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SONATE 2020

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

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Summary

SONATE is a decision aid tool for planning of sonar exercises, to mitigate impact on marine life. The story of SONATE started with the Nansen-class frigates of the Norwegian Navy, which are equipped with 1-8 kHz sonars. Such sonars are potentially harmful to marine life. To mitigate this potential problem, FFI developed SONATE for the Royal Norwegian Navy.

SONATE combines geographical information of marine life with “Procedure for use of active sonar in Norwegian waters” issued by the Royal Norwegian Navy based on recommendations from FFI. The procedure contains guidelines for planning and execution of sonar exercises.

The first version of SONATE was published in 2006. Several versions built on different platforms were published the following years. These are described in detail in earlier FFI reports, the latest being published in 2015.

In 2015, SONATE was the final delivery of the FFI project “Sonar and Marine Environment”, and at that point, no further development or updates were planned.

In 2019, the Norwegian Navy requested an update of SONATE with databases and sonar instructions. This report describes the 2020 update, which is based on the 2015 SONATE ArcReader version. The database in SONATE has been updated with new information from the Institute of Marine Research about species distribution and abundance, and updated information on fishery activity and aquaculture from the Directorate of Fisheries. The functionality of SONATE has been modified according to the users’ request, and we have recommended new sonar guidelines as a basis for the new naval sonar procedures. This report summarizes the functionality of SONATE 2020 and the scientific basis for the new sonar procedures.

Sammendrag

SONATE er et beslutningsstøtteverktøy for planlegging av sonarøvelser, med fokus på marint liv. Historien om SONATE startet med innfasingen av Sjøforsvarets Nansen-klasse fregatter, som er utstyrt med 1-8 kHz sonarer. Slike sonarer er potensielt skadelige for marint liv, og for å minimere denne risikoen utviklet Forsvarets forskningsinstitutt (FFI) SONATE for Sjøforsvaret.

SONATE kombinerer geografisk informasjon om marint liv med Sjøforsvarets prosedyre for bruk av aktiv sonar i norske farvann, som er utstedt av Marinen og basert på faglige anbefalinger fra FFI. Prosedyren beskriver retningslinjer for planlegging og gjennomføring av sonarøvelser.

Den første versjonen av SONATE kom i 2006, og flere versjoner, bygget på ulike plattformer, kom de følgende årene. Disse versjonene er beskrevet i detalj i tidligere FFI-rapporter, den siste kom i 2015.

I 2015 var SONATE del av sluttleveransen fra FFI-prosjektet Sonar og havmiljø, og ytterligere utvikling eller oppdatering av SONATE var ikke planlagt.

I 2019 ba Marinen FFI om å oppdatere SONATE med de tilhørende databasene og sonarinstruks. Denne rapporten beskriver 2020-oppdateringen, som er bygget på SONATE ArcReader-versjonen fra 2015. SONATE-databasen er oppdatert med nye data fra Havforskningsinstituttet på utbredelse av marine arter samt nye data fra Fiskeridirektoratet på fiskeriaktivitet og oppdrettsanlegg. Funksjonaliteten i SONATE er forbedret i tråd med ønsker fra brukere i Sjøforsvaret, og vi har anbefalt nye sonarretningslinjer som grunnlag for en oppdatert versjon av Sjøforsvarets prosedyre for bruk av sonar. Denne rapporten oppsummerer funksjonaliteten i SONATE 2020 og det vitenskapelige grunnlaget for den nye sonarprosedyren.

Contents

Preface

This report is a user manual to SONATE, first meant for users in the Royal Norwegian Navy, but also users of other nationalities. It describes the databases behind the tool, and it gives a brief history of the SONATE tool. It also describes the scientific basis for FFI's recommendations on mitigation measures during planning and execution of sonar operations. This recommendation is the basis for the Sonar-procedure used by the Norwegian Navy.

In 2015, SONATE was part of the final delivery from the FFI project Sonar and Marine Life, and no further development or updates of SONATE were planned.

In 2019 the Royal Norwegian Navy, asked FFI to make a new update of SONATE and the databases. This report describes the 2020 update, which is based on the ArcReader version from 2015.

During the update process in 2020, the navy have given valuable input and comments to the tool. As the Arc Reader technology has some technical limitations, some requests could not be fulfilled. We are nevertheless thankful for all discussions during the process.

We would like to thank Jørgen Svendsen at the Norwegian Directorate of Fisheries for all help with fishing activity data, and all effort in explaining the details of this dataset.

We also would like to thank Alexander Christian Beck at IMR for support with python scripting and downloading of distribution maps from the IMR server.

Horten, 13.12.2020

Nina Nordlund

1 Introduction

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.

Anthropogenic noise, as naval sonar, seismic surveys, detonations and shipping are considered a form of pollution that need to be regulated (Kvadsheim et al. 2020). More than 15 years of research shows that the environmental impact of sonars are manageable, but more knowledge is needed on new sonar systems and new operational concepts. The effects on fish populations, possible negative impact on fisheries and direct injury on marine mammals are limited (Kvadsheim et al. 2020), whereas recent research show that sonar lead to behavioural disturbance of several species of marine mammals. The Royal Norwegian Navy recently introduced new Procedures for use of active sonar in Norwegian waters to minimize any negative effects on marine life (Appendix A). The procedure contains guidelines for planning of sonar operations and procedures to be used during operations. The Norwegian Environmental Agency has acknowledged that the Navy is self-regulating their noise pollution in a responsible manner, but they also require that the Navy continues to develop the knowledge on effects of sonar on marine life and update SONATE and the sonar instruction accordingly (Miljødirektoratet 2017).

The sonar-procedure 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 procedures that define the actions to mitigate environmental impact (Appendix A).

The first version of SONATE was introduced in 2006; the next version in 2011 and the last version came in 2015. The 2020 version is an update of the 2015 version, with minor changes in the user interface. Only the data contained in the tool have been updated, the tool itself has only undergone small changes.

2 Background and short history

The SONATE tool has a long history, and the first version of SONATE was distributed to the Norwegian Defence in 2006.

In 2008, it the Royal Norwegian Navy and FFI agreed to work towards an internet-based version of SONATE instead of continuing to develop the stand-alone version. This decision was made because the Norwegian Defence wanted to minimize the number of independent software and gather several applications on common platforms.

An internet-based version of SONATE was released in 2011, and an updated version in 2015. Prior to the release in 2015, it became clear that the navy needed an off-line back-up solution for the on-line version of SONATE to be used when the internet connection on naval vessels was too poor. FFI then made a standalone version for ArcReader and distributed this with the internet version. The feedback after 2015 is that the Norwegian Defence has used only the Arc Reader version, not the internet version.

More details on the development of SONATE, and the background for the decisions made, are described in Nordlund & Kvadsheim (2015).

When the decision was made to update SONATE in 2019/2020, with a low budget, it was therefor decided to update only the standalone version (Nordlund & Kvadsheim 2019).

3 Input data

Input data to SONATE 2020 comes from two main sources. Input data are distribution maps of fish and marine mammals, whaling and fishing activity, safari activities and fish farm locations.

The 2015 version contained additional information from other sources than those included in the guidelines. This information is reduced in the 2020 version for two reasons: One is that this information is unnecessary in order to be able to follow the guidelines and can thus confuse more than enlighten, and the other to save effort in facilitating the input data.

Input data	**Source**
Distribution maps (fish and marine mammals) from Norwegian waters	Institute of Marine Research (IMR)*
Fishing activity	Norwegian Directorate of Fisheries **

*POC: Alexander Christian Beck at IMR

** POC: Jørgen Svendsen, who has been of valuable help in transferring data, and interpretation.

3.1 Distribution maps

During the last years, IMR has made their database of distribution maps available on the internet. This has made updating of the distribution maps in SONATE less demanding than earlier, when extensive editing of the data was necessary. With the help of a python script received from IMR, the data was downloaded in short time and with small effort.

3.2 Fishing activity data

Fishing activity data are in SONATE 2020 presented differently than in previous versions. This is because the Directorate of Fisheries have changed their way of storing and presenting the data. Fishing activity data are now available as shape files showing tracks of fishing vessels illustrating were and when fishing have been going on. The data are divided in classes of fishing tools used.

The dataset of fishing activity in SONATE 2020, contains data from 2017, 2018 and 2019.FFI received the last update of these data in July 2020. The fishing activity data holds no information on vessel names or sizes.

4 The SONATE tool

SONATE 2020 is a decision aid tool for use during planning and execution of sonar exercises. SONATE combines geographical information with the “Procedure 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 sonar-procedure 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 sonar-procedure also states restrictions to avoid conflicts with commercial interests, such as fish farms, fishery, whaling and safaris. The procedure 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.

As mentioned above, the 2020 version of SONATE comes solely as an ArcReader tool. SONATE-ArcReader is available from a DVD attached to this report. An installation instruction is also available on the DVD.

4.1 User interface overview

The ArcReader user window is divided in two main parts - table of contents to the left, and 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 are:

- In the table of content
  - A layout view can have several data frames (In SONATE Maps and Links).
  - To turn on or off layers, use the tick boxes.
  - A layer with sub-layers is called group layer.
  - 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 or to see the symbols of the layer.
  - Layers are drawn from bottom of table of contents to the top. That means that layers further up can hide the layers at the bottom of the list.
  - The data are organized in months.
- 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.

See Figure 4.1 for an overview of the ArcReader window.

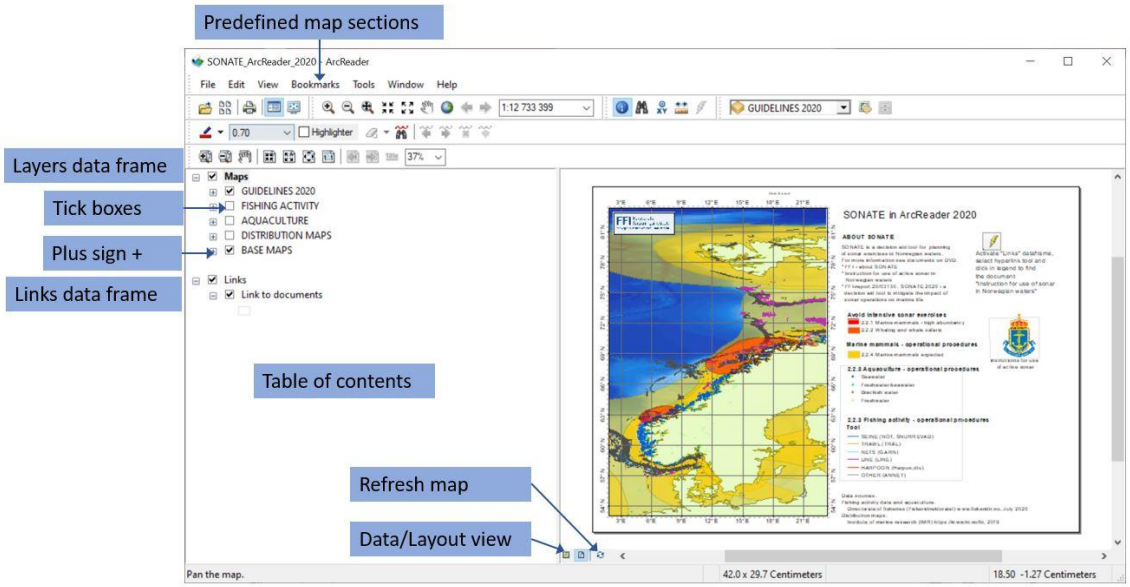

Figure 4.1 Overview of the ArcReader window. Table of contents to the left. Map to the right. This layout has two data frames; ***Maps*** *and* ***Links***

To see the layers in a group layer, for instance the layers under **GUIDELINES 2020**, click the "+"-sign. There may be several levels of layers under a group layer, as illustrated in Figure 4.2.

