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Agenda item 5

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REVIEW OF THE GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE (MEPC.1/Circ.833) AND IDENTIFICATION OF NEXT STEPS

Report of the Working Group

Introduction

1 The Working Group on Reduction of Underwater Radiated Noise (URN), chaired by Ms. Marie-Lucie Susini (Belgium), met from 23 to 26 January 2023.

2 The Group was attended by delegations from the following Member States:

ALGERIA
ANGOLA
ARGENTINA
BAHAMAS
BANGLADESH
BELGIUM
BRAZIL
CANADA
CHILE
CHINA
CROATIA
DENMARK
ECUADOR
FINLAND
FRANCE
GERMANY
GREECE
INDIA
INDONESIA
ITALY
JAPAN
KUWAIT
LIBERIA
MALAYSIA
MALTA
MARSHALL ISLANDS
MEXICO
MOROCCO
NETHERLANDS
NEW ZEALAND
NORWAY
PANAMA
PAPUA NEW GUINEA
PHILIPPINES
POLAND
PORTUGAL
REPUBLIC OF KOREA
RUSSIAN FEDERATION
SINGAPORE
SPAIN
SWEDEN
SWITZERLAND
THAILAND
TÜRKİYE
UNITED ARAB EMIRATES
UNITED KINGDOM
UNITED STATES

a representative from the following Associate Member of IMO:

HONG KONG, CHINA

observers from the following intergovernmental organizations:

EUROPEAN COMMISSION (EC)
INTERNATIONAL WHALING COMMISSION (IWC)

and the following non-governmental organizations in consultative status:

INTERNATIONAL CHAMBER OF SHIPPING (ICS)
INTERNATIONAL ASSOCIATION OF PORTS AND HARBORS (IAPH)
BIMCO
INTERNATIONAL ASSOCIATION OF CLASSIFICATION SOCIETIES (IACS)
OIL COMPANIES INTERNATIONAL MARINE FORUM (OCIMF)
FRIENDS OF THE EARTH INTERNATIONAL (FOEI)
INTERNATIONAL ASSOCIATION OF DRILLING CONTRACTORS (IADC)
CESA
INTERNATIONAL ASSOCIATION OF INDEPENDENT TANKER OWNERS (INTERTANKO)
CRUISE LINES INTERNATIONAL ASSOCIATION (CLIA)
INTERNATIONAL ASSOCIATION OF DRY CARGO SHIPOWNERS (INTERCARGO)
WORLD WIDE FUND FOR NATURE (WWF)
INTERNATIONAL PARCEL TANKERS ASSOCIATION (IPTA)
INTERNATIONAL MARINE CONTRACTORS ASSOCIATION (IMCA)
INTERNATIONAL CHRISTIAN MARITIME ASSOCIATION (ICMA)
INTERNATIONAL TRANSPORT WORKERS' FEDERATION (ITF)
INTERNATIONAL FUND FOR ANIMAL WELFARE (IFAW)
THE NAUTICAL INSTITUTE
SUPERYACHT BUILDERS ASSOCIATION (SYBASS)
PACIFIC ENVIRONMENT
CLEAN SHIPPING COALITION (CSC)
INUIT CIRCUMPOLAR COUNCIL

Terms of reference

3 The Working Group on Reduction of Underwater Radiated Noise (URN,) taking into account the comments made and decisions taken in plenary, as well as proposals and information in documents SDC 9/5/2, SDC 9/5/3, SDC 9/5/4, SDC 9/5/5, SDC 9/5/6, SDC 9/5/7, SDC 9/INF.2, SDC 9/INF.9, SDC 9/INF.10 and SDC 9/INF.11, was instructed to:

.1 finalize the draft revised Guidelines for the reduction of underwater radiated noise from commercial shipping to address adverse impacts on marine life, based on annex 1 to document SDC 9/5, incorporating, as appropriate, provisions for the Noise Management Planning Integrated tool (SDC 9/5, annex 2) and on energy efficiency compliance measures and URN relationships (SDC 9/5, annex 3);

.2 finalize and prioritize the work plan to further prevent and reduce underwater radiated noise from shipping, based on the annex to document SDC 9/5/1;

.3 finalize and prioritize the list of provisional suggestions to promote the work of the Organization to increase awareness, uptake and implementation of the Guidelines, and the provisional list of suggested next steps to further prevent and reduce underwater radiated noise from shipping, based on annex 7 to document SDC 9/5, and formulate recommendations for next steps, taking into account annexes 4 to 6 to document SDC 9/5; and

.4 submit a written report by Thursday, 26 January 2023.

Further development of the draft Revised Guidelines

4 In accordance with the terms of reference, the Group further developed the draft Revised Guidelines for the reduction of underwater radiated noise from shipping to address adverse impacts of marine life, with a view to improving their uptake, structure, effectiveness and clarity, as set out in annex 1. Major discussions of the Group are outlined in the subsequent paragraphs.

Additional inputs

5 Before embarking on technical discussions, the Group noted with appreciation that:

.1 the delegation of Canada had incorporated the late comments made in the Correspondence Group in document SDC 9/INF.2 into the draft revised text of the Guidelines, except for the general comments or structural changes; and had prepared a more revised version of the draft Guidelines; and

.2 the delegation of ICC prepared an additional draft annex intending to supplement, and provide information and guidance to operators transiting Inuit Nunaat and the Arctic.

6 In this respect, the Group agreed to use the more revised version of the draft text incorporating the modifications in document SDC 9/INF.2 as a basis; and to consider the additional draft annex on Inuit Nunaat and the Arctic (see paragraph 17).

Application provisions

7 The Group had a debate over the scope of application in section 2 of the draft Revised Guidelines. In this respect, the Group discussed whether the revised Guidelines should be applicable to all ships or all commercial ships or without any specification. The Group also considered which types of ships should be excluded from the scope, such as offshore energy exploration and/or production, and Government owned ships which did not conduct commercial activities.

8 Following discussion, the Group agreed that the Guidelines might be applied to any ship which did not cover the introduction of noise from war ships and naval auxiliaries, or the deliberate introduction of noise for purposes other than shipping.

9 In this respect, the Group noted the following statement made the delegation of the United States:

"The United States appreciates the discussion to clarify the scope of application of the draft Revised Guidelines to align with IMO practices and procedures. Therefore, while understanding the need to harmonize language, the United States does not view the term 'any ship' to be an expansion of the scope of the application of the 2014 Guidelines (MEPC.1/Circ.833)."

Purpose

10 The Group discussed the purpose of the draft Revised Guidelines in section 3. In particular, the Group deliberated on the assistance of maritime authorities in establishing mechanisms and programmes through which noise reduction efforts could be realized.

11 Despite noting some concerns regarding the inclusion of such purpose and that it could be outside the remits of the SDC Sub-Committee, the Group agreed that the draft Revised Guidelines could provide assistance to other stakeholders on the development of such programmes and, therefore, maritime authorities should be included, as well.

Definitions

12 The Group further developed the definitions in section 4, in particular, reviewed the glossary initially contained in appendix 1 (SDC 9/5, annex 1); and migrated relevant terms into the definitions section.

13 The Group also discussed whether sensitive sea areas should be defined for clarity. Despite some views that it would be helpful in implementing the Revised Guidelines, the Group:

.1 agreed to use the term "national and international designated protected areas", in line with the existing terminology used in chapter 11 of the Polar Code;

.2 noted the following statement by WWF:

"WWF is concerned that the proposal to replace sensitive sea areas/sensitive areas with the term national and international designated protected areas is too narrow; and that the term does not encompass areas with seasonally high densities of noise-sensitive marine life, such as fish and marine mammal migratory routes. For such areas, protected areas, such as MPAs, may not be a measure that is employed for their conservation. Thus, under this wording, these important areas, essential for ecological connectivity of ecosystems, would be excluded from consideration in several areas of the Guidelines.

We would propose broadening this term to include additional text adapted from the Polar Code:

National and international designated protected areas and areas with densities of marine mammals and other noise-sensitive species including seasonal migration areas."; and

.3 further discussed if detailed information related to the "national and international designated protected areas" could be collected by the Organization to be shared across relevant stakeholders, making it easy to obtain the details; and agreed to pursue the issue further by asking the appropriate bodies of the Organization for further advice on how to establish such information sharing platform.

New section on underwater radiated noise management planning (URNMP)

14 The Group discussed the new section 5 on Underwater Radiated Noise Management Planning (URNMP) and noted the following views:

.1 For new ships, a notation system could be used similar to the three tiered Nitrogen Oxide (NO_x) compliance framework; and for existing ships, operational limits could be applied through IMO adopted "Particularly Sensitive Sea Areas" (PSSAs), where certain routeing measures could also have a positive effect in terms of reducing the impacts of underwater noise.

