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SONATE 2015 – a decision aid tool to mitigate the impact of sonar operations on marine life

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English summary

The Royal Norwegian Navy has five frigates equipped with 1-8 kHz active sonars. Such sonars are potentially harmful to marine life. Naval sonar exercises have been accused of causing whale stranding and habitat exclusion of both fish and marine mammals.

More than 10 years of research shows that the environmental impact of sonars are less than first suspected. The effects on fish populations, possible negative impact on fisheries and direct injury on marine mammals are minimal. Use of sonar has on the other hand been shown to lead to behavioural effects for several species of marine mammals. The Royal Norwegian Navy has introduced an *Instruction for use of active sonar in Norwegian waters* to minimize any negative effects on marine life. The instruction contains guidelines for planning of sonar operations and operational procedures.

The instruction is integrated in a decision aid tool – SONATE, developed by FFI for the Norwegian Navy. SONATE is a tool for use during planning and execution of sonar exercises, with the aim to minimize the impact on marine life and the conflicts with activities such as fisheries, fish farming, tourism etc. SONATE combines cartographic information on species distribution, fishing activity and fish farms with the guidelines that define the actions to mitigate environmental impact.

The first operational edition of SONATE (1.0) was introduced in 2006, and SONATE 3.2 was released in 2011. This was the last version of SONATE as standalone software programmed in Python. This version of SONATE is now phased out and a new edition introduced, SONATE 2015.

SONATE 2015 is introduced in two different versions. SONATE-WMS is based on internet technology, and SONATE-ArcReader is an offline version for use without sufficient internet connection. The motivation to end the initial standalone version of SONATE was partly a request from the Royal Norwegian Navy to collect more tools on a common platform, and also to simplify the process of updating the database.

The two new editions of SONATE (WMS and ArcReader) are equivalent and have more or less the same functionality. Both the 2015 versions also support the new *Instruction for use of active sonar in Norwegian waters* issued in April 2015 for use within the Navy.

SONATE 2015 is a final deliverable from the FFI project Sonar and Marine Life. There is no plan for a continuation of this project and this version of SONATE therefore constitute the final hand-over of SONATE from FFI to the Navy. The geographical information in SONATE needs to be updated regularly. We recommend yearly updates of the species distribution maps from the Institute of Marine Research, and of the fishery and fish farming information from the Directorate of Fisheries. The instruction for use of sonar should also be updated when new knowledge of effects of naval sonars on marine life becomes available.

Sammendrag

Det norske forsvaret har fem fregatter i Fridtjof Nansen-klassen som er utstyrt med 1-8 kHz aktive sonarer. Slike sonarer kan være potensielt skadelig for marint liv. Militære sonarøvelser har blitt beskyldt for å være årsaken til massestranding av hvaler, og at fisk og pattedyr forlater området.

Resultatene fra mer enn 10 års forskning tilsier at miljøeffektene er mindre enn man først fryktet. Effektene på fiskebestander og mulige negative påvirkninger på fiskeri samt risiko for direkte skade på sjøpattedyr er minimal. Bruk av aktiv sonar har riktignok vært påvist å kunne føre til atferdsmessige endringer hos mange arter av sjøpattedyr. Sjøforsvaret har derfor innført en «Instruks for bruk av aktiv sonar i norske farvann» for å begrense negative effekter på marint liv. Instruksen inneholder føringer for planlegging av sonarøvelser og operative prosedyrer.

Instruksen er integrert i et beslutningsstøtteverktøy – SONATE, som er utviklet av FFI for Sjøforsvaret. SONATE er et verktøy for bruk under planlegging og utføring av sonarøvelser, med den hensikt å minimere påvirkningen på marint liv og konflikter med aktiviteter som fiskeri, oppdrettsanlegg, turisme og så videre. SONATE kombinerer kartfestet informasjon om arters utbredelse, fiskeriaktivitet, hvalfangst og oppdrettsanlegg med føringene som definerer hvilke hensyn som bør tas i hvilke områder.

Den første operative utgaven av SONATE (1.0) ble lansert i 2006, og i 2011 kom SONATE 3.2. Dette var den siste versjonen i rekken av SONATE som frittstående programvare programmert i Python. Denne utgaven av SONATE fases nå ut i forbindelse med lansering av SONATE 2015.

SONATE 2015 lanseres i to ulike versjoner. SONATE-WMS er nettbasert, men for at Forsvaret fortsatt skal ha tilgang på SONATE når de er uten internett-tilgang eller har liten båndbredde, har vi også utviklet en offline-versjon kalt SONATE i ArcReader (2015). Motivasjonen for å gå vekk fra den opprinnelige standalone-løsningen var blant annet at Forsvaret ønsket en utvikling mot å samle flere verktøy på samme plattform samt å forenkle oppdatering av verktøyet.

De to nye versjonene av SONATE (WMS og ArcReader) er likeverdige og har stort sett samme funksjonalitet. Begge støtter også den nye instruksen utstedt av Sjef Sjøforsvarets skoler i april 2015 for bruk i Sjøforsvaret.

SONATE 2015 er en sluttleveranse i FFI-prosjektet Sonar og Havmiljø. Det er ikke planer om å videreføre dette prosjektet, og denne leveransen innebærer derfor en endelig overlevering av SONATE fra FFI til Sjøforsvaret. Den geografiske informasjonen som ligger i SONATE, må oppdateres regelmessig. Vi anbefaler årlige oppdateringer av utbredelseskart fra Havforskningsinstituttet og tilsvarende oppdatering av informasjon om fiskeriaktivitet og havbruksanlegg fra Fiskeridirektoratet. I tillegg bør retningslinjene for bruk av sonar oppdateres med ny kunnskap om effekter av militære sonarer på havmiljø.

Contents

Preface

The story of SONATE started in 2003 with the FFI (Norwegian Defence Research Establishment) project “LFAS og Havmiljø”. John Kenneth Grytten designed the first versions of SONATE in collaboration with Erik Sevaldsen and Petter Kvadsheim. Nina Nordlund took over Grytten's work when he resigned from FFI in 2006. The first version of SONATE (SONATE 1.0) which was implemented in operational use by the navy was issued in 2006. I 2007 SONATE 2.0 was issued with significantly improved functionality. This version was developed with the help of Frank Benders who was a visiting scientist at FFI from TNO in 2007. In 2008 SONATE 3.0 was completed, and the last version of SONATE on the original python software platform, SONATE 3.2 (2011) was completed in 2011. These were all standalone offline versions. In parallel to the work with SONATE on the original platform, development of an internet based version called SONATE-WMS started in 2009. This work was carried out in cooperation with the Institute of Marine Research and the METOC project at FFI. An operative version of SONATE-WMS was finished November 2014.

To ensure an offline version of SONATE, SONATE-ArcReader was developed. This version was finalized in November 2014.

1 Introduction

The Royal Norwegian Navy operates five frigates in the Fridtjof Nansen-class, all equipped with 1-8 kHz active sonars.

More than 10 year of research shows that the environmental impacts of sonar are less than suspected initially. The potential effects on fish populations and fisheries are minimal, and risk of direct injury on marine mammals are also low and can be reduced further by simple mitigation measures such as ramp-up (von Benda-Beckmann et al. 2013). Use of sonar may on the other hand lead to behavioural effects on several species of marine mammals. Such effects might imply changes in diving behaviour, habitat avoidance, cessation of feeding or increased energy costs.

As a way to mitigate this potential problem, FFI (The Norwegian Defence Research Establishment) has developed SONATE for the Norwegian navy, a decision aid tool that will help reduce the environmental impact of naval exercises. The SONATE project is executed by FFI and funded by the Norwegian Ministry of Defence.

SONATE is a decision aid tool for use during planning and execution of sonar exercises, with the aim to minimize conflicts with sea based industry (fisheries, fish farms, tourism) and influence of marine life. SONATE contains cartographic information on distribution maps, fishing activity and fish farms. SONATE combines the cartographic information with the "*Instruction for use of active sonar in Norwegian waters*". The combination of the guidelines and the cartographic information defines which precautionary actions to be taken in which areas and periods.

All units using active sonar and all staff involved in planning of exercises which involves use of sonar, shall have access to SONATE. Operations within the recommendations given by SONATE for different areas and time periods ensure that the operations are executed within the guidelines for sonar operations in Norwegian waters. Foreign military units are also requested to comply with these guidelines during operations within Norwegian territorial waters.

The instruction for use of sonar are issued by the chief of the naval academy (Commodore Thomas T Wederwang) on behalf of the chief of the Norwegian Navy (Rear Admiral Lars Saunes) based on extensive research on effect of sonar of fish and marine mammals by FFI with national and international collaborators (e.g. Kvadsheim et al. 2005, 2007, 2009, 2010a, 2010b, 2011, 2012a, 2012b, 2014, Miller et al. 2011, 2012, 2014, Doksæter et al. 2009, 2012, Sivle et al. 2012a, 2012b, 2014, Kuningas et al. 2013, von Benda-Beckman et al. 2013, Fahlman et al. 2014, Antunes et al. 2014).

In 2015, SONATE is released in two editions. SONATE-WMS is an internet based tool. WMS stands for Web Map Service and is a standard protocol for serving georeferenced map images over the Internet. In addition, an off-line version is developed, SONATE-ArcReader, to be used in cases of no-internet access or limited bandwidth.

The content of the two editions are similar to earlier editions and we have sought to make the presentation of the data as identical as possible in the two new editions.

This report is written as a user's manual to the two editions of SONATE 2015 (SONATE-WMS and SONATE-ArcReader).

Chapter 2 gives an overview of the history of SONATE and background for the current version. Chapter 3 gives a description of the input data used in SONATE, and chapter 4 gives a description of the two SONATE 2015 editions and their respective user interfaces.

2 Background for current solution

The first version of SONATE was distributed to the Norwegian Defence in 2006. These first versions were stand-alone software that could be installed on any independent computer. It was programmed in Python with a PostgreSQL/postgis database. SONATE is developed at FFI as part of the SONAR & Marine Life program (p1199).

In 2008 it was decided to work towards an internet based version of SONATE instead of continuing to develop the stand-alone version. This decision was based on the fact that the Norwegian Defence wanted to minimize number of independent software and gather several applications on common platforms. Another argument for changing platform was the fact that the administration of data in SONATE was time consuming and complicated and that we wanted to make the update of SONATE more streamlined. This decision was taken by the project review board, and FFI and the Navy agreed to this strategy.

Since the decision was made to transfer SONATE from the standalone software to an internet based tool in 2008, the maintenance of the python code has been held to a minimum, and the status in 2015 is that to be able to continue on this platform, the code would have to be completely rewritten.

The Norwegian Defence is developing an internet based tool that will eventually distribute geographical information such as meteorological and oceanographic conditions, ship traffic etc. A beta version of this GEOMETOC-service was developed at FFI and were planned to be eventually transferred to restricted networks in the Norwegian Defence. The original plan was to make SONATE a part of this service.

There have been delays in this work, and SONATE could therefore not be made available through the planned portal on the restricted network. However, SONATE does not contain any restricted information and could therefore be made available through a map-service on the internet. Navy vessels do not always have sufficient bandwidth on the unrestricted network to rely on internet access, and therefore it was decided that in addition to the web based version of SONATE, an off-line version which could be downloaded and installed on a computer on board before heading to sea was also necessary.

As a transfer of SONATE-WMS to the GEOMETOC-service was not possible within the project period, it was decided to make SONATE-WMS available through an FFI WMS server as a temporary solution. This is not an ideal solution, and it's not a durable solution, because the FFI WMS server is primarily used for research to prototype different internet based information services. The server is maintained, but not on a 24/7 basis, and thus is not an ideal operational solution for the navy.

A crucial component of SONATE is the distribution maps of marine mammals and fish which FFI are supplied with from Institute of Marine Research (IMR). The update of these data in SONATE has since the first version been a time consuming process, because data from IMR has to be prepared and adapted before loading it into SONATE. Therefore FFI has over the years been looking for a way to streamline the process of transferring data from IMR to SONATE. Through the national Norwegian Marine Data Centre (NMDC) infrastructure program, IMR and FFI collaborated and agreed on a suitable database structure for the distribution data. The plan was to eventually let SONATE-WMS get data directly from the NMDC database at IMR, without having to establish a local copy of the database at FFI. This depended not only on FFI adapting the GEOMETOC-WMS to the database structure, but also that IMR adapted their management of distribution data to this new database structure keeping data in a PostgreSQL/postgis database. The latter has been delayed, so that the streamlining of transferring data from IMR to SONATE has not been achievable within the project. Therefore this data transfer still involves manual transfer of data and adaptation of the data to the FFI database.

With these factors in mind, a SONATE-WMS as part of the GEOMETOC-service (which is under development in the Defence) was not possible, and another solution therefore had to be found.

Several solutions were considered. A number of these included making SONATE a part of other already existing WMS portals or other systems. But it turned out most of these were not suited or not mature enough to include systems like SONATE, at least not within this project. A list of the considered solutions is found in Chapter 5. To ensure access to SONATE when internet access is not available, the offline ArcReader version of SONATE were developed in parallel. This is a GIS (Geographical Information System) software by ESRI™ Industries (http://www.esri.com/). The publisher of the tool (in this case FFI) sets up a map with all data layers and other information in the ArcGIS software. The tool ArcPublisher converts this map into a so-called published map that can be read (not edited) by the free software ArcReader.

Also considered in this development process was the possibility that the SONATE project will not be continued after the current project ends, and starting a long developing process with completely new code and maybe software would be too time consuming and risky. The Arc products are already in use to manage the SONATE data and transferring this to an offline version in ArcReader was a relatively simple task.

