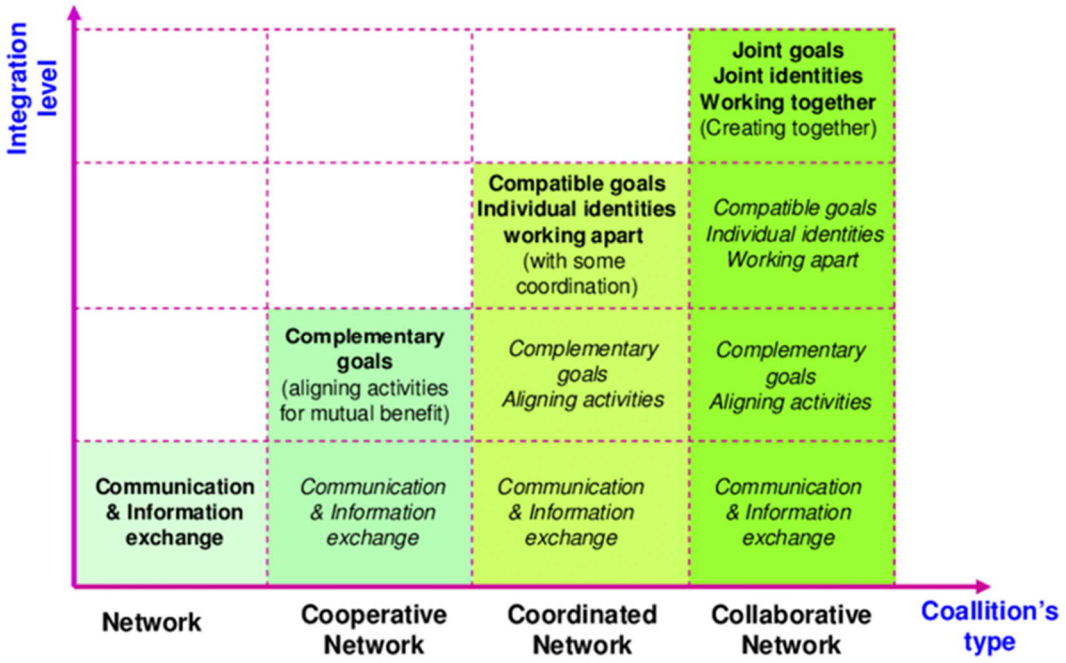
The idea of joint monitoring is that tasks should be done by those parties that are best equipped to do so. Thus the scarce knowledge on underwater noise is used most effectively and the programme supports the strong community of experts in this field. Other advantages can found in efficiency, cost reduction and process harmonisation. At the same time, a good balance should be found in distributing the tasks among the participating countries. Finally all countries should have influence on the programme.



Major product: a common set of soundscape maps. The aim of joint monitoring is to produce one set of maps of underwater noise without 'seams' caused by combining the results of different (national) programmes.

Ambition level of the joint monitoring programme (coordinated network)
A joint monitoring programme is based on a shared responsibility for the monitoring of ambient noise in the North Sea. Joint monitoring can be economically beneficial, as joint development of methods and joint analysis of results can be more cost-efficient. 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.

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. Himmelman (2001) has developed a model for understanding different levels of commitment. His model sets out four levels, being: networking, cooperation, coordination and collaboration. As shown in the figure below, each of the above definitions builds on the next definition. Along the continuum, the amounts of common goal-oriented activities, commitment, and resources that actors must invest into the joint endeavour are increasing.



Examples of joint endeavours (adapted from Camarinha-Matos and Afsarmanesh, 2006)

The (proposed) ambition level for the joint monitoring programme is best represented by a 'coordinated network' in the figure. 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).

How has this Implementation Plan been prepared?

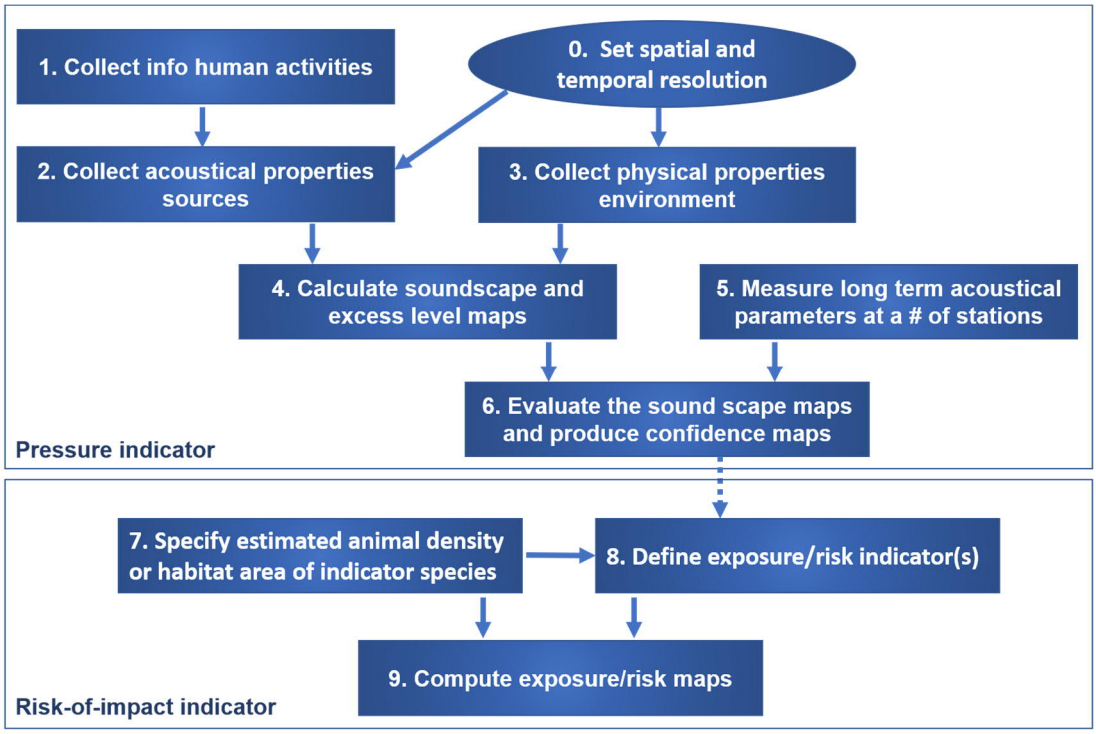
To advice on the course of the developments the Jomopans project has formed a Policy Advisory Board (PAB). The members of the PAB are the marine managers of the North Sea countries responsible for underwater sound issues. The PAB has discussed the major issues for a joint monitoring programme.

During the PAB meetings draft versionss of the implementation plan have been discussed. Some key recommendations from the PAB were:

- There should be a clear differentiation between shared tasks (like modelling) and national tasks (like measurements). Note that shared tasks don't need to be financed centrally.
- The organization should be embedded in the OSPAR structures, especially EIHA and ICG Noise.
- A financial overview is important for follow-up decision making.

Shared and national tasks in the monitoring programme

In the Implementation Plan all tasks within the programme have been outlined. The basis for the tasks is formed by the assessment framework for ambient noise (see separate proposal for EIHA) and contains the stepwise approach as outlined in figure below. In this scheme some tasks can be best executed once for the whole North Sea region (shared tasks) and other can be best executed on a national level.



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

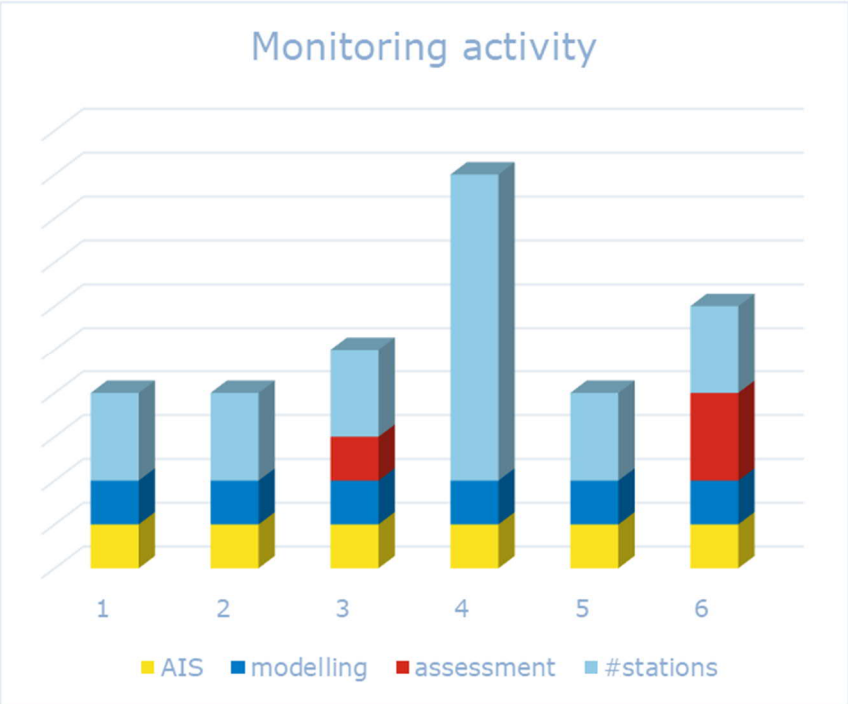
Shared tasks
The major shared tasks are a central coordination of the programme and the modelling efforts (together with all data collection needed for modelling).

National tasks
Measurements can be best organised under full responsibility of the national authorities. Setting up measurement sites, all logistics and data handling have a strong national aspect. The Jomopans standards on measurements ensure a harmonised way of measurement resulting in comparable data.

Monitoring cycle
The MSFD has a 6-year cycle. Every 6 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.

It is not necessary to have a full monitoring of ambient noise every year. We therefore propose to define a monitoring cycle with years of increased activity and a basic monitoring for other years. This cycle should be aligned with the cycles of OSPAR and the MSFD.

ICG Noise agreed to have an intermediate assessment for impulsive noise every 3 years and the same is proposed for continuous noise. Each year a basic measurement effort should be done to have a continuous ‘health check’ on continuous noise in the North Sea. Certain changes in the data can be detected from these measurements as well as the effect of events can be detected. Once every 6 years an extended measurement effort will be performed with stations covering the whole North Sea.