.2 URNMP was suggested to provide concrete guidance to shipowners and operators to implement certain noise reduction measures on a voluntary basis. Such plans had already been implemented in some countries where the methods to reduce URN were clearly indicated.

.3 For some existing ships, it would be difficult to estimate the impact of certain modifications to the ship and its propulsion systems, in particular, ahead of time. Therefore, such URNMP might need to be appropriately adapted.

.4 Appropriate goals should be identified before URNMP tools were drafted.

.5 Consideration should be given to which parties would approve and inspect URNM plans and whether it would be part of the Ship Energy Efficiency Management Planning (SEEMP). It would be inappropriate at this stage to include URNMP within SEEMP, as it might create confusion with respect to the non-mandatory nature of the Guidelines.

.6 URNMP should be specified whether it was for a ship or fleet, or the operation of a ship or fleet.

15 Following discussion the Group agreed to:

.1 reformulate this section by providing two model templates with varying levels of detail in a new appendix 3 to help guide shipowners/designers in this process; and

.2 insert the contents of former sections 6 (Baseline URN measurements) and 7 (URN goals setting) therein, and create a new appendix containing section 8 (URN prediction), which had been previously covered in the main body of the draft Revised Guidelines in annex 1 to document SDC 9/5.

URN reduction approaches

16 The Group discussed the pending issues on the section on URN Reduction Approaches, in particular the insertion of a new annex provided by ICC (see paragraph 6). Although the Group appreciated the guidance provided for the operators transiting Inuit Nunaat and the Arctic, it was agreed not to include a separate appendix to the draft Revised Guidelines containing specific regional aspects for consistency at an international level.

17 Nevertheless, acknowledging the value of such guidance, the Group inserted the draft guidelines for underwater radiated noise reduction in Inuit Nunaat and the Arctic in annex 2, with a view to being utilized in the future by the interested parties, e.g. as a standalone circular.

Evaluation and monitoring, and incentivization

18 The Group discussed the evaluation and monitoring (section 8), and noted:

.1 the views on the importance of recognized URN measurement, analysis and postprocessing; and

.2 the information provided by the delegation of IACS that the work on the harmonization of relevant guidelines within IACS unified requirements (UR) was planned to be completed in the first half of 2023. These guidelines, using the ISO Standard 17208 publications as the underlying scientific doctrine, details the hydrophone string configurations, deployment methods, met-ocean limits, ship track and recording extents, all post processing specifications to correct for ship position relative to hydrophone, corrections for propagation losses/environmental, etc., with a view to achieving the same results when any ship is measured anywhere on the globe, by any classification society using the harmonized procedure.

19 With regard to the incentivization (section 9), the Group discussed a proposed matrix on Responsibility Assignment in support of the Preamble/Introduction that was initially suggested in the annex to document SDC 9/INF.2. Having noted that responsibilities and accountabilities should not be discussed at this stage due to the non-mandatory nature of the draft Revised Guidelines, and that the matrix could be considered as part of the future work on URN, the Group agreed to attach it to the report, as set out in annex 3. Regarding the placement of the incentivization section, the Group agreed that it would be more suitable to follow URNMP (section 5), as section 5 describes the opportunities various parties have, in order to support an effective URNMP.

20 In this respect, the Group noted the following statement made by the delegation of Brazil:

"The Brazilian delegation noted that incentive schemes involve political discussions, as they can impact states, and should be analysed more holistically, and take into account a risk assessment before their implementation."

21 In this regard, the Group noted some views that the following matters captured in the draft Revised Guidelines could be evaluated by MEPC on their scope and consequences, as they may be considered outside the Sub-Committee's remit (MSC 92/26/Add.3, annex 40):

.1 evaluation and monitoring (section 8), which encourages potential URN monitoring efforts that could be implemented along the shipping lanes in partnership with interested port authorities, stakeholders, and support community-led efforts; and

.2 incentivization (section 9), which encourages the implementation of certain measures.

Finalization of the draft Revised Guidelines

22 The Group had a debate over the level of maturity of the draft Revised Guidelines and whether they were considered finalized with a view to approval by MEPC. In this respect, the Group noted some split views that:

.1 given that sufficient consideration was given to the draft Revised Guidelines by the Correspondence Group reporting to this session and the Working Group and that no new substantive text had been introduced by the Group, the draft text should be approved at the earliest opportunity, so that further experience could be gained by implementing the Revised Guidelines and, therefore, the draft text was considered finalized for approval; and

.2 the draft text should further be progressed through a correspondence group, if established, noting that new texts had been incorporated during the Group's work which might require additional review until SDC 10.

23 Nevertheless, taking into account the overwhelming majority of the views expressed that the revision work was complete, the Group invited the Sub-Committee to:

.1 note the finalization of the draft Revised Guidelines; and

.2 invite MEPC 80 to approve them.

Pending issues and workplan beyond SDC 9

24 Due to the time constraints, the Group was unable to consider:

.1 provisional consideration of the impact and interrelation of the proposed actions to further reduce URN in the context of achieving other regulatory goals, including ship safety and energy efficiency, as well as the vision and mandate of the Organization to reduce pollution from ships (SDC 9/5, annex 4);

.2 provisional suggestions to promote the work of the Organization to increase awareness, uptake and implementation of the guidelines and identify most appropriate tools, through the review of, inter alia, document SDC 8/14/2 (SDC 9/5, annex 5);

.3 provisional list of areas that required further assessment and research (SDC 9/5, annex 6); and

.4 provisional list of suggested next steps, taking into account document SDC 8/14/8 (SDC 9/5, annex 7).

25 In this respect, the Group, taking into account the progress made and pending issues, considered the work plan, based on the annex to document SDC 9/5/1 (Canada); and prepared a draft revised work plan accordingly, as set out in annex 4, with a view to endorsement by the Sub-Committee.

26 Additionally, the Group was unable to consider the effective date of the draft Revised Guidelines and the associated MEPC circular cover note due to time constraints; and therefore, requested the Secretariat to prepare the draft cover note for inclusion in the Sub-Committee's final report.

Reestablishment of the Correspondence Group

27 Having considered the above matters and noting the draft revised work plan, the Group recommended that the Sub-Committee re-establish the Correspondence Group on Underwater Radiated Noise, under the coordination of Canada,* and instructed it to:

.1 revise the original flowchart on the URN Noise Management Planning process to reflect the Revised Guidelines, and appendix 3, to be used as a tool for raising awareness of the Revised Guidelines, based on the annex to document SDC 9/INF.2;

.2 finalize and prioritize the provisional list of suggested next steps to further prevent and reduce underwater radiated noise from ships, based on annexes 4 to 7 of document SDC 9/5; and

.3 submit a written report to SDC 10.

Action requested of the Sub-Committee

28 The Sub-Committee is invited to approve this report in general and, in particular, to:

.1 note the discussion and comprehensive work of the Group on the draft Revised Guidelines for the reduction of underwater radiated noise from shipping to address adverse impacts on marine life (paragraphs 4 to 21 and annex 1);

.2 note the discussion of the Group on how the information related to the "national and international designated protected areas" could be collected by the Organization for the purposes of the draft Revised Guidelines (paragraph 13.3);

.3 note the draft guidelines for underwater radiated noise reduction in Inuit Nunaat and the Arctic, with a view to being utilized in the future by interested parties; and consider issuing as a separate circular (paragraphs 16 and 17, and annex 2);

.4 note the draft responsibility assignment matrix with regard to URN reduction (paragraph 19 and annex 3);

.5 agree to the draft Revised Guidelines for the reduction of underwater radiated noise from shipping to address adverse impacts on marine life, for submission to MEPC 80 with a view to approval (paragraph 22 and annex 1);

.6 endorse the draft work plan for the continued work on the underwater radiated noise (paragraphs 24 and 25, and annex 4);

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* **Coordinator:**
Mrs. Amélie Laprade
Senior Policy Advisor, Environmental Policy
Transport Canada, Government of Canada
Mobile: +1 343-571-8870
Email: amelie.laprade@tc.gc.ca

Subject to the agreement on the above by the Sub-Committee

.7 in accordance with the draft work plan, invite MEPC 80 to:

  .1 approve the convening of an expert workshop on the relationship between energy efficiency and underwater noise, with the participation of relevant experts (annex 4); and

  .2 encourage interested Member States and international organizations to submit lessons learned/best practices in the implementation of the Revised Guidelines by MEPC 85, including outreach and awareness efforts to support uptake, with a view to identifying necessary revisions to the Revised Guidelines (annex 4);

.8 request the Secretariat to prepare the associated draft MEPC circular for the Revised Guidelines, for inclusion in the final report of the Sub-Committee (paragraph 26); and

.9 consider the recommendation to re-establish the Correspondence Group on Underwater Radiated Noise with the terms of reference prepared by the Group to continue the remaining work intersessionally and take action, as appropriate (paragraph 27).

