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Behavioural responses of cetaceans to naval sonar signals in Norwegian waters – the 3S-2012 cruise report

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English summary

Marine mammals are sensitive to sound in their environment and there is a continuing need to quantify the sensitivity of the animals to behavioural disturbance, in order to regulate the use of powerful anthropogenic sound sources and recommend procedures to mitigate impacts. The $3S^2$-project will produce quantitative information on how cetaceans react to sonar and relevant control sounds. This report summarizes the achievements, activities and data collection of an international research trial (3S-2012) conducted in Norwegian arctic waters as part of this project. The overall objectives of the trial were to investigate the effect of sonar on three primary target species; humpback whales, bottlenose whales and minke whales, and to investigate the effectiveness of ramp up using the humpback whale as a model.

The trial took place between Bear Island and the west coast of Spitsbergen in June 2012 using FFI research vessel HU Sverdrup II. During the trial a total of 400 sightings of over 900 individual marine mammals were recorded. We deployed 16 DTAGs, 13 to humpback whales and 3 to fin whales as a secondary target species. These tags recorded a total of more than 172 hours of data. We completed 7 full experimental cycles with humpback whales, which included recording of effect of tagging, pre exposure baseline behaviour, and multiple sonar exposure experiments. Playback of killer whale and control sound were conducted for 5 of the 7 experiments. Photo identification studies were undertaken as well as biopsy collection to look at gender and body condition of the experimental subjects. Additional data on environmental conditions such as prey field, background noise and sound propagation conditions were also collected. However, no tags were deployed to any minke whales, despite a significant effort to try to tag them, nor to northern bottlenose whales, because none were sighted, and therefore no experiments were carried out on those two target species.

After two of three planned field seasons under the $3S^2$-project the dataset is very unbalanced in the sense that we have conducted 10 sonar exposure experiments to humpback whales, 1 to a minke whale and no experiments to bottlenose whales. For next year's trial (3S-2013) we therefore recommend a much stronger focus on the presumably more sensitive species, minke whales and bottlenose whales. The consequence of this should be that we change field site and or period to optimize our chances of success with those target species.

Norsk sammendrag (Norwegian summary)

Sjøpattedyr er følsomme for lyd i deres miljø, og for å kunne regulere bruken av intense akustiske kilder er det et behov for å kvantifisere hvordan menneskeskapt lyd påvirker deres atferd og hvilken biologisk relevans en slik påvirkning har. $3S^2$-prosjektet har som målsetning å generere kvantitativ informasjon om hvordan hval reagerer på militære sonarpulser og relevante kontroll-lyder. Denne rapporten oppsummerer aktivitetene, data innsamlingen og utfallet fra et internasjonalt forskningstokt som ble gjennomført som en del av dette prosjektet. Hovedmålsetningen med 3S-2012 toktet har vært å undersøke hvordan vågehval, nebbhval og knølhval reagerer på militære sonare. I tillegg ønsket vi å studere i hvilken grad den såkalte «*ramp up*» prosedyren reduserer risikoen for skade på sjøpattedyr. Resultatene vil kunne brukes som grunnlag for retningslinjer for sonaroperasjoner.

3S-2012 toktet foregikk mellom Bjørnøya og vestkysten av Spitsbergen i juni 2012 med FFIs forskningsfartøy HU Sverdrup II. Under 3S-2012 toktet har vi gjort 400 observasjoner av over 900 individer av sjøpattedyr. Vi har satt på 16 DTAG'er (sensorpakker); 13 på knølhval og 3 på finhval. Disse sensorpakkene har registrert til sammen 172 timer med data. Vi har gjennomført 7 eksperimenter med knølhval. Disse inkluderer registrering av effekten av selve merkingen, normalatferd før og eventuelle endringer i atferd under sonareksponeringer og under eksponering for lyden av spekkhoggere som spilles tilbake til dyrene. Vi har også tatt fotografier av rygg- og halefinne samt vevsprøver for å kunne bestemme kjønn og kondisjon. I tillegg ble det registert data om miljøet hvor disse eksperimentene ble gjennomført. Bakgrunnsstøy, lydhastighetsprofiler og temperturpofiler samt tilstedeværelse av byttedyr i vannmassen ble registert. Det ble derimot ikke merket noen vågehval eller nebbhval og det ble derfor ikke gjennomført noen eksperimenter på disse.

Etter to av tre planlagte feltsesonger i $3S^2$-prosjektet er vårt samlede datasett ubalansert i betydningen at vi har gjennomført 10 eksperimenter på knølhval, 1 eksperiment på vågehval og ingen på nebbhval. Vi anbefaler derfor at neste års tokt (3S-2013) fokuserer mye sterkere på de antatt mer sensitive artene; vågehval og nebbhval. Konsekvenser av dette bør være at operasjonsområdet og periode endres for å optimilisere mulighetene med disse artene.

Contents

Preface

The 3S-2012 trial was conducted as part of the $3S^2$-project by the 3S-group. We are an international research consortium with the aim to investigate behavioral responses of cetaceans to naval sonar signals, in order to establish safety limits for sonar operations. The 3S-2012 trial was the second of three planned sonar trials within the $3S^2$-project. During these trials, field experiments are conducted where target whales are tagged and their behavior observed before during and after exposure to naval sonar signals and control sounds. The execution of field experiments, such as 3S-2012, in high Arctic waters requires very special skills and equipment, not to mention incredible endurance. This report summarizes the outcome of the, in many ways, most successful trial conducted by the 3S-group. This success was accomplished by a team of 17 scientists from 7 different countries (Norway, The Netherlands, USA, Portugal, New Zealand, Denmark and France) in addition to the crew of 7 on the research vessel HU Sverdrup II. The research group included people with background in biology, underwater acoustics, oceanography, electronics, mechanical engineering, environmental science and operational sonar use.

Group photos: *The most important components of the trial; the scientific team (left) and ship's crew (right). The science team, front row left to right; Lars Kleivane, Machiel Oudejans, René Dekeling, Lise Doksæter Sivle, Fleur Visser, Charlotte Curé, Paul Ensor. Back row, left to right: Frans-Peter Lam, Thomas Sivertsen, Mark van Spellen, Eva Hartvig, Ricardo Antunes, Sander van IJsselmuide, Petter Helgevold Kvadsheim, Rune Roland Hansen, Paul Wensveen, Patrick Miller. The ship's crew, from left to right: Notre Chef de Cuisine Olav Reknes, First Officer Terje Haugen, Chief Engineer Erling Elias Olsen, Captain Johnny Remøy, Steward Evy Rønnes, Able Seaman Ole Martin Jakobsen and even more Able Seaman Henning Bergsnes. A very able group of people that made things possible for the scientific team!*

The main partners of the $3S^2$-project conducting the 3S-2012 trial are:

- The Norwegian Defense Research Establishment (FFI)
- The Netherlands Organization for Applied Scientific Research (TNO)
- Sea Mammal Research Unit (SMRU), Scotland
- Woods Hole Oceanographic Institution (WHOI), USA

In addition the following organizations are contributing to the project through their association with one or several of the 3S-partners:

- Institute of Marine Research (IMR), Norway
- LK-ARTS, Norway
- Kelp Marine Research (KelpMR), The Netherlands
- Balena Research Ltd, New Zealand

The $3S^2$ research project is mainly funded by;

- The Norwegian Ministry of Defence
- The Netherlands Ministry of Defence
- Office of Naval Research, USA

In addition we have also received financial support from;

- WWF-Norway
- DGA, French Ministry of Defense
- TOTAL foundation
- The Norwegian Research Council
- Bleustein-Blanchet foundation

3S: *The 3S-logo with the symbols of the main partners and sponsors*

1 Introduction – cruise objectives and tasks

Marine mammals are sensitive to sound in their environment. There is a continuing need to quantify the sensitivity of these animals to behavioural disturbance, and determine how potential behavioural changes may affect biologically significant activities, in order to regulate the use of powerful anthropogenic sound sources and design procedures to mitigate impact. This study will produce quantitative information on how cetaceans react to sonar and relevant control sounds. Behavioural responses to naval sonar are thought to be a factor in cetacean stranding events, which have included two of our target species; minke whales and northern bottlenose whales. Allied navies have a shared responsibility to address this environmental issue, although specific regulations and species of concern will vary nation by nation.

Recent research conducted in Norwegian waters by our 3S research group, and by the BRS team at AUTEC and SOCAL have established that behaviour of individual animals and the groups in which they live can be studied in very fine detail during controlled sonar exposure experiments which involve the use of tag devices and visual and acoustic monitoring. These studies are currently providing critical data on behavioural reaction thresholds of several different species. Such data are needed to quantify the risk of sonar exposure to cetaceans and to establish safe operating procedures. The "Ramp-up" procedure already implemented by some navies, consist of a gradual increase of source level upon start of transmissions, in order to allow animals an opportunity to evacuate the immediate vicinity of the source before sound levels reaches harmful levels. Thus, this procedure is assuming that the animal responds to the sonar signals by an avoidance response and that this response lowers the risk of more severe effects such as hearing impairment. Although intuitively useful, this procedure has been controversial between scientists, environmental groups and naval operational decision makers, because the mitigating effect of ramp-up has never been documented and it might influence the effectiveness, realism and fidelity of the training.

This report summarizes the achievements, activities and data collection of an international research trial conducted in Norwegian arctic waters in June 2012. The data collected are currently being analysed and final results and recommendations will be published in suitable formats later.

1.1 Cruise objectives

Investigate behavioral responses of cetaceans to naval sonar signals, including studies of the effectiveness of Ramp Up in order to establish mitigation measures for sonar operations.

1.2 Cruise tasks

The objective of the trial will be met through the execution of the following specific primary and secondary tasks:

1.2.1 Primary tasks

1. Tag minke whales and northern bottlenose whales with DTAG and record vocal-, movement- and surface behavior, and thereafter carry out sonar dose escalation experiments (SDE) where the tagged animals are exposed to LFAS sonar signals and control experiment.
2. Tag humpback whales with DTAGs and record vocal -, movement- and surface behavior, and thereafter carry out sonar ramp-up experiments where the tagged animals are exposed to LFAS sonar signals and control experiments.

1.2.2 Secondary tasks

1. Tag fin whales with DTAG and thereafter carry out sonar dose escalation experiments.
2. Carry out control experiments where tagged animals are exposed to a playback of killer whale sounds and a reference sound.
3. Tag animals and record natural undisturbed behavior of target species.
4. Collect group behavioral data to investigate the effect of tagging.
5. Collect data on relevant environmental conditions in the study area; prey field mapping and measurements of ambient noise and acoustic propagation conditions.
6. Test the use of the ARTS system to launch the next generation DTAGs (DTAG3) on to our target species.
7. Biopsy sampling of target species.
8. Collection of bio-acoustic data using towed arrays.

Secondary tasks were given a lower priority if they interfered with our ability to accomplish the primary tasks.

1.3 Structure of cruise report

The first part of this report (chapter 1-4) gives and overview of the trial and the outcome, and is intended for the external readers within the scientific community and sponsors. The report also contains a list of appendices with additional details and documentation of our data collection. These appendices are mostly intended for internal use within the 3S-research group, for data analysis and planning of future trials.

2 Method – equipment and experimental procedure

2.1 Equipment

Conducting controlled sonar exposure experiments on free ranging cetaceans at sea requires a variety of sophisticated equipment. Detailed description of ship, tag boats, tagging equipment, tags, sonar source and towed acoustic arrays are given in the 3S-2012 cruise plan (Appendix E).

2.2 Experimental procedure

The operation cycles through different phases; a search phase, a tagging phase, a pre-exposure phase, an exposure phase, a post-exposure phase, and then after a data checking and resting phase we return to search phase. The default timing of the different experimental phases varies from species to species and is summarized in Figure 2.2. The details of our experimental procedures are given in the cruise plan (Appendix E), but are summarized below.

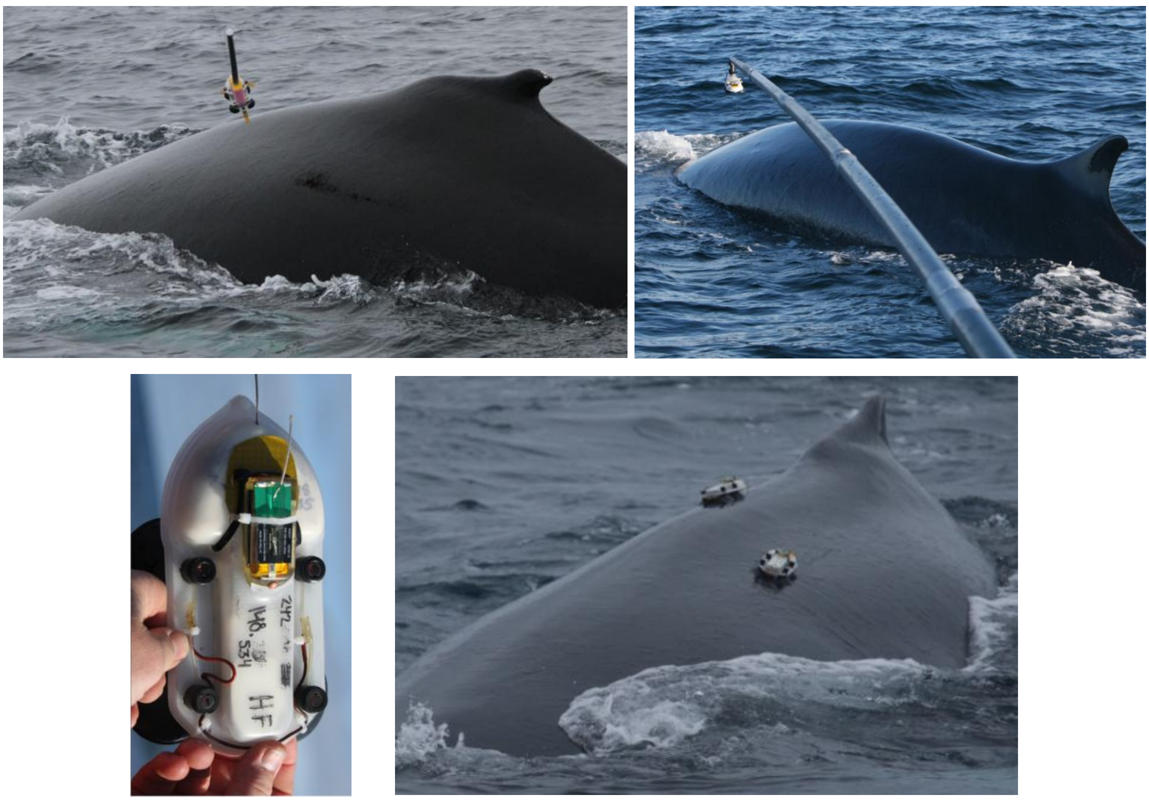


Figure 2.1 The ARTS system (upper left) and the cantilever long pole system (upper right) were used in parallel to tag humpback whales and fin whales with suction cup attached DTAGv2 tags with a Sirtrack GPS logger piggybacked to it (lower left). Animals were often double tagged to increase the chance that at least one tag stayed attached for the entire duration of the 15 hr experiment (lower right). Photo clockwiseee; Paul Ensor, Rune Roland Hansen, Paul Ensor, Lars Kleivane.

The search for target species was done using by a visual team from the elevated platform on the roof of the bridge of the Sverdrup and an acoustic team operating a towed array (Delphinus). During dedicated search for the baleen whale target species, the acoustic effort turned out to be of little use since the animals are not vocalizing (Kvadsheim *et al*., 2011), so instead visual effort was maximized. When a target species was detected, group and surface behavioral observations were performed by the visual team for 60 min before a tag boat team was launched to deploy a tag on the animal and collect photographs for photo-identification of individuals and documentation of tags. DTAGv2 with the addition of a GPS logger attached on top was the primary tag used, with non-invasive suction cup attachment for all species except the minke whales. For minke whales the suction cups were replaced by minimally invasive barbs. This was done because previous experience has shown that suction cups do not stick to this species (Kvadsheim et al. 2011). Collections of group and surface behavioral observations continued from Sverdrup also during tagging and for 60 min after termination of tagging attempts to investigate any effects of tagging on the behavior. After a successful tag deployment, attempts were made to put on a second tag on the same animal for 1 hr before tagging ceased and the tag boat team returned to Sverdrup. The tagged animal was initially tracked visually by the marine mammal observer team on Sverdrup. After about 2 hours a visual team was deployed in a specially equipped Man Over Board boat (MOBHUS, also referred to as “tag boat 2”) with an observation platform in the aft with space for two observers and tracking equipment. From then on and until tag recovery the tagged animal was tracked from MOBHUS and visual observations of surface and group behaviour were recorded from there. Every 3-4 hr the 4 people on MOBHUS were replaced by a new and rested team. After a period of 3-6 hrs collecting pre exposure data on the behaviour of the tagged animal, the first approach by the source vessel was initiated. The first approach was a silent approach where the source vessel approached the animal with the towed sonar source deployed but without any active transmissions. During the second and third approach the source ship transmitted a 1.3-2.0 kHz hyperbolic up-sweep signal. The time interval between approaches was at least 1 hr. If the tagged animal was a humpback whale, a Ramp-up procedure was used during the approaches, while if it was a minke whale or a bottlenose whale a Dose-escalation procedure would be used.

During the Ramp-up experiments conducted on humpbacks the source vessel approached the animal at a speed of 8 knots on an estimated intercept course to attempt to achieve a closest point of approach (CPA) of 0m. Transmission started 5 min before the estimated CPA and no course changes were allowed after start of transmission. At CPA the transmitted source level reached maximum level (214 dB re 1µPa @ 1m) and transmissions continued for another 5 min while the source ship still continued on the same course. The specific ramp-up scheme used was carefully chosen based on simulations of the potential outcome (von Benda Beckmann et al. 2011). Two other types of vessel approaches, the Silent and No-ramp-up runs, served as controls, and were conducted using exactly the same navigational protocol and timing as the Ramp-up run, but with different transmission schemes. No dose escalation experiments were conducted during the 3S-2012 trial.

After completion of the sonar exposure and a 1 hr post exposure period, the animal was exposed to playbacks of killer whale sounds and a reference noise signal. Around the time of tag release, attempts were made to collect a biopsy sample of the tagged animal. After tag recovery, the MMO team on MOBHUS returned to Sverdrup. All collected data were subsequently downloaded, checked and backed up before we returned to search mode to look for the next target animal as soon as the crew were reasonably rested.

Time		**Tag on = T0**		**T1**	**T2**	**T5**	**T6**	**T7**		**T9**	**T10**	**T11**		**T13**	**T17**	Tag off!
Phase	Search-Sighting	Pre tagging 1 hr	Tagging ?	2nd tagging	Post tagging	Pre exp.	Silent		**Sonar 1**		**Sonar 2**		K W 1	1hr	K W 2	Post exp. Biopsy	Tag recovery CTD Data checking Resting Search
Tracking from	HUS					MOBHUS											
Watch/ Team						A (4hrs) T1			B (4 hrs) T2				C (3 hrs) T1			D (4 hrs) T2	

Figure 2.2 Default timing of the different phases of the ramp up experiments on humpback whales. The grey row on top is a time scale (in hrs). T0 is the time of the first tag attachment. The blue row indicates the different phases of the experiment. Sonar was either an approach with or without ramp up. The yellow row indicates from which platform the tracking of the focal animal is conducted. The green row indicate which MOBHUS, HUS and Socrates teams is on watch. For bottlenose whales, minke whales and fin whales a dose escalation procedure was planned to be used where the timing of the experiments would vary from species to species (see Appendix E for details).

2.3 Permits and risk management

All animal experiments were carried out under permits issued by the Norwegian Animal Research Authority (Permit No. S2011/38782), in compliance with ethical use of animals in experimentation. The research protocol was approved by the University of St Andrews Animal Welfare and Ethics Committee and Woods Hole Oceanographic Institution's Animal Care and Use Committee. In accordance with the permit, dedicated mitigation observations by nominated observers on the source ship were made to assure that no marine mammals were too close to the source and were thus exposed to received sound pressure levels over 180 dB re 1μPa, as required by the permit. The stand-off range between source and animals during full power transmission was 50m. An emergency shut-down procedure was implemented and exercised, to immediately stop transmissions if any animals were approaching this safety zone or if any animal showed any signs of pathological effects, disorientation, severe behavioural reactions, or if any animals swam too close to the shore or entered confined areas that might limit escape routes. During the 3S-2012 trial, no emergency shut-down was necessary.

3 Results – overview of operation and achievements

3.1 Overview of operation

The 3S-2012 trial took place between Tromsø and Svalbard, 70°-80° northern latitude and 6°-21° eastern longitude, between June 1st and July 1st 2012 using FFI research vessel HU Sverdrup II. The most limiting factors for this type of operation are the weather and the availability of study animals. Since the 3S-2011 trial was conducted in the same area and at the same time of year, it has some relevance to compare the weather and number of target whale sightings during the two trials.

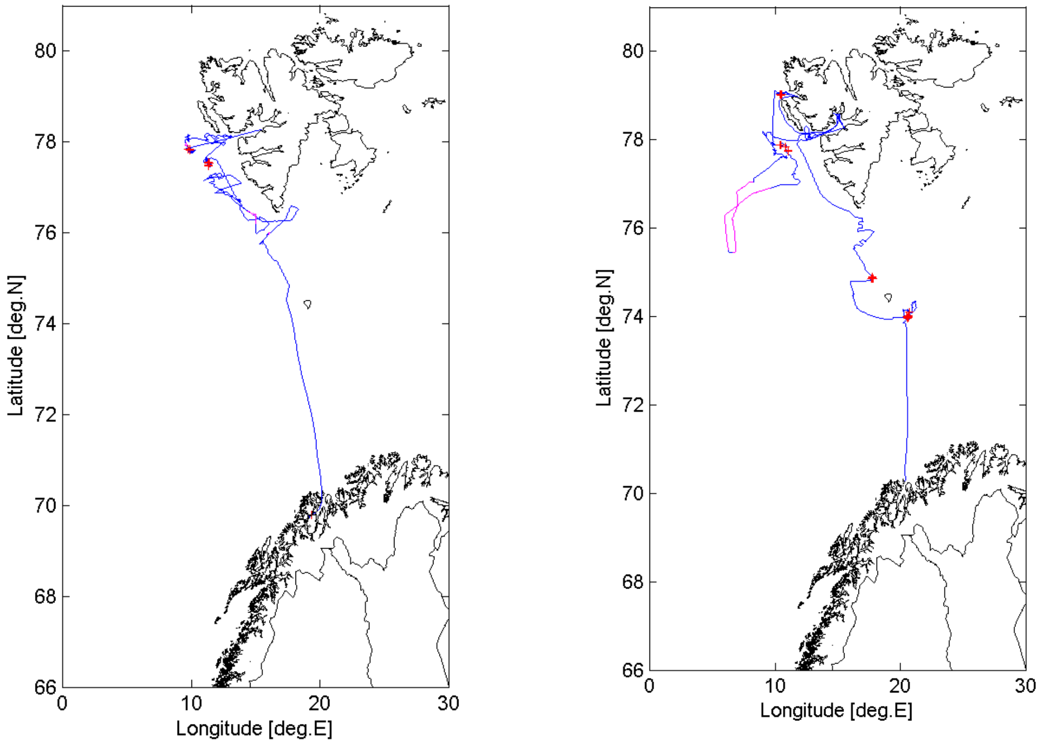


Figure 3.1 Sail tracks for the first half (June 1-14) (left) and second half (June 15-30) (right) of the trial. Socrates transmissions are shown in red. Towing of Delphinus array during acoustic survey are shown in magenta. See Appendix D for daily sail tracks.

As a rule of thumb we consider sea state 0-1 good working conditions, whereas at sea state 2-3 tagging approaches to whales by our small tag boats becomes increasingly difficult and very dependent on the wind strength. At sea states 4 and above we are non-operational. Of the 31 days of operation this year we were transiting or docked for technical reasons (mainly installation and de-installation) for 6 days, which left 25 working days (same as last year). Of these 25 days, we had good working conditions for 15 days, we were limited by weather for 4 days and prevented from working because of the weather for 6 days. Last year these numbers were 18 days, 5 days and 2 days, respectively. The weather statistics the past 10 years imply that on average we should have 20-25 days of working conditions in June in this area. Thus, the weather has been within the normal range both years, but conditions in 2011 were somewhat better than this year.

Table 3.1 The weather at noon (local time=UTC+2) as recorded in the ships log. Wind force is given on the Beaufort scale.

Date	Area	Wind	Weather	Sea state
June 01.	Tromsø	NW1	Clear sky	1
June 02.	Tromsø-Grøtsundet	SW2	Changing cloud cover	1
June 03.	Tromsø bank	E5	Clear sky	1
June 04.	Bear Island	E6	Clouded	4
June 05.	Storfjord Channel	N2	Changing cloud cover	2
June 06.	Hornsund bank	E2	Changing cloud cover	2
June 07.	Hornsund Bank	S2	Changing cloud cover	2
June 08.	Hornsund Bank	SE3	Changing cloud cover	1
June 09.	Bellsund bank	SE2	Clear sky	1
June 10.	Icefjord Channel	NE2	Clouded	1
June 11.	Tampen Bank	N2	Clouded	2
June 12.	Icefjord Banks	E2	Changing cloud cover	2
June 13.	Longyearbyen	SE3	Clouded	2
June 14.	Isfjord Channel	E1	Rain	1
June 15.	Shelf break off Spitsbergen	N3	Changing cloud cover	3
June 16.	Knipowich ridge	NW2	Changing cloud cover	1
June 17.	Knipowich ridge	W4	Clouded	2
June 18.	Bellsund bank-Isfjord bank	NE2	Clouded	2
June 19.	Kongsfjord Channel	NE3	Rain	1
June 20.	Ny Ålesund	SE3	Changing cloud cover	3
June 21.	Kongsfjord-Isfjord Channels	SW6	Changing cloud cover	2
June 22.	Nordfjord	SW4	Clouded	1
June 23.	Nordfjord-Isfjord	SW2	Changing cloud cover	1
June 24.	Isfjord Channel-Spitsbergen	N4	Clouded	3
June 25.	Storfjord Channel	NE2	Changing cloud cover	2
June 26.	Kveithola	W1	Clouded	1
June 27.	Humpback ridge-Barents Sea Channel	NE3	Changing cloud cover	2
June 28.	Leirdjupet	W3	Changing cloud cover	2
June 29.	Leirdjupet-Barents sea Channel	SW2	Changing cloud cover	2
June 30.	Tromsøflaket-Tromsø	SW2	Changing cloud cover	3
July 1.	Tromsø	SW2	Changing cloud cover	1

Regarding availability of whales, our strong impression was that we spent more time searching for target species in the beginning of the trial this year compared to last year, but particularly for humpbacks there was a high sighting rate towards the end of the trial. The baleen whales migrate into this area in the spring and early summer, and we speculate the cold Arctic 2012 spring might have delayed the bloom of plankton and therefore also the northern migration of the whales. Our marine mammal observers recorded 400 sightings this year of a total of 906 marine mammals (Figure 3.1). Last year they recorded 544 sightings of 1694 marine mammals (Kvadsheim et al. 2011). This confirms our impression that we found less animals this year. However, if we look at the target species we found the same number of fin whales and 3 times more humpbacks this year compared to last year (Table 3.2). We found fewer minke whales this year, and no bottlenose whales (Table 3.2). The higher number of individuals observed in 2011 also reflects higher abundance of small dolphin species, which generally are found in large groups. Few sightings of dolphins were made in 2012.

We sailed out of Tromsø on June 3rd after an efficient period of installing and testing equipment and exercising the experimental drill. We had bad weather during the transit north and only on June 5th condition were good enough to man the MMO-platform and start searching for marine mammals south of South Cape. The next three weeks were spent along the west coast of Spitsbergen working with humpback whales, minke whales and fin whales, except for a short 2 days excursion off shore to search for bottlenose whales. The last few days were spent around

Bear Island working with humpback whales and minke whales before we returned to Tromsø on June 30.

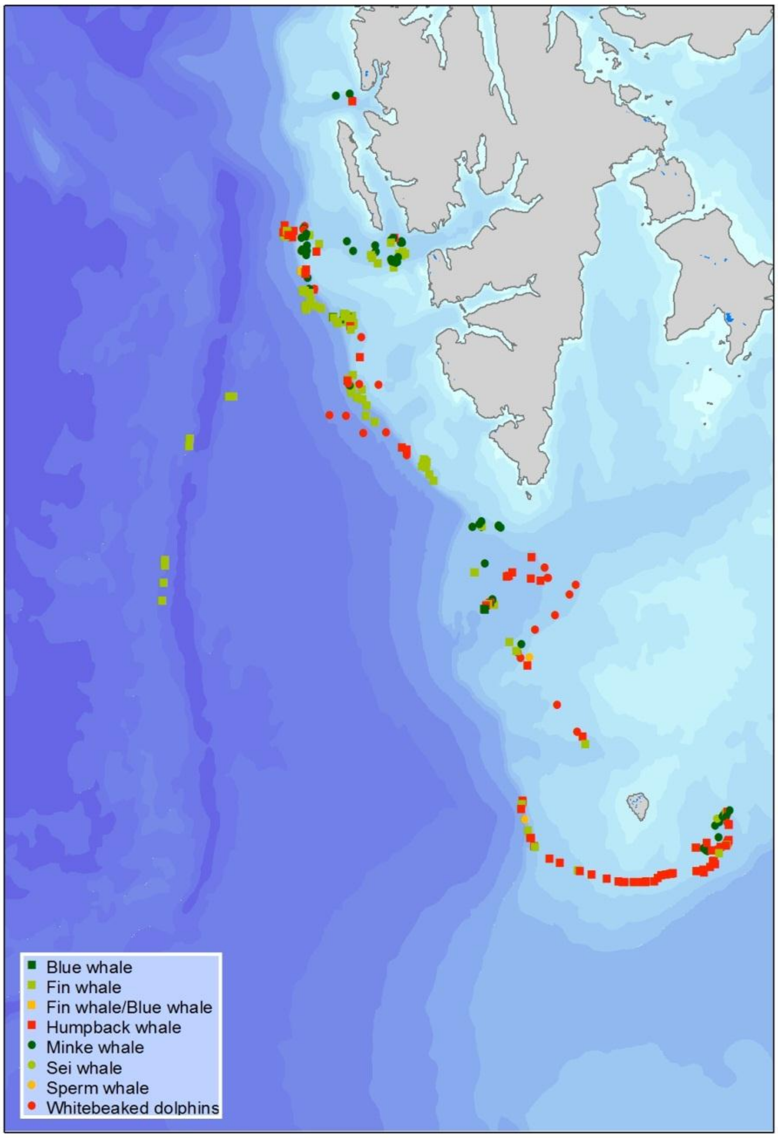


Figure 3.2 Initial sightings of marine mammals during 3S-2012.

3.2 Achievements

During 3S-2012 we deployed 13 DTAGs to 9 different humpback whales, and 3 tags to 3 different fin whales (16 tag deployments in total). We collected data during 8 experimental events with humpback whales and 3 with fin whales. Sonar exposure experiments were conducted with 7 of the 8 tagged humpbacks (in one experiment two associated whales were tagged), and the playback of killer whale sound and reference (noise) sounds were conducted with 5. Only baseline behavior data was collected on fin whales, and tag duration was generally short (0-5 hours). No tag was deployed to any minke whales nor to any bottlenose whales. The data collection of all 11 experimental events is summarized in table 3.3.

Table 3.2 Sightings of marine mammals during the 3S-2012 trial compared to the 3S-2011 trial. There were no sightings of bottlenose whales during this year's trial.

		2012		2011	
Species	**Latin name**	**Sightings**	**Best[1]**	**Sightings**	**Best[1]**
Whitebeaked dolphin	*Lagenorhyncus albirostris*	30	275	59	709
Unidentifyed dolphin		4	19	17	137
Minke whale	*Balaenopetera acutorostrata*	78	80	98	102
Sperm whale	*Physeter macrocephalus*	2	2	16	17
Fin whale	*Balaenoptera physalus*	120	169	132	169
Humpback whale	*Megaptera novaeangliae*	86	170	40	54
Blue whale	*Balenoptera musculus*	5	5	37	44
Sei whale	*Baleanoptera borealis*	2	3	1	1
"Big" cetacean		46	61	29	34
Unidentified whale		16	16	70	82
Bearded seal	*Erignathus barbatus*	1	1	0	0
Harp seal	*Pagophilius groenlandicus*	6	80	8	80
Unidentified seal		4	25	14	178

[1] Best estimate of number of animals in sightings.

Figures 3.3.-3.5 show an example of data collected during an experiment on humpback whales from 'tag-on', through a silent approach and two sonar exposure runs, as well as playbacks of killer whale and noise control sounds, until 'tag-off' 18 hrs later. On June 12th, an adult humpback whale which seemed to be strongly associated with a smaller animal was tagged (tag id. mn164a) in the outer part of the Isfjord channel (Figure 4.1). The tag stayed attached for 9 hours, before it prematurely came off. However, it was quickly picked up and redeployed on the smaller animal (tag id. mn164b), after which it stayed on until release time (another 9 hours). This allowed completion of a full experimental cycle. After tag deployment the animals were initially tracked from Sverdrup until the tracking was taken over by the tagboat (MOBHUS) team after about 1 hr (Figure 3.4). After a period of 3 hrs of pre-exposure data collection, Sverdrup approached the animals three times in a very strict pre-defined pattern. The first approach was a silent approach, whereas the second approach was a sonar exposure experiment including a 5 min ramp-up. The third approach of the source ship was similar to the second except that full power transmissions were not preceded by any ramp-up (no ramp-up control). After the sonar exposures the animals were exposed to a playback of killer whale sounds and broadband noise control sounds. In the end, the Sverdrup again took over tracking before the tag finally released after 18 hrs. Biopsy samples were collected from both animals. In-depth analysis of the type of data shown in figure 3.3.-3.5. will allow us to document potential avoidance, or changes in social behavior and dive pattern of the humpback whales during sonar exposure and compare this to natural anti-predator responses (killer whale playbacks). With the experimental design used for the sonar exposure experiments on humpback whales we will also be able to document the efficacy of the ramp-up procedure in mitigating impact to the animals.

