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PART II: SACLANTCEN Marine Mammal and Human Divers Risk Mitigation Rules - Planning

2.1. EVALUATION OF ENVIRONMENTAL RISK – ENVIRONMENTAL SCOPING STUDY (ESS) OF WORK AREA – REQUIREMENTS AND RESPONSIBILITIES

2.1.1. Requirements

Prior to any SACLANTCEN experimental activity in which it is intended to utilise high level sound sources, the designated Scientist-in-Charge is to cause a documented Environmental Scoping Study (ESS) to be undertaken.

The ESS is to identify environmental problems which may be encountered. The following is a check list of the issues and activities to be considered for the selected trials area:

- Research any previous studies of operational area.
- Determine known marine mammal activity:
  - Expected species
  - Breeding ground or not
  - Seasonal variations
- Itemise details of high level sound sources (Explosives/Sonars/Seismic Systems, etc.) to be used. Transmission source levels, pulse types, frequencies, duration and location.
- Acoustic modelling with forecast propagation, etc.
- Known wreck sites and Fishermans' Fasteners.
- Determine if there are recognised diving sites within 20 kms of work area or any other expected diving activity.
- Swimming beaches within 20 kms of area.
- Consultation with appropriate authorities/experts.
- Appropriate warning notices to be developed ready for despatch.
- Assess the impact of the high level sound on each of the environmental elements – divers and marine mammals in area concerned.
- Determine visual and acoustic monitoring requirements of experiment.
- Complete the ESS Matrix – Annex BBB.
- Audit trail of all environmental precautionary activities to be maintained on file.

2.1.2. Responsibilities

The Scientist-in-Charge (SIC), supported as required by the Naval Adviser and his staff and by any relevant external authorities, is responsible for ensuring that the above check list issues are completed, that any related risk mitigation procedures are briefed to the Master of the research vessel prior to the conduct of the experiment and that a Project Environmental File be submitted as an appendix to the Cruise Report on completion of the experiment so as to provide an auditable trail of activities. (Note: Any classified information should be filed as a separate annex).

2.2. ASSESSMENT OF RISK TO HUMANS IN THE MARINE ENVIRONMENT FROM HIGH LEVEL SOUND

Since the early days of warship sonar operation, many of the world's Navies, when transmitting on such systems and when underwater explosives are to be detonated, have taken measures to ensure that no diving activity is taking place in the general vicinity. Naval and commercial navigational warning messages have provided these alerts to relevant local authorities.

The Code of Practice for Scientific Diving, Second Edition 1996, Chapter 10.7, makes the following statements:

"Most acoustic devices, such as echo-sounders, range-finders and directional beacons, radiate such little power as to be harmless. However, there are acoustic systems, used in geophysical research, and military sonars that radiate power at levels high enough to be harmful to divers. When divers are likely to be active near such systems the Chief Diver should establish contact with the operators of such systems to ensure that power is not radiated during diving."

Three main physiological symptoms can be associated with LF high level sound sources. The first involves the Pacinian corpuscle, a sensor of the nervous system that is distributed throughout the epidermis and provides for vibrotactile sensitivity. The frequency response of the Pacinian corpuscles peaks at about 250Hz, the most annoying frequency in divers' complaints of tingling and numbness. The second effect involves acoustically forced vibrations of gas pockets in the gastrointestinal tract, which may be responsible for complaints of abdominal discomfort. The third major effect is one involving temporary hearing threshold shifts caused by the high levels of sound. Other effects, including tissue or arterial resonance, lung haemorrhage and so on, may also be important.

At present, medical and acoustics scientists are addressing these effects to determine the appropriate exposure thresholds at a variety of source levels. At the same time, environmental acousticians are looking at shallow water scenarios which favour the propagation of LF high level sound in areas where divers are likely to be found. Although it is premature to discuss what these acceptable exposure thresholds might be, acoustic bio-affects scientists are now concerned with low frequency energy even when delivered at relatively low energy levels over considerable ranges.