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ANNEX 1

DRAFT REVISED GUIDELINES FOR THE REDUCTION OF UNDERWATER RADIATED NOISE FROM SHIPPING TO ADDRESS ADVERSE IMPACTS ON MARINE LIFE

1 PREAMBLE

1.1 Commercial shipping is one of the main contributors to underwater radiated noise (URN) which has adverse effects on critical life functions for a wide range of marine life, including marine mammals, fish and invertebrate species, upon which many coastal Indigenous communities depend for their food, livelihoods and cultures.

1.2 The effective mitigation of URN impact from ships on marine life requires international collaboration and action at various levels, involving multiple stakeholders including, but not limited to, seafarers, designers, shipbuilders, shipowners and ship operators, maritime authorities, suppliers, manufacturers and classification societies. Member States also play an important role in setting expectations for noise reduction targets and establishing mechanisms and programmes through which noise reduction efforts may be realized.

1.3 Sound is the primary sensory mechanism used by aquatic fauna for social interactions, reproduction, navigation, detection of obstacles and prey, predators and other threats. The most relevant noise sources from ships overlap with hearing ranges and the use of sound by different species. Depending on the species, documented impacts on marine mammals, fish, and invertebrates from URN include developmental impairment, poor body condition, increased predation, decreased offspring survival, less feeding, DNA fragmentation, behavioural changes, masking issues and physiological responses. Although impacts of shipping noise have been assessed considering the environment-related characteristics of different regions and the noise sensitivity of different species, based on field observations, laboratory experiments, modelling approaches, and Indigenous Knowledge, further data on noise impact on ecological and commercial key species will help inform stakeholders.

1.4 It is important to recognize that for both new and existing ships, the technical feasibility and cost-effectiveness of URN reduction measures considered either individually or in combination, will be strongly dependent on the design, operational parameters, and requirements relevant to a particular ship. A successful strategy to reduce URN should be a process that includes, to the extent possible, the design stage, the baselining of URN measurements (predicted or actual), the development of URN targets, the implementation, and monitoring and assessment of technical and operational measures to achieve those targets. The interactions and contributions between the implementation of URN reduction measures and other objectives such as, but not limited to, energy efficiency, biofouling reduction and ship safety should be carefully considered.

2 APPLICATION

2.1 These Guidelines may be applied to any ship, taking into account their design and construction, and modifications, as well as their operation.

2.2 These Guidelines do not address the introduction of noise from war ships and naval auxiliaries and the deliberate introduction of noise for other purposes such as sonar or seismic activities.

3 PURPOSE

3.1. The purpose of these Guidelines is to:

.1 provide an overview of approaches applicable to designers, shipbuilders and ship operators to reduce the URN of any given ship; and

.2 assist relevant stakeholders in establishing mechanisms and programmes through which noise reduction efforts can be realized.

3.2. Given the complexities associated with ship design and construction, and the various approaches for reducing and mitigating URN from ships, these Guidelines focus on identifying primary contributors to URN generated by ships and a general approach that designers, shipbuilders, shipowners and ship operators can undertake. These are associated with propellers, hull form, onboard machinery, wake flow, as well as operational and maintenance aspects.

3.3 These Guidelines describe URN reduction management planning as a tool that may be applied to the operation, design, construction and modification of ships, as far as reasonable and practical.

3.4 In addition to ship and equipment designers, shipbuilders and shipowners and operators, maritime authorities, classification societies, suppliers, manufacturers and other stakeholders are encouraged to introduce and apply these Guidelines to their specific activities and consider any other technologies and operational measures not included in these Guidelines, which may be more appropriate for specific applications and have demonstrated their effectiveness to further reduce URN.

3.5 The development of technological solutions to reduce URN and the scientific knowledge around the impact of URN on marine life will continue to evolve. These Guidelines will be reviewed and updated on a regular basis to ensure that relevant parties have the best available information to inform URN reduction efforts and to take account of linkages with energy efficiency compliance measures. Member States and Observers are encouraged to pass on experience and information received from ship and equipment designers, shipbuilders and operators, scientific organizations, civil society, Indigenous Knowledge holders, and others, to assist in improving and updating these Guidelines.

4 DEFINITIONS

For the purposes of these Guidelines, the following definitions apply:

Baseline URN: the ship's source level (and associated source depth), for typical operational conditions, that follows from initial predictions and trials or preferably standardized measurements.

Cavitation: the reduction of the ambient pressure by a static or dynamic means that can be caused by the propeller or other devices, causing the formation of bubbles in the liquid. The formation refers to both the creation of a new cavity or the expansion of a pre-existing one. When these bubbles are travelling to regions of higher ambient pressure, they collapse generating the major source of noise from powered ships.

Cavitation inception speed: the ship speed at which cavitation becomes detectable (either visually or acoustically).

Existing ship: a ship which is not a new ship.

Hearing range: the range of frequencies the ear or any other sensory organ of an animal can detect.

Indigenous Knowledge: a systematic way of thinking applied to phenomena across biological, physical, cultural and spiritual systems. It includes insights based on evidence and acquired through direct and long-term experiences and extensive and multigenerational observation, lessons, and skills. It has developed over millennia and is still developing in a living process, including knowledge acquired today and in the future, and it is passed on from generation to generation. Under this definition, Indigenous Knowledge goes beyond observations and ecological knowledge, offering a unique "way of knowing".

Masking: where noise interferes with the detection and perception of other sounds important to marine fauna. Masking may, among other effects, cause a reduction or loss of communication range for marine species.

New ship: a ship for which the building contract is placed, or in the absence of a building contract, the keel of which is laid, or which is at a similar stage of construction, on or after the effective date of these Guidelines.

Propeller noise: caused by flow phenomena on the propeller as it operates in the wake field of the ship hull. Propeller noise is composed of non-cavitating propeller noise and cavitation noise. Once cavitation occurs, it is typically the most dominant noise source.

Radiated Noise Level (RNL): expressed as a sound pressure level in decibels. RNL is a ship source level that assumes the ship can be treated as an acoustic point source. It is computed by taking the product of the distance from a ship reference point, D, and the far-field root-mean-square sound pressure, PRMS(D), at that distance for a specified reference value.

Mathematically, $RNL = 20 \cdot$ dB

The reference value for pressure (PREF) is 1 micro-Pa. The reference value for distance (DREF) is 1 meter. A full technical definition is provided in ISO -17208-1.

Sound Pressure Level (SPL): For underwater noise, 10 times the base-ten logarithm of the square of the ratio of the underwater root-mean-square sound pressure (P) divided by the reference sound pressure of 1 micro-Pascal, $SPL = 10 \cdot \log_{10}(P/P_{REF})^2$, where PREF = 1 micro-Pascal

Structure-borne noise: Structure-borne noise is vibration in the structure of the ship which will generate noise when a vibrating surface excites the surrounding medium, i.e foundation, pipes, other coupled machines or linked auxiliary equipment. Structure-borne noise is usually measured and quantified using vibration metrics.

Source Level: for underwater source levels see ISO 18405, Underwater acoustics – Terminology. In general, the Source Level is used to quantify how much sound (or vibration) is generated by a device (machinery or other entity such as a ship) at a reference distance (conventionally at 1 m for underwater acoustics).

Underwater radiated noise (URN) level: for the purposes of these Guidelines refers to noise from any ships. URN level is to be reported in decibels as a sound pressure level.

Vibration isolation mounts: vibro-elastic elements (steel springs, rubber or other systems) used to isolate machinery vibration from the ship's structure by reducing the amplitude of vibrational energy. Vibration isolation mounts may also be used to protect the equipment from harmful vibration from outside the ship (e.g. shock inputs during rough weather).

5 UNDERWATER RADIATED NOISE (URN) MANAGEMENT PLANNING

5.1 URN Management Planning is a generalized approach applicable to ships in accordance with section 2 that includes possible strategies for URN reduction in the design, construction, operation and/or modification.

5.2 Given the complexities associated with ship design and construction and the various approaches to reducing URN, shipowners and designers should undertake URN Management Planning at the earliest design stages. Similarly, URN Management Planning may be carried out for existing ships as far as reasonable and practicable.

5.3 URN Management Planning is intended to be a flexible tool that allows a customized approach, and may include establishing the baseline (predicted or actual) of a ship's URN, setting URN targets which should be specific and where possible, quantitative, and evaluating, alone and in combination, various technological, operational and maintenance approaches to reduce URN. Two model templates, with varying levels of detail, are provided in appendix 3 to help guide shipowners/designers in this process.

5.4. Various parties have the following opportunities to support an effective URN Management Planning, including but not limited to:

.1 Shipowners: develop and implement URN Management Plan, include URN requirements into ship design specifications and maintain ships to those specifications.

