European Marine Strategy Framework Directive

MONITORING GUIDANCE FOR UNDERWATER NOISE IN EUROPEAN SEAS

PART I - Executive Summary & Recommendations

2nd Report of the Technical Subgroup on Underwater Noise and other forms of energy (TSG Noise)

Interim Guidance Report

May 2013

This report can be cited as follows:

Monitoring Guidance for Underwater Noise in European Seas - 2nd Report of the Technical Subgroup on Underwater noise (TSG Noise). Part I – Executive Summary. Interim Guidance Report. May, 2013.

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TSG Noise acknowledges valuable contributions and comments received from:

Mark Prior, Mike van der Schaar, Özkan Sertlek, John Campbell, Michael Dittrich, Foort de Roo, Geert Aarts, Jeroen Janmaat, Bill Pramik, Sander von Benda-Beckmann and Leo de Vrees (EC).

Interim Guidance Report:

TSG Noise was tasked to deliver guidance so that European Member States could initiate programmes for underwater noise monitoring. As monitoring must be operational by 2014, first guidance was required by spring 2013. The Interim Guidance report provides the basis for the noise monitoring programme however since new information continues to be compiled TSG Noise can review and update the guidance later in 2013. In addition, the results and feedback that may arise at the training workshop (preliminary planned now for Autumn 2013) can be incorporated. This also means the inclusion of new findings into the design of the register for impulsive noise generating activities, and from currently running initiatives around the Baltic Sea, The Netherlands, Germany and Ireland, for ambient noise. For this reason this report has been designated as an interim guidance until Autumn 2013.

TSG Noise was supported by Arcadis and Coastal & Marine Union (EUCC) under framework contract ENV.D.2/FRA/2012/0025.

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Summary

The Marine Strategy Framework Directive (MSFD) requires European Member States (MS) to develop strategies that should lead to programmes of measures that achieve or maintain Good Environmental Status (GES) in European Seas. As an essential step reaching good environmental status, MS should establish **monitoring programmes for assessment**, enabling the state of the marine waters concerned to be evaluated on a regular basis.

In 2010, in Commission Decision 2010/477/EU, criteria and methodological standards on GES of marine waters were published. Two indicators were described for Descriptor 11 (Noise/Energy): Indicator 11.1.1 on low and mid frequency impulsive sounds and Indicator 11.2.1 on continuous low frequency sound (ambient noise).

As a follow up to the Commission Decision, the Marine Directors in 2010 agreed to establish a Technical Subgroup (TSG) under the Working Group on Good Environmental Status (WG GES) for further development of Descriptor 11 Noise/Energy. TSG (Underwater) Noise in 2011 focused on clarifying the purpose, use and limitation of the indicators and described methodology that would be unambiguous, effective and practicable. In February 2012, TSG Noise delivered its first report [Van der Graaf et al., 2012][1]. For both the impulsive and the ambient noise indicators significant progress was made to their practical implementation, and most ambiguities were solved.

In December 2011, EU Marine Directors requested the continuation of TSG Noise, and the group was tasked with recommending how MS might best make the indicators of the Commission Decision operational. TSG Noise was asked first to provide monitoring guidance that could be used by MS in establishing monitoring schemes for underwater noise in their marine waters. Further work includes providing suggestions for (future) target setting; for addressing the biological impacts of anthropogenic underwater noise and to evaluate new information on the effects of sound on marine biota, with the view to considering indicators of noise effects.

The present document is **Part I** of the ***Monitoring Guidance for Underwater Noise in European Seas*** (Interim Guidance Report) and provides MS with the information needed to commence the monitoring required to implement this aspect of MSFD. TSG Noise has focused on ambiguities, uncertainties and other shortcomings that may hinder monitoring initiatives and has provided solutions, and describes methodology for monitoring both impulsive and ambient noise in such a way that information needed for management and policy can be collected in a cost-effective way. TSG Noise has no doubt that further issues will arise once monitoring starts, but hopes the principles laid out in this guidance will help resolve these.