4.2 Data view and layout view

The ArcReader file will by default open in layout view. In this view, the legends and explanations are included, and these will be included in a print of the page as well. The layout view may be a bit crowded, and details in the map might be difficult to see. Details in the map will show better in data view. To change between these to view modes, use the small buttons below the map, pointed out in Figure 4.1. Figure 4.1 is in layout view, while Figure 4.2 **Feil! Fant ikke referansekilden.** shows a typical data view, with the map details more visible. The graticule will not be visible in data view. Be aware that there are two toolboxes for navigation in the map, one for data view, one for layout view. See Figure 4.3 for example and Figure 4.4 for the appearance of the toolbars. The toolbar for navigation in layout view will be visible only when in layout view.

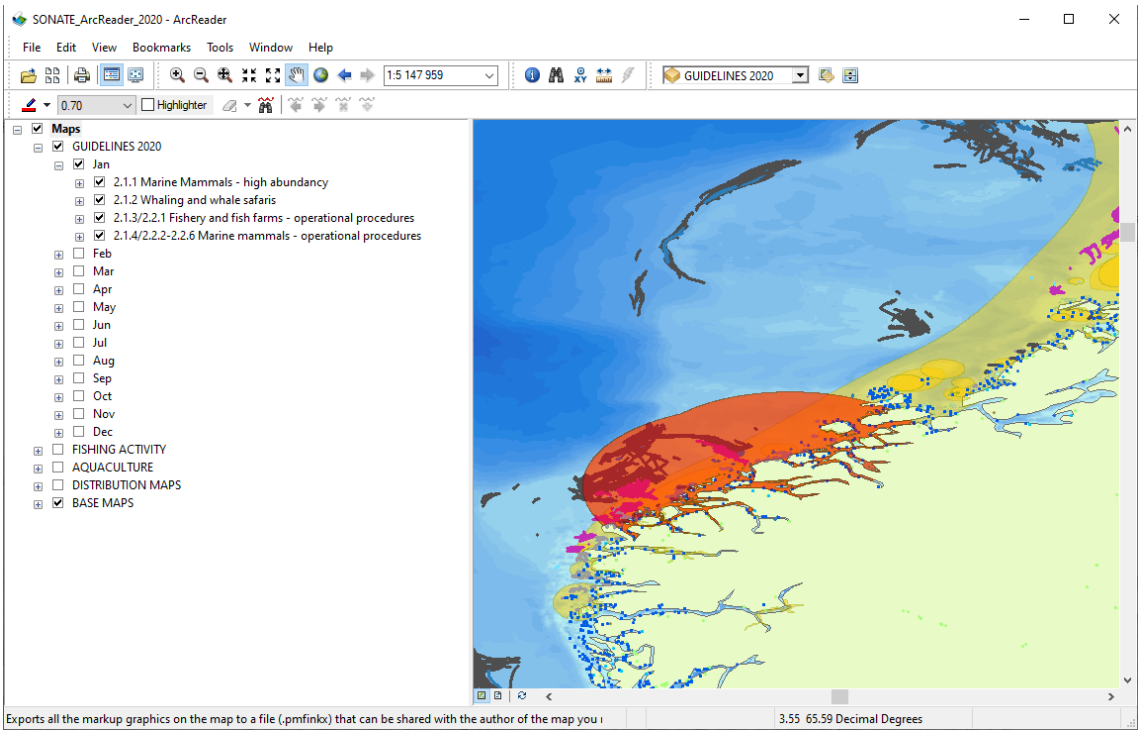

Figure 4.2 Example of data view. Details in the map emerges more clearly.

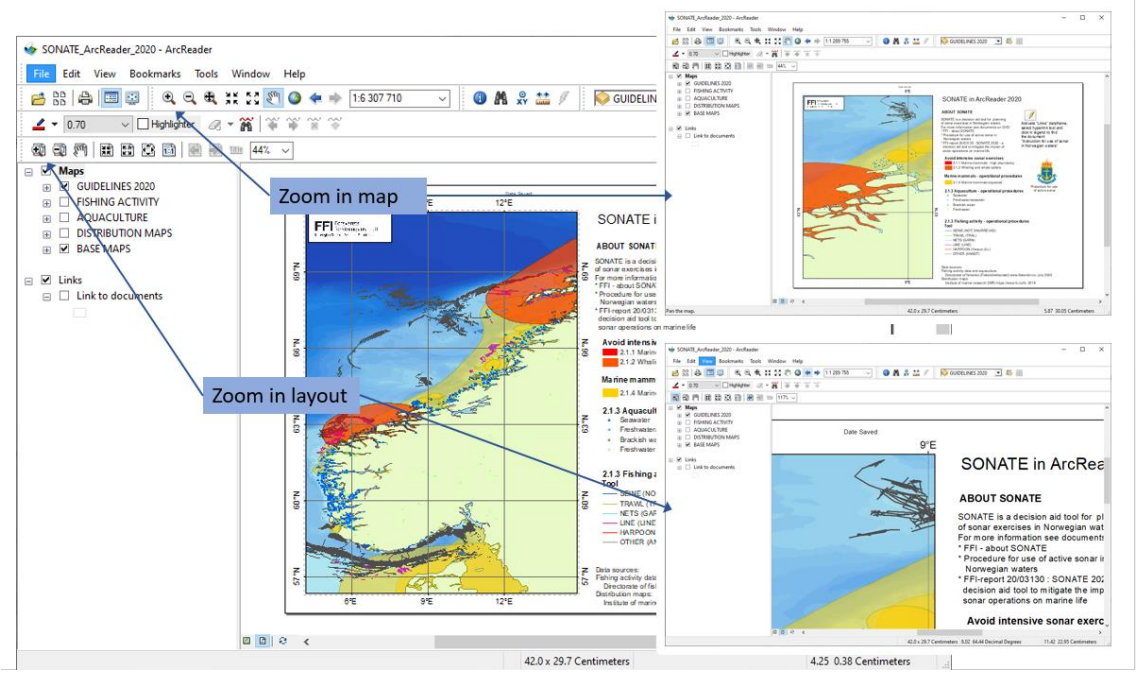

Figure 4.3 Two different zoom-toolbars. The zoom-tool for data view will zoom in to a smaller area on the map, the zoom toolbar for layout view; will zoom in on the layout.

Figure 4.4 Note the difference of the two toolbars for navigation. Data view navigation to the left, layout view navigation to the right.

4.3 Data frames and hyperlinks

One layout can contain several data frames. A data frame is usually a map, but in "SONATE in ArcReader 2020", the data frame **Links** contains links to the document "Procedures for use of sonar in Norwegian waters". See Figure 4.5.

To get these links to work, right-click the "Links" data frame in the table of contents, and select activate. Then click the hyperlink tool . Areas in the legend with hyperlinks attached will be hatched. Click one of the hatched areas, and the relevant part of the instructions will pop up. A pdf-reader is required for this to work. See Figure 4.6 for example.

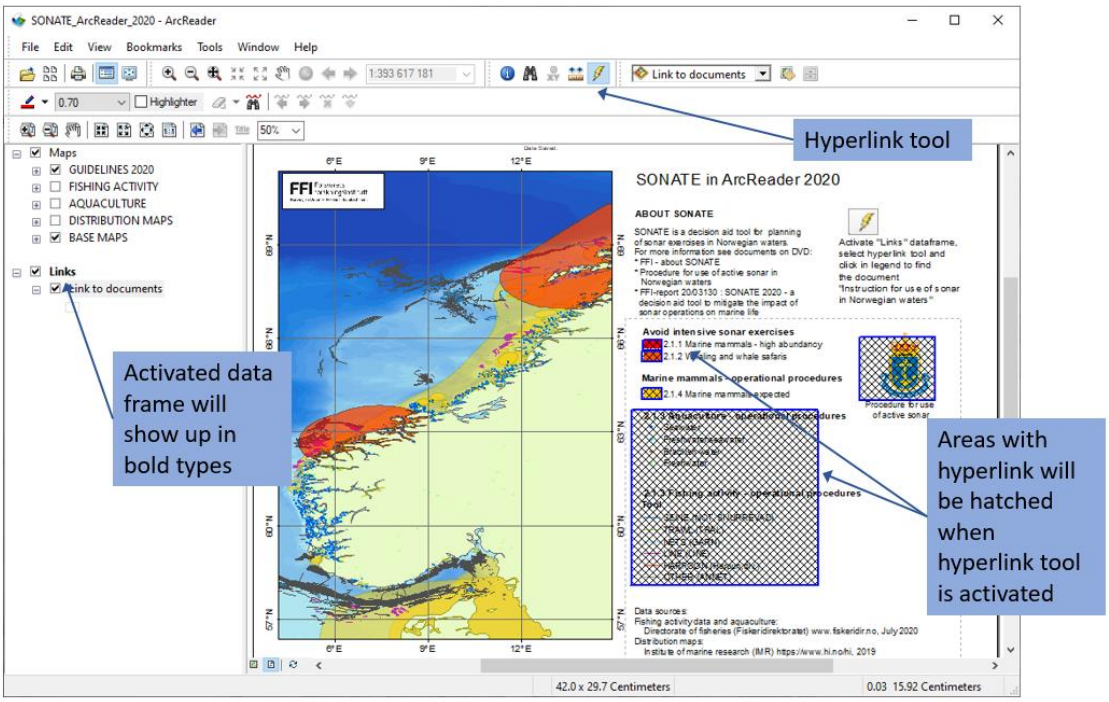

Figure 4.5 Activated layers and hyperlinks

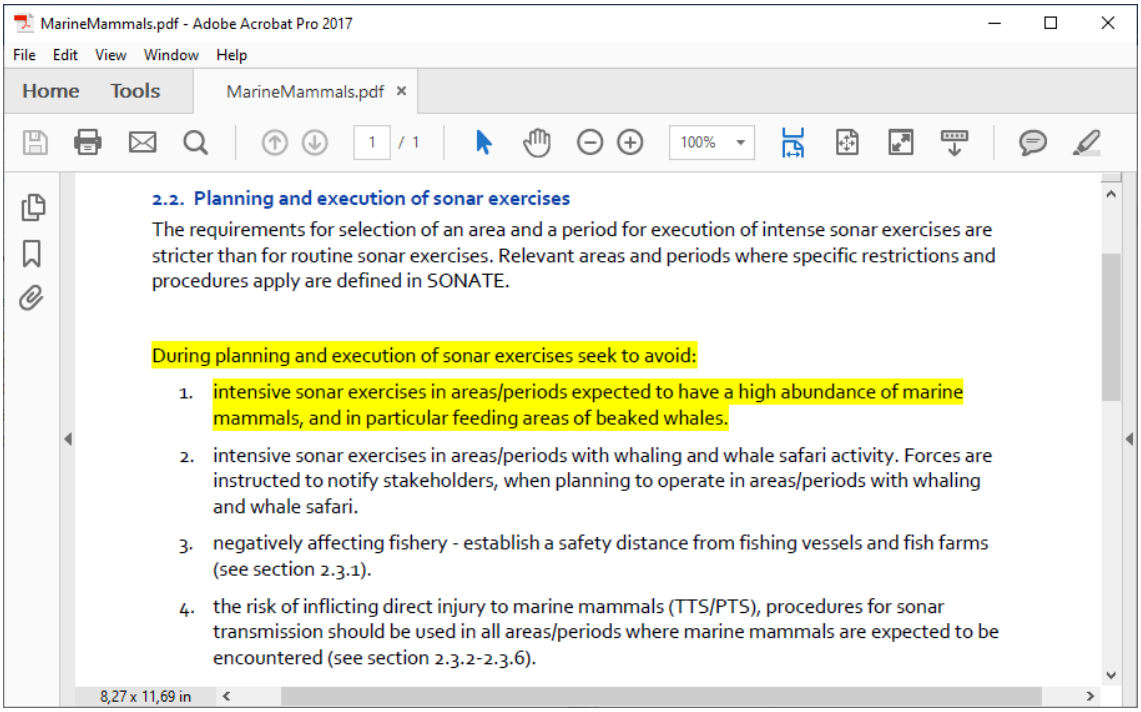

Figure 4.6 Example of extract of the procedure that will pop up when clicking one of the links.