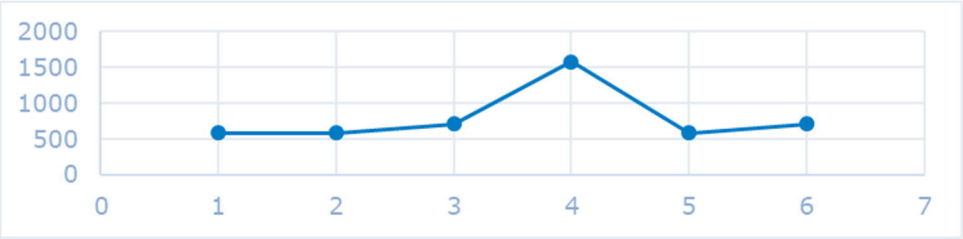


Schematic illustration of monitoring activities in a 6-year cycle

Costs

An estimate has been made of the total costs for the monitoring programme. In this the different intensity of the activities in a 6-year cycle has been accounted for. The table below shows a summary of the total costs for the whole North Sea. 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.

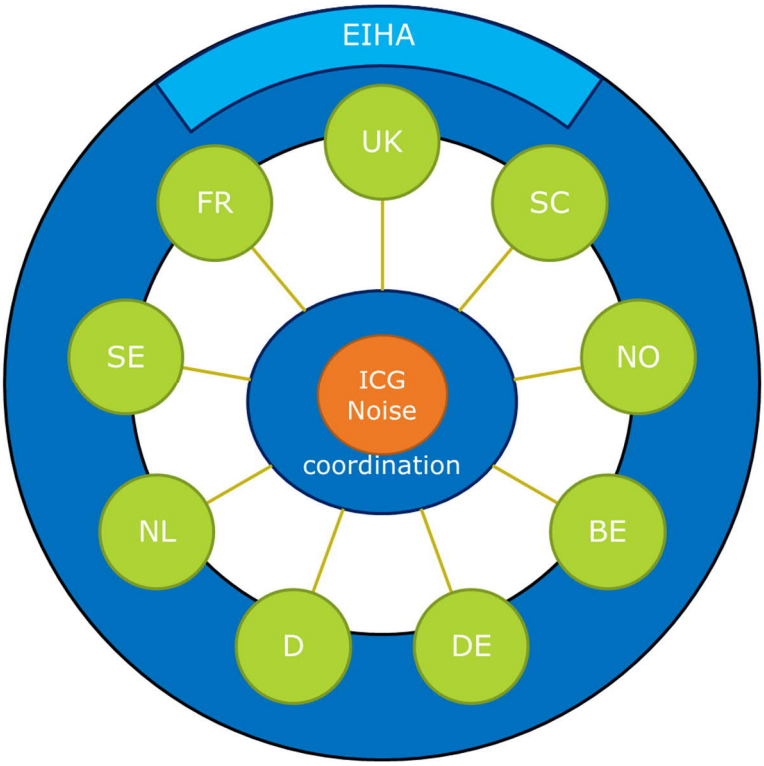
Activity / task	Y1	Y2	Y3	Y4	Y5	Y6
Programme management	€ 60 000	€ 60 000	€ 60 000	€ 60 000	€ 60 000	€ 60 000
Technical support	€ 25 000	€ 25 000	€ 25 000	€ 25 000	€ 25 000	€ 25 000
Collect information	€ 40 000	€ 40 000	€ 40 000	€ 40 000	€ 40 000	€ 40 000
Modelling	€ 50 000	€ 50 000	€ 50 000	€ 50 000	€ 50 000	€ 50 000
Measurements	€ 408 400	€ 408 400	€ 408 400	€ 1 400 400	€ 408 400	€ 408 400
Evaluation			€ 65 000			€ 65 000
Assessment and reporting			€ 60 000			€ 60 000
Totals	**€ 583 400**	**€ 583 400**	**€ 708 400**	**€ 1 575 400**	**€ 583 400**	**€ 708 400**
Average	**€ 790 400 per year**					



Yearly costs along the 6-year monitoring cycle

Organizational structure

The organization of the monitoring programme should be embedded in the OSPAR structures. 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.



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 InterCorrespondence Group in 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.
This 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 continuous 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. Another concern is a shared budget. At this moment ICG Noise has no budget available. Any task to be subcontracted is now volunteered by one of the contracting parties. It is anticipated that once every three years the amount of shared work is high and in the other two years low. This is related to the preparation of an assessment, similar to the 3-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 is also adopted for ambient noise monitoring. This means that each nation has a responsibility in the measurements and that one or more contracting parties volunteer to perform the shared activities needed for the modelling part of the monitoring. In annex C an example is given how these tasks can be delegated on an even basis. These contracting parties should increase the amount of time and budget available to their representatives in ICG Noise.

Transition phase

At the end of the Jomopans project the monitoring programme for ambient noise will not be operational yet. This implementation plan is an advice to OSPAR on the outlines of such a programme. The OSPAR EIHA committee will eventually decide on the implementation.

Various elements of the programme have been developed and used in the Jomopans project and it would be counterproductive not to ccontinue this. Therefore the Jomopans project advises to enter a transition phase after the Jomopans project. This phase must be used to discuss and agree on an 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'). The Jomopans project is looking into the possibility to (partly) finance this transition phase through a project extension from Interreg NSR.

1 Implementing Ambient noise monitoring

From 2018 to 2021 eleven institutions from all countries around the North Sea have worked together in the Jomopans project (Joint Monitoring of Ambient Noise North Sea). One of the major reports of this project is the Implementation Plan.

1.1 Aim of the Implementation Plan

The Jomopans project has developed a framework of a monitoring programme for ambient noise in the North Sea. This framework contain example North Sea maps for 2019, national infrastructure for measuring at sea, a GES management tool and a procedure for producing noise maps for other years. It is essential for the evaluation of GES that this monitoring programme is implemented after the Jomopans project ends. The aim of this Implementation Plan is to propose the means to make the monitoring programme operational. Following the objectives of Jomopans, the plan strives towards an operational joint programme on ambient noise for the North Sea.

The Implementation Plan gives answers to the following questions:
- Which tasks could best be organised jointly, and what is best done nationally?
- How should the monitoring programme be organised?
- What role can OSPAR play in the programme?
- What size budget is needed for the monitoring programme?

Based on all experience the Jomopans team obtained during the last three years and discussions within the team and with the members of the Policy Advisory Board, this advice report has been drafted. It is up to policy makers to take this advice and implement a fully operational monitoring programme which delivers the information for marine management of underwater noise.

1.1.1 Jomopans deliverables

The key results from the Jomopans project form the foundation to build the operational monitoring on. The results will be documented and be made available for the years after the project ends.

- Detailed the framework for the monitoring of ambient noise
- Produced examples for one year (2019) of monitoring, resulting in
    - Measurements at more than 14 stations across the North Sea
    - Soundscape maps, giving monthly statistical parameters of sound pressure level and excess level of ambient sound
    - Validation of these maps and confidence maps
- Web based tool to present all maps, derived metrics and distribution maps of indicator species. This tool can be used to evaluate GES (Good Environmental Status)
- A range of standards and guidelines for terminology, measurements, data processing and modelling. These standards will be included in discussions on standardisation by ISO.

1.1.2 Follow up for Jomopans

This Implementation Plan is targeted at the policy makers of the countries bordering the North Sea to work on an agreement for joint monitoring of ambient noise. Ambient noise monitoring in the North Sea is needed as input to the Quality Status Report of OSPAR ad to evaluate and maintain GES (MSFD).

The results from Jomopans must be transferred from the typical project environment to the environment of operational monitoring. This requires a different type of organisation, that fits into to existing monitoring of the North Sea countries. The monitoring should also relate to the agreements within OSPAR and the requirements by the EU Marine Strategy Framework Directive, if applicable.

The key feature of Jomopans is to develop a **joint** monitoring programme. The implementation plan pays ample attention to this aspect. For joint monitoring to function, mutual agreement by the responsible institutions of the participating countries must be reached. This implementation plan advises to use the existing structures of OSPAR to do this.

1.2 Monitoring as a joint effort

1.2.1 End result of joint monitoring (one map)

Noise pollution is by nature is a transnational phenomenon. Not only do sound propagate across borders, sources (ships) also move across borders. Commercial shipping is the 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 proposed monitoring programme 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 shows no discontinuities along national boundaries. Measurements remain a national responsibility but the geographical distribution of stations is chosen to give the best coverage for the North Sea. The idea of joint monitoring is that tasks should be done by those parties that are best equipped to do so. Thus the scarce knowledge on underwater noise is used most effectively and the programme supports the strong community of experts in this field. Other advantages can found in efficiency, cost reduction and process harmonisation.

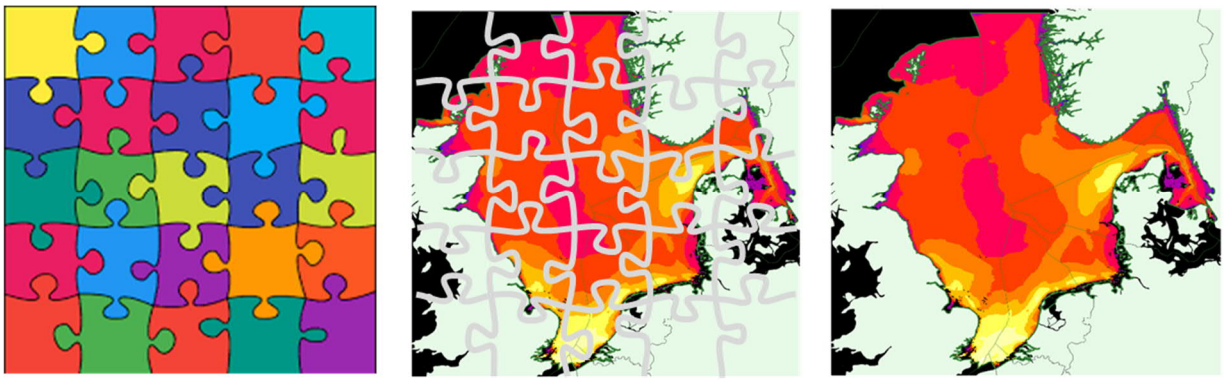


Figure 1: Major product: a common set of soundscape maps. The aim of joint monitoring is to produce one set of maps of underwater noise without 'seams' caused by combining the results of different (national) programmes.

At the same time, a good balance should be found in distributing the tasks among the participating countries. Finally all countries should have influence on the programme.

1.2.2 Ambition level of the joint monitoring programme

A joint monitoring programme is based on a shared responsibility for the monitoring of ambient noise in the North Sea. Joint monitoring can be economically beneficial, as joint development of methods and joint analysis of results can be more cost-efficient. It also provides the opportunity to exploit the best expertise of the institutions of the North Sea countries. Other benefits include the agreement on common standards for measurements, modelling, assessment and presentation of data. This increases comparability between assessments in neighbouring countries and prevents conflicts and disagreements on results, which are based in differences in methods, rather than the underlying environmental conditions.

On the other hand the central coordination of the joint monitoring programme comes at the cost of national decision making. The central coordination role should preferably be limited.