3 Input data

The input data to SONATE comes from different sources. Input data are distribution maps of fish and marine mammals, whaling activity, fishing activity, safari activities (e.g. whale watching) and fish farm locations (Table 3.1.).

Table 3.1 Table showing SONATE input data and data sources.

Input data	**Source**
Distribution maps (fish and marine mammals) from Norwegian waters	Institute of Marine Research (IMR)
Distribution maps – Eastern Barents Sea	PoMM*
Word wide distribution maps – expected density from habitat model	UK Hydrographic Office, PoMM*
Fish farms	Norwegian Directorate of Fisheries
Word wide observations/sightings of marine mammals	PoMM*
Fishing activity	Norwegian Directorate of Fisheries
Safari activities	From tourist companies
Fishing zones and locations	Norwegian Directorate of Fisheries
Whaling areas	FFI, based on data from IMR

** PoMM – The EDA project "Protection of Marine Mammals". See 3.2*

3.1 Distribution maps from IMR

The distribution maps are obtained from Institute of Marine Research (IMR, Bergen, Norway). The distribution maps used in SONATE-WMS is kept in a PostgreSQL/postgis database at FFI.

This is a copy of the original database at IMR which was created during the pre-project to NMDC. This database has a structure adapted to the needs of both IMR and FFI. Initially we hoped that the distribution data in SONATE could be loaded to the SONATE-WMS directly from the database at IMR, without holding a local copy at FFI. This has not been possible to achieve within the current SONATE project period, mainly because IMR has been delayed in the process of transferring from their existing data management system, to a system that includes the database structure from the NMDC pre-project.

For the earlier editions of SONATE (e.g. SONATE 3.2 - 2011) FFI has received shape files from IMR. These shape files have also been used in the new SONATE-ArcReader edition.
The dataset used in SONATE-WMS includes distribution maps of 17 species of marine mammals, and 12 species of fish in Norwegian waters. The dataset used in ArcReader includes 11 species of marine mammals and 9 species of fish (see Table 3.2 for a complete list of species). This covers the most important species in Norwegian waters. In the North Sea, Norwegian Sea, most of the Greenland Sea and the Barents Sea, this dataset gives a complete data coverage. For some species the distribution maps cover a larger area.

In addition to geographical distribution of species, these data hold information on time period for which the maps apply. For some species the distribution varies with age-class, life stage (feeding,

moulting, spawning etc.), and this is reflected in the maps in SONATE. Most distribution maps are originally delivered as valid for whole months, but for a few species, the validity period is given for larger or shorter periods. At these few occasions, the validity period in SONATE-ArcReader is extended to the beginning and end of month. For SONATE-WMS the original dates are kept.

Both editions of SONATE also contains maps with information on safari activities (e.g. whale watching) and areas of whaling activity.

Table 3.2 SONATE contains distribution maps for the species in the table below (Norwegian names in parentheses.

SONATE-WMS	**SONATE-ArcReader**
MAMMALS:	**MAMMALS:**
Bearded seal (Storkobbe)	Bottlenose whale (Nebbhval)
Beluga (Hvithval)	Fin whale (Finnhval)
Bottlenose whale (Nebbhval)	Grey seal (Havert)
Fin whale (Finnhval)	Harbour porpoise (Nise)
Grey seal (Havert)	Harbour seal (Steinkobbe)
Harbour porpoise (Nise)	Harp seal (Grønlandssel)
Harbour seal (Steinkobbe)	Hooded seal (Klappmyss)
Harp seal (Grønlandssel)	Humpback whale (Knølhval)
Hooded seal (Klappmyss)	Killer whale (Spekkhogger)
Humpback whale (Knølhval)	Minke whale (Vågehval)
Killer whale (Spekkhogger)	Sperm whale (Spermhval)
Minke whale (Vågehval)	
Narwhale (Narhval)	
Ringed seal (Ringsel)	
Sperm whale (Spermhval)	
Walrus (Hvalross)	
White beaked dolphin (Kvitnos)	
FISH:	**FISH:**
	Blue whiting (Kolmule)
Capelin (Lodde)	Capelin (Lodde)
North Sea Cod (Nordsjøtorsk)	North Sea Cod (Nordsjøtorsk)
North East Arctic Cod (Nord-øst-arktisk torsk)	North East Arctic Cod (Nord-øst-arktisk torsk)
Coastal Cod (Kysttorsk)	Coastal Cod (Kysttorsk)
Deepwater Redfish (Snabeluer)	Deepwater Redfish (Snabeluer)
	Greenland halibut (Blåkveite)
North Sea Haddock (Nordsjøhyse)	North Sea Haddock (Nordsjøhyse)
North East Arctic Haddock (Nord-øst-arktisk hyse)	North East Arctic Haddock (Nord-øst-arktisk hyse)
Norwegian Spring Spawning Herring (Norsk vårgytende sild)	Norwegian Spring Spawning Herring (Norsk vårgytende sild)
Fjord Herring (Fjordsild)	Fjord Herring (Fjordsild)
North Sea Herring (Norsdjøsild)	North Sea Herring (Norsdjøsild)
Horse mackerel (Taggmakrell)	Horse mackerel (Taggmakrell)
Mackerel (Makrell)	Mackerel (Makrell)
North Sea Saithe (Nordsjøsei)	North Sea Saithe (Nordsjøsei)
North East Arctic Saithe (nord-øst-arktisk sei)	North East Arctic Saithe (nord-øst-arktisk sei)
Sprat (Brisling)	Sprat (Brisling)
Fjord Sprat (Fjord brisling)	Fjord Sprat (Fjord brisling)
	Polar Cod (Polartorsk)

3.2 PoMM data

From 2010 to 2013 FFI participated in the EDA (European Defence Agency) project PoMM (Protection of Marine Mammals).

The EDA project PoMM was based on an agreement between the Ministries of Defence of Germany, Italy, the Netherlands, Norway, Sweden and the United Kingdom.

One of the aims of the project was to establish a common marine mammal database, being essential for risk mitigation tools. It provides knowledge on marine mammals with focus on the abundance, seasonal distribution and density of different species in all areas of operational interest for European Navies. The database contains sighting records, seasonal probabilities of occurrence, habitat use (e.g. feeding, reproduction) and species' characteristics such as appearance, behaviour and vocalization.

PoMM experienced slow progress in delivery of data from external sources, but the partners still think the resulting database will be a useful tool in the future. Collection of density data and distribution data has been difficult, mainly due to the fact that very little data of this kind actually exists. Observation data (point sightings) was easier to find and get permission to use.

The PoMM dataset offers the possibility to expand the geographical coverage of SONATE to areas outside of Norwegian waters. Only three datasets that are relevant for SONATE was identified and collected during PoMM and one of these datasets are the IMR collection of distribution maps that have been a major part of the SONATE tool since the first version (see 3.1). The other two are a Russian dataset describing distribution of relative density of marine mammal species in the Barents Sea (See 3.2.1) and a dataset of predicted density delivered by the UK Hydrographic Office (UKHO) (see 3.2.2).

3.2.1 Russian distribution maps (PoMM)

This dataset were digitized at FFI from the report «AN ASSESSMENT OF THE INTEGRAL VULNERABILITY OF THE BARENTS SEA FROM OIL CONTAMINATION» by Shavykin and Ilyin 2010.

This dataset is included in the offline version of SONATE (SONATE-ArcReader).

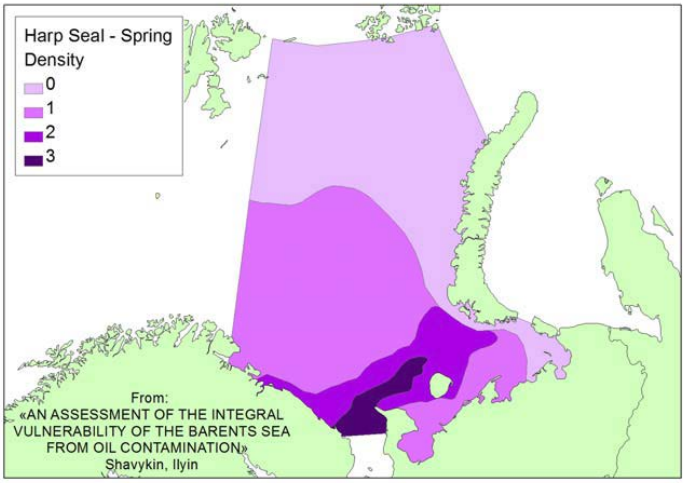

Figure 3.1 Example of relative density data from the Russian dataset, showing density of harp seal in spring

3.2.2 UKHO density maps (PoMM)

This is a global coverage dataset of marine mammals, including density from a habitat model, predicting a relative expected density of a species depending on how well the physical habitat (water depth, bathymetry, water temperature etc.) matches the preference of that species.

Some of these data, the species most relevant for Norwegian waters, are included in the offline version of SONATE (SONATE-ArcReader).

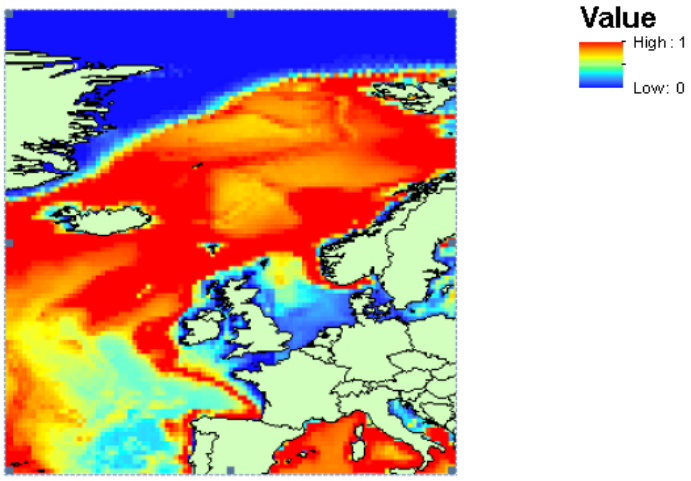

Figure 3.2 Example of predicted density data from the UKHO dataset, showing predicted density (annual mean) of killer whales

3.2.3 Observation data (PoMM)

The PoMM project collected a large amount of marine mammal observations (point sightings). Some of these are included in the offline version of SONATE. These data cannot give a good description of distribution of marine mammals because they often reflect density of observers (ships) more than density of animals, but can at least give an indication of where to expect to find certain species. Some of these data are included in SONATE-ArcReader but are not linked to the guidelines.

3.3 Fishery information

Fishing activity data are obtained from The Directorate of Fisheries (Point of contact: Randi Sofie Sletten mailto: randi-sofie.sletten@fiskeridir.no . The Directorate of Fisheries divides the Norwegian Waters into fishing areas and fishing locations, in which catch of fish is reported. These areas and locations are also used in SONATE to display fishing activity (Figure 3.).

The fishing activity data holds information on catch period (monthly), area, location, fishing tool, species (or groups of species), catch (in kg) and number of vessels which have reported catch from the location within a month. Be aware that this dataset only holds information on catches delivered in Norway. Figure 3.4 shows an example of how fishing activity data are presented in SONATE-WMS.

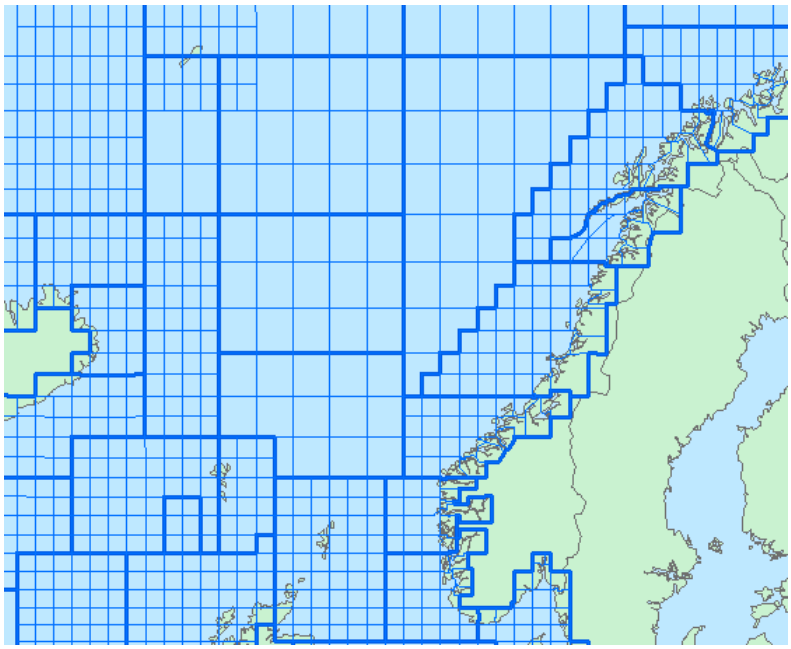

Figure 3.3 Maps showing example of fishing areas (heavy blue line) and fishing locations (thin blue lines). Fishing activity is registered location wise.

Forsvarets forskningsinstitutt

Year/Month	Sea area	Catch kg/km²	Worth NOK	Vessel(s)/km²	Area km²
2013/1	30/3	43 563	80	0.00009	11645

Figure 3.4 Example of how fishery activity information is shown in SONATE-WMS.

3.4 Fish farms

The fish farms data are obtained from the Directorate of Fisheries ("http://www.fiskeridir.no/akvakultur/registre"), on an excel file, and contains fish farming concession holders name and address, species, production capacity, geographic coordinates etc. Be aware that the fish farm locations presented in SONATE are existing concessions. Some companies have concessions on several locations and move the fish farms between these. This means that not all fish farm locations indicated in SONATE contains a physical farm at all times. Example of fish farms in SONATE-WMS is shown in Figure 4.7.