.2 Designers: design ships as defined by shipowners' operational plan to meet URN requirements.

.3 Ship builders: build ship to meet URN specifications.

.4 Ship operators: operate ship to meet URN goals and any additional regional requirements they are sailing in.

.5 Maritime authorities: take supportive actions that enable and advance URN Management Planning, for example, supporting deployment of tools to measure ship noise levels, support innovation and adoption of noise reduction technologies, and communicate URN information.

.6 Classification societies: assist shipowners/builders through predictions, trials, relevant URN notations, certification, as reasonable and practicable, etc.

.7 Suppliers and Manufacturers: provide equipment to shipbuilders and shipowners, which will assist the ship to meet URN specifications.

6 URN REDUCTION APPROACHES

6.1 The primary sources of URN generated by ships are associated with propellers, hull form, onboard machinery, wake flow as well as operational and maintenance aspects. At typical operating speeds, or near the design ship speed, most of URN is caused by propeller cavitation, but onboard machinery and operational aspects are also relevant, especially below cavitation inception speed. Propeller noise itself can be a dominant contributor to overall URN. The optimal URN mitigation strategy for any ship should at least consider all relevant noise sources and mitigation strategies, including any that are not covered in these Guidelines, which may be more appropriate for specific applications.

Design and technical noise reduction approaches

6.2 The greatest opportunities for reduction of URN will be during the initial design and build stages of the ship. For existing ships, it is unlikely to be practical to match the URN performance achievable by new designs, with exception of possible modification of propellers in some cases. The following design considerations are therefore primarily intended for consideration for new ships. However, consideration may be given to the modification of existing ships when reasonable and practicable. Table 1 summarizes the design and technical noise reduction approaches that are applicable to new and/or existing ships.

Hull design and modification

6.3 Flow around the hull may have an influence on URN, since the hull form influences the inflow of water to the propeller. Uneven or non-homogeneous wake fields are known to increase propeller cavitation. Therefore, the ship hull form with its appendages should be designed such that the wake field is as homogeneous as possible to reduce cavitation. Furthermore, the excitation of the ship structure induced by the propeller should not be neglected.

6.4 Consideration should be given to structure-borne noise, to reduce hull URN. Some mitigation measures could be optimization of scantling, application of a decoupling coating, and structural damping.

Propeller design and modification

6.5 Propellers should be designed and selected to minimize cavitation while considering and optimizing effects on energy efficiency. Cavitation can be the dominant URN source and may increase underwater radiated noise significantly. At typical operating speeds, cavitation can be reduced under normal operating conditions through good design, such as optimizing propeller load, ensuring uniform water flow through propellers (is influenced by hull design), and careful selection of the propeller characteristics such as: diameter, blade number, blade area, pitch, skew, rake and sections. Analyses and study of hull-propeller interaction can optimize the design of the propeller, hull, rudder and ship performance concurrently.

6.6 Noise-reducing propeller design options are available for many applications and should be considered. However, it is acknowledged that the optimal propeller with regard to underwater radiated noise reduction cannot always be employed due to technical or geometrical constraints (e.g. ice-strengthening of the propeller, mass). It is also acknowledged that some design principles for cavitation reduction can cause decrease of efficiency. Some new state-of-the-art propeller design and concepts have been developed, including high skewed propellers, forward-skew propellers and contra-rotating propellers.

6.7 Some emerging technologies are available to reduce required propulsion power like wind-assisted-propulsion or hull-lubrication by means of air injection. Those technologies can be considered for possibly reducing the propeller loading and cavitation noise. Considerations should be given that propulsion load reduction does not have adverse effects on URN, for instance by producing cavitation on the suction side at the same power load level. Air bubble injection into the stern and propeller is also used for reducing URN.

Wake flow improvement

6.8 Improving hydrodynamic performance by optimizing hull form design, hull and propeller appendages (e.g. by adoption of a Propulsion Improving Device/ Energy Saving Device or an asymmetric stern design) can increase performance and fluid inflow to propeller and reduce URN.

6.9 In order to improve the inflow of a ship propeller, there are many devices that could be used, but these may cause cavitation and as such, should be carefully designed either for new ships or existing ships. Cavitation performance of such devices could be evaluated, and model tested in a cavitation test facility along with the propeller cavitation test, as follows:

.1 Installation of wake conditioning devices and optimization of the rudder design.

.2 Pre-Swirl Stator (PSS): some stators before the propeller that can decrease the Blade Passing Frequency (BPF) of propeller noise and increase the propeller efficiency.

.3 Pre-Shrouded Vanes (PSV): Vane and some stators before the propeller that can improve the cavitation performance of the propeller and increase the propeller efficiency.

.4 A hub cap with fins may be useful to improve the wake of a ship propeller. It can recover energy from the propeller wake and increase the propeller efficiency. A hub cap with fins can also help to avoid hub vortex cavitation, etc.

Machinery design and modification

6.10 Consideration should be given to the selection of propulsion system and onboard machinery along with appropriate structure-borne sound control measures, proper location of equipment in the hull, and optimization of foundation structures that may contribute to reducing underwater radiated and onboard noise affecting passengers and crew. The ship machinery/equipment line-up should be optimized when or where there is a need to have a reduced noise profile. Reduced URN can be achieved by securing equipment that may not be needed at all times or even during certain parts of a transit. In addition, depending on the ship propulsion plant configuration, further URN reduction can be achieved through selective operation of engines and generator sets. For example, inboard mounted engines may produce lower URN than outboard mounted engines. A "quiet ship profile" can be developed by the measurement of URN of various equipment to understand each unit's contribution to the overall ship noise.

6.11 Airborne sound can excite structure-borne noise that is transmitted into the water. Designers, shipowners and shipbuilders should request that engine/machinery manufacturers supply information on the airborne sound levels and vibration produced by their machinery to allow analysis by methods described in appendix 2 and recommend methods of installation that may help reduce URN.

6.12 Consideration should be given for the appropriate use of vibration isolation mounts, as well as improved dynamic balancing for reciprocating and rotating machinery such as refrigeration plants, air compressors, and pumps. Vibration isolation of other items of equipment such as hydraulics, electrical pumps, piping, large fans, vent and air conditioning ducting may be beneficial for some applications, particularly as a mitigating measure where more direct techniques are not appropriate for the specific application under consideration. Active noise control can also be considered to dampen structure-borne vibration from these sources.

6.13 Vibration isolation mounts can reduce the vibration from machinery to the supporting structure and reduce the structure-borne noise. Because of the propulsion and thrust transfer arrangement, resilient mounts for engines can be mostly considered for four-stroke engines with geared drive, and not the two-stroke engine with direct drive. Two-stroke engines cannot use resilient mounting as the propeller thrust is transferred by the engine directly to the ship structure by the large engine seating area. Flexible coupling between the engine and gearbox can reduce vibration in a geared drive, and further reduce the structure-borne noise. Vibration isolators are more readily used for mounting diesel generators to their foundation for reducing structure-borne noise. In some cases, the adoption of a diesel-electric system should be considered as it may facilitate effective vibration isolation of the diesel generators which is not usually possible with large direct drive configurations.

6.14 Alternative power and propulsion systems can help reduce URN. Electric propulsion (e.g. diesel-electric, fuel cell and full electric or battery, podded propulsions or azimuth thrusters) is identified as a promising configuration option for reducing underwater noise. The use of high-quality electric motors and installations will also likely help to reduce vibration being induced into the hull from the electric motor.

Maintenance and operational approaches

6.15 Although the main components of URN are generated from the ship design (i.e. hull form, propeller, the interaction of the hull and propeller, and machinery configuration), operational adjustments and maintenance measures should be considered as ways of reducing noise for both new and existing ships. Operational approaches could be particularly important for ships that lack design features or technologies to reduce noise, or for all ships that operate in national and international designated protected areas where additional measures need to be taken to decrease the adverse impacts of shipping noise on marine wildlife. Table 1 summarizes the operational and maintenance approaches that are applicable to new and/or existing ships.

Maintenance approaches

6.16 Maintaining the surface quality/finish of propellers, such as when polishing is done properly, removes marine biofouling and vastly reduces surface roughness, helping to reduce propeller cavitation.

6.17 Reducing hull roughness and maintaining a smooth underwater hull surface, by utilizing proper coatings, cleaning, and proactive in-water hull maintenance,[1] may also improve a ship's energy efficiency by reducing the ship's resistance and propeller load. However, it should be noted that ultrasonic anti-fouling systems emit high-frequency sound energy in frequency ranges and at amplitudes that can be harmful to aquatic species. The use of such systems should be avoided where possible in national and international designated protected areas.

