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Special Publication

NURC-SP-2008-003

NATO Undersea Research Centre Human Diver and Marine Mammal Risk Mitigation Rules and Procedures (second edition)

Marine Mammal Risk Mitigation Project

December 2008

About NURC

Our vision

- To conduct maritime research and develop products in support of NATO's maritime operational and transformational requirements.
- To be the first port of call for NATO's maritime research needs through our own expertise, particularly in the undersea domain, and that of our many partners in research and technology.

One of three research and technology organisations in NATO, NURC conducts maritime research in support of NATO's operational and transformation requirements. Reporting to the Supreme Allied Commander, Transformation and under the guidance of the NATO Conference of National Armaments Directors and the NATO Military Committee, our focus is on the undersea domain and on solutions to maritime security problems.

The Scientific Committee of National Representatives, membership of which is open to all NATO nations, provides scientific guidance to NURC and the Supreme Allied Commander Transformation.

NURC is funded through NATO common funds and respond explicitly to NATO's common requirements. Our plans and operations are extensively and regularly reviewed by outside bodies including peer review of the science and technology, independent national expert oversight, review of proposed deliverables by military user authorities, and independent business process certification.



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NATO Undersea Research Centre
Marine Mammal Risk Mitigation
Rules and Procedures, 2nd edition

Marine Mammal Risk Mitigation Project

This document, which describes work performed under Project 4F1 (Marine Mammal Risk Mitigation) of the NURC Scientific Programme of Work, has been approved by the Director

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NATO Undersea Research Centre Marine Mammal Risk Mitigation Rules and Procedures

Marine Mammal Risk Mitigation Project

Executive Summary: The goals of the NATO Marine Mammal Risk Mitigation project include the development of risk mitigation protocols, computer tools, and in-water devices to provide risk mitigation before sonar experiments so to avoid potential negative impact on marine mammals. At the beginning of this project there were no comprehensive and systematic databases of marine mammal sightings and strandings for Mediterranean Sea cetaceans. One of the first actions of the NATO Undersea Research Centre (NURC) Marine Mammal Risk Mitigation project was the development, in cooperation with various European nations and organizations, of a standardized geo-referenced collection of strandings and sightings of cetaceans in the Mediterranean. These data, supplemented with new information collected during NURC sea trials and data “mined” from historical documents, provides the baseline information for the major scientific goals of the Marine Mammal Risk Mitigation project at NURC, the development of a predictive cetacean habitat model, and the creation and evaluation of on-site acoustic risk mitigation procedures and tools for use by NURC researchers. This document outlines risk mitigation protocols and procedures that are in use by NURC at this time. This is an updated, public release version of the NURC Staff Instruction 77. These procedures are re-evaluated and modified as new information becomes available from continued research by the Marine Mammal Risk Mitigation project as well as other documented sources.

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NATO Undersea Research Centre Marine Mammal Risk Mitigation Rules and Procedures

Marine Mammal Risk Mitigation Project

Abstract: The goals of the NATO Marine Mammal Risk Mitigation include the development of risk mitigation protocols, computer tools, and in-water devices to provide risk mitigation before sonar experiments so to avoid potential negative impact on marine mammals. This document outlines the procedures and marine mammal risk mitigation protocols that are in use by NURC at this time. This is an updated, public release version of the NURC Staff Instruction 77. These procedures are reevaluated and modified as new information becomes available from continued research by the Marine Mammal Risk Mitigation project as well as other documented sources.

Keywords: marine mammal - risk mitigation - sonar

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Introduction

During the last decade, mass strandings of beaked whales in close spatial and temporal proximity to active sonar experiments and military exercises increased concern about the effect of mid-frequency (1-10 kHz) sonar on marine mammals.

Marine mammals exhibit a wide range of behavioral responses to anthropogenic sound including alterations in respiration rate, vocalization, locomotion speed and direction, diving pattern, and distribution of individuals within a group. These responses vary in severity from minor and brief modifications to severe and extensive alterations depending on various species and sound characteristics. Intense or prolonged sounds may also impact the physiology of marine mammals; for example, sounds may interfere with mammals' ability to hear biologically significant signals or communications, a condition called auditory masking. The mammals may also undergo a threshold shift of their hearing capabilities, either temporarily or permanently, as a result of auditory fatigue or damage to auditory components such as sensory hair cells or ear membranes. However, the specific behavioral reaction and physiological mechanism that result in the stranding of beaked whales in proximity to the use of high powered sounds are unknown.