The Monitoring Guidance for Underwater Noise is structured, as follows:

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

Part I of the Monitoring Guidance is the executive summary for policy and decision makers responsible for the adoption and implementation of MSFD at national level. It provides the key results and recommendations presented in Part II that support the practical guidance for MS and will, enable assessment of the current level of underwater noise.

Part II, is the main report of the Monitoring Guidance, that provides the specifications for the monitoring of underwater noise, with a dedicated section on impulsive noise (Criterion 11.1 of the Commission Decision) and ambient noise (Criterion 11.2 of the Commission Decision). It provides a detailed guide to those who will implement the monitoring/modelling, and noise registration technical specifications.

[1] The first TSG Noise Report (27 February 2012) is available online: http://ec.europa.eu/environment/marine/pdf/MSFD_reportTSG_Noise.pdf

Part III, the background information and annexes, is not part of the guidance, but is added for additional information, examples and references that support the Monitoring Guidance specifications.

1. Introduction to Underwater Noise

In the EC Decision 2010/477/EU on criteria and methodological standards on GES of marine waters, two indicators were published for Descriptor 11 (Noise/Energy) of the MSFD 2008/56/EC. These are: Indicator 11.1.1 on 'low and mid frequency impulsive sounds' and Indicator 11.2.1 on 'Continuous low frequency sound (ambient noise)'. As a follow up to the EC Decision, the Marine Directors in 2010 agreed to establish a TSG under the WG GES for further development of Descriptor 10 Marine Litter and Descriptor 11 Noise/Energy. For practical reasons Directorate-General Environment (DG ENV) decided that the work would be carried out by two separate groups. This report compiles the recommendations of TSG Noise. Text box 1 shows the extract of the EC Decision specifically for the indicators of Descriptor 11.

Text Box 1: Extract of the indicators for Descriptor 11 (Noise/Energy) from EC Decision 2010/477/EU

Descriptor 11: Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

Together with underwater noise, which is highlighted throughout Directive 2008/56/EC, other forms of energy input have the potential to impact on components of marine ecosystems, such as thermal energy, electromagnetic fields and light. Additional scientific and technical progress is still required to support the further development of criteria related to this descriptor, including in relation to impacts of introduction of energy on marine life, relevant noise and frequency levels (which may need to be adapted, where appropriate, subject to the requirement of regional cooperation). At the current stage, the main orientations for the measurement of underwater noise have been identified as a first priority in relation to assessment and monitoring, subject to further development, including in relation to mapping. Anthropogenic sounds may be of short duration (*e.g.* impulsive such as from seismic surveys and piling for wind farms and platforms, as well as explosions) or be long lasting (*e.g.* continuous such as dredging, shipping and energy installations) affecting organisms in different ways. Most commercial activities entailing high-level noise levels affecting relatively broad areas are executed under regulated conditions subject to a license. This creates the opportunity for coordinating coherent requirements for measuring such loud impulsive sounds.

11.1. Distribution in time and place of loud, low and mid frequency impulsive sounds

- Proportion of days and their distribution within a calendar year over areas of a determined surface, as well as their spatial distribution, in which anthropogenic sound sources exceed levels that are likely to entail significant impact on marine animals measured as Sound Exposure Level (in dB re 1 µPa 2 .s) or as peak sound pressure level (in dB re 1 µPa peak) at one metre, measured over the frequency band 10 Hz to 10 kHz (11.1.1)

11.2. Continuous low frequency sound

- Trends in the ambient noise level within the 1/3 octave bands 63 and 125 Hz (centre frequency) (re 1□Pa RMS; average noise level in these octave bands over a year) measured by observation stations and/or with the use of models if appropriate (11.2.1).

