World-wide a concern exists about the influence of man-made noise, and particularly of high power sonar, on marine life in the sea. Most concern lies with marine mammals. This concern is fed by recent strandings of whales that could be related to military sonar transmissions and signals generated during seismic surveys.

Marine mammals spend most of their lives submerged. Sound is their principal sensor for precisely the reasons that led humans to develop sonar. Sound propagates efficiently through water and is used by whales and dolphins for a variety of purposes:
- finding prey/detecting predators;
- communication;
- navigation.

As most marine mammals have good hearing sensitivity they may be vulnerable to high sound intensities. Unfortunately, precise knowledge on this vulnerability is lacking at this moment, although many studies are performed in this field.

TNO RESEARCH PROGRAMME SAKAMATA
Because little is known about the influence of active sonar on marine mammals many governments and organisations apply the precautionary principle. In practice this means that the following mitigation measures for the use of active sonars are laid down into law:
1. Careful planning of sonar operations;
2. Monitoring of marine mammals in best possible way before using the sonar;
3. Operational risk mitigation measures (e.g. Ramp-up schemes).

In that respect TNO has build up a research programme supported by the Royal Netherlands Navy to focus on these aspects.
CAREFUL MISSION PLANNING
Before planning an active sonar operation (e.g. an ASW exercise or a seismic survey), it should be checked carefully which marine mammals normally live in the operation area in that season.

MARINE MAMMAL MONITORING
Not using the sonar if marine mammals are present is a very efficient mitigation measure. The point is however, how do we know if marine mammals are present? In situ monitoring of marine mammals can be done visually or by audio, but is very difficult.

OPERATIONAL RISK MITIGATION MEASURES
An example of a risk mitigation measure is a ramp-up scheme. This is includes to slowly raise the source level, so that animals can escape and keep receive levels acceptable to prevent ear-damage or worse. A well-designed ramp-up scheme takes into account:
- Sonar specifications (source level, centre frequency, pulse duration, duty cycle, etc.)
- Species of marine mammals present (hearing sensitivity for the given frequency, swimming speed)
- Environmental conditions (propagation loss as function of range, bearing and depth)

The computation of a ramp-up scheme or other risk mitigation measures are not easy to implement and accurate knowledge on marine mammals hearing and behaviour is crucial. For at least 10 years, TNO has been involved in research on marine mammal hearing sensitivity in collaboration with marine mammal experts (SeaMarco). The validated hearing sensitivity curves (W.C. Verboom) that resulted from this research are essential in TNO risk mitigation calculation. Within SAKAMATA, TNO is pursuing its efforts to develop knowledge on marine mammal behaviour and hearing sensitivity through international collaborations (WHOI, St Andrews, FFI, FWG, NURC) and scientific sea surveys.

TOOLS TO SUPPORT RISK MITIGATION MEASURES
Within TNO’s SAKAMATA research programme, two software packages are developed to assist the operator in implementing the mentioned risk mitigation measures:
1. SAKAMATA (risk-mitigation tool)
2. Identification & registration tool (IRMA)

Both software packages are supported with a dedicated and up-to-date database that incorporates extensive information on marine mammals and insight into their behaviour. Within the SAKAMATA programme efforts are made to validate the data with scientific surveys, reported sightings and international cooperation.

SAKAMATA
The SAKAMATA tool supports the mission planning and the calculation of risk mitigations measures. In SAKAMATA a scenario can be defined by positioning a platform and attaching sonars to it. Also the environmental parameters and date need to be specified. When a scenario is defined, SAKAMATA will determine the most vulnerable species for this operation. The maximum allowed sound pressure level for the sonar frequency in question is derived from validated hearing sensitive curves. Alternatively a fixed sound pressure level can be used for each marine mammal group. Propagation loss for the given sonar in the given area is computed by ALMOST, the sonar performance model of TNO. This information is used to compute the received level depending on range and depth of the marine mammal. The stand-off ranges for each marine mammal group are computed and a ramp-up scheme is designed. The received sound pressure level of the endangered mammal is always lower than the maximum allowed sound pressure level, for a given swimmable speed.

IRMA
In situ monitoring should support the mission planning. The SAKAMATA database contains audio and visual information to support the monitoring process. Pictures of mammals and a description with useful hints are available for each species in the database. Furthermore typical sounds and a description is available. Marine mammal watchers can be supported with a dedicated Identification & Registration of Marine Animals (IRMA) tool. A PC version and a special version for the PDA have been developed at TNO.

MARINE MAMMAL DATABASE MANAGEMENT
Both IRMA and SAKAMATA can be provided with a Marine Mammal Database Management Tool (M2DMT) to allow the user to easily maintain the marine mammal database. The database can be updated to support new knowledge and modified legislation. The IRMA and SAKAMATA software packages are commercially available and can be adapted to your specific wishes and your nation’s laws.

TNO
TNO is an independent innovation organisation that connects people and knowledge in order to create the innovations that sustainably boost the competitiveness of industry and wellbeing of society.

TNO focuses its efforts on seven themes including Defence, Safety and Security: TNO works on a safe and secure society by creating innovations for people working in defence organisations, the police, emergency services and industry.

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