Practical and ethical constraints limit the number of studies regarding anatomical structure, hearing sensitivity, and behavioral responses to a small number of marine mammal species.

Therefore, data from these studies has been extrapolated to species where information is minimal. Limits on the use of anthropogenic sounds that are outlined in this document are therefore deliberately conservative, or precautionary, and may be modified to reflect the results of future studies.

The Marine Mammal Risk Mitigation (MMRM) project was initiated to develop the scientific foundation needed for the development of procedures, decision aids and associated tools to help mitigate the acoustic risk on marine mammal. The MMRM project will maintain the NURC policy and risk mitigation rules to conform to best available techniques and environmental practices.

2.1 Policy

As a matter of policy, the Centre will take preventive measures to circumvent harm to marine mammals from sound energy by institution of procedures outlined in Staff Instruction 77. In addition, all operations conducted on vessels or from shore are to be conducted in accordance with applicable environmental laws, local regulations and accepted maritime practice.

2.2 Responsibilities

The SIC, supported by the MMRM Project Leader, the NURC Chief Diving Officer, and appropriate external authorities, is responsible for ensuring that the procedures are completed and that any related risk mitigation procedures are briefed to the Master of the research vessel prior to the experiment. Copies of the Monitoring Report (Annex B) and Sighting Report (Annex C) must be submitted to the MMRM Project Leader and included as an annex to the Cruise Report. When the Centre's vessels are operating together with other research vessels, all units will adhere to the same environmental policy. This policy will either be the NURC policy outlined here or one that is stricter. The policy to be used is to be agreed upon before the sea-going activity commences. The Programme Officers are to verify that the sea trials are planned in accordance with this staff instruction.

2.3 Implementation

All personnel involved will adhere to the procedures in this staff instruction in order to ensure that marine mammals are exposed to harmful noise levels. It is recognized that the implementation of the policy and procedures will present some difficulties at sea which could cause delays to experiments and may require additional resources as well as specific training. Furthermore, the difficulty of undertaking effective acoustic and visual monitoring programs with the systems and personnel available is understood. SIC and the research vessel Masters are, however, to make the best effort possible to minimize the risk to marine mammals.

The Centre has a lengthy history of using sound for research in the Mediterranean Sea. Many of our institutional objectives require the discharge of energy into the marine environment; it must be done prudently and consistent with our conservation objectives. Since the establishment of this policy, no deleterious effects of the research are known to have resulted. Continued application of this policy and recommended mitigation measures will minimize the potentially harmful effects of high-level sound on marine mammals.

3.1 Assessment of Risk

Marine mammals are difficult to detect visually and acoustically. The amount of time cetaceans spend on the surface is minimal and depends on the species and the activity (i.e., feeding, etc.). Acoustic identification of cetaceans may be possible from the detection of whistles, creaks, chirps and moans made by the mammals.

The influence of sound energy on marine mammals is a function of the sound level at the point of reception by the mammal. When submerged, they are much more at risk from the potential effect of high level sound due to potential abnormal behavioral reactions than when on the surface. The mitigation rules are based on available scientific evidence and the application of a conservative bias to protect the mammals at risk.

From sound level strength at the point of reception, maximum source-level strength will be determined by propagation loss over distance. While source-level may be adjusted when in the presence of marine mammals to comply with the mitigation rules, prudence is the responsibility of the NURC Scientist-in-Charge.

As an exception, small, generally fast moving marine mammals are known to be attracted to certain noise sources and are not harmed by approaching the source. In the event that such animals approach the sound source after the commencement of normal operations, the operation should not be suspended, provided that transmission will be terminated if the mammal is identified as a beaked whale or being on the endangered species list.