3.5 Instruction for use of active sonar in Norwegian waters

Based on current knowledge on effect of naval sonar on marine life, FFI recommend to the navy operational restrictions on the use active sonar in Norwegian waters. Based on this, an *"Instruction of use of sonar in Norwegian waters"* is issued for use within the navy. The instruction contains guidelines for planning of sonar operations and operational procedures. The current version of this document was issued on April 1 2015 and can be found in Appendix A. The original document is issued in Norwegian, but an English translation is attached to it. The document contains criteria which identify areas and periods in SONATE were specific restrictions apply. This can for example be areas/periods with high density of sensitive species and were sonar activity should be limited. The instruction also contains specific instruction on where and when operational procedures might apply, such as ramp up or stand-off ranges. Operations within the recommendations given by SONATE for different areas and time periods ensure that the operation will be executed in compliance with the prevailing instruction.

4 The SONATE tools

SONATE 2015(SONATE-WMS and SONATE-ArcReader) is a decision aid tool for use during planning and execution of sonar exercises. SONATE combines geographical information with the "*Instruction for use of sonar in Norwegian waters*" (Appendix A) with the aim to minimize influence on marine life and conflicts with activities such as fisheries, fish farming, tourism etc.

The instruction recommend different degrees of restrictions depending on which species (more or less vulnerable) occurs in an area, the density of species and life stage (some species are more vulnerable in certain life stages). The instruction also recommends restrictions to avoid conflicts with commercial interests, such as fish farms, fishery, whaling and safaris. The instruction is linked to the geographical information in SONATE and gives the user an overview of which precautions to take in certain areas and in certain time periods.

4.1 SONATE-WMS

SONATE-WMS is an internet based tool developed at FFI in collaboration between the Sonar and marine life (p1119) and the GEOMETOC project (p1215). It is based on the GEOMETOC-WMS developed by the same group. GEOMETOC-WMS is a tool used to test concepts of serving the Norwegian Defence with geographical information such as oceanographic data, meteorological data, ship traffic etc

The SONATE data used in SONATE-WMS is stored in a PostgreSQL/postgis database at FFI (see 3.1).

SONATE-WMS is found at https://geometoc.ffi.no/
For username and password, please contact:
Royal Norwegian Navy/KNMT/TAS/METOC, Point of contact: jojohnsen@mil.no
FFI/Maritime systems, Point of contact Nina.Nordlund@ffi.no

4.1.1 User interface description of SONATE-WMS

The SONATE-WMS window is a map with some additional tools and controls, see Figure 4.1. In the upper right corner, there are three tabs. Under Profile the user can select Norwegian or English profile (see Figure 4.2). In the Map Control, also in upper right corner, the user selects which layers to show on the maps (under "Add/remove overlays") and manipulates the sequence of drawing, and switches layers on and off (under "Active overlays") (See Figure 4.3).

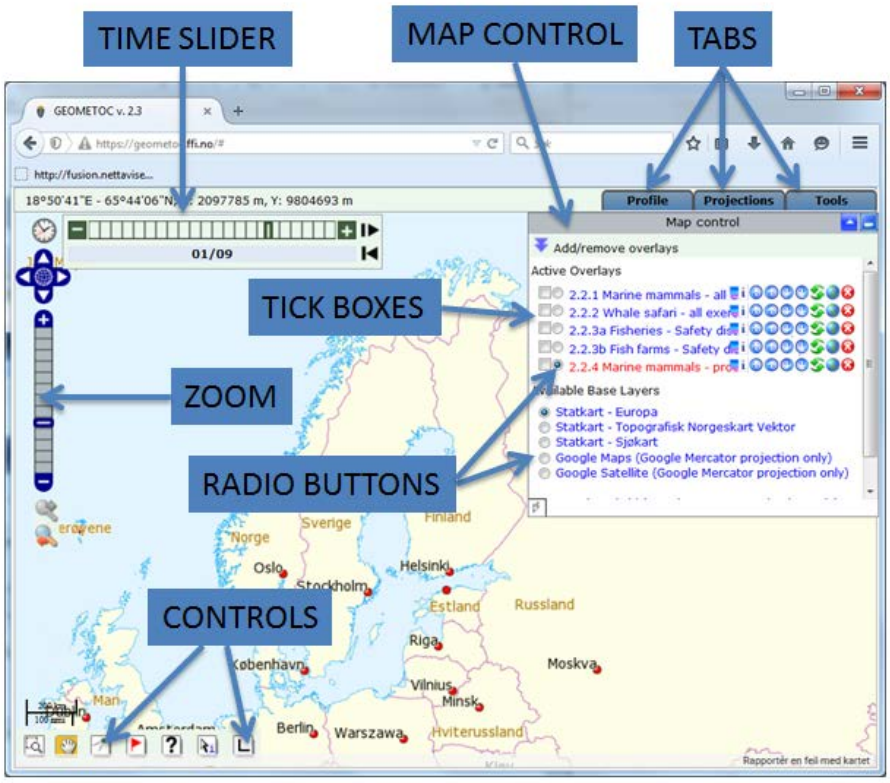

Figure 4.1 The start window of SONATE-WMS, with main features.

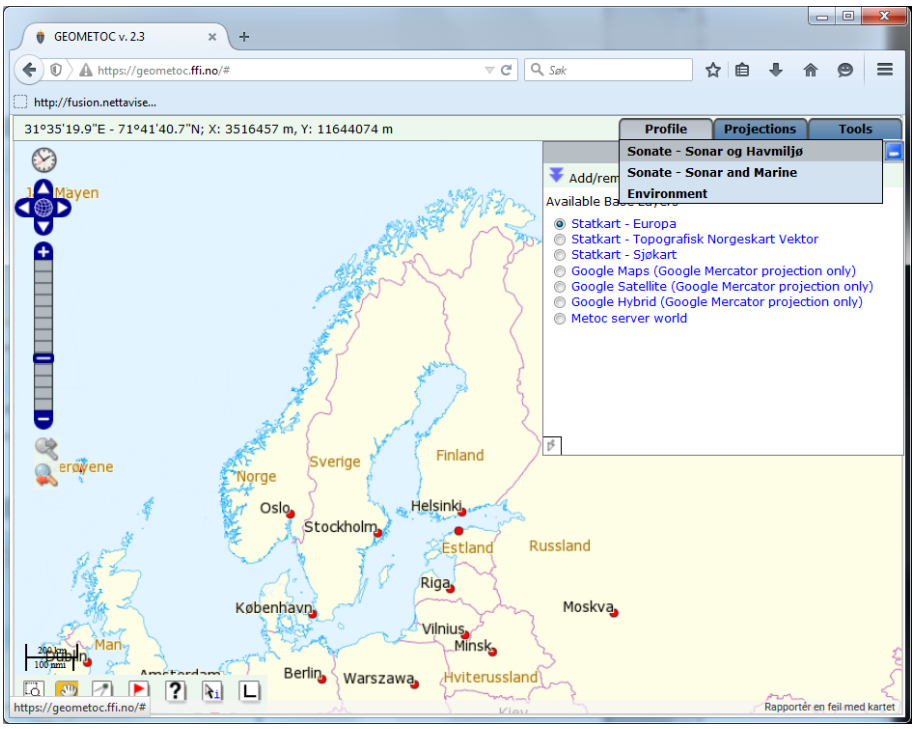

Figure 4.2 The start window of SONATE-WMS. The user can select Norwegian or English profile

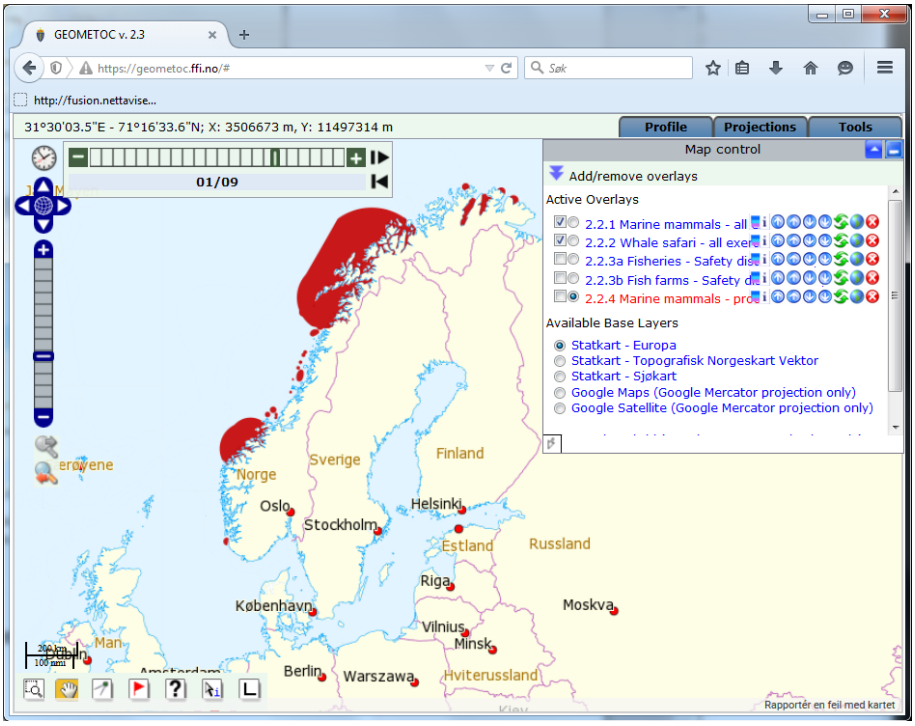

Figure 4.3 Under «Add/remove overlays» the user can select datasets to show on the map. Under «Available base layers» one finds a selection of background maps.

The menu of layers to choose between is build up like a tree structure, with the main headings Fish Farms, Fisheries, Species and Guidelines (see Figure 4.4). Layers are turned on and off with the tick boxes, and the last one turned on, will be be the top layer on the map.

In the lower left corner of the SONATE-WMS, there is a selection of control buttons (see Figure 4.5). The most relevant controls for SONATE-WMS are the zoom button and the i-button, the last one giving extra information on map features.

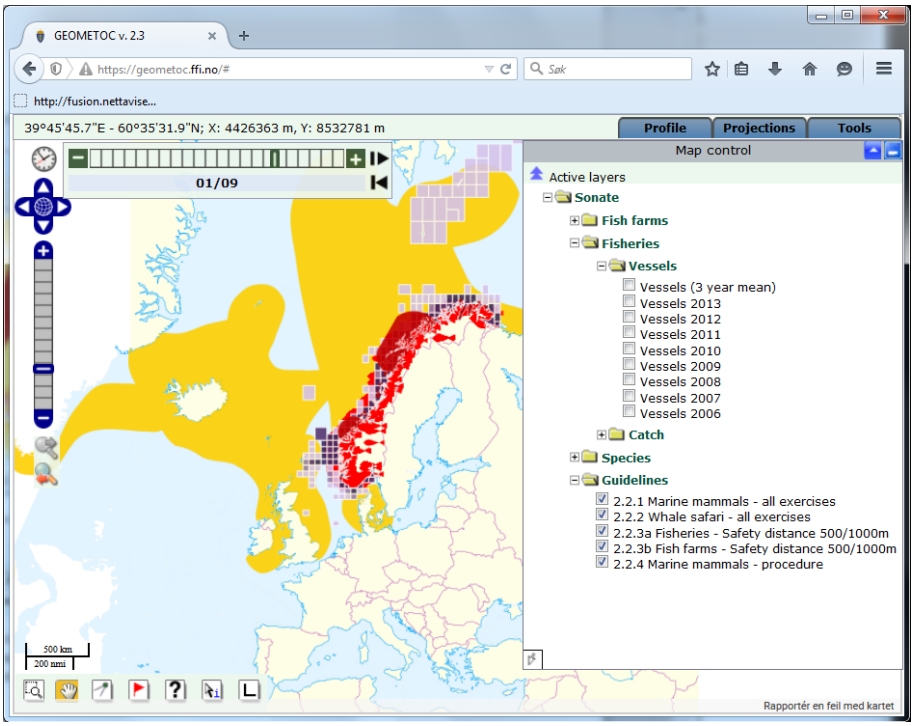

Figure 4.4 The menu of layers is built up as a tree structure.

Figure 4.5 Controls in bottom left corner. From left: zoom in, pan, put waypoints/markers on the map, click controls for help, information on map features ('i'-button), sound propagation model (Lybin).

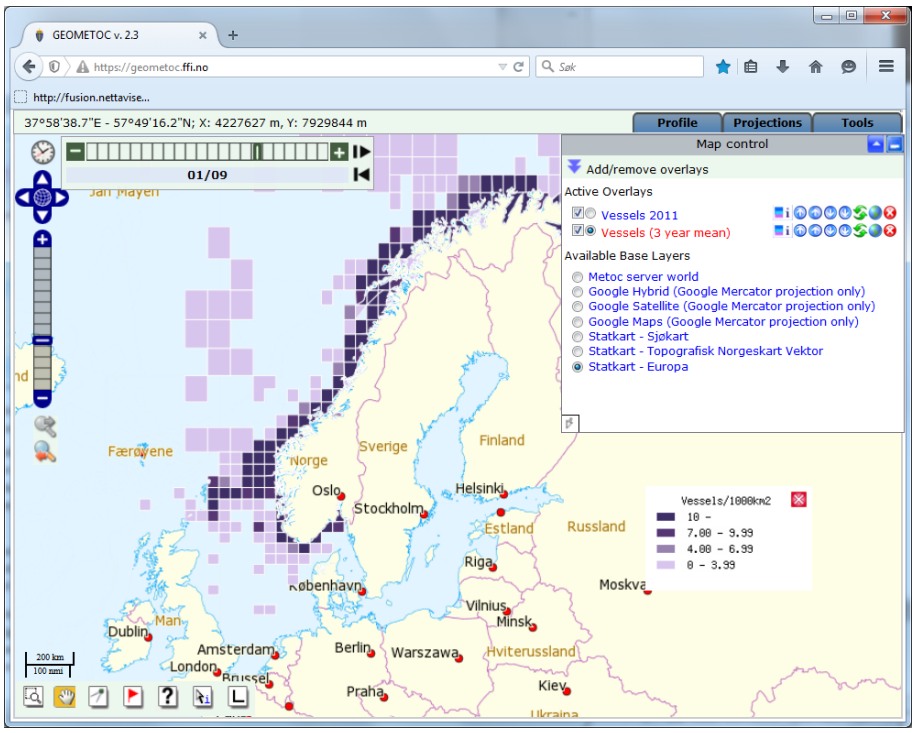

Figure 4.6 Example of fisheries information in SONATE-WMS. The radio button controls which layer to query - here, the Vessel -layer (3-year mean). A legend may be switched on with the "i"-button in MapControl window

Under the heading Fisheries one finds information on number of active fishing vessels and catch, both shown as the mean value for the 2011-2013 and as yearly values. Additional information can be found by using the i-button in the lower left of the SONATE-WMS window. One selects the layer to query with the radio button in the Map Control (See Figure 4.6 and Figure 4.1).