4.4 The «i» button and expanded layers

The «i»-button gives information of the layers in the point of the map the user is clicking. First, activate the “i”-button, then click a point on the map. See Figure 4.7. When clicking a point on the map, a new window will pop up, with a list of the layers in that point, or only the top-most layer, depending on mode. The mode can be either “show all visible layers” or “show top most layer”. See Figure 4.8. By clicking one of the layers in the “Identify” window, the layer will turn green for a moment.

If one of the layers in the table of contents is of special interest, the other layers can be turned off.

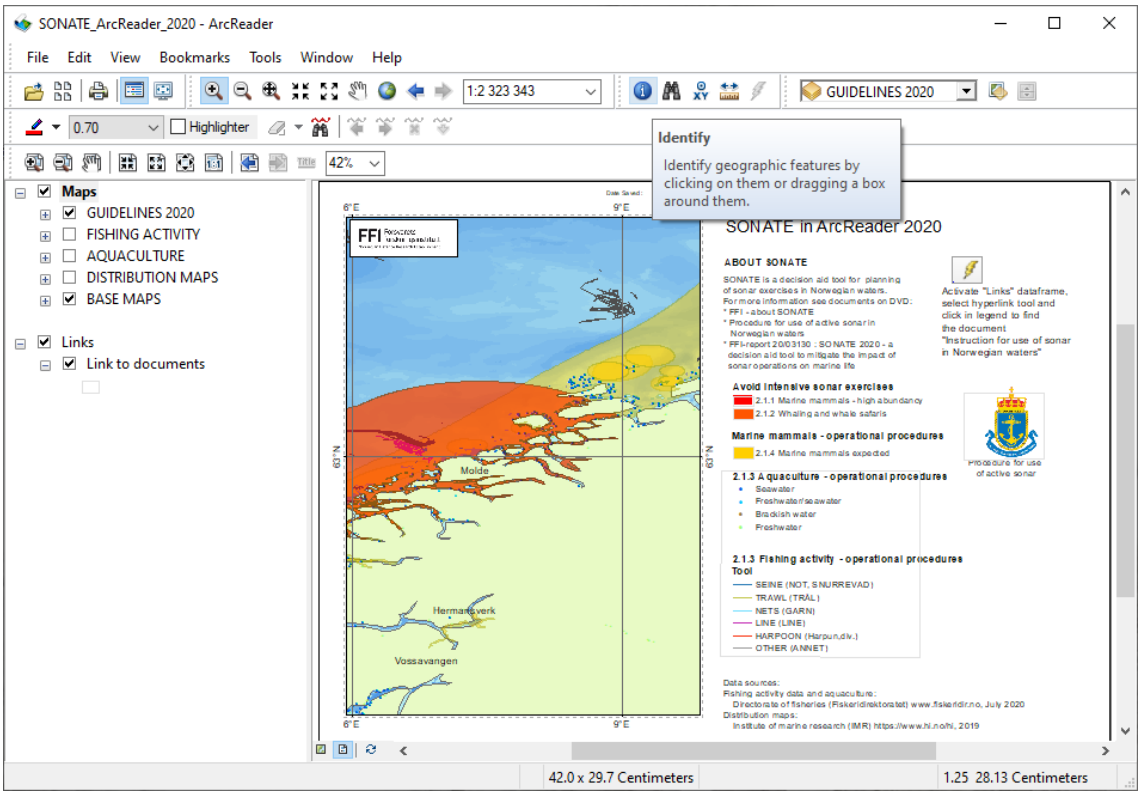

Figure 4.7 The "i"-button

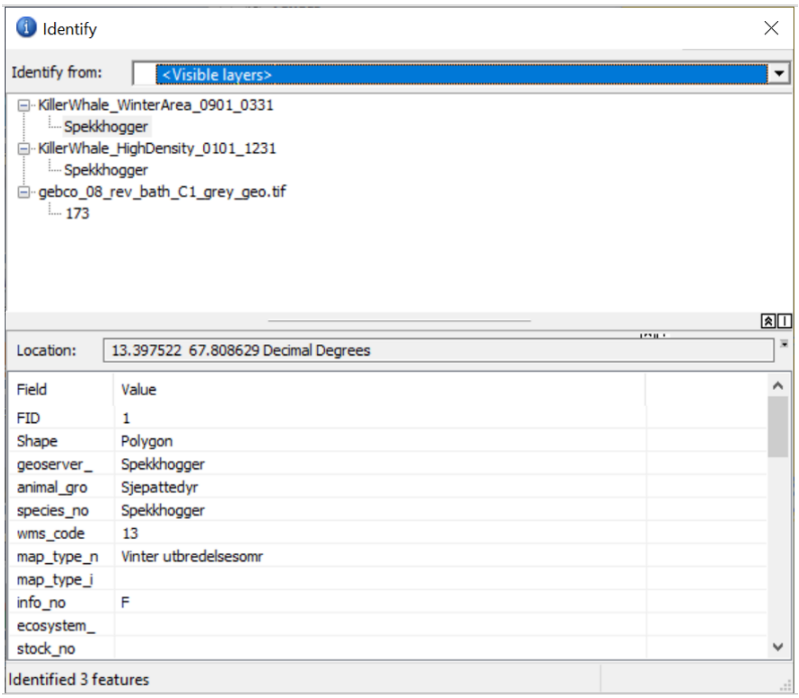

Figure 4.8 The "i"-button options. Select mode in the drop down menu at the top. Visible layers or top most layer

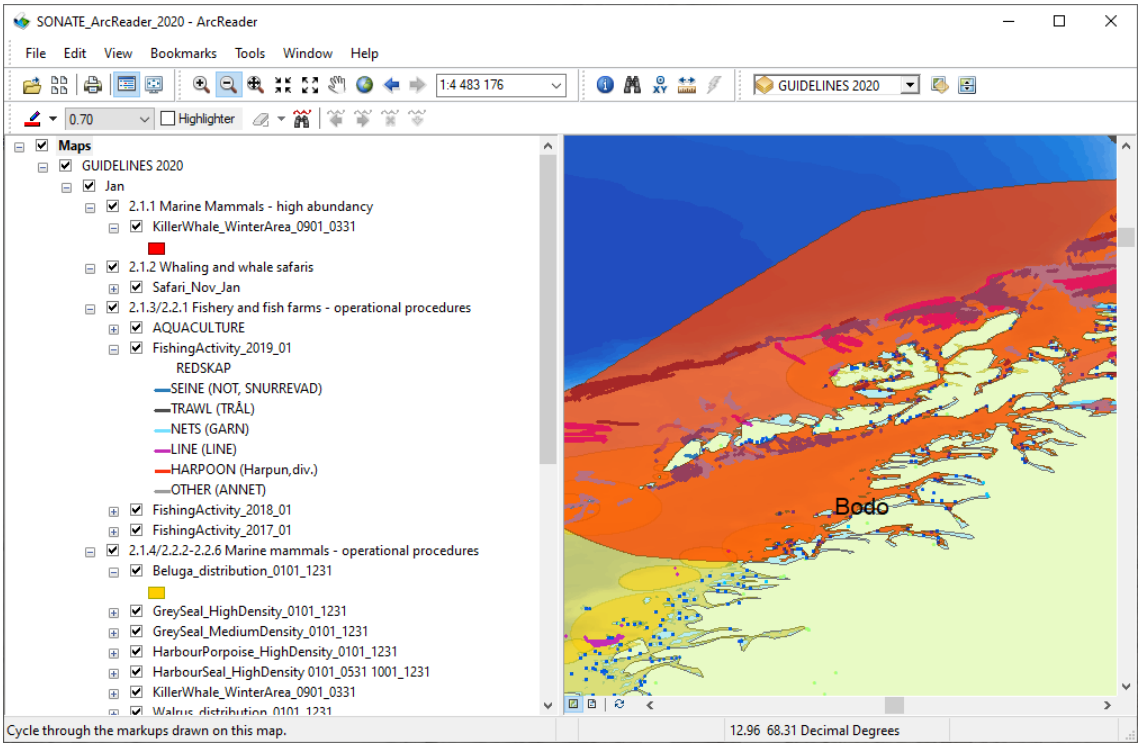

Figure 4.9 Click the "+"-sign to expand the layers. Click the tick-box to turn off or on the layers.

4.5 The different map layers

The examples above shows only a few of the layers in the table of contents. Below is a short explanation of most of the layers in SONATE.

4.5.1 GUIDELINES 2020

This group layer shows the areas affected by the sonar procedures for each month. Areas with stronger restrictions have a darker colour and are in the top layers. By default, all layers below the top layer in the tree structure are set in visible mode. Explore the tree structure to see all layers.

The guidelines layer is divided in 4 sections, which reflect the structure of the sonar-procedure document:

- Marine mammals – high abundancy – Sonar-Procedure section 2.1.1, see Figure 4.11
- Whaling and whale safaris – Sonar-Procedure section 2.1.2, see Figure 4.13
- Fishery and fish farms – Sonar-Procedure section 2.1.3 and 2.2.1, see Figure 4.12 and Figure 4.14
- Marine mammals – operational procedures – Sonar-Procedure Section 2.1.4 and 2.2.1-2.2.6, see Figure 4.10

The user can show all layers or layers related to specific sections in the Sonar-Procedure. Figure 4.10 shows an example with all layers for all guidelines visible for June. Figure 4.11 shows only layers related to section 2.1.3 of the Sonar-Procedure.

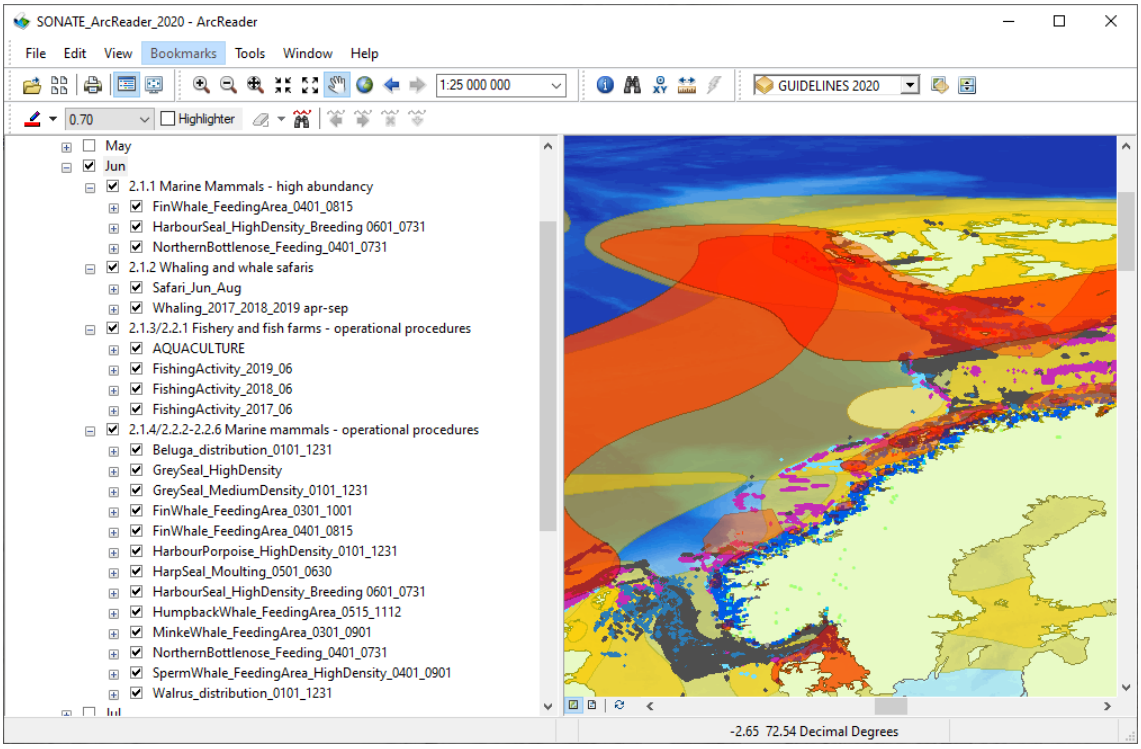

Figure 4.10 The guideline layer with the sublayers expanded. This option shows all areas affected by any of the sections of the sonar-procedure for June.