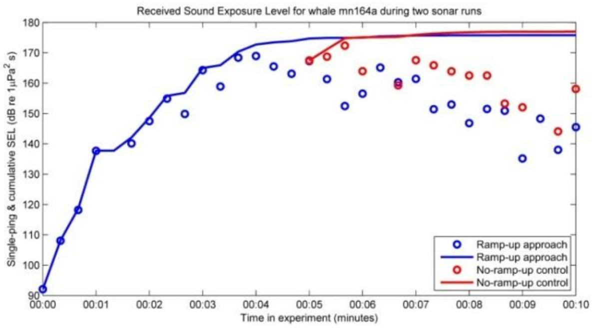


Figure 3.3 Received single ping (circles) and cumulative sound exposure level (line) of humpback whale mn164a during two sonar exposure experiments. The source ship approached on a straight course to intercept the animal. During the first approach, full power transmissions were preceded by a 5 min ramp up of the transmitted source level (blue), while the second approach was a no ramp up control (red).

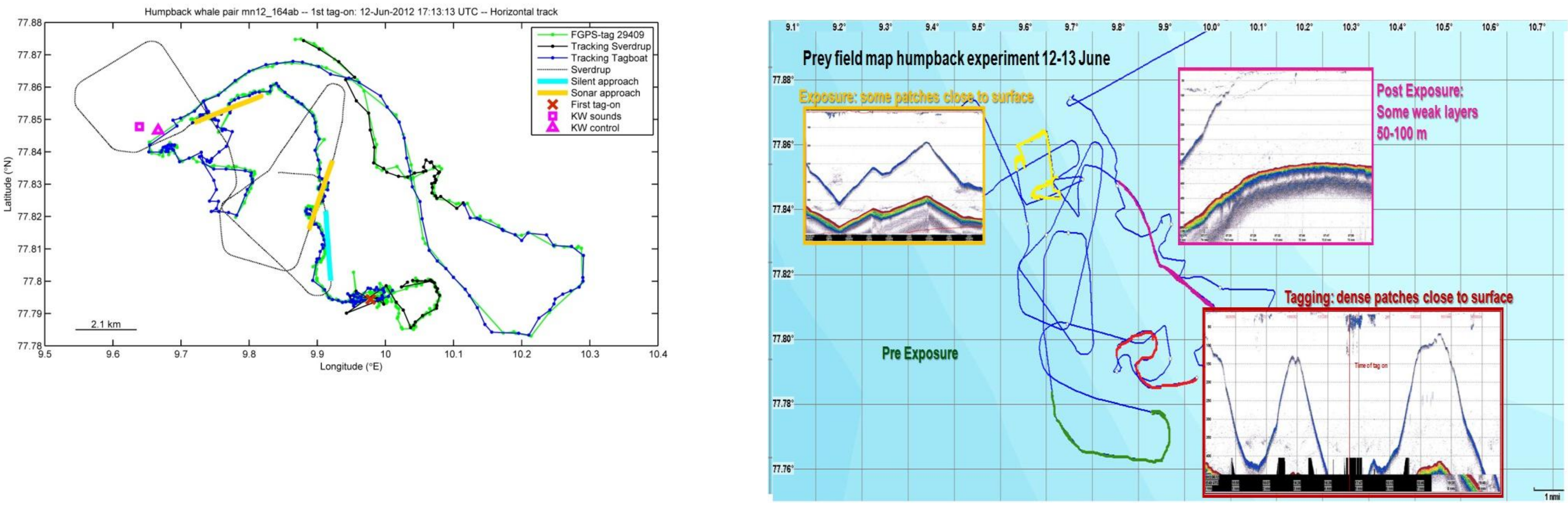


Figure 3.4 Left panel: Horizontal tracks of humpback whales mn164ab during a full experimental cycle on June 12. The source ship Sverdrup is also included in the track. In this plot the surface track of the animal is based on the fixes made by the marine mammal observers on Sverdrup or the tag boat and is overlaid with the track generated by the GPS logger on the animal. Right panel: Prey field mapping from Sverdrup in the different phases of the experiment on the pair of humpbacks on June 12 using 38 kHz echosounder.

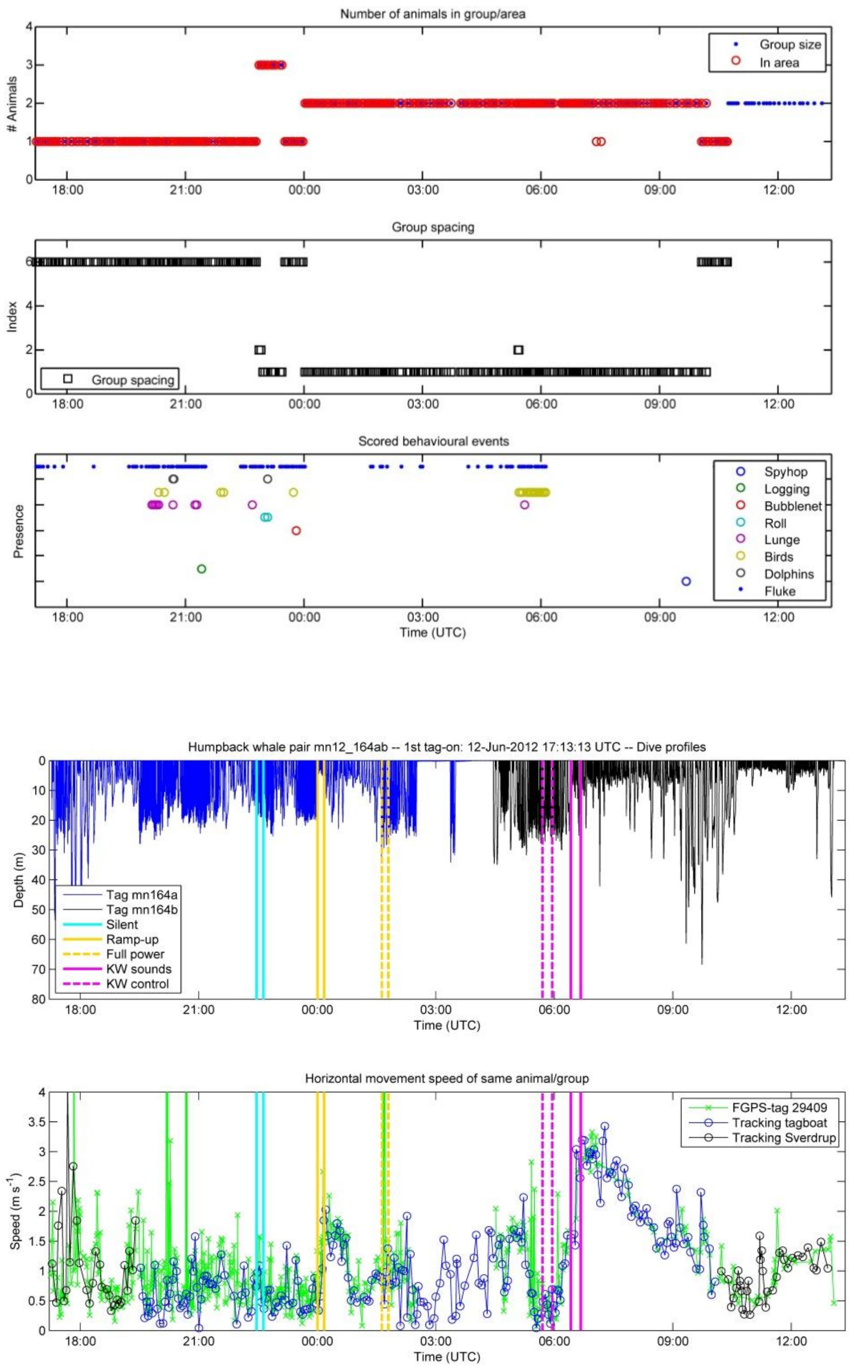


Figure 3.5 Data summary of mn164a and 164b on June 12. The two animals were strongly associated throughout the experiment and when the tag prematurely released from the biggest animal (164a) after 9hrs, it was quickly redeployed on the smaller animal (164b). Upper three panels show social behavior at the surface (Visser et al. 2011), with group size, group spacing and behavioral display events. Lower two panels show the dive record and horizontal movement speed based on the sighting and GPS-tag tracks of the animals.

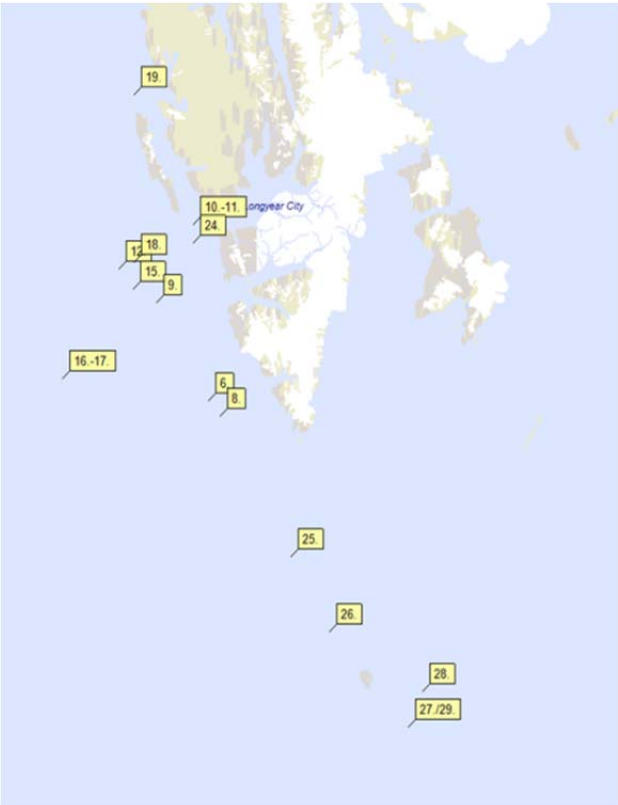
Table 3.3 Overview table of experimental events during 3S-2012, showing which datasets were collected in each experiment (Figure 2.2.). An experimental event is initiated whenever a tag is placed on an animal. Seven additional datasets were collected on the effect of tagging, but a tag was never deployed in these cases. The locations of the experiments are indicated on figure 4.1. HW=humpback whales, FW=fin whales.

Exp event ≠	Tag id	Date	Tag on whale time (hrs)	Effect of tagging	Pre exp. duration hrs.min	Silent	Ramp up	No ramp control	Killer whale playback	Control sound playback	Biopsy	Comments
HW 1	mn158a	06.06	~13	√	08:30	—	—	—	—	—	—	Lost whale, no track
HW 2	mn161ab	09.06	~13	√	03:36	√√	√	√	√	√	√	Two tags on same animal. First silent cancelled due to navigation error.
HW 3	mn164ab	12.06	~9+9	√	03:06	√	√	√	√	√	√	Tag off and re-deployed on associated animal
HW 4	mn170a	17.06	~17	√	02:57	√	√√	—	√	√	√	Two different associated animals were tagged simultaneously
	mn170b	17.06	~16	√	02:57	√	√√	—	√	√	√	
HW 5	mn171ab	19.06	~17+17	√	03:07	√	√√	—	√	√	√	Two tags on same animal
HW 6	mn178a	25.06	~9	√	03:00	√	√√	—	—	—	√	
HW 7	mn179a	27.06	~10	—	03:12	√√	√√	—	—	—	√	Fishing vessel alongside during first silent approach
HW 8	mn180ab	28.06	~15+15	√	02:49	√	√√	—	√	√	√	Two tags on same animal
FW 1	bp160a	08.06	~7	—	04:50	—	—	—	—	—	—	
FW 2	bp164a	12.06	~0	√	—	—	—	—	—	—	—	
FW 3	bp167a	15.06	~5	√	02:55	—	—	—	—	—	—	

4 Discussion – recommendations and future plans

4.1 Trial outcome

In terms of total number of tags deployed (n=16) and number of sonar exposure experiments conducted (n=7), the 3S-2012 trial is the most successful trial conducted by the 3S-group thus far. In addition to the primary objective, which was to conduct sonar exposure experiments, we also met several of the secondary objectives collecting a lot of data on responses to killer whale playback, effects of tagging, prey field mapping and we collected comprehensive photo-ID images, photo-documentation of tags and biopsy samples. These datasets add a lot of value to the primary data collected.



Date	Event
June 6.	Tagged a humpback but lost the animal, recovered the tag the next day (HW1).
June 8.	Tagged a fin whale and collected 7 hrs of baseline data (FW1).
June 9.	Tagged a humpback and completed full experimental cycle (HW2).
June 10-11.	Tried to tag minke whales.
June 12.	Tagged a humpback and completed full experimental cycle (HW3).
June 15.	Tagged a fin whale and collected 5 hrs of baseline data (FW3).
June 16-17.	Searched for beaked whales, but no sightings.
June 18.	Tagged two associated humpbacks, and completed full experimental cycle (HW4).
June 19.	Tagged a humpback and completed full experimental cycle (HW5).
June 24-25.	Tried to tag minke whales
June 26.	Tagged a humpback and completed ramp up experiment (HW6).
June 27.	Tagged a humpback and completed ramp up experiment (HW7).
June 28.	Tried to tag minke whales
June 29.	Tagged a humpback and completed full experimental cycle (HW8)).

Figure 4.1 Geographical position of main events during 3S-2012. A "full experimental cycle" takes about 15 hrs and includes a silent vessel approach, two sonar exposure sessions and playback of killer whale and control sounds. With humpback whales, the sonar approaches were designed to test effectiveness of ramp up. See also daily tracks (Appendix D) for more details.

However, the 3S-2012 trial had as a primary task to conduct sonar exposure experiments on minke whales and bottlenose whales, and we did not manage to conduct any such experiments. With bottlenose whales we had few opportunities to even search for them in their deep water offshore habitat, mostly because of bad weather forecast in that region. The effort to tag minke whales was comparable to that of humpback whales; we spent more than 14 hours trying to tag minke whales without success, whereas we deployed 13 tags to humpback whales in about 15 hours of combined tagging effort. Thus, even though the effort to tag minke whales was higher during 3S-2011 (21 hrs), there still was a significant effort this year, but without success.

4.2 Status of data collection

The 3S-2012 trial was the second of three full scale sonar exposure trials planned under the $3S^2$-project. The $3S^2$-project has as our primary objective to investigate the effect of sonar on three target species; humpback whales, bottlenose whales and minke whales, and to investigate the effectiveness of ramp up using the humpback whale as a model. So far, after two of three planned full scale trials, we have conducted 10 exposure experiments to humpback whales, each including multiple exposure sessions, and most including killer whale playbacks. We have conducted only one single sonar exposure experiment to minke whales and none to bottlenose whales (table 4.1). Given that each of the three target species were equally prioritized at the start of the project, the combined dataset is now very unbalanced.

The preliminary impressions from our experiments on humpback whales are that even though they occasionally respond to and avoid the sonar source, they are not particularly sensitive. A power analysis performed after the 3S-2011 trial also indicated that we needed in the order of 10-12 experiments to answer the question of the efficacy of ramp up properly. This is now achieved. At the same time our single experiment on a minke whale from 2011 indicates that this species might be very responsive and sensitive to sonar. Bottlenose whale is a beaked whale, and other species of beaked whales has also been shown to be particularly sensitive. Given the status of data collection on the different species, and the assessment of sensitivity, we therefore recommend to turn the focus of next year's trial away from humpback whales, and focus more strongly on minke whales and bottlenose whales.

Table 4.1 Overview table of total datasets collected under the $3S^2$-project on the three main target species.

	Sonar CEE	**Killer whale playback**	**Baseline records**
Humpback whales	**10** (2011/2012)	**8** (2011/2012)	**14** (2011/2012)
Minke whales	**1** (2011)	**0.5** (2011)	**1.5** (2010/2011)
Bottlenose whales	**0**	**0**	**0**

4.3 Recommendations and future plans

Given the fact that the amount of data collected for the different target species is very unbalanced after 2 out of 3 planned full scale sonar trials are completed, we should either adjust the scope of the project or re-prioritize between the three target species. We recommend that the scope of the project remains unchanged, and that all three species remain on the target list (humpback whales, minke whales and bottlenose whales). However, we re-prioritize into a much stronger focus on the presumably most sensitive species, minke whales and bottlenose whales, at the cost of the number of replicates achievable for the ramp up experiment on humpback whales. The species priority at the start of 3S-2013 trial should be minke whales, bottlenose whales, humpback whales and fin whales, in that order, and in particular aiming to (at least) reproduce another dose-escalation experiment on a minke whale. This priority should be re-evaluated as data collection progresses during the trial. However, effort to collect data on humpback whales and fin whales, should be on a not to interfere basis with respect to the two higher priority species. A power analysis will be conducted before next trial to assess to which extent we need more data on humpback whale. However, given the current imbalance in the $3S^2$-dataset, the outcome of such an assessment is not likely to change the order of the species priority. The highest priority for the 3S-2013 trial should be to replicate the minke whale experiment from 2011, using the CTAG from the start, to optimize our chances of getting a tag on. Alternatively, we will try to use the minimally invasive DTAG and CTAG in a parallel tagging effort.

A decision to change the species focus would also imply that going back to Bear Island-Spitsbergen would also require re-evaluation, since we have not managed to collect any data on bottlenose whales and little data on minkes whales in that area in the two previous years. Based on the original analysis of candidate field sites (Kleivane et al., 2011) we therefore recommend that combining Vestfjorden with Jan Mayen is the best option for 3S-2013. The Jan Mayen field site is not well known. Based upon the available information it has great potential as a field site for $3S^2$, although there appears to be a risk of prolonged bad weather (particularly fog), and while sightings of bottlenose whales are frequent in this area there is limited information about their distribution and abundance (Kleivane et al., 2011). It is also an isolated field site, where we will not get any kind of support and it is a long transit from any port (500-550 nmi). The risk that going to Jan Mayen could reduce the outcome of the trial therefore has to be managed carefully. The risk of failure must be balanced against the potential of success and cost of leaving Vestfjorden, which is known to be a good field site for minke whale work, before making the decision to go. Criteria for making this decision will be established as part of the cruise plan for 3S-2013. Weather and expected animal abundance in Jan Mayen versus Vestfjorden, as well as the progress of data collection on minke whales in Vestfjord has to be considered. To mitigate the risk and to assure that we get precise in situ information about weather and animals during the operation, we will establish good communication and collaboration with personnel on Jan Mayen. A systematic risk assessment, considering also other types of risk, will also be conducted and presented at the cruise planning meeting in March 2013. This risk assessment will have to consider available information about weather, animal abundance, extra need for spare parts and equipment, logistical preparation needed, crew replacement etc., using all available sources of information. It should also be considered if budgets allow for a few days extension of the trial, beyond 30 days, because of the unstable weather and long transit time to Jan Mayen. Since the CTAG and the invasive DTAG was never tested during this years's trial, it will be important to find an opportunity to test these tags on animals prior to next year's full scale trial.

The 3S-group also has plans to conduct a baseline trial in 2013. This is planned to take place in Vestfjorden in May-June and will focus on collecting baseline data on minke whales and to conduct killer whale playbacks on minke whales and pilot whales. To which extent we also need baseline data for bottlenose whales will depend on our success with this species during 3S-2013 next year.

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Appendix A Details of data collection

This appendix is mostly intended for internal documentation of the data collection. It contains more detailed descriptions of the data collected, examples of what the data looks like and data collection tables.

A.1 Ramp Up experiments on humpback whales

The experimental design of the Ramp-up experiment on Humpback whales required that the source vessel was navigated towards the animal in an identical fashion between Silent runs, Ramp-up sonar runs, and No-ramp-up sonar control runs. Because of the importance of navigation, each type of vessel approach (either with or without sonar transmissions) was conducted using two separate intercept calculators to advise the experimental coordinator on which approach path he should choose; 1) the MARIA software used by the Norwegian Navy, and RUtool specially designed by SMRU for this purpose (Figure A.1).

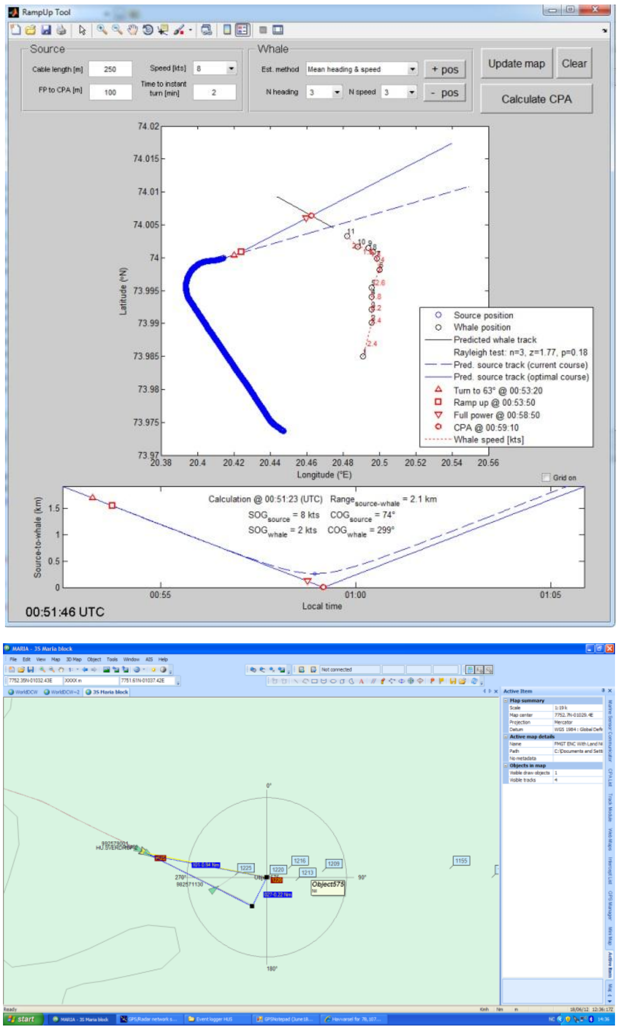


Figure A.1 *Two independent intercept calculators, the RU-tool (upper panel) and Maria (lower panel) were used for navigational support during the ramp up experiment. The positions of the whales, as reported by the MOBHUS team tracking it, were fed into the tools which then calculated the best sailing path of the source ship in order to intercept the whale closely during the approach. The two tools used somewhat different logic. The movement of the whale is often unpredictable, and while RU-tool predicted the future movements of the whale based on the last few sightings, the MARIA tool used the movement of the tracking boat (MOBHUS), which is usually within 100m of the whale. The final course correction and start time of the experiment (which is 5 mins before the calculated intercept point) was usually determined only minutes before the start of the experiment. Ultimate decisions on course changes and start of transmission were always done by the experimental coordinator based on all available information.*

One important assumption behind the Ramp-up procedure is that the animal will receive a lower total acoustic dose because it will start to avoid the source during the increase of the sound level (ramp-up). Our experimental design includes prediction of received levels during hypothetical No-ramp-up control runs based on Silent run geometry and propagation models, so conducting No-ramp-up sonar runs in the field is not essential to empirically test the efficacy (in terms of TTS/PTS) of ramp-up. During last year's cruise (3S-2011) only sonar runs including ramp-up were conducted. After assessment of last year's behavioural response data two No-ramp-up control runs were conducted this year to check our propagation models and to test for effects on the severity of the behavioural response.

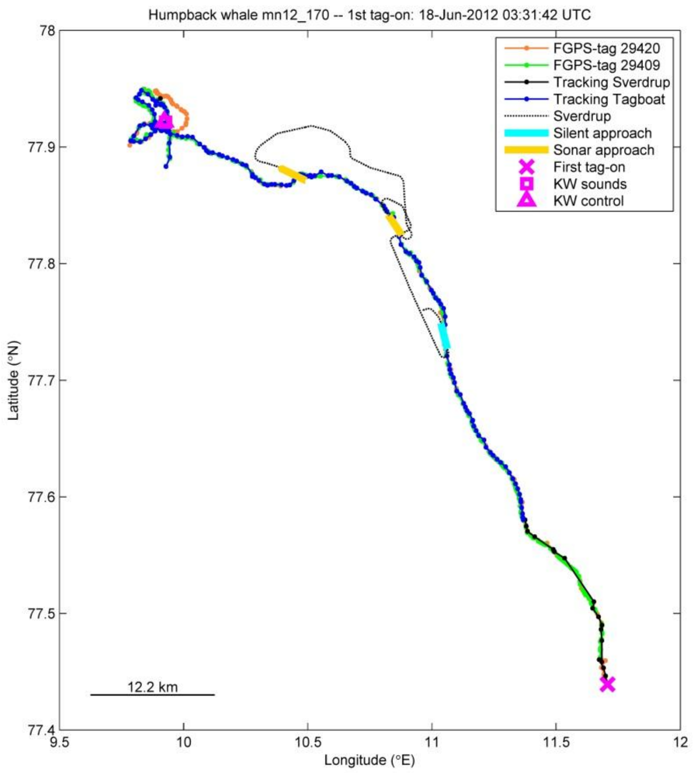


Figure A.2 *Track of two associated humpback whales during experiment mn170ab. Both animals were tagged with a combination of DTAG and GPS-logger. During most the tag record the two whales kept a relatively steady speed and course, but later switched to more sinuous movements while lunge feeding at depth and at the surface*

The humpback whale tracks showed good correspondence between the tracks produced by the GPS tag attached to the DTAG and the tracks generated by sightings from observers on either MOBHUS or HU Sverdrup (Figure A.2). Other data streams such as the depth (Figure A.3.) and 3D-accelerometer data recorded with the DTAG provide crucial information about the behaviour of the animal and will also be included in the quantitative analysis approach. The observations of the marine mammal observers during the experiments and preliminary analyses of the data suggest that both horizontal and vertical avoidance responses have occurred, but only in a subset of the experiments. Different time-domain approaches (e.g. state-space modeling) will be explored during the data analysis phase to quantitatively combine all the information from the different high-resolution data streams that were recorded during the experiments.

In total we conducted 7 experiments on 8 humpbacks whales during 3S-2012. These experiments include multiple approaches; 10 silent approaches, 14 ramp up approaches and 2 no-ramp up control approaches. An example of the data streams from one experiment is shown in figure A2-A.3. Another example (experiment mn164ab) is shown in figures 3.3-3.5 and all experiments are summarized in table 3.3.

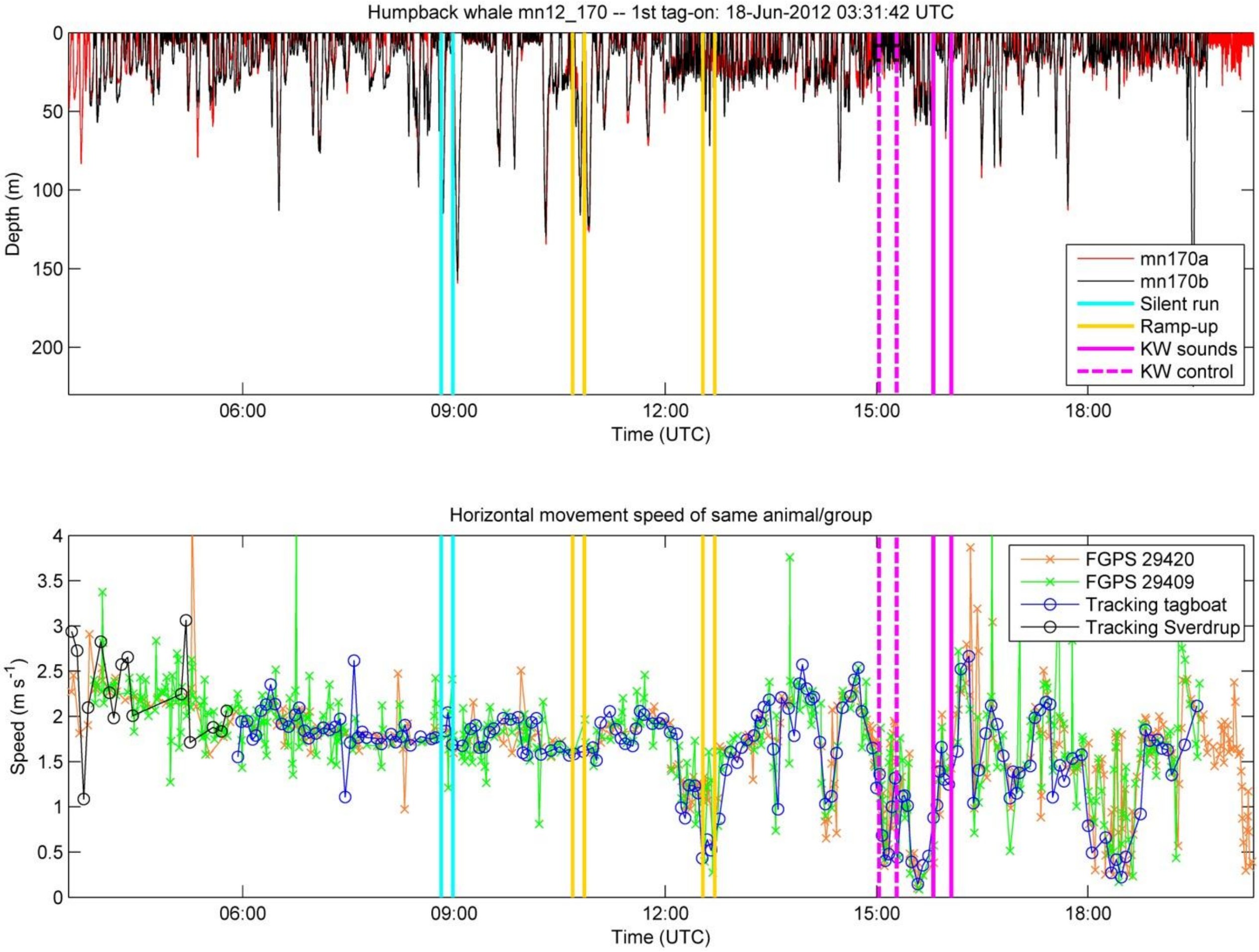


Figure A.3 Dive record (upper panel) and horizontal movements speed (lower panel) of two associated humpback whales during experiment mn170ab. The experimental conditions are indicated on the upper panel; blue lines = silent approach, green lines = ramp up approaches, magenta lines = playback of killer whale and control sounds.

A.2 Prey field mapping

Acoustic data from the ships echosounder (Simrad ER 60, 12, 38 and 120 kHz) were collected during all phases of the experiment; searching, tagging and CEE. These can be used to map the distribution of available prey in the area. Data are collected along Sverdrup`s track, and therefore not in the exact position of the tagged animal, but it will give an overview of the spatial and temporal distribution of prey in the area. Figures A4 to A6 provide some examples.