Information on fish farms concession is found under the heading fish farms, and detailed information (concession holder, position, capacity, fish species etc.) can be found by clicking on it in the map after having pressed the "i"-button (see Figure 4.7).

In the *Map Control* layers can be switched on and off, the sequence of drawing can be changed by using the arrows (see Figure 4.8), the button marked "i" will draw a legend on the map and green arrows will redraw layer. Holding the cursor above the symbols in the *Map Control* will give information on the buttons functionality.

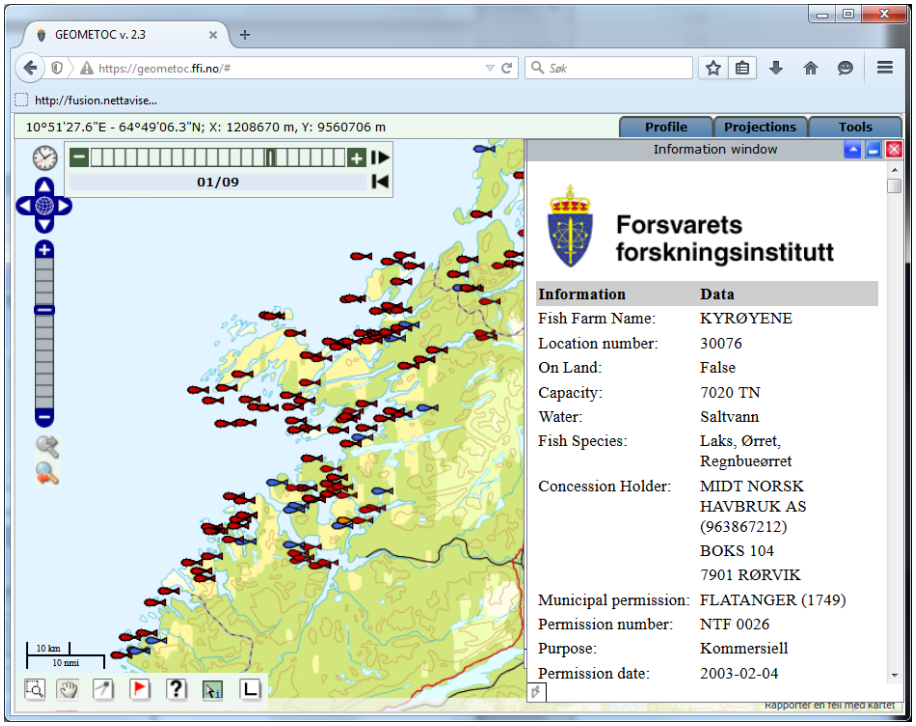

Figure 4.7 Example of fish farm information in SONATE-WMS

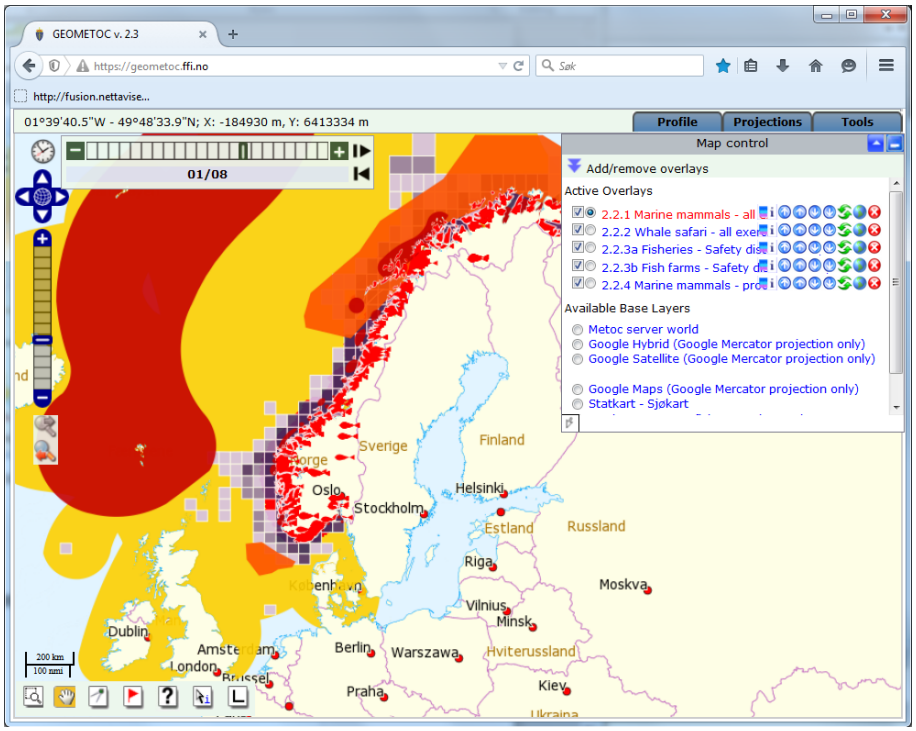

Figure 4.8 Figure shows example of SONATE with all guidelines switched on for May. A link to the "Instruction for use of active sonar in Norwegian water" can be found by clicking on an area with the "i"-button.

4.2 SONATE-ArcReader

The offline version of SONATE-ArcReader is a solution to make SONATE available on-board naval ships in periods with restricted internet access. SONATE-ArcReader is available from a DVD attached to this report. An installation instruction is also found on the DVD (see the file "SONATE in ArcReader Installation.txt").

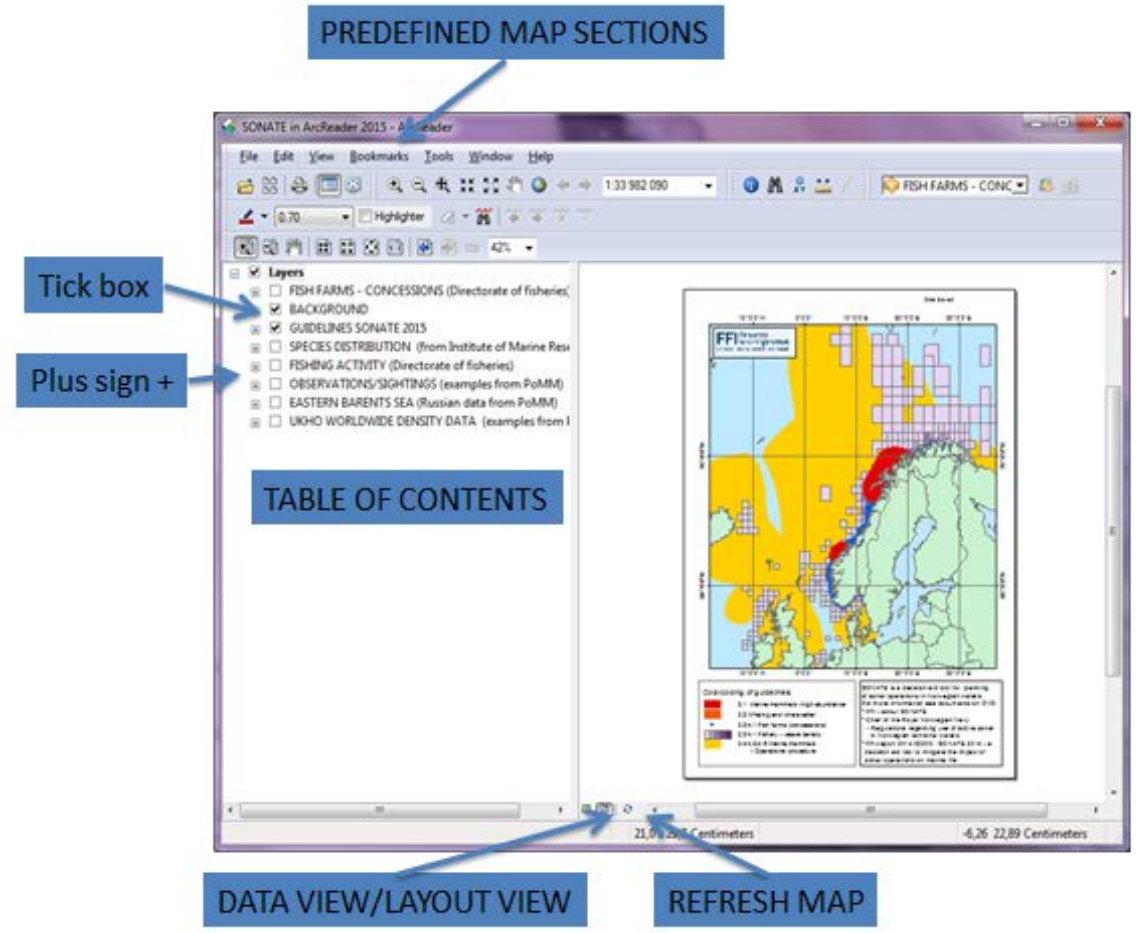

Figure 4.9 The main features of the ArcReader window. Table of contents to the left, map to the right. The map can be shown in two ways: data view and layout view. Layout view shows the map on a page, it includes a legend and some additional information and is suited for printing. In data view only the map is visible, and it is easier to zoom in and out and look at details in the map.

The offline version is equivalent to the WMS version, but will naturally not be updated at the same frequency. If available, the WMS solution should therefore be the preferred option. The content of SONATE-ArcReader is similar to SONATE-WMS, with some additions. SONATE-ArcReader also contains some data collected during the PoMM (Protection of Marine Mammals) project. PoMM was an EDA (European Defence Agency) project with the aim (among others) to establish a common database of marine mammal observations and density maps for use in sonar mitigation aid tools (Knoll et al. 2013).

PoMM data in SONATE-ArcReader contains a world wide dataset from the UK Hydrographic Office describing expected density of marine mammals, depending on physical conditions and knowledge of habitat use - a so-called habitat model. Another POMM dataset included in SONATE-ArcReader is a report containing distribution maps of marine mammals in the eastern Barents Sea (Shavykin and Ilyin 2010) which was digitized at FFI. A vast amount of observations/sightings were collected during PoMM, and maps of the most relevant species are included in SONATE-ArcReader. PoMM data are not linked to the sonar instruction, but are available as additional information for planning purposes.

Updating the off-line version of SONATE is not a very streamlined task. The distribution maps are kept in a folder structure of shape files. Data from the PoMM project has been exported from a local copy of the final database with sql statements. For the habitat model data, python scripts adapted to ArcGIS has been run to convert the exported data into shape files and to interpolate the data to grids for easy visualisation. These scripts can be made available by contacting FFI/Maritime systems (point of contact Nina.Nordlund@ffi.no).

4.2.1 User interface description

The ArcReader user window is divided in two main parts - table of contents to the left, a map to the right. On top and at the bottom of the window one finds several functions and tools.