NAVORD OP 3696 – Explosives Safety precautions for Research Vessels – provides the following guidance on the potential hazards to surface swimmers:

"Detonation of Sound Underwater Signals (SUS) represents probable fatal results for personnel in the water nearby. The lethal and injury distance may be determined as follows:

Lethal Distance	Injury Distance
$LD = 13.41\sqrt[3]{w}$	$ID = 64\sqrt[3]{w}$

Where LD = Lethal distance in metres, ID = Injury distance in metres, W = Weight of TNT or equivalent in pounds

Thus: Lethal and Injury Distance for Underwater Explosions to Swimmers is:

Weight Of Explosive	Lethal Distance (Metres)	Injury Distance (Metres)
1.1 oz (31.5 gm)	5.5	8.2
1.8 lb (0.82 kg)	16.5	23.8
2 lb (0.91 kg)	17.1	24.7
4 lb (1.81 kg)	21.3	31.1

A recent report (Defence Evaluation Research Centre (UK)) suggests that exposure of divers to high level sound can cause hearing loss vertigo, nausea and vomiting. Furthermore, a volunteer experienced a shattering sensation, violent blow to the chest and head and an aching pain in the chest which lasted a few hours at a range of 9.7 metres from a 1.25 lb TNT charge detonating at 4.6 metres depth. Various other injuries were sustained at different depths with the injuries produced assessed as being functions of blast, shock and bubble pulse, water movement and effect of depth. Various equations have been developed. For work with SUS explosives, the theoretical tolerance levels for a diver at 10 m depth and the source at 10 m depth are shown at Annex CCC.

Although for non-explosive sources it is overcautious, prior to experiments the Centre should take all measures to establish a 5 km diver exclusion zone from any high level sound source and, during the experiment, ensure as far as practicable that no diving operations are being conducted within the zone.

As general rule of thumb, the sound level at the diving site should not exceed 150 dB re 1µpa.

2.3. ASSESSMENT OF RISK TO MARINE MAMMALS FROM HIGH LEVEL SOUND

The sensitivity levels of marine mammals to high level sound is not currently well known and is not consistent across the species. Lack of uniformity in marine mammal hearing organs suggests a conservative, yet practical approach.

As a general rule of thumb, marine mammals should not be ensonified at levels above 160 dB re 1µpa at the reception point.
[Note: This level will be reviewed regularly as the results of science becomes available].

As a standard interim measure using a maximum sound source level of 226 dB re 1µpa, @ 1 m the stand off distance will be a 2 km observation zone surrounding the source. Adjustments may be made to comply with these limits.

The influence of sound energy on marine mammals is a function of the sound level at the point of reception by the mammal. Based upon scientific evidence available and using a conservative bias as a safety measure to protect mammals, a received sound level of 160dB re 1µpa is safe (with an ample margin for assurance) to marine mammals in all frequencies.

Using sound level strength at the received point as the limitation, maximum source level strength will be determined by propagation loss over distance. As an established physical principle, propagation loss in the water medium is 60 dB at 1 km and 66dB at 2 km (using 1 meter as the standard reference). To ensure that the sound strength limit at the location of a mammal is not exceeded, the propagation strength at the sound source can be no higher than 226 dB re 1µpa at 1 metre when received at 2 km. Propagation strength and safety range may be adjusted when in the presence of marine mammals but the limitation of 160 dB re 1µpa at the point of reception will not be exceeded.

As an exception, small, generally fast moving marine mammals are known to be attracted to certain noise sources. 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(s) is recognised as listed in the endangered species list as an extraordinary precaution.

2.4. RISK REDUCTION MEASURES AND RESPONSIBILITIES

2.4.1. Planning (environmental protection and monitoring)

These guidelines reflect principles which Scientists-in-Charge are to use when planning their marine operations whenever it is intended to employ high level sound sources. The measures should assist in ensuring that human divers and marine mammals are protected against possible injury.

- Trials area to be selected based on the ESS, on the in-house marine mammal and dive site data base, including consideration to avoidance of wrecks, mammal breeding areas, special sanctuaries, etc.
- Advanced public announcement to relevant authorities.
- Consider invitation to observers onboard taking security aspects into account.
- Evaluate source levels required to meet scientific objectives.
- Sound propagation/prediction modelling from source.
- Apply robust rules of thumb (Part II, para. 2 and 3).
- Consultation with relevant authorities

- Heighten awareness by organising visual and acoustic lookout training, sound recording, video etc., prior to operations
- Include section in Pre-Cruise Brief on precautions to be taken
- The Operational Area Clearance/Nav Warning Requests should take account of the ESS.
- To allow visual lookout, operations at night to be minimised.
- Plan tracks and operations to provide mammal escape routes and avoidance of embayment.
- Avoid coastal areas with complex, steep sea bed topography.
- Results of ESS and summary of planning activities to be properly reflected in the Test Plan
- In-house Marine Mammal and Diver Site Data Base to be updated with any additional information.
- Standard form of marine mammal log to be arranged (Bridge/Laboratory) – See Annex DDD.