3.2 Environmental Scoping Study (ESS)

Prior to any NURC experimental activity using high-level sound sources other than normal navigation and standard shipboard equipment (ADCP, fathometer, etc.), the Scientist In Charge (SIC) is to prepare an Environmental Scoping Study (ESS). The objectives of the ESS are to identify potential environmental hazards associated with the use of sonars or other equipment (bottom grabs, cores, etc.) and identify measures to mitigate these hazards. Special attention is needed when sea trials are carried out in waters where the Centre normally does not work and the environmental knowledge is limited. The MMRM Project Leader will maintain documents and graphics indicating known areas where certain restrictions may apply, and where habitats of marine mammal species of concern are present. The MMRM Project Leader also maintains an updated file of laws, regulations and protected areas to be used for planning purposes.

The following is a checklist of the activities to be accomplished prior to any trial employing high-level acoustic devices:

- Research any previous studies of the proposed trial area.
- Determine known marine mammal habitats.
 - Avoid operating in known beaked whale habitats which include complex steep sea bed topography.
- Itemize details of high-level sound sources to be used, including transmission source levels, pulse types, frequencies, duration, time of day, and location.
- Perform acoustic propagation modeling of operations.
 - Determine the safety range for mammals (see below)
- Avoid operations that may cause embayment.
- Determine and confirm visual and acoustic monitoring requirements of experiment.
- Consult with the MMRM project Leader, Diving Officer and other internal and external authorities and experts as appropriate.
- Complete the ESS Matrix (Annex A) and include in Test Plan.
- Include section in Pre-Cruise Brief on mitigation measures to be taken.
- Prepare the request for permission to carry out the activity.
- Maintain records of all environmental precautionary activities.
- Complete Monitoring Report (Annex B) and the Sighting Report (Annex C) during experiment. Include forms in post-cruise report and send copies to the MMRM Project Leader for inclusion in the sightings data base.

3.3 Procedures At Sea

3.3.1 Prior to Operations

Prior to energizing the sound source, the following risk reduction measures must be accomplished:

Monitoring

- Trained visual and acoustic monitors are on station, briefed and equipped.

- When available, aircraft and helicopters are on station to aid visual search.
- Alert other units involved to establish visual and acoustic watches as above; agree on reporting procedures.
- Details of the visual and acoustic lookout will be recorded in the Monitoring Report (Annex B) and scientific logs respectively.

Clearing the Area

- Transit work area with trained visual lookouts and passive listening systems (i.e., array, sonobuoy) deployed.
- Listen, look and record from at least 30 minutes before to 30 minutes after operations.

Ramp-Up Procedures

If no indication of marine mammal presence is detected within the appropriate safety range (see below) for at least 30 minutes:

- Ramp-up source gradually from 150 dB re 1 μ Pa @ 1m, or lowest possible setting if higher than 150 dB re 1 μ Pa @ 1m, to the final sound level in equal increments not to exceed the rate of 6 dB/ 5 minutes.
- If no evidence exists of marine mammals within safety range, commence operations after ramp-up. Otherwise, repeat area clearance and ramp-up.

3.3.2 During Operations

- Keep source level as low as possible, consistent with achieving the work.
- Repeat ramp-up procedures if transmissions stop for more than 30 minutes.
- For active transmissions during the night, the transmissions must commence at least 30 minutes prior to sunset. Enough daylight time must be allocated to allow for a 30 minute area clearance and applicable ramp-up period. If transmissions cease for more than 30 minutes during the night, they may not begin again until after an area clearance and ramp-up are performed after sunrise.
- Suspend operations upon detection of fast moving marine mammals within safety range. Noted exception is for mammals approaching within 45 degrees of the stern when using a source.
- Terminate transmissions if any marine mammal within range of double the calculated safety range is recognized as belonging to the endangered species list (Annex D) or is identified as *Ziphius cavirostris*.
- Report sightings/acoustic identification in the Sighting Report (Annex C).
- Photograph or video any sightings whenever possible.

- Inform the Incident Action Team (IAT; Annex E) if there is suspicion that marine mammals could have been affected by the research activity.

3.3.3 Safety Ranges

The following categories and definitions are to be used only for the purposes of this instruction. Safety ranges and times will be determined prior to commencing an experiment. The safety range is the distance from the transmitting source where the received peak sound pressure level (SPL) or sound exposure level (SEL; where applicable) is equivalent to or less than the criteria listed below. Peak sound pressure is the maximum absolute value of the instantaneous sound pressure during a specified time. Sound exposure level is a measure of the physical energy of the noise that takes into account both intensity and duration.