Useful features to be aware of is:

- In the table of content
    - To turn on or off layers, use the tick boxes
    - Pressing down the ‘ctrl’ button and clicking a tick box will turn on or off all layers on that specific level
    - A ‘+’ indicates that more information is found below. Click the ‘+’ to expand the group layer
    - Layers are drawn from bottom of table of contents to the top. That means that the layers at the bottom of the list can be hidden by layers further up.
    - The data are organized in months. Layers are normally given names reflecting month number (Jan=01, Feb=02 etc.)
- The “i”-button gives additional information of the features in the map. One can choose to get information on all layers (a lot), visible layers or top layer.
- There are two different views of the map
    - Layout view shows a map page, with legend and additional information
    - Data view shows only the map itself
    - When in layout view there are two different zoom/pan tools available. One for the map itself, and one for the layout page

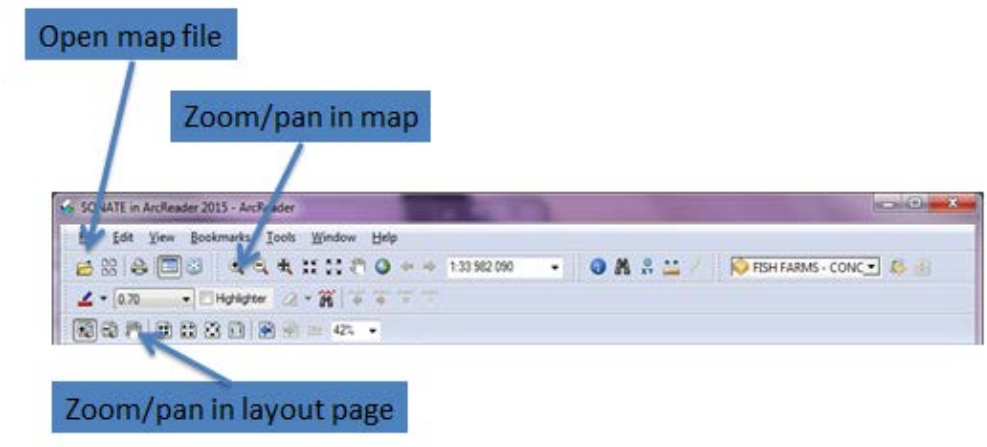

Figure 4.10 The main controls of the ArcReader window

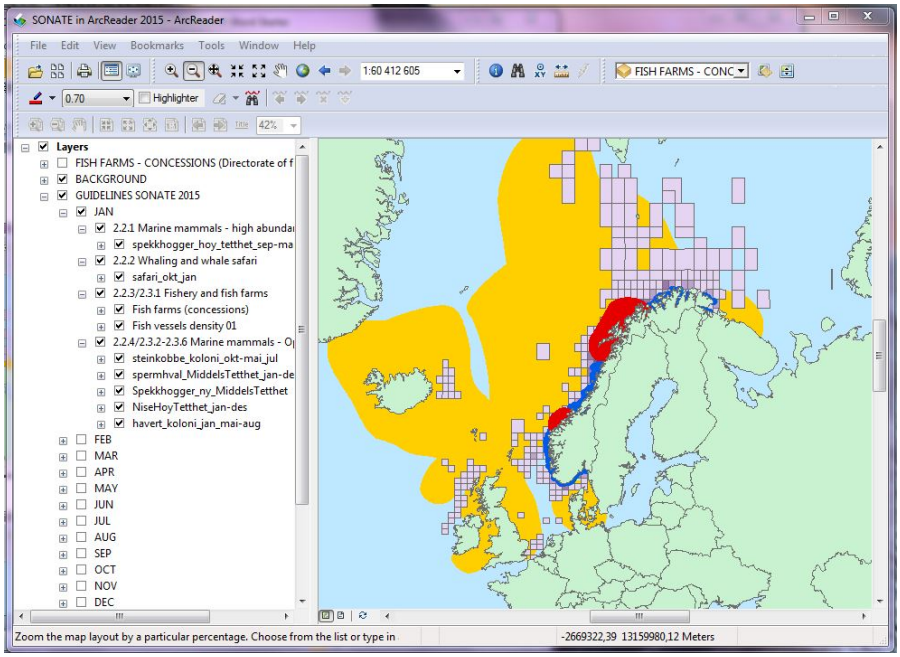

Figure 4.11 Areas covered by different regulations in January.

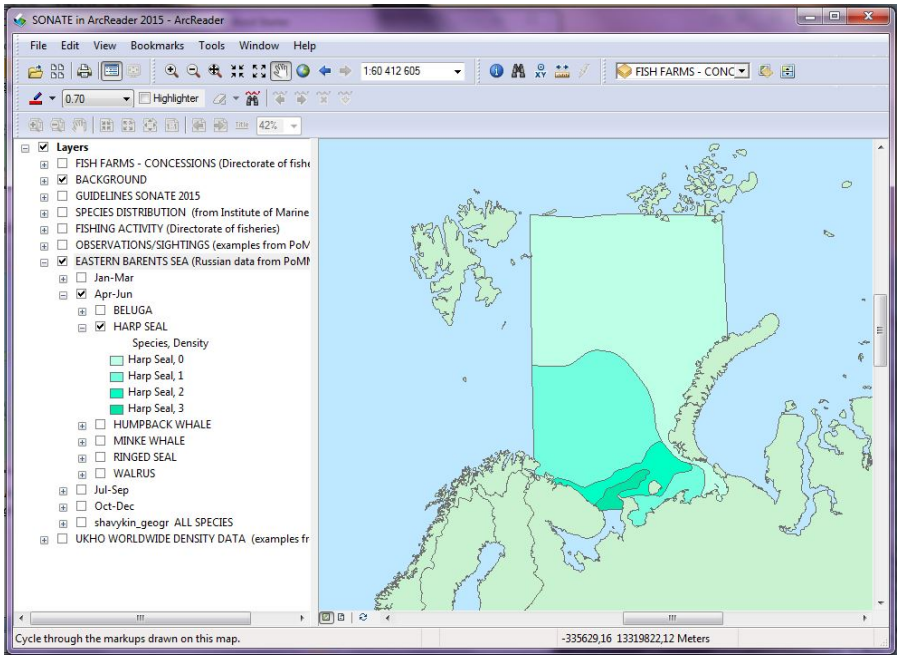

Figure 4.12 Example from the Eastern Barents Sea dataset from PoMM. The colours give an indication of relative density. Darker colour means higher density.

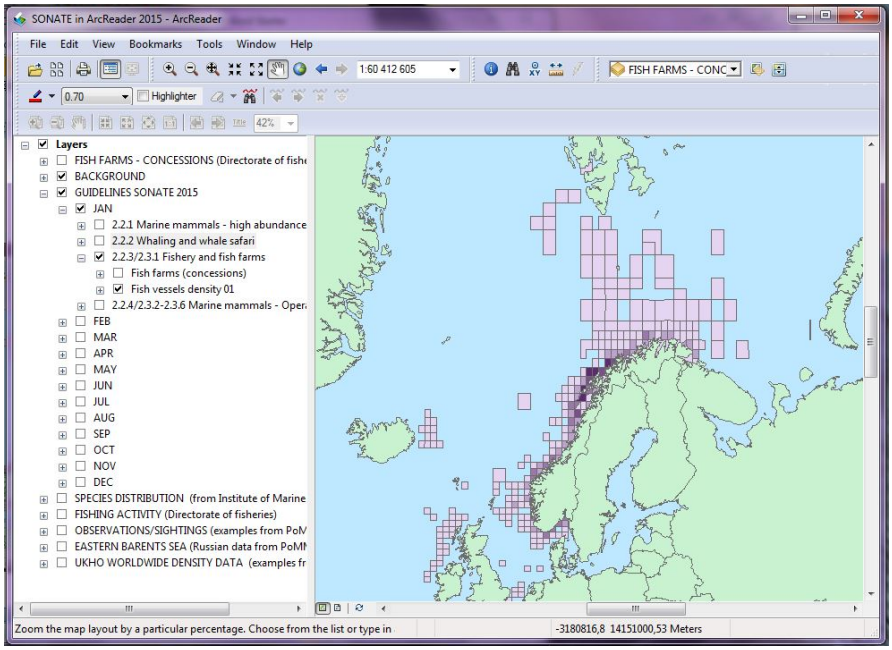

Figure 4.13 Example of fishing activity data.

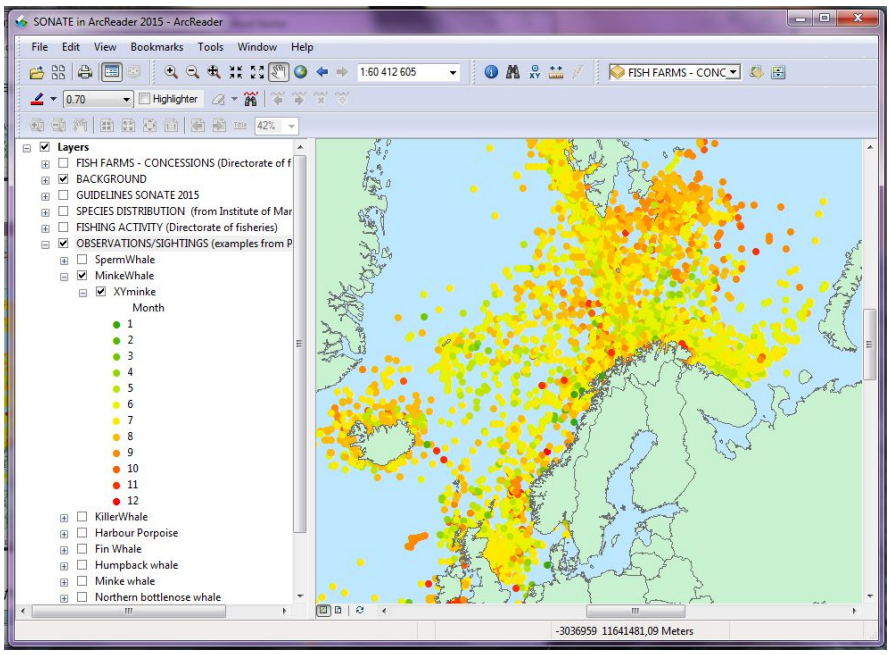

Figure 4.14 Example of observation/sightings data from the PoMM database.

5 Future plans

5.1 Possible technical solutions for SONATE in the future

The Royal Norwegian Navy has requested that SONATE is integrated in other applications or software, instead of being a stand-alone application. This is both to reduce management time with updating of software, and to be able to find as much as possible information available from the same source or application. Another request for SONATE has been easier update of both database and software.

Even if we have not completely reached these goals, SONATE-WMS has become part of another application (GEOMETOC-WMS) currently used by the Navy. Update of the database has become easier with the database structure designed under the NMDC pre-project.

The main components of the SONATE-WMS and SONATE-ArcReader are similar to earlier versions, and users will probably recognize the main features of the user interface and functionality. There will however, be a need for future updates of data on distribution of marine mammals, fisheries, safaris and whaling activity.

The current solution for SONATE-WMS is not a good permanent solution because SONATE is made available through a server used for research and prototyping, and not through a stable server being maintained by an operational organization. We have therefore evaluated possible solutions for the future. We have been looking at several ongoing projects in Norway, to see if any of them are suited to serve the Royal Norwegian Navy with SONATE information. Some of these projects are relevant and realistic possibilities, while some are less realistic. Below is a list of evaluated solutions and a few keywords that describe these.

5.1.1 Evaluated future SONATE solutions

SONATE standalone (programmed in python)

This will mean a continuation of the earlier SONATE 3.2 (2011) which was programmed in python. Further development of the existing python software will be needed, and a complete rewriting of the code. A new structure of the database serving the software with distribution maps and other data will probably be needed. This is partly because the maintenance of the data is complicated and partly because the database structure is not optimal for making the software efficient. As this is a standalone software is does not comply with the earlier request from the Royal Norwegian Navy, that applications which can be integrated with already existing systems are preferred.

SONATE-WMS (FFI GEOMETOC server)

This is the current solution for SONATE 2015. The long-term plan for SONATE was originally to develop and test SONATE-WMS on the FFI GEOMETOC server and then move it to the planned GEOMETOC-service of the Navy (see below). This solution would mean a simpler management of data in SONATE and also easier update of the data. We have also evaluated the possibility to keep SONATE-WMS on the FFI server, but as this is a test server, this will not be a good permanent solution. Transfer to the GEOMETOC-service has been delayed and implementation of SONATE more complicated than expected.

SONATE-ArcReader

SONATE-ArcReader is a standalone and offline solution, available for the user with free software (ArcReader). SONATE in ArcReader is the existing offline solution, distributed with this report. The distributor will have to manage user interface and map layers.

SONATE on GEOMETOC-service developed by the Norwegian Defence

The implementation of the GEOMETOC-service has been delayed and SONATE has never been part of the existing requirement specification. Nevertheless, we assume that this solution would meet many of the requirements from the Norwegian Defence for a new SONATE, as it will make update of software easier (part of a larger application), it will also be part of an application fitted for both offline and online use.

SONATE in NMDC

The Norwegian Marine Data Centre project plans an internet based application to get access to their collection of marine data, and FFI and IMR has agreed to a suitable database structure for the SONATE data. IMR plans to transfer their distribution database to this database structure within the NMDC project. This will eventually ease the data flow of distribution data from IMR to SONATE.

SONATE in IMRs WMS

IMR has a WMS portal with distribution maps, but not based on the database structure adapted to use in SONATE (time dependency is missing). SONATE would fit nicely with other data IMR is distributing. On the other hand this would be a system with no connection to other Defence systems.

SONATE in BarentsWatch (https://www.barentswatch.no/)

BarentsWatch is another WMS (internet) based map service. It is to be adapted to narrow bandwidth. IMR already delivers distribution data to BarentsWatch, but only without the time dependent information.

SONATE in HALO

HALO is a WMS service developed by met.no. It is not managed by the Defence is probably not a realistic option for SONATE because other types of data will be given higher priority:

SONATE in MARIA

MARIA is the standard software used by Norwegian Defence to display navigation maps. Thus, SONATE in MARIA is a realistic possibility, as this is a system widely used by the Defence. On the other hand, sharing of SONATE with foreign countries may be problematic or impossible. MARIA can be used offline. MARIA can also connect to WMS services.

Summary

We have not come to a conclusion about which solution is the most fitted to serve the Royal Norwegian Navy with SONATE in the future. As the project Sonars and Marine Life is terminated, no further development on SONATE will be done in the nearest future. If, at a later stage, the development is taken up again, the list above will be a starting point for where to look for good solutions. Which one is best fitted, will depend on the progress of the different solutions in the future, and new possibilities may and will probably appear.

5.2 SONATE for planning of seismic operations

When an oil company or seismic company today applies for permit to carry out a seismic survey, it is a circumstantial process that includes several authorities. Among these is Institute of Marine Research who evaluates the risk of impact on fish populations and Directorate of Fisheries who assess possible impact on fisheries. Some fish species may avoid areas of seismic activity (Dalen et al. 2008). In particular in spawning periods the fish is considered vulnerable, and the advice is to avoid all seismic survey activity in these periods and areas, and also to avoid areas of concentrated migration towards these areas.

IMR has been requesting a tool which give the adviser quick access to the necessary information. If such a tool existed, it would also create better transparency and predictability for the permit

applicant, and environmental issues could be taken better into consideration at an earlier stage. FFI and IMR have discussed the possibility of making a common planning tool for the Norwegian Defence (sonar) and the oil industry (seismic surveys). Criteria or guidelines for where and when to avoid seismic surveys could be integrated in the tool, similar to what is already the case in SONATE. The idea has been to make such a tool available for all stakeholders. So far this initiative has not been funded.