These advantages and disadvantages should be considered in setting the ambition level of the joint monitoring programme. Joint monitoring can involve different levels of commitment. Himmelman (1996) has developed a useful model for understanding these different levels of commitment, which he sees as a continuum. His model sets out four levels, being: networking, cooperation, coordination and collaboration. These levels are defined as follows:

- **Networking:** involves communication and information exchange for mutual benefit;
- **Cooperation:** in addition to exchanging information, it involves aligning / altering activities so that more efficient results are achieved;
- **Coordination**: involves not only information exchange and adjustments of activities, but also sharing resources for achieving compatible goals. Coordination is achieved by division of some tasks (not extensive) among participants.
- **Collaboration:** a process in which participants share information, resources and responsibilities to jointly plan, implement, and evaluate a program of activities to achieve a common goal. This concept is derived from the Latin collaborare, meaning "to work together".

As shown in Figure 2, each of the above definitions builds on the next definition. Along the continuum, the amounts of common goal-oriented activities, commitment, and resources that actors must invest into the joint endeavour are increasing.

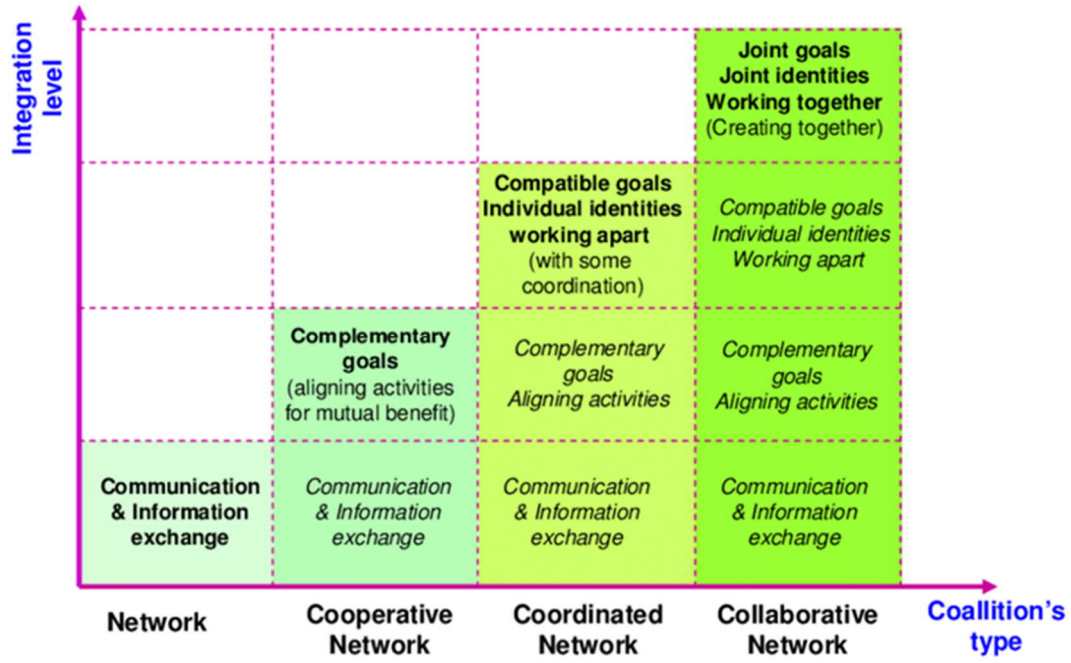


Figure 2: Examples of joint endeavor (adapted from Camarinha-Matos and Afsarmanesh, 2006)

The ambition level for the joint monitoring programme is best represented by a 'coordinated network' in the Figure 2. This is because the coordination role is limited at this integration level, with the participants sharing resources (e.g. money and 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).

1.3 How has this Implementation Plan been prepared?

To prepare for the implementation of the joint monitoring programme the Jomopans project has formed a Policy Advisory Board (PAB). The members of the PAB are the marine managers of the North Sea countries responsible for underwater sound issues. The PAB has discussed major issues for a joint monitoring programme. A decision to start a joint monitoring programme should be endorsed by all national authorities of the North Sea countries.

The PAB agreed to prepare a proposal for the policy makers of the countries concerned to work on an agreement for joint monitoring. During the PAB meetings draft versions of this implementation plan have been discussed. Now the final plans is ready and can be used as input to further discussion by EIHA. This discussion should lead to the organisation and budgets needed to implement the joint monitoring.

In June 2021 an End Event is planned. At that event the Jomopans project will be formally closed and the project results, including this implementation plan, will be presented to the major stakeholders and the public. The implementation of the monitoring programme is the responsibility of the national authorities. A form will be sought to mark this occasion, e.g. by mean of a declaration of intent that underlines the intention of the national authorities to collaborate on the monitoring of ambient underwater noise.

2 Ambient noise, OSPAR and EU

Following the adoption of a monitoring strategy for ambient noise (Snoek, 2015) by the OSPAR committee EIHA (Environmental Impact of Human Activities, April 2015) the INTERREG North Sea Region (NSR) Jomopans project (Joint Monitoring of Ambient Noise North Sea) has been setup and started in January 2018.

The basis of the Jomopans project is the notion that underwater noise is a transnational problem and should be tackled through international co-operation. In Jomopans 11 institutes from all countries bordering the North Sea participate to set up the monitoring programme.

This implementation plan outlines the advice of the Jomopans team to enact the monitoring programme after the project ends.

2.1 MSFD Descriptor 11 and OSPAR

In 2008 the European Commission approved the Marine Strategy Framework Directive (MSFD: 2008/56/EC), requiring all European Union (EU) Member States, to reach or maintain a Good Environmental Status (GES) in marine waters by 2020. GES is described by eleven descriptors and all the Member States must set criteria and methodological standards for each descriptor in their marine waters.

Descriptor 11 focuses on the introduction of energy into the marine environment, including underwater noise and describes two types of underwater sound, divided into two criteria:
- loud, low and mid frequency impulsive sounds (D11C1) and
- continuous low frequency sound (D11C2).

Measures should be taken by member states and the progress must be monitored. The EU/MSFD Technical Group on Underwater Noise (TG Noise) is commissioned to advise on the two criteria of underwater sound. Currently TG Noise is working on the development of a common methodology to assess effects of underwater noise, as a first step towards development of Threshold Values for D11C1 and D11C2.

The MSFD requires for Member States to co-operate at a regional level. For the North Sea this co-operation is enabled by the regional sea convention OSPAR (the Convention for the Protection of the Marine Environment of the North-East Atlantic). OSPAR is the treaty by which 15 national governments & the EU (together the “Contracting Parties”) cooperate to protect the marine environment of the North-East Atlantic. Within OSPAR the Contracting Parties decided to align the environmental strategy with the MSFD and also non-EU Contracting Parties expressed to comply to this decision.
The work on underwater noise is co-ordinated by the Intersessional Correspondence Group on Noise (ICG-Noise). OSPAR has no formal role and acts on behalf of the Contracting Parties, but OSPAR can facilitate mutual discussions and some common systems. An example of this is the OSPAR data management system ODIMS.

Environmental monitoring forms part of the implementation timeline of the MSFD, as shown in Figure 3. The implementation of the MSFD now finds itself in the second 6-year cycle. The tasks that currently lie ahead for policy makers are: the updates on the assessment of marine waters, the determination of GES and the monitoring programmes assessing the status of marine waters. It also contributes to the Coordinated Environmental Monitoring Programme (CEMP) of OSPAR. OSPAR now defines its environmental strategy (North East Atlantic Environmental Strategy, NEAES) and plans to publish a Quality Status Report in 2023 (also in Figure 3). This implementation plan is directly relevant to these tasks for the MSFD and for OSPAR, particularly to the monitoring programmes.

A political priority for the second cycle is to focus on essential elements to implement the MSFD and to do so with a certain degree of efficiency. This calls for working together (e.g. harmonisation) and using resources wisely (e.g. joint assessment). These principles of work are promoted by this Implementation Plan. In Chapter **Fout! Verwijzingsbron niet gevonden.** a business case is presented that emphasises the potential cost savings using joint monitoring. This shows that a single standardised, joint monitoring approach results in a considerable reduction in cost compared with multiple national monitoring programmes.

As there are strong analogies between the MSFD and OSPAR approaches (refer to Figure 3), the Jomopans Implementation Plan is also directly relevant to the work within OSPAR. In the same way as for the determination of GES, a joint monitoring programme for the North Sea will provide information for the OSPAR Quality Status Report. To ensure that Jomopans supports both approaches, the elements of the monitoring programme are based on the OSPAR framework for the indicator for

ambient sound. This indicator serves to promote consistency in the assessment methodology across the North-East Atlantic and the sub-regions of the MSFD (including the North Sea). The monitoring should be a continuous activity, when implemented.

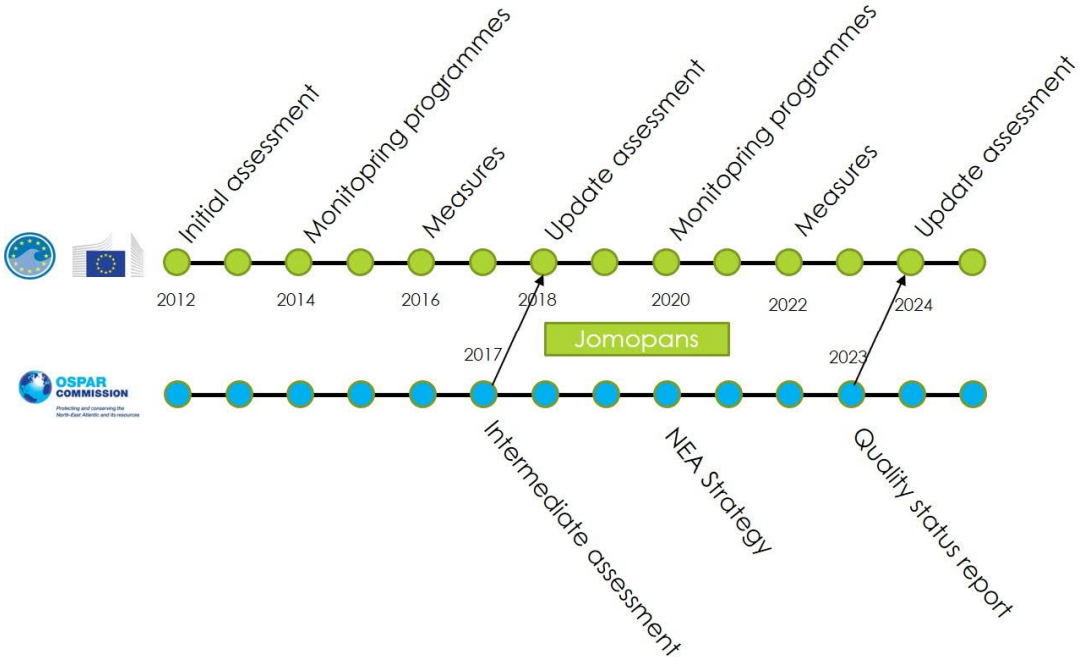


Figure 3: Timeline for the MSFD (upper) and the OSPAR (lower) assessment and reporting..