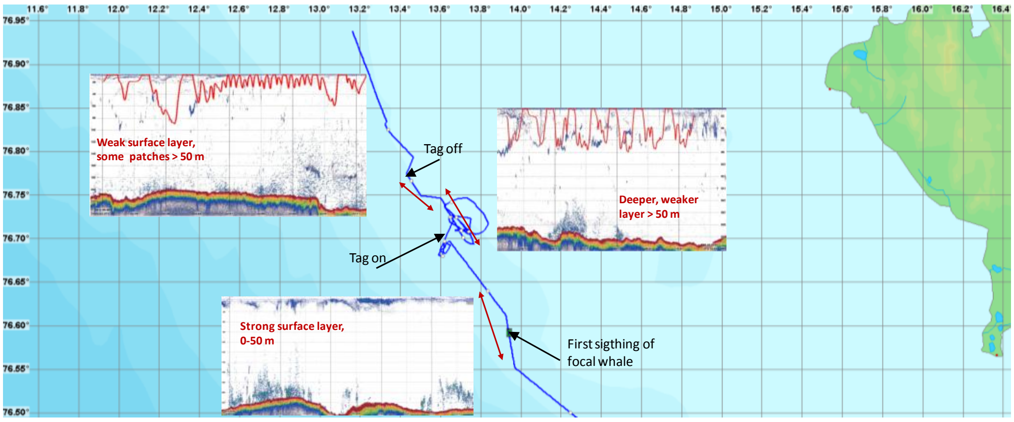


Figure A.4 *Prey field mapping for fin whale bp160a tagged on June 8. Map showing track of Sverdrup in blue, with example of echograms from some part of the track, indicated by red arrows. First echogram is from the area where the focal fin whale was sighted and while following it for the pre-tagging and tagging period. Second echogram represents the area were the whale stayed for most of the period it was tagged, where the whale was moving in circles in the same area for approximately 4 hours. The dive profile (superimposed on the echograms in red) has the same temporal window as the echogram, and assuming the echogram is representative for the area where the whale was, the diving depth seem to correspond to a layer of potential prey localized at 50-100 m depth. Based on the matching depth of dives and location of acoustic backscatter as well as the circular movement in the same area for a long period of time, the whale may likely have been feeding in this period. The last echogram represent the last period the tag was on the animal. The whale had than started travelling north. Echogram shows a few deep (50-100 m) patches of potential prey, with a weak surface layer. Dives conducted in this period were generally shallower, and may indicate the whale to be travelling rather than feeding.*

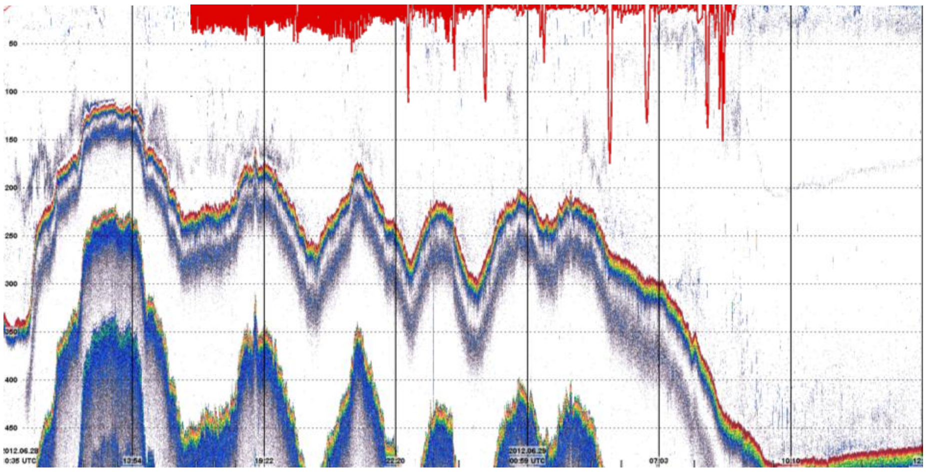


Figure A.5 *Entire dive record and echogram for humpback mn181b, 28-29.June. The whale stayed in the same general area south of Bear Island with a bottom depth of 150-200 m for most of the period, before moving further south into deeper water in the end of the period. A more detailed presentation of this record in given in figure A.6.*

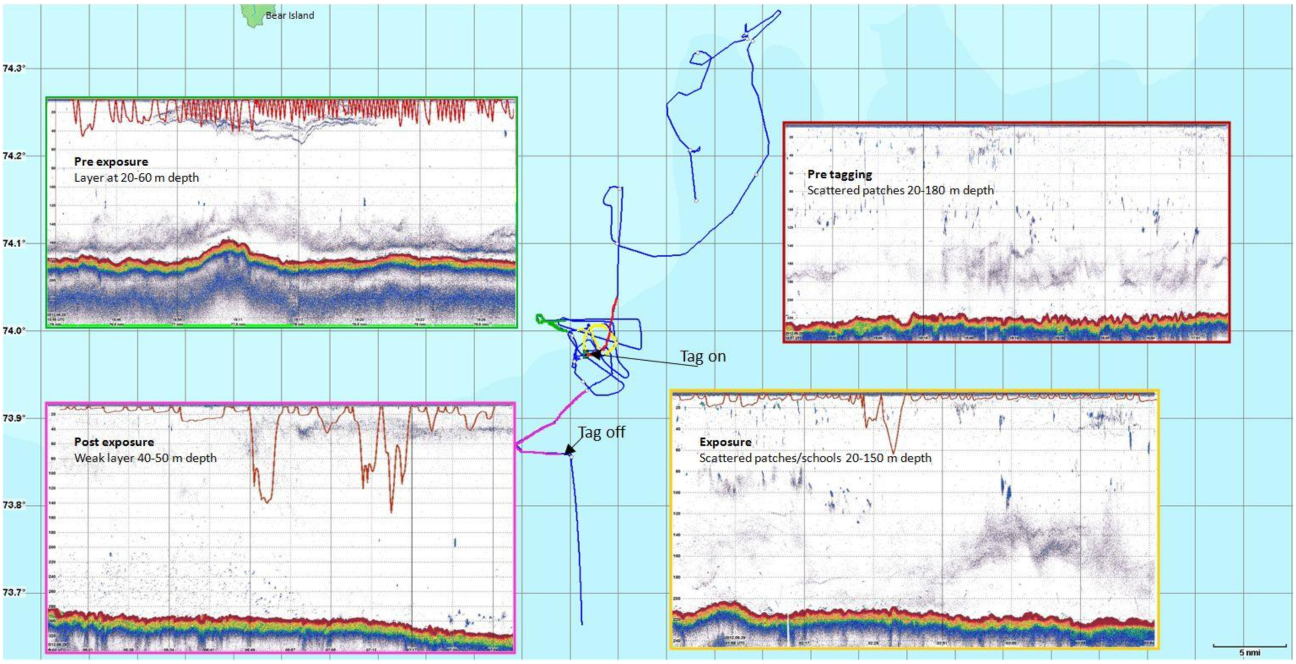


Figure A.6 Prey field mapping for humpback whale mn180 on the 28-29. June. The map shows the track of Sverdrup in blue, with echograms representing the different periods of the experiment; pre tagging, pre exposure, exposure and post exposure. Color frame of echogram corresponds to the color of track on the map to show location of the recorded echogram. During most of the experimental phases, the whale moved around in the same general area somewhat south of Bear Island. The period were Sverdrup is closest to the whale is in the Pre tagging phase (red), as the whale is than tracked from Sverdrup. The echogram here is hence a good representation of the prey field at the location of the whale. During pre exposure (green), Sverdrup stays somewhat away from the whale as tracking is conducted from MOBHUS. However, looking at the dive profile and the echogram, dives have a relatively good correspondence with a layer at 20-60 m depth, indicating that the whale may be feeding at this layer. During exposure (yellow), Sverdup is also generally far from the whale, except during passage during the run. In this period, no clear layers were recorded by Sverdrup, only some deeper patches. Except from two deep (~80 m) dives, the whale were mostly shallow diving in this period. In the post exposure period (pink), Sverdrup still stays somewhat away from the focal whale. In this period, Sverdrup recorded only some weak layers at 40-50 m depth. The whale was in this period conducting some deep dives (~140 m). If these were feeding dives, other prey patches not recorded by Sverdrup may have been present at the location of the whale.

A.3 Baseline data collection

Knowledge of baseline behavior of our target species is important to identify possible changes in behavior during exposure experiments and to assess the biological significance of such behavioral changes. During 3S-2012 we collected 24 hours of baseline behavior in 8 different humpback whales (~3 hours on each animal) during the pre-exposure phase preceding the sonar exposure experiments (table 3.3.) In addition 8.5 hours of dive data were collected on humpback whale mn158a. However, since we lost this whale during tracking and the GPS tag fell off the DTAG, there is no track of this whale. We also collected a total of ~8hrs of baseline data in two fin whales (table 3.3., figure A.7).

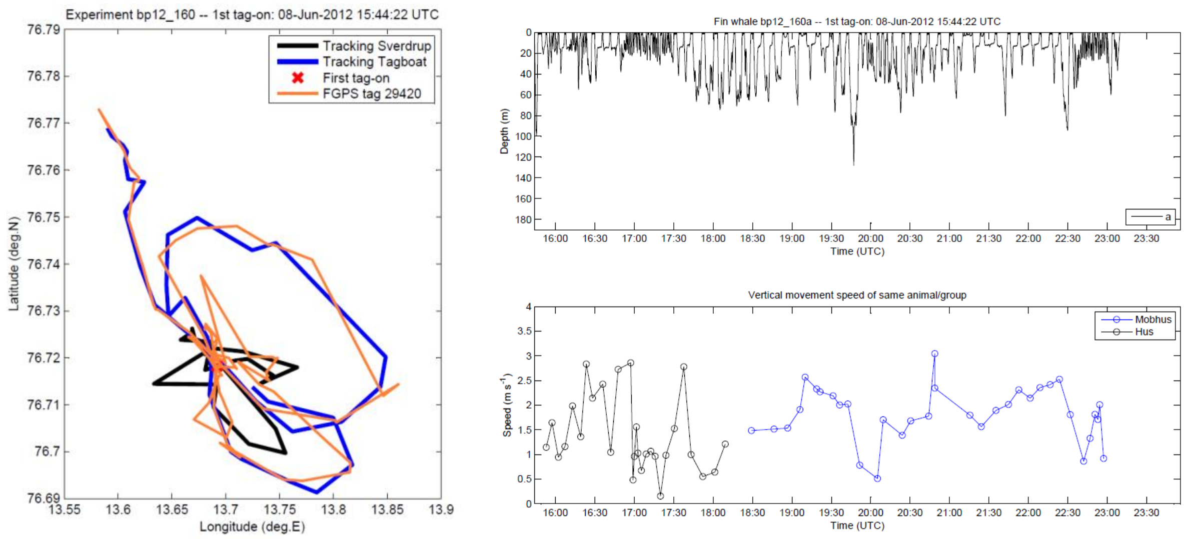


Figure A.7 Left panel: Track of tagged fin whale bp160a from June 8th during a 7 hours long baseline period. The GPS tracks based on the sightings of the observers on the tagboat or Sverdrup and the GPS track from the Fastloc logger on the animal are overlaid. Right panels: Dive record (top) and horizontal speed (bottom) of fin whale bp160a. The tag prematurely released after 7 hours, and therefore no exposures were conducted.

A.4 Killer whale playbacks

Killer whales are potential predators of many other cetacean species. The playbacks of killer whale sounds are based upon the argument that behavioral responses of animals to predation risk represent a good model of disturbance. The idea is that responses to disturbance stimuli such as sonar signals should be analog to predation risk as they both create similar trade-offs between avoiding perceived risk or continuing fitness-enhancing activities (e.g. feeding, parental care, mating displays). Thus, behavioral responses to killer whale playbacks provide a model of natural behavioral disturbance which is particularly relevant to interpret the reactions of animals to sonar exposures.

To ensure that animals specifically responded to killer whale sounds and not just to any sound, we also used a broad band noise as negative control. We expected that the animals would not react to this noise control or that they would react differently compared to the killer whale sounds stimulus.

Each experiment of killer whale playbacks was performed from tagboat 1 and roughly required 1hour and a half to complete. The two sound stimuli (noise and unfamiliar mammal eating killer whale sounds) lasted 15 min each and were played back in a randomized order. Playback experiments were performed to only one of the main target species; the humpback whale. Position of the playback vessel was decided according to the travel path of the tagged animal. For all experiments, the playback started at an estimated distance of 800m from the focal animal, slightly ahead and to the side of its path. Actual position of the playback vessel relative to the focal animal was checked afterwards using tracking data. Communication between tagboats 1 and 2 was needed to correctly define the position of the playback vessel.

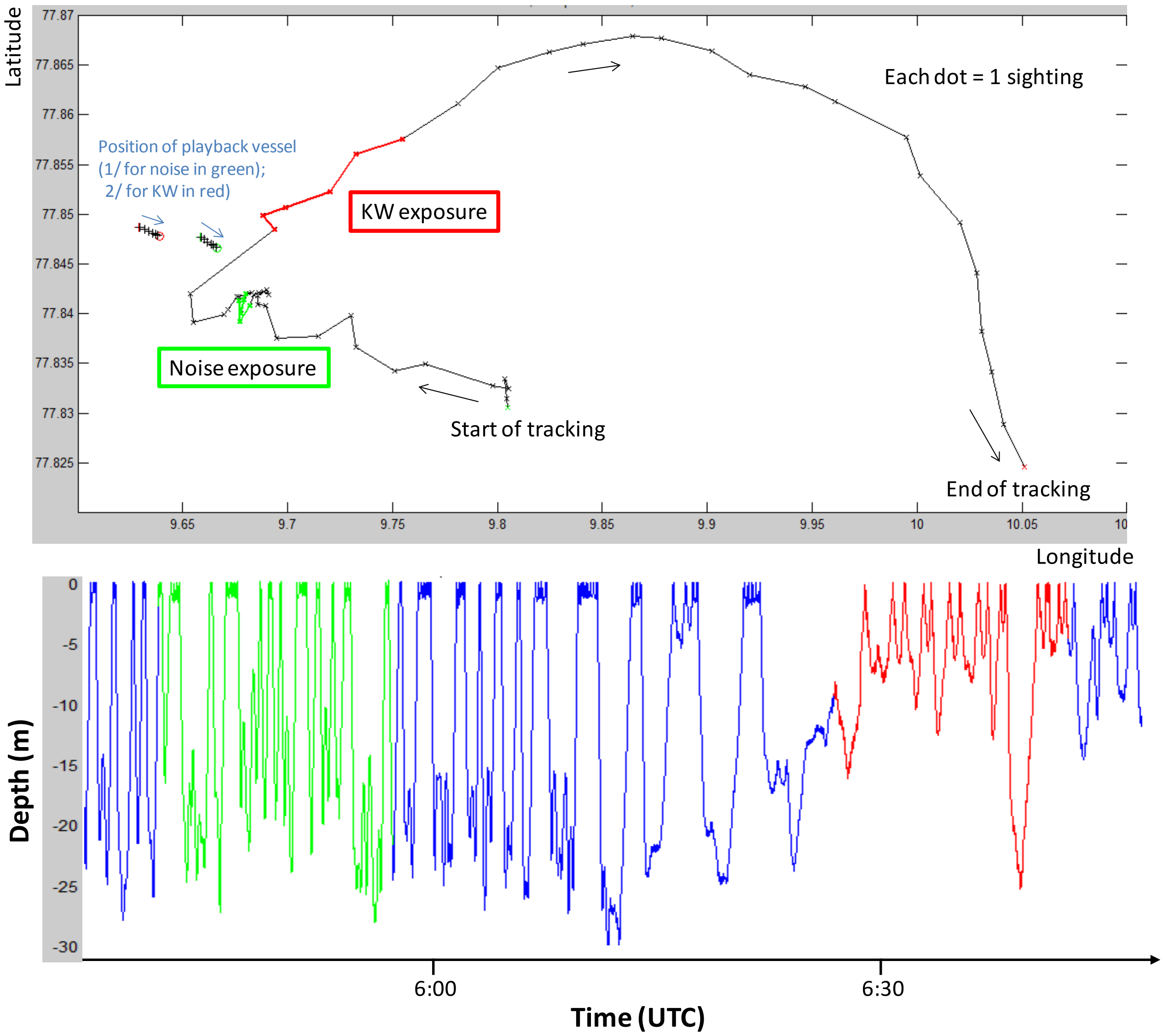


*Figure A.8 Upper panel: Track of tagged humpback whale Mn164b before, during and after playback experiment. Each * corresponds to 1 sighting of the focal animal. Black: pre, post and in between exposures periods. Green: control playback (noise) period. Red: killer whale playback (KW) period. At the start of the KW playback the humpback pair was closer than the map might suggest, because the focal whale was first sighted (first red dot) 17 mins after the start of playback, which was 6 mins after the previous (most westerly) sighting. Lower panel: Dive profile of tagged humpback whale Mn12_164b before, during and after playback experiment. Blue: baseline; Red: KW playback; Green: Noise playback. During the noise playback, the animal showed similar pattern of dive compared to pre exposure period. During the KW playback, the dive profile changed, showing shallower dives and less surfacing compared to baseline.*

Two kinds of acoustic signals were broadcasted to the animals:

- Natural vocalizations of unfamiliar transient mammal-feeding killer whales, previously recorded in British Columbia in 2005 (using Dtag) in a behavioral context of foraging. The playback of these sounds simulates the presence of a potential predator.
- A broad band noise (as a negative control). The noise signal is a sequence of background noise selected from previous recordings (2005), amplified up to get the average RMS power equal to the stimulus, and repeated until getting the same duration as the stimulus (15 min).

All acoustic signals have a similar average RMS power and duration of 15min. To avoid pseudoreplication, we used 3 different set of killer whales stimuli and 3 different noise stimuli.

Table A.1 Summary of the 5 playback experiments performed on humpback whales

D-Tag ID and sighting number of the focal animal	**Date and time of playback**			**Acoustic signals & comments on responses**	
	Date	*Time of Start (GMT)*	*Time of End (GMT)*	*Acoustic signals*	*Comments*
Mn12_161a #998	10 June	04:59:48 05:48:30	05:14:48 06:04:00	1- Noise 2- KW	No visible response to noise. Strong avoidance response. Changed direction away from the source + fast travel. Animals kept responding after the end of KW playback.
Mn12_164b #316 (mobhus sighting number)	13 June	05:41:55 06:25:15	05:56:55 06:40:15	1- Noise 2- KW	No visible response to noise. Strong avoidance response (changed direction away from the source + fast travel). Animals kept responding for a long time after the end of KW playback (see figure 1).
Mn12_170a&b #1147	18 June	15:01:59 15:48:12	15:17:00 16:03:30	1- Noise 2- KW	Note: mother with calf, both tagged. Low response to noise: animal seems to approach the sound source. Weaker response to KW than previous tested animals. Animal seems to respond more after the end of KW playback.
Mn12_171a&b #1158	19 June	21:57:10 23:06:10	22:12:14 23:20:57	1- KW 2- Noise	Similar response as 18 June: weaker response to KW than other previous tested animals. Animal seems to respond more after the end of KW playback. No or low response to noise.
Mn12_180a&b #1291	29 June	03:24:24 04:10:00	03:39:00 04:25:00	1- Noise 2- KW	Note: mother with calf. No visible response to noise. Strong avoidance response (changed direction away from the source + fast travel). Animals kept responding for a long time after the end of KW playback.

A.4.1 Summary of the responses

Figures A.8 show the track and dive profile of one tested tagged humpback whale. The figure illustrates the response of the animals to the playback sounds. Table A.1. summarizes the 5 playback experiments conducted.

Responses to unfamiliar mammal-eating killer whale sounds: Moderate to strong avoidance response: animals changed direction of horizontal movement and started a fast travel away from the sound source, along with a decrease in number of surfacings (Table A.1).
Responses to noise (negative control): No or low visible response to noise for the five tested humpback whales.

A.5 Visual tracking

Totally, 420 h and 44 min of visual effort was conducted over a period of 22 days. Three days had no visual effort due to bad weather. On average, 2.7 persons were doing observations from HUS. During the searching phase, 3.12 persons were on average observing, while during tagging (including pre-tagging, tagging and post tagging) an average of 3.41 persons were observing. During experiments, the main visual effort was conducted from MOBHUS (tag boat 2), with a reduced visual effort of average 1.15 persons doing visual observations from Sverdrup. A total of 400 sightings of totally 906 animals (best estimate) of 13 different species were registered during the 3S-2012 field trial (Table 3.2). This was somewhat lower than during the previous trial (3S-2011) where 544 sightings of 1694 animals of 16 different species were recoded. These numbers confirms the overall impression that we found fewer animals in 2012, particularly in the beginning of the trial. However, if we look at the target species we found the same number of fin whales and 3 times more humpbacks in 2012 compared to 2011 (Table 3.2). We found fewer minke whales in 2012, and no bottlenose whales (Table 3.2). Thus, we found more humpback whales in 2012 than in 2011 and also conducted more experiments on them. We found fewer minke whales in 2012, and conducted fewer experiments than in 2011. However, the effort to tag minke whales was still significant. In total we sighted 78 minke whales (solitary animals), and minke whales were sighted in 14 days of the 19 days of operational work. We spent 14 hours 23 min in total trying to tag minke whales during 3S-2012, but without success. During 3S-2011 we spend 20 hours 58 min trying to tag minkes, but we also tagged 5 animals during that time. In comparison we tagged 13 humpback whales in 15 hours 28 min during 3S-2012.

Table A.2 Daily visual effort on Sverdrup. Given in the table is total time (duration) of visual observations, and the average number of MMOs doing observations (visual effort). This is given as total effort for the day, and for three categories of activities; Searching, Tagging and Experiment.

Date	Daily total		Searching		Tagging		Experiment	
	duration	visual effort	duration	visual effort	duration	visual effort	duration	visual effort
04.06.2012	-	-	-	-	-	-	-	-
05.06.2012	21:28:35	2.70	15:43:36	2.75	06:38:49	3.14	-	-
06.06.2012	23:59:59	3.00	13:17:58	3.50	05:18:52	3.38	05:09:49	1.00
07.06.2012	23:59:59	3.75	24:00:00	3.75	-	-	-	-
08.06.2012	23:59:59	2.70	11:37:52	3.50	04:54:11	3.28	05:41:26	1.00
09.06.2012	23:59:59	3.31	02:40:34	4.00	10:03:40	3.46	08:18:44	2.00
10.06.2012	11:12:09	2.18	0.056817	2.00	02:55:44	4.00	06:54:36	1.00
11.06.2012	23:59:59	3.87	12:56:50	3.20	11:02:29	4.22	-	-
12.06.2012	23:59:59	3.26	06:51:59	3.33	12:18:54	3.50	04:37:12	1.00
13.06.2012	13:22:51	1.40	-	-	-	-	13:22:51	1.40
14.06.2012	09:33:16	3.45	06:18:52	3.80	02:01:11	-	-	-
15.06.2012	13:08:04	3.22	10:51:01	3.50	13:08:04	3.11	-	-
16.06.2012	20:51:04		19:44:06	2.85	-	-	01:06:58	1.00
17.06.2012	23:59:59	2.75	22:21:38	2.71	01:38:21	3.00		
18.06.2012	20:48:12	2.00	-	-	05:38:11	3.50	15:10:01	1.00
19.06.2012	16:19:47	2.24	02:50:57	4.00	04:20:39	3.00	09:08:11	1.00
20.06.2012	06:08:17	1.75	-	-	-	-	06:08:17	1.75
21.06.2012	-	-	-	-	-	-	-	-
22.06.2012	-	-	-	-	-	-	-	-
23.06.2012	06:14:18	3.00	08:14:41	3.00	-	-	-	-
24.06.2012	11:27:42	2.80	11:27:42	2.80	-	-	-	-
25.06.2012	22:51:29	3.43	21:33:54	3.38	01:17:35	4.00	-	-
26.06.2012	23:51:07	1.79	07:52:38	1.71	01:56:47	3.00	14:01:42	1.00
27.06.2012	23:59:59	1.69	06:32:47	1.75	02:35:06	3.00	15:08:07	1.00
28.06.2012	23:59:59	3.36	04:30:31	3.73	12:55:29	3.57	05:34:53	1.00
29.06.2012	07:41:56	1.00	-	-	-	-	07:41:56	1.00

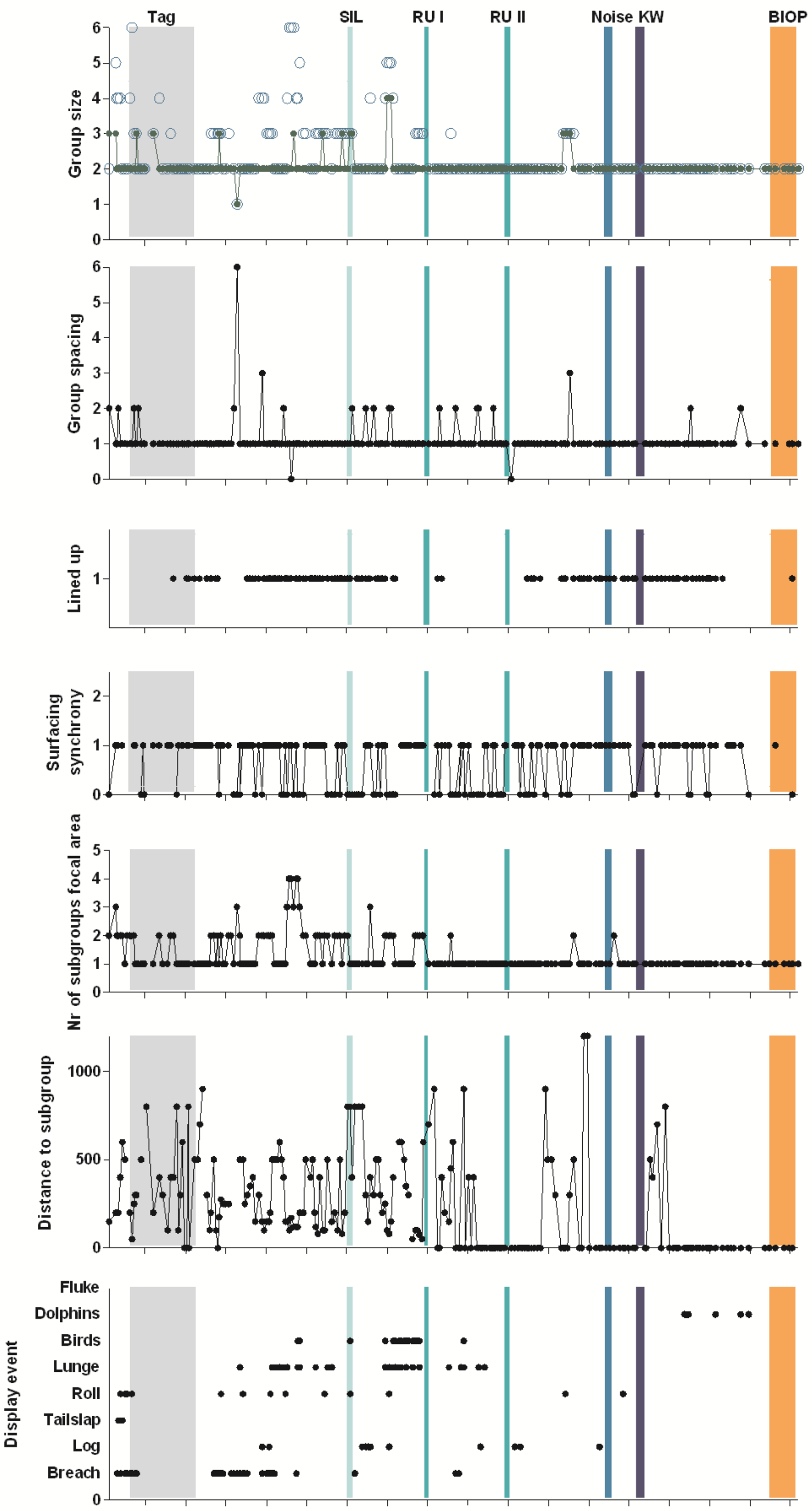
[1]Includes all visual effort when searching for animals

[2]Includes all visual effort during tracking of animals from HUS, during pretagging, tagging and post tagging, as well as occasional brief periods of tracking before MOBHUS takes over during experiment.

[3]Includes all visual effort from HUS during experiments, when MOBHUS is doing the main tracking of the focal animal(s).

A.6 Social and surface behavior

Social and surface behavior data was collected for humpback whales, minke whales and fin whales. The protocol for data collection was identical to the group behavioral protocols used during the 3S-2011 trial, as adapted for the $3S^2$ target species (Visser *et al.* 2011). In addition to the protocol in 2011, the number of surfacings of the focal whale during the pre-tagging and tagging phase was recorded. In case of solitary whales, only surface behavioral parameters were recorded (*e.g.* display events). Combined sampling of group behavior and tracking of the focal whale were established well from both the Sverdrup and the MOBHUS observation platforms. Pre, during and post tagging group behavior data was collected from the HUS observation platform. Group behavior data during baseline, exposure, post-exposure and biopsy phases was collected from the MOBHUS observation platform.



<u>Figure A.9</u> Example of group behavior data for humpback whale Mn180ab (sighting no 1291 on June 28th). Experimental conditions are indicated as vertical lines on all panels. From top to bottom the panels show group size, group spacing, line up, surface synchrony, no of subgroups in focal area, distance to nearest subgroup and display events. The focal animal was strongly associated with another animal (probably a calf) throughout the experiment, but also occasionally split and joined with some of the numerous other humpbacks in the area.

Table A.3 Social and surface behavior tracking effort for humpback whales, fin whales and minke whales during and outside of experimental events. Effort is listed as the duration (hr:min) of combined tracking and group and surface behavioral sampling for pre- during and post-tagging phases.

Species	Date time start tracking	Dtag data set	Total time tracking	Pre-tagging	Tagging	Post-tagging
Humpback	06.06.2012 13:33	Mn158a	5:29:00	01:12	03:36	00:41
Humpback	09.06.2012 15:34	Mn161a + b	15:46:00	01:00	02:28	00:58
Humpback	12.06.2012 15:48	Mn164a + b	21:19:00	01:11	03:05	01:00
Humpback	17.06.2012 22:30	Mn170a + b	21:10:00	01:00	02:06	03:16
Humpback	19.06.2012 10:42	Mn171a + b	17:51:00	00:19	00:41	01:44
Humpback	25.06.2012 23:22	Mn177a	11:08:21	00:46	00:51	01:16
Humpback	27.06.2012 07:32	Mn179a	11:44:00	-	00:38	00:57
Humpback	28.06.2012 15:03	Mn180a+b	17:09:00	00:33	01:40	00:56
Humpback	05.06.2012 09:19		3:44:09	00:57	02:21	00:26
Humpback	14.06.2012 23:15		4:38:00	01:18	01:51	01:29
Humpback	15.06.2012 04:34		0:28:00	00:28	-	-
Humpback	15.06.2012 05:40		1:40:00	00:41	00:44	00:15
Minke	08.06.2012 01:02		0:40:00	00:40	-	-
Minke	09.06.2012 08:50		2:05:00	00:58	01:07	-
Minke	10.06.2012 20:32		0:33:00	00:28	00:05	-
Minke	10.06.2012 21:13		1:25:00	-	01:25	-
Minke	11.06.2012 00:44		0:26:00	00:06	00:20	-
Minke	11.06.2012 17:29		4:16:00	00:35	02:49	00:52
Minke	11.06.2012 22:57		0:49:00	-	00:33	00:16
Minke	12.06.2012 02:55		0:54:00	00:11	00:43	-
Minke	12.06.2012 13:02		2:49:00	00:25	01:32	00:52
Minke	19.06.2012 07:11		1:45:00	00:54	00:51	-
Minke	24.06.2012 04:45		0:36:57	00:15	00:21	-
Minke	28.06.2012 05:28		1:04:00	00:32	00:32	-
Fin whale	08.06.2012 15:32	Bp160a	7:32:00	00:12	01:04	01:26
Fin whale	12.06.2012 10:09	Bp164a	2:44:00	01:00	01:23	00:21
Fin whale	15.06.2012 18:39	Bp167a	5:35:00	00:22	01:32	00:40
Fin whale	08.06.2012 12:37		2:49:00	01:14	01:35	-
Fin whale	11.06.2012 13:59		3:22:00	01:47	01:31	00:04
Fin whale	14.06.2012 15:09		2:04:00	01:33	00:31	-
Fin whale	15.06.2012 10:30		0:31:00	00:31	-	-
Fin whale	15.06.2012 15:17		0:49:00	-	00:49	-
Fin whale	28.06.2012 11:22		2:03:00	00:53	01:10	-
Total Humpback			**132:06:30**	**9:25:00**	**20:01:00**	**12:58:00**
Total Minke			**17:22:57**	**5:04:00**	**10:18:00**	**2:00:00**
Total Fin whale			**27:29:00**	**7:32:00**	**9:35:00**	**2:31:00**

A.6.1 Humpback whales

We collected 12 tracks for humpback whales, of which 8 had successful Dtag deployments (Table A.3, Figure A.9). Data were collected during 10 tagging phases, 8 baseline periods, 7 experiments (Silent, Ramp-up, Full exposure, Biopsy) and 5 killer whale playbacks (Table A.3.). In total 132 hours of combined tracking and group behavioral sampling data was collected, of which 35 hours of tagging data and 30 hours of baseline data. In contrast to 2011, humpback whales were observed generally alone or in pairs.

A.6.2 Minke whales

We collected 12 tracks for minke whales with a total duration of 17 hours (Table A.3). Individual minke whales could be tracked for 1-2 surfacings up to 4:16 hours, depending on behavioral state and sea state conditions. Successful tracking of minke whales required very calm conditions (sea state 0-1).
As in 2011, minke whales were generally observed alone, sometimes shortly associated with other large baleen whales (fin or humpback whales), generally in an area with several other minke whales. Observed behavioral states were mostly travelling and feeding. Surface behavior parameters, such as the number of surfacings per surfacing bout, were collected systematically.

A.6.3 Fin whales

We collected 9 tracks of fin whales, of which 3 had successful Dtag deployments (Table A.3). Data were collected during 2 experimental phases (baseline) and 4 tagging phases.

In total 27,5 hours of combined tracking and group behavioral sampling data was collected, of which 11,5 hours of tagging data and 8 hours of baseline data. Fin whales were generally observed in fluent groups of 1 to 3 animals, within larger aggregations spread over a larger area. Fin whale social and surface behavior was collected for the first time this year, following the social behavioral protocol (Visser et al. 2011). Tracking was established less easily than for the other baleen whales, mostly due to the fluent nature of groups, long dives and large distances travelled between surfacings.

A.7 Effects of tagging

A.7.1 Humpback whale

Pre, during and post tagging data was collected from the Sverdrup observation platform for 10 humpback whale focal groups. In one case pre-tagging was not established, as it was not possible to consistently track one focal whale in an area with up to twenty humpback whales. In total 9,4 hours of pre-tagging data was collected (Table A.3). The duration of the tagging phase(s) was generally short, 0.6 – 3.7 h, including the effort for second tag on attempts. In total 20 hours of tagging data was collected. In one experiment, multiple tagging phases were conducted for the same focal whale due to early tag off. The duration of post-tagging phases was 0.3 – 2.3 hours. In total 14 hours of post-tagging data was collected (Table A.3).

A.7.2 Minke whale

Pre, during and post tagging data was collected from the HUS observation platform for 2 minke whale whale focal groups during 12 trackings (Table A.3). In total 5.1 hours of pre-tagging data, 10 hours of tagging data and 2 hours of post-tagging data was collected (Table A.3).

A.7.3 Fin whale

Pre, during and post tagging data was collected from the HUS observation platform for 4 fin whale focal groups during 9 trackings. In total 7.5 hours of pre-tagging, 9.5 hours of tagging and 2.5 hours of post-tagging data was collected (Table A.3).