1.1 Types of underwater noise

There are many kinds of anthropogenic energy that human activities introduce into the marine environment including sound, light and other electromagnetic fields, heat and radioactive energy. Among these, the most widespread and invasive kind of anthropogenic energy is underwater sound. It is likely that these levels, and associated effects on the marine ecosystem have been increasing since the advent of steam-driven ships, although there have been very few studies that have quantified such a change. The numbers of anthropogenic electromagnetic fields are increasing due to the increasing number of power cables crossing our seas but these emissions are relatively localised to the cables. Light and heat emissions are also relatively localised, but may have significant local effects (Tasker *et al*. 2010).

Energy input can occur on many scales in both space and time. Anthropogenic sounds may be of short duration (*e.g.* impulsive) or be long lasting (*e.g.* continuous); impulsive sounds may however be repeated at intervals (duty cycle) and such repetition may become diffuse with distance and reverberation and become indistinguishable from continuous noise. Higher frequency sounds transmit less well in the marine environment whereas lower frequency sounds can travel far. In summary, there is great variability in transmission of sound in the marine environment.

Marine organisms that are exposed to noise can be adversely affected both on a short timescale (acute effect) and on a long timescale (permanent or chronic effects). Adverse effects can be subtle (*e.g.* temporary reduction in hearing sensitivity, behavioural effects) or obvious (*e.g.* worst case, death). These adverse effects can be widespread (as opposed to local for other forms of energy) and, following the recommendations of Tasker *et al*. (2009), the EC decided in September 2010 that the two indicators for underwater noise listed in Text Box 1 should be used in describing GES (EC Decision 2010/477/EU on criteria and methodological standards on GES). This interim guidance report therefore focuses largely on providing guidance for monitoring these indicators of underwater sound rather than on other sources of energy.

2. TSG Noise Recommendations

2.1 Monitoring guidance for impulsive noise

This chapter contains recommendations provided by the TSG Noise for the establishment of monitoring programmes of **impulsive noise** as covered by the EU MSFD indicator 11.1.1. The basic principle of the MSFD addresses the ecosystem rather than individual animals or species. This indicator illustrates the cumulative impact of activities, rather than that of individual projects or programmes (dealt with by other EU legislation). Effects of localised singular activities are therefore not covered, and this indicator on its own is not intended, nor is it sufficient, to manage singular events. Environmental Impact Assessments (EIA) can be used to assess and, where necessary, limit the environmental impacts of individual projects.

Indicator 11.1.1 on low and midfrequency impulsive sounds:
The proportion of days and their distribution within a calendar year, over geographical locations whose shape and area are to be determined, and their spatial distribution in which source level or suitable proxy of anthropogenic sound sources, measured over the frequency band 10 Hz to 10 kHz, exceeds a value that is likely to entail significant impact on marine animals (11.1.1).

For further considerations and explanation, see the 1st TSG report [Van der Graaf et al., 2012].

The impact that is addressed by Indicator 11.1.1 is "considerable" displacement. This is the displacement of a significant proportion of individuals over a relevant time period and spatial scale. The indicator addresses the cumulative impact of sound generating activities and possible displacement associated.

The purpose of this indicator is to assess the pressure on the environment by making available an overview of all low and mid-frequency, impulsive sound sources over a period of one year throughout regional seas. This will provide MS with an overview of the environmental pressures from these sources, which have not been previously measured.

2.1.1 Set-up a Noise Register

A first step is to establish the current level and trend of these impulsive sounds. This should be done by setting up a **register of the occurrence of these impulsive sounds.** Such a noise register may be used to underlie a relatively coarse scale map. The temporal scale of the map is one day, while the proposed spatial scale is of sea blocks of approximately 10 nmi x 5 nmi.

Seismic surveying, pile-driving, explosives, sonar working at relevant frequencies and some acoustic deterrent devices are the **most important sound-sources that should be considered for inclusion in the register**. There are additional sources of possible concern (*e.g.* boomers, sparkers, scientific echo sounders). Since a registry that leaves out part of the sound sources is not useful if the aim is to address cumulative effects of all sources of impulsive noise, and therefore it is recommended that information on all sources should be included in the registry. TSG Noise therefore suggest that data on explosions and from activities of which the sole purpose is defence or national security should be included in the register, on a voluntary basis, but notes that this is a national policy issue.