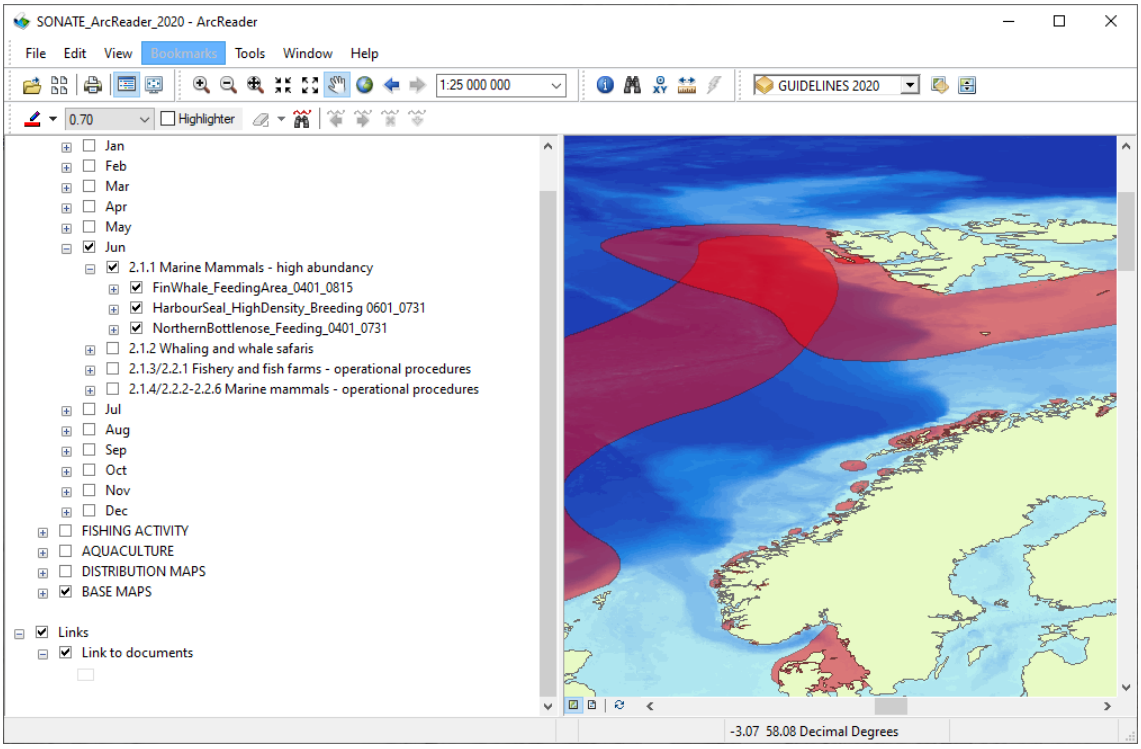

Figure 4.11 Example for June with layers related to section 2.1.1 in the sonar-procedure visible.

4.5.2 Fishing activity

Data source: Directorate of Fisheries, last update of data 2020.July.14, with reference to "Avtale om bruk av informasjon til forskning", signed by FFI 2020.Sep.24.

Under the group layer **Fishing activity**, the user will find three series of fishing activity data, from the years 2017, 2018 and 2019. These are divided into months, which makes it possible to study variations from year to year. The data also gives information on fishing tools used. Information of nationality and vessel size is not available in this dataset. Use the "i"-button or the "HTML popup" button to study details in the dataset (see description in Chapter 4.4.)

The group layer **Whaling** contains whaling information extracted from the fishing activity data from the years 2017-2019.

The layer **Whaling areas** are based on the whaling data set, but also historical knowledge of where whaling takes place. The layer **Whaling areas** is intended to provide an overview of where whaling activity can be expected.

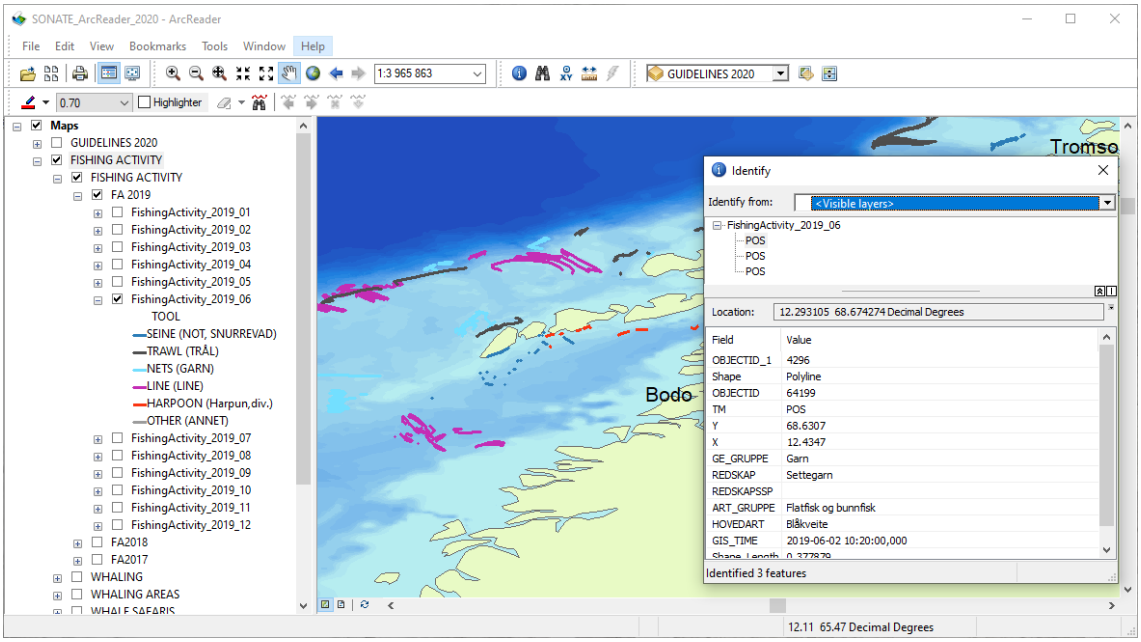

Figure 4.12 Fishing activity information for June 2017-2019 is available. Different colours shows different tools. Unfortunately, the information in the "Identify" window is in Norwegian.

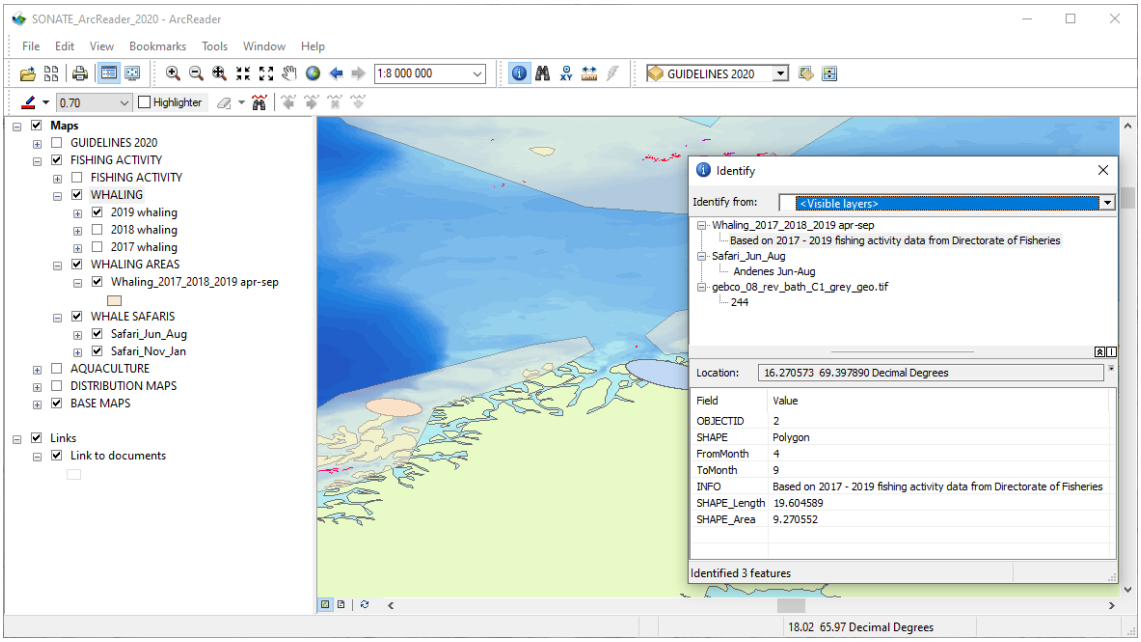

Figure 4.13 The whaling information layers.

4.5.3 Aquaculture

This layer shows a dataset of aquaculture (fish farm) concessions (locations) from February 2020. Be aware that locations can be temporary sanitized. The dataset is updated regularly, and updated dataset can be found at www.fiskeridir.no.

The legend of the layer gives information of the environment (fresh water, sea water etc). The "i"-button gives more information, for instance contact person for the site. Unfortunately, this information is available only in Norwegian.

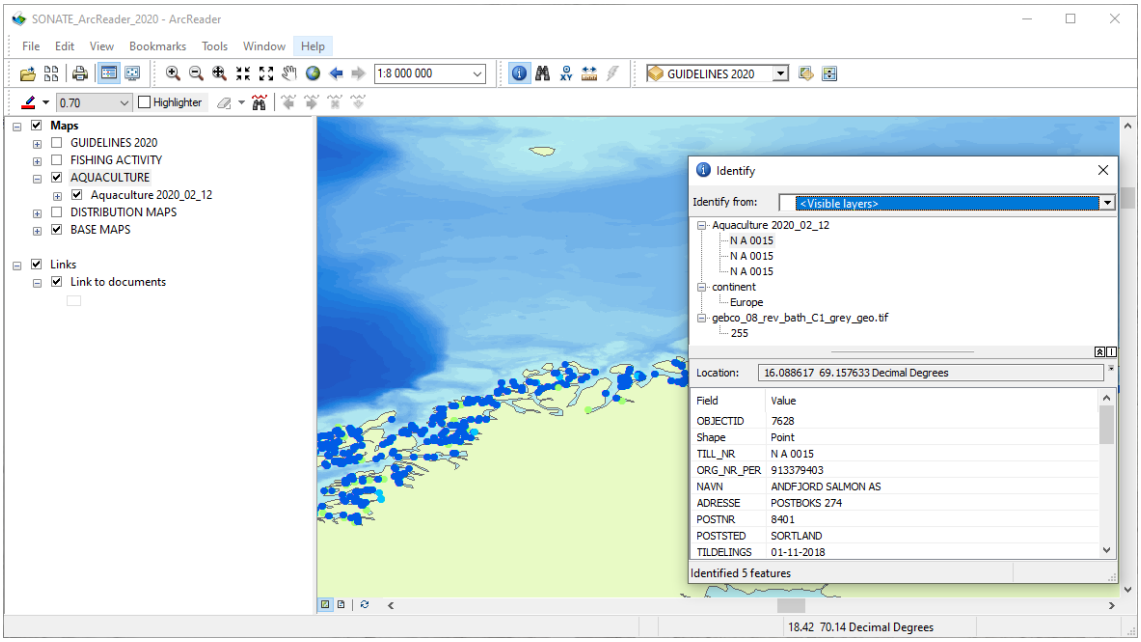

Figure 4.14 Aquaculture layer with "Identify" window.