A.8 Tagging

Tag boat 1 (TB1) was set up to deploy tags using both a hand held pole (8m) and a 16m long cantilever pole (figure A.10), while tag boat 2 (TB2 or MOBHUS) was setup to deploy tags using the tag-launcher ARTS (figure A.10), similar to 3S-2011 trial. As last year the default tag for two of the priority species, the humpback whale and the bottlenose whale, was the standard DTAGv2 holding a fastLoc GPS logger (figure 2.1.), while the setup for minke whales was to use the DTAGv2 with four small invasive barbs (figure A.12). Prior to the 3S-2012 trial, an extensive testing period using different barbs on dummy targets and on one stranded harbor porpoise being towed through the water for 17 hours, resulted in the choice of barb design to be as small as possible (while still functional). Three different barbs were tested. For secondary tags the plan was to use the CTAG holding a fastLoc GPS logger. The CTAG was developed for the $3S^2$-project in order to serve as a back-up for the DTAG in case we were not able to approach minke whales close enough to deploy DTAGs. The CTAG does not contain acoustic sensors, but it does contain motion sensor similar to the DTAG, however with much lower sampling rate (Kvadsheim *et al.* 2011).

Figure A.10 Upper panel; tag boat 1 tagging a humpback whale using the cantilever pole system (photo: Paul Ensor). Lower panel; tag boat 2 tagging a humpback whale using the ARTS system (photo: Rune Roland Hansen). See also figure 2.1.

The plan of having at least 1 tag team in stand by mode, ready to be deployed within 30 min, continuously around the clock was successfully achieved by letting the two tag teams follow the 6 hours on and 6 hours off watch schedule used by the rest of the 3S-team. In some occasions this strict regime was adapted to maximize tagging effort.

A.8.1 Humpback whales

During 3S12 we deployed 13 tags to humpback whales with an average time to attach tags to a whale of just 80 min. 7 of these tags were deployed with the ARTS system from TB2 and 6 with the cantilever pole from TB1. On three occasions two tags were placed on the same animal, and on one occasion two associated animals were tagged (table 3.3.). In another event with a pair of associated animals, the initial tag deployment was on the larger animal (164a), after about 9 hrs the tag slid off, but was successfully redeployed on the smaller animal (164b) after a number of attempts. The tag endurance time on the animal did not seem to between the two deployment systems used (Figure A.11). Generally, the problem of premature releases of the tags from the humpback whales, was much less of a problem in 3S-2012 than 3S-2011. We don't have any good explanation for this, as procedures and equipment were mostly the same. A possible reason is that we generally had better placements of the tag high on the animal in 3S-2012. Different behavior of the animals, possibly with less breaches and rubbing against others, is another possible explanation. Release of the Dtag from the whale often took longer from the scheduled release time than expected, possibly due to colder water temperatures during 3S-2012. This required some adjustment of planned release times. Overall, tagging of humpback whales was efficient and robust, tag boats where launched without being able to successfully deploy a tag in only a few cases.

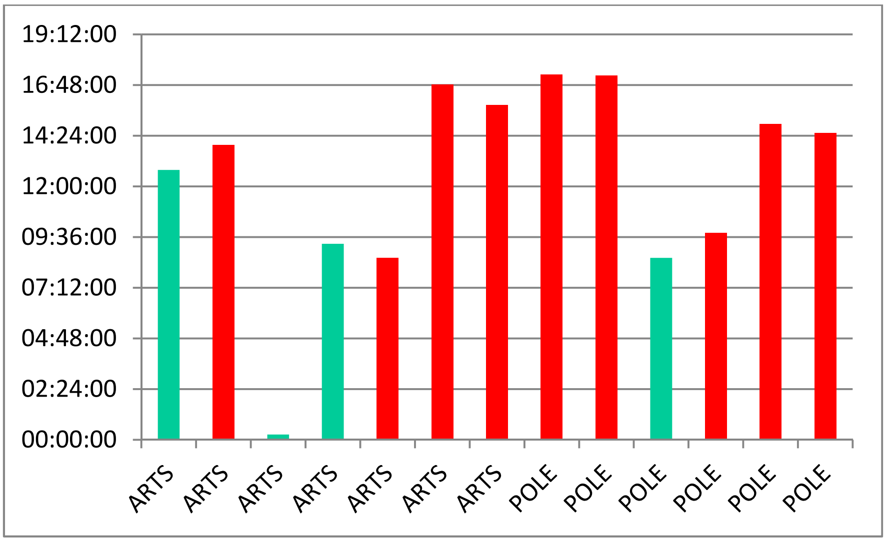


Figure A.11 Tag attachment duration on humpback whales using either the ARTS system or the cantilever POLE to deploy the tag. Tag release time was usually set to 15 hours. In 9 occasions, the tag stayed on until it was intentionally released by the electronic release mechanism (red bars). In 4 occasions the tag unintentionally came off prematurely (green bars).

A.8.2 Minke whales

With the experience from last year, we were optimistic in terms of having tagging opportunities from small boats on this species. The initial tagging tactics during 3S-2013 was to launch the tag boat on sight of minke whales in good weather conditions. Both tag boats were to be deployed, depending on watches, however with priority for TB2 with the primary use of the ARTS-system. Combined, we spent more than 14 hours trying to tag minke whales during 3S-2012, but without success. Tag boats were launched on multiple occasions without having been close to any target. On the 11th of June in the outer part of Isfjord Channel TB2 approached 2 minke whales on slow travel. These animals were not seeking the boat, but on a few occasions we were almost close enough for a tagging attempt. After 90 minutes they split up, and TB2 tried numerous approaches of various whales in the area, a total of 5-6 whales, without having any close encounters. There was no further close contact with minke whales until we came to the outside of Kongsfjorden on June 19, where after some time TB2 had a seeking minke whale around the boat. This was the first, of only two “seekers” during 3S-2012. There were two unsuccessful tagging attempts on this whale before it disappeared. The wind then increased and TB1 tagged a humpback whale in the same area, after which we were engaged in an experiment for the next 16hrs.

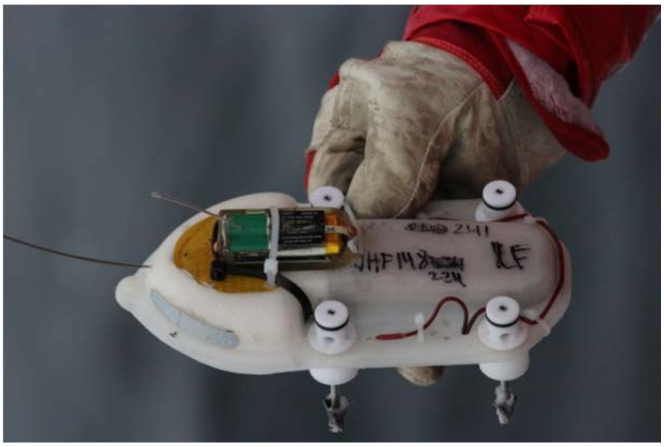


Figure A.12 The minimum invasive barb Dtag developed to be deployed on minke whales where non-invasive suction cups have been shown to be inefficient. Photo: Paul Ensor.

Our next encounter with minke whales was on the 24th of June in the outer part of Isfjord Channel. TB2 tried to approach a number of minke whales (n=6) without getting closer than 50 m, until we suddenly had a “seeker” around the boat. The first tagging attempt was on 12 meter using 10,5 bar of barrel pressure, but it was a miss behind the animal. The next attempt was at 10m using 10,5 bar where the ARTSCarrier hit the waterline in front of the animal. On the 28th of June SE of Bear Island in Leirdjupet TB2 again launched and started to close on 7 different whales without any close encounters.

In summary, the launching pressure was kept in the 10 to11 bar setting, while distances where mostly in the range from 10-12 meters for minke whales, and for humpback whales in the range of 14-16 meters.
During the initial approach of minke whales the support of the MMOs from HUS, and the communication with the MMO platform was vital and important to successfully relocate and work with the minke whales.
On 5 different days we encountered and tried to approach roughly 23 minke whales, whereas only 2 animals were close enough for tagging attempts. Both those two whales where “seekers” approaching the tag boat.
The CTAG was also never deployed during the cruise, however on the 14 of June the CTAG was prepared for deployment. The CTAG2012 was similar to that used in 2011 with a VHF beacon, a TDR with tilt& compass, GTR galvanic release, an anchor attachment, and extended with the GPS FastLoc logger from Sirtrack.

Though the details of some procedures can be improved, our conclusion is that the primary reason for a lack of success with tagging minke whales during the 3S-2012 trial is that very few of the encountered animals exhibited “seeking” behaviour. Many animals were encountered, but it was impossible to approach closely enough to attempt tagging in the absence of “seeking” by the whales. We are not sure why fewer minke whales did “seeking” behaviour during 3S-2012 than during 3S-2011.

A.8.3 Bottlenose whales

During 3S-2012 there were no sightings of this target species, and as a consequence, no whales were tagged either!

A.8.4 Fin whales

As a secondary target species, the fin whale was not in focus other than in periods where we could not tag primary species. One fin whale was tagged on the 7th of June and another one on the 15th of June. However both tag released after less than 8 hours, and only baseline data was collected on both tags. While tag attachment to this species is feasible, the duration of tag-attachment using suction cups appears to be too short to reliably conduct sonar experiments.

A.8.5 Range testing of radio tracking equipment and positions

The first humpback whale tagged this year (158a) was lost during tracking due to a low tag attachment. A systematic circular search for the tag with a diameter of 30nm, boxing the most probable search area resulted in tag contact after about 10 hours of search. The tag was found 12nm from where we lost contact with the tagged animal.

Testing of tracking equipment during the search of tag 158a on the 6th of June, resulted in the following range measures:

- Highest radar position on HUS with a hand held Yagi antenna and receiver R-1000: 12 nm
- MMO platform on HUS with a handled Yagi antenna and receiver R-1000: 9 nm
- MMO platform HUS using the DDF2011, receiver R-100 audio contact: 8 nm
- MMO platform HUS using the DDF2011, receiver R-100 with directionality: 4 nm

Table A.4 DTAG table of 3S-2012

Date	Time	Species	Data-set	Lat/Long	Tag-ID	Experiment	Time on animal	Release time	Skin	ARTS/ Pole	Release
June 6th 2012	17:04:15	Humpback	Mn12_158a	76º 49.38N 13º 12.126E	238	Base Line	12 hours 47 min	16 hours	no	ARTS	Yes, after it detached
June 8th 2012	17:44:22	Fin whale	Bp12_160a	76º 25.854N 13º 24.846E	246	Base Line	7 hours 24 min	16 hours	yes	ARTS	No
June 9th 2012	15:47:42	Humpback	Mn12_161a	77º 20.61N 11º 11.43E	246	CEE KW PB	13 hours 57 min	16 hours	no	ARTS	Yes
June 9th 2012	19:03:22	Humpback	Mn12_161b	77º 20.064N 11º 09.93E	238	SHORT	15 min	16 hours	no	ARTS	No
June 12th 2012	14:11:07	Fin whale	Bp12_164a	77º 53.317N 09º 54.319E	238	SHORT	Half a dive	16 hours	no	Pole	No
June 12th 2012	19:13:13	Humpback	Mn12_164a	77º 28.62N 09º 35.652E	238	CEE	9 hours 17 min	15 hours	no	ARTS	Yes
June 12th 2012	19:13:13	Humpback	Mn12_164b	77º 28.62N 09º 35.652E	238	KW PB	8 hours 37 min	15 hours	no	ARTS	Yes
June 15th 2012	21:08:48	Fin whale	Bp12_167a	77º 35.027N 10º 55.151E	242	Base Line	5 hours 19 min	16 hours	yes	Pole	No
June 18th 2012	05:31:42	Humpback	Mn12_170a	77º 37.60N 10º 24.15E	242	CEE KW PB	16 hours 50 min	15 hours	no	ARTS	Yes
June 18th 2012	05:49:48	Humpback	Mn12_170b	77º 27.76N 10º 40.77E	235	CEE KW PB	15 hours 52 min	15 hours	no	ARTS	Yes
June 19th 2012	13:22:03	Humpback	Mn12_171a	79º 01.618N 10º 40.27E	235	CEE KW PB	17 hours 18 min	15 hours	no	Pole	Yes
June 19th 2012	14:21:37	Humpback	Mn12_171b	79º 01.823N 10º 40.120E	246	CEE KW PB	17 hours 15 min	15 hours	no	Pole	Yes
June 26th 2012	02:28:20	Humpback	Mn12_178a	74 51.718N 17 48.324E	246	CEE	8 hours 37 min	14 hours	no	Pole	No
June 27th 2012	09:57:13	Humpback	Mn12_179a	74 02.725N 20 40.84E	246	CEE	9 hours 48 min	8.5 hours	no	Pole	Yes
June 28th 2012	18:03:24	Humpback	Mn12_180a	73 59.006N 20 24.551E	246	CEE KW PB	14 hours 57 min	14 hours	no	Pole	Yes
June 28th 2012	19:07:52	Humpback	Mn12_180b	73 59.005N 20 24.518E	241	CEE KW PB	14 hours 32 min	14 hours	no	Pole	Yes

Table A.5 Overview of data collected with Sirtrack Fastloc GPS (FGPS) tags during 3S-2012. Column initial position is the latlon that was used during processing of the raw data and not the actual location derived from the first gps fix. Recording file name contains the date and time when the raw data was off-loaded.

FGPS ID	DTAG ID	Recording filename	Start time	Initial position		Raw data	Processed	Comments
			UTC	Lat	Lon			
29409	mn164ab	Obs130612_183500_Tag29409	12.06.2012 07:30	77,82	10,12	x	X	2nd humpback whale CEE - 2nd animal tagged with same tag
29409	mn170b	Obs190612_030705_Tag29409	18.06.2012 23:26	77,46	11,68	x	X	3rd humpback whale CEE
29409	mn171b	Obs200612_141738_Tag29409	19.06.2012 07:38	79,00	10,50	x	X	4th humpback whale CEE
29409	mn180a	Obs290612_183023_Tag29409	28.06.2012 15:33	74,10	20,60	x	X	7th humpback whale CEE
29420	bp160a	Obs090612_031505_Tag29420	08.06.2012 08:24	76,77	13,58	x	X	Fin whale baseline data
29420	mn161b	Obs090612_230244_Tag29420	09.06.2012 06:00	77,59	12,00	x	X	1st Humpback whale CEE (attached for 15 min)
29420	bp164a	Obs120612_210341_Tag29420	12.06.2012 07:30	78,03	9,55	x	X	Tagging fin whale (attached for 7 min)
29420	bp167a	Obs160612_140539_Tag29420	15.06.2012 18:46	77,60	10,53	x	X	Fin whale baseline data
29420	mn170a	Obs190612_030504_Tag29420	17.06.2012 23:26	77,63	10,40	x	X	3rd humpback whale CEE
29420	mn178a	Obs260612_115217_Tag29420	25.06.2012 23:55	74,87	17,73	x	X	5th humpback whale CEE
29420	mn179a	Obs270612_211606_Tag29420	27.06.2012 07:04	74,04	20,37	x	X	6th humpback whale CEE
29420	mn180b	Obs290612_183252_Tag29420	28.06.2012 15:24	74,10	20,60	x	X	7th humpback whale CEE
29510	mn161a	Obs100612_092331_Tag29510	09.06.2012 08:39	77,63	11,17	x	X	1st Humpback whale CEE - few fixes because of SWS setting
29510	mn171a	Obs200612_141344_Tag29510	19.06.2012 07:40	79,00	10,50	x	x	4th humpback whale CEE
29533	mn158a	This tag fell off during first humpback whale deployment						

A.9 Biopsy

Genetic analysis of the biopsy samples collected will provide valuable information of the gender , individual identity and potentially elucidate any genetic relationship between associated animals. In addition, since long blubber profiles (60mm) were collected, biochemical analysis of the blubber layer will give information on health and body condition on the animal. The equipment applied during biopsy sampling was the whale-tag launcher ARTS using the LKDart (figure A.13) and a 60mm Finn Larsen biopsy tip. Successful sampling was achieved for all attempts on Humpback whales, except for tagged whale mn179a. No biopsy attempts were made on tagged whale mn158a. In total 10 biopsy samples of humpback whales and 2 biopsy samples of fin whales were collected (table A.6). There were no biopsy attempts on the two other target species, the minke whale nor the bottlenose whale.

Table A.6 Data table of biopsy sampling

2012 June	Position	No.	Code	System	Range/P	R	ID	Comments
8	76.26N-13.25E	0132	bp160A	SC	SC			
10	77.67N-11.10E	0235	mn161AB	ARTS/LKDart	35m/11bar	0	ok	40mm sample, RL,
13	77.81N-10.17E	miss	mn164A	ARTS/LKDart	18m/11bar	0		Hit water in front
13	77.81N-10.17E	0335	mn164A	ARTS/LKDart	20m/11bar	0	ok	50mm sample, LL,
13	77.79N-10.29E	miss	mn164B	ARTS/LKDart	20m/11bar	0		Hit water in front
13	77.79N-10.29E	0435	mn164B	ARTS/LKDart	20m/11bar	0	ok	4mm sample, RL
16	77.35N-10.55E	0532	bp167A	SC	SC			Skin from suction cup
18	77.54N-09.52E	0635	mn170B	ARTS/LKDart	30m/11bar	0	ok	29mm sample, LL, mother to 0635?
18	77.53N-09.56E	0735	mn170A	ARTS/LKDart	17m/11bar	0	ok	40mm sample, LL, calf to 0535?
20	79.02N-10.16E	miss	mn171AB	ARTS/LKDart	20m/11bar	0		Hit water in front
20	79.02N-10.16E	0835	mn171AB	ARTS/LKDart	18m/11bar	2	ok	42mm sample , RBL, fluke slaps
25	74.49N-17.38E	0935	mn178A	ARTS/LKDart	15m/11bar	1	ok	50mm blubber sample, LR, active swim
25	74.38N-17.36E	1035	no tag	ARTS/LKDart	19m/11bar	1	ok	45mm blubber sample, LRD, active swim
27		miss	mn179A	ARTS/LKDart	30m/11bar	2		Hit water in front, fluke slaps
29	73.51N-20.24E	1135	mn181AB	ARTS/LKDart	17m/11bar	0	ok	48mm blubber sample, LR
29	73.51N-20.24E	1235	Follow	ARTS/LKDart	24m/11bar	2	ok	37mm blubber sample, LL, fluke slaps

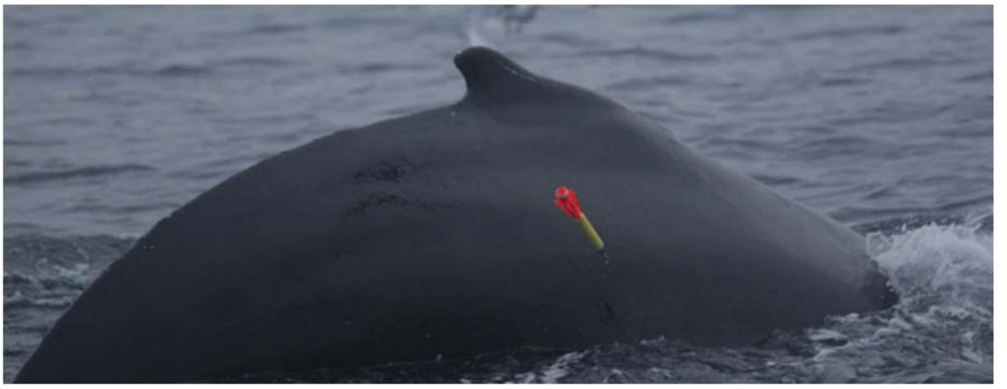


Figure A.13 Successful shot to collect a biopsy sample from a humpback whale. The floating dart penetrates blubber and skin, stamps out a tissue profile and bounces off. Photo: Lars Kleivane.

A.10 Photo id

Digital photographs of whales approached for tagging were collected for individual identification with the primary aim to eliminate, as far as possible, re-tagging of individuals previously exposed to sonar during 3S-trials. Photographs of the target species were collected from the tag boats during all tagging approaches, as well as opportunistically from H.U. Sverdrup II. No assessment of the either the quality of photographs or their usefulness for photo-identification studies was made in the field. Sequence images were obtained during the tag deployment process as well as detailed images of tags on animals.

A.10.1 Humpback whales

The unique pigmentation pattern of individual humpback whale flukes (as well as documentation of their dorsal fins) was used to identify individual humpback whales and thus eliminate the possibility of re-tagging individuals of this species.

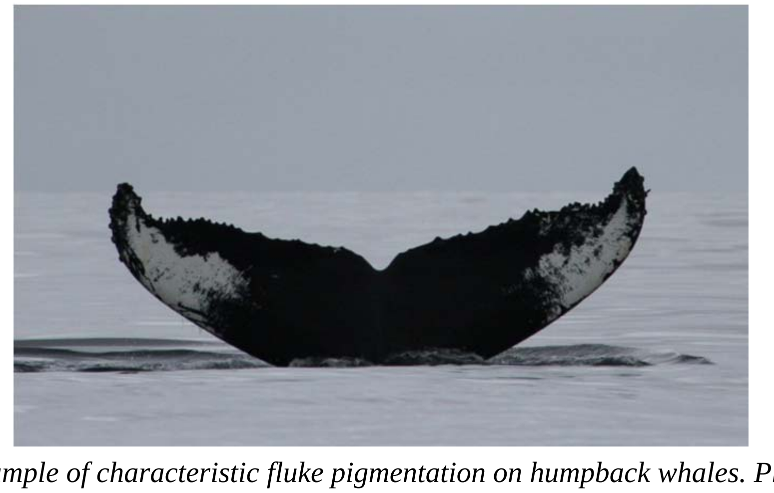


Figure A.14 Example of characteristic fluke pigmentation on humpback whales. PhotoPaulEnsor

A total of 42 individual humpback whales were photographed during the cruise, including all of the tagged individuals, which were extensively photographed (Table A.7). Apart from Photo-ID images of the tagged individuals, photo-ID images of many other individuals were obtained opportunistically from the tag boats and H.U. Sverdrup.

Two humpback whales were re-sighted during the cruise. These individuals were detected travelling as a pair, tagged and exposed to sonar on June 12th. They were re-sighted (and photographed) together as a pair on 15 June (20.5 nmiles from the previous sighting location). These two individuals were re-sighted again on 16 June also near the same location (though not photographed).

Individual humpback whale flukes were matched to all biopsy samples of this species. Photo-ID images of the dorsal fin of one individual were used to indisputably identify it as a target for biopsy sampling following release of the tag (tag # 12_Mn170A).
Preliminary examination of digital images of the 42 humpback whales photographed revealed no re-sightings of those tagged during the 3S-2011 trial undertaken in the same geographic location.

A.10.2 Fin whales and minke whales

Individual fin whales and minke whales approached for tagging were also normally individually identifiable from photographs due to subtle variations in pigmentation of the flanks and the presence of scars on the body surface and dorsal fins. However, for these species when prominent differences between individuals did not exist, identification of individuals was possible only after post processing of photographs.

Based on photo-ID images, two individual minke whales were each approached twice for tagging. They were initially detected a few body lengths apart and approached for tagging on 11 June. The individuals separated during the tag approach attempts and were re-sighted and identified a few hours later (in the same geographic location). They were both separately the target of subsequent tagging attempts.

Figure A.15 Minke whales usually don't have conspicuous marking which can easily be used for photo id.

Four fin whales including 2 of the tagged individuals had very distinct markings which could clearly be used to identify individuals during the trial.

Table A.7 Summary of photo-identification and photo-documentation of tagging sequences of humpback, fin and blue whales during 3S-2012

	Date	Daily archive subfolder name/Time start photos GMT	Latitude N	Longitude E	Tag Number	Number of individuals
Humpback whale	5 June	5_June_12 humpback opportunistic 1 from Sverdrup #no logger PHE/13:59	75.8790	015.7380	-	1
	5 June	5_June_12 humpback tagging attempt sequence Tag boat 1 #890 RRH/09:30	75.7701	015.3318	-	1
	6 June	6_June_12 12_Mn158A tagging sequence & second attempt boat 2 logger #906 PHE/15:01	76.8231	013.2004	12_Mn158A	1
	6 June	6_June_12 humpback opportunistic 1 & 2 from Sverdrup LK/14:29	76.8196	013.2059	-	1
	6 June	6_June_12 humpback opportunistic 1 & 2 from Sverdrup LK/21:09	76.9242	012.4272	-	1
	6 June	6_June_12 humpback this whale tracked instead of 12_Mn158A mobhus # RRH/23:34	77.0453	011.8062	-	1
	9 June	9_June_12 12_Mn161A Mn161B tag sequence & two other shots boat2 logger #998 PHE/16:41	77.5653	011.3210	12_Mn161A&B	1
	12 June	12_June_12 12_Mn164A #1 tagging sequence boat 2 logger #1053 PHE/16:49	77.7988	009.9777	12_Mn164A	1
	12 June	12_June_12 12_Mn164B focal follow LK/02:58	78.1324	009.7902	12_Mn164B	1
	12 June	* 3S 2012 12_June_12 humpbacks #1 logger #998 and #2 Mn164A & associated whale #3 LK/23:37	77.8805	009.9991		1*
	15 June	15_June_12 humpback tagboat 2 no chance for shot logger #1074 PHE/01:06	78.0546	010.0056	-	1
	15 June	15_June_12 Mn resight whales #1 #2 previous 12_Mn164A&B 12 June PHE/05:08	78.0985	009.1936	re-sight 12_Mn164A&B	-
	15 June	15_June_12 humpback logger #1085 from Sverdrup PHE/05:56	78.1568	009.0188	-	1
	16 June	No photos	78.1308	009.2035	re-sight 12_Mn164A&B	-
	18 June	18_June_12 12_Mn170A tag sequence 12_Mn170B logger #1147 tag boat 2 PHE/02:55	77.9387	009.8498	12_Mn170A&B	3 (adult/calf + another)
	18 June	18_June_12 Mn unsuccessful tag attempt boat 1 logger #1147 RRH/23:48	77.9411	009.7915	-	1
	19 June	19_June_12 12_Mn171A&171B tagging sequence logger #1158 tag boat 1 RRH/22:44	79.0295	010.5769	12_Mn171A&B	1
	19 June	19_June_12 humpback whale #2 associated during trials with humpback tag Mn171A&171B LK/18:24	79.0003	010.4021	-	1
	26 June	26_June_12 12_Mn178A tagging sequence tag boat 1 RRH/12:27	74.8615	017.7678	12_Mn178A	1
	26 June	26_June_12 humpback flukes #1 to #10 in vicinity of 12_Mn178A/03:06-10:16	74.8553	017.7079	-	10
	27 June	27_June_12 12_Mn 179A tagging sequence tag boat 1 RRH/07:44	74.0273	020.5344	12_Mn179A	1
	27 June	27_June_12 humpback flukes #1 to #6 opportunistic /03:27	73.9779	019.4865	-	1
	27 June	27_June _12 humpback flukes #1 to #6 opportunistic /06:18	74.0238	020.7522	-	5
	28 June	28_June_12 Humpback tagging sequence 12_Mn181A&B tag boat 1 PW/15:51	74.2348	020.8265	12_Mn181A&B	2 (cow/calf)
	28 June	28_June_12 humpback opportunistic /11:03	74.1214	021.0870	-	1
	28 June	28_June 12 humpbacks #1 to #3 vicinity of 12_Mn181A&B/16:38	74.0102	020.5666	-	1
	28 June	28_June 12 humpbacks #1 to #3 vicinity of 12_Mn181A&B /22:52	74.0102	020.5666	-	1
	28 June	28_June 12 humpbacks #1 to #3 vicinity of 12_Mn181A&B /23:38	74.0102	020.5666	-	1
						Total 42

***Images for this individual are found only in the humpback photo-id subfolder.**
All images collected are included in the comprehensive daily archive subfolders; the best photo-id images for each individual are summarised in the respective species photo-id subfolders.

Table A.7 (continued). Summary of photo-identification and photo-documentation of tagging sequences of humpback, fin and blue whales during 3S-12

	Date	Daily archive subfolder name/Time start photos GMT	Latitude N	Longitude E	Tag Number	Number of individuals
Fin whale	8 June	8_June_12 12_Bp160A tag sequence and double tag attempt logger #906 PHE LK RRH/14:45	76.7087	013.7007	12_Bp160A	1
	12 June	No photos			12_Bp164A	
	15 June	15_June_12 fin whale tag attempt tag boat 2 two shots two misses logger #1109 PHE/15:48	77.6943	009.9187	-	1
	15 June	15_June_12 12_Bp167A tagging sequence boat 1 RRH/19:08	77.5931	010.9025	12_Bp167A	1
	28 June	28_June_12 Fin whale 3 animals tag boat 2 PHE/12:40	74.1328	020.5739	-	1
						Total 4

Blue whale	9 June	9_June_12 blue whale tag boat 1 logger #965 RRH/07:33	77.6205	011.1725		1
	9 June	9_June_12 blue whale tag boat 2 logger #unknown PHE/11:32	77.6077	011.1614		1
	12 June	12_June_12 blue whale tag boat 1 no logger # RRH/11:17	77.8826	009.9279	Resight of 9 June 11:32	-
	15 June	15_June_12 blue whale from Sverdrup logger #1115/05:09	77.6740	010.4332	Resight of 9 June 11:32	-
	18 June	18_June_12 blue whale from Sverdrup RD/16:19	77.4800	011.6735		1
						Total 3

A.10.3 Blue whales

Solitary blue whales were photographed opportunistically on 5 occasions during the cruise. Examination of photo-ID images shows that one of the blue whales was detected three times. The individual was initially sighted on the 9th of June, and subsequently re-sighted on the 12th (22.7 n.miles from the initial sighting position), and again on 15th of June (10.2 nmi from the initial sighting position) (Table A.7).

Figure A.16 Blue whales were sighted, photo id'd, and positively re-sighted during the 3S-2012 trial. Photo: Rune Roland Hansen.

A.11 Physical environment

Measurements of sound propagation conditions were made in connection with the sonar exposure experiments. The DTAG has a hydrophone in it, which measures the sound levels on the animal during the sonar exposures. However, in our analysis it is important in order to understand the response of the animal to have an idea of the overall sound picture in the environment. To achieve this without measuring the sound levels at different depth and positions during the experiments (which would be impossible), sound speed profiles are used as input to sound propagation models (figure A.17).

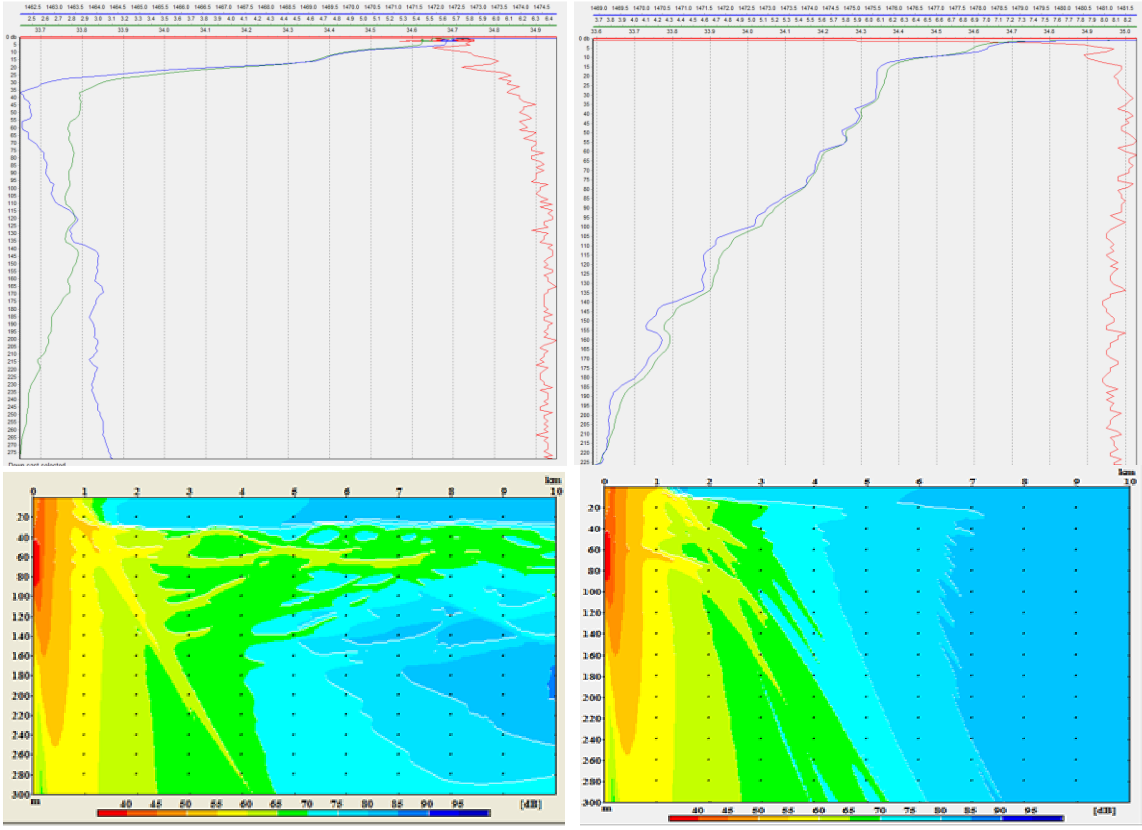


Figure A.17 Upper panel: Profiles of temperature (green) salinity (red) and sound speed (blue) through the water column during the experiment in Kongsfjord (left) on June 19th (Cast HUS-05) and in open ocean south of Bear island (right) on June 27th (cast HUS-09). In the coastal environment there is a layer of relatively fresh and "warm" water, which generates a sound channel around the depth of the source (60-65m). In the open ocean south of Bear Island the salinity is constant, but a gradual reduction of temperature with depth generates a downward refracting sound propagation condition. Lower panel: Transmission loss estimated by propagation model Lybin based on the transmission characteristics of Socrates and the sound speed profiles HUS-05 (left) and HUS-09 (right).

Profiles of temperature, salinity and depth are used to calculate the sound speed profile through the water column, and were therefore collected using an SAIV SD200 CTD profiler at the position of the closest point of approach of the third approach of the tagged animal by the source ship (table A.8). However, this could only be done after the experiment when the source ship could stop, and therefore we also collected a temperature profile using XBT's during each approach (table A.9).