SIC should consult with the Marine Mammal Project Leader to determine which criteria are pertinent in the desired operational area. The ranges are not listed here as they will vary according to the sound propagation characteristics of the specific experiment and environment. Therefore, the Environmental Scoping Toolkit (EST), or other propagation loss models, must be used to determine the safety range.

Sounds are classified into two categories: 1. Nonpulse – broadband and/or tonal, continuous or intermittent such as vessels transiting, drilling and mid-frequency sonar 2. Pulse – brief, broadband, atonal transients such as an explosion, single airgun, watergun, or pile strike.¹

For the purposes of this instruction, marine mammals are separated into five categories: 1. Low-frequency cetaceans, 2. Mid-frequency cetaceans 3. High-frequency cetaceans 4. Pinnipeds in water and 5. Beaked Whales. (Table A4)² Note that the bandwidths defined with the terms, “low”, “mid”, and “high” in the above categories should not be confused with the bandwidths assigned to these same terms when discussing sonar frequencies. The fifth category, beaked whales, is treated separately due to specific incidents in which some species of this category stranded under certain environmental conditions when exposed to nonpulse sounds. It is not known what exposure levels these mammals received; however, it is thought to be below that which impacts hearing thresholds. Therefore, even more conservative standards are applied to these animals.

Marine mammals may alter their behaviour or undergo a threshold shift in hearing level, either permanent or temporary, as a result of interaction with active sonar transmissions or other sound sources. A small number of experiments on a few species have produced limited data regarding the extent of the interactions and the associated acoustic characteristics. These experiments considered single exposure events and do not necessarily account for cumulative effects. Criteria for safe levels of sonar operations are

¹ Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, P.L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals*, 33(4).571

² Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, P.L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals*, 33(4).

based on this available data, and are therefore applied with precaution to other species. These criteria are primarily based on levels at which auditory injury may occur, but in some cases consider the exposure at which a behavioural change may occur.

The scientific data on which broad and simple marine mammal guidelines should be based does not yet exist. The level of current knowledge in the field dictates that the criteria put forward will have limitations and be applicable for specific purposes. The criteria presented below support the execution of scientific research conducted under the guidance of this NURC staff instruction.

Table 1: Marine Mammal Categories³

Marine Mammal Categories	Species
Low-frequency cetaceans	<i>Balaena, Caperea, Eschrichtius, Megaptera, Balaenoptera</i>
Mid-frequency cetaceans	<i>Steno, Sousa, Sotalia, Tursiops, Stenella, Delphius, Lagenodelphis, Lagenorhynchus, Lissodelphis, Grampus, Peponocephala, Feresa, Pseudorca, Orcinus, Globicephala, Orcaella, Physeter, Delphinapterus, Monodon</i>
High-frequency cetaceans	<i>Phocoena, Neophocaena, Phocoenoides, Platanista, Inia, Kogia, Lipotes, Pontoporia, Cephalorhynchus</i>
Pinnipeds in Water	<i>Arctocephalus, Callorhinus, Zalophus, Eumetopias, Neophoca, Phocarctos, Otaria, Erignathus, Phoca, Pusa, Halichoerus, Histriophoca, Pagaophilus, Cystophora, Monachus, Mirounga, Leptonychotes, Ommatophoca, Lobodon, Hydrurga, Odobenus</i>
Beaked Whales	<i>Ziphius, Mesoplodon, Berardius, Tasmacetus, Hyperoodon</i>

Nonpulse

When nonpulse sources (i.e., tactical active sonar, vessel noise, acoustic deterrent devices, acoustic tomography sources, drilling) are present in conjunction with marine mammals, the following unweighted, received peak pressure levels shall not be exceeded for avoiding temporary threshold shift (TTS) or, in case of beaked whales, as matter of policy (Table 2).

³ Adapted from Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, P.L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals*, 33(4).

Table 2: Nonpulse Marine Mammal Criteria

Category of Marine Mammal	Received Unweighted Peak Sound Pressure Level (dB _{peak} re 1 μPa)
Low-frequency cetaceans	224
Mid-frequency cetaceans (except beaked whales)	224
High-frequency cetaceans	224
Pinnipeds in water	212
Beaked whales	170

Multiple Pulses

Some research and data exist for the distinction of multiple pulse criteria from single pulse criteria for marine mammals. When multiple pulse sources (i.e., multiple air guns, water guns, strikings) are present in conjunction with marine mammals, the following unweighted received peak pressure levels shall not be exceeded for avoiding TTS or, in case of beaked whales, as matter of policy (Table 3).