4.5.4 Distribution Maps

Under distribution maps lays all distribution maps for marine mammals and fish used as a basis for the procedures. This may be useful when one have special interest in one or a few specific species. By default, all the layers in this group are turned off. Explore the tree structure to see details.

The distribution maps available are (Norwegian species names in brackets):

- Cetaceans: Beluga (hvithval), fin whale (finhval), harbor porpoise (nise), killer whale (spekkhogger), long finned pilot whale (grindhval), minke whale (vågehval), northern bottlenose whale (nebbhval), sperm whale (spermhval), white beaked dolphin (kvitnos).

- Seals: Bearded seal (storkobbe), grey seal (havert), harbor seal (steinkobbe), harp seal (grønlandssel), hooded seal (klappmyss), walrus (hvalross).

- Fish: Atlantic halibut (kveite), blue whiting (kolmule), capelin (lodde), coastal cod (kysttorsk), Greenland halibut (blåkveite), north-east Atlantic cod (NEA torsk), North Sea cod (nordsjøtorsk), mackerel (makrell), north-east Arctic Haddock (nord-øst-arktisk sei), North Sea Herring (nordsjøsild), Norwegian spring spawning herring (norsk vårgytende sild), polar cod (polartorsk), sprat (brisling).

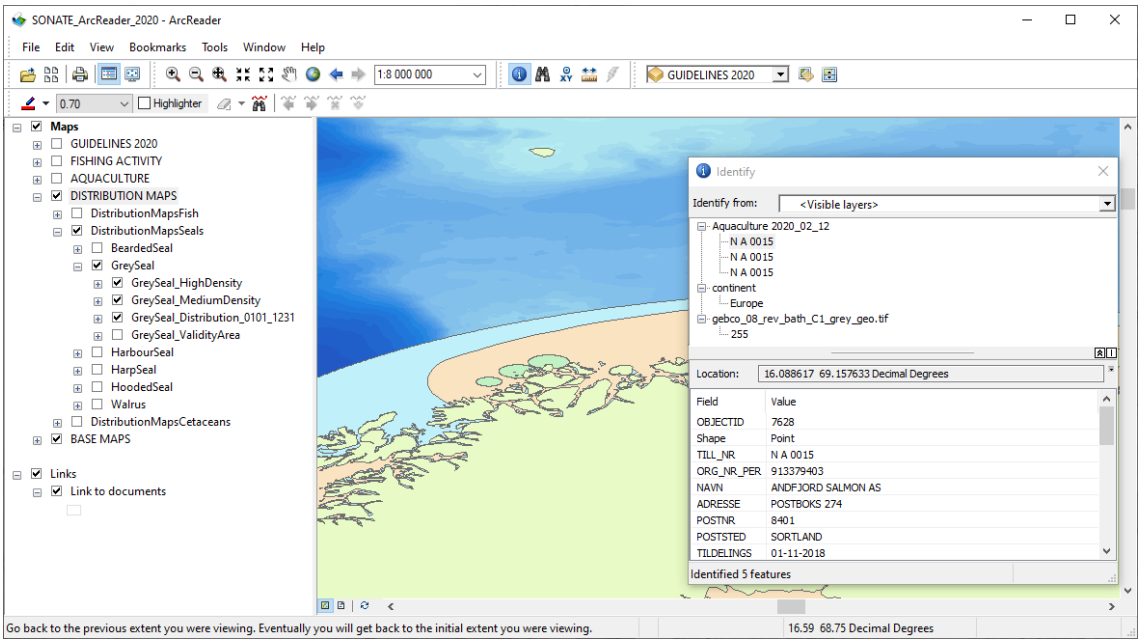

Figure 4.15 Example from the Distribution Maps group layer

4.5.5 Base maps

The base maps are bathymetry, land contours, and when zoomed in closely, a more detailed map with place names and roads will appear.

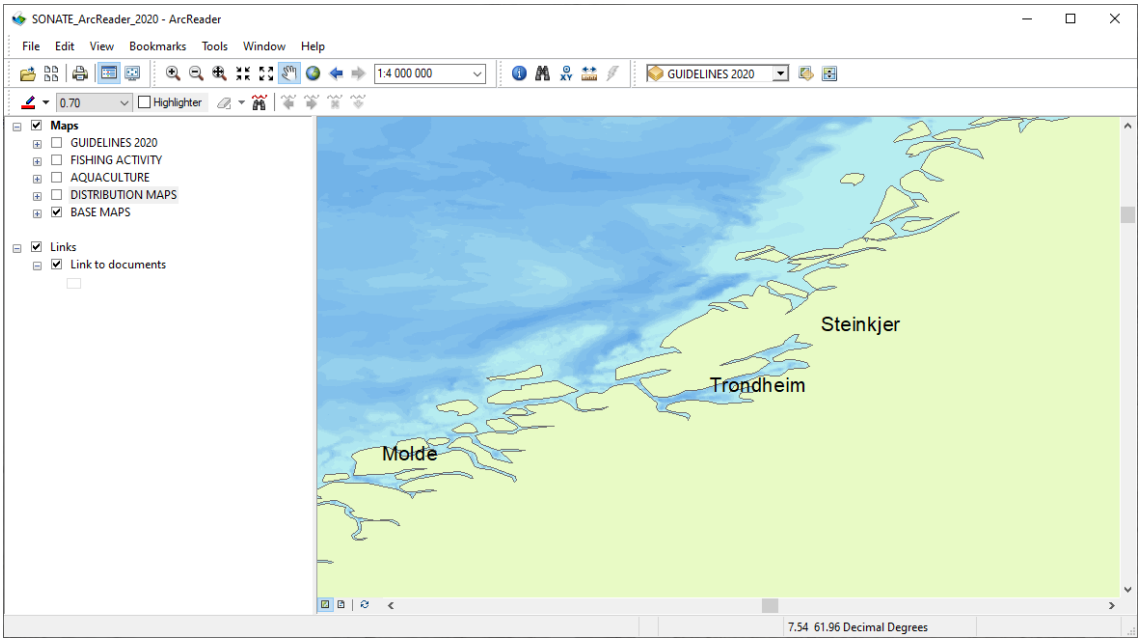

Figure 4.16 Base map with main place names (visible when zoomed inn closer than 1:5000000)

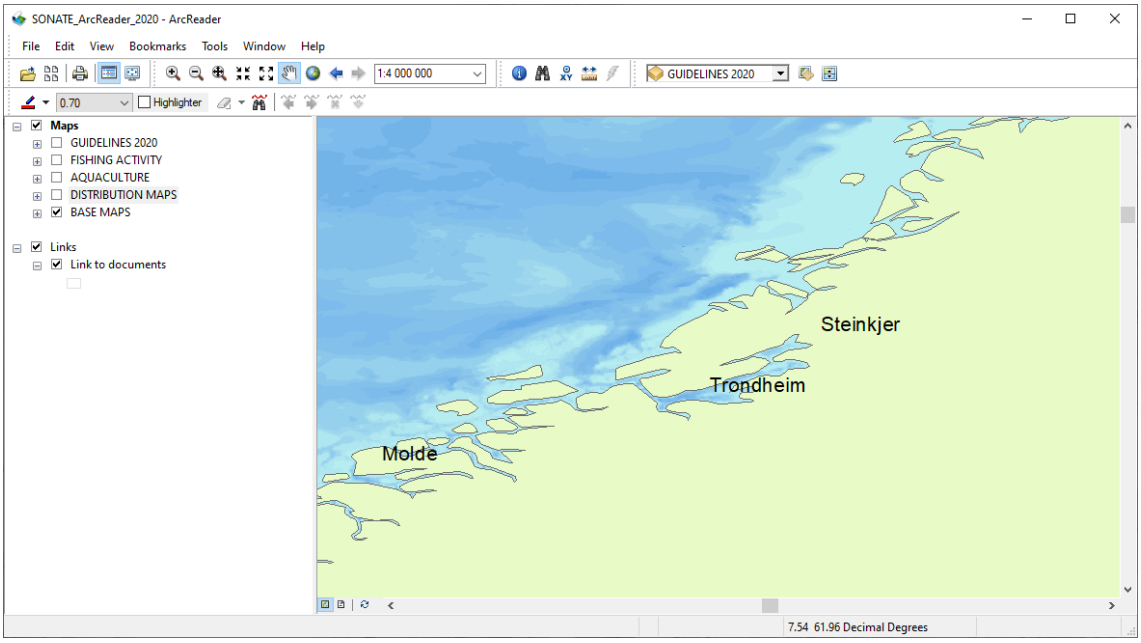

Figure 4.17 Base map with details (visible when zoomed in closer than 1:400 000)

5 Scientific basis for the sonar procedure

Since 2003 FFI has been conducting research effort with the objective to develop knowledge of how naval sonar might affect marine life. Supported by the Norwegian Ministry of Defence, FFI has conducted experiments on both fish and marine mammals, in the field and in the laboratory. In recent years, FFI has partnered with national and international collaborators, and most of the financial support we currently receive comes from naval authorities in US, UK and the Netherlands.. Based on the collected knowledge, combined with literature knowledge, FFI submit recommendations to the Norwegian Navy on procedures for use of active sonar in Norwegian waters. The 2015 version was a military instruction (Wedervang 2015), and was recently replaced by a new updated Military Procedure (Andresen 2021) (Appendix A). Such regulations are important to minimize environmental impact of sonar. NATO also require environmental mitigation measures during NATO lead sonar exercises, and request the host nation to supply this (NATO 2018). The scientific basis for our recommendations is summarized in this chapter.

5.1 Behavioural responses of marine mammals to naval sonar

Active naval sonar activity in an area can result in avoidance responses in marine mammals, and they might leave the exercise area (e.g. Kuningas er al. 2013, Miller et al. 2012, 2014, 2015, Antunes et al. 2014, Harris et al. 2015, Sivle et al. 2015, Kvadsheim et al. 2017, Wensveen 2019). This can result in lost feeding opportunities (Isojunno 2016, Sivle et al. 2016), risk of mother-calf separation (Miller et al. 2012), and increased energetic cost (Kvadsheim et al. 2017). Minke whales and bottlenose whales have been identified as particularly sensitive species (Miller et al. 2015, Kvadsheim et al. 2017, Wensveen et al. 2019).

Marine mammals can also change dive patterns in response to sonar exposure (Sivle et al. 2012a). Deep diving cetaceans (bottlenose whales and sperm whales) have a higher risk of developing gas emboli (decompression sickness), compared to shallow divers, and changes in their dive pattern in response to an anthropogenic disturbance can increase the risk further (Kvadsheim et al. 2012, Fahlman et al. 2014). However, recent studies indicate that sperm whales are not very responsive to sonar (Isojunno et al. 2020), whereas bottlenose whales are very sensitive, and change their dive pattern when exposed to sonar (Wensveen et al. 2019).