6.18 Machinery vibrations induce structure-borne noise. Proper maintenance of the moving parts and machinery, as well as vibration isolation mounts, helps to keep the vibration and noise low and prevent increasing the noise from operating those machinery.

[1] Swain, G., Erdogan, C., Foy, L., Gardner, H., Harper, M., Hearin, J., Hunsucker, K.Z., Hunsucker, J.T., Lieberman, K., Nanney, M. and Ralston, E., 2022. *Proactive In-Water Ship Hull Grooming as a Method to Reduce the Environmental Footprint of Ships*. Frontiers in Marine Science, p.2017

Operational approaches

6.19 Optimizing the ship's trim and draught can reduce the required power and therefore propeller cavitation noise.

6.20 Operators can adjust and optimize ship's routeing, speed and sail time to reduce time at anchor and the URN in port and coastal areas. Voyage planning can facilitate the use of alternate routes to avoid and slowdown, when it can be safely done, in national and international designated protected areas and during critical times of year to decrease impacts of URN on marine life and communities which depend on them. Hydrographic offices and maritime administrations should consider marking and updating national and international designated protected areas in charts to enable the seafarers and harbour users to plan voyages to minimize the impact of their ship's URN on marine life.

6.21 Best practices include reviewing information on national and international designated protected areas to determine whether ships transit through or have operations in such areas. These may include but are not limited to: sea-ice covered regions, including Inuit Nunaat, busy ports and shipping lanes overlapping with important or critical habitat for endangered, threatened, or protected species, Important Marine Mammal Areas (IMMAs), Marine Protected Areas as characterized by the Convention on Biological Diversity and other national/regional area-based protection.

6.22 In Inuit Nunaat, a number of characteristics of the region and the activities within them could increase the impacts from underwater radiated noise. This includes potential for icebreaking activities, presence of noise-sensitive species, and potential interference with Indigenous hunting rights. Additional efforts to decrease impacts to marine wildlife are advisable for ships that operate in these areas, including particular attention to reducing the noise impact from icebreaking and implementation of operational approaches and monitoring.

Ship speed

6.23 In general, for ships equipped with fixed pitch propellers, reducing ship speed, shaft RPM and/or engine output can be a very effective operational measure for reducing underwater noise, mainly due to reduced cavitation. This is especially the case when speeds are slower than the cavitation inception speed, but even small reductions in power can greatly reduce cavitation. Thus, overridable shaft power limitation or overridable engine power limitation (such as may be adopted to meet the IMO EEXI requirements) would be expected to reduce URN in situations where these limits are below the ship's usual operating power.

6.24 Measure and understand the ship's Cavitation Inception Speed (CIS) and then operate below CIS in national and international designated protected areas when practicable. For ships equipped with controllable pitch propellers, there may be no reduction in noise with reduced speed. Therefore, consideration should be given to optimum combinations of shaft speed and propeller pitch.

6.25 However, there may be other, overriding reasons for a particular speed to be maintained, such as safety, operation and energy efficiency. Consideration should be given in general to any critical speeds of an individual ship with respect to cavitation and resulting increases in URN.

Table 1 Summary of design, technical, operational and maintenance URN reduction approaches applicable to new and/or existing ships as far as practicable. This list is not exhaustive and should not restrict any other design options that a shipowner may consider as a solution. Further information is available in document MEPC 74/INF.28.

URN Reduction Approaches	New ship	Existing ship
Optimize ship hull form (and appendages) design for hydrodynamic performance and homogenous wake field to reduce cavitation	X	X
Optimizing propeller design to reduce cavitation, optimizing load, ensuring a uniform water flow and hull-propeller interaction and careful selection of the propeller characteristics such as: diameter, blade number, blade area, pitch, skew, rake, and sections and innovation material	X	X
Emerging technologies like wind-assist technologies to reduce propeller loading and cavitation noise	X	X
Air injection to propeller	X	X
Wake flow improvement	X	X
Careful selection of onboard machinery and installation with appropriate structure-borne noise levels control measures, proper location of equipment in the hull, and optimization of foundation structures	X	
Machinery installation and isolation for instance resilient mount and flexible coupling in four-stroke engines with a reduction gear, vibration isolation mounts and improved dynamic balancing for reciprocating machinery	X	X
Optimizing the ship's trim to reduce the required power and therefore propeller cavitation noise	X	X
Improving voyage planning (e.g. optimum route, coordinated across fleets, national and international designated protected areas/sea-ice covered region, including well-known habitats or migratory pathways)	X	X
Reducing speed shaft RPM and/or engine output for ships equipped with fixed pitch propellers[2]	X	X
Ships routeing measures[3] to avoid national and international designated protected areas including well-known habitats or migratory pathways	X	X
Propeller maintenance (and cleaning/coating)	X	X
Hull maintenance (coating and in-water hull maintenance and cleaning, except acoustic antifouling systems where possible in national and international designated protected areas)	X	X

[2] It is vital that sufficient speed and power for safe navigation is maintained. Please refer to MEPC.1/Circ.850/Rev.3 on G*uidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions*.

[3] "Ship routeing measures" refers to the process of moving existing recognized shipping lanes away from national or international protected areas, which may include important marine mammal habitat or migratory pathways. Ship routeing is known as an effective measure to reduce ship noise exposure in the marine environment.

7 ENERGY EFFICIENCY AND URN REDUCTION

7.1 Careful consideration should be given to the interrelationships between energy efficiency, GHG and URN reduction while adhering to regulatory obligations and ensuring that the level of URN will meet set goals as established in the URN Management Plan. Many of the energy efficiency improvement options to meet energy efficiency regulations (EEDI, EEXI and CII) may result in an improvement in URN performance and could provide positive synergies with climate policies. Where URN reduction measures are not supportive of energy efficiency, then regulatory obligations pertaining to energy efficiency and emissions must take precedence. URN measures should not come at the expense of IMO requirements on GHG reduction and energy efficiency or other IMO requirements affecting the ship safety as for example manoeuvrability.

7.2 Designers, builders, shipowners and operators should investigate and consider the risk of increasing URN with ship design to achieve lower EEDI, EEXI and/or CII.

7.3 Scrutiny should be given to the co-design of hull and propeller as a unit, such that a uniform wake flow is created to reduce propeller cavitation, as this will also increase energy efficiency, and reduce emissions.

7.4 Reducing propeller cavitation is an effective means of reducing URN. Measures aimed at reducing applied or installed propulsion power and propeller thrust loading, with the appropriate safety caveats,[4] are options to improve energy efficiency, reduce emissions, and typically result in URN reduction, e.g. wind assistance, optimized hull design, and regular maintenance and hull cleaning to avoid fouling and reduce hull resistance are all effective measures for reduced emissions and URN.

7.5 URN computational methods should integrate optimization methods to include the parameters affecting energy efficiency and other emissions at the same time as underwater noise. This will allow optimization with respect to URN, other emissions and efficiency/performance.

8 EVALUATION AND MONITORING

8.1 Evaluation and ongoing monitoring of URN is an essential step towards the assessment of the effectiveness of efforts to reduce noise in the oceans. This may be done through actual measurement of ship URN, or through the modelling of ship URN based on its characteristics and design parameters, as well as environmental conditions.

8.2 Modelling of URN needs to take into account sound propagation loss as this is influenced by several environmental parameters (e.g. sea state, sea ice, sound speed profile, sea water temperature, sound absorption, currents, bathymetry, the properties of the sea bottom). There exist a variety of underwater sound propagation models to address the objectives of the specific application.

8.3 Efforts should be made to better understand status and changes in URN. Monitoring capacity developed in partnership with interested ports should be encouraged along shipping lanes and used in incentive programmes to complement other URN monitoring programmes, where possible.

8.4 Efforts should be made to support community-led efforts to understand underwater noise from shipping and its impacts on marine species and coastal communities.

[4] MEPC.1/Circ.850/Rev.3.

8.5 Member States and other stakeholders, including classification societies, designers, shipbuilders, shipowners and ship operators, suppliers and manufacturers may contribute data, where possible, to the global understanding of ship noise emissions, including through established monitoring programmes of ship source levels and/or ambient noise.

8.6 URN data gathered, and results of applied measures may be shared through the appropriate body of the Organization. Data can be shared anonymously for the purpose of supporting planning and development by the Member States, and other stakeholders.

9 INCENTIVIZATION

9.1 Maritime authorities, financial and insurance institutions and others are encouraged to promote establishing incentive schemes to support the implementation of underwater radiated noise monitoring programmes and noise reduction efforts by suppliers, designers, builders, shipowners and operators, where considered appropriate. Incentives can also support the collection and sharing of data about ship URN generally.