Table 3: Multiple Pulse Marine Mammal Criteria

Category of Marine Mammal	Received Unweighted Peak Sound Pressure Level (dB _{peak} re 1 μPa)
Low-frequency cetaceans	224
Mid-frequency cetaceans (except beaked whales)	224
High-frequency cetaceans	224
Pinnipeds in water	212
Beaked whales	170

Single Pulse

When single pulse sources (single explosion, air gun, water gun, strike, single ping of certain sonars) are present in conjunction with marine mammals, the following unweighted, received peak pressure levels shall not be exceeded for avoiding TTS or, in case of beaked whales, as matter of policy (Table 4).

Table 4: Single Pulse Marine Mammal Criteria

Category of Marine Mammal	Received Unweighted Peak Sound Pressure Level (dB _{peak} re 1 μPa)
Low-frequency cetaceans	224
Mid-frequency cetaceans	224
High-frequency cetaceans	224
Pinnipeds in water	212
Beaked whales	170

Annex A: Environmental Scoping Study Matrix

Activity	Valued Ecosystem Components	
	Biological	
	Marine Mammals	Marine Habitat
Use of Acoustic Sources		
Use of Explosive Charges		
Collection of samples of seabed sediment including cores		
Use of Ocean Bottom Seismometer		
Tagging of mammals		

LEGEND

- N** Effect Negligible/Non-Existent
- I** Insignificant Effect
- S** Significant effect or Public Concern
- U** Unknown Effect
- M** Mitigable Effect
- P** Positive Effect

Annex B: Monitoring Report

Date	Time	Latitude/ Longitude	Area of Operations (i.e., Ligurian Sea)	Wind (Beaufort)	Cetacean Watch Time On/Time Off	Type of Sonar	Operating Characteristics (Frequency, source level, duty cycle, total time of operation, etc)

Annex C: Sighting Report

Date	Time	Latitude/ Longitude	Area of Operations (i.e., Ligurian Sea)	Wind (Beaufort)	Species	Number of Animals	Adult/ Juvenile	Animal's bearing from vessel	Animal's distance from vessel	Activity (i.e., traveling, resting, breaching)	Notes

Annex D: Marine Mammals of the Mediterranean Sea

English name	Italian name	Latin name	IUCN Category ^{4 5}	SI77 Category
Monk seal	Foca monaca	<i>Monachus monachus</i>	CR	Pinniped in water
Fin whale	Balenottera comune	<i>Balaenoptera physalus</i>	EN	Low-frequency cetacean
Loggerhead	Tartaruga comune	<i>Caretta caretta</i>	EN	N/A
Leathery turtle	Tartaruga liuto	<i>Dermochelys coriacea</i>	CR	N/A
Sperm whale	Capodoglio	<i>Physeter macrocephalus</i>	VU	Mid-frequency cetacean
Striped dolphin	Stenella	<i>Stenella coeruleoalba</i>	LR cd	Mid-frequency cetacean
Cuvier's beaked whale	Zifio	<i>Ziphius cavirostris</i>	LR cd/DD	Mid-frequency cetacean
Bottlenose dolphin	Tursiope	<i>Tursiops truncatus</i>	LR cd/DD	Mid-frequency cetacean

⁴ UNEP-WCMC. 16 August, 2007. *UNEP-WCMC Species Database: CITES-Listed Species*

⁵ IUCN 2006. *2006 IUCN Red List of Threatened Species*. <www.iucnredlist.org>. Downloaded on 16 August 2007

English name	Italian name	Latin name	IUCN Category ^{6 7}	SI77 Category
Risso's dolphin	Grampo	<i>Grampus griseus</i>	LR cd/DD	Mid-frequency cetacean
Common dolphin	Delfino comune	<i>Delphinus delphis</i>	LR lc	Mid-frequency cetacean
Long-finned Pilot whale	Globicefalo	<i>Globicephala melas</i>	LR lc	Mid-frequency cetacean

Critically Endangered (CR): a species with an extremely high risk of extinction in the wild in the immediate future.