The **main items in the register**, needed to derive the amount of pulse-block days (the number of days that in an area (block) a certain threshold (pulse) is exceeded) as required in the text of the Commission Decision, are:

- Pulse-generating activity
- Day
- Location
- Source level

Once a register is established, it will be possible to determine the coarse scale spatial and temporal distribution of impulsive noise sources. This quantified assessment of impulsive noise sources could be used in future to determine policy targets. It should also be possible to establish a baseline of "current condition".

Minimum noise thresholds have been defined for low and mid-frequency sources as a basis for including sources in the register.

For impact pile-drivers and multiple explosions no minimum threshold should be used and all pile-driving activities and all use of multiple explosions at a single site should be registered.

For sonar, airguns, acoustic deterrents and single explosions, minimum thresholds should be used for uptake in the registers.

The thresholds that were derived and recommended are specified in Part II of the monitoring guidance and will ensure that all sources that have a potential for significant population level effect will be included in the register. However, the use of these relatively low thresholds will result in sources being registered that actually have a relatively low potential for impact, while there are more powerful sources that are likely to have a much greater, potential impact. There is a need for more detail in the register than only the temporal and spatial scales, but also other information, of which the source level is the most important. If this information is available it should be recorded and so that it can be used to enhance the register. This will include recording activities to assess and evaluate the total pressure from impulsive sources. In a later phase the register may serve as a management tool.

If Member States wish to improve the quality and usability of the register, it is recommended that additional information such as source properties level or proxy should be added to the register. This will improve the accuracy of assessing the impact of anthropogenic sound sources on the marine environment. For more detailed specifications please refer to Part II of this Monitoring Guidance.

2.1.2 Interpretation of results, thresholds and targets

For this indicator it is recommended to use the **reference state** as a baseline, i.e. a state where there is negligible population displacement level impact from anthropogenic noise. This is a zero-line, *e.g.* no significant displacement (where 'no significant displacement' means 'no significant displacement caused by man-made sound').

Once the register is set-up one of the first applications will be to determine the actual level and distribution of impulsive noise. This level can be used in future to determine policy targets and is thus proposed as the baseline.

There is presently insufficient knowledge to determine when too much disturbance would compromise GES. TSG Noise stresses that setting a realistic target is only possible once the baseline (i.e. actual level) is known and is contingent on the availability of information on the impacts of noise. TSG Noise will continue to work in 2013 and 2014 to provide advice on **thresholds and targets**. This advice will be on the type of target MS should consider. Setting the threshold level is up to the MS themselves.

2.1.3 Options for addressing spatial scale

There are **two spatial units** that should be used in the analysis. The first is the blocks or grid size used for registering the data. The second is the assessment areas used for the analysis.

In the first report of the TSG Noise, options for addressing spatial scale were set out. It was recommended that one grid size should be used by all MS. For practical reasons TSG Noise proposes to use standard hydrocarbon licensing blocks for collection of data for seismic surveys, since most MS commonly use these licensing blocks. Use of these blocks may be practicable when collecting data for other relevant sources, but sometimes other approaches may be needed.

For the analysis of the data the use of these blocks may be practicable, but MS should realize that the actual size of the area impacted by a source may vary (most notably depending on source level). Making use of standard blocks to describe the impacted area may not be accurate enough. This can be better evaluated in the future using actual monitoring data.

2.2 Monitoring guidance for ambient noise

This chapter provides a guide for **the monitoring of ambient noise** as covered by the EU MSFD indicator 11.2.1.

To make indicator 11.2.1. operational and to comply with the Commission Decision of 2010 (CD): to monitor trends, advice on scope and optimal approach are provided.