5.3 DETONATE

DETONATE is a planned module in SONATE for calculation of shock wave distribution and mapping of effect zones related to underwater detonations. These calculations will be based on an imperical-theoretical model developed by FFI some time ago (Kjellsby og Kvalsvik 1997). DETONATE will combine these calculations with geographical information of fish and marine mammals which is already found in SONATE and give information about the risk for negative effect on marine life. DETONATE should also define restrictions based on size of detonation, environmental information (water depth, bathymetry) and marine life in an area.

DETONATE is planned to be developed as part of the AMMRISK project (p1300) at FFI.

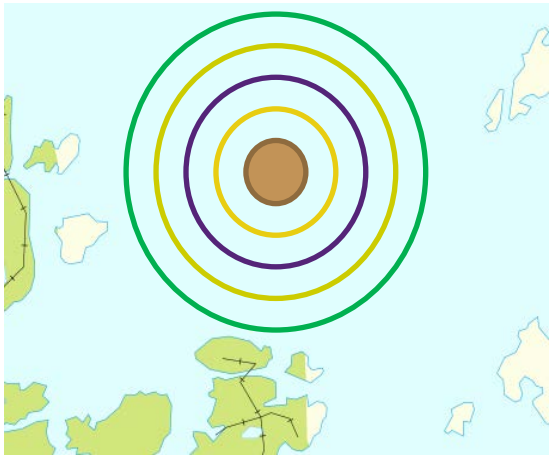

Figure 5.1 Illustration of DETONATE. Uniform topography and bathymetry environments will result in circular isobars for sound level and corresponding effects zones.

References

Antunes R., Kvadsheim P.H., Lam F.P.A., Tyack, P.L., Thomas, L., Wensveen P.J., Miller P. J. O. (2014). High response thresholds for avoidance of sonar by free-ranging long-finned pilot whales (Globicephala melas). Mar. Poll. Bull. (DOI: 10.1016/j.marpolbul.2014.03.056)

Kjelsby E., og Kvalsvik K. (1997). Begrensning av skalde på marin fauna ved undervannsspreningner. FFI rapport 97/04847

Dalen, J., Hovem, J.M., Karlsen, H.E., Kvadsheim, P.H., Løkkeberg, S., Mjelde, R, Pedersen, A., Skiftesvik, AB (2008). Kunnskapsstatus og forskningsbehov med hensyn til skremmeeffekter og skadevirkninger av seismiske lyd-bølger på fisk og sjøpattedyr. Rapport til OD, FD og SFT, 69 s.

Doksæter, L., O.R. Godø, N.O. Handegard, P.H. Kvadsheim, F.P. Lam and P.J.O. Miller (2009). Behavioural responses of herring exposed to low- (1-2 kHz) and mid- (6-7 kHz) frequency sonar signals and killer whale feeding sounds. J. Acoust Soc. Am: 125: 554-564

Doksæter,L., Handegard, NO., Godø, OR., Kvadsheim, PH. and Nordlund, N., (2012). Behavior of captive herring exposed to naval sonar transmissions (1.0–1.6 kHz) throughout a yearly cycle. J. Acoust. Soc. Am. 131: 1632-1642.

Fahlman A, Tyack PL, Miller PJ and Kvadsheim PH (2014). How man-made interference might cause gas bubble emboli in deep diving whales? Frontiers in Physiology 5, article 13.

Knoll et al. (2013). Protection of Marine Mammals (PoMM) Final Report, FWG-Report 64 WTC 71 -0087/2013 FR

Kuningas S, Kvadsheim PH, Lam FPA, Miller PJO (2013). Killer whale presence in relation to naval sonar activity and prey abundance in northern Norway. ICES J. Mar. Sci. (Sept 4. doi:10.1093/icesjms/fst127)

Kvadsheim, P.H., Miller, P.J.O., Tyack, P., Sivle, L.D., Lam, F.P.A., and Fahlman, A. (2012). Estimated tissue and blood N2 levels and risk of in vivo bubble formation in deep-, intermediate and shallow diving toothed whales during exposure to naval sonar. Frontiers in Phyisol. 3: article 125 (doi: 10.3389/fphys.2012.00125)

Kvadsheim, P.H., E.M. Sevaldsen, L.P. Folkow & A.S. Blix. (2010). Behavioural and Physiological Responses of Hooded Seals (Cystophora cristata) to 1 to 7 kHz Sonar Signals. Aquatic Mammals 36: 239-247.

Kvadsheim, P., Lam, FP., Miller, P., Wensveen, P., Visser, F., Sivle, LD., Kleivane, L., Curé, C., Ensor, P., van Ijsselmuide, S., and Dekeling, R. (2012). Behavioural responses of cetaceans to naval sonar signals in Norwegian waters – the 3S-2012 cruise report. FFI-rapport 2012/02058.

Kvadsheim, P., Lam, FP., Miller, P., Wensveen, P., Visser, F., Sivle, LD., Oudejans, M., Kleivane, L., Curé, C., Ensor, P., van Ijsselmuide, S., and Dekeling, R. (2014). Behavioural responses of cetaceans to naval sonar signals – the 3S-2013 cruise report. FFI-rapport 2014/00752. (http://rapporter.ffi.no/rapporter/2014/00752.pdf).

Kvadsheim, P., F. Benders, P. Miller, L. Doksæter, F. Knudsen, P. Tyack, N. Nordlund, F-P. Lam, F. Samarra, L. Kleivane, O.R. Godø. (2007). Herring (sild), killer whales (spekkhogger) and sonar – the 3S-2006 cruise report with preliminary results. FFI Rapport 2007/01189.

Kvadsheim, P.H., Lam, F.P. Miller P. Doksæter, L., Visser, F., Kleivane, L., van Ijsselmuide, S., Samarra, F., Wensveen, P., Curé, C., Hickmott, L., and Dekeling, R. (2011). Behavioural response studies of cetaceans to naval sonar signals in Norwegian waters - 3S-2011 cruise report. FFI rapport 2011/01289.

Kvadsheim, P.H. & E.M. Sevaldsen (2005). The potential impact of 1-8 kHz active sonar on stocks of juvenile fish during sonar exercises. FFI Rapport 2005/01027.

Kvadsheim, PH, Sevaldsen, E.M., Scheie, D., Folkow, L., Blix, AS. (2010). Effects of naval sonar on seals. FFI-rapport 2011/00685

Kvadsheim, P, FPA Lam, P Miller, AC Alves, R Antunes, A Brocconcelli, S van Ijsselmuide, L Kleivane, M Olivierse and F Visser (2009). Cetaceans and naval sonar – the 3S-2009 cruise report. FFI rapport 2009/01140

Miller, P.J.O., Antunes, R., Alves, A.C., Wensveen, P., Kvadsheim, P.H., Kleivane L., Nordlund, N., Lam, F.P., vanIjsselmuide, S., Visser, F., and Tyack, P. (2011). The 3S experiments: studying the behavioral effects of sonar on killer whales (Orcinus orca), sperm whales (Physeter macrocephalus), and long-finned pilot whales (Globicephala melas) in Norwegian waters. Scottich Ocean Inst. Tech. Rept. SOI-2011-001.

Miller, P.J.O., Kvadsheim, P.H., Lam, F.P.A.., Wensveen, P.J., Antunes, R., Alves, A.C., Visser, F., Kleivane, L., Tyack, P.L., Sivle, L.D. (2012). The severity of behavioral changes observed during experimental exposures of killer (Orcinus orca), long-finned pilot (Globicephala melas), and sperm whales (Physeter macrocephalus) to naval sonar. Aquatic Mammals 38: 362-401 (DOI 10.1578/AM.38.4.2012.362)

Miller, P.J.O., Antunes, R., Wensveen, P., Samarra, F.I.P., Alves, A.C., Tyack, P., Kvadsheim, P. H., Kleivane, L., Lam, F. P., Ainslie, M. and Thomas, L (2014). Dose-response relationships for the onset of avoidance of sonar by free-ranging killer whales. J. Acoust. Soc Am.135, 975-993.

Nordlund N.,Benders F. (2008). A decision aid tool to mitigate the impact of sonar operations in Norwegian waters on marine life. FFI-rapport 2008/01414 SONATE 3.0.

Nordlund N., Benders F., Kvadsheim P.H. (2011). SONATE 2011 – a decision aid tool to mitigate the impact of sonar operations on marine life. FFI-rapport 2011/00685.

Shavykin A.A., Ilyin G.V. (2010). AN ASSESSMENT OF THE INTEGRAL VULNERABILITY OF THE BARENTS SEA FROM OIL CONTAMINATION. Russian Academy of Sciences, Kola Science Center, Murmansk Marine Biological Institute, WWF Russia Barents Sea Regional Office

Sivle, L.D., Kvadsheim, P.H., Fahlman, A., Lam, F.P., Tyack, P., and Miller, P. (2012). Changes in dive behavior during sonar exposure in killer whales, pilot whales and sperm whales. Frontiers in Physiol.3: article 400 (doi: 10.3389/fphys.2012.00400).

Sivle, L.D., Kvadsheim, P.H. and Ainslie, M.A. (2014). Potential for population-level disturbance by active sonar in herring. ICES J. Mar. Sci. doi: 10.1093/icesjms/fsu154

Sivle, L.D., Kvadsheim, P.H., Ainslie, M.A., Solow, A., Handegard, N.O., Nordlund, N., Lam, F.P.A. (2012). Impact of naval sonar signals on herring (Clupea harengus) during summer feeding. ICES J. Mar. Sci. (doi:10.1093/icesjms/fss080)

von Benda-Beckmann, A.M., P.J. Wensveen, P.H. Kvadsheim, F.P.A. Lam, P.J.O. Miller, P.L. Tyack, M.A. Ainslie (2013). A theoretical assessment of ramp-up effectiveness at mitigating impact of sonar sounds on marine mammals. Cons. Biol. DOI: 10.1111/cobi.12162

Appendix A Instruction for use of sonar in Norwegian waters

Instruks for bruk av aktiv sonar i norske farvann

Fastsettes til bruk i Sjøforsvaret

Haakonsvern, 01.april 2015

Wedervang, Thomas T
Flaggkommandør
Sjef Sjøforsvarets skoler

KORTTITTEL:	Instruks for bruk av aktiv sonar i norske farvann
SIKKERHETSGRADERING:	UGRADERT
HJEMMEL:	Bestemmelse for delegering av fagansvar i Sjøforsvaret
GJELDER FOR:	Sjøforsvaret
UTGIVER:	Sjef Sjøforsvarets skoler
FAGMYNDIGHET:	Generalinspektøren for Sjøforsvaret
FAGANSVAR:	Sjef Sjøforsvarets skoler
IKRAFTTREDELSE:	2015-04-15
FORRIGE VERSJON:	Bestemmelse for bruk av aktiv sonar i norske farvann, 31.august 2011

Instruks for bruk av aktiv sonar i norske farvann

Innhold

1 Innledning

1.1 Formål

Denne instruksen har som formål å sikre at Sjøforsvarets bruk av aktive sonarer ikke fører til unødig negativ påvirkning på bestander av fisk, bestander eller enkeltindivider av sjøpattedyr og næringsvirksomhet knyttet til disse.

1.2 Virkeområde

Denne instruksen gjelder for alle norske militære enheter som anvender aktive sonarer som sender i frekvensområdet 500 Hz til 10 kHz med kildenivå over 160 dB.

Norske enheter som øver i fremmed nasjons farvann skal anvende angjeldende nasjons regelverk. Under øvelser underlagt for eksempel NATO eller FN, vil disse organisasjonenes regler være gjeldende. Dersom slikt regelverk ikke eksisterer, skal denne instruksen anvendes.

Utenlandske enheter som øver i norsk territorialfarvann skal anmodes om å følge denne instruksen.

Denne instruksen dekker ikke effekter som skyldes andre typer påvirkninger fra militær aktivitet. Hensynet til dykkere er heller ikke ivaretatt gjennom denne instruksen.

1.3 Definisjoner og forkortelser

ATAS	Aktiv tauet sonar (ATAS=Active Towed Array Sonar)
CW-signaler	Enkelttonesignal (CW=Continuous Wave).
Duty cycle	Se Transmisjonssyklus
Dykkersyke	Gass oppløst i kroppsvæske danner bobler i vev under trykkfall på grunn av overmetning. I blodbanen kan boblene danne blodpropper, noe som kan føre til skade på vevet.