Table A.8 CTD casts taken during 3S-2012

Station no	Date	Time UTC	Position	Ecco depth	Cast depth	Source depth	Event
HUS-01	09.06.12	0:14	76°49,20'N 13°21,50'E	170	150		Fin whale, tag off before silent run.
HUS-02	10.06.12	04:28	77°29,42'N 11°20,12'E	315	300	~65	RampUp exp on humpback. CPA of third approach
HUS-03	13.06.12	04:50	77°51,20'N 09°46,10'E	602	580	~65m	RampUp exp on humpback. CPA of third approach
HUS-04	18.06.12	13:22	77°52,20'N 10°29,90'E	154	145	~65m	RampUp exp on humpback. CPA of third approach
HUS-05	19.06.12	21:05	79°01,23'N 10°29,55'E	190	180	~65m	RampUp exp on humpback. CPA of third approach
HUS-06	22.06.12	08:52	78°33,70'N 14°57,00'E	91	85		Test of parachute DTAG in Nordfjord
HUS-07	22.06.12	09:27					Empty cast
HUS-08	26.06.12	10:07	74°51,40'N 17°46,40'E	315	300	~61	RampUp exp on humpback. CPA of third approach
HUS-09	27.06.12	17:14	73°58,00'N 20°33,10'E	238	230	~65	RampUp exp on humpback. CPA of third approach
HUS-10	29.06.12	02:09	74°00,20'N 20°28,90'E	216	200	~61	RampUp exp on humpback. CPA of third approach

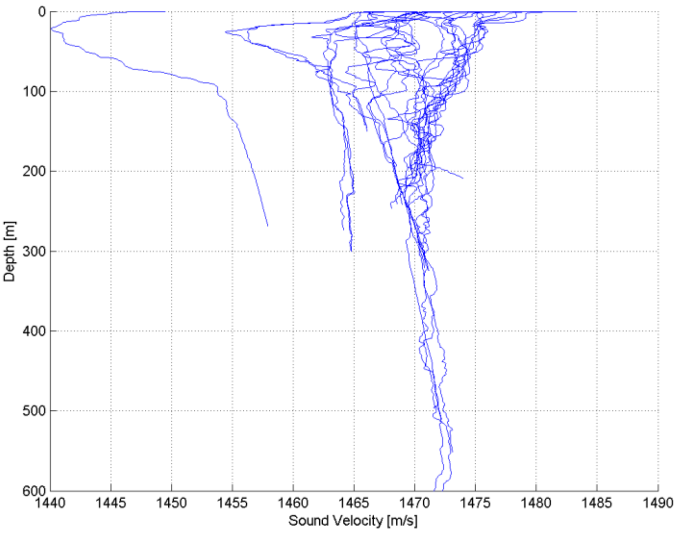


Figure A.18 Overview of all XBT-profiles, demonstrating variability of sound speed profiles. Here sound speed is given as provided by manufacturer's calculation, based on measured temperature and fixed salinity of 35‰.

Table A.9 XBT casts taken during 3S-2012

File name	DATE	TIME UTC	N deg	N min	E deg	E min	H (m)	COMMENT
T7_00002.EDF	5-6-2012	19:49:31	76	14,9565	17	7,9771		Not to be trusted. After light bulb experiment
T7_00003.EDF	9-6-2012	0:07:09	76	49,4400	13	20,7500		Together with CTD cast HUS-01
T7_00004.EDF	9-6-2012	23:31:30	77	32,5761	11	16,9731		cee003 silent run
T7_00005.EDF	10-6-2012	1:09:29	77	32,1651	11	26,1531		cee003 rampup exp
T7_00006.EDF	10-6-2012	2:30:56	77	29,9526	11	21,4221		cee003 full power exp
T7_00007.EDF	12-6-2012	8:49:37	77	55,4607	9	37,9441		cee004 Lubell test experiment
T7_00008.EDF	12-6-2012	9:13:07	77	55,6709	9	36,6291		cee004 Lubell test experiment
T7_00009.EDF	12-6-2012	22:34:31	77	48,4827	9	55,0071		cee005 silent run
T7_00010.EDF	13-6-2012	0:08:01	77	49,3123	9	53,8227		cee005 rampup exp
T7_00011.EDF	13-6-2012	1:47:07	77	51,3866	9	48,4555		cee005 full power exp
T7_00012.EDF	18-6-2012	8:55:22	77	44,2333	11	2,9718		cee014 silent run
T7_00013.EDF	18-6-2012	10:46:55	77	49,9541	10	51,1957		cee014 ramp-up
T7_00014.EDF	18-6-2012	12:38:36	77	52,5148	10	27,2897		cee014 ramp-up
T7_00015.EDF	19-6-2012	16:55:25	79	2,2192	10	26,6644		cee015 silent run
T7_00016.EDF	19-6-2012	18:44:54	79	1,9328	10	26,8252		cee015 ramp-up
T7_00017.EDF	19-6-2012	19:57:51	79	1,3714	10	26,3221		cee015 ramp-up
T7_00018.EDF	26-6-2012	5:18:54	74	53,3505	17	44,4868		cee016 silent run
T7_00019.EDF	26-6-2012	7:31:43	74	51,3520	17	45,3857	313	cee016 ramp up
T7_00020.EDF	26-6-2012	9:01:42	74	51,3353	17	48,2796	320	cee016 ramp up
T7_00021.EDF	27-6-2012	12:24:50	74	5,4335	20	39,6469	160	cee017 silent run
T7_00022.EDF	27-6-2012	13:54:27	74	1,3660	20	37,7352	218	cee017 silent run
T7_00023.EDF	27-6-2012	15:13:07	73	59,9299	20	36,0919	234	cee017 ramp-up
T7_00024.EDF	27-6-2012	16:24:01	73	57,8272	20	33,0521	243	cee017 ramp-up
T7_00025.EDF	28-6-2012	21:06:29	73	59,9910	20	25,8153	205	cee018 silent run
T7_00026.EDF	28-6-2012	23:01:20	73	59,0614	20	29,8305	213	cee018 ramp-up
T7_00027.EDF	29-6-2012	1:03:02	74	0,2942	20	30,2271	215	cee018 ramp-up

Ambient noise levels were also measured as a pilot study in order to describe the environmental context of the sonar exposure experiments. This was by lowering a hydrophone off the tag boat after the killer whale playback experiment.

A.12 Passive acoustics

Based on lessons learned from last year (3S-2011), it was decided not to spend any effort on passive acoustics during operations with larger baleen whales (Kvadsheim et al., 2011). Therefore, the Delphinus array was only towed while in survey mode, searching for northern bottlenose whales (Figure 3.1.). Survey opportunities for bottlenose whales where rather limited, due to unfavorable weather forecasts for the offshore area. Most survey activities were concentrated at 16th and 17th June. No bottlenose whales were detected during these surveys (acoustically or visually). Apart from this actual survey, 3 experiments were performed to verify system performance:

- Experiment with imploding light bulbs, 5th June to test Delphinus performance.
- Experiment with Lubell transducer, 12th June, to test Delphinus ability to detect and localize bottlenose whale type sounds.
- Experiment to test mechanical limits during dual tow (SOC+Delphinus), 16th June

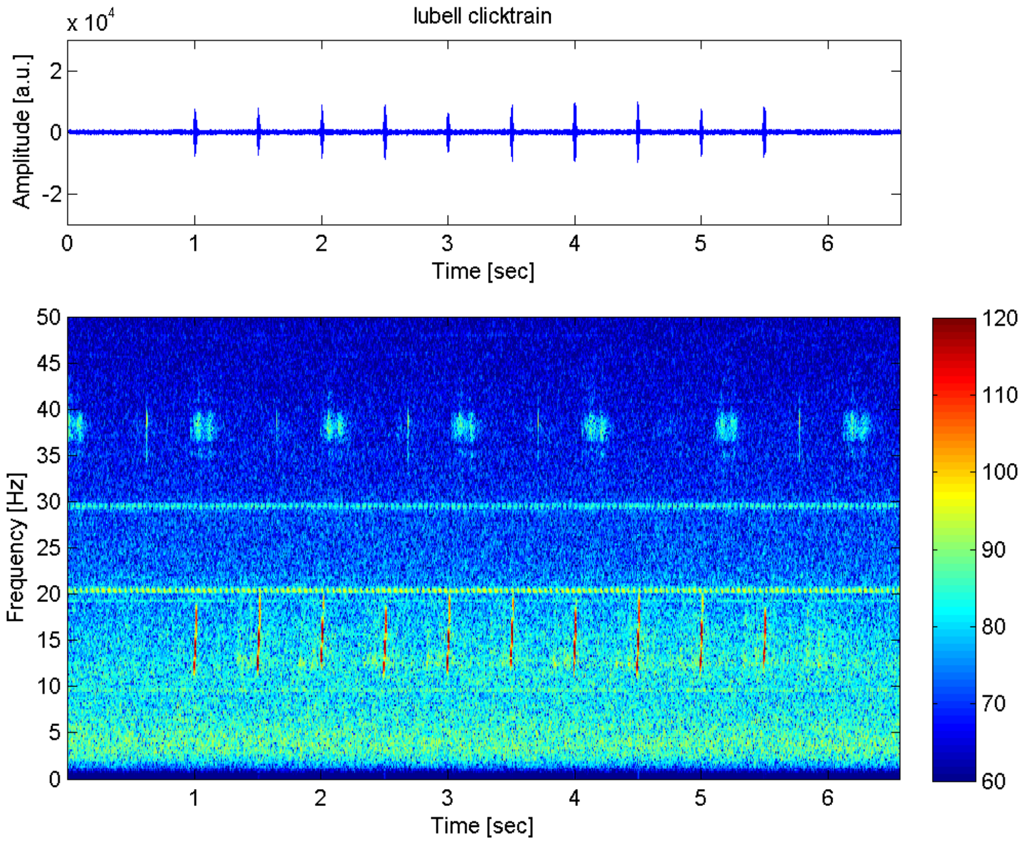


Figure A.19 Time-Amplitude (upper panel) and Time-Frequency plot (lower panel) of the Lubell click train signal detected by Delphinus.

At the start of the experiment on June 12th different signals where compared (imploding light bulbs, hammering on a steel pipe (the pipe partly below the water surface) and Lubell underwater speaker transmitting alternating signals every 25 s (e.g. figure A.19): Sweep 12-20 kHz (0.5 s), click train (10 clicks, ICI 0.5s), also the 38 kHz echosounder from HUS could be detected clearly, especially during turns.
The following observations were done based on these tests:

- XCORR provides reliable target bearings up to 3500m (with Lubell test signal).
- Based on TMA-plot the estimated position was correct within approx. 100m.
- Measurement errors for bearing estimation are a combination of errors in the estimation of the array heading and position and errors in the xcorr measurements. During and shortly after turns the estimations of the array heading/position is deemed to be the major cause of bearing errors. During straight tracks with a steady array the errors are probably more equally caused by the array heading estimation and acoustic measurements.
- Results at short range < 500m are probably biased due to near-field effects. It might be worthwhile to investigate solutions (including ranging) for this.

- For now Port-Starboard discrimination (using the triplet sensor) and ranging seems difficult due to correlation peaks that spread out. This is most likely a combination of propagation effects (multi-path) and (poor) signal quality of the resulting received signal from the Delphinus hydrophones along the array.
- It looks like signals from the front have less SNR compared so signals from behind. This can be caused by shielding of the spacers in the array and/or directivity of the UHF hydrophones, as the hydrophones point aft-wards.

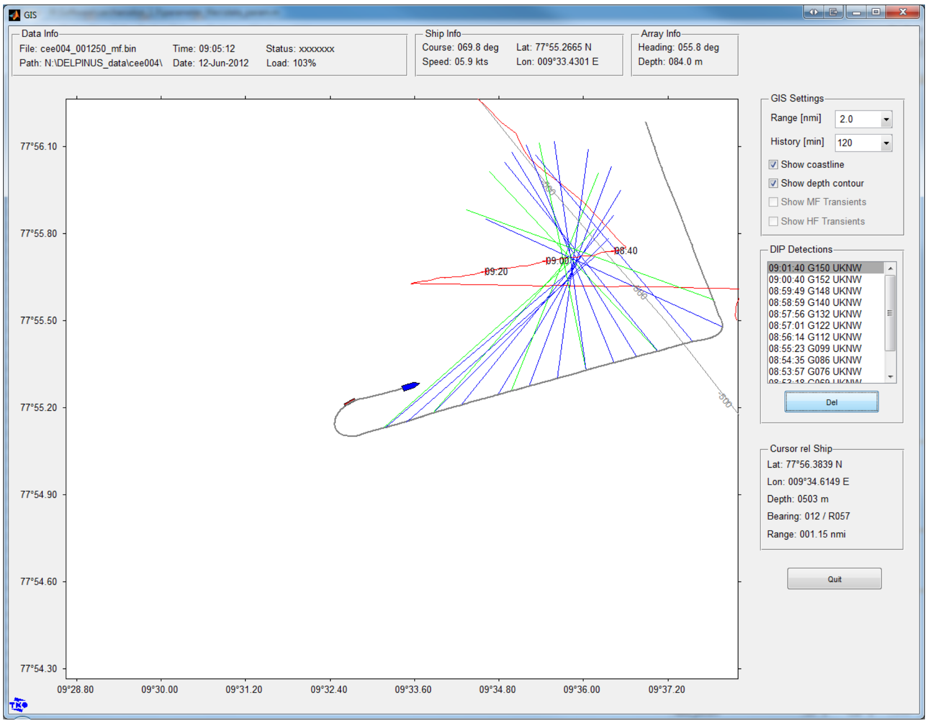


Figure A.20 Target Motion Aanalysis of the Lubell click train signal detected by Delphinus. Own ship (track) and array (track) are depicted by the blue ship symbol and red box on the grey line. The track of the tag-boat playing the sounds is depicted by the red line. Bearings of the detected Lubell signals are shown in blue (XCORR) and green (MF beamformer).

In conclusions these test were useful in evaluating the system, and to identify needs for further improvements, even though a real bottlenose whale target would have been better.

In order to conduct experiments on bottlenose whales according to the established protocol, both the Socrates sonar source and the Delphinus passive acoustic array have to be towed at the same time, while simultaneously trying to achieve the correct geometry of the exposure experiment. We therefore tested the operational limits during such a dual tow on June 16th using different turns (90 degree port and starboard) at different turn rates (15-25 degrees/minute) and at different tow speed (3-6 knots were tested). The cable scope was 150m and 640m for the Socrates and Delphinus system, respectively.

The resulting depth variations during the turns do not show a very clear picture due to speed variations, wind and current variations during the turns. The speed of the vessel tended to drop slightly when turning towards the prevailing wind direction. Also, because of the wind drift there was in general a difference in heading and COG. Overall it was found out that during slower speeds the array and source sink deeper during turns. Overall it was found out that during starboard turns the array and source sink deeper than during port turns. Visual observations of the tow cables during the turns showed a more stable situation during port turns.

Based on this test these new dual tow sailing restrictions were implemented:

- Starboard turn at 3-12 kts with 20 deg/min max.
- Port turn at 3-12 kts with 25 deg/min max.
- While turning, speed should remain constant.

Existing single tow sailing restrictions are kept in force:

- Port/Starboard turns at 3-12 kts with max 30 deg/min.

Table A.10 Overview of acoustic recordings and transmissions (Delphinus and SOC) during 3S-2012.

Exp Name	**Systems**	**Start Time (UTC)**	**Duration [HH:MM]**	**Size [GB]**	**Summary**
MinkyDinky01	Delphinus	02-06-2012 14:53	00:35	13	System test
MinkyDinky02	Delphinus	02-06-2012 15:29	00:21	10	System test
MinkyDinky03	Socrates	02-06-2012 16:30	-	1	System test
Cee001	Delphinus	05-06-2012 14:45	01:21	39	Light bulb test
Cee002	Delphinus	08-06-2012 07:51	03:43	84	Survey
Cee003	Socrates + OWID	09-06-2012 22:00	-	1	Humpback exposure
Cee004	Delphinus	12-06-2012 07:41	02:00	45	Localization test with Lubell
Cee005	Socrates + OWID	12-06-2012 22:00	-	1	Humpback exposure
Cee006	Delphinus	16-06-2012 06:55	01:55	47	Survey
Cee007	Delphinus	16-06-2012 08:53	06:07	161	Survey
Cee008	Delphinus	16-06-2012 15:04	05:26	152	Survey
Cee009	Delphinus+ Socrates	16-06-2012 20:32	00:43	19	Survey + dual tow test
Cee010	Delphinus+ Socrates	16-06-2012 21:18	02:12	13	Dual tow test, Delphinus was off except depth sensor.
Cee011	Delphinus	17-06-2012 01:30	06:00	101	Survey (UHF module only)
Cee012	Delphinus	17-06-2012 07:30	06:18	104	Survey (UHF module only)
Cee013	Delphinus	17-06-2012 13:48	01:59	33	Survey (UHF module only)
Cee014	Socrates + OWID	18-06-2012 08:30	-	1	Humpback exposure
Cee015	Socrates + OWID	19-06-2012 16:48	-	1	Humpback exposure
Cee016	Socrates	26-06-2012 05:15	-	1	Humpback exposure
Cee017	Socrates + OWID	27-06-2012 12:00	-	1	Humpback exposure
Cee018	Socrates + OWID	28-06-2012 21:00	-	1	Humpback exposure
Total				829	

Appendix B Recommendations from the 3S-2012 team

At the last day of the 3S-2012 trial a "*hot wash up*" de-brief was held on board with the entire science team to recapitulate the events of the trial and to summarize any lessons learned. The key output of this meeting is a list of issues which points to potential improvements to our procedures, technical capabilities or human skills (Table B.1.). This helps us in being systematic about improving the performance of the group a little bit every year. This list was revisited at the post cruise meeting in St. Andrews in Sept. 2012, where again most of the 3S-2012 team was gathered. Here it was discussed which action items should be followed up, priority, feasibility check, who should be responsible and deadlines.

Table B.1 List of issues raised by the 3S team to further improve data collection.

Issue raised by 3S-team	Comments/Follow-up/actions	Responsibility Deadline
EQUIPMENT		
Data link between MOBHUS and HUS for transfer of whale position updates.	*Unfeasible, unless we can use the "Wild" system. Ask SOCAL*	SMRU Oct 2012
Acoustic triplet functionality	*Priority is high, but feasibility is uncertain*	TNO 3S-2013 trial
Test and improve the range of the DDF	*Test is feasible, improvement is uncertain.*	FFI 3S-2013 trial
Verify dynamic range of RL array	*High priority*	SMRU 3S-2013 trial
Received level measurements in the water column (vertical array) (for CTAG use)	*This requirement might be combined with background noise measurements.*	All (TNO lead) 3S-2013 trial
Compass on TB1 and TB2 need maintenance, not readable now	*Fix or replace it!*	FFI 3S-2013 trial
New computer for the MMO-deck on HUS	*Possibly ruggedized but screen size more important. Low priority*	SMRU 3S-2013 trial
Backup for VHF-communication in cases were VHF tracking is critical (interferences on DDF).	*Make intercom system available*	FFI 3S-2013 trial
FIELD SITE		
Consider to change field site and period if species priority changes	*Minke whales and bottlenose whales are higher priority for 3S13. Change field site to Vestfjorden-Jan Mayen*	3S-board 3S-2012 Post cruise meeting
Verify possibility to make use of air search (scouting trips) beforehand.	*Depend on field site*	FFI 3S-13 meeting
TAGGING/TRACKING		
Increase chance of success when you get one	*Field training, target practice, improve sight system for ARTS*	FFI 3S-2013 trial
Train more than one ARTS tagger and bring additional ARTS-systems	*High priority*	FFI 3S-2013 trial
More use of the CTAG	*Will give us longer range, and more opportunities but lower quality data*	3S 3S-13 meeting
Improve sensors on CTAG	*Key is to keep it small. Feasibility uncertain.*	FFI 3S-2013 trial
Field test of invasive DTAG	*Best opportunity is on humpbacks in January. High priority, feasible.*	FFI 3S-13 meting

Table B.1 continued from previous page			
	Comments/Follow-up/actions	**Responsibility**	**Deadline**
PROTOCOL/PROCEDURAL ISSUES			
Background noise measurements, asses what other BRS-groups are doing	*Consider work done in European working group TSG Noise. Medium priority, feasible.*	TNO	3S-13 meeting
Background noise measurements, evaluate usability of measurements as done in 3S-2012	*Medium priority, feasible.*	TNO	3S-13 meeting
Backup of MOBHUS Logger data during crew changes during experimental phase	*A simple procedure should be established were the backup is brought back to HUS at every crew change.*	SMRU	3S-2013 trial
Stay with minkes when minke whale condition	*Depend on species priority*	Cruise leader	Cruise plan
Assess more structured use of pictures and videos (build into protocol). What can we get out of it?	*Avoid undesired effect (distraction, privacy aspects, negative PR). What is the equipment need?*	KMR	3S-13 meeting
Replacing tracking with GPS logger	*Implies that logger also transfer position to source boat. We also have to suffer behavioural observations. Currently not feasible.*		
Assess needed duration of pre-tagging phase versus avoiding missing tagging opportunities	*clear procedure needed*	3S	3S-13 meeting
Look at the role of mitigation observer during exposure	*Make clear what is needed for mitigation/safety and what is useful for evaluation of exposure run*	Cruise leader	Cruise plan
Try to be more systematic in doing prey field mapping	*Feasible at least in some phases of the experiment.*	IMR	3S-13 meeting
CRUISE MANAGEMENT			
Daily order seem to be read by all, when it's up by 08:00	*Make sure it is*	Cruise leader	3S-2013 trial
Open management meetings not needed.	*This year good communication through the CO/XO on watch.*		
Data management – a clear data folder structure should be set up during the next trial, with a central server and a wireless network	*High priority/low cost. Should be implemented in cruise plan*	SMRU/TNO/FFI	3S-13 meeting
Implement data management procedure which needs to be followed during trial	*Depending on choice of equipment (central server)*	All	3S-13 meeting
Where possible, prevent that essential tasks on board are dependent on a single person	*Implement as much as possible*	All	3S-2013 trial

3S-13 meeting = deadline is cruise planning meeting for the 3S-2013 trial (March 2013).
3S-2013 trial = deadline is start of the 3S-2013 trial (June 2013).

Appendix C Data inventory

Table C.1 The data inventory table contains a complete list of all data, files and folders collected and generated during the trial, and eventually uploaded to the central database at the end of the trial.

Folder	**Subfolders/short description of data**	**Content details**
Documents	single files in root	TNO CEE logbook and recording overview, experiment timeline based on Logger effort table, KelpMR logbook, Dtag deployment durations, biopsy data overview
"	Daily work plans	Cruise leaders dairy, watch plan, and daily work plans that were put up on the whiteboard
"	Data inventories	Initial versions of FFI and TNO seperately
"	Event logger HUS	For each day the GPS log from the Maria computer on bridge
"	Maria files	Maria raw data and printscreens of vessel tracks and events shown in marine charts
"	MMO docs	Docs related to MMO work
"	Slides meetings	PPT slides used during the group meetings
"	TNO docs	Documents related to TNO's work. Includes screendumps folder with a selection of printscreens from TNO's acoustic station
CTD	CTD log, raw data CTD files, Lybin output	SD200W can be used to read the raw CTD files. Lybin transmission loss model output can be found in doc file.
DTAG	Raw (.dtg) DTAG data	Organised by species and tag ids. Sensor and audio data can be extracted with ffsrdall.exe. Also includes cal and prh files
Echosounder	Echosounder (EA600) data of prey field	
GPS tag	Sirtrack Fastloc GPS raw and processed data	Organised by tag id. Processed data in .pos files in txt format
Logger backup	Access databases created by Logger	Final versions of the Logger stations on HUS and MOBHUS. Checked databases provided in xls files
Observer cals	Raw and processed data including scripts	Primary results in two pdf files
Orca playbacks	Transmitted sound files with log file	
OWID recorder	OWID acoustic recordings	Recordings with calibrated hydrophone of ambient noise and killer whale playbacks.
Pics and videos	For cruise report	Photos of tagged animals for cruise report
"	Fun pics	Photos made with private cameras sorted by name of camera owner
"	Images of tags	More photos of tagged animals
"	Photo ID	Photo ID data per day and species, including tagging sequences and biopsy attempts. Includes document with summary of dataset
"	Photogrammetry	Photos possibly suitable for photogrammetry
"	Videos	Videos by maker. The folder "Combined by Rune" includes work-related videos of multiple makers, and a summary document
"	Whales selected	Selection of whale pictures

Table C.1. continued from previous page		
Folder	**Subfolders/short description of data**	**Content details**
Socrates logs	Log files of SOCRATES II sound source	Times of transmissions can be found in the file transmission.log in each subfolder
Social behaviour	Files related to group behavioural sampling	Waypoints from tests with handheld GPSs recording breath times
Tagboat GPS	Tagboat tracks from Garmin handheld GPSs	Stored in gpx (general exchange) and/or gdb (Mapsource) format. GPX is in standard ASCI txt format
TNO GPS	Recordings of GPS mounted on TNO container	Raw NMEA logs and all data combined in two Matlab workspace files including scripts
TNO tracks	Daily sailing tracks	Overview of tracks from GPS-data from TNO GPS\mat-files. For this release the gps-logging was stopped at 08:00 UTC, 30-06-2012
VD array	Recordings from the VolkerDeecke array	
Sound samples	Examples of sound clips	A few humpback whale social sounds found on the Dtag during data checks
XBT	XBT data	One temperature profile was measured during each exposure run

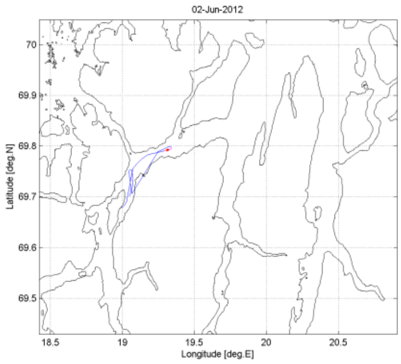
Appendix D Short diary with daily sail tracks

This appendix contains a short description of the day by day activity (diary) with a figure illustrating the sailed track that day. Sail track in red indicates active sonar transmission using the Socrates system, and sail track in magenta indicate towing of the Delphinus array.

June 1.

Crew embarks HU Sverdrup II and starts installation of equipment on board. Joint brief of trial objectives and procedures. Formal 3S-dinner at Skarven restaurant.

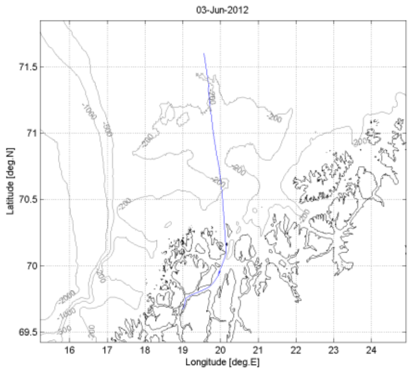
June 2.



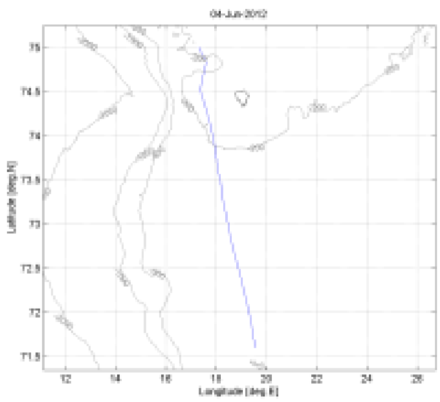
Continue installation and test of equipment. Fuel, water and food supplies on board. Exercise of the experimental drill in Grøtsundet. Transit back to port in Tromsø.

June 3.

Final test of equipment. Sea ready the ship. Departed from Tromsø at 10:00. Range tests of VHF direction finders during Transit. Transit in eastern gale (force 7) across Tromsøflaket towards Bear Island.



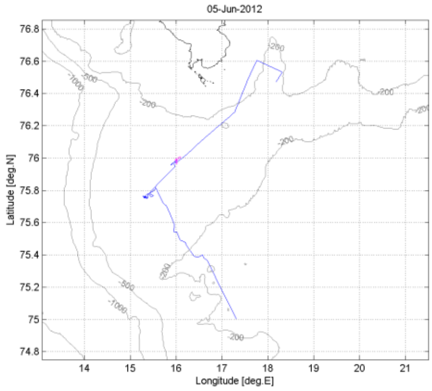
June 4.



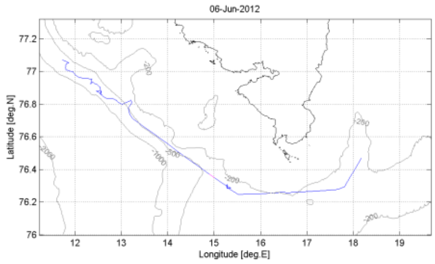
Passed Bear Island in eastern fresh breeze. Crossed over Humpback Ridge. Some sightings of large blows, but impossible working conditions. Continue to transit northwards towards Spitsbergen.

June 5.

Reach the southern slope of the Storfjordrenna at 02:00, the MMO station is now fully manned and have started to search for whales. Sightings of a few minke and humpback whales. Attempts to tag were not successful. Wind is picking up. Light bulb test with the array (Delphinus) revealed a short circuit in the acoustic section.



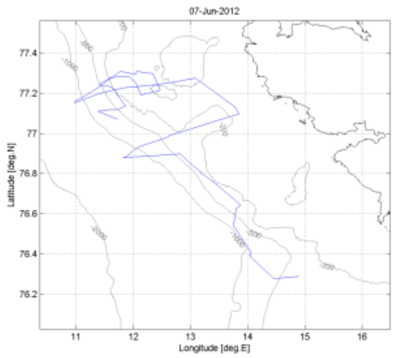
June 6.



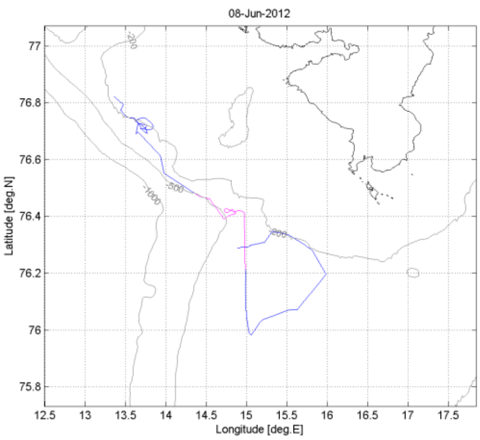
Continue to search also east of South Cape. No whale sightings. Turned back west and observed a humpback and a fin whale travelling together. Tag placed on the humpback, but a bad low placement. Tried to put a second tag on, but unsuccessful. Start experiment, but lost the animal.

June 7.

Searching for lost tag all day. Recover tag 8.8 nmi west of last known whale position and thus rescue not only the tag but also a 13 hr long baseline dataset. However, the GPS logger had fallen off and is lost. Continue searching southwards towards South Cape.



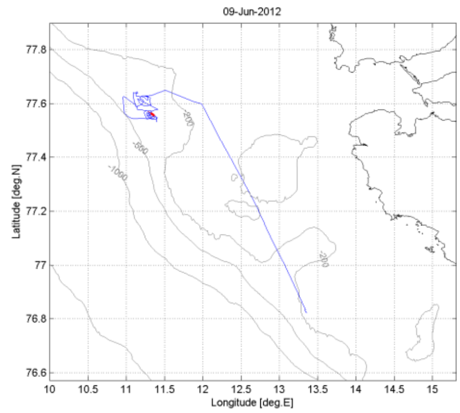
June 8.



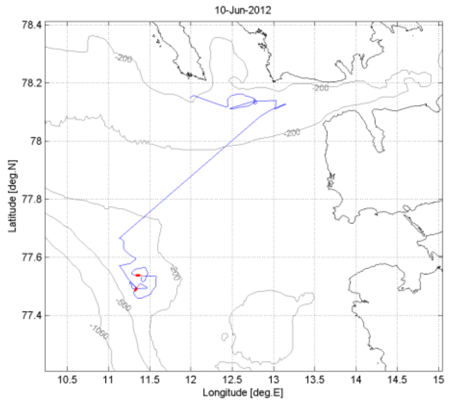
Searching northwards again along 200m depth contour. Very few sightings, mostly fin whales. Tagged a fin whale and initiated experimental procedure. Tag off after 8 hrs, before first approach. Another nice baseline dataset though.

June 9.

Working on the southern side of Egg bay all day. Sightings of many fin whales, but also some minkes and blue whales. Attempts to tag minkes and fin whales, but no success. Sighting of a humpback, which was quickly tagged and experimental procedure commenced. Completed full experimental cycle.



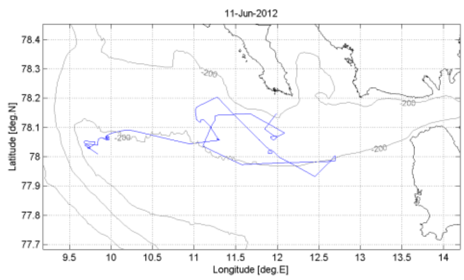
June 10.



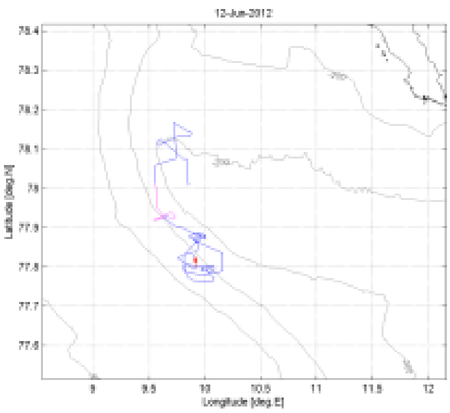
Transited NE to Icefjord Channel during resting period. Several attempts to tag minkes under very good conditions. Difficult to get close. Three whaling ships enter the area and we therefore search westwards out of the channel to avoid interfering with their activity.