The risk of biological significant behavioral responses increases with received sound pressure levels above140 dBrms (re 1µPa) (Harris et al. 2015). A new hypothesis to explain why some species are more sensitive than others, are that sonar pulses might trigger anti-predator responses, and different species have different predation risk (Curé et al. 2016, Harris et al. 2017).

How severe a behavioral response to an anthropogenic disturbance are, depends on the duration of the response. Many biological processes are diurnal, but responses can endure longer than the sonar exposure. Exposures with a duration of more than 12 hrs are therefore associated with

higher risk than exposures of shorter duration. It is therefore recommended that the criteria for appropriate areas and periods for conducting intense sonar exercises of extended duration should be stricter than for routine sonar exercises. The same strict criteria should also be used for exercises involving multiple sonar sources or continuous active sonar (CAS) with high duty cycle. This is based on recent studies indicating that CAS has the same impact as conventional pulsed active sonars (PAS) on behavior, if the accumulated energy is the same, but CAS has potential higher masking effects than PAS (Isojunno et al. 2020).

Figure 5.1 Tagging of sperm whales (left) and pilot whales (right) with acoustic and motion sensor tags to study behavioural responses to naval sonar (Kvadsheim et al. 2020). Photos: Saana Isojunno (left), Elizabeth Henderson (right).

5.1.1 Recommendations to minimize behavioural disturbance of marine mammals

Based on this we recommend that the navy avoid intensive sonar exercises in areas/periods expected to have a high abundance of marine mammals (seal colonies during breeding and important whale feeding grounds), and in particular feeding areas of beaked whales. Such areas/periods are defined in SONATE.

5.2 Potential effects of naval sonar on whaling and whale watching

Naval ASW sonar transmissions in an area can result in avoidance responses in marine mammals (e.g. Miller et al. 2014), and they leave the area at least during the sonar operations (Kuningas et al. 2013). The threshold for avoidance will vary between different species (Harris et al. 2015) and it will also vary within a species depending on the behavioral context of the animals (e.g. are they feeding, migrating, socializing or breeding) (Sivle et al. 2015). Minke whales and bottlenose whales are identified to be particularly sensitive species (Kvadsheim et al. 2017, Wensveen 2019), with response thresholds for avoidance lower than 140 dB (SPL). Commercial activity related to marine mammals (whaling and whale watching), can therefore be negatively affected by naval sonar activity in the same area.

5.2.1 Recommendations to minimize impact on whaling and whale watching

Based on this we recommend to avoid intensive sonar exercises in areas/periods with whaling and whale safari activity. Forces should notify stakeholders, when planning to operate in areas/periods with whaling and whale safari. Such areas/periods are defined in SONATE.

5.3 Potential effects of naval sonar on fish and fishery

Extensive research have shown that naval sonar have little or no effect on fish (Jørgensen et al. 2005, Doksæter et al. 2009, 2011, 2012, Sivle et al. 2012b) nor on fish populations (Kvadsheim & Sevaldsen 2005, Sivle et al. 2014). However, there are still uncertainties if fish can detect and react to transient sounds or at very high received levels close to the source (Sivle et al. 2014).

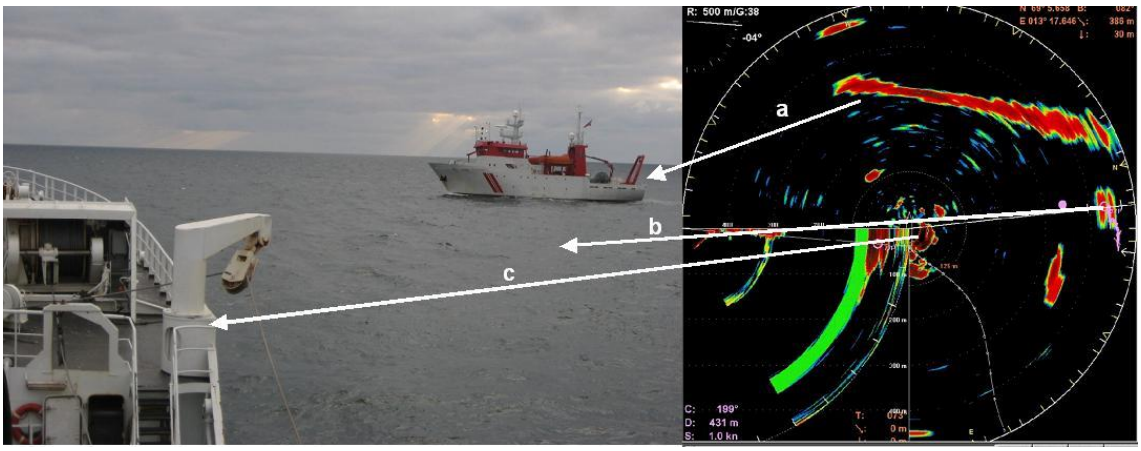

Figure 5.2 Studying the effect of naval sonar on herring (Sivle et al. 2012b). Left picture of FFI research vessel HU Sverup II (a) towing a naval sonar source and fishing vessel MS Nybo (c) using a high frequency fishery sonar to track fish schools (b).

Such responses are expected to be short and are not likely to effect the survival rate of fish, but can potentially affect catch rates of commercial fishery if the fish moves away or change behavior (Sivle et al. 2014). To assure that commercial fisheries are not negatively affected, a safety distance from fishing vessels can be established. Transmissions outside of the safety zone are not expected to trigger responses, based on known exposure levels from the literature (Sivle et al. 2014). The safety distance will vary with the source level of the sonar, duty cycle and the speed of the source. Fish in fish farms can also be stressed by transmissions closer than the safe distance, but the duration of the response will be short and primarily triggered by the passing ship more than the sonar transmissions (Sivle et al. 2014).

5.3.1 Recommendations to minimize impact on fishery and fish farms

To reduce the risk of negatively affecting fishery, we recommend maintaining a 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 (fish farms) 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.

5.4 Potential injury to marine mammals

Marine mammals have very sensitive hearing, and the ears are developed to absorb acoustic energy and might be injured by loud sounds. Criteria for direct injury (hearing impairments) to marine mammals has been developed (Southall et al. 2019). The criteria has two thresholds; Temporary Threshold Shifts (TTS) are used to indicate an increasing risk that permanent injury can happen, and Permanent Threshold Shifts (PTS) are used as threshold for inflicted injury (Kvadsheim et al. 2020). Risk of TTS/PTS depend on the sound exposure level (SEL) accumulated over 24 hrs, and on the peak pressure level (SPL) (Southall et al. 2019). For impulsive sounds both SPL and SEL need to be considered, but naval sonar signals are considered to be non-impulsive sounds where the SEL criteria is the most important. Energy in the frequency band of the sensitive hearing of a species are more destructive than energy outside of this band. Different species of marine mammals have different hearing curves and are therefore categorized into functional hearing groups (low-frequency whales, high-frequency whales, very high frequency whales, seals and other marine mammals). Separate weighting functions for the SEL criteria are then used for each group. Overall high frequency and very high frequency whales (delphinids and porpoises) are the most sensitive species. However, within the naval sonar band (500-10.000Hz) these species have a -12 to -40dB weighting level based on the hearing. Considering all marine mammals we therefor end up with a conservative TTS threshold of 165-180 dB SEL (re 1µPa2·s) and a PTS threshold of 185-200 dB. Based on this, safety zones around sonar sources of different source levels can be defined. In doing so we assume that animals that are exposed to levels close to threshold of injury will move away and only be exposed to a few pulses of very high source level. The movements of the source and the duty cycle also need to be considered.

5.4.1 Recommendations to minimize risk of injury to marine mammals

Risk of direct injury to marine mammals from Naval sonar, 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 165 dB (re 1µPa·s). 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 (re 1µPa·m), the risk of direct injury is neglectable, because animals need to be closer than 100m from the source.

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.

To minimize risk of injury to marine mammals, a safety distance of 1000 m should be established in areas/periods were marine mammals are expected to be encountered. If transmitted source level exceeds 225 dB (re 1µPa·m), or duty cycle exceeds 10%, or the speed of the sonar platform is less than 5 knots, the safety distance should be increased to 2000 m. During active sonar transmission at source levels (SL) above 200 dB, the danger zone defined by the safety distance should be monitored visually and/or using available passive acoustic sensors. During operations in the dark, visual monitoring should be supported by available infrared sensors to look for whale blows. 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.

5.5 RAMP-UP

Ramp-up is a gradual increase in source level at the start of transmissions to allow marine mammals to escape from the immediate vicinity of the source were sound level can be dangerous when the source is transmitting at full power. Ramp-up has been used by navies and seismic companies for years without scientific evidence that it works. Recent studies have however documented that the risk of direct injury to marine mammals during sonar operations can be mitigated by use of a ramp procedure in most scenarios (von Benda-Beckmann et al. 2014, Wensveen et al. 2017). The risk and the effect of ramp-up will vary with the responsiveness (response threshold) of the animals in the area, the speed of the source, the swim speed of the animals, the full source level of the sonar, the inter ping interval, and the duration of the ramp-up (von Benda-Beckmann et al. 2014). Ramp-up procedures with a duration of more than 5 min seem to not give any additional risk mitigation gain. An optimal ramp-up procedure for most operational scenarios are recommended below based on von Benda-Beckmann et al. (2014).

5.5.1 Recommendations regarding ramp-up

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 200 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 should be repeated. If visual conditions do not allow for visual control of the danger zone, the Ramp-Up procedure should always be used.

Ramp-up can interfere with the fidelity of some training elements during naval exercises (e.g tactical sonar use). If ramp-up are not used, there should be more strict requirements to use other

risk mitigation measures, such as avoiding areas with high density of marine mammals, visual monitoring of the safety zone, use of infrared sensors in the dark and low speed.

5.6 Other recommendations

5.6.1 Transmissions at high speed

If the sonar platform moves at high speed the animals might struggle to get away, and might end up in the safety zone of the vessel. If the vessel speed and the transmission interval imply that the vessel covers more than 200m between two successive transmissions (pings), or the speed exceeds 15 knots, one should 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 safety zone is difficult.

5.6.2 Transmissions in narrow or constricted waters

In narrow or constricted waters animals might be chased towards the shore, and have limited escape options to stay away from the safety zone. Ultimately, such scenarios might increase the risk of stranding. During transmissions in narrow or constricted waters one should therefore 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.

5.6.3 Use of helicopter operated sonar and sonobuoys

For stationary sonars such as helicopter operated dipping sonars and active sonar buoys the animals can more easily escape from the safety zone. If marine mammals are not observed in the area of operation, it is therefore sufficient that a 500 m danger zone surrounding the drop point of a helicopter operated sonar 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 max 200 dB. The transmitted level may then be increased to the desired level within 1 minute (short ramp-up).

5.6.4 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 and to allow reconstruction of any undesired events such as marine mammal strandings. 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 be documented. Any deviation from the sonar instruction should also be documented with the cause of the infringement. Documentation should be archived for at least 1 year.

5.7 International regulations

NATO has established their own guidelines for NATO operations involving sonar (NATO 2018). These guidelines are based on national guidelines of NATO nations (Dekeling et al. 2016) and the NATOs guidelines should be considered minimum requirements during joint NATO exercises if the host national does not have national sonar regulations that are more strict. In Norwegian waters this means that the Norwegian sonar guidelines will apply during NATO exercise in Norwegian water.

6 Conclusions and recommendations

FFI has delivered an updated SONATE 2020 version of the decision aid tool for sonar operations to the Royal Norwegian Navy. The database in SONATE has been updated with new information about species distribution and abundance from Institute of Marine Research, and updated information on fishery activity and aquaculture from Directorate of Fisheries. The functionality of SONATE has been modified according to the users' request, and we have recommended new sonar guidelines, as a basis for the new naval sonar procedure (Andresen 2021) (Appendix A), replacing the 2015 version (Wedervang 2015). This report summarizes the functionality of SONATE and the scientific basis for the sonar procedure (Andresen 2021).