9.2 Incentivization could be, for instance, based on relevant URN ship class notations, recognition of a URN Management Plan, URN reduction targets, ship and engine technologies and maintenance, ship speed reduction programmes, Onshore Power Supply (OPS) in port or other voluntary sustainability certifications which include evidence of URN reduction or complementary benefits on efficiency and maintenance (e.g. preventing biofouling by in-water cleaning of ship hull and propeller could increase efficiency and minimize the transfer of invasive species).

9.3 Examples of incentives are discount on the port dues, fairway fees, discount or extra services or products, promotion, among others.

9.4 Suppliers, designers, builders, shipowners and operators should make themselves aware and strive to achieve incentives related to URN reduction.

APPENDIX 1

INTERNATIONAL URN MEASUREMENT STANDARDS, RECOMMENDATIONS AND CLASSIFICATION SOCIETY RULES

1 Shipowners, designers and operators and other stakeholders may use the most appropriate and updated noise measurement standard listed below for their context.

2 ANSI S12.64 and ISO-17208-1[5] are two versions of the same standard. It included three grades: survey, engineering and precision, with the latter being the most accurate methodology. ISO-17208-1 was taken from S12.64 and adopted for international use, with the primary difference being the removal of the three grades. Both standards are for the measurement of the Radiated Noise Level (RNL) of a ship in deep water. ISO-17208-2[6] provides a methodology to take data measured using ISO-17208-1 and convert the measured RNL to Monopole Source Level (MSL). These two standards would be most relevant to the measurement of ship noise. Both standards would be necessary, when using MSL metrics.

Non-exhaustive List of URN Measurement Standards

Standard or Organization	**Date Issued**	**Scope**	**Methodology**	**Minimum Water Depth**
ICES-CRR-209[7]	May 1995	Applies only to fishery research vessels (R/V). This document provides guidance on ambient noise, fish hearing, ship noise, fish reaction to ship noise, URN instrumentation, noise mitigation for R/V's.	The intended methodology for results in sound pressure level at 1 meter in 1 Hertz (narrowband) spectrum. No distance correction process is given.	Not specified
ANSI/ASA S12.64[8]	Sept 2009	Applies to any ship of any size with speed less than 50 knots. (This is the first standard for URN measurement of commercial ships.)	Results are in sound pressure level at 1 m assuming the ship is modelled as a point source using spherical spreading. There are three grades of measurement: Precision, Engineering, and Survey.	*Prec.*: 300 m or 3x L *Eng*: 150 m or 1.5x L *Survey*: 75 m of 1x L

5 **ISO 17208-1** Underwater acoustics — Quantities and procedures for description and measurement of underwater sound from ships — Part 1: Requirements for precision measurements in deep water used for comparison purposes.

6 **ISO 17208-2** Underwater acoustics — Quantities and procedures for description and measurement of underwater sound from ships — Part 2: Determination of source levels from deep water measurements.

7 International Council for the Exploration of the Seas (ICES), Cooperative Research Report 209, *Underwater Noise of Research Vessels, Review and Recommendations*, dated May 1995.

8 American National Standards Institute (ANSI) / Acoustical Society of America (ASA) S12.64-2009; *Quantities and Procedures for Description and Measurement of Underwater Sound from Ships – Part 1: General Requirements*, dated September 2009.

Standard or Organization	**Date Issued**	**Scope**	**Methodology**	**Minimum Water Depth**
			Uses three hydrophones located in the water column with a beam aspect.	Where L is overall ship length.
Bureau Veritas, DNV[9]	November 2015	Applies to commercial ships which includes any ship engaged in commercial trade or carrying passengers for hire.	Results are in sound pressure level at 1 m using calculated propagation loss with the ship modelled at a monopole sound source.	Not specified
ISO-17208-1[10]	March 2016	Same as S12.64 (above)	Methodology and results are mostly the same as S12.64 but with a single grade between the precision and engineering grades of S12.64. Uses three hydrophones located in the water column with a beam aspect.	Greater of 150 m or as given in Note (1)
ITTC Guidelines 7.5-04[11]	September 2017	Applies to measuring underwater radiated noise from surface ships.	Results are in sound pressure level at 1 m assuming spherical spreading and adjusted by a distance normalization.	300m or three times ship length for highest grade; 150 m or 1.5 times ship length for middle grade; 75 m or 1 times ship length for lowest grade.
Lloyds Register[12]	Feb 2018	Applies to any ship which had URN measured and certified in accordance with LR's *SHIPRIGHT* notation.	Deep water correction provided assuming measurements in accordance with ISO-17208-1. Shallow water shall be performed as given in ISO-17208-1. Uses three hydrophones located in	Greater of 60 m or as given in Note (2)

9 Achieve Quieter Oceans by Shipping Noise Footprint Reduction (AQUO) and Suppression of UW Noise Induced by Cavitation (SONIC), *Guidelines for Regulation on UW Noise from Commercial Shipping*

10 International Standards Organization (ISO), ISO-17208-1-2016; *Underwater acoustics — Quantities and procedures for description and measurement of underwater sound from ships — Part 1: Requirements for precision measurements in deep water used for comparison purposes*, dated March 2016.

11 International Towing Tank Conference (ITTC), Recommended Procedures and guidelines - Underwater Noise from Ships - Full scale measurements.

12 Lloyd's Register (LR), *Additional Design Procedures, Additional Design & Construction Procedure for the Determination of a Vessels Underwater Radiated Noise*, February 2018.

Standard or Organization	**Date Issued**	**Scope**	**Methodology**	**Minimum Water Depth**
			the water column with a beam aspect.	
Bureau Veritas[13]	July 2018	Applies to any self-propelled ship.	Results are in sound pressure level at 1 m using calculated transmission loss with the ship modelled at a monopole sound source. Uses three hydrophones located in the water column with a beam aspect.	Greater of 60 m or as given in Note (3)
China Classification Society[14]	October 2018	Applies to ships applying for CCS class notation.	Results are in sound pressure level at 1 m assuming spherical spreading and using calculated transmission loss.	When the single-hydrophone method is used, the keel clearance is in general not to be less than 40m and not less than 60m for a multiple-hydrophone method.
ISO-17208-2[15]	July 2019	This document specifies methods for calculating an equivalent monopole source level by converting radiated noise level values obtained in deep water according to ISO 17208-1.	This is not a ship measurement standard, must use ISO-17208-1 for field measurements.	N/A
DNV[16]	July 2019	Applies to all ships looking to achieve the DNV-GL *SILENT* notation.	Deep water methodology to follow ISO-17208-1 (given above). Shallow water uses unique method with a single bottom	150 m (for deep water testing regardless

13 Bureau Veritas (BV), *Underwater Radiated Noise*, Rule Note NR 614 DT R02 E, dated July 2018.

14 China Classification Society, *Guidelines for underwater radiated noise of ships*, October 2018.

15 International Standards Organization (ISO), ISO-17208-2-2019; *Underwater acoustics — Quantities and procedures for description and measurement of underwater sound from ships — Part 2: Determination of source levels from deep water measurements* dated July 2019.

16 Det Norske Veritas / Germanischer Lloyd (DNV/GL), Class Guideline DNVGL-CG-0313, *Measurement procedures for noise emission*, dated July 2019.

Standard or Organization	Date Issued	Scope	Methodology	Minimum Water Depth
			mounted hydrophone and distance correction performed using actual site measured transmission loss or the relationship 18xLog(r) where r is the distance between the ship and hydrophone.	of ship length) 30 m (for shallow water testing)
DNV[17]	July 2020	Applies to all ships looking to achieve the DNV-GL *SILENT* notation.	Results are in sound pressure level at 1 m assuming the ship is modelled as a point or line source as determined during the evaluation. This document only provides the limits and need to conduct measurement according to DNVGL-CG-0313 (above).	N/A
ABS[18]	May 2021	Applies to self-propelled commercial and research ships	Results are in sound pressure level at 1 m using spherical spreading for deep water and calculated transmission loss (by provided equation) for shallow water. Uses three hydrophones located in the water column with a beam aspect.	Greater of 60 m or as given in Note (4)
RINA[19]	2021	Applies to all ships looking to achieve the RINA *DOLPHIN QUIET* or *TRANSIT* notations.	Results are in sound pressure level at 1 m assuming the ship is modeled as a point source using spherical spreading. Uses three hydrophones located in the water column with a beam aspect.	150 m or as given in Note (5)
Korean Register[20]	July 2021	Applies to new and existing ships that have applied for the optional notation URN (Underwater Radiated Noise) for the ship's underwater radiated noise	Results are in sound pressure level at 1 m	At least 60 m

17 Det Norske Veritas / Germanischer Lloyd (DNV/GL), Rules for Classification, Ships, Part 6, *Additional class notations, Chapter 7 Environmental Protection and Pollution Control*, dated July 2020.