June 11.

Sightings of several fin whales. Tagging attempts not successful. Switch to working with minkes, several close attempts to tag them, but no success.



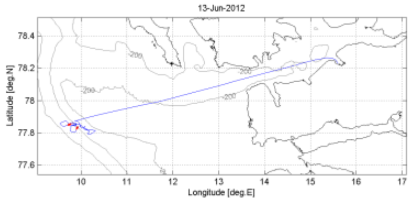
Jun12.



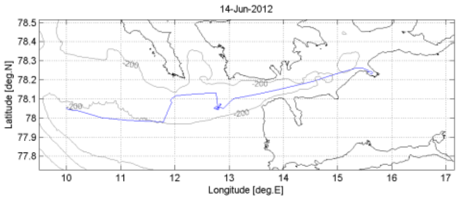
Continue to try to tag minkes but still no success. We have found no “seekers” this year so far. Tagged a fin whale, but tag came off after only 5 min. Sailed towards deeper water. Sighting of a humpback, which was quickly tagged. Completed full experimental cycle. Tag came off midway through the experiment but was redeployed. Tag release was 4 hrs late.

June 13.

Transited to Longyearbyen to get some food supplies during resting period.



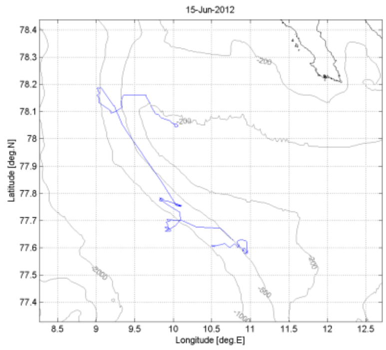
June 14.



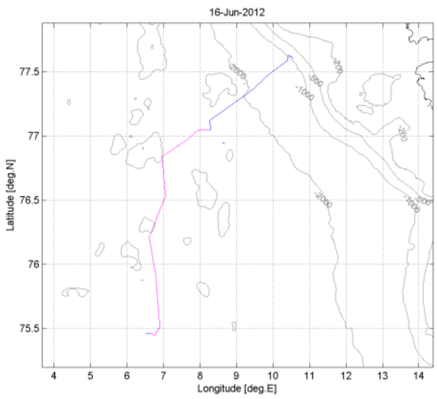
Searching through the Icefjord Channel. Sightings of fins and minkes. Tagging attempts on both species, but without success. Several whaling ships in the area. Searched westwards out of the channel to avoid being too close to them.

June 15.

Searching along the 800-1000m depth contour off the shelf break of Spitsbergen in boarderline conditions. Several sightings of humpbacks. Tagging attempts failed. Re-sighting of animals from experiments on June 12. Conditions improves further south. Sightings of many fin whales and blue whales. Several tagging attempts before a fin whale was finally tagged successfully. Started experimental procedure, but tag came off after 5 hrs. Another good baseline dataset, but some frustration that we don’t manage to get the exposures done because of short tag durations on fin whales.



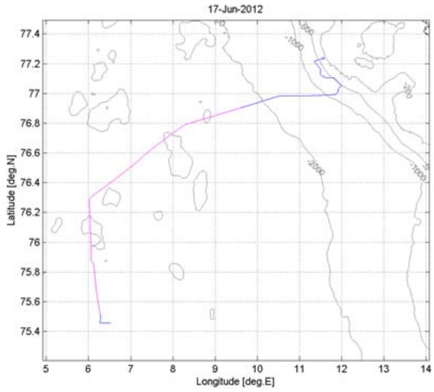
June 16.



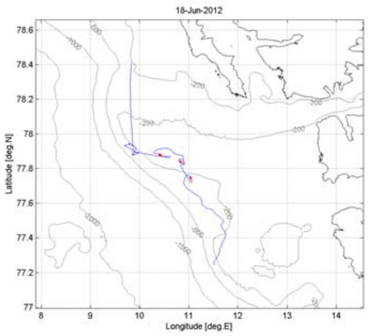
Transited to the Knipowich ridge, and start searching for bottlenose whales visually and acoustically. Search on the ridge from 77-75°N, 7-8°E, without any sightings or detections.

June 17.

Still no sightings of beaked whales. Wind increases from west, therefore we turn back north along the ridge and eventually turned back towards the coast of Spitsbergen.



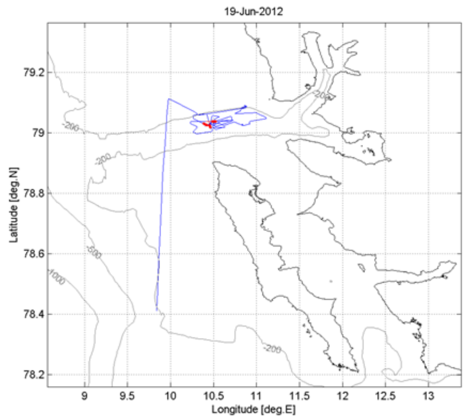
June 18.



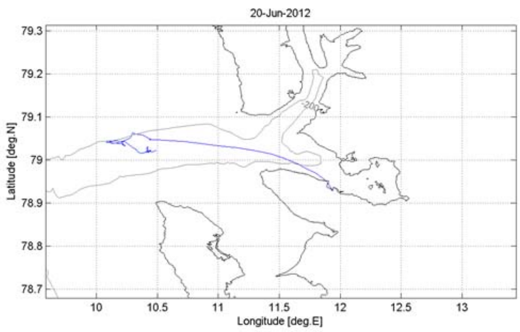
Sightings of high numbers of fin whales. No tagging attempts. Sighting of two associated feeding humpbacks. Both tagged, and experimental procedure commenced. Completed full experimental cycle.

June 19.

Transited to Kongsfjord during the resting period. Nice conditions and improving upon arrival. Sighted several minkes and had a very close tagging attempt. Sighted a humpback, tagged it twice and conducted a full experimental cycle.



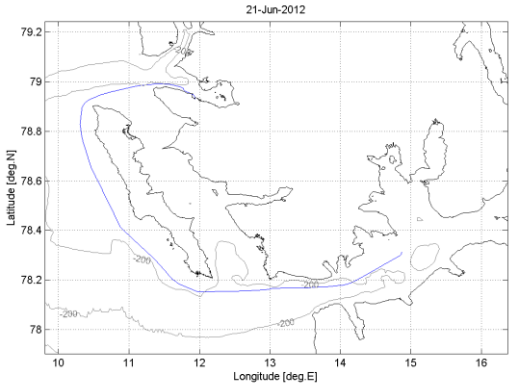
June 20.



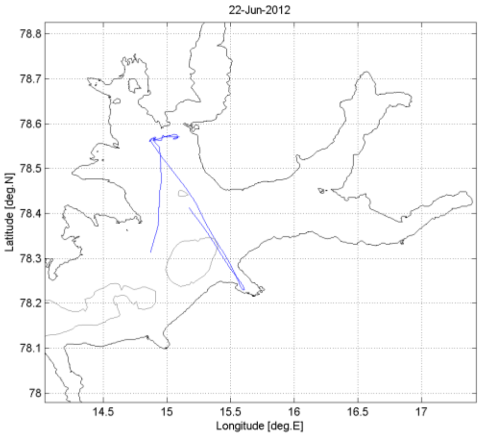
Encountered really bad weather in the end of the experiment, but recovered the tag (release was late again). Transited to New Ålesund for the resting period. Visited British Antarctic Survey research vessel James Clark Ross.

June 21.

Transited in bad weather from Kongsfjord Channel to Isfjord Channel. Non operational because of the weather.



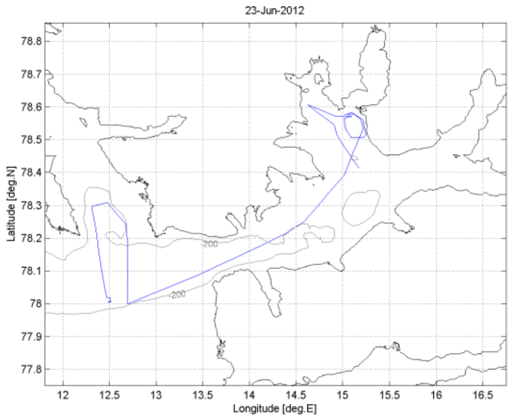
June 22.



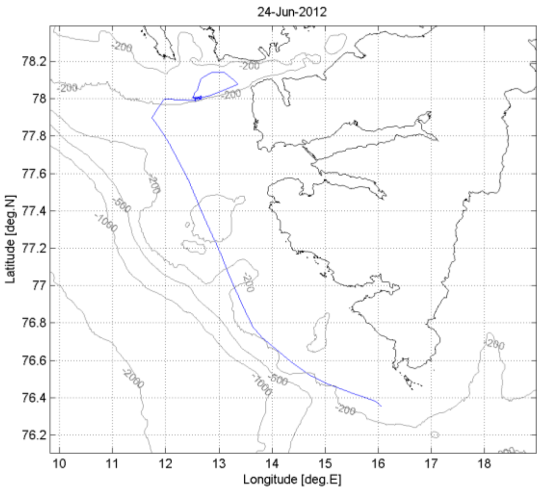
Calibration of the MMOs and some other tests done in Nordfjord. Still unworkable conditions. Lost a DTAG during experimentation with it as a slow descending acoustic recorder. It never surfaced again!

June 23.

Continue to search for lost tag inside fjords, and with a shore party. Give up and transit to Isfjord Channel. Still very difficult weather conditions.



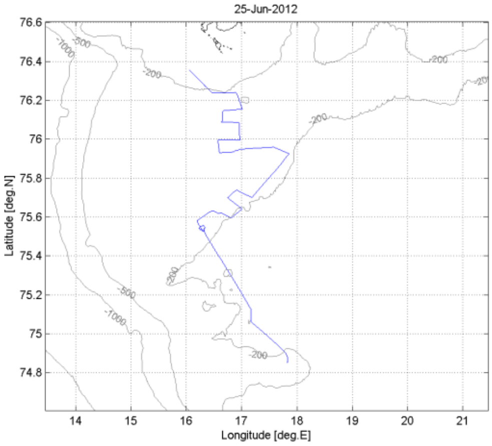
June 24.



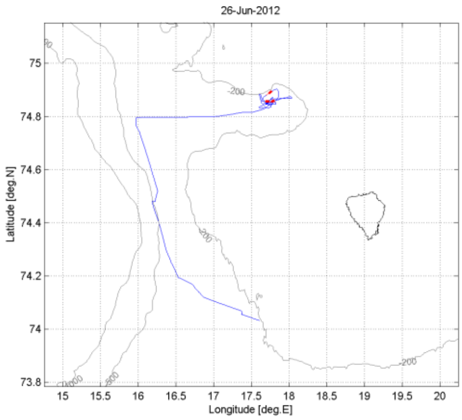
Sightings of several minkes in Isfjord Channel. Very low visibility due to fog. Tagging attempts with two very close approaches. Wind was turning north and increasing to unworkable levels. Transit southwards along the coast of Spitsbergen towards South Cape.

June 25.

Conditions improving south of South Cape. Searching southwards in the Storfjord Channel with very nice conditions. Sightings of several humpbacks are ignored to focus on minkes under these nice conditions. Finally sighting of minke whales after hours of searching. Commenced tagging attempts, but never even close. Continue south with the intention to also work with humpbacks and fins, because of the low number of minke sightings.



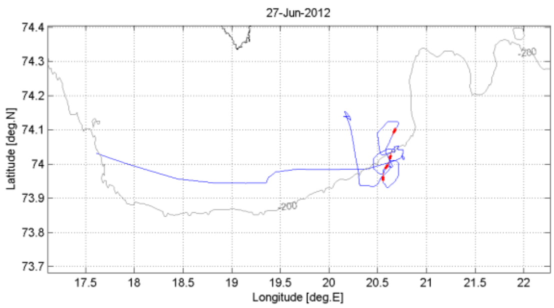
June 26.

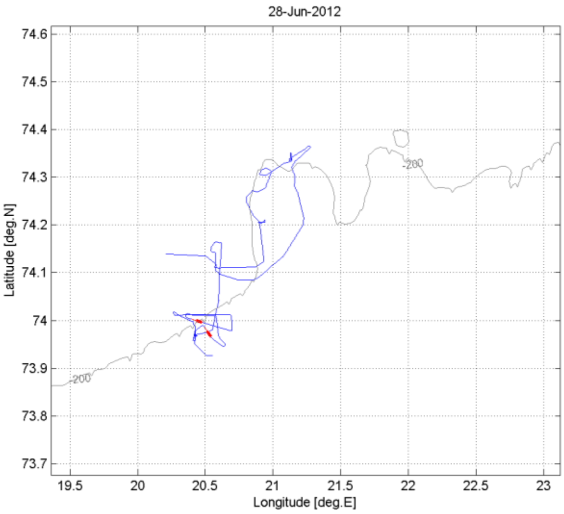


Reach Kveithola (Halibut hole) north of Bear Island. Sightings of 30-50 humpbacks. Quickly tagged a humpback in a group of 4-5 and completed ramp-up experiment. However, the animal breached and tag came off after 2nd sonar exposure. Killer whale playback was therefore cancelled. Transited westwards out of Kveithola to the shelf break during the resting period.

June 27.

Sailing southwards along the Humpback ridge. Sightings of many humpbacks and a few fins during the night, but condition is again unworkable. Turn east on to the shelf were conditions are expected to be better. Sightings of many humpbacks. Started tagging attempt on humpback on the Southern slope of Bear Island (Barents Sea Channel). Quickly tagged humpback in a group of 3. Release time was shorted to allow for a final experiment before time is running out. Completed full ramp up experiment, but no time for killer whale playbacks.



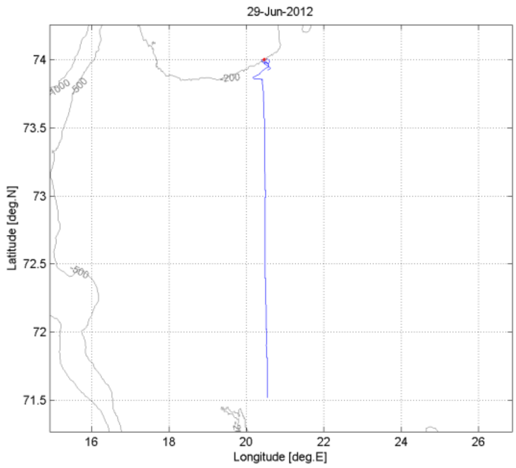


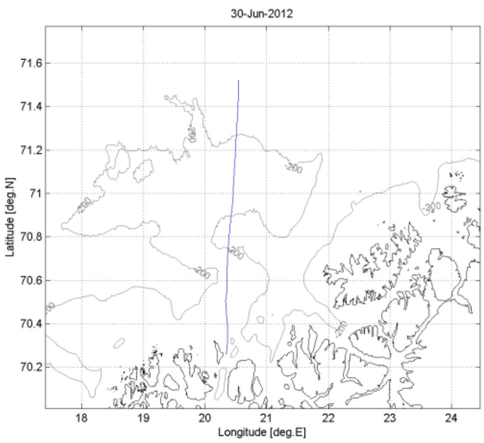
June 28.

Many sightings of minke whales and continuous tagging attempts, but no close ones. Run out of time to do a full 20 hr experiment with the invasive DTAG (which does not have a programmable release). Switches therefore to humpback tagging. Sightings of 80-100 humpbacks. Quickly double tag an animal travelling with a juvenile.

June 29.

Completed full experimental cycle with the humpback, silent-RampUp-RampUp + killer whales playback. Start the transit to Tromsø in the resting period.





June 30.

Transitting towards Tromsø. De-brief of cruise. Celebration of ourselves and a good result of the trial.

July 1.

Off loading, dissembarkment. End of 3S-2012-trial.

Appendix E 3S-2012 Cruise plan

3S-2012
Cruise Plan

Final

The 3S-12 research trial is conducted by the 3S-consortium as part of the $3S^2$-project

3S-12 cruise plan

CONTENT

3S-12 cruise plan

PROJECT OBJECTIVE

Investigate behavioral responses of cetaceans to naval sonar signals, including studies of the effectiveness of Ramp Up, sensitization or habituation, in order to establish mitigation measures for sonar operations.

CRUISE TASKS

Primary tasks:

1. Tag minke whales and northern bottlenose whales with DTAG and record vocal-, movement- and surface behavior, and thereafter carry out sonar dose escalation experiments (SDE) where the tagged animals are exposed to LFAS sonar signals and control experiment without any active transmissions.
2. Tag humpback whales with DTAGs and record vocal -, movement- and surface behavior, and thereafter carry out sonar Ramp UP experiments where the tagged animals are exposed to LFAS sonar signals and control experiment.

The three main target species (northern bottlenose whales, minke whales and humpback whales) all have equal priority at the start of the trial. Prioritization will be reassessed during the trial, as we make progress (or not).

It is expected that at the time of the start of the trial the formal decision at the NL MOD on future funding for TNO to participate on the planned 3S-13 trial will still be pending. The 3S-board will assess the situation at the start of the trial and if there is a significant risk that the TNO funding will not be approved, working with bottlenose whales will be considered a secondary task. This re-ranking of priorities is necessary to secure that we get a consistent and complete dataset on at least the two species where we already have collected data.

Secondary tasks:

1. Tag fin whales with DTAG and thereafter carry out sonar dose escalation experiments.
2. Carry out control experiments where tagged animals are exposed to a playback of killer whale sounds and a reference sound.
3. Tag animals and record natural undisturbed behavior of target species.
4. Collect group behavioral data to investigate the effect of tagging.
5. Retrieve information about the acoustic environment of the study area by collecting ambient noise, CTD and XBT measurements, and do acoustic propagation modeling.
6. Test the use of the ARTS system to launch the next generation DTAGs (DTAG3) on to our target species.
7. Biopsy sampling of target species.
8. Collection of bio-acoustic data using towed arrays.

The primary tasks have a higher priority than the secondary tasks. We will try to accomplish as much as possible also with the secondary tasks, and some of them are incorporated in our regular experimental protocol. However, secondary tasks will be given a lower priority if they interfere with our ability to accomplish the primary tasks.

3S-CONSORTIUM

The main partners of the 3S^2-project conducting the 3S-12 trial are:

- The Norwegian Defense Research Establishment (FFI), Norway
- The Netherlands Organization for Applied Scientific Research (TNO), The Netherlands
- Sea Mammal Research Unit (SMRU), Scotland
- Woods Hole Oceanographic Institution (WHOI), USA

In addition the following organizations are contributing to the project through their association with one or several of the 3S-partners:

- Institute of Marine Research (IMR), Norway
- LK-ARTS, Norway
- Kelp Marine Research (KelpMR), The Netherlands
- Balena Research Ltd, New Zealand

The 3S^2 research project is sponsored by;

- The Royal Norwegian Navy and the Norwegian Ministry of Defense
- The Royal Netherlands Navy and the Netherlands Ministry of Defense
- Office of Naval Research, USA

SAILING SCHEDULE

June

Fri 01. Embarkment of scientific crew at 08:00 on RV HU Sverdrup II (HUS) in Port Breivika, Tromsø. Technical installation of equipment commences.
16:00 – Cruise brief of scientific crew
19:00 - Joint dinner in town.

Sat 02. Continued installation and testing of equipment. Engineer tests and drill of operation in harbor basin. Safety training for tag boat team members.
14:00 Brief of ship’s crew.

Sun 03. Departure as soon as we are ready (tentative 08:00)
General safety brief by. Transit through Grøtsundet towards operation area. Final drill and tests of equipment. Fully operational upon passage of Fugløya. Regular watch plan implemented at 20:00.

04-29. Regular 3S-operation, no scheduled port calls.

Sat 30. Transit to Tromsø. Cruise de-brief meeting with entire science crew. Start working on Cruise report, de-installation and packing. ETA Tromsø at 20:00. Celebration ☺.

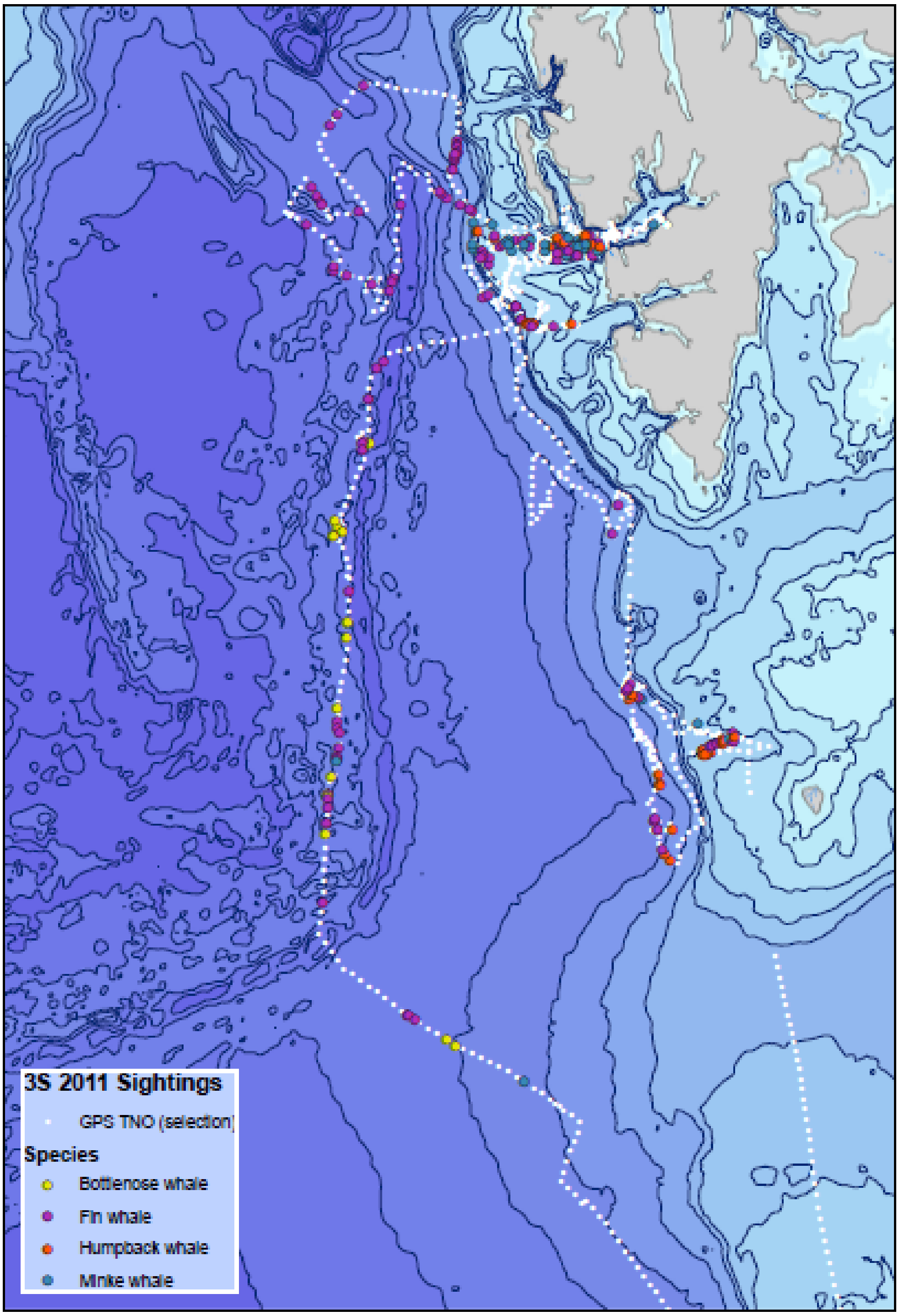
July 1. De-installation and packing.

July 2. Off-loading and dissembarkment in the morning

OPERATION AREA

The operation area and period will be mostly the same as during 3S-11. It is determined based on the experience from 3S-11 and a thorough analysis of availability of target animals and weather condition. Our operation area will be in open ocean primarily along the continental shelf break between Bear Island and Svalbard (74°N_17°E – 79°N_0°E). The distance from the southern to the northern part of this area is 600 nmi, and thus we are not going to cover all parts of the area equally thorough. Based primarily on the experience form 3S-11 we will focus our search for baleen whales in the area along the shelf break between Bear Island and the Icefjord Channel on Spitsbergen. However, due to operational restrictions of the Socrates system we cannot operate in waters shallower than 200-300m. Based on the experience from 3S-11 the search for bottlenose wales will be focused in the deep water areas west off the Barents Sea shelf break between Bear Island and South Cape (on Spitsbergen), and along the Knipovish ridge. Compared to 2011 we plan not to spend much time searching in the Fram Strait since we searched this area very thoroughly last year without any sightings of bottlenose whales.

The weather in this area is quite stable in the summer, and statistically we will have 15-25 days of working conditions. Decision on where within the operation area we will be at any given time will depend on weather, species priority, and reports of marine mammal sightings.



The operation area for 3S-12 is mainly based on the experience from 3S-11. The map shows positions of sightings of target species during 3S-11.

MAIN LOGISTICAL COMPONENTS

R/V H.U. Sverdrup II (HUS)
Length: 180 feet
Max speed 13 knots
Crew: 7
Scientific crew: 17
Phone: +47 95138992 (Cruise leader)

Captain*;** Jonny Remøy. ***First officer*;** Terje. **Chief engineer;** Erling ***Matros; Henning. ***Matros;*** *?* ***Steward*;** Bernt. ***Catering assistant*;** Liv

Sverdrup will be outfitted with the Socrates source and operating software, Delphinus towed array system, Digital Direction Finder VHF tracking system, two tag boats with cradle for loading/off-loading. Fuel for the tag-boats. In addition Sverdrup will also carry CTD probes.

Visual and acoustic search for marine mammals, VHF- and visual tracking of tagged animals, recording of behavioral observations of tagged animals, operation of sonar source and preparation of the tags will be done from the Sverdrup. Sverdrup will also lodge the entire research team and be the command center for the operation.

Tagging boats

Two tag boats can be deployed from HUS. Tag boat 1 is a four stroke outboard engine fibre glass work boat, and tag boat 2 is a water jet propulsion Man Over Board boat. Tag boat 1 is deployed using the ships derrick crane, and tag boat 2 is deployed using a dedicated davit. Tag boat 1 can be deployed and operate at sea conditions up to sea state 2, while tag boat two is a heavier more robust system which can be deployed and operated up to sea state 3. The tag boats will be launched when whales are sighted and weather permits tagging attempts. In the tagging phase they will carry tagging gear (ARTS, pole, tags with necessary accessories), documentation sheets, GPS, camera and communication gear (VHF). The tag team will usually consist of three people; a driver, a tagger and someone in charge of photo id/documentation.

Tag boat 1 will primarily be used for hand pole and long pole tagging. It will therefore be equipped with a cantilever swivel in the bow. Tag boat two will primarily be used for ARTS-tagging, and are therefore equipped with an elevated platform in the bow.

Tag boat two will also be used in the tracking phase. It will therefore be outfitted with an observation platform in the aft with space for two observers. It will also be equipped with VHF-tracking antennas and DDF receiver in addition to compass, binoculars, range finders and a data recording systems which consist of a fully ruggedized laptop running the Logger software. It will also be towing a small acoustic array (the VD-array of SMRU) which records the sonar levels and vocal activity close to the tracking boat. During tracking the crew will consist of 4 people, a driver, a data recorder and two marine mammal observers.

Tag boat 1 (left) and Tag boat 2 (right). Tag boat 1 will be equipped with a swivel in the bow for the cantilever pole. Tag boat 2 has a 2 person elevated MMO-station behind the driver for the tracking phase, and an elevated shooting platform in the bow for the tagging phase.

Sonar source – SOCRATES

The multi purpose towed acoustic source, called SOCRATES II (Sonar CalibRAtion and TESting), will be used and operated from the Sverdrup. This source is a sophisticated versatile source that is developed by TNO for performing underwater acoustic research. Socrates has two free flooded ring transducers, one ring for the frequency band between 0.95 kHz and 2.35 kHz (source level 214 dB re 1 µPa @ 1m), and the other between 3.5 kHz and 8.5 kHz (source level 199 dB re 1 µPa @ 1m). It also contains one hydrophone, depth, pitch, roll, and temperature sensor. All these sensors can be recorded. Because of risk of cavitation and damage to the source, it must stay below cavitation depth during operation. A minimum of 200 m water depth is required. Appendix A describes further details of SOCRATES and gives detailed operational instruction.

Acoustic array – Delphinus

During the trial, the TNO developed Delphinus array will be used. It will be deployed from the Sverdrup to primarily acoustically search for marine mammals and track bottlenose whales during experiments. The Delphinus is a single line array, 74 metres, long containing 18 LF hydrophones used for the detection and classification of marine mammal vocalization up to 20 kHz. Three UHF hydrophones with total baseline of 20m are used for the detection, classification and localization of marine mammal vocalizations up to 160 kHz. Additionally there is a single triplet (consisting of 3 UHF hydrophones), which will be used to solve the left-right ambiguity for the localization. The array is also equipped with depth and roll sensors.

In the early phase of the trial, we want to do some testing of the array, in order to improve the (knowledge of) tracking capabilities for bottlenose whales. We also need to test and practice the challenging maneuvering during experiments with bottlenose whales (Appendix A).

The Socrates (left) and Delphinus (right) on board the Sverdrup in 2006.

Delphinus needs to be deployed before Socrates and Socrates will be recovered out of the water before Delphinus. When a CTD sensor is used to measure the sound speed profile Socrates and Delphinus need to be out of the water. More information about sailing and deployment restrictions can be found in Appendix A.

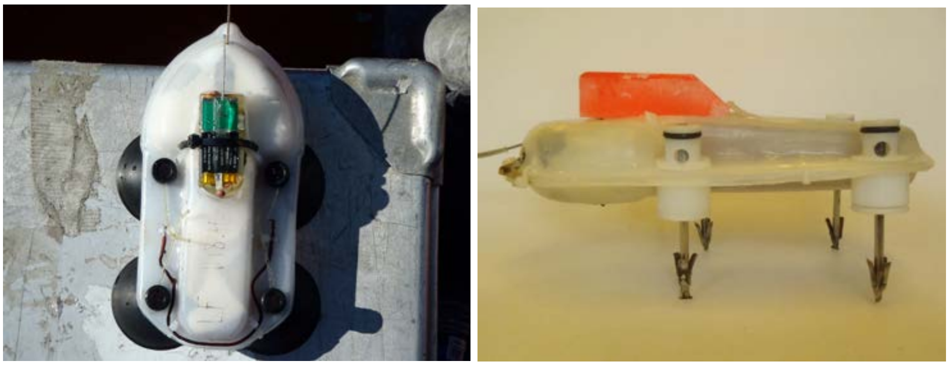
Acoustic array - VD-array

The VD array was built by Volker Deecke (VD) of the Sea Mammal Research Unit. It is composed of a 60m tow cable, with 2 Benthos AQ4 hydrophones separated by 96cm. The VD array will be used from the observation boat (tag boat 2/ MOBHUS). It's primary function will be to record sonar transmissions near the tagged whale. During exposure of minke whales and humpback whales, the array plugs into a rugged, self-standing pelican case which contains a breakout box and a Marantz recorder at 96 kHz. However, during tracking of tagged bottlenose whales it will also be used to try to acoustically detect onset of clicking from MOBHUS. Recordings from the array will be made onto a dedicated ruggedized laptop which continuously displays spectrograms for manual detection of bottlenose whale clicks.

Whale tag – DTAG2

The version 2 DTAG is the main tool used to record the behavior of the whales. The DTAG, is a miniature sound and orientation recording tag developed at WHOI. The tag is attached to the whale using a hand held or cantilever operated carbon fibre pole, or a pneumatic remote deployment system (ARTS). For deployments on all species except minke whales the tag is attached to the animal with four suction cups. At a pre-set time of 16 hrs the vacuum is released from the suction cups and the tag floats to the surface. Our experience from 3S-11 was that suction cups do not stick to skin of minke whales. Therefore, for DTAG deployments on minke whales the suction cups are replaced by four small 30mm long invasive arrows with barbs. Different anchors have been tested on dead animals to arrive at an anchor which is minimum invasive, but still remains attached for the desired duration. After 18-20 hrs a galvanic time release detaches the tag from the attachment and the tag floats to the surface. The galvanic releases are less accurate than the electronic releases used with suction cups. The invasive DTAG can be used with all deployments systems.

The tag contains a VHF transmitter used to track the tagged whale during deployment and to retrieve the tag after release. All sensor data are stored on board the tag and the tag therefore has to be retrieved in order to obtain the data. DTAGs record sound at the whale as well as depth, 3-dimensional acceleration, and 3-dimensional magnetometer information. DTAG audio will be sampled at 96 kHz and other sensors at 50 Hz, allowing a fine reconstruction of whale behaviour before, during, and after sonar transmissions.



DTAG2 with suction cups (left) and with small 30mm invasive barbs (right). Both tags will also have a GPS logger piggybacked to them.

3S-12 cruise plan

Whale tag - DTAG3

WHOI is developing a new version DTAG, the DTAG3. This tag will be smaller and lighter than DTAG2, and will also have a higher data storing capacity. In the future new sensor such as GPS and heart rate sensors will also be implemented. This tag is still in a developing phase, and we will not use them for the exposure experiments. However, we may try to do some testing with DTAG3 dummies, and deployments of them using the ARTS-system.