2.4.2. On scene assessment

Knowing that marine mammals are present in the area is difficult. Whales can remain submerged, holding their breath, for up to about 1 hour. The instant surface is reached, the blowhole is exposed to the air and opened. The animal immediately exhales or "blows" and creates a characteristic spout. In large whales, the spout may rise more than 6 metres. With practice, species can be identified from the characteristics of the spout. Dolphins and porpoises generally surface 2 to 3 times per minute to breathe. Dive times and surfacing behaviour are more erratic when they are feeding, but most dives are unlikely to exceed 5 minutes. Marine mammals are capable of brief swimming speeds of about 30 knots and of sustained movement at 8 knots. If disturbed they may alter their heading rapidly.

Feeding seabirds can sometimes indicate the presence of marine mammals.

Some species may be attracted to boats from some distance away, probably by engine noise. They may accompany a vessel for a considerable period and even bowride if it is fast-moving. The arrays of hydrophones which are towed by a research ship may also be attractive to dolphins.

When submerged they are much more at risk from the potential effect of high level sound than when on the surface.

Marine mammals communicate using whistles, creaks, chirps and moans. Trains of clicks are used for echo-location and foraging. All these noises may be heard with a hydrophone at distances up to several kilometres and can reveal the presence of marine mammals.

When the area cleared for high level sound operations during the ESS is reached, the following action/activities are to be adopted - these are known as “The Risk Reduction Measures”:

- Place properly briefed and trained lookouts, preferably using binoculars.
- When available, utilise aircraft/helicopters to aid visual search.
- Activate and place a listening watch on the underwater telephone (Laboratory is prime watch; bridge back up watch).
- Set acoustic watch on passive towed array (if available). Focused beamforming methodology to be adopted for circular search out to 2 to 3 km.
- If available, deploy remote sensing sonobuoys in appropriate pattern for range information.
- Alert any other involved units to establish visual and acoustic watches as above. Reporting procedure to be agreed.

EXECUTION AT SEA

LOOK, LISTEN AND RECORD

- Transit work area with trained visual lookouts and where available passive listening systems (i.e. array, sonobuoy, u/w telephone) deployed
- Listen, look and record from at least 30 minutes before to 30 minutes after operations
- Details of visual and acoustic lookout to be maintained in scientific log books – Bridge and Laboratory.
- If no visible or acoustic signs of marine mammals are evident within 2 kilometres after 30 minutes then:

SLOW BUILD UP

- Ramp up source gradually from 150 dB re 1μpa @ 1 metre.
- If no evidence of marine mammals within 2 kms after 20 minutes, commence operations. Otherwise delay and repeat
- Continuous operations are then permissible
- Keep source level as low as possible consistent with achieving the work
- If transmissions stop for more than 4 hours, the start up procedure is to be repeated

OPERATIONS

- Operations are to be suspended on sighting or hearing marine mammals within 2 km except for
  - Animals approaching within 45 degrees of the stern (use acoustics to alert lookout)
  - The small, fast moving species, which are known to be attracted to certain noises
- Transmissions are to be terminated if any marine mammal is recognised as listed on the endangered species list.
- Sightings/acoustic identification to be reported on "Marine Mammal Recording form" – Annex CCC.
- Photograph or video film any sightings whenever possible to aid verification of identification.

1. CONSERVATION/FOLLOW UP REPORTING

To further marine mammal interest and knowledge onboard and thus to elevate awareness and vigilance to assist their protection, the publication "Whales, Dolphins

and Porpoises" (Eyewitness Handbook) is provided to the Masters of both research vessels, which will provide a helpful guide to their identification. In order to further marine biological knowledge on migration patterns and to assist the Centre to plan experiments in the least populated areas, the following reporting arrangements are to be adopted. The Scientist-in-Charge is to include a Project Environmental File annexed to the Cruise Report with the following information:

- Details of visual and acoustic lookouts maintained onboard.
- Sightings or acoustic identification plus photographs when available (Annex CCC forms). **Note:** These forms also to be forwarded to the appropriate "Nature Conservation Organisation".
- Summary of precautions taken.
- Complete the Project environmental file by including all the above.
- Update the Marine Mammal and Diving Site Data Base.

BIBLIOGRAPHY

1. NAVORD OP3696 - Explosives Safety Precautions for Research Vessels.

2. Code of Practice for Scientific Diving, UNESCO 1996 - Second Edition.

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4. Guidance for Minimising Acoustic Disturbance to Marine Mammals from Seismic surveys (DERA(UK)), 1998.

5. Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions, D.R. Ketten, 1995/6.