Faresone	Området rundt en sonarkilde hvor sjøpattedyr kan skades direkte av transmisjoner.
FFI	Forsvarets forskningsinstitutt
FM-signaler	Frekvensmodulert signal (FM=Frequency Modulated).
FN	De Forente Nasjoner
Fiskeriaktivitet	Fiskeriaktivitet i SONATE er gitt både som antall båter som har levert fangst fra et område (antall/km2 per måned), og som total mengde fangst (kg/km2 per måned) fra et område. Områdene er definert av Fiskeridirektoratet.
GIS	Generalinspektøren for Sjøforsvaret
HMS	Skrogmontert sonar (HMS=Hull Mounted Sonar).
Intensive sonarøvelser.	Øvelser som innebærer at flere fartøyer bruker aktiv sonar eller at ett fartøy driver aktiv sonarutsending i et område definert av 140 dB lydtrykk-isobaren rundt sonarkilden i mer enn 12 timer.
Kildenivå	SL (source level): Lydtrykknivå som genereres av lydkilden der lydtrykket er målt i fjernfeltet og referert til 1 m fra kildens senter. Det gjennomsnittelige (rms) lydtrykket ved 1 m omregnes til lydtrykknivå i desibel (dB) i forhold til styrken av en plan lydbølge med referanselydtrykk 1µPa middelverdi (rms). Kildenivået i desibel er lik 20 log(p/p_0) hvor p er kildens lydtrykk ved 1 m og p_0 er referanselydtrykket. I teksten brukes bare antall dB uten referanseangivelse.
KNMT	Sjøforsvarets kompetansesenter (KNM Tordenskjold)
Lydtrykknivå	SPL (Sound Pressure Level): Logaritmisk måleenhet for gjennomsnittlig lydtrykk (rms) relativt til en referanseverdi (dB re 1µPa).
Lydeksponeringsnivå	SEL (Sound Exposure Level): Kvadratet av lydtrykket integrert over tid (ofte brukt som mål på akustisk dose) (dB re 1µPa^2·s).
NATO	North Atlantic Treaty Organization.
Nebbhval	Art av tannhval (Hyporoodon ampullatus) i norske farvann. Kalles bottlenose whale på engelsk, og betegnes av og til også som bottlenose på norsk. Nebbhvaler er også betegnelsen på en gruppe hvaler hvor Hyporoodon ampullatus inngår som en av 19 arter, men hvor bare Hyporoodon ampullatus opptrer regelmessig i norske farvann.
Norske farvann	Med norske farvann menes her norsk territorialfarvann inkludert Jan Mayen, norsk økonomisk sone, vernesonen rundt Svalbard og tilstøtende internasjonale farvann.
Ping	Utsending av en aktiv akustisk puls fra en sonar.
Ramp-Up	Innledende gradvis økning av kildenivå for å redusere risiko for å skade skjøpattedyr.
Rutinemessige sonarøvelser	Øvelser hvor bare ett fartøy driver sonarutsending i et område definert av 140 dB lydtrykk-isobaren rundt sonarkilden i under 12 timer.
Signalintervall	Tiden fra starten av utsendt signal til starten av neste signal.
Signalvarighet	Varigheten av utsendt signal (ping).
Sikkerhetsavstand	Et definert område rundt fiskefartøy, oppdrettsanlegg eller observerte sjøpattedyr hvor kildenivå til aktiv sonarutsending ikke skal overstige 200 dB.
Sildefisk	Gruppe av fisk (inkluderer sild og brisling i norske farvann).
Sjøpattedyr	Sel og hval.
Sonarøvelser	Bruk av aktiv sonar i fredstid (rutinemessige eller intensive sonarøvelser).
SONATE	Planleggings- og beslutningsstøtteverktøy for sonarøvelser i norske farvann (se kap. 2.1).

Transmisjonssyklus	Duty cycle. Prosentvis andel av tid med aktiv transmisjon. Sendes det for eksempel ut en puls på 1 sekund hvert 20 sekund er transmisjonssyklusen 5 %.
VDS	Variabel Dybde Sonar.

2 Hoveddel

2.1 Beslutningsstøtteverktøyet SONATE

SONATE er et planleggings- og beslutningsstøtteverktøy for sonarøvelser i norske farvann. Samtlige enheter som berøres av denne instruksen og alle som har ansvar for planlegging av øvelser som involverer bruk av sonarer, skal ha tilgang til dette verktøyet. Bruk av de operative anbefalingene som SONATE gir for bestemte områder i bestemte perioder, sikrer operasjon i tråd med gjeldende instruks. SONATE inneholder historiske data om utbredelse av arter og fiskeriaktivitet gjennom året. Disse kan endre seg fra år til år. Dersom den faktiske situasjonen avviker fra det som oppgis i SONATE, skal de restriksjonene som gjelder i dette området og denne perioden endres tilsvarende i henhold til regelverket (se punkt 2.2). Kystvaktsentralen har ofte oppdatert nåtidsinformasjon om fiskeriaktivitet i et område.

SONATE er utviklet av FFI, eies av GIS og forvaltes av KNMT/METOC (nornavtrainestmetoc@mil.no).

2.2 Føringer i forbindelse med planlegging av sonarøvelser

Det settes strengere krav til valg av område og periode for gjennomføring av intensive sonarøvelser enn for rutinemessige sonarøvelser. Definisjoner er gitt i kapittel 2 i dette dokumentet. Relevante områder og perioder hvor spesifikke restriksjoner og prosedyrer gjelder, er definert i SONATE.

Under planlegging og gjennomføring av sonarøvelser gjelder:

1. Unngå intensive sonarøvelser i områder/perioder som er ventet å ha høy tetthet av sjøpattedyr, og spesielt beiteområder for nebbhval og spermhval (notasjon A, kapittel 4)
2. Unngå intensive sonarøvelser i områder/perioder med hvalfangst og hvalsafari. Det pålegges styrker å varsle om planlagt sonaraktivitet i områder og perioder hvor det foregår slik fangst eller safari (notasjon B, kapittel 4).
3. For å redusere risikoen for negative effekter på fiskeriene, skal en sikkerhetsavstand til fiskefartøy og oppdrettsanlegg opprettes (se kapittel 2.3.1)
4. For å redusere risikoen for direkte skade på sjøpattedyr, skal operative prosedyrer for sonartransmisjon brukes i alle områder og perioder hvor sjøpattedyr er forventet å forekomme (se kapittel 2.3.2-2.3.6).

2.3 Operative prosedyrer

2.3.1 Sikkerhetsavstand til fiskefartøy og oppdrettsanlegg

En sikkerhetsavstand på 500 m til fiskefartøy i aktivt fiske og til oppdrettsanlegg med fisk skal overholdes for å unngå negative effekter. Dersom utsendt kildenivå overstiger 225 dB, eller transmisjonssyklusen (duty cycle) overstiger 10 %, eller farten på sonarplattformen er mindre enn 5 knop, skal sikkerhetsavstanden økes til 1000 m (notasjon C, kapittel 4).

2.3.2 Sikkerhetsavstand til sjøpattedyr

For å minimere risikoen for skader på sjøpattedyr, skal det etableres en sikkerhetsavstand på 500 m til observerte sjøpattedyr. Dersom utsendt kildenivå overstiger 225 dB, eller transmisjonssyklusen (duty cycle) overstiger 10 %, eller farten til sonarplattformene er mindre enn 5 knop, skal sikkerhetsavstanden økes til 1000 m. Under aktiv sonartransmisjon ved kildenivå (SL) over 200 dB, skal faresonen definert av sikkerhetsavstanden overvåkes visuelt og/eller ved bruk av tilgjengelige passive akustiske sensorer. Sjekk spesielt for tilstedeværelse av delfiner nær baugen. Dersom

sjøpattedyr opptrer innenfor faresonen, skal transmisjonen avsluttes eller kildenivå reduseres til 200 dB, inntil dyret er utenfor faresonen (notasjon D, kapittel 4).

2.3.3 Ramp-up prosedyre

En optimal ramp-up reduserer risikoen for skade på sjøpattedyr ved at de skremmes bort fra faresonen rundt sonarkilden før kildenivå når skadelige nivåer. I områder/perioder hvor sjøpattedyr forventes å forekomme, og utsendt kildenivå overstiger 200 dB, skal sonarutsendelsen initieres med følgende ramp-up prosedyre:

Reduser farten, fortrinnsvis til under 8 knop. Start transmisjon med redusert kildenivå (maksimum 180 dB) og øk gradvis kildenivået over en periode på minst 3 minutter. Bruk korte ping-intervall (mindre enn 10 s) og ping-varighet på 0,3 s – 1 s. Om transmisjonen avbrytes i mer enn 5 minutter, skal ramp-up prosedyren gjentas. Dersom siktforholdene ikke gjør visuell kontroll i faresonen mulig, er ramp-up prosedyren spesielt viktig (notasjon E, Kapittel 4).

2.3.4 Transmisjon i høy fart

Dersom fartøyets fart og transmisjonsintervallet tilsier at fartøyet beveger seg mer enn 200 m mellom to etterfølgende transmisjoner (ping), eller farten overstiger 15 knop, skal en være spesielt oppmerksom på sjøpattedyr i fartøyets fartsretning. Transmisjon i høy fart bør unngås dersom visuell kontroll av faresonen er vanskelig.

2.3.5 Transmisjon i trange farvann

Ved sonarbruk i trange farvann skal man være spesielt oppmerksom på sjøpattedyr i fartøyets fartsretning for å unngå å jage dem med sonaren. Sonarutsending i trange farvann skal i størst mulig grad unngås dersom visuell kontroll i fartsretningen er vanskelig. Kombinasjonen trange farvann og høy fart skal unngås dersom visuell kontroll i fartsretningen er vanskelig.

2.3.6 Bruk av helikopteroperert sonar og sonarbøyer

Dersom sjøpattedyr ikke er observert i området, er det ved bruk av helikopteroperert sonar (VDS) og sonarbøyer med kildenivå over 200 dB, tilstrekkelig at en 500 m sikkerhetssone rundt dropp-punktet er visuelt undersøkt før aktiv utsending starter. Dersom sjøpattedyr er observert i området, eller sikten ikke tillater visuell kontroll av sikkerhetssonen, skal sending starte med redusert nivå (under 200 dB), men kan økes til ønsket operativt nivå i løpet av 1 minutt.

3 Dokumentasjon

All bruk av aktive sonarer skal logges med starttid, stopptid, posisjon og anvendt sonarsystem (HMS, ATAS, VDS) slik at man i ettertid kan dokumentere at prosedyrene er fulgt. Dersom det er praktisk mulig skal også type utsending logges (CW/FM, frekvensbånd, pulsintervall, effekt og pulslengde). Observasjoner av sjøpattedyr og fiskeriaktivitet under sonarbruk skal også dokumenteres. Avvik fra denne instruks for bruk av sonarer skal begrunnes, dokumentasjon bør lagres i minst 1 år.

4 Notasjoner

A. Sonaraktivitet i et område kan resultere i unnvikelsesresponser hos sjøpattedyr, og de kan forlate øvelsesområdet. Dette kan resultere i tapte beitemuligheter, risiko for separasjon av mor og kalv, og økte energikostnader. Vågehval og nebbhval er identifisert som spesielt sårbare arter. Sjøpattedyr kan også endre dykkeatferd som en respons på sonaraktivitet. Dyptdykkende arter (nebbhval og spermhval) har en høyere risiko for å utvikle dykkersyke sammenlignet med gruntdykkende arter, og endringer i dykkemønsteret kan øke risikoen ytterligere. Risikoen for biologisk signifikante atferdsresponser øker med mottatt lydtrykknivå over 140 dB (SPL). Alvorlighetsgraden av atferdsresponser avhenger alltid av responsens varighet. Mange biologiske prosesser er døgnrytmiske, men responser kan vare

lenger enn eksponeringen for sonar. Eksponeringer med varighet som overstiger 12 timer medfører derfor høyere risiko enn eksponeringer med varighet under 12 timer. Derfor er kravene for valg av område og periode for en intens sonarøvelse strengere enn for en rutinemessig øvelse.

B. Sonaraktivitet i et område kan resultere i unnvikelsesresponser hos sjøpattedyr, og de kan komme til å forlate øvingsområdet. Terskelen for unnvikelse varierer mellom arter og hvilken biologisk kontekst dyrene befinner seg i (beiting, vandring, sosialisering osv). Vågehval og nebbhval er identifisert som særlig sårbare arter, med responsterskler for unnvikelse på under 140 dB (SPL). Kommersiell aktivitet relatert til sjøpattedyr (hvalfangst eller hvalsafari), kan derfor bli påvirket av sonaraktivitet i det samme området.

C. Forskning har vist at militære sonarer har liten eller ingen innvirkning på fiskepopulasjoner. Likevel er det fortsatt usikkert om noen fiskearter kan reagere kortvarig dersom de befinner seg i umiddelbar nærhet av sonaren. Slike korte responser vil ikke påvirke overlevelsesraten hos fisk, men kan påvirke fiskeri og fangstrater. For å unngå negative effekter på fiskerier, er det derfor etablert sikkerhetsavstander. Transmisjon utenfor sikkerhetsavstanden vil ikke utløse fluktresponser. Sikkerhetsavstandene vil variere med sonarens kildenivå, transmisjonssyklus og kildens fart. Fisk i oppdrettsanlegg kan bli stresset av en sonar som passerer nærmere enn sikkerhetsavstanden, men varigheten av slike stressresponser vil være veldig korte og er primært trigget av det passerende skipet og ikke sonaren.

D. Risikoen for direkte skade som redusert hørsel hos sjøpattedyr avhenger av lydeksponeringsnivå (akkumulert akustisk energi, SEL), mer enn maks mottatt lydtrykknivå (SPL). Risikoen for skade varierer mellom artene men øker generelt ved lydeksponeringsnivå (SEL) over 180 dB. Avstanden fra sonarkilden som trengs for å holde nivåene under dette avhenger av kildenivå, transmisjonssyklus samt dyrets og sonarkildens hastighet. Ved kildenivå under 200 dB, er risikoen for direkte skade neglisjerbar.

E. Det er dokumentert at ramp-up reduserer risikoen for skade signifikant i de fleste scenarioer. Risikoen og effekten av ramp-up vil variere avhengig av responsterskelen hos dyrene i området, sonarkildens hastighet, dyrets svømmehastighet, sonarens kildenivå, ping-intervall og varigheten på ramp-up. Varighet på mer enn 5 minutter synes derimot ikke å redusere risikoen ytterligere. En optimal ramp-up prosedyre for de mest vanlige operative scenarioer er definert i kapittel 2.3.3.

5 Ikrafttredelse

Instruks for bruk av aktiv sonar i norske farvann trer i kraft 2015-04-15. Samtidig settes Bestemmelse for bruk av aktiv sonar i norske farvann av 2011-08-31 ut av kraft.