Data Deficient (DD): a species with inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.

Endangered (EN): a species not Critically Endangered but with a high risk of extinction in the wild in the medium-term future.

Vulnerable (VU): a species not Critically Endangered or Endangered but with a high risk of extinction in the wild in the medium-term future.

Lower Risk (LR): a species that has been evaluated but does not satisfy the criteria of any of the categories Critically Endangered, Endangered or Vulnerable. Species included in the lower risk category can be separated into three subcategories:

- Conservation Dependant (cd)
- Near Threatened (nt)
- Least Concern (lc)

⁶ UNEP-WCMC. 16 August, 2007. *UNEP-WCMC Species Database: CITES-Listed Species*

⁷ IUCN 2006. *2006 IUCN Red List of Threatened Species*. <www.iucnredlist.org>. Downloaded on 16 August 2007

Annex E: Incident Action Team

E.1 Introduction

Marine mammal incidents are rare in the NURC operating areas. Nevertheless, it is important for the Centre to be prepared to respond to these incidents quickly and without confusion to determine if actions by Centre personnel may have contributed to the incident, assist national authorities analyze its cause, and assess the oceanographic conditions related to the incident. The Marine Mammal Incident Action Team (IAT) was established to quickly respond to information related to these types of incidents.

E.2 Composition

The team is made up of the following, supported as necessary by other Centre personnel:

1. MMRM Project Leader (PL)
2. NURC Chief Diving Officer (for cases involving human divers)
3. Head, Information Services Branch (ISB)
4. Head, Programme Office (PG)
5. Head Systems Technology (ST) or Applied Research (AR), if their department personnel are involved in the incident.
6. Security Officer (Italian) for coordination with Italian military authority where required.
7. Relevant Program Officer, if not already at sea.

E.3 Decision tree

1. Notify the MMRM PL upon knowledge of a mass (2 or more animals) marine mammal incident in the area of operation. Notification of an incident may come from local residents, a MMRM partner, newspaper, or direct observation from NRV Alliance or CRV Leonardo.
2. MMRM PL will obtain information on the location and operation of NURC ships and the specifics of the incident. The MMRM PL will notify other member(s) of IAT.
3. Decision Points:
 - a. No NURC involvement and no NURC ship in area:
 1. MMRM PL may collect pertinent oceanographic information from Centre assets and other supporting organizations. This information may be offered to national authorities to assist in the analysis into the causes of the incident.
 2. MMRM PL gives feedback to notifier where appropriate.

3. No further action required.
- b. Possible NURC involvement or NURC vessel in area of marine mammal incident.
1. MMRM PL generates memorandum for record (copy to D, DD, PG).
 2. IAT assesses issues and makes recommended course of action to DD/D.
 3. D/DD notifies SIC of decision.
- c. Probable NURC involvement
1. MMRM PL generates memorandum for record.
 2. SIC retain all records and recordings made during sea test.
 3. IAT convene board of inquiry in consultation with D, DD, and appropriate Department Head. Board may consist of outside experts.
 4. IAT produce report of findings of board of inquiry.

Document Data Sheet

Security Classification RELEASABLE TO THE PUBLIC		Project No. 04F
Document Serial No. NURC-SP-2008-003	Date of Issue December 2008	Total Pages 21 pp.
Author(s) Marine Mammal Risk Mitigation Project		
Title NATO Undersea Research Centre Marine Mammal Risk Mitigation Rules and Procedures (2 nd edition)		
Abstract <p>The goals of the NATO Marine Mammal Risk Mitigation include the development of risk mitigation protocols, computer tools, and in-water devices to provide risk mitigation before sonar experiments so to avoid potential negative impact on marine mammals. This document outlines the procedures and marine mammal risk mitigation protocols that are in use by NURC at this time. This is an updated, public release version of the NURC Staff Instruction 77. These procedures are reevaluated and modified as new information becomes available from continued research by the Marine Mammal Risk Mitigation project as well as other documented sources.</p>		
Keywords marine mammal - risk mitigation - sonar		
Issuing Organization NURC Viale San Bartolomeo 400, 19126 La Spezia, Italy [From N. America: NURC (New York) APO AE 09613-5000]		Tel: +39 0187 527 361 Fax: +39 0187 527 700 E-mail: library@nurc.nato.int

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