The MSFD and further specified by the Commission Decision of 2017 requires member states to monitor ambient noise in order to evaluate and maintain GES in the regional seas, including the North Sea.

Sound or noise
For this report the term "noise" is used when discussing sound that has the potential to cause negative impacts on marine life.
The more neutral term "sound" is used to refer to the acoustic energy radiated from a vibrating object, with no particular reference for its function or potential effect.
"Sounds" include both meaningful signals and "noise" which may have either no particular impact or may have a range of adverse effects.

From: "Towards thresholds for underwater noise", TG Noise in preparation, 2020

Ambient sound
The term ambient sound is defined as the sound that would be present in the absence of a specified activity (ISO 18405: 2017), like sound measurements. Ambient sound can be anthropogenic or natural, as well as continuous and impulsive. The part of the ambient sound that can cause negative impacts on marine life is called ambient noise.

2.2 Assessment framework

ICG-Noise set up a framework (see Table 1 and figure 4) for an indicator to assess the impact of ambient noise on the marine environment. This framework was discussed and approved in last EIHA[1] meeting of April 2019 (Kinneging, 2020). The framework now needs further refinement to set up an indicator for ambient noise. At the EIHA meeting of April 2020 a refined approach was presented, for which a draft report (Van Oostveen et al, 2020) has been prepared. EIHA agreed on a stepwise approach for the ambient noise indicator, although it required an update on the report in the autumn 2020. In the picture below (Figure 4) the relationship between the different steps of the framework is expressed. It indicates whether different steps can be progressed at the same time or are dependent on each other. This OSPAR indicator will be used for the OSPAR Quality Status Report 2023 and the

[1] OSPAR Committee on Environmental Impact of Human Activities (approval postponed to autumn 2020).

MSFD Assessment 2024.
Note that monitoring is an integral part of this stepwise approach to evaluate the OSPAR indicator and a monitoring programme is a logical consequence of the common indicator for ambient noise. The monitoring method will be describes in CEMP (Common Environmental Monitoring Programme) Guidelines. These guidelines will be drafted and progress will be monitored by the ICG Noise. The EIHA working group is tasked with the formal approval of all proposal from ICG Noise.

Table 1: Framework of indicator ambient sound based on the candidate indicator of ambient noise (EIHA 2019) with minor changes for EIHA2021.

Activity / task	Description of activity
1. Collect information on human activities	The human activities that generate low-frequency continuous sound need to be evaluated. Sources of this information are AIS (for shipping intensities), VMS (for fishery activities) and the OSPAR impulsive noise register (for other sources of noise). These data need to be obtained with a temporal resolution of 1 hour maximum.
2. Collect acoustic properties of the sources	Acoustical properties of most of the sources are not available in a sufficient detail. Literature can provide statistical proxies for these properties. Jomopans has developed in co-operation with JASCO and the ECHO project (Port of Vancouver) a model for ship noise source levels, RANDI3.1c . It is important to continuously improve the knowledge of the source properties. These models can be verified using field measurements where required.
3. Collect physical properties of the environment	Bathymetry and properties of the sea bottom (composition) are important for the numerical modelling of sound propagation. These parameters can be considered static. (Meteo) parameters, like wind, rain, current, temperature, isoclines, salinity are dynamic.
4. Calculate soundscape and excess level maps	Through acoustical propagation modelling sound scape maps (sound pressure level as well as background level) will be calculated as defined in the indicator metric. Acoustical models for sound from natural sources are available and being evaluated. Propagation models for sound propagation of various sound sources can be chosen. From these excess level maps and dominance maps can be derived.
5. Measure long term acoustical parameters at a number of stations	At a number of measurement stations the soundscape is monitored on an ongoing basis. From these measurements statistical parameters of the SPL can be derived. The measurements can be used to validate the modelling as well as for other purposes.
6. Evaluate the soundscape maps and produce confidence maps	Using the sound scape maps and the measurements a validation is performed, and confidence maps will be produced which indicate where there is greater or lesser confidence in the model predictions.
7. Specify estimated animal density or habitat area of indicator species	Use density estimation data if available and appropriate, otherwise use areas (e.g. habitat quality mapping, MPA, Spawning grounds, etc.).
8. Compute exposure/risk map by combining 6 and 7	Including quantitative assessment of confidence in the risk values derived.
9. Compute exposure/risk indicator(s)	A risk indicator must be computed for each relevant region, that can be assessed against a GES criterion.

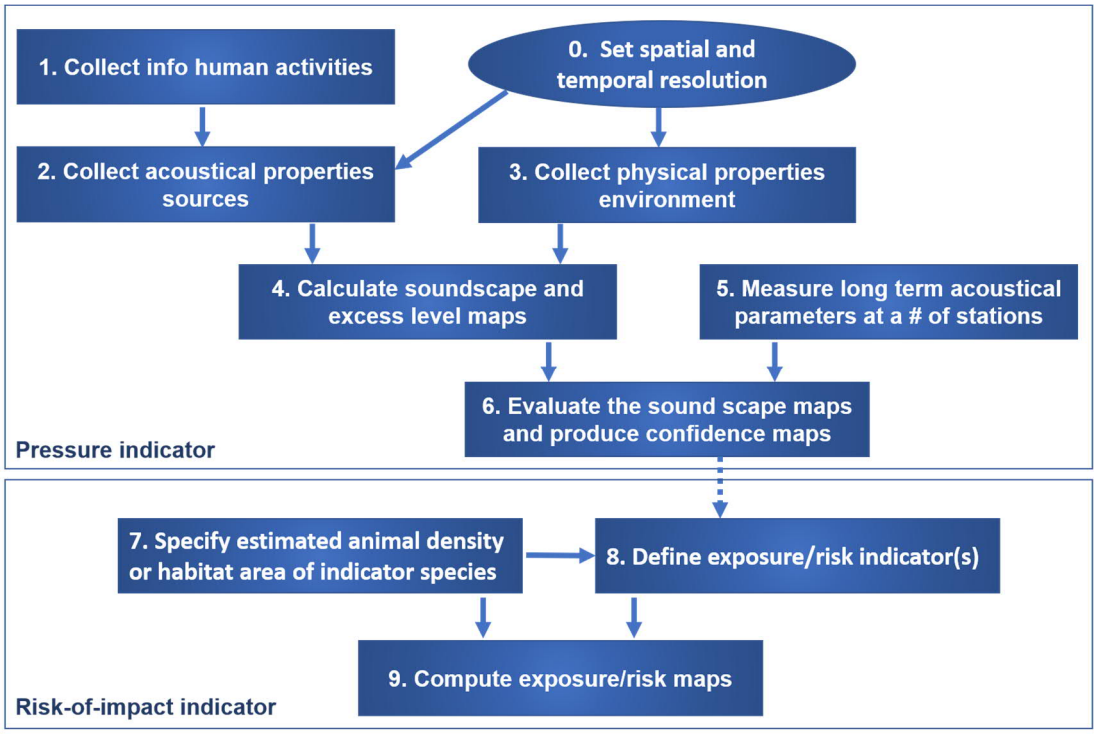


Figure 4: Framework ambient sound indicators (from Van Oostveen et al, 2020)

The assessment framework contains on the content the elements that have to be performed in a joint monitoring programme for ambient noise. They form the basis for defining the building blocks of such a programme as outlined in chapter 3 of this report. This framework has been discussed in OSPAR ICG Noise and approved by OSPAR EIHA in autumn 2020.

3 Approach and activities monitoring programme

In Jomopans the monitoring strategy as adopted by OSPAR EIHA (see Snoek, 2015) was used to for the projects setup. The basic strategy is to obtain soundscape maps of the North Sea by using the results from both modelling and measurement.
The activities of modelling and measurements are very different and it is concluded that these activities should be organised separately. For modelling a centralised organisation is best suited to produce a seamless regional map (see section 1.2.1). Measurements obtain the sound pressure levels and the statistics of these for the measurement locations. Due to logistics and local conditions the measurements can best be organised by the national bodies responsible for environmental monitoring.

3.1 Approach to joint monitoring

3.1.1 Combination of modelling and measurements

A framework for the monitoring of ambient noise was built upon the method proposed by the European Commission MSFD Technical Group on Underwater Noise and the latest knowledge from relevant regional projects (in particular the EU LIFE+ project Baltic Sea Information on the Acoustic Soundscape, BIAS). Previous projects focused on measurements or modelling. Jomopans combined both measurements and modelling, to produce soundscape maps and build a GES Tool for ambient sound. A combination of measurements and validated models (soundscape maps) is regarded the best way to describe levels and trends of ambient sound. A balance must be found between modelling and measurements and the combination of these two elements of the strategy is the key factor in successful, sufficiently precise and cost effective management of ambient noise.
A number of work packages worked on the following topics: Standardisation, Modelling, Measurements, Assessment of sound level predictions and GES policy advice and management tools.
A framework of standards is required for work on modelling and measurement of acoustical parameters. Standardisation is an ongoing process (often coordinated by the International Organisation for Standards, ISO) and the publication of standards takes a lot of time. Jomopans has built on standards, that were developed within other projects, such as BIAS, the Atlantic Deepwater Ecosystem Observatory Network (ADEON). Standards that were developed to be used within the project will be actively promoted in other projects for underwater noise monitoring and Jomopans will actively contribute to the science plan promoted by the International Quiet Ocean Experiment.

3.1.2 Modelling

The use of numerical models is cost-effective and can be operated in a controlled environment. Maps of the ambient sound levels for the North Sea region must be calculated based on information on human activities (currently restricted to shipping, by far the most significant contributor) and of natural sound sources (wind driven surface waves). Modelling is a powerful tool for a better insight into causes and distribution of underwater noise and is required for adequate spatial coverage. Modelling frameworks will be developed and evaluated. As a result, a modelling frameworks will be available which gives optimal results for sound propagation in the North Sea. It is preferred if these frameworks can be made available under an Open Source license (e.g. Creative Commons BY-NC).