This is an English translation of the original document in Norwegian "Instruks for bruk av sonar i norske farvann" issued by Commodore Thomas T Wedervang on April 15th 2015 on behalf of Chief of the Norwegian Navy (GIS).

Instruction for use of active sonar in Norwegian waters

(April 15th 2015)

1. Introduction

1.1. Objectives

These guidelines are intended to minimize negative effects of active naval sonars on the marine environment. The objectives are to avoid significant negative effects on populations of fish, individual marine mammals and on commercial activity related to fish and marine mammals. The guidelines do not cover effects of other types of military activity other than use of active sonar. Protection of divers is NOT covered by these guidelines.

1.2. Application

These guidelines apply to all Norwegian military units which employ active sonar transmitting in the frequency range from 500 Hz to 10 kHz at source levels (SL) above 160 dB.
Norwegian units operating outside Norwegian waters will comply with the prevailing guidelines of the host nation. International operations under the leadership of NATO or UN will be run according to these organizations' guidelines. If such guidelines do not exist, the Norwegian guidelines will apply. Foreign units operating in Norwegian territorial waters should be requested to comply with the Norwegian Guidelines.

1.3. Definitions and abbreviations

ATAS	Active Towed Array Sonar
Beaked whales	Family of toothed whales (Lat: *Ziphiidae).* Only the Bottlenose whale (Lat; *Hyperoodon ampullatus*) appears in Norwegian waters.
Cetaceans	Whales, dolphins and porpoises.
CW-signals	Continuous Wave (constant frequency) signal.
Danger zone	Area around a sonar source where marine mammals risk being injured by transmissions.
DCS	DeCompression Sickness. Dissolved gas coming out of solution and forming bubbles in tissue during a reduction in pressure. In the blood, the bubbles may embolize blood vessels, leading to severe ischemic damage.
Duty cycle	The percentage of the time signals are transmitted.
FFI	Norwegian Defence Research Establishment (Forsvarets Forskningsinstitutt)
FM-signals	Frequency Modulated signal (frequency sweep).
Fishing activity	Fishing activity in SONATE given as the number of boats which have delivered catch from an area or as the total amount of catch (in kg/km^2/month) from an area.
GIS	Generalinspektøren i Sjøforsvaret (Chief of the Norwegian Navy)
Herrings	Herring (no; *sild*) and brisling (sprat) (no; *brisling*) (in Norwegian waters).
HMS	Hull Mounted Sonar
Intensive sonar exercises.	Exercises involving sonar transmission from more than one platform or that one vessel are actively transmitting sonar signals for more than 12 hrs within an affected area defined by the 140 dB sound pressure level (SPL) isobar from the source.
KNMT	Norwegian Naval Training Establishment
Marine mammals	Pinnipeds and cetaceans (seals, whales, dolphins and porpoises).

NATO	North Atlantic Treaty Organization.
Norwegian waters	Norwegian territorial water including Jan Mayen, Norwegian economic zone, plus the protection zone of Svalbard and adjoining international waters.
Ping	Transmitted signal pulse from active sonar.
Ramp Up	Initial gradual increase of transmitted source level in order to mitigate risk to marine life.
Routine sonar exercises.	Exercises involving sonar transmissions from only one platform for less than 12 hrs within an affected area defined by the 140 dB sound pressure level (SPL) isobar from the source.
Signal duration	Duration of transmitted signal (ping).
Signal interval	The time period between the start of subsequent pings.
Sonar exercises	Peacetime active sonar transmission (Routine sonar exercises and Intensive sonar exercises).
SONATE	A decision aid tool for planning and execution of sonar exercises in Norwegian waters (see section 2.1.)
SL	Source level; sound pressure in dB generated by an acoustic source, measured in the far field but referred to 1 m distance from the centre of the source. The mean sound pressure (rms) at 1 m distance is converted to dB-values relative to a plane wave with sound pressure of 1μPa rms. The source level in dB is calculated as 20 $\log(p/p_0)$ where p is the source pressure and p_0 the reference pressure.
SPL	Sound Pressure Level. Logarithmic measure of the effective root mean square sound pressure of a sound relative to a reference value (dB re 1μPa).
SEL	Sound Exposure Level. Sound pressure squared and integrated over time (commonly used as a measure of acoustic dose) (dB re 1$\mu Pa^2 \cdot s$).
UN	United Nations
VDS	Variable Depth Sonar

2. Main section

2.1. SONATE decision aid tool

SONATE is a decision aid tool for planning of sonar exercises in Norwegian waters. All units affected by these guidelines (section 1.2. *Application*) and all staff involved in planning of exercises which involves use of sonars, shall have access to SONATE. Relevant areas and periods where specific restrictions and procedures apply are defined in SONATE. Operations within the recommendations given by SONATE for different areas and time periods ensure that the operations will be executed in compliance with the guidelines defined here. SONATE contains data on the distribution of marine species and fishing activity at different times of the year. This might change from one year to the next. If the actual conditions in an area differs from the predictions shown in SONATE, the prevailing guidelines must be altered correspondingly according to section 2.2. The Norwegian Coast Guard often possesses up-dated information of fishing activity in an area.

SONATE is developed by FFI, owned by GIS and managed by KNMT/METOC (nornavtrainestmetoc@mil.no).

2.2. Guidelines for planning of sonar operations

The requirements for selection of an area and a period for execution of intense sonar exercises are stricter than for routine sonar exercises. Necessary definitions are given in section 2 of this document. Relevant areas and periods where specific restrictions and procedures apply are defined in SONATE.

During planning and execution of sonar exercises the following applies:

1. Avoid intensive sonar exercises in areas/periods expected to have a high abundance of marine mammals, and in particular feeding areas of beaked whales and sperm whales (annotation *a*, section 4)

2. Avoid intensive sonar exercises in areas/periods with whaling and whale safari activity. Forces are instructed to notify stakeholders, when planning to operate in areas/periods with whaling and whale safari (annotation *b*, section 4)

3. To reduce the risk of negatively affecting fishery, a safety distance from fishing vessels and fish farms should be maintained (see section 2.3.1).

4. To reduce the risk of inflicting direct injury to marine mammals, procedures for sonar transmission should be used in all areas/periods where marine mammals are expected to be encountered (see section 2.3.2-2.3.6).

2.3. Operational procedures

2.3.1. Safety distance from fishing vessels and fish farms

A safety distance of 500 m from fishing vessels actively engaged in fishing and from aquaculture installations containing fish should be maintained to avoid negative effects. If the transmitted source level exceeds 225 dB, or duty cycle exceeds 10%, or the speed of the sonar platform is less than 5 knots, the safe distance should be increased to 1000 m (annotation *c*, section 4).

2.3.*2. Safety distance from marine mammals*

To minimize risk of injury to marine mammals, a safety distance of 500 m should be established in areas/periods were marine mammals are expected to be encountered. If transmitted source level exceeds 225 dB, or duty cycle exceeds 10%, or the speed of the sonar platform is less than 5 knots, the safety distance should be increased to 1000 m. During active sonar transmission at source levels (SL) above 200dB, the danger zone defined by the safety distance should be monitored visually and/or using available passive acoustic sensors. Check in particular for presence of bow riding dolphins. If marine mammals appear within the danger zone, transmissions shall be ceased, or source level reduced to 200 dB, until the animal is outside of the danger zone (annotation d, section 4).

2.3.3. Ramp-Up procedure

An optimal ramp up reduces risk to marine mammals by allowing animals to evacuate the danger zone around the sonar source before it reaches dangerous levels. In areas/periods where marine

mammals are expected to be encountered and transmitted source level exceeds 200 dB, sonar transmissions should be initialized by the following ramp-up procedure:
Reduce speed, preferably to less than 8 knots. Start transmissions at reduced source level (maximum 180 dB) and gradually increase the source level over a period of at least 3 min. Use short inter-ping intervals (less than 10 s) and ping durations of 0.3 sec to 1 sec. If transmissions are interrupted for more than 5 min, the Ramp-Up procedure shall be repeated. If visual conditions do not allow for visual control of the danger zone, the Ramp-Up procedure should always be used (annotation e, section 4).

2.3.4. Transmissions at high speed
If the vessel speed and the transmission interval imply that the vessel covers more than 200 m between two successive transmissions (pings), or the speed exceeds 15 knots, one must at all times have a strong focus on presence of marine mammals in the travelling direction of the vessel. Transmissions at high speed should be avoided if visual control of the danger zone is difficult.

2.3.5. Transmissions in narrow or constricted waters
During transmissions in narrow or constricted waters one must have a strong focus on the presence of marine mammals in the travelling direction of the vessel to avoid chasing them with the sonar. Transmissions in such waters should be avoided if visual control of the danger zone is difficult. The combination of high speed and narrow or constricted waters must be avoided if visual control is difficult.

2.3.6. Use of helicopter operated sonar and sonobuoys
If marine mammals are not observed in the area of operation, it is sufficient that a 500 m danger zone surrounding the drop point of a helicopter operated VDS or sonobuoy is visually examined for presence of marine mammals before transmitting at levels exceeding 200 dB. If marine mammals are observed in the area, or visibility conditions do not allow for visual examination of the danger zone, transmission should start at a source level of less than 200 dB. The transmitted level may then be increased to desired level within 1 minute.

3. Documentation

All use of active sonars should be logged with start-up time, position and applied sonar system (HMS, ATAS, VDS) to document compliance with the guidelines. If practical, type of transmission (CW/FM, frequency band, pulse interval, transmitted power and pulse length) should also be logged. Observations of marine mammals and fishing activity in areas of active transmission should also be documented. Any infringement against these guidelines must also be documented with the cause of the infringement. Documentation should be archived for at least 1 year.

4. Annotations

a) Sonar activity in an area can result in avoidance responses in marine mammals, and they might leave the exercise area. This can result in lost feeding opportunities risk of mother calf separation and increased energetic cost. Minke whales and bottlenose whales are identified as particularly sensitive species. Marine mammals might also change their dive pattern in response to sonar activity. Deep diving cetaceans (beaked whales and sperm whales) have a higher risk of developing decompression sickness (DCS) compared to shallow diving cetaceans, and changes in their dive pattern might increase this risk further. The risk of biological significant behavioural responses increases at received levels above 140 dB (SPL). The severity of behavioural responses always depends on the duration of the response. Many biological processes are diurnal, but responses might endure beyond the duration of the exposure. Exposures of durations exceeding 12 hrs are therefore associated with more risk than exposures shorter than 12 hrs. Therefore the requirements for selection of an area and a period for execution of intense sonar exercises are stricter than for routine sonar exercises.

b) Sonar activity in an area can result in avoidance responses in marine mammals, and they might leave the exercise area. Threshold of avoidance varies between species and the context the animal is in. Minke whales and bottlenose whales are identified as particularly sensitive species, with response thresholds of avoidance below 140 dB (SPL). Commercial activity related to marine mammals (whaling or whale watching), might therefore be affected by sonar activity in the same area.

c) Research has shown that naval sonar has little or no impact on fish populations. However, in the area closest to a sonar source, it is still uncertain if some fish species might respond to sonar transmissions. Such short responses are unlikely to affect the vital rates of the fish, but might affect fishery catch rates. Safety distances known to not trigger any escape responses in fish are established to avoid negative impact on fishery. Such safety distances will vary with the transmitted source level, duty cycle and speed of the source. Fish in fish farms might be stressed by a sonar source passing closer than the safety distance, but the duration of this stress response will be very short, and is primarily triggered by the ship not the sonar.

d) Risk of direct injury to marine mammals, primarily hearing impairment, is determined by the accumulated acoustic energy rather the peak pressure levels. Risk of injury varies between species but is generally increasing at sound exposure levels (SEL) above 180 dB. The distance from sonar source to animal required to stay below this level depend on the transmitted source level, duty cycle and speed of the sonar and animal. At source levels below 200 dB, the risk of direct injury is neglectable.

e) Ramp-Up has been shown to reduce risk of injury to marine mammals significantly in most scenarios. The risk and effect of ramp-up will vary depending on the responsiveness of the animals in the area, speed of the source, swim speed of the animal, sonar source level, ping interval and the duration of the ramp up (although durations of more than 5 min does not seem to reduce risk further). An optimal ramp up for the most common operational scenarios is defined in section 2.3.3.

5. Implementation

This *Instruction for use of active sonar in Norwegian waters* will enter into force April 15th 2015. At the same time *Regulations regarding use of active sonar in Norwegian territorial waters* of August 31st 2011 will enter out of force.

Appendix B Acronyms

ArcGIS - GIS software from ESRI

ArcPublisher – Software from ESRI. Part of ArcGIS. For making “published maps” to read in free software (ArcREader)

ArcReader – free software from ESRI. To read “published maps” from ArcGIS/ArcPublisher.

EDA – European Defence Agency

ESRI – software publisher. www.esri.com

FFI – Forsvarets Forskningsinstitutt/ Norwegian Defence Research Establishement

GEOMETOC-service /GEOMETOC kjernetjenester – planned internetbased map service for publishing maps and other geographical information to the Norwegian Defence.

GIS – Geographical Information System, usually software to assemble geographical information to maps (topographic, thematic maps etc)

GIS – Chief of the Norwegian Navy

IMR – Institute of Marine Research, Bergen, Norway www.imr.no

NMDC – Norwegian Marine Data Centre. Project with the aim to make available marine data from Norwegian research institutions

PoMM – Protection of Marine Mammals –project under EDA. Participants: Germany, Italy, Netherlands, Norway, Sweden, UK

RNN – Royal Norwgian Navy

UKHO – UK Hydrographic Office

WMS – Web Map Server. A standard protocol for serving georeferenced map images over the Internet.