Whale tag - CTAG

Previous attempts to tag minke whales with suction cups tags has shown that this might be very difficult. It's difficult to get whales within DTAG tagging range, and suction cups do not seem to attach to their skin. We will try to use small invasive attachments of the DTAG, but this has not been fully tested. We have therefore developed a small and light invasive tag, to be used as back up if "DTAGing" turns out to be too difficult. The CTAG is developed to be deployed using the ARTS system at distances up to 15m. Compared to the DTAG the CTAG contains a simpler set of sensors; a VHF-transmitter, and a Star Oddi DST Magnetic logger with time depth recorder, 3D magnetic and tilt sensors. In addition the CTAG will also contain a GPS-logger. It is attached to the whale by a small barb (5 cm long) which penetrates the skin and anchors in the blubber. The tag is released from the animal using a galvanic time release. The tag does not contain acoustic sensors. The CTAG will therefore be used as an alternative only after initial tagging attempts with DTAGs has failed, and if the conditions or animals make further DTAG approaches unfeasible.

Whale tag - GPS tags

During 3S-11 we successfully tested SirTrak Fastloc GPS loggers by attaching them to the back of the DTAG. This tag is a valuable back up, which keeps collecting data of surfacing positions of the tagged animal, even if the tracking boat looses track of it for a while. This year all tag deployments (suction cup and invasive DTAGs and CTAGs) to all species (minkes, humpbacks, bottlenose whales and fin whales) will therefore include a GPS tag piggybacked to the main tag. Accurate positioning of the tag high on the back of the animal is crucial for the GPS tag to work properly.

Biopsy sampling

In the end of the experiment, after sonar exposure but before the tag detaches, a biopsy sample will be taken from the experimental animal. A standard Finn Larsen biopsy tip will be used for this. It is a hollow and sharp needle, which samples a small piece of skin and blubber tissue from the back of the animal. The biopsy tip is 8mm in diameter and penetrates 60mm into the blubber. The tissue is used to sex and i.d. the animals, to assure that they have not been exposed before. Tissue samples will be made available for other projects to look at e.g. biochemical composition, presence of environmental pollutions or for genetic analysis. Since the biopsy sample is taken before the tag detaches, we will use the stored data to also look at possible behavioral changes related to the biopsy sampling.

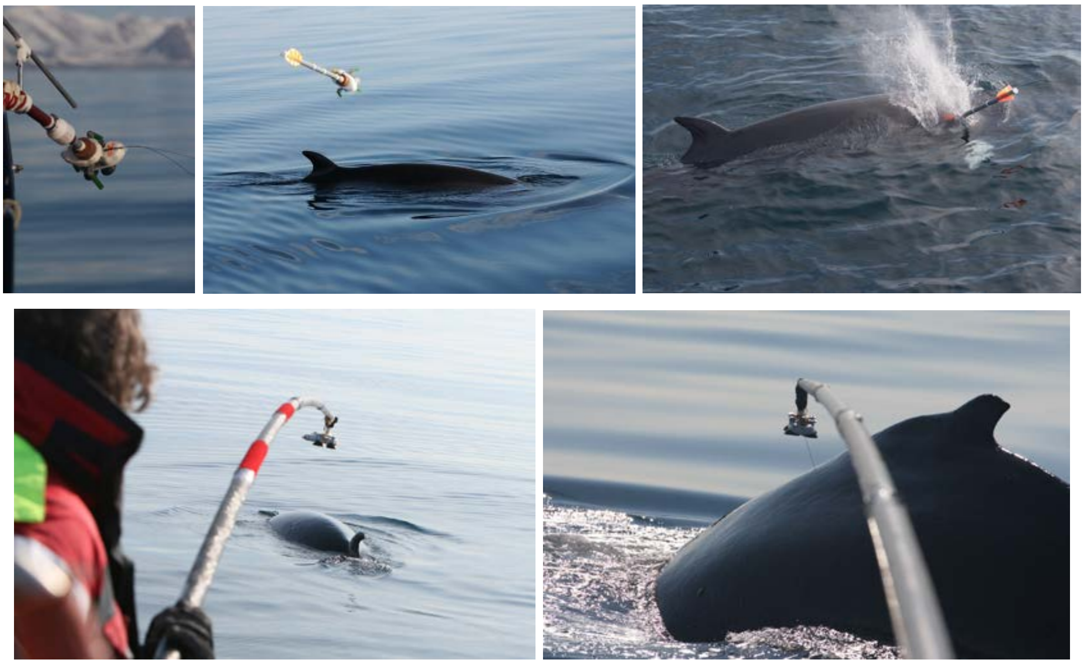
Tag deployment systems

The tags will be deployed using three different techniques, the ARTS-system, the hand held pole and the long cantilever pole.

The ARTS pneumatic tag launcher launches the tags through the air on to the animals. It was developed to be used with the DTAG during the 3S-project to enable longer tagging ranges, rapid changes of directions and to ease approach of animals which avoid the pole. During this trial it will be used to deploy DTAGs to all target species. In addition the ARTS system will be used to deploy the CTAG and for biopsy sampling.

The hand held pole techniques for deployments of DTAGs have been used in many previous field trials, and are therefore an established and robust technique. The pole is a 7m long carbon fibre windsurfer board mast, with the tag placed on a straight robot arm in one end. The limitation of this system is however, that you have to be very close to the animal (within 5-6 m) to tag it, and tagging efficiency is a limiting factor during controlled exposure experiments. The hand held pole will be used for deployments of DTAGs on bottlenose whales and minke whales.

The cantilever long pole technique is also well established technique used in many previous trials. The pole is 15 m long and placed on a swivel in the bow. Because of the length, the pole it is counterbalanced and placed in a bracket. For use on minke whales, in our continued attempts to find non-invasive attachment techniques, we will also try to test the “scraper tagger” developed last year. This consists of a mechanism which scrapes off the loose upper skin layer on the animal before placing the suction cup tag on the next layer underneath.



Tag deployment systems: The ARTS system (upper panel) used to deploy a DTAG (middle) and a CTAG (right). The hand held pole (lower left) and the cantilever pole (lower right) used to deploy DTAGs. When deploying the tag with the ARTS the tagger shoots from the elevated platform in the bow of tag boat 2. The pole techniques will primarily be used from tag boat 1.

Tracking and data collection

To visually search for animals in the search phase, and to observe the behavior of the animals during tagging and tracking, a marine mammal observer platform will be installed on the roof of the bridge of Sverdrup. This platform will be equipped with two baby big eyes, a wind shield, binoculars, protractor, intercom to the bridge, a ruggedized computer running Logger and a VHF digital direction finder system.

On tag boat 2 there will be a small elevated station for two observers, and space for a data recorder beneath them. This platform will be equipped with intercom between the observers and the data recorder, binoculars, laser range finders, compass, protractor, VHF direction finder, and a fully ruggedized computer running Logger. The Logger software is used on both Sverdup and on tag boat 2 to record the position of the animals and social behavior based on the input of the marine mammal observers. As a back-up for data collection paper notes will be used.

Naked eye, baby Big Eyes and binoculars will be used by MMOs on the marine mammal observer platform on Sverdrup.

The MOBHUS/tag boat 2 tracking boat equipped with an elevated observation platform (right) and antennas for radio tracking of the tag.

Detailed instruction for the marine mammal observers are found in the 3S-Observer Handbook distributed to all Marine Mammal Observers (MMOs) before the trial.

Responsibilities:

FFI

Personnel: Cruise leadership, marine mammal observers, local knowledge, oceanographic measurements, tag-boat drivers, ARTS tagging.

Equipment: Research vessels with crew, 2 tag boats, gas for tag boats, 2 CTD's, 2 VHF-tracking systems with antennas and cables (R1000/2000+DDF2011), power supply for tag boat, digital video camera, CTAGs, ARTS-DTAG carriers and robots, VHF-communication equipment, Ruggedized computer, rifle.

SMRU

Personnel: PI, pole tagger, marine mammal observers, photo id/documentation, acoustic recordings.

Equipment: GPS tags, VD-array, digital cameras, VHF receiver (148-150 MHz), VHF cables, hand-held GPS, killer whale playback equipment, Logger software for two platforms, tracking equipment (laser range finders, compass, protractor etc), hand held tagging poles, cantilever tagging poles, digital camera.

3S-12 cruise plan

WHOI

Personnel: DTAG-technician

Equipment: LF DTAG2s + HF DTAG2s, DTAG accessories, cantilever handle and yard arm, 2 DTAG robots straight, 2 DTAG robots 90º, VHF receiver and DDF, 2 baby big eyes.

TNO

Personnel: Software and hardware operators and technicians for Socrates and Delphinus, marine mammal observer.

Equipment: Socrates source, Delphinus array including processing and recording, XBTs, GPS recorder, AIS-recorder, ambient noise recorder.

KelpMR

Personnel: Marine mammal observer

Equipment: Ruggedized computer

IMR

Personnel: Marine mammal observer

Equipment:

LK-ARTS

Personnel: Tagger and marine mammal observer

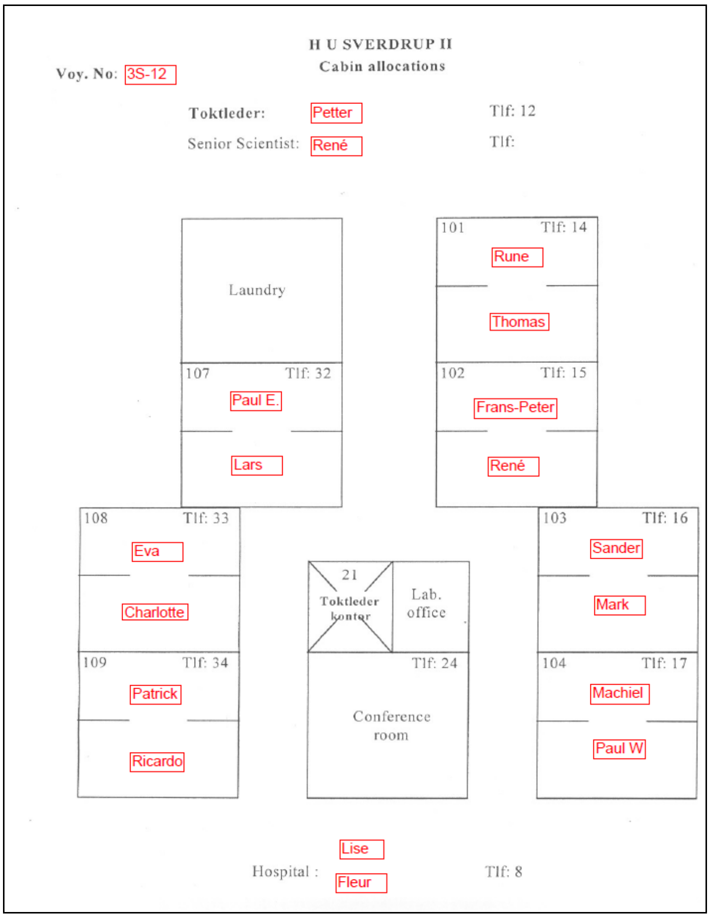
Equipment: 2 ARTS units, rifle, digital camera, Handheld GPS, tagging and biopsy equipment.

CREW PLAN

There will be no scheduled crew changes during the trial. The total number of scientific crew is 17 people:

Name	Main role	Secondary roles	Affiliation	Nationality
Petter Kvadsheim	Executive chief scientist (CO)	MMO	FFI	NOR
René Dekeling	Executive scientist (XO)	Sonar/MMO	RNLN	NL
Patrick Milller	PI/Tagger	MMO/ acoustics TB2	SMRU	US
Frans-Peter Lam	Chief scientist sonar	MMO	TNO	NL
Mark van Spellen	Sonar operator	Hardware engineer	TNO	NL
Sander van IJsselmuide	Sonar operator	Software engineer	TNO	NL
Lars Kleivane	Tagger/Biopsy	Tag boat driver/MMO	FFI/LKARTS	NOR
Ricardo Antunes	Tag boat driver	MMO/acoustics TB2	SMRU	PORT
Thomas Sivertsen	Tag boat driver	MMO	FFI	NOR
Eva Hartvig	Tag technician DTAG/CTAG	MMO HUS	WHOI	DAN
Lise Doksæter	Lead MMO HUS	Data management	IMR	NOR
Fleur Visser	Lead MMO HUS	Data management	KelpMR	NL
Rune Roland Hansen	MMO	Photo id.	FFI	NOR
Machiel Oudejans	MMO	Data management	SMRU	NL
Paul Ensor	MMO	Photo id./management	FFI/SMRU	NZ
Paul Wensveen	MMO/Sonar	Data management	SMRU	NL
Charlotte Curé	MMO/killer whale playback	Data management	SMRU	FRENCH

3S-12 cruise plan



Cabin plan

DAILY WORK PLAN

The 3S-trial is a complicated operation which requires different teams to work together in a highly coordinated manner. The different teams include, visual teams, acoustic teams, tagging teams, cruise management and the ship's crew. In addition, the crew is divided between different platforms (Sverdrup, Tag boat 1 and Tag boat 2), depending on which phase of the operation we are in. The operation goes through different phases which require very different staffing from the different teams. The main phases are; search phase, tagging phase, pre-exposure phase, exposure phase and post exposure phase. Finally, the operation is conducted in an area and at a time where the sun does not set, which enable us to operate 24 around the clock. This is a challenge but also a great opportunity we have to make the most of the time available.

Main phases of the operation

3S-12 cruise plan

The complexity of all this requires a structured watch plan, which considers a minimum staffing requirement from the different teams, but we also have to be flexible when the operation moves into the more labor demanding experimental phases. It also requires a well defined chain of command and communication plan.

Planning meetings

Every morning before breakfast (0700), the chief scientists from the main 3S partners and the XO (Kvadsheim, Lam, Miller, Dekeling) will convene to plan the activities for that day. Search areas and patterns, species priority, logistical constraints, crew dispositions etc will be discussed and implemented in the daily plan. The plan for the day will be announced on a poster board on board before 09:00. Every evening at 2030, the chief scientist will meet again to make adjustments to the daily plan, and plan activities for the coming night. If you have an idea or would like to bring something to the attention of the cruise management team, you might address one of the chief scientists at any time. However, the first 15-30 min of the afternoon meeting is open to anyone who would like to address the management group with ideas or concerns. Please announce beforehand that you will be attending the meeting so that it can be added to the agenda. Occasionally, the cruise leader may call for a plenum meeting with the entire scientific crew.

Watch plan in search and tagging phases

The entire crew will follow a basic regular seamen's watch plan of 6 hrs on and 6 hrs off, with change of watch at 8 and 2 am and pm, coordinated with the meals on-board. This will cover the basic staffing requirement during the search and tagging phases. Secondary MMO's might be instructed to also support the visual search during part of their watch, depending on their other tasks. At the start of the watch the CO/XO and lead MMO will organize the watch and make a watch plan for the MMO's which also includes the secondary MMO's.

	Watch			
Name	**08 - 14**	**14 – 20**	**20 - 02**	**02 - 08**
Petter Kvadsheim	X		X	
René Dekeling		X		X
Patrick Miller	X		X	
Frans-Peter Lam	X		X	
Mark van Spellen		X		X
Sander v IJsselmuide	X		X	
Lars Kleivane		X		X
Ricardo Antunes	X		X	
Thomas Sivertsen		X		X
Eva Hartvik	X		X	
Lise Doksæter		X		X
Fleur Visser	X		X	
Rune Roland Hansen	X		X	
Machiel Oudejans		X		X
Paul Wensveen		X		X
Paul Ensor		X		X
Charlotte Curé	X		X	
	9	**8**	**9**	**8**

Basic watch plan used in the survey phase. The entire crew will follow a regular 6 hrs on and 6 hrs off seamen's watch plan. This watch plan implies that there are 3 dedicated MMOs and 4 secondary MMOs on watch at any time. Secondary MMOs should support the primary MMOs as much as possible!

3S-12 cruise plan

As part of our positive and pro-active 3S-culture, and to avoid any gaps in the effort you are expected to arrive on your post 10 min prior to the start of your watch. This allows for organized information exchange between teams, the new team will be ready and the retiring team is dismissed in time.

Watch plan in experimental phases

The default timing of the experimental phases is illustrated in the figure below. As soon as an animal has been tagged and until the tag is recovered (pre-exposure, exposure and post-exposure phases), extra manpower is needed, and therefore a separate watch plan will be implemented. In the 15-20 hrs from tag on to tag off, the tagged animal will mostly be tracked from MOBHUS. A watch plan of two MMO-teams of 4-5 people, which takes turns and rotate every third to fourth hour between MOBHUS and resting "duty" will be established. In addition a separate watch plans for the remaining MMOs, who will stay on the Sverdrup as well as for the acoustic team will also be established.

Watch	MOBHUS	HUS	SOCRATES
A	MOBHUS T1	HUS T1	SOC T1
B	MOBHUS T2	HUS T2	SOC T2
C	MOBHUS T1	HUS T1	SOC T1
D	MOBHUS T2	HUS T2	SOC T2
E	MOBHUS T1		

Watch plan used in the experimental phases from tag on (T0) until tag recover (T0+15-20 hrs). As soon as a tag is successfully deployed on an animal, it will be determined who is on which teams for the coming experiment. The duration of each watch varies with the species.

Operational status

In extended periods of good weather, and if we are successful in finding animals and tagging them, there is a risk that the work load on the team will be too high, and that eventually we will all suffer from collective exhaustion. In these periods, the basic watch plan has to be considered to be normative. It is better to have some level of search effort all the time than periods with no effort at all. On the other hand, increased risk to personnel in some phases of the operation, and increased risk of reduction in the quality of the data collected in other phases are factors which also have to be considered carefully in these periods of intense work load. Thus, the cruise leader may decide to reduce effort during search and tagging phase to rest the crew. Because of this risk of crew exhaustion, the cruise leader may also reduce effort in periods of bad weather. To make sure everyone is aware of the operational status a traffic light system will be implemented. The operational status will be clearly indicated in the main operation room and the bridge of the ship.

Operational status green – we are fully operational with continuous full visual, acoustic and tagging effort.
Operational status yellow – we are partly operational with reduced effort on visual, acoustic and tagging effort.
Operational status red – we are not operational, everyone can rest!

3S-12 cruise plan

DATA COLLECTION

Compared to the protocol used last year, where all species had the same scheme, we have made the following changes: For humpback whales the duration of the pre-exposure period is reduced to only 3 hrs to maximize the chance of getting the exposures done before the tag comes off. For minke whales the duration of the post tagging period and the intervals between the exposures is increased because minke whales might respond to the tagging and have a continued response also after sonar and killer whale sound exposures. The scheme for northern bottlenose whales and fin whale is kept the same as last year, except that for bottlenose whales we will try to keep the behavioral context constant and consistent with the protocol used by the SOCAL and BRS groups for beaked whales. The sonar exposure will commence as soon as possible after the animals have started vocalizing during the second deep dive cycle. The timing below is the ultimate timing used if the animal never starts deep diving and vocalizing.

Humpback whales

Time	**Tag on = T0 T1 T2 T5 T6 T7 T9 T10 T11 T13 T17**																Tag off!
Phase	Search-Sighting	Pre tagging 1 hr	Tagging ?	2nd tagging	Post tagging	Pre exp.	Silent		**Sonar 1**		**Sonar 2**		K W 1	1hr	K W 2	Post exp. Biopsy	Tag recovery CTD
Tracking from	HUS					MOBHUS											Data checking
Watch/ Team						A (4hrs) T1		B (4 hrs) T2				C (3 hrs) T1			D (4 hrs) T2		Resting Search

Minke whales

Time	**Tag on = T0 T2 T5 T7 T8 T12 T16 T20**																Tag off!
Phase	Search-Sighting	NO pre-tagging	Tagging ?	NO 2nd tagging	Post tagging	Pre exp.	Silent	1 hr	**Sonar 1**	2hr	**Sonar 2**	2hr	K W 1	2hr	K W 2	Post exp. Biopsy	Tag recovery CTD
Tracking from	HUS					MOBHUS											Data checking
Watch/ Team						A (3 hrs) T1	B (3 hrs) T2		C (4 hrs) T1			D (4 hrs) T2				E (4 hrs) T1	Resting Search

Bottlenose whale and Fin whales

Time	**Tag on = T0 T1 T2 T5 T8 T9 T13 T16 T17**																Tag off!
Phase	Search-Sighting	Pre tagging 1 hr	Tagging ?	2nd tagging	Post tagging	Pre exp.	Silent	1 hr	**Sonar 1**	1hr	**Sonar 2**	1hr	K W 1	1hr	K W 2	Post exp. Biopsy	Tag recovery CTD
Tracking form	HUS					MOBHUS											Data checking
Watch/ Team						A (3 hrs) T1	B (4 hrs) T2		C (4 hrs) T1			D (3 hrs) T2			E (1 hrs) T1		Resting Search

Default timing of the different phases of the experiment for the different target species. The grey row on top is a time scale (in hrs). T0 is time of first tag on. Blue row indicate the different phases of the experiment. Sonar is either dose escalation LFAS-exposures of bottlenose whales, minke whales and fin whales or LFAS Ramp up exposures of humpbacks. The yellow row indicates from which platform the tracking of the focal animal is conducted. The green row indicate which MOBHUS, HUS and Socrates teams is on watch. For bottlenose whales the timing shown is the ultimate timing used if the animals never go deep diving and vocalizing.

3S-12 cruise plan

Search

From the Sverdrup we will be able to access online AIS information covering the entire Barents seas through an AIS-satellite service. Based on this we will contact other ships (fishing vessels, whalers, research vessels and coast guard vessels) in the area and request information about possible marine mammal sightings. Weather forecast and knowledge of sightings (historical or current) will determine where we search for whales, visually and acoustically. Since we have 24 hours of daylight, visual and acoustic search for whales will continue around the clock.

The Sverdrup will search for whales in the specified locations using towed array acoustics and visual observations. During search for the baleen whales we will consider if we should use the Delphinus system to allow for potential acoustic detections, or not to allow for more manoeuvrability of the Sverdrup. When a target species marine mammal is detected, a decision will be made whether or not to attempt tagging. If yes, the tag boat(s) will be launched with taggers and photo-id capability.

Northern bottlenose whales, minke whales and humpback whales are primary target species. However, we may opportunistically also try to tag fin whales as a secondary objective if weather is borderline, since they may be easier to tag in "bad" weather, or in case we can't find the primary targets. A rule whether or not to attempt to tag and do an experiment for each species will be made the day prior.

Pre-tagging, tagging and post-tagging

Pre tagging observation should be initiated from the MMO platform on Sverdrup as soon as the sighted animals are approached using the established protocol described in the *3S MMO Observer Handbook* which is distributed to all MMO on the team. When tracking animals from Sverdrup, a tracking distance of about 1000 m from the animals should be maintained. Before the tag boats are allowed to approach the animals and start tagging attempts the visual observers on Sverdrup will collect group behavior data for 30-60 min.

If the focal species is bottlenose whales we will primarily keep the Delphinus system in the water, and keep the animal within a 2*2 nmi box while sailing at 5-6 knots. This hopefully enables us to monitor when the animals go into deep diving mode, and acoustically track them through that phase. However, we will also try not to use the Delphinus during the tracking phase to assess the advantage of manoeuvrability instead of acoustic detection capability.

During tagging, the MMOs on Sverdrup should continue to track the focal animal and collect group behavior data according to the established protocol. In addition they should also provide support to the tag-boats. For safety reasons the tag boats should stay within 3 nmi of the Sverdrup at all times, depending on visibility and sea conditions.

Version 2 DTAGs with GPS logger attached to it will be used as the primary tag with all target species. For minke whales we will use the invasive attachment and with the other species we will use suction cup attachment. If suction cups tags does not work with fin whales, we will consider to use invasive DTAGs, but only after non-invasive techniques has been tried. The CTAG will only be used as a back up tag if the DTAG does not work properly. Both the ARTS system and the pole tagging system will be used on equal terms to deploy the DTAGs to all species. For humpbacks and fin whale the cantilever pole will be used, for minkes the long hand held pole, and for bottlenose whales the short hand held pole will be used, in addition to the ARTS. Which tag team and deployment system is attempted first will primarily depend on which tag team is on duty. The pole system will be used from tag boat 1 and the ARTS from tag boat 2. One or two tag boats will be used at the same time depending on group structure and spacing.

Once a tag has successfully been deployed on an animal, the 2nd tag boat will move to the tagged animal and attempt to tag a 2nd animal, but only if we are working with bottlenose whales or Humpbacks and we feel comfortable that the animal will stay together. Attempts to put a second tag on the same animal will also be made, but not with invasive tags. Tag boats will take photo-identification photographs and track the tagged animal initially, until tracking is picked up by HUS using the VHF digital direction finder system. Tagging might continue for a maximum of 1hr, attempting to tag more animals. The other tag boat should move to assure that it is working with the same group of animals as the tagged animal. If we manage to deploy more than one tag, this increases the total number of whales tested (and helps assure that a tag will remain attached for the full duration of the experiment), but has the cost of taking time attempting to tag from the pre-exposure time. The decision to cease attempting to tag should be made within one hour of initial tag deployment. Any decision to further extend tagging attempts should be based on considerations such as the success of the first attachment (in terms of VHF tracking and likelihood of long attachment) and the behavioral state of the animals in the group.

When Sverdrup has established good tracking of the first tagged animal, both tag boats will continue to try a second tagging within the same group for about 1 hour. The MMOs on Sverdrup should continue to collect post-tagging group behavioral observations until the end of the post tagging period. If pre-tagging and tagging phase observations have been successful, but tag-deployment has not been successful after one hour, the tag boat will leave the 'effects-of-tagging' group for ½ hr to enable post-tagging data collection. Detailed tracking and behavioural observations will cease after post-tagging data has been collected, but sightings will be recorded to support the tagging teams.

Once the tracking from the Sverdrup is reliable and tagging efforts cease, tag boat teams will transfer back to Sverdrup. Care will be needed during the recovery not to loose the tagged whale. At this point, the first MOBHUS team should prepare the boat and equipment for tracking, while the first HUS team keeps tracking the focal animals.

Pre-exposure

When one or two animals have been tagged and the decision is made to stop tagging, both tagging teams will transfer back to HUS. After a period of post-tagging observations, an MMO team of at least four people will then be re-deployed in MOBHUS, and take over tracking the tagged animals and also do the group behavior data recording, until the tags are recovered in the end of the experiments. The reason for not doing the tracking from Sverdrup is that our experimental protocol with a moving source, does not allow tracking from the source ship during exposures. In order to collect a dataset which is consistent from pre- to post exposure, we therefore have to do the tracking from MOBHUS also in the pre-exposure period. The MMO team on MOBHUS will consist of four people, a driver, a data recorder and two MMOs. They should alternate between these roles. At least every 4 hour the entire MMO team on MOBHUS will be replaced. Tag boat 1 will be used to transfer the MMO teams between MOBHUS and Sverdrup. When MOBHUS has taken over tracking of the animal, the MMO team on the Sverdrup will be relieved. However, there should be a reduced effort on the Sverdrup as well to serve as back up in case the MOBHUS team loose contact with the tagged animal. As soon as MOBHUS takes over tracking of the tagged animals and until the "tag off message", HUS should maintain a minimum distance of 1nmi from the tagged animal, except during the approaches. The MMOs on Sverdrup should also make sure they continue to record sightings of other animals, since they have a better view of the larger picture of animal activity in the area. It is very important to document the behavioral context of the exposures, i.e. what type of behavior are the animals involved in prior to exposure. The pre-exposure phase last 2-6 hours depending on the need for baseline data from the specific species and behavioral context.

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Exposure

When minke whales, fin whales or bottlenose whales are tagged, the dose escalation (Silent-LFAS-LFAS) protocol should be used for the sonar exposure. However, the dose escalation protocol will not be the same for these species. When humpback whales are tagged, the Ramp Up protocol should be used. Because of depth limitations of the source, two different frequency bands will be used depending on the species and type of experiment. Both signals are transmitted as hyperbolic up-sweeps. Prior to full power transmission a ramp up procedure will always be used, starting at 152 dB and increasing to full power at 214 dB. After the sonar exposures we will conduct another experiment where the animals are exposed to playbacks of killer whale sounds and a control signal.

Target species	*Signal*	*Bandwidth (Hz)*	*Ramp up*	*Protocol*	*Approach distance*	*KW playback control sound*
Bottlenose whales (3S-style exposure)	$LFAS_{deep}$	1000-2000	Linear 152-214dB in 10min, 20s IPI	Dose escalation	5 nmi	Broadband noise
Bottlenose whales (BRS-style exposure)	$LFAS_{deep}$	1000-2000	Linear 152-214dB in 20min, 20s IPI	Dose escalation	1 nmi	Non
Minke whales Fin whales	$LFAS_{shallow}$	1300-2000	Linear 152-214dB in 10min, 20s IPI	Dose escalation	5 nmi	Humpback whale sounds
Humpback whales	$LFAS_{shallow}$	1300-2000	Non-linear 152-214dB in 5min, 20s IPI (specified further below)	Ramp up	1250 m	Broadband noise

During exposure experiment two types of signals and three different ramp-up schemes will be used as specified in the table.

<u>DOSE ESCALATION EXPERIMENTS ON MINKE WHALES</u>

The MMO team on the MOBHUS will continue to track the tagged animals visually and using the VHF-direction finder throughout the experiments. Miller with be a 5th MMO on the MOBHUS during the exposure to act as mitigation observer. In preparation for the exposure, the Socrates will be deployed and HUS will distance itself from the observation vessel (MOBHUS) and the tagged animals. During the exposure phase, 5 different exposure runs will be carried out:

1.) SILENT: silent vessel approach with Socrates deployed but not transmitting.
2.) LFAS: hyperbolic Up-sweep of 1000ms duration with 20s PRT.
3.) LFAS: hyperbolic Up-sweep of 1000ms duration with 20s PRT.
4.) Playbacks of killer whale sounds
5.) Playback of humpback whale sounds

The order of the exposures is fixed except for the two playback signals. The silent control approach is always conducted first to avoid sensitizing the animal towards the source ship. The two repeated LFAS sonar exposures allow us to look at possible sensitization or habituation to the sonar. Prior to full power transmission a 10 min linear ramp up scheme from 152 dB to 214 dB is transmitted. This ramp up is longer than during the ramp up experiment because in addition to being a mitigation measure for non focal animals in the area, it is also part of the dose escalation. The playback of killer whale sound are always conducted last and will be cancelled if the animals respond strongly to the sonar to allow for a longer post exposure period. During LFAS HUS will approach the position of the tagged animals, as reported from the MOBHUS, head on at 8 knots starting with ramp-up from a distance of 5nmi. The primary goals of the start location are to place the source to the side or in front of the whale's direction of movement. The final decision to start sonar transmission is made by Kvadsheim after consultation with Miller and the Socrates operator. The course of the source ship will be adjusted if the animals change position, to continue to approach them head on, until the source ship is 1000m from the animals. After this the course will not be changed to allow the animals to avoid the signals. During the exposure, behavioral changes will be recorded from the MOBHUS, who will stay close to the animals. However, visual observations also from the source ship are an important part of the risk mitigation protocol, because other animals might be in the area. After about 30 min the HUS will pass the tagged animals and continue on a straight course, still transmitting for another 5 min. If the animal is clearly avoiding the sonar, the course should be locked before we reach the 1000m distance. If after 30 min of transmission we have still not approached the animal within 1000m, the course should be locked independent of the current distance. Transmissions should continue until 5 min after CPA, but never longer than 60 min of full power transmissions. After end of the exposure the HUS will re-position for the next exposure. The second exposure will start two hours following the end of the first exposure, once the source vessel is in a new acceptable location. All protocols will be identical for the first, second and third exposures (except for the missing active transmissions during Silent). After the final exposure, tag boat 1 will be deployed to conduct a playback of killer whale sounds and humpback whale sounds. Thus, compared to last year the control sound for minke whales is changed from a broadband noise signal to humpback whale sounds.

DOSE ESCALATION EXPERIMENTS ON FIN WHALES

If we decide to do exposure experiment to fin whales, we will adapt the minke whale exposure protocol. Sonar signal, control sound and vessel approaches will thus be the same as for minke whales. However, since we are using suction cups DTAGs, the timing of the different phases of the experiment will have to follow the bottlenose whale exposure protocol. If we see a strong response also in fin whales, we have to extend the periods between exposure conditions.

DOSE ESCALATION EXPERIMENTS ON BOTTLENOSE WHALES

With bottlenose whales we are planning two alternative protocols. Alternative one is to approach the animal according to the protocol for minke whales, except that we will use $LFAS_{deep}$ instead of $LFAS_{shallow}$, and the control sound for the killer whale playback will be a broadband noise signal instead of humpback whale sounds.

Alternative two is a protocol which breaks with a long 3S tradition of gradually approaching from a distance at any random behavioral state of the animals, but in essence implies that we try as much as possible to standardize our exposure protocol with the procedure used by other groups working with other beaked whales. This BRS style procedure, which is what we will try to do first, before falling back on a regular 3S style approach (alternative 1) as a back up, implies that we have to continuously monitor the animal acoustically, and start the exposure as soon as possible (within 5min) after the animal moves into a deep dive and starts vocalizing (clicking). This is done to better enable comparison between bottlenose whales and other beaked whales studied. It's essential that the exposure starts immediately after onset of echo-vocalization during a deep dive, or we will lose statistical power in that comparison.