3.1.3 Measurements

A measurement method for long term monitoring of ambient sound is developed. Measurement locations were chosen to provide a broad territorial spread across the North Sea and to obtain data from all sources of underwater sound. One station (LoVe station in Northern Norway) was dedicated for measurements in an area with very low shipping activity. It is proposed not to include the LoVe station in the North Sea monitoring programme, but there remains a need to validate models for natural background sound sources. Recording instruments for underwater sound, i.e. hydrophone systems, were calibrated to ensure accuracy and provide a direct quantification of the parameter of interest (i.e. sound pressure levels). There exist no particular problems with interpretation of that parameter. On the downside, measurements are specific to the time and location where the measurements are made (i.e. they provide a number but no context), and whilst quality of measurements can be tracked and assessed, field measurements, if they should by themselves have the required spatial and temporal coverage, are very costly to obtain.
Modelling on its own is insufficient because without measurements there is no way of verifying the accuracy of the model predictions and there is no way of discovering sources unaccounted for, or exceptional sound propagation conditions. Measurements on their own are insufficient because data from the measurement stations cannot adequately capture the important spatial variability of the ocean sound field. A combination of validated models and measurements is best way to overcome these problems mentioned.

3.1.4 Management tools

A GES management tool has been developed, based upon modelled sound maps validated with measurements for 2019, and the spatial distribution of representative marine animals. The tool developed can complement and support marine spatial planning and ecosystem based management. At the end of the Jomopans project the GES Tool only contains data for one year (2019).

In order to ensure the proper application and use of the GES tools, the key stakeholders played an important role in the project and must continue to be involved in the programme. These stakeholders are regulators, planners and managers from national authorities that need a tool to manage ambient noise and to determine whether they achieve GES. This tool is therefore developed in close co-operation with these stakeholders. Most importantly, a Policy Advisory Board was formed by authorities from all countries and was regularly consulted on the user requirement.

3.1.5 Monitoring timeline

The MSFD has a 6-year cycle. Every 6 years an assessment has to be reported to the European Commission based on the result of the monitoring programme. The next reporting year is 2024.
The OSPAR reporting cycle tries to align with the MSFD such that the OSPAR assessments can be used for the MSFD as well. The next OSPAR assessment will be the Quality Status Report in 2023.

In principle MSFD monitoring can consist of a yearly effort in modelling and measurement around the North Sea. It is not necessary to have a full monitoring of ambient noise every year. As a minimum every 6 years a major effort should be made to gather all information for the assessment. These choices have a major impact on the required budgets and in annex B the effects are summarised of a minimum, median and maximum scenario.

In the main text we define a monitoring cycle with years of increased activity (campaign years) and a basic monitoring for other years. This cycle should be aligned with the cycles of OSPAR and the MSFD (see section 2.1).

Being the first assessment of ambient noise it is proposed the Jomopans and Jonas results will be used for this assessment. Both Jomopans and Jonas base their results on data from the year 2019.
ICG Noise agreed to have an intermediate assessment for impulsive noise every 3 years and the same is proposed for continuous noise.
Each year a basic measurement effort should be done to have a continuous ‘health check’ on continuous noise in the North Sea. Certain changes in the data can be detected from these measurements as well as the effect of events (e.g. the Covid-19 pandemic) can be detected. Once every 6 years an extended measurement effort will be performed with stations covering the whole North Sea (a ‘campaign year’).
The basic monitoring also includes a check on the AIS data and modelling. Jomopans showed that a thorough check on AIS is needed before modelling, but it will also indicate trends in shipping. Since the AIS information doesn’t directly relate to the ambient noise also an acoustic modelling is needed. It is possible to perform the activity every other year or every three years, but it should cover all years.

Figure 5 shows qualitatively the relative effort in the monitoring programme for the 6-year cycle. Year 1 is the year of a major measurement effort and the target year for the assessment; a minor and a major assessment is done in years 3 and 6 preceded by modelling in the years 2 and 5; AIS and VMS analysis is done every year.

Note that this monitoring cycle applies for the monitoring obligations under the OSPAR framework and the MSFD. There are many more applications for measurements beside the MSFD monitoring, but these outside the scope of the Jomopans project. In annex A.5 some of these other applications are mentioned.
Countries will employ measurement stations in accordance to their own responsibilities and needs and these stations form the backbone of the MSFD monitoring programme as well.

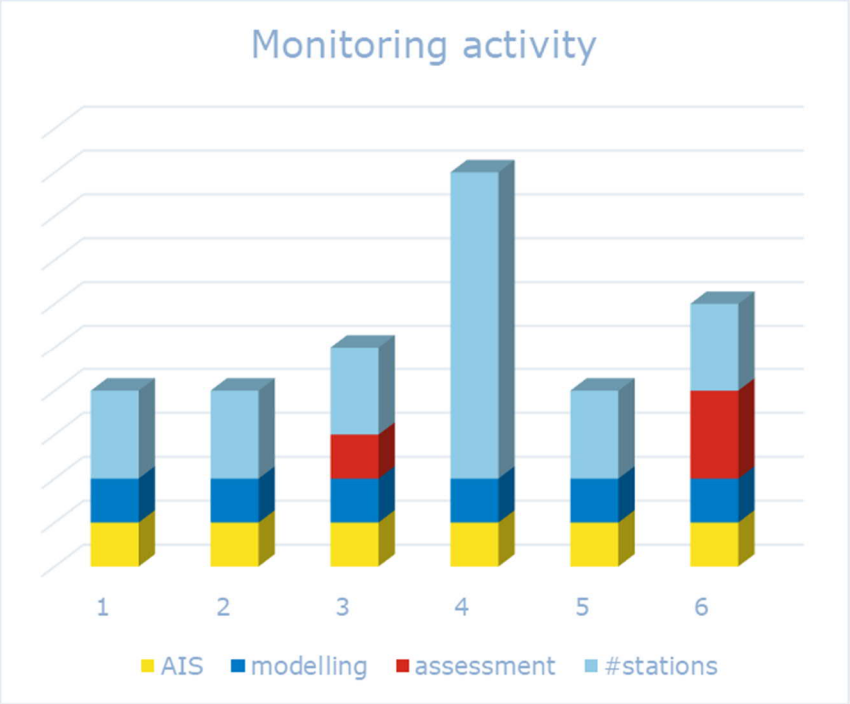


Figure 5: Schematic illustration of monitoring activities in a 6-year cycle

3.2 Coordination of ambient noise monitoring

In this section we summarise which activities and tasks should be handled for the coordination of the whole programme. The programme will be executed as part of the work of ICG Noise (see chapter 4 for a discussion on this).

3.2.1 Objective

A central programme management should facilitate the cooperation of the people and institutes that comprise the programme. Key for this management is the definition of all tasks and the planning of the activities in time and cost. A multi-year monitoring plan will be made with a yearly update to be agreed by the steering committee (section 4.1).
A second objective is the execution of central tasks for the monitoring programme. These are:

- Steering committee (see also chapter 4)
  The Steering Committee should be kept informed and regular and ad-hoc meetings should be organised.
- Communication
  Stakeholders should be involved in the activities, as either clients, suppliers or collaborators. Clients to the main information products need to be involved in regular updates of the monitoring programme. Coordination with similar programmes in other marine regions is needed. A communication strategy needs to be made.
- Knowledge management
  The monitoring programme is based on expert knowledge. Scientific advancements have been made in the last decades, but still many questions remain and are investigated around the world. This knowledge should be monitored and the programme can also contribute. A specific type of knowledge is a contribution to standardisation activities in ISO working groups.
- Quality assurance
  In step 6 (section 0) of the scheme confidence maps of the information products will be generated. This is a technical description of the quality of the soundscape maps. At a central level the quality of the total monitoring programme and the process to generate the output should be assessed. A plan needs to be made on how to achieve this.

3.2.2 Description of (sub)activities / (sub)tasks

The following activities are identified:

- Programme management
  - Regular meetings of team, steering committee and advisory board
  - Yearly update of monitoring plan
  - Yearly report of the programme
  - Financial report of the programme
  - Participate in OSPAR and EU bodies

- Communication
  - Stakeholder meetings in all countries
  - Website
  - Newsletters
  - Press contacts
  - Articles
- Knowledge management
  - Support ISO working groups
  - Contribute to scientific world (conferences, journals)
- Quality assurance
  - Quality plan

Depending on the choice of implementation not all activities are needed or they can be implemented in the separate countries.

3.2.3 Outcome

The outcome of the coordination is the execution of the monitoring programme. Risks should be managed and deviations from plans should be discussed with the appropriate management levels.

3.2.4 Centralised or decentralised

There is a need for a central coordination of the monitoring programme. Organisation of meetings, reporting to a steering committee, harmonisation with other programmes and some common communication tasks.
The communication effort is dependent on the ambition of the programme for a further outreach beyond the partner organisations of the programme. The ambition level needs to be discussed.
Knowledge management can be best delegated to one of the more scientifically oriented partners in the programme. Decentralised communication is not effective.
Quality management can best be implemented in the steps of the process. Jomopans will deliver a set of standards documents and working guidelines. These need to be documented and maintained,.

3.2.5 Budget

The effort of a programme manager is estimated to about 2 days per week for a manager at academic level. Also additional communication and administrative support needs to be included. The budget for coordination can therefore be summarised to:

Table 2: Budget summary for coordination.

Activity / task	Required budget (per year)
Programme manager	€ 40 000
Communication	€ 10 000
Knowledge management	p.m.
Administrative support	€ 10 000
Total	**€ 60 000**

3.3 Technical support for the programme

The monitoring programme needs technical support for data and tools:

- Support and development and hosting of GES Tool
- Data management and storage
- Data dissemination
- Standardisation

3.3.1 Objective

To provide and maintain the technical infrastructure for the monitoring programme.

3.3.2 Description of (sub)activities / (sub)tasks

The support of the GES Tool is proposed to be implemented by OSPAR Data and Information System (ODIMS). During the development of the tool it will be embedded into ODIMS. Governance on ODIMS will be done by the OSPAR ICG Data working group.

Biological data on species distributions, habitats and sensitivities included in the GES tool must be evaluated and updated through input from relevant fora (such as OSPAR and ICES expert groups).

At the initiative of HELCOM ICES has built a database for ambient sound measurements. It is advised this database will be used to store the measurements data at an aggregation level that is allowed by the countries (considering security regulations). Governance of the database is done by EN Noise (HELCOM) and ICG Noise (OSPAR).

Standardisation is important in any international co-operation and Jomopans has contributed various proposal to ISO. Future developments should be followed and supported.

3.3.3 Centralised or decentralised

Technical support can best be placed at the hosting party of the facility (GES Tool, Database). For the costs involved in the facilities an agreement between the countries is needed, possibly via the OSPAR secretariat. Governance of these facilities is agreed outside the programme (OSPAR and HELCOM). A central documentation is needed and this must be updated regularly.

3.3.4 Budget

The costs for maintenance of the GES Tool is estimated to € 10 000, which is about 10% of the development costs. Costs for new developments and extensions is not included. About the same amount is budgeted for the ICES data base for measurement data. The variable costs for this database is included in the budget for measurements. Finally an amount of € 5 000 is reserved for supporting the standardisation process. The budget for technical support can therefore be summarised to:

Table 3: Budget summary for technical support.