> *Indicator 11.2.1: Trends in the annual average of the squared sound pressure associated with ambient noise in each of two third octave bands, one centred at 63 Hz and the other at 125 Hz, expressed as a level in decibels, in units of dB re 1 µPa, either measured directly at observation stations, or inferred from a model used to interpolate between or extrapolate from measurements at observation stations* [Van der Graaf, 2012].

To reach the overarching aim of the MSFD: ensure that Good Environmental Status is reached, trends only are not sufficient. Trends indicate whether the actual pressure on the environment (*e.g.*, shipping noise) is rising or falling, but to describe GES, actual levels, based on wider overview of the area, created by combination of modelling and mapping will be needed.

The **combined use of measurements and models** (and possibly sound maps) is the best way for Member States to ascertain levels and trends of ambient noise in the relevant frequency bands. Member States should be careful to balance modelling with appropriate measurements. The first TSG Noise report [Van der Graaf *et al.,* 2012] describes standards that measurement equipment should comply with, along with comments about possible shortcomings of commercially available equipment. Models also require standards and definitions needed to clarify what is an appropriate model and what is not.

As mentioned before, the CD does not require that MS describe the complete noise field in their waters; a limited number of monitoring stations (measurement locations) would suffice. However it is considered that the use of models will contribute directly to effective ambient noise monitoring and assessment against an indicator, but that measurements are necessary to provide ground truth at some specific locations. There are several reasons to use modelling:

1. The use of modelling to create noise maps facilitates trend estimation in a more cost-effective manner.
2. The use of models identifies trends for different source types, by directly identifying the cause of any fluctuations thus facilitating mitigation action.
3. Models permit the removal of selected sources if considered not causing a departure from GES (such as natural sources of sound, both biotic and abiotic (*e.g.* lightning).
4. The use of models would provide Member States with a better overview of actual levels and distribution of levels across its sea area, and thereby identify departures from GES.

In addition, modelling has a number of advantages that could contribute to a greater understanding of the likely impacts of noise in the future (see for more detail Part II).

The **use of models and sound maps** is not an extra requirement to the measuring of ambient noise, but rather can be a way of achieving compliance with the MSFD and CD, while obtaining better results at lower costs, than if measurements alone are made. However, Member States should be careful to not shift the balance too much in favour of modelling *only* but ensure that modelling will be validated or corrected with measurements.

The use of mapping has some history and in implementing the MSFD and one can make use of previous experience. Relevant EU regulation is summarised in part II providing some useful background for the MSFD.

2.2.1 Outline of the monitoring programme

TSG Noise advises **Member States within a sub region to work together to establish an ambient noise monitoring system**. No precise locations for deploying equipment necessary to monitor relevant frequency bands of ambient noise have yet been defined. However, TSG Noise is providing a set of guidelines for **monitoring strategy** and guidance **for reporting results**.

It is the responsibility of the MS to define exact locations for the monitoring of Indicator 11.2.1.

The indicator is a pressure-indicator that should be used to document trends and not to provide a complete coverage of all noise for the area of interest. If a trend is detected in an area, it should also provide evidence about the trend in other areas (for example an MPA). Thus a **limited set of monitoring stations per region / basin should suffice** to satisfy the requirements of the indicator. This is dependent on available information regarding spatial distribution of activities in each region. In deep water regions, a single measurement point (at low frequency) may be representative of a wider region, because low frequency sound propagates well in deep water, in shallow water to a lesser degree. But still, in deep water, there may be factors effecting the measured values - sound channels are likely to occur, together with convergence zones.

Since measurement stations can be very costly TSG Noise has considered whether a limited number of measurement stations per basin can be sufficient. For optimal planning of the placement of measurement stations, a **monitoring strategy** will be required. The purpose of the measurements is to give input for modelling; provide confidence to model predictions that are used to extrapolate to other parts of each basin; or the measurement can be used directly as the representative value for a region, leading to different measurement strategies.