18 American Bureau of Shipping (ABS), *Underwater Noise and External Airborne Noise*, dated May 2021.

19 Registro Italiano Navale (RINA), Dolphin Quiet Ship and Dolphin Transit Ship, dated 2021.

20 Korean Register: Guidance for Underwater Radiated Noise (July 2021).

WATER DEPTH NOTES:

1. 1.5 x overall ship length which is the longitudinal distance between the forward-most and aft-most part of a ship.

2. 0.3 x v^2 where v is ship speed in m/s or 3 x $(B \times Dt)^{½}$ where B is ship width and Dt is ship draft both in meters.

3. 0.3 x v^2 where v is ship speed in m/s. Deep water is 200 m or 2x the ship length unless the ship is greater than 200 m then 1.5 times the ship length.

4. 0.3 x v^2 where v is ship speed in m/s. Deep water is the greater of 150 m or 1.5x the ship length.

5. Measurements can be performed in shallow water as long as adequate procedure for actual transmission loss has been agreed with RINA.

APPENDIX 2

TYPES OF COMPUTATIONAL MODELS FOR OPTIMIZING SHIP DESIGN AND TECHNICAL UNDERWATER RADIATED NOISE REDUCTION APPROACHES

Types of computational models for optimizing ship design and technical URN reduction approaches are:

.1 **Flow characteristics:** Computational Fluid Dynamics (CFD) can be used to predict and visualize flow characteristics, cavitation and hydroacoustic sources around the hull and appendages, and the wake field in which the propeller operates. Also, propeller analysis methods such as lifting surface methods or CFD can be used for predicting and trialling the effect of cavitation on the propeller performance.

.2 **Noise radiation**: Finite Element Analysis (FEA) and Boundary Element Method (BEM) and Statistical Energy Analysis (SEA) can be used to estimate radiated noise due to flow field, cavitation, and machinery excitations. Bathymetry, sea bottom, sea surface and the elastic ship structures can be accounted for. Other methods to predict radiation include hybrid methods, wave-based methods, and Energy Flow Method (EFM). Most methods can be used both for structures and fluids.

.3 **Noise propagation**: the noise path from source to receptor, depends on the environment and some sound characteristics. Methods, such as ray theory, normal modes, wavenumber integration or parabolic equations can be used for modelling long range propagation of sound.

Standardized model tests of propeller URN in combination with cavitation tests provide the possibility for manufacturers, suppliers, shipowners and shipbuilders to agree whether contractual specifications regarding the propeller contribution to URN are fulfilled before the ship is built.

.1 Model-scale cavitation tests[21] have a possibility to offer at present the most accurate prediction and trial of URN source levels of cavitating propellers showing good to acceptable agreement with sea trials on URN source levels. However, scale effects and the effect of facility dependent background and reverberation noises should be considered carefully, and further improvements on these topics are expected from on-going studies. Furthermore, as these model tests focus on cavitation noise only, the impact of a cavitation noise mitigation measure can be well evaluated. The impact of this mitigation measure on the total ship noise requires knowledge of the other noise sources such as machinery and structure-borne noise.

.2 The ship, its propeller, and special appendages (such as shaft bracket, Fin Stabilizer, etc.) could be model tested in a cavitation test facility such as a cavitation tunnel for measuring the design aspects with respect to cavitation induced pressure pulses, cavitation inception speed and radiated noise.

URN model predictions and trials should be assessed, when possible, with scaled or full-size model validation tests preferably in controlled environments.

[21] ITTC – Recommended Procedures and Guidelines, Model-Scale Propeller Cavitation Noise Measurements, 7.5–02–03–03.9

APPENDIX 3

SAMPLE TEMPLATES FOR URN MANAGEMENT PLANNING

To assist shipowners with the development of a URN management plan that can be customized to meet their needs, two templates are provided as samples of what a URN management plan may contain. These are provided solely for guidance and can be further modified to address specific contexts of individual shipowners.

Sample Template #1: Aspirational plan with initial steps:

Underwater Radiated Noise Management Plan

1. Objective

This section should include an overview of the high-level objective regarding URN reduction of ships. For example, this may be framed as "Over the next five years, we intend to achieve the following objectives [….], and identify further opportunities to reduce the noise from our ships".

2. Approach

This section should describe the various efforts that will be taken to achieve the overall objective. This may include investments in research, efforts to measure the noise signature of ships, identification/implementation of operational or technical solutions relevant to the ship.

3. Monitoring/Evaluation Methods

This section should include a brief outline of how the shipowner/ship operator intends to monitor, assess, and evaluate the progress of their plan over time.

<u>Sample Template #2: Detailed plan that more explicitly follows the Plan-Implement-Monitor-Evaluate cycle</u>

Underwater Radiated Noise Management Plan

1. Overview

This section should include an overview of the high-level objective regarding the URN reduction of ships and the intention of the plan. For example, this may be framed as "Over the next five years, we intend to achieve the following objectives [….], implement the following steps […] identify further opportunities to reduce the noise from our ships".

2. Baseline URN

This section should provide an overview of how a baseline URN could be determined.

As far as practicable, efforts should be made to determine a ship's baseline. Ship baseline URN condition may be predicted (computational/empirical/model tests) or preferably measured. Baselining the predicted and/or measured URN ship condition should be conducted under the ships' normal operating conditions, including typical operational speed and draught, with use of standard operating equipment/machinery.

URN should be measured to an objective standard. Appendix 1 summarizes the availability of recognized measurement standards that have been used in research and to support port programmes. Appendix 2 provides examples of computational models for optimizing ship design and technical noise reduction approaches.

3. URN targets

This section should outline the overall target source-noise reductions that the plan is aiming to achieve. The information below provides some possible guidance on how said targets could be established.

Research has documented significant variability among regions in underwater sound propagation conditions, contributions to underwater radiated noise levels and hearing sensitivity and adverse physiological or behavioural responses to ship noise among marine species. Biologically-based noise limits are thus likely to reflect this variability, with any universal limit serving as a summary of impact reduction interests across diverse environments. However, individual ship-based noise targets established by ship class, tonnage, or another characteristic can be established based on baseline measurements, actual or predicted. These URN reduction targets can be gradually strengthened over a specified period, to be established by the shipowner (MEPC 74/INF.36).

URN targets for a given ship should consider the ship's purpose, type, URN prediction and baseline measurement, as well as operational considerations. URN reduction targets can also be established by adoption of one of the classification societies' sets of URN related rules. Alternatively, shipowners can establish URN reduction targets, inter alia, reducing noise levels by a certain percentage.

4. URN Reduction Approaches and related actions

This section provides the opportunity to clearly articulate the approaches to be taken to reduce underwater noise. This could include a combination of both technical and operational approaches, that may be adapted over time. It may also include the identification of research initiatives or other collaborative projects to advance knowledge and awareness of URN reduction efforts. See section 6 of the guidelines for guidance of the types of approaches that could be utilized.

5. Monitoring and Evaluation

This section should show how ship noise reduction efforts could be monitored and evaluated.

As part of URN Management Planning, shipowners and operators should develop a monitoring approach to evaluate periodically the effectiveness of ship noise reduction efforts in comparison with baseline measurements and URN targets and to guide and enhance activities aimed at noise reduction (section 8). Such evaluation may include forms of URN measurements, simulations, modelling or other scientific methods of data gathering and evaluation.

Consideration should be given to measuring the ship's URN from the identified noise sources at expected range of typical operating conditions to determine if the URN targets of the ship are being met. These enable ship operators to optimize ship operation and adjust URN levels appropriately along a route (e.g. by optimization of the ship's trim, thereby reducing the required power, or by reducing speed, when safe to do so, both possibly resulting in reduced propeller cavitation noise). Verification of maintenance of previously acceptable noise levels may also be demonstrated by records of adequate maintenance of machinery hull and propeller condition.

Between measurement activities, URN can be monitored in situ. Development of real-time dynamic voyage optimization tools which provide personalized analytical information to increase efficiency, save on fuel and costs, and reduce emissions show promise for adaptive management. Noise reduction should be added as a further optimization option.

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ANNEX 2

DRAFT GUIDELINES FOR UNDERWATER RADIATED NOISE REDUCTION IN INUIT NUNAAT AND THE ARCTIC

Foreword

These Guidelines are intended to supplement and provide additional information and guidance to operators transiting Inuit Nunaat and the Arctic. As well, they are intended to fulfill the commitment of the Correspondence Group on the Review of the Underwater Noise Guidelines, which was instructed to: "enable engagement of Inuit and other Indigenous communities and the incorporation of Indigenous Knowledge" in the updating of the Guidelines.

Draft Arctic Annex

Guidelines for Underwater Noise Reduction in Inuit Nunaat and the Arctic (AHDR boundaries)

Unique Arctic and Inuit Nunaat Operating Environment:

- Inuit Nunaat is a unique environment and adverse impacts to marine wildlife in this area from shipping noise may be significantly increased as a result.