We have earlier evaluated possible future technical solutions for SONATE, as described in detail in Nordlund & Kvadsheim (2015). It is not in the scope of the 2020 update to evaluate further possible future SONATE solutions, but the technical solutions described in Nordlund & Kvadsheim (2015) is a starting point for such evaluations. During the work with the 2020 version, discussions with the users have revealed some recommendations for future changes of the tool. In general, they find it difficult to get access to all relevant information in a specific area. They also experience that the tool is working slowly. The navy has also reported that some of the users have been using an old version of SONATE. This have happened even though FFI has had anual meetings or given classes at the LMOPS with naval users. We are not sure what went wrong, but this shows the importance of close contact with the users. We have experienced that the users we have met, have been very accustomed with the use of SONATE.

The recommendations for the future is to keep even closer contact with the users, with the help of the Navy.

We have been trying to follow the recommendations from the users when it comes to the technical solution of SONATE, but to fulfil all proposed modification and to implement proposed new functionality we probably need to re-develop SONATE on a new platform. This was not in the scope and budget of the 2020 update, and need additional funding in the future.

Finally, we recommend that the Norwegian Navy/MOD reengage in funding of research to develop the knowledge on how naval sonar effect marine life, together with allied navies from USA, UK, The Netherlands and France currently funding this.

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Appendix

A Procedure for use of active sonar in Norwegian waters

This chapter contains the document “Procedure for use of active sonar in Norwegian water”. The main document is in Norwegian, an English translation is attached below.

Prosedyre for bruk av aktiv sonar i norske farvann

Fastsettes til bruk i Sjøforsvaret

Haakonsvern, 12.03.2021

Rune Andersen
Kontreadmiral
Sjef Sjøforsvaret

Metadata

KORTTITTEL:	
SIKKERHETSGRADERING:	Ugradert
UTGIVER:	Sjef Sjøforsvaret
SAKSBEHANDLENDE VDELING:	MAR/KNMT/MKS ASW
FAGMYNDIGHET:	Sjef Sjøforsvaret
FAGANSVAR:	Sjef Marinen
GJELDER FOR:	Sjøforsvaret
HJEMMEL:	Instruks for Sjef Sjøforsvaret (2017-05-01)
IKRAFTTREDELSE:	2021-04-01
FORRIGE VERSJON:	Instruks for bruk av aktiv sonar i norske farvann (2015-04-01)

Innhold

1 Innledning

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

1.1 Virkeområde

Prosedyren gjelder for alle enheter i Sjøforsvaret 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 benytter gjeldende nasjons regelverk. Under øvelser underlagt for eksempel NATO eller FN, vil disse organisasjonenes ordreverk være gjeldende. I fravær av andre føringen, anvendes denne prosedyren.

Utenlandske enheter som øver i norsk territorialfarvann anmodes om å følge denne prosedyren. NATO har etablert egne retningslinjer for sonarbruk (NATO MC547). NATOs retningslinjer kan betraktes som en minstestandard som skal brukes under NATO øvelser, dersom vertsnasjonen selv ikke har nasjonale føringer som er strengere. Dette innebærer at det er den norske sonar-prosedyren som gjelder under NATO øvelser i norske farvann.

1.2 Avgrensning

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

1.3 Faglig grunnlag for prosedyren

Det faglige grunnlaget for prosedyren er utarbeidet av FFI og oppsummert i FFI rapport 20/03130 (Nordlund & Kvadsheim 2020).

1.4 Definisjoner og forkortelser

ATAS	Aktiv tauet sonar (ATAS=Active Towed Array Sonar)
CAS	Kontinuerlig Aktiv Sonar, duty cycle på mer enn 50%
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 er i SONATE fremstilt som fartøylinjer med aktivt fiske basert på fiskerisporingsdata fra Fiskeridirektoratet. Data fra de tre siste årene er inkludert og kan splittes opp på år, måned og ulike redskapsgrupper.
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, eller at ett fartøy bruker CAS.
Kildenivå	SL (Source Level): Lydtrykknivå som genereres av lydkilden der lydtrykket er målt i fjernfeltet og referert til 1 m fra kildens senter. Gjennomsnittlig (rms) lydtrykk 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/p₀)* hvor *p* er kildens lydtrykk ved 1 m og p_0 er referanselydtrykket. I teksten brukes bare antall dB uten referanseangivelse.
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 1µPa2·s).
NATO	North Atlantic Treaty Organization.
NATO MC547	NATO publikasjon: "Code of conduct for the use of active sonar to ensure the protection of marine life within the framework of alliance maritime activities. Military Committee MC547, 2018 (NATO unclassified, but not releasable to the public).
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.
Nordlund & Kvadsheim 2020.	FFI rapport med tittelen «SONATE 2020 – a decision aid tool to mitigate the impact of sonar operations on marine life" av Nina Nordlund & Petter Kvadsheim. FFI rapport 20/03130 https://publications.ffi.no/nb/item/asset/dspace:6726/20-03130.pdf
Norske farvann	Med norske farvann menes her norsk territorialfarvann inkludert Jan Mayen, norsk økonomisk sone, vernesonen rundt Svalbard og tilstøtende internasjonale farvann.
PAS	Pulset Aktiv Sonar, duty cycle på 50% eller mindre.
Ping	Utsending av en aktiv akustisk puls fra en sonar.
PTS	«Permanant threshold shift» permanent irreversibel hørselskade. Terskel for PTS bruker som kriterium for at permanent skade har skjedd.
Ramp-Up	Innledende gradvis økning av kildenivå for å redusere risiko for å skade sjøpattedyr.
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).
Sj Sjø	Sjef Sjøforsvaret
Sjøpattedyr	Sel og hval.
SST	Sjøforsvarsstaben
Sonar-prosedyren	Dette dokumentet (Prosedyre for bruk av aktiv sonar i norske farvann 2020)
Sonarøvelser	Bruk av aktiv sonar i fredstid (rutinemessige eller intensive sonarøvelser).
SONATE	Planleggings- og beslutningsstøtteverktøy for sonarøvelser i norske farvann (se kap. 2).
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 %.
TTS	«Temporary Threshold Shift» Et temporært reversibelt hørselstap. Terskel for TTS brukes som kriterium for en økende risiko for at fysisk skade kan skje (PTS).

VDS	Variabel Dybde Sonar.

2 Hoveddel

2.1 Generelt om SONATE

Beslutningsverktøyet SONATE er et planleggings- og beslutningsstøtteverktøy for sonarøvelser i norske farvann. Samtlige enheter som berøres av denne prosedyren og alle som har ansvar for planlegging av øvelser som involverer bruk av sonarer, skal ha tilgang til SONATE. Bruk av de operative anbefalingene som SONATE gir for bestemte områder i bestemte perioder, sikrer operasjon i tråd med gjeldende prosedyre. 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, endres restriksjonene som gjelder i dette området og denne perioden (se punkt 2.2). Kystvaktsentralen har ofte oppdatert nåtidsinformasjon om fiskeriaktivitet i et område.

SONATE er utviklet av FFI, eies av Sjef Sjøforsvaret og forvaltes av FFI på SSTs vegne. Brukermanual finnes i FFI rapport 20/03130 (Nordlund og Kvadsheim 2020).

2.2 Planlegging og gjennomføring av sonarøvelser

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

Under planlegging og gjennomføring av sonarøvelser søker en å unngå:

1. intensive sonarøvelser i områder eller perioder som er ventet å ha høy tetthet av sjøpattedyr, og spesielt beiteområder for nebbhval.
2. intensive sonarøvelser i områder eller perioder med hvalfangst og hvalsafari. Styrker må varsle om planlagt sonaraktivitet i områder og perioder hvor det foregår slik fangst eller safari.
3. risikoen for negative effekter på fiskeriene, slik at en sikkerhetsavstand opprettes til fiskefartøy og oppdrettsanlegg (se kapittel 2.3.1)
4. risikoen for direkte skade på sjøpattedyr (TTS/PTS), ved å benytte operative prosedyrer for sonartransmisjon 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

For å unngå negative effekter, benyttes en sikkerhetsavstand på 500 m til fiskefartøy i aktivt fiske og til oppdrettsanlegg med fisk.

Dersom utsendt kildenivå overstiger 225 dB, eller transmisjonssyklusen (duty cycle) overstiger 10 %, eller farten på sonarplattformen er mindre enn 5 knop, økes sikkerhetsavstanden til 1000 m.

2.3.2 Sikkerhetsavstand til sjøpattedyr

For å minimere risikoen for hørselsskader på sjøpattedyr (TTS/PTS), etableres en sikkerhetsavstand på 1000 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, økes sikkerhetsavstanden til 2000 m. Under aktiv sonartransmisjon ved kildenivå (SL) over 200 dB, overvåkes faresonen som er definert av sikkerhetsavstanden visuelt og/eller ved bruk av tilgjengelige passive akustiske sensorer.

Under operasjoner i mørke, suppleres visuell monitorering med bruk av infrarøde sensorer dersom det er tilgjengelig for å detektere hvalblåst. Sjekk spesielt for tilstedeværelse av delfiner nær

baugen. Dersom sjøpattedyr oppdages innenfor faresonen, avsluttes transmisjonen eller kildenivå reduseres til 200 dB, inntil dyret er utenfor faresonen.

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 eller perioder hvor sjøpattedyr forventes å forekomme, og utsendt kildenivå overstiger 200 dB, initieres sonarutsendelsen med følgende ramp-up prosedyre:

1) Reduser farten til under 8 knop. Start transmisjon med redusert kildenivå (maksimum 200 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, gjentas ramp-up prosedyren. Dersom siktforholdene ikke gjør visuell kontroll i faresonen mulig, er ramp-up prosedyren spesielt viktig.

2) Det innføres unntak for kravet om ramp-up dersom prosedyren reduserer verdien av øvingselementer (for eksempel taktisk sonarbruk). Dersom ramp-up ikke gjennomføres settes det strengere krav til andre former for risikoreduserende tiltak, som; a) å unngå områder med høy tetthet av sjøpattedyr, b) visuell kontroll i sikkerhetssonen, c) bruk av infrarøde sensorer i mørket og d) lavest mulig fart.

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 en 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, starter sending 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 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 logges også type utsending (CW/FM, frekvensbånd, pulsintervall, effekt og pulslengde). Observasjoner av sjøpattedyr og fiskeriaktivitet under sonarbruk dokumenteres også. Avvik fra denne prosedyre for bruk av sonarer skal begrunnes. Dokumentasjon bør lagres i minst 1 år.

4 Ikrafttredelse

Prosedyre for bruk av aktiv sonar i norske farvann trer i kraft 2021-04-01. Samtidig settes «Instruks for bruk av aktiv sonar i norske farvann» av 2015-04-01 ut av kraft.

This is an English translation of the original document in Norwegian "Prosedyre for bruk av aktiv sonar i norske farvann" issued by chief of the Royal Norwegian Navy, Rear Admiral Rune Andersen March 12th 2021.

Procedure for use of active sonar in Norwegian waters

(March 12th 2021)

1. Introduction

This procedure intend to minimize risk of unnecessary negative effects of active sonars on populations of fish, populations or individual marine mammals and commercial activity related to fish and marine mammals.

1.1. Application

The procedure applies to all Norwegian naval 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 regulations 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 procedure. NATO has established a code of conduct for use of active sonar (MC547/2). The NATO guidelines can be considered a minimum standard to be used under NATO led exercises if the host nation does not have more strict national procedures. This implies that it is the Norwegian procedures that apply during NATO led exercises in Norwegian waters.