The monitoring should focus on **shipping noise and individual ship noise assessment**. Placement of measurement stations near a shipping lane is recommended in order to record a period of time where a single vessel is dominating the noise. Processing shall then extract directivity patterns of individual vessels.

The **arithmetic mean** should be used to establish **average ambient noise levels.** The value found will be dominated by the noisiest contribution. Therefore, monitoring in the established high pressure areas (such as commercial traffic lanes) will be emphasised by this contribution. Any other contribution, especially contribution at the regional scale will be de-emphasised. As a consequence, significant pressure fluctuation at a region scale will be disregarded by only listening near traffic lanes.

In order to establish the statistical significance of the trend, additional statistical information about the distribution is necessary. Until better advice becomes available, it is recommended that the **complete distribution be retained for this purpose in bins of 1 dB**.

Since sound propagates over large distances, especially for the low frequencies in the context of the MSFD, the noise contribution from any major traffic lanes spreads at long distances. Therefore, **remotely placed hydrophones** would be able to capture the diversity of noise contributions in a more balanced way, even other components of shipping noise that would have been masked otherwise. Such monitoring strategy is likely to be suitable for representative monitoring at a regional scale.

Considering that, at the low frequencies of the MSFD, any piece of European waters is in the noise footprint of a shipping lane, it is **recommended an initial set of rules for the placement of measurement devices** (in order of importance):

1- With relatively few measurement stations per basin, these should be at locations suitable for validating the model prediction used for interpolation and extrapolation. Monitoring may be more cost effective if existing stations are used for monitoring other oceanographic features.
2- In deep water, devices should be placed in areas of low shipping density. The range to shipping lanes may be greater in deep water as low frequency sound can propagate long distances.
3- Place one hydrophone close to the bottom (a priori subject to the lower variability of noise levels). If budgets allow for a second hydrophone, it should be placed at the depth where the lowest value for the yearly averaged sound speed is expected (if that information is available), and in deep water that depth should be preferred over the seabed or the sea surface.

4- Consider special topography and bathymetry effects upon acoustics *e.g.* when there are pronounced coastal landscapes or islands/archipelagos it may be considered to place hydrophones on opposite sides,
5- In waters subjected to trawling, use locations that are protected from fishing activities or locations where trawling is avoided due bottom features (*e.g.* underwater structures/wrecks);
6- Consider, and if possible avoid being close to, the presence of other sound sources that might interfere with measurements *e.g.* offshore activities like oil and gas exploration.
7- Any mooring has to be designed for noise measurements.

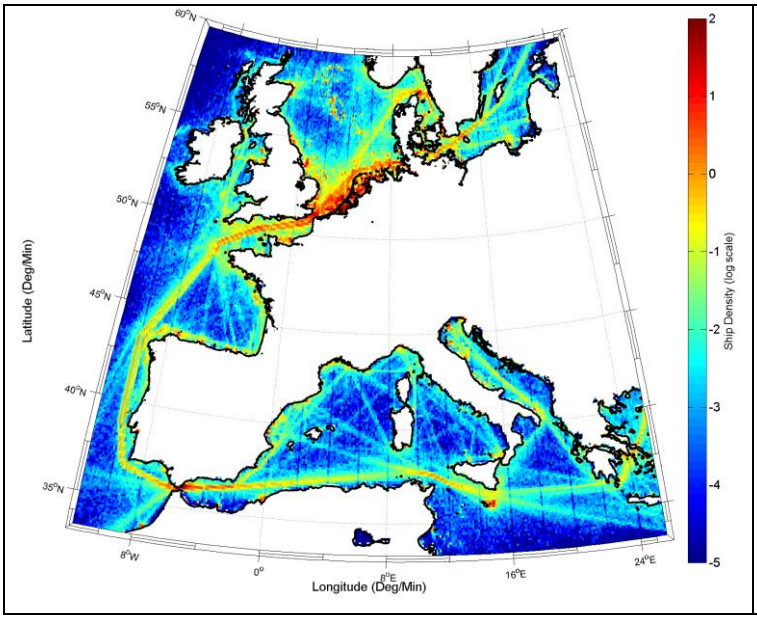

Figure 1: Density map of ship traffic based on AIS data (source Quiet-Oceans based on Marine Traffic website.