- Sound levels throughout Inuit Nunaat are lower than elsewhere[1] making it more vulnerable to increases from industrial activity. The geography and properties of the surrounding marine areas are different to non-polar waters. Sea ice together with the shallowness of the seabed, shallowness of the deep sound channel, water temperature and changing salinity gradients affect underwater sound propagation.[2] Thus, vessel ice breaking and increases in commercial shipping have a higher potential for sound disturbance than in other areas of the ocean.[3]

- Inuit Nunaat is home to endemic marine wildlife that rely on sound for their biological activity and show some of the most sensitive responses to noise of any cetacean. They may be uniquely negatively impacted by the introduction of underwater radiated noise from commercial ships. Behavioural changes as a result of noise from commercial ships have been observed in marine wildlife,[4] representing significant risks to Indigenous communities for whom harvesting these marine species is fundamental to their livelihoods.

Noise Management Planning in Inuit Nunaat:

- Inuit and Indigenous peoples have extensive knowledge about underwater radiated noise impacts on marine wildlife, and its impacts in sensitive areas. This knowledge should be used by mariners in voyage planning and operations in order to minimize impacts to sensitive marine species and local communities.[5]

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1 Underwater Noise Pollution from Shipping in the Arctic, Protection of the Arctic Marine Environment Working Group (PAME), May 2021.

2 https://link.springer.com/chapter/10.1007/978-3-030-44975-9_6

3 Underwater noise pollution from ships in the Arctic (PAME, 2021)

4 https://www.sciencedirect.com/science/article/pii/S096456911500160X

5 https://www.qia.ca/marine-hunting/

- Vessels operating in Inuit Nunaat should consider the special characteristics of the region and the activities within them which could increase the impacts of underwater radiated noise. This includes the presence of noise-sensitive species, and potential interference with Indigenous hunting rights.

- Operational approaches[6] could be particularly important for ships that are unable to reduce shipping noise in Inuit Nunaat (e.g. icebreakers), and for all ships that operate in sensitive marine areas where additional measures need to be taken to decrease the adverse impacts of shipping noise on marine wildlife. Ship speed reduction has been proven to significantly decrease a ship's underwater radiated noise emissions and should be adopted more broadly in Inuit Nunaat waters.[7]

- Shipowners and operators should contribute to monitoring impacts of underwater radiated noise from shipping on marine wildlife and results should be used to further support a reduction of underwater radiated noise impacts to wildlife. This type of monitoring should use both Indigenous Knowledge and scientific methods where appropriate. Monitoring data should be made available to researchers and Indigenous communities affected by ship noise.

- Ship operators and shipowners transiting Inuit Nunaat waters should study and monitor (and report) their underwater radiated noise emissions and their cavitation patterns to optimize their operations and reduce their acoustic signature.

- Ship operators and shipowners transiting Inuit Nunaat waters should consider retrofitting vessels with technology that could help reduce their underwater radiated noise emissions. This includes the use of electric engines or flow control devices attached to vessel hulls.

- Efforts should be made to support community-led shipping governance efforts, including building Inuit capacity and infrastructure to understand and manage underwater radiated noise from shipping and its impacts on marine species and coastal communities.

Definitions – AHDR Arctic, Inuit Nunaat, and Indigenous Knowledge:

- Arctic Human Development Report (AHDR) Arctic Boundary[8] - the AHDR boundary incorporates the definition outlined in the Arctic Monitoring and Assessment Programme (AMAP) reports from 1997 and 2002 and is fully inclusive of Inuit Nunaat. AMAP is one of six Working Groups of the Arctic Council.

- Inuit Nunaat[9] (Inuit Homeland) - is an area composed of Inuit Nunangat, Canada; Alaska, USA; Greenland, Denmark; and Chukotka, Russian Federation.

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6 https://irc.inuvialuit.com/sites/default/files/2021-02/PVM%20Booklet_final2021.pdf

7 https://publications.gc.ca/collections/collection_2021/mpo-dfo/Fs152-9-2021-5-eng.pdf

8 https://oaarchive.arctic-council.org/handle/11374/51

9 Inuit Nunaat map

- Indigenous Knowledge is a systematic way of thinking applied to phenomena across biological, physical, cultural, and spiritual systems. It includes insights based on evidence and acquired through direct and long-term experiences and extensive and multigenerational observation, lessons, and skills. It has developed over millennia and is still developing in a living process, including knowledge acquired today and in the future, and it is passed on from generation to generation. Under this definition, Indigenous Knowledge goes beyond observations and ecological knowledge, offering a unique 'way of knowing'.[10]

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[10] Underwater noise pollution from ships in the Arctic (PAME, 2021)

ANNEX 3

DRAFT RESPONSIBILITY ASSIGNMENT MATRIX

Component	***Responsible (minimum 1 actor)***	***Accountable (max 1 actor)***	***Consulted***	***Informed***
Underwater Radiated Noise Management Planning	designer, builder, operator	owner	maritime administration (member / coastal and port state)	classification society intergovernmental organization
Baseline URN Measurements	designer, builder, operator	owner	classification society	maritime administration (member / coastal and port state)
URN Goals Setting (ship based noise targets)	designer, builder, operator	classification society	owner	maritime administration (member / coastal / port state)
URN Goals Setting (environmental targets)	maritime administration (member / coastal / port state) intergovernmental organization	maritime administration (member / coastal / port state)	nongovernmental organization intergovernmental organization	classification society designer, builder, operator, owner
URN Prediction (single ship radiated noise)	designer, builder, operator	owner	classification society	maritime administration (member / coastal and port state)
URN Prediction (soundscape modeling)	maritime administration (member / coastal and port state)	maritime administration (member / coastal / port state)	nongovernmental organization intergovernmental organization	operator classification society
URN Reduction Approaches	owner, designer, builder	owner	operator classification society	maritime administration (member / coastal / port state)
Energy Efficiency and URN Reduction	designer, builder, operator classification society	owner	nongovernmental organization intergovernmental organization	maritime administration (member / coastal / port state)
Evaluation and Monitoring (Single ship radiated noise)	owner, builder, operator	owner	classification society	maritime administration (member / coastal and port state) intergovernmental organization
Evaluation and Monitoring (Ocean shipping noise)	maritime administration (member / coastal / port state) intergovernmental organization	maritime administration (member / coastal / port state)	nongovernmental organization	operator / owner classification society
Incentivization	maritime administration (member / coastal / port state) financial institution classification society	maritime administration (member / coastal / port state)	nongovernmental organization intergovernmental organization	owner, operator

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ANNEX 4

DRAFT WORK PLAN FOR THE CONTINUED WORK ON THE REVISED GUIDELINES

	Outcome	Measures/Actions	Lead (SDC WG, CG, SDC, MEPC, etc.)	Timeline
1.	Finalize the revised Guidelines	Amend and finalize the revision of the 2014 Guidelines, taking into account documents SDC 9/5, SDC 9/INF.2 and any other documents submitted for this agenda item	SDC 9	January 2023
		Recommend to MEPC to approve the revised Guidelines	SDC 9 MEPC 80	July 2023
2.	Identify ways to implement the revised Guidelines and promote the work of the Organization to increase the awareness, the uptake and implementation of the revised Guidelines and identify most appropriate tools	Recommend to MEPC 80 to encourage Member States and observers to submit lessons learned/best practices in the implementation of the revised Guidelines by MEPC 85, including outreach and awareness efforts to support uptake with a view to identify necessary adjustments/modifications to the Guidelines	SDC 9 MEPC 80 MEPC 81 MEPC 82 MEPC 83 MEPC 84 MEPC 85	July 2026
		Revise the original flowchart on the URN Noise Management Planning process to reflect the approved guidelines and appendix 3, to be used as a tool for raising awareness of the revised Guidelines	SDC 9 CG SDC 10 MEPC 81	Spring 2024
3.	Organize an expert workshop on potential co-benefits and trade-offs that may exist between the reduction of underwater radiated noise from ships and energy efficiency, and produce a paper to be submitted to the relevant body	Recommend to MEPC to approve the convening of an expert workshop on the relationship between energy efficiency and underwater noise, inviting relevant experts from other relevant IMO bodies	SDC 9 MEPC 80 Relevant body	Workshop conducted in 2023; Completion by Spring 2024
4.	Develop a proposal for a programme of action to be presented at SDC 10 which could be reviewed/finalized at MEPC 81	Establish a correspondence group to finalize and prioritize the provisional list of suggested next steps to further prevent and reduce underwater radiated noise from ships, as set out in annexes 4 to 7 of SDC 9/5	SDC 9 SDC 9 CG SDC 10 MEPC 81	Spring 2024

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