1.2. Limitation

This procedure only consider impact from active sonar use, not other military activity. Diver safety are not considered by this procedure.

1.3. Scientific basis for the procedure

The scientific basis for this procedure is established by the Norwegian Defence Research Establishment (FFI), and summarized in the FFI rapport 20/03130 (Nordlund & Kvadsheim 2020).

1.4. Definitions and abbreviations

ATAS	Active Towed Array Sonar
Beaked whales	Family of toothed whales (Lat: Ziphiidae). Only the Northern Bottlenose whale (Lat; *Hyperoodon ampullatus*) appears in Norwegian waters.
CAS	Continuous Active Sonar, duty cycle higher than 50%
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)
Fishing activity	Fishing activity in SONATE presented as tracks of fishing vessels during active fishing based on data from the Directorate of Fisheries. Data from the last three years are included, and can be split up by year, month and fishing gear.
FM-signals	Frequency Modulated signal (frequency sweep).
HMS	Hull Mounted Sonar
Intensive sonar exercises	Exercises involving sonar transmission from more than one platform or that one platform 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, or that CAS are used.
Marine mammals	Pinnipeds and cetaceans
NATO	North Atlantic Treaty Organization.
NATO MC547/2	NATO publication "Code of conduct for the use of active sonar to ensure the protection of marine life within the framework of alliance maritime activities". Military Committee MC547/2, 2018 (NATO unclassified, but not releasable to the public).
Nordlund & Kvadsheim 2020.	FFI rapport "SONATE 2020 – a decision aid tool to mitigate the impact of sonar operations on marine life" by Nina Nordlund & Petter Kvadsheim. FFI-rapport 20/03130 https://publications.ffi.no/nb/item/asset/dspace:6726/20-03130.pdf
Norwegian waters	Norwegian territorial water including Jan Mayen, Norwegian economic zone, plus the protection zone of Svalbard and adjoining international waters.
PAS	Pulsed Active Sonar, duty cycle lower than 50%
Ping	Transmitted signal pulse from active sonar.
PTS	Permanent Threshold Shift. A permanent irreversible hearing impairment. Threshold of PTS is used as criteria that direct injury has occurred
Ramp Up	Initial gradual increase of transmitted source level in order to mitigate risk to marine mammals
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.
Safety distance	A defined distance from the source to fishing vessels, fish farms or observed marine mammals where the source level should not exceed 200 dB.
Signal duration	Duration of transmitted signal (ping).
Signal interval	The time period between the start of subsequent pings.
Sonar exercise	Peacetime active sonar transmissions (Routine sonar exercises and

	Intensive sonar exercises).
Sonar procedure	This document (Procedure for use of active sonar in Norwegian water)
SONATE	A decision aid tool for planning and execution of sonar exercises in Norwegian waters (see section 2.1).
Sound Exposure Level (SEL)	Sound pressure squared and integrated over time (commonly used as a measure of acoustic dose) (dB re 1µPa²·s).
Sound Pressure Level (SPL)	Logarithmic measure of the effective root mean square sound pressure of a sound relative to a reference value (dB re 1µPa).
Source level (SL)	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_o) where p is the source pressure and p_o the reference pressure.
TTS	Temporary Threshold Shift. A temporary reversible hearing impairment. Threshold of TTS is used as criteria for increasing risk of direct injury (PTS)
UN	United Nations
VDS	Variable Depth Sonar

2. Main section

2.1. About SONATE

SONATE is a decision aid tool for planning of sonar exercises in Norwegian waters. All units affected by these guidelines and all staff involved in planning of sonar exercises shall have access to 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 sonar procedures. 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 procedures will change accordingly (section 2.2). The Norwegian Coast Guard often possesses up-dated information of fishing activity in an area.

SONATE is developed and managed by FFI, and owned by chief of the Royal Norwegian Navy. User manual can be found in FFI rapport 20/03130 (Nordlund and Kvadsheim 2020).

2.2. Planning and execution of sonar exercises

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

During planning and execution of sonar exercises seek to avoid:

1. intensive sonar exercises in areas/periods expected to have a high abundance of marine mammals, and in particular feeding areas of beaked whales.

2. 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.
3. negatively affecting fishery - establish a safety distance from fishing vessels and fish farms (see section 2.3.1).
4. the risk of inflicting direct injury to marine mammals (TTS/PTS), 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 (fish farms) 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.

2.3.2. Safety distance from marine mammals

To minimize risk of injury to marine mammals, a safety distance of 1000 m from observed marine mammals should be established.

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 2000 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.

During operations in the dark, when available visual efforts should be supported by use of infrared sensors to detect whale blows. 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.

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:

1. Reduce speed to less than 8 knots. Start transmissions at reduced source level (maximum 200 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 is particularly important.
2. The ramp-up requirement can be exempted if the procedure reduces the value of specific training elements (e.g. tactical sonar use). If a ramp-up is not used, there are stricter

requirements to use other risk mitigation measures, like a) avoid areas with high density of marine mammals, b) visual control of the danger zone, c) use of infrared sensors in the dark, and d) lowest possible speed.

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 narrow or constricted 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 forward 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 sonar procedure.

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 of this procedure must also be documented with the cause of the infringement. Documentation should be archived for at least 1 year.

4. Implementation

This *Procedure for use of active sonar in Norwegian waters* will enter into force April 1st 2021. At the same *time Instruction for use of active sonar in Norwegian waters* dated April 1st 2015 will enter out of force.

B Link between the Sonar Instruction and map layers in SONATE

Based on the scientific basis for the sonar instructions (chapter 5), the following criteria is used to link the Sonar instruction to maps in SONATE. These criteria defines areas/periods where the different instructions apply. The numbers below refer to the relevant section of the Sonar instruction (Appendix A):

2.2.1. Marine mammals high abundance:

Intense sonar exercise should be avoided in areas/period with known high abundance of marine mammals. This is typical areas/periods were animals aggregate to breed (seal colonies) or feeding areas. Beaked whales are considered a particular sensitive species, and lower density feeding areas are therefore also included.

SONATE maps: harp seals breeding area (Feb-March), hooded seal breeding area (March-April), harbor seal high density breeding (June-Sept), grey seal breeding areas (Sept-Oct), killer whales winter feeding area (Sept-March), northern bottlenose whales feeding (Jan-Dec), fin whale feeding areas (March-Oct).

2.2.2. Whaling and whale safaris:

Intense sonar exercises in areas/periods where commercial whale watching or whaling happens regularly should be avoided. Whale watching areas are not registered anywhere, and the SONATE database might therefore not be complete. Whaling areas/periods are defined based on catch statistics from the Fishery Directorate. The number of whaling vessels in Norway are low and dropping (<15 ships the past years), but occasionally the whaling activity can be high within the whaling areas. The whaling period is April-September. Details of whaling activity can be found under the “Fishing activity” (harpoon = whaling).

SONATE Maps: whale safari Nov-Jan, whale safari June-August, whaling areas 2017-2019 Apr-Sept

2.2.3. Fishery and fish farms – operational procedures (2.3.1.)

Safety zones apply to all fish farms with fish and fishing vessels engaged in active fishing. The safety zone procedure is defined in section 2.3.1 of the Sonar instruction (Appendix A). Aquaculture (fish farm) concession locations based on data from the Fishery Directorate are given in SONATE. Not all locations contain fish at all times, because aquaculture sites has to be regularly sanitized. The Fishery Directorate has updated information on the status of each fish

farm. Fishing activity is indicated in SONATE as vessel tracks during active fishing based on the vessel monitoring system that the Fishery Directorate has on all fishing vessels. Data from 2017, 2018, 2019 are included per month, different fishing gear are indicated as color of the tracks (seine, trawl, nets, line, harpoon, other). The data can be used for planning purposes, to avoid areas with dense fishing activity, but the safety zone is defined by the position of each fishing vessel and fish farm during the operation.

SONATE maps: Aquaculture (Jan-Dec), Fishing activity 2017 (monthly), Fishing activity 2018 (monthly), Fishing activity 2019 (monthly).

2.2.4. Marine mammals – operational procedures (2.3.2-2.3.6)

In areas where marine mammals are expected to be encountered, operational procedures to minimize risk should be used. The operational procedures are defined in section 2.3.2-2.3.6 of the Sonar instruction (Appendix A). Areas are defined as area with a moderate or high risk of encountering marine mammals.

SONATE maps: grey seal high density (Jan-Aug, Nov-Dec), grey seals medium density (Jan-Dec), grey seals distribution (Jan-Dec), harbor seal high density (Jan-May, Oct-Dec), harbor seal distribution (Jan-Dec), harp seals breeding area (Feb-March),-harp seals moulting area (May-June), walrus distribution (Jan-Dec), fin whale feeding areas (March-Oct), harbor porpoise distribution (Jan-Dec), harbor porpoise high density (Jan-Dec), killer whale winter area (Sept-March), humpback whale feeding area (May-Nov), beluga distribution (Jan-Dec), minke whale feeding area (April-Sept), northern bottlenose whales feeding (Jan-Dec), sperm whale feeding area high density (Jan-Dec).

About FFI

The Norwegian Defence Research Establishment (FFI) was founded 11th of April 1946. It is organised as an administrative agency subordinate to the Ministry of Defence.

FFI's mission

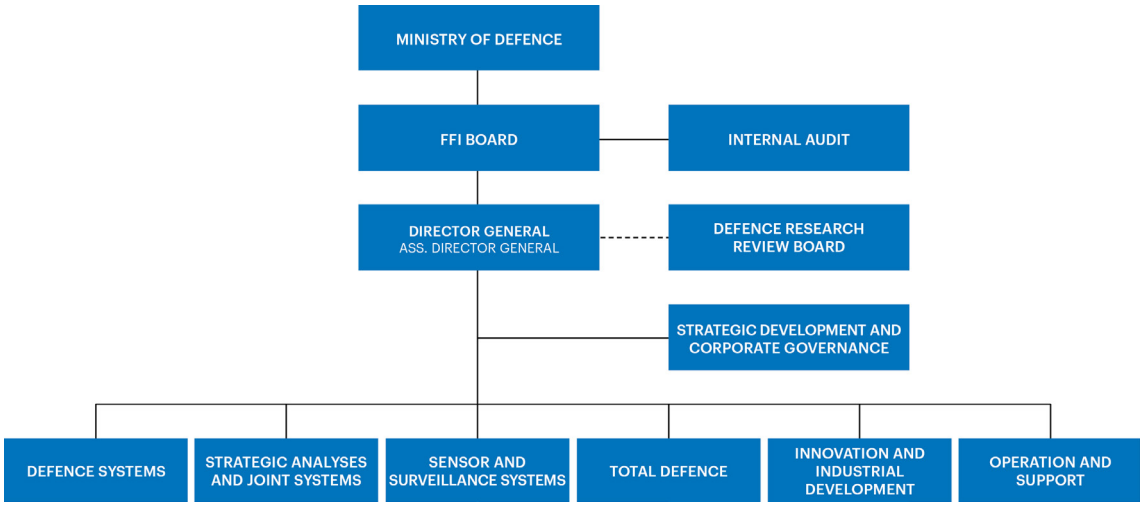
FFI is the prime institution responsible for defence related research in Norway. Its principal mission is to carry out research and development to meet the requirements of the Armed Forces. FFI has the role of chief adviser to the political and military leadership. In particular, the institute shall focus on aspects of the development in science and technology that can influence our security policy or defence planning.

FFI's vision

FFI turns knowledge and ideas into an efficient defence.

FFI's characteristics

Creative, daring, broad-minded and responsible.



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