Activity / task	Required budget (per year)
GES Tool	€ 10 000
Database ICES (fixed costs)	€ 10 000
Standardisation	€ 5 000
Total	**€ 25 000**

3.4 Step 1-3. Collect information on human activities, source properties and environmental properties

Various input data need to be collected annually, to inform the sound propagation modelling. These data involve the actual human activities, that produce continuous sound, and environmental data.
The use of these data are described in the Jomopans report on modelling.
Under the assumption that ships and wind are the primary driving sources for continuous sound.
Source models for ships and wind.

In introduction: scale and resolution of the monitoring. May not be extended to very fine scales.

3.4.1 Objective

Collect all information in order to be able to do the modelling.
Data on human activities:

- Shipping (AIS and VMS)
- Operational windfarms
- Offshore installations
- Other sources

Environmental data:

- Bathymetry
- Bottom composition
- Wind
- Waves

What if information is not yet taken into account?

- Small boats (no AIS),
- oil platforms (no source model)
- impulsive noise at large distances
- Operational windfarms
- Offshore installations
- Other sources
- Breaking waves (surf)

3.4.2 Description of (sub)activities / (sub)tasks

The following data should be collected:

- Shipping activities
  AIS data are often difficult to obtain for low costs. Also the quality of the data must be checked thoroughly. Double counting or missing data can occur and preprocessing of AIS proved to be a considerable effort in Jomopans (see De Jong et al, 2021).
- Bathymetry and bottom composition can be obtained from EMODNET
- Wind and waves can be obtained through Copernicus services

3.4.3 Outcome

Information is available in time, in proper format to be used in next steps.
Recommendations on improvement of the process.

3.4.4 Centralised or decentralised

These data are needed for the modelling step in the process (step 4).
The responsibility of collecting these data and quality assurance of the data can be best delegated to the party that will execute the modelling effort.

3.4.5 Budget

The major costs for collecting data comes from the purchase of AIS data. AIS is at this moment no open data and has to be purchased. It has been found that these data need an extensive quality control to be useable for sound modelling. The budget is based on the AIS costs for the Jomopans project.
It is considered that other data, like sea floor data and meteorological data (wind, wave, etc) can be obtained for free from EMODNET. The budget for collecting data can therefore be summarised to:

Table 4: Budget summary for data collection.

Activity / task	Required budget (per year)
AIS purchase	€ 25 000
AIS quality control	€ 15 000
Bathymetry and geology	€ 0
Meteorological data	€ 0
Total	**€ 40 000**

3.5 Step 4. Modelling soundscape maps

The soundscape maps will be generated through sound propagation modelling. In the Jomopans modelling guidelines report the method is described on how to make soundscape maps.

3.5.1 Objective

Through acoustic propagation modelling, soundscape maps will be calculated for the required parameters, Sound Pressure Level (SPL) percentiles (5th, 10th, 25th, 50th, 75th, 90th, and 95th). A set of soundscape map of natural sound should be made separately. This would enable to produce maps of the excess level. The temporal and spatial resolution of the maps can be dependent on the region. Jomopans makes monthly maps with a resolution of 5 km.

3.5.2 Description of (sub)activities / (sub)tasks

- Source model (describing the radiated shipping source level) based on properties from AIS of the source
- Model for background sound (wind, waves, etc)
- Sound propagation model
  Most appropriate model for the North Sea
  - Normal mode model
  - Ray tracing
  - Wave equation model
  - Etc
- Time steps: size to be determined
- For selected 1/3 Octave bands (63 Hz, 125 Hz and … Hz)
- Calculate sound field for selected time
- Calculate background levels for selected time
- Calculate Excess Level
- For each month calculates percentiles of Excess Level

- Input resolution for AIS and Time
- Output resolution for map (3 km) and time (month)

3.5.3 Outcome

Soundscape maps of North Sea

- 3 frequency bands
- Output resolution in terms of monthly percentiles.
    - Jomopans makes monthly maps with a resolution of 3 km. AIS input data for the complete month are used. The output AIS data needs to be interpolated to regular time series with a temporal resolution of 10 minutes.
    - For other sound sources the resolution needs to be determined, depending on available information.
- Quantity (number of maps)

3.5.4 Centralised or decentralised

Modelling can best be performed for the whole North Sea Area and cannot be split between countries. The number of parties that are capable to execute this task is limited and can either be governmental organisations, (semi)private knowledge institutes and some specialised consultancy companies. A European procurement procedure has to be followed for the outsourcing of the modelling work. This involves a lot of work and a team is needed to guide this process. In this process the requirements for the modelling should be specified.

3.5.5 Budget

Modelling is a highly specialist activity. A few institutes have numerical models available, that are capable and validated to do this type of modelling. Also the modelling itself requires a lot of attention from specialists.
The budget for modelling can therefore be summarised to:

Table 5: Budget summary for modelling.

Activity / task	Required budget (per year)
Data preparation	€ 5 000
Modelling	€ 40 000
Map production	€ 5 000
Total	**€ 50 000**

3.6 Step 5. Measure long term acoustical parameters at several stations

Ambient sound data will be obtained by hydrophone measurements at selected locations within the area of the North Sea. In the Jomopans measurement-guidelines report the method is described on how to conduct measurements of ambient sound.

The basic role of measurement stations in the monitoring programme is the local validation of the modelling and production of uncertainty maps. In addition, measured data of noise from individual ships are important in the work of studying different parameters such as ship categories, age and speed and other, on the radiated sound. Apart from this also other considerations play a role, such as a policy choice to have more stations or the stations to serve other applications.

Measurements are a national responsibility and also the choice of measurement setup is. The costs can vary depending on this choice. In this report we give some estimates of these cost based on the Jomopans experience to help the national authorities to make choices and to prepare budget estimates.

3.6.1 Objective

To gather long term measurements of the ambient sound levels at the North Sea.
Details on the measurement are described in the measurement guidelines (Fischer et al, 2020).

3.6.2 Description of (sub)activities / (sub)tasks

- Jomopans used a mix of systems in the stations. We use difference hydrophones, cabled and autonomous stand-alone stations and this has not hampered the joint monitoring project. By selecting the locations for measurements on a North Sea scale the highest costs reduction can be reached. In annex A some considerations are given on the selection of locations for measurements.Measurements according to standards (e.g. Jomopans)
- Quality assurance / Quality control (also according to standards)
- Auxiliary data gathering
- Bench mark processing and calibration
- Processing of measurements
    - Unified processed data (1s average, unless legal restriction apply)
    - Unified/Agreed data format (e.g. HDF5)
- Data hosting and sharing platform
- Data archiving

3.6.3 Outcome

Processed long-term measurement data for sound pressure level (SPL), in unified data format:

- Ambient sound data:
    - Data within a frequency range of 10 Hz – 20Khz (within 34 x 1/3-octave bands which include the two 1/3-octave bands centred on 63 Hz and 125 Hz) with a temporal resolution of 1s (or higher due to national restrictions)
    - Statistic data: Percentiles (e.g. 1, 5, 10, 25, 50, 75, 90, 95, 99%)
    - Metadata with additional information of measurements
- Processed data is available for all Member states

3.6.4 Centralised or decentralised

It is best to organise the measurement on a national level. Equipment, ship resources and local conditions are important and could be handled on a national basis.
The main financial benefit of a joint monitoring programme stems from a reduced number of stations, that can be reached when the whole North Sea effort is regarded integrally. Therefore central coordination of the location selection is advised.

3.6.5 Budget

The highest budget line for ambient noise monitoring is formed by the field measurements. Hydrophones and additional equipment need to be deployed on often remote locations, involving equipment costs and logistical costs (ship time). There is a risk of the equipment getting lost during the operation. In most cases the loss of data is considered to be more severe than loss of equipment and it is recommended to have a backup available for the measurement equipment. This is also useful to make the deployment operation more efficient. The existing station can be replaced by a similar station and the data retrieval and battery recharging can be done on land.

It should be noted that no two stations are the same (different equipment, different locations, stand-alone or autonomous). Large differences can be found.
It is advised that measurements will be a separate part of the total monitoring effort under the responsibility of the countries themselves. Thus each country can make its own decisions. Based on the experience in the Jomopans project some costs are given for equipment, mobilisation and personnel.

Equipment

Equipment is an investment with a depreciation time of 3 year.
Hydrophones are list from € 14,000 to € 25,000. Backup equipment and calibration of this are required. Extra costs for a cabled station were not mentioned, but I suppose an extra € 25,000 equipment should be assumed.

Equipment	€ 25,000 per station
Extra costs	€ 25,000 per cabled station
Calibration	€ 10,000 per station per year

Therefore a standalone station (and backup) will cost € 26 700 per year on average[2].
For a cabled station (and backup) this is € 35 000 per year on average.

[2] =station+ backup in 3 years=€ 50,000/3= € 16,700 per station per year, plus € 10,000 calibration.

Mobilisation/demobilisation and/or service
Mobilisation costs were listed from € 6,000 per recovery (near shore) to € 35,000 per recovery (far station), but also € 40,000 to € 50,000 per year. For some countries a combination with other survey trips can be made, thus reducing the costs considerably.

Mobilisation € 25,000 per year for a near station
Mobilisation € 50,000 per year for a far station

Personnel/management
It is not very clear what costs were included in the management of measurements. The costs range from € 5,000 to € 25,000 per year. In the used numbers processing is excluded.

Personnel € 20,000 per year per station

Processing
The data from all station have to be processed and stored in the database. The costs for this is:

Processing € 20,000 per year per station

A scenario has been chosen to come to a final budget estimate (see also section 3.1.5 on monitoring time line). We make a distinction between a base year and an intensive year.
In a base year in total 4 measurement station are operational (2 cabled near shore station, 1 stand-alone near shore station, 1 stand-alone far station).
In an intensive year in total 14 stations are operational (2 cabled near shore station, 8 stand-alone near shore station, 4 stand-alone far station).

The budget for measurements can therefore be summarised to:

Table 6: Budget summary for measurements.

Activity / task	Required budget (base year)	Required budget (intense year)
Station costs, equipment	€ 123 400	€ 390 400
Mobilization	€ 125 000	€ 450 000
Personnel	€ 80 000	€ 280 000
Processing	€ 80 000	€ 280 000
Total	**€ 408 400**	**€ 1 400 400**

3.7 Step 6-9. Evaluation maps

Using the sound scape maps and the measurements a validation is performed and confidence maps will be calculated.