3. Conclusions

The main recommendations of the interim guidance report for MS regarding underwater noise monitoring and registration are presented for both the impulsive and ambient noise indicators as follow:

3.1 Monitoring Guidance Impulsive Noise

Interpretation and aim: TSG Noise agreed that the impact that is addressed by this indicator is "considerable" displacement. This is the displacement of a significant proportion of individuals over a relevant time period and spatial scale. The indicator addresses the cumulative impact of sound generating activities and possible displacement associated. rather than that of individual projects.

Sound Register: A **first step is to establish** the current level and trend of impulsive noise. This should be done by setting up **a register of the occurrence of the impulsive noise**.

TSG Noise recommends for impulsive noise: TSG Noise recommends that MS work together in setting up a register, both at regional seas level and the EU level. Seismic surveying, pile-driving, explosives, sonar working at relevant frequencies and some acoustic deterrent devices are the **most important sound-sources that should be considered for inclusion in the register**. There are additional sources of possible concern (*e.g.* boomers, sparkers, scientific echo sounders). It is recommended that information on all such sources should be included in the registry.

The **main items in the noise register**, needed to derive the amount of pulse-block days (the number of days that in an area (block) a certain threshold (pulse) is exceeded) as required in the text of the Commission Decision, are:

- Pulse-generating activity
- Day
- Location
- Source level

Once a register is established, it will be possible to determine the coarse scale spatial and temporal distribution of impulsive noise sources. This quantified assessment of impulsive noise sources could be used in future to determine policy targets. It should also be possible to establish a baseline of "current condition".

3.2 Monitoring Guidance Ambient Noise

Interpretation and aim: TSG Noise agrees that ambient noise modelling should ideally be done in conjunction with measurements. The use of modelling will strengthen the analysis by overcoming bias introduced by changes in human activities or the by the natural variability of the environment, and will extend the monitoring to poorly or un-covered areas.

Monitoring: A first step towards monitoring is **to establish the current level and any trend in ambient noise**. This should be measured directly at observation stations, or inferred from a model used to interpolate between or extrapolate from measurements at observation stations.

TSG Noise recommends for ambient noise:

- ✓ The **combined use of measurements and models** (and possibly sound maps) is recommended as the best way for Member States to ascertain levels and trends of ambient noise in the relevant frequency bands. Member States should be careful to balance modelling with appropriate measurements.
- ✓ **Standards that measurement equipment should comply with**.
- ✓ The **use of mapping**.
- ✓ That Member States **adopt the arithmetic mean as averaging method**.

- ✓ That the **complete distribution be retained in bins of 1 dB** in order to establish the statistical significance of the trend.

In conclusion, factors to be considered while setting up the **noise monitoring strategy / plan** are:

- To **avoid interference with other noise sources** and **to reduce the risk of equipment loss**, areas where trawling occurs is to be avoided. Areas with a rocky seabed, or underwater structures such as wrecks and or with low intensity of trawler fishing are preferred

- Member States are encouraged to **jointly set-up monitoring programmes** (*e.g.* Regional Seas level) and cooperate in the design and set up of monitoring stations and exchange of expertise.

- Monitoring can be **most cost effective where existing monitoring stations are used**. Where there are only few measurement stations these should be at suitable locations for validating the model prediction used for interpolation and extrapolation. In addition, mooring should be designed for noise measurements.

The present recommendations are further developed and specified in **Parts II** (Technical Specifications) and **III** (background information, examples and annexes) that complete and complement the Monitoring Interim Guidance report.