In order to achieve this, Sverdrup, towing Delphinus, will keep the tagged animal within a 1 by 1nmi box. In addition MOBHUS will tow the VD-array on a ruggedized computer to increase the chance of detecting onset of echo-vocalization. Since this requires an extra hand onboard MOBHUS, Antunes and Miller will do double shifts to make sure one of them is on board MOBHUS at all time. The pre-exposure period will have to include at least one whole dive deep cycle, before switching to the exposure phase. At onset of clicking on the next deep dive cycle, we will initiate a silent approach. This enables us to check that tracking and geometry of the approach works out before deciding to do a sonar exposure. Since Sverdrup has to stay close to the animal to track them acoustically, it means we can not approach from a distance. Sverdrup will have to tow both the Delphinus and Socrates systems in a dual tow, while boxing the animal within the 1 by 1nmi box. As soon as clicking is detected Sverdrup will slow down to minimum speed (3-4 knots), turn towards the assumed position of the animal and sail on a straight intercept course while transmitting a 20 min long linear Ramp up from 152-214 dB + 5 min of full power. After the first exposure we will assess if there is time for a second exposure, or if we should move on to killer whale playbacks. It is preferable that also the killer whale playback is conducted in the same behavioral context for the animals, i.e. soon after start of clicking during deep dives. Whether this is feasible or not will have to be assessed when we learn more about the deep diving frequency of bottlenose whales. It is not realistic however, to do both killer whale and control sound playback, and therefore killer whale playback will have to be considered a positive control for the sonar exposures.

If the animals have not done any deep feeding dives, or we have not detected the clicking after 5 hrs of pre exposure, Sverdrup will distance herself and do a regular 3S-style approach from 5 nmi distance, starting with a 10 min linear ramp up. After the first exposure we will follow the regular scheme indicated in the watch plan, do a second exposure, before doing killer whale and control sound playbacks.

RAMP UP EXPERIMENT ON HUMPBACK WHALES

After tagging and a post tagging and pre-exposure period the tagged animal will be exposed to the following experimental conditions:

1.) SILENT: silent vessel approach with Socrates deployed but not transmitting.
2.) RampUp using $LFAS_{shallow}$ (1.3-2.0kHz).
3.) NO-RampUp using $LFAS_{shallow}$ (1.3-2.0kHz).
4.) Playbacks of killer whale sounds and broad band noise signal

The order will be kept constant to avoid sensitize the animal towards the source ship. We will conduct a few No-ramp up approaches but might chose to replace this with another regular Ramp-Up approach instead after the first few experiments. This implies that condition 2 and 3 will be the same. The playback of killer whale sound are always conducted last and will be cancelled if the animals respond strongly to the sonar to allow for a longer post exposure period.

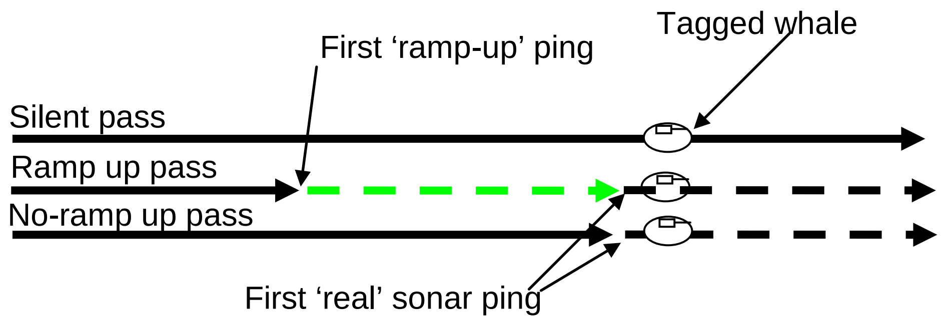

Diagram of the Ramp Up experimental deign. The oval represents a tagged subject whale, and the pointed lines represent the source vessel course. In all three runs the animal is approached as directly as possible, and the course of the vessel is fixed at a pre-determined distance, before the planned start of ramp-up signals. In the silent pass, no sonar transmissions are made. In the ramp-up pass, a ramp-up sequence is transmitted in addition to full-level signals. In the no-ramp-up pass, transmission starts with the first full level ping at the closest point of approach.

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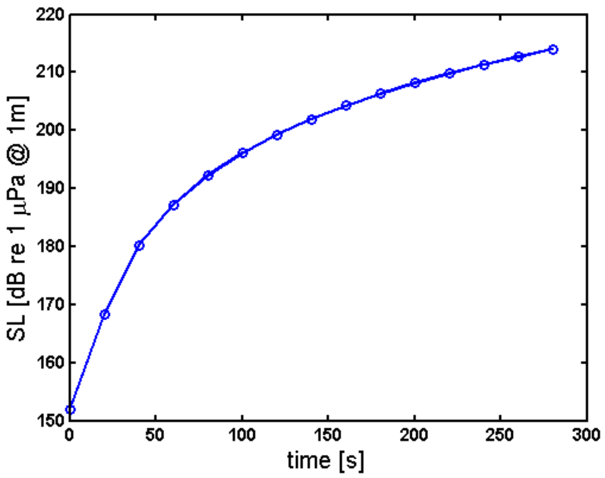
Time between exposures will be 1 hr and each exposure will have a duration of 10 min. During the Ramp Up approach, sonar transmissions will be initiated approximately 1250 m from the tagged animal, and the source ship will approach at 8 knots on a straight and constant course while gradually increasing the transmitted source level from a minimum level of 152 dB to the maximum level of 214 dB at the closest point of approach, and then continue to transmit for another 5 min while moving away from the animal after passage. A CPA of 0m will be estimated based on the moving pattern of the animal in the pre-exposure phase. From the point of first ping and throughout the transmission scheme the source ship will maintain a constant course independent of the animal's movement. The Silent approach and the NO-Ramp Up approach will follow the exact same procedure, except that there is no active transmissions during silent, and that transmissions only starts at full power at CPA during NO-Ramp UP.

A digital test bed has been established to simulate the effectiveness of the Ramp Up procedure in minimizing risk to marine mammals during sonar operations. The model makes assumptions on how the animal might respond, and this model is then used to generate specific hypothesis to be tested. Thus, the test bed is used to find an optimal ramp scheme to be tested so that we only have to test one. The transmission scheme to be transmitted by Socrates during the experiments is defined below.

Ramp Up transmission scheme:

RAMP UP; Pulse duration = 500 ms, Pulse Repetition Time = 20s, Vessel speed = 8 knots, Source depth = 60-100m, Ramp up time = 5min (1250m transect), Steepness factor of increase of SL = 4, Initial source level = 152dB, Maximum source level = 214 dB, Signal= $LFAS_{shallow}$ 1.3-2.0 kHz hyperbolic up-sweep.

FULL POWER; Pulse duration = 1000 ms, PRT = 20s, Vessel speed = 8 knots, Source depth = 50m, Duration = 5 min (1250m transect), Signal= $LFAS_{shallow}$ 1.3-2.0 kHz hyperbolic up-sweep.



Transmission scheme for Socrates during the Ramp up experiment.

Killer whale playback and control

The killer whale playbacks will require 2-4 hr to complete. Two stimuli will be played as part of each playback as follows (15 min control sound, 30 min gap, 15 min orca). 'Orca' stimulus contains natural vocalizations of mammal eating killer whales, recorded in similar behavioral contexts, i.e. when the killer whales were foraging. 'Control' (as a negative control) is either A)

a sequence of background noise selected from previous recordings (2005), amplified up to get the Average RMS Power equal to the stimulus, and repeated until getting the same duration than the stimulus (15 min), or B) a recording of singing humpback whales. We will use noise signals as control sound during exposures of bottlenose whales and humpback whales and we will use humpback whale sounds as the control sound with minke whales and fin whales. All acoustic signals have a similar Average RMS Power and duration of 15±2 min. Amplitude is low at the beginning of the stimulus and progressively increased up to its normal value to simulate an approaching source. At the end of the stimulus, amplitude progressively decreases to simulate a source leaving.
The playback will be done from tagboat 1, with the transmission starting slightly ahead and to the side of the tagged whale, at a planned distance of 800m. The playback operator (Curé) may first join MOBHUS to see the whale track in order to plan the position of the playbacks.

Post-exposure

After termination of the exposure phase, we will go back to an operational modus similar to the pre-exposure phase. The tagged animals will still be tracked from MOBHUS. Towards the end of the post exposure phase, when tag release is just 30 min away, a biopsy team on MOBHUS will try to sample a biopsy of the tagged animal(s). If needed we may also attempt to attach a 2ndary tag for post-experiment monitoring. The duration of this deployment will only be 3 hrs maximum. The total duration of suction cup DTAGs using the electronic release of the tag will usually be set to 16 h. Invasive DTAGs and CTAGs have a galvanic release expected to release after 18-20 hours. When all tags have been retrieved, the MMO team will transfer back to HUS to download and secure the data. Visual and behavioral data will also have to be checked, corrected and secured (backed up). Then after at least a 6 hr period of resting the troops, we return to the search phase.

Mitigation during transmission

During transmissions, MMOs on Sverdrup will assure that no whales are too close enough to the source that they might be exposed to sounds over 180 dB re 1µPa as required by the permit. The stand off range between source and animals during full power transmission is 50m. If any animals are approaching this safety zone an emergency shut down of sonar transmission will be ordered. Transmission will also be ceased immediately if any animal shows any signs of pathological effects, disorientation, severe behavioral reactions, or if any animals swim too close to the shore or enter confined areas that might limit escape routes. The decision to stop transmission outside the protocol is made by Kvadsheim or by the PI (Miller) observing the whales from the MOBHUS. For efficiency of communication, a VHF radio protocol should be established to allow for Miller and Kvadsheim to speak directly to each other on the radio.

Prey field mapping

To give us an idea of the prey field in the area we are working we will keep the 38 kHz and 200 kHz single beam echosounder of Sverdrup on monitoring mode during search phase, when we are primarily searching for baleen whales in relatively shallow water. In the experimental phases (from tag on to tag off) we also want to record prey field data on the echosounder, primarily using the 38kHz, except that during the experimental approaches the echosounder will be turned off. However, when searching for or working with bottlenose whales we will not do any prey field mapping because both the 12 kHz and the 38kHz could interfere with the animals and the 200 kHz does not give any useful information of the deep prey field.

Sound speed profiles (CTD and XBT) and ambient noise

A temperature profile (XBT) should be taken as soon as possible after end of transmission during all animal approaches of the source ship, including silent approaches. This is particularly important during the Ramp Up experiments with humpback whales. In addition, sound speed profiles should be taken whenever acoustic transmissions (sonar signals or killer whale playback) have been used in an area. CTD profiles will be taken form the Sverdrup, but Sverdrup cannot reduce speed beyond 3 knots when towing Socrates or Delphinus. After an exposure experiment, Socrates and Delphinus are usually recovered on the Sverdrup, which allows Sverdrup to collect CTD profiles along the exposure path (at the CPA) using the CTD probe. CTD profiles should preferably also be collected on a routine basis to monitor the acoustic propagation conditions in the operation area. This will enable us to plan the acoustic experiments using transmission loss models (e.g. LYBIN). During this cruise we will also try to measure levels of ambient noise in relation to the exposure experiments to better describe the context of the exposure and to document any unusual disturbance in the ambient noise field (in the addition to the sonar).

MANAGEMENT AND CHAIN OF COMMAND

Operational issues

Operational decisions such as decisions on sailing plan, decisions to deploy tag boats/Socrates/ Delphinus, crew dispositions etc are ultimately made by the cruise leader. The cruise leader is also the coordinator and leader of the exposure experiments. However, the cruise leader is obliged to consult with the chief scientist of the 3S-partners on decisions affecting their area of interest or responsibility.

Safety issues

The captain of the ship makes final decisions on safety issues.

Permit issues

The permit holder is Petter Kvadsheim. He makes final decisions on permit issues. However, Lise Sivle, Lars Kleivane and Patrick Miller also have responsibility for permit compliance during tagging and exposure.

Sonar operation safety issues

A Risk Management Plan for the operation of Socrates and Delphinus is specified to minimize risk to this high value equipment (Appendix A). Final decisions on issues related to the safety of Socrates and Delphinus are made by the chief scientist of TNO (Lam).

Scientific issues

Final decisions regarding the protocol for execution of the exposure experiments lies with the PI.

COMMUNICATION PLAN

In all phases of this trial the crew will be split in different groups (acoustic teams – marine mammal observation teams – tag teams - coordination/management) and platforms (Sverdrup – tag boat 1 – tag boat 2). Coordination and thus clear communication between these units will be crucial, especially in critical phases. To ensure good communications all teams must bring a VHF radio and a spare one. Cell phones are of no use, we will be out of range!

The radio call signals for the different units will be:

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"Sverdrup"	Sverdrup (HUS) bridge (HQ)
"Tag boat I"	4 stroke outboard engine work boat
"Tag boat II"	Water jet propulsion MOB (MOBHUS)
"Socrates"	Sonar operator on Sverdrup (Socrates and Delphinus)
"Obs deck "	Marine mammal visual observation deck on Sverdrup

A main working channel (channel A), and an alternative channel (channel B) in case of interference, will be specified.

During the tagging phase, communication to and from the tagging teams must be limited. Tag boats should stand by on the main channel (A), while communication between the other stations, with little imminent relevance to the tag boat teams, should happen on the alternative channel (B). "Sverdrup" will monitor both channels at all time. Messages to the tag boats, which is not urgent, should be channeled through the "Sverdrup", who will relay the information when appropriate. An intercom channels between Sverdrup and Socrates and Obs deck will be implemented.

Tag boats must report in to "Sverdrup" to confirm communication lines every hour! We are mostly operating in open ocean, and this safety procedure is an invariable rule. Tag boat teams who fail to comply with this will be called back and recovered without further warning.

If not otherwise specified in the daily work plan the following channels should be used:

Main working channel	**Channel A**	**Maritime VHF channel 73**
Alternative channel	**Channel B**	**Maritime VHF channel 67**

RISK MANAGEMENT AND PERMITS

FFI has obtained necessary permits from appropriate civilian and military authorities for the operation described in this document. The operation area is entirely within Norwegian territorial waters or the exclusive economic zone of mainland Norway or Svalbard, thus all under Norwegian jurisdiction. The operation is considered a military activity under the jurisdiction of Norwegian military authorities. RV HU Sverdrup II will carry a Royal Norwegian Navy Ensign and be placed under command of government official from The Norwegian Defense Research Establishment. Principle scientist Petter Kvadsheim is the commanding officer ultimately responsible for the operation.

Since the operation includes animal experimentation, we will operate under permits from the Norwegian Animal Research Authority (permit no S-2011/38782) acquired by Petter Kvadsheim. The permits include tagging (DTAG and CTAG) and acoustic exposure of minke whales, bottlenose whales, humpback whales and fin whales according to the protocol described here. Permits also allow biopsy sampling of target species. The exposure experiments are permitted under the condition that maximum exposure level does not exceed 180 dB (re 1 μPa), (50m stand off range) and that project participants are skilled in handling the animals. In addition to Kvadsheim, Patrick Miller, Lars Kleivane and Lise Sivle will be field operators responsible for permit compliance in the field.

Procedures to mitigate environmental risk will be implemented as described in this document and in the permit documents. Risk to humans should be minimized through the regular safety regime implemented for all relevant working operations on board. The cruise leader is primarily responsible for these risk issues. A separate risk management plan, to mitigate risks to expensive equipment, such as the SOCRATES system the towed arrays, has also been specified (Appendix

A). All personnel involved in handling this equipment, including navigators, must be aware of the content of this plan. Risk involved in the handling and operation of this equipment is the primary responsibility of the TNO chief scientist.

PUBLIC OUTREACH AND MEDIA

During the cruise, all media contact should be referred to the cruise leader (Kvadsheim) who will coordinate with the 3S-board members (Miller, Lam, Tyack) and FFI's information office. An on-shore PR-contact will be appointed by FFI, and will serve as the POC for all inquires from media.

TRAVEL AND ACCOMMODATION

Travel

Port in/out Tromsø:

There are frequent direct flights from Oslo to Tromsø with SAS and Norwegian Airlines. Tromsø airport is a 15 min taxi drive from both port terminal and from down town Tromsø.

Hotels

If you need to organize with hotel accommodation in Tromsø, our recommendation is Scandic Hotel, Tromsø. It's not very central but close to the airport and the dock. Reference booking code D000004112 for Norwegian Defense, and you should be given a discount. The discounted standard room price is 790-,NOK, or roughly 100 Euro pr night.
http://www.scandichotels.no/

There are several hotels more centrally placed in town, but Tromsø is a very expensive city. The most favourable alternative to Scandic is Hotel Polar, which is roughly 135 Euro pr night.
http://www.thonhotels.no/hoteller/land/norge/tromso/thon-hotel-polar/

SHIPPING

For loading and off-loading Sverdrup will be docked at Breivika port terminal in Tromsø. This port has a port crane for lifting of the heavy equipment.

For shipping equipment to Tromsø, coordinate with FFI, and use this address:

HU Sverdrup II
c/o Steinar Sørensen
Bring Logistics Tromsø AS
Terminalgaten 42 Breivika
NO-9261 Tromsø

Phone +47 77 64 80 90

CONTACT INFORMATION

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GENERAL ADVICE

The scientific trial you will be involved is a unique experience. Make it enjoyable for yourself and others. Be positive and constructive by finding solutions to problems before complaining.

Weather conditions will be the most limiting factor during the cruise. In June the air temperature will still be relatively cold at sea in these Arctic oceans (0-15 ºC). Make sure you bring high quality clothing for all layers. Floatation suit is mandatory for everybody working on the tag boats. However, it’s what you wear under the suit which keeps you warm. A hat, gloves and shoes which keep you dry are your most important tools.

The entire cruise is north of the Arctic circle and it’s midsummer, thus we will have midnight sun, and thus 24 hours of daylight and working conditions. There will not even be a dusky period around midnight. This is a big advantage to the operation and our chances of success, because we can work around the clock and don’t have to consider retrieving tags before dark. However, make sure you get some sleep! A watch plan will be specified, it is your duty to work when on duty, but also to rest when off duty. We must maximise the time available with good conditions to attempt as many experiments as possible. You should expect long hours of hard work while these good weather windows happen. You will have long hours of rest when weather conditions deteriorate.

Cruise methods and procedures have been fixed in advance, and need to be kept standardized with previous cruises. There is very little that can be changed without affecting the data being collected. If you can think of improvements, discuss them with the cruise leader and principal investigator first before implementing.

This cruise is not a whale watching cruise, so whenever you are on duty keep focused on your tasks. If you are off duty use well your resting period and do not disturb/distract the ones that are on duty. It is probable that you will share a cabin with other people, so keep it tidy and pleasant for everyone. If you have any problems please speak to the cruise leaders directly and openly as soon as possible. A delay may make matters worse or cause ill feeling between work colleagues.

The food on the Sverdrup is known to be good. However, on a cruise of this duration without port calls, we will run out off fresh food such as fruit, dairy products and vegetables. It might be a good idea to bring you favourite food goodies (*e.g.* tea, coffee, chocolate, cookies, etc.).

Prepare yourself mentally that we might be at high sea without even sight of land for weeks at the time. We will be out of cell phone range most of time. Warn the people at home that you are still alive, even if you don’t pick up their calls. You will be allowed to call home, but not unlimited, due to the limited number of satellite based phone lines. The ship has continuous satellite based internet connection and internal wireless network. However the bandwidth is limited so avoid downloading large files and switch off software updates. If we sail north of 78°N we will lose internet connection because of the low elevation of geostationary satellites. Please accept it and enjoy it! We will off course still have emergency communication systems. There are a few available computer stations on board, but these have to be shared. You are welcome to bring your laptop and connect to the network.

Be prepared!   ENJOY!   Good luck!
Petter Kvadsheim (cruise leader)

REFERENCES

The following list of other internal documents within the 3S-group also has relevance to the execution of the trial.

Alves, A.C., Visser, F., Samarra, F., Antunes, R., Swift, R., Miller, P. (2011) *"3S-Observer handbook"*. Available from Patrick Miller at pm29@st-andrews.ac.uk

Kleivane, L., Nordlund, N., Kvadsheim, P.H. (2011). *"3S^2 2011-2013 Evaluation of alternative field sites within Norwegian waters"*. Available from Petter Kvadsheim at phk@ffi.no

Kvadsheim, P.H. (2012)**.** Permit from Norwegian Animal Research Authority – *"3S^2 Behavioral response studies of cetaceans to naval sonar signals in Norwegian waters"*. Available from Petter Kvadsheim at phk@ffi.no

Kvadsheim, P.H., Lam, F.P., Miller P., Tyack, P. (2012). *3S^2-Analysis and publication plan.* Available from Petter Kvadsheim at phk@ffi.no

Kvadsheim, P.H., Lam, F.P., Miller P., Doksæter, L., Visser, F., Kleivane, L., vanIjsselmuide, 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 report* **2011/01289** (http://rapporter.ffi.no/rapporter/2011/01289.pdf)

Kvadsheim, P.H., Lam, F.P., Miller P. and Dekeling R. (2011). *"3S-2011 Cruise plan"*. Available from Petter Kvadsheim at phk@ffi.no

Miller, P. and Tyack, P. (2010). Research proposal to ONR *"3S^2 Behavioral response studies of cetaceans to naval sonar signals in Norwegian waters"*. Available from Patrick Miller at pm29@st-andrews.ac.uk

TNO, SMRU, FFI and WHOI (2011). *"3S Joint Research Agreement"*. Available from Frans-Peter Lam at frans-peter.lam@tno.nl

Von Benda-Beckmann, S. (2011).*"3S2 Ramp-up experiment - experimental protocol and theoretical ramp-up design"*. Available from Frans-Peter Lam at frans-peter.lam@tno.nl

Specifications, deployment, operation and recovery of SOCRATES and Delphinus systems

In this appendix, technical details and sailing restrictions are presented for SOCRATES and Delphinus systems, both to be towed by H.U. Sverdrup II. Sailing restrictions are driven by 3 factors: to avoid hitting the sea floor, to avoid cavitation during (high power) transmission and to avoid entanglement while towing both systems simultaneously (dual tow).

Bottom Avoidance SOCRATES II and Delphinus array

During the trials the SOC2 towed body will be operated with a minimum cable scope of 100 m. In the Table below the maximum cable scope is indicated for different water depths.

Water depth [m]	110	150	200	250	300	400	500
Max Cable scope SOC2 [m]	100	170	260	400	500	500	500(*)
Max Cable scope Delphinus [m]	170	270	400	500	600	660	660

(*) beyond 500m water depth, the maximum cable scope for SOC2 equals the water depth.

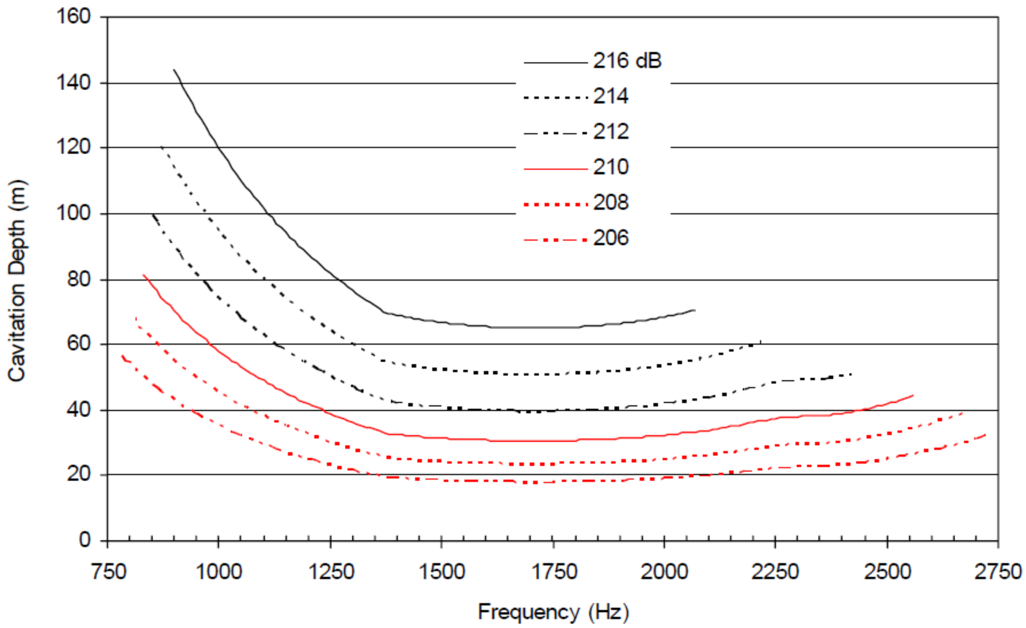
These values are based on the speed-depth diagrams at speed 3 kts with a safety margin of 20 m. When applied a minimum speed of 4 kts should be enforced.

The cable scope of the Delphinus array should be longer (≥ 20m) than the cable scope of the source in order to get both systems at the same operating depth. The array itself is neutrally buoyant. Therefore it will only sink by the weight of the cable. When H.U. Sverdrup II would need to come to an unplanned stop the array will slowly sink to the bottom. In this case there will be time to recover the array in order to minimize damage to the system.

Turn rate

During dual tow, turns of H.U. Sverdrup II are carried out with a maximum turn rate of 15 degrees/minute. If the experimental set-requires otherwise a look-out from TNO should check the equipment on the aft deck. During single-tow operations the maximum turn rate is 30 degrees/minute.

Cavitation
Because of cavitation the source cannot be operated at full power at small depths. Cavition depths depend on sonar frequency as shown in the Figure below (curves from Ultra Canada).



The maximum source level of SOC2 is 214 dB. At *f* = 1000 Hz this results in cavitation depth of 100m. In order to reduce cavitation "shallow tow pulses" are defined that have a minimum frequency of *f* = 1300 Hz. This reduces the cavitation depth to 60 m.

Full band pulses (1000-2000Hz)
In case other pulses (including frequencies *f* < 1300 Hz) are used and if the sonar depth is less than 100 m the source level should be adjusted with 1 dB per 10 m as shown in the table below.

Source level [dB]	214	213	212	211	210	208	206	204
SOC2 min depth [m]	100	90	80	70	60	50	40	30
SOC2 min cable scope [m] @ 6 kts	250	220	190	160	140	110	100	100
Min water depth [m] @ 6 kts	190	180	160	145	130	110	110	110
SOC2 min cable scope [m] @ 8 kts	470	410	350	290	230	180	140	100
Min water depth [m] @ 8 kts	280	260	240	210	180	160	130	110

Shallow tow pulses (1300-2000Hz)
In case special *shallow tow pulses* (*f* > 1300 Hz) are used and if the sonar depth is less than 60 m the source level should be adjusted with about 1 dB per 5 m as shown in the table below.

Source level [dB]	214	213	212	211	210	209	208	206
SOC2 depth [m]	60	55	50	45	40	35	30	25
SOC2 cable scope [m] @ 6 kts	140	120	110	100	100	100	100	100
Min water depth [m] @ 6 kts	130	120	110	110	110	110	110	110
SOC2 cable scope [m] @ 8 kts	230	200	180	160	140	120	100	100
Min water depth [m] @ 8 kts	180	170	160	140	130	120	110	110

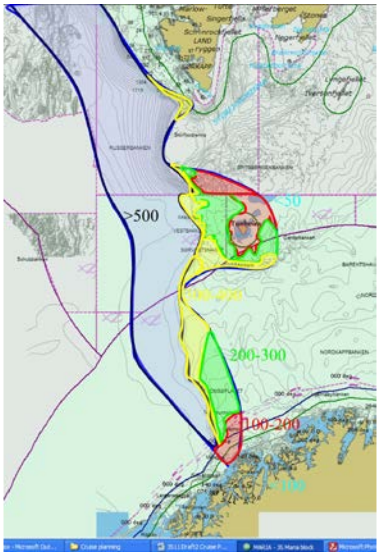
Overall depth guidelines

The above information, can be summarized with the following table for exposure runs at 8 knots (and without turning):

Signal	***Bandwidth (Hz)***	***Modulation***	***Source level dB re 1μPa@1***	***Tow speed Kts***	***Min tow depth m***	***Min water depth m***	***Min cable scope m***	***Target species***
$LFAS_{deep}$	1000-2000	HFM up-sweep	214	8	100	280	470	Bottlenose whales
$LFAS_{shallow}$	1300-2000	HFM up-sweep	214	8	60	180	230	Minke whales Humpback whales, Fin whales

Depth limits for the two earlier defined types of signals, $LFAS_{deep}$ and $LFAS_{shallow}$ during straight exposure runs at 8 knots without turns. Sailing restrictions for BRS-type exposures are discussed below.

As an overall result, the following areas for different depth limitations can be recognized for the operation area, as shown in figure below:



Depth contours for the operation area. Red area = 100-200m. Green areas = 200-300m, yellow areas = 300-400m, blue areas = >500m. $LFAS_{shallow}$ (1.3-2.0kHz) can be used in all areas except the red area, while $LFAS_{deep}$ (1.0-2.0kHz) can only be used in the yellow and blue areas.

BRS-style exposure runs with N.Bottlenose whales and dual tow

As explained in the Cruise Plan, there is a preference for BRS-style exposure runs with Northern bottlenose whales, which means starting to close in on the tagged animal or group as soon as they start clicking during their second deep dive. Because we aim to keep tracking acoustically in parallel as much as possible, this implies that this should be done with dual tow (SOC2 and Delphinus). The manoeuvring as explained in the cruise plan is very challenging: it describes dual tow, with constant turning ('boxing') while sailing at (very) low (possibly changing) speed. This manoeuvring needs to be tested in advance in order to verify the safe limits. Until then the following guidelines will be in place as a starting point:

- Minimum speed is expected to be 4 kts (constant speed preferred). This is both for acoustic functionality, as well as for safety of system (to prevent entanglement)
- Turn rate for dual tow is 15 deg/minute, this implies 6 minutes for 90 degrees, and 24 minutes for 360 degrees. At higher speeds (beyond 6 knots) a higher turn rate could be considered (to be verified by testing)
- With numbers as stated above, the minimum box is likely to be 1x1nmi at 4 knots (to be verified by testing)
- It takes about 5-10 minutes for the array to get stable after turning (or changing speed). During this stabilization time the acoustic functionality is ranging from poor to sub-optimal.
- Note that handling, like deploying and recovering SOC (see below), should take place during a straight course. Deploying SOC between two corners of a 1x1nmi box will be (too) tight.
- Note that during dual tow it is more challenging to launch and recover tagboats. Special attention is required at these moments.

We should evaluate how things are working out while testing. If needed, test again!

Deployment and Recovery of systems

Seastate

The SOCRATES source and Delphinus/CAPTAS arrays will be deployed to and including sea state 4. It will be recovered if sea state is forecasted to be higher than 5. The decision to recover will be taken by the chief scientist sonar and the responsible TNO technician, and communicated with the captain of H.U. Sverdrup II and the cruise leader.

Deployment and Recovery Speeds

Deployment and recovery time for the SOCRATES to/from a cable scope of 100 m takes approximately 30 minutes and similar for the towed array. Stabilization time of towed body and towed array is about 5 minutes. During deployment and recovery, the tow ship speed is approximately 4 – 5 kts. When the handling supervisor on the aft deck is comfortable with the actual circumstances (wind, currents and sea state) deployment speed could eventually be increased to max. 8 kts.

Sequence

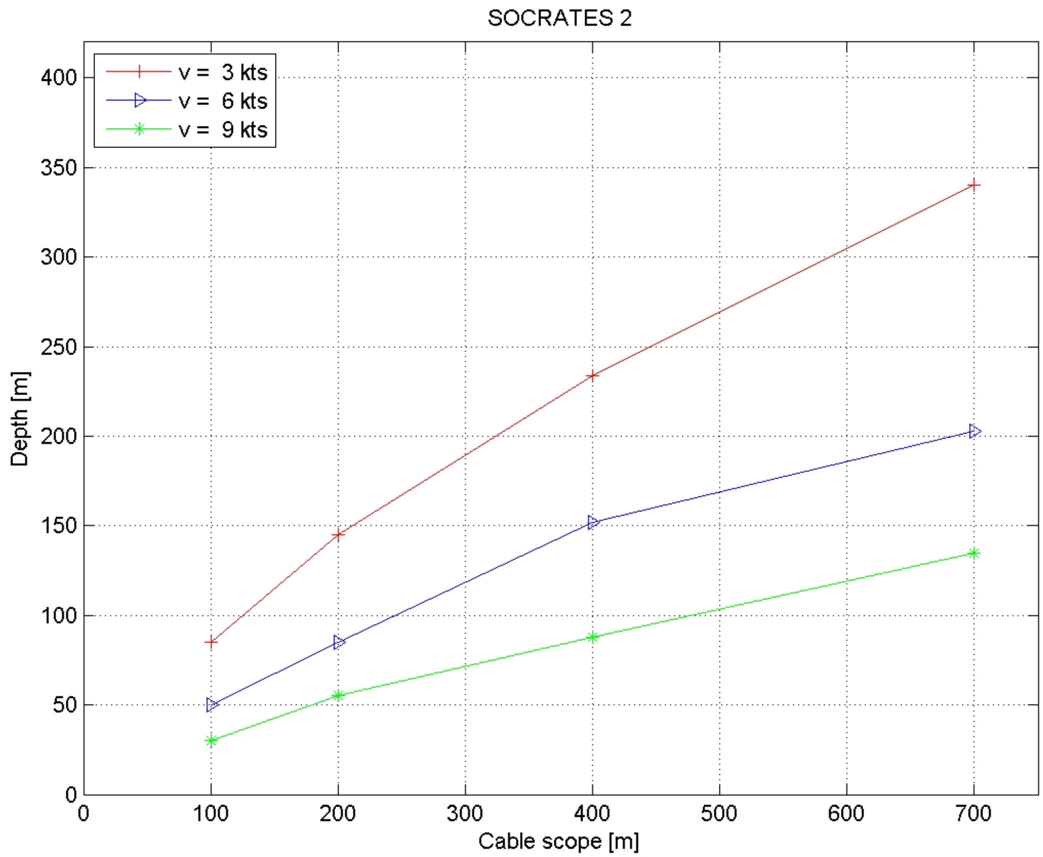
H.U. Sverdrup II can tow both the SOCRATES source and the Delphinus array simultaneously. The deploying sequence will be first the towed array and then the SOCRATES towed source. Consequently the retrieval sequence will be first SOCRATES and then the array.