- Use measurements at different locations (with different sediment type, water depth, temperature and ocean condition).
- Comparison of measurements with models must be executed using statistical techniques (to be determined).
- Identify environmental parameters which are more important than others. For example: sediment grainsize.
- Make an estimate for the uncertainties there are, based on measurements we have. Prediction at site level. Do we have enough data points to do the statistics? This can be figured out when doing it.

Confidence in the predictions is an important factor for policymakers.

In the GES Tool that was developed in the Jomopans project the soundscape maps are combined with the maps of the spatial distribution of certain indicator species or otherwise maps of sensitive areas (habitats) for underwater noise.
The production of these maps is outside the monitoring programme for ambient noise, but these maps can be products of either other MSFD descriptor (especially D1 and D4) or be the result from specific projects.

3.7.1 Objective

- Evaluate the soundscape maps
- produce confidence maps
- Compute exposure/risk maps

3.7.2 Centralised or decentralised

The validation of the soundscape maps must be done independently from the modelling and can best be done by one party for consistency. This step is essential in the whole monitoring programme and also the key for the overall quality assurance (see section 3.2).
The execution of this step should be done independently from the modelling and the measurement steps.

3.7.3 Budget

The validation and production of confidence maps is also a highly specialist activity. The production of risk maps and risk curves is closely related to the assessment and is considered to be done by the countries (7) themselves.
The budget for modelling can therefore be summarised to:

Table 7: Budget summary for evaluation.

Activity / task	Required budget (per year)
Analysis	€ 30 000
Risk maps and risk curves	€ 35 000
Total	**€ 65 000**

3.8 Assessment and reporting

The assessment based on the results from the monitoring programme should be reported to OSPAR (via ICG Noise) and the EU (MSFD reporting cycle).

3.8.1 Objective

An assessment of the environmental status of the North Sea regarding ambient noise should be made. This assessment will be used of the OSPAR Quality Status Reports (next QSR2023) and for EU member states for the art.8 reporting of the MSFD (next reporting in 2024).

3.8.2 Centralised or decentralised

ICG Noise is tasked by OSPAR to prepare the assessments based on Common Indicators. This assessment will be made centrally. Although the reporting obligation under the MSFD is a responsibility of the member states regional co-operation is encouraged and the OSPAR assessment is meant to be used.

3.8.3 Budget

Assessment and reporting is considered to be done for each country separately, although the end result will be coordinated, at the cost of € 5 000 per assessment. Not all country fall under the EU and MSFD obligations.
The budget for modelling can therefore be summarised to:

Table 8: Budget summary for assessment.

Activity / task	Required budget (per year)
OSPAR assessment	€ 35 000
EU MSFD assessment	€ 25 000
Total	**€ 60 000**

3.9 Budget summary

Table 9: Budget summary

Activity / task	Y1	Y2	Y3	Y4	Y5	Y6
Programme management	€ 60 000	€ 60 000	€ 60 000	€ 60 000	€ 60 000	€ 60 000
Technical support	€ 25 000	€ 25 000	€ 25 000	€ 25 000	€ 25 000	€ 25 000
Collect information	€ 40 000	€ 40 000	€ 40 000	€ 40 000	€ 40 000	€ 40 000
Modelling	€ 50 000	€ 50 000	€ 50 000	€ 50 000	€ 50 000	€ 50 000
Measurements	€ 408 400	€ 408 400	€ 408 400	€ 1 400 400	€ 408 400	€ 408 400
Evaluation			€ 65 000			€ 65 000
Assessment and reporting			€ 60 000			€ 60 000
Totals	**€ 583 400**	**€ 583 400**	**€ 708 400**	**€ 1 575 400**	**€ 583 400**	**€ 708 400**
Average	**€ 790 400 per year**					

Figure 6: Yearly costs for 6-year monitoring cycle

In annex B the budgets for three scenarios are given. In this section we have chosen to present the medium scenario, which has a good trade-off in the amount of information that is gathered and the total costs.

In annex C an example is given on how the costs can be spread over the countries. In the implementation phase the countries must agree on the precise scheme.

4 Organisation

4.1 Organisational structure

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.

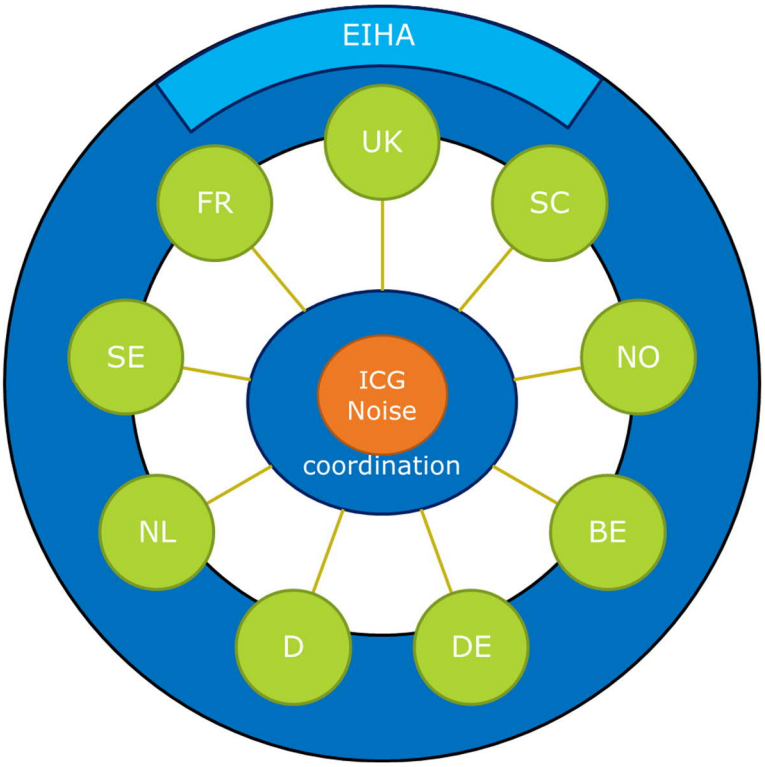


Figure 7: Organisational structure for coordination of the monitoring programme. ICG Noise acts as a coordinating committee for the programme, where the OSPAR Contracting Parties work together. OSPAR EIHA is the Steering Committee for the monitoring programme.

4.1.1 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.

4.1.2 ICG Noise (OSPAR InterCorrespondence Group in 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. One of the members of ICG Noise will be appointed as Programme Manager for the daily coordination. Reporting of the programme to EIHA will be combined with the yearly progress report of ICG Noise to EIHA. ICG Noise meets once per year in person.

4.1.3 Work tasks

The technical work for the monitoring programme is split over a number tasks as outlined in chapter 3. It is intended to allocate the responsibility of the tasks to the participating countries such that a

balanced distribution of costs is reached (see annex C).
The coherence of the monitoring programme is reviewed by a programme manager (task Programme Management). The programme manager can be tasked to prepare the monitoring programme to be operational in 2022.

4.2 Transition phase

At the end of the Jomopans project the monitoring programme for ambient noise will not be operational yet. This implementation plan is an advice to OSPAR on the outlines of such a programme. The OSPAR EIHA committee will eventually decide on the implementation.

Various elements of the programme have been developed and used in the Jomopans project and it would be counterproductive not to continue this. Therefore the Jomopans project advises to enter a transition phase after the Jomopans 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'). The Jomopans project is looking into the possibility to (partly) finance this transition phase through a project extension from Interreg NSR.

4.2.1 Agreement on monitoring programme

In this report an operational joint monitoring programme is described. The requirement of a light organisational structure can be reached by dividing the tasks for the programme over the North Sea countries. The countries must agree on the size of the programme, described by the three scenarios (annex B) or anything in between. The countries must also agree on the efforts they want to do on behalf of the whole programme and it is the aim to balance the different contributions.

In annex C an example of the task allocation to countries is presented, based on the budget estimates. The transition phase will be used to refine this work and come to an agreement between the North Sea countries.

4.2.2 Continuing activities

In section 3.1 it has been argued that a basic level of measurements must be present in all years. Some of the measurement stations from Jomopans can also be employed during the transition period. Some questions have arisen, like the effects of the Covid-19 pandemic on underwater noise that need continuing attention using the Jomopans methods.
Most important is to keep the Jomopans team loosely together. In the past years the Jomopans team has worked together with increasing enthusiasm. Some major questions on ambient noise (monitoring) need the peer-to-peer discussions that Jomopans facilitates.

4.2.3 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 define ISO standards.
- An enormous amount of measurement data has been gathered, The Jomopans project has used these data for validation and further analysis. Much more can be done with these data that is not within the scope of the project. Therefore we propose to transfer the measurement data to the ICES database (commissioned by HELCOM) that is now being populated with data.
- 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.
- A large number of soundscape maps were produced and will be made available in the GES Tool.
- During the transition period marine managers can review the GES Tool and explore the use for marine policy.

4.2.4 Knowledge and information gaps

In the Jomopans project a number of knowledge gaps were identified, that should be addressed in the coordinated joint monitoring program foreseen to be established to succeed Jomopans or in dedicated research projects.

- The knowledge on the effects of continuous noise on marine animals should improve such

that science based threshold values can be determined.

- The contribution of sources of continuous noise needs to be evaluated. In Jomopans a source model for major ship types has been developed. This model needs more validation and for other sources the source strengths have to be determined.
- The effects of the quality of the input data on the soundscape maps must be determined:
    - Incomplete AIS
    - Ships without AIS
    - Absence of some commercially sensitive VMS data
- Distribution and sensitivity of marine animals is needed to make an assessment of (risk of) impact possible
- Evaluation of various options for measurement to mitigate the effects of continuous noise.

Apart from knowledge gaps all elements of the monitoring programme are subjected to continuous improvements. This includes incorporating the experience gained from measurements and modelling into improved, more accurate and cost-efficient designs for field measurements and soundscape modelling.

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Annex A Criteria for choosing measurement stations

Annex A.1 Introduction

The most expensive elements of underwater noise monitoring are the measurement stations. In the preparation of the implementation plan it was shown that the reduction of the number measurement stations by working together was key to the cost reduction of the monitoring programme.
In the discussion during the Edinburgh consortium meeting of 3-4 September 2019 it was concluded that criteria were needed on the choice of the number and location of measurement stations. This memo gives some first considerations on these criteria.
The basic role of measurement stations in the monitoring programme is the validation of the modelling and production of soundscape maps. Apart from this also other considerations play a role. It can be policy choice to have more stations or the stations serve other applications.
This memo doesn't discuss the temporal distribution of measurements.

Annex A.2 Physical/environmental properties

Sound propagation is highly dependent on the physical properties of the sea, like bathymetry and the composition of the seafloor. In the North Sea a number of distinct areas can be recognised. Each of these should be sampled sufficitiently.

- Relatively shallow, sandy North Sea with depth ranging from 10 m to 100 m.
- Deep trenches. In the North Sea the Norwegian Trench has a depth from 100 to 700 m.
- Coastal zones with depths up to 10 m
    - now chosen not to include in monitoring
    - only local nose issue
- Non-open sea areas like the Kattegat and river estuaries (Scheldt, Thames, Eems, Elbe)

Since the final aim of the monitoring is to assess Good Environmental Status environmental conditions can also be considered.

- Habitat type.
- Presence of key species.
- Marine protected areas.

Annex A.3 Human and administrative elements

Noise sources may vary in strength and character and the monitoring programme should be able to give information on all types of sources. Therefore measurements stations should be located near major sources of underwater noise as well as on relatively quiet locations for the natural sources.

- Shipping lanes at sea and at the entrance of harbours. Also for types of ships:
    - Trade (bulk carriers, container ships, coastal shipping)
    - Fisheries
    - Recreational
- Wind farms.
- Other human activities (oil and gas, fish farms, …)
- Quiet zones with prohibited or low shipping.

Annex A.4 National considerations

Measurement can best be organised through the national programmes of the North Sea countries. Therefore also a balance has to be found in the efforts of the contributing countries.
On the other hand countries can have other considerations to make choices:

- Costs of the stations
- Policy considerations
- Knowledge position of national institutes
- National security issues (limiting stations in certain areas)

Annex A.5 Other applications

Finally a measurement station can serve multiple applications, like

- Surveillance of ship traffic
- Biological monitoring
- Source measurements
- Science

Annex B Budget scenarios

In this annex we summarised some scenarios on the extend of the monitoring programme and the impact on the budget. The medium scenario is the one use in this report (section 3.9).

In the minimum scenario the measurements are limited to year preceding an assessment year (every 3 years), where alternatingly a basic setup and the full setup is used. Also in the minimum scenario not every year the AIS data are evaluated. The risk of this scenario is that for some years no information will be available at all.

The maximum scenario aims to perform the full monitoring every year. An assessment can be made using the medium scenario, but in combination with other applications for measurement (see annex A.5) a more intensive scenario can be chosen.

Annex B.1 Minimum scenario

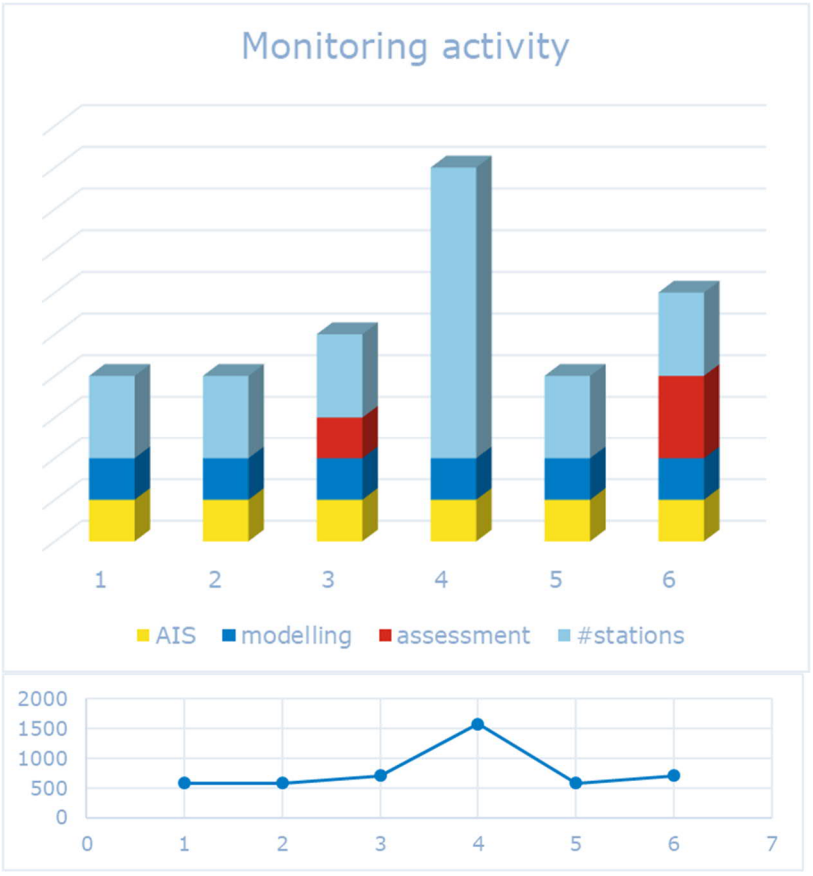
Table B1: Minimum budget summary

Activity / task	Y1	Y2	Y3	Y4	Y5	Y6
Programme management	€ 20 000	€ 20 000	€ 60 000	€ 60 000	€ 20 000	€ 60 000
Technical support	€ 25 000	€ 25 000	€ 25 000	€ 25 000	€ 25 000	€ 25 000
Collect information		€ 40 000			€ 40 000	
Modelling		€ 50 000			€ 50 000	
Measurements	€ 408 400			€ 1 400 400		
Evaluation			€ 65 000			€ 65 000
Assessment and reporting			€ 60 000			€ 60 000
Totals	**€ 453 400**	**€ 135 000**	**€ 210 000**	**€ 1 485 400**	**€ 135 000**	**€ 210 000**
Average	**€ 438 100 per year**					

Annex B.2 Medium scenario

Table B2: Medium budget summary

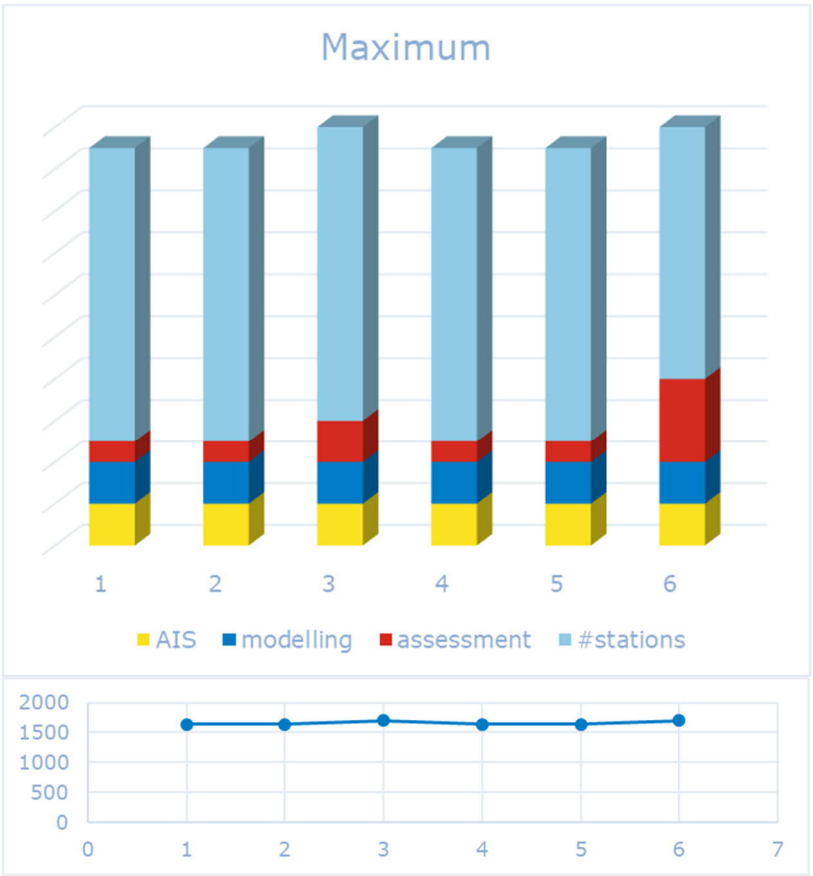
Activity / task	Y1	Y2	Y3	Y4	Y5	Y6
Programme management	€ 60 000	€ 60 000	€ 60 000	€ 60 000	€ 60 000	€ 60 000
Technical support	€ 25 000	€ 25 000	€ 25 000	€ 25 000	€ 25 000	€ 25 000
Collect information	€ 40 000	€ 40 000	€ 40 000	€ 40 000	€ 40 000	€ 40 000
Modelling		€ 50 000			€ 50 000	
Measurements	€ 408 400	€ 408 400	€ 408 400	€ 1 400 400	€ 408 400	€ 408 400
Evaluation			€ 65 000			€ 65 000
Assessment and reporting			€ 60 000			€ 60 000
Totals	**€ 533 400**	**€ 583 400**	**€ 658 400**	**€ 1 525 400**	**€ 583 400**	**€ 658 400**
Average	**€ 790 400 per year**					



Annex B.3 Maximum scenario

Table B3: Maximum budget summary

Activity / task	Y1	Y2	Y3	Y4	Y5	Y6
Programme management	€ 60 000	€ 60 000	€ 60 000	€ 60 000	€ 60 000	€ 60 000
Technical support	€ 25 000	€ 25 000	€ 25 000	€ 25 000	€ 25 000	€ 25 000
Collect information	€ 40 000	€ 40 000	€ 40 000	€ 40 000	€ 40 000	€ 40 000
Modelling	€ 50 000	€ 50 000	€ 50 000	€ 50 000	€ 50 000	€ 50 000
Measurements	€ 1 400 400	€ 1 400 400	€ 1 400 400	€ 1 400 400	€ 1 400 400	€ 1 400 400
Evaluation	€ 65 000	€ 65 000	€ 65 000	€ 65 000	€ 65 000	€ 65 000
Assessment and reporting			€ 60 000			€ 60 000
Totals	**€ 1 640 400**	**€ 1 640 400**	**€ 1 700 400**	**€ 1 640 400**	**€ 1 640 400**	**€ 1 700 400**
Average	**€ 1 660 400 per year**					



Annex C Example of costs per country

The monitoring programme can be implemented without budgets being transferred between countries. Each country can perform one or more tasks of the programme such that the costs are spread evenly (approximately).
In this annex we present an **example** of how the workload (and associated budgets) can be spread among 8 countries (A to H). In the implementation phase the countries must agree on the precise scheme.
The numbers are based on the budgets presented in chapter 3.

Table C1: Workload per country

Country	Tasks	Budget per year
A	• Cabled station, permanent	€ 100 000
B	• Cabled station, permanent	€ 100 000
C	• Standalone station, near shore, permanent	€ 91 700
D	• Standalone station, far, permanent	€ 116 700
E	• Programme management • Technical support • Standalone station, near shore, one year	€ 100 300
F	• Collect information • Modelling • Standalone station, far, one year	€ 109 400
G	• Evaluation • Assessment • Standalone station, far, one year • 2 Standalone station, near shore, one year	€ 91 700
H	• Standalone station, far, one year • 4 Standalone stations, near shore, one year	€ 80 600
Totals		**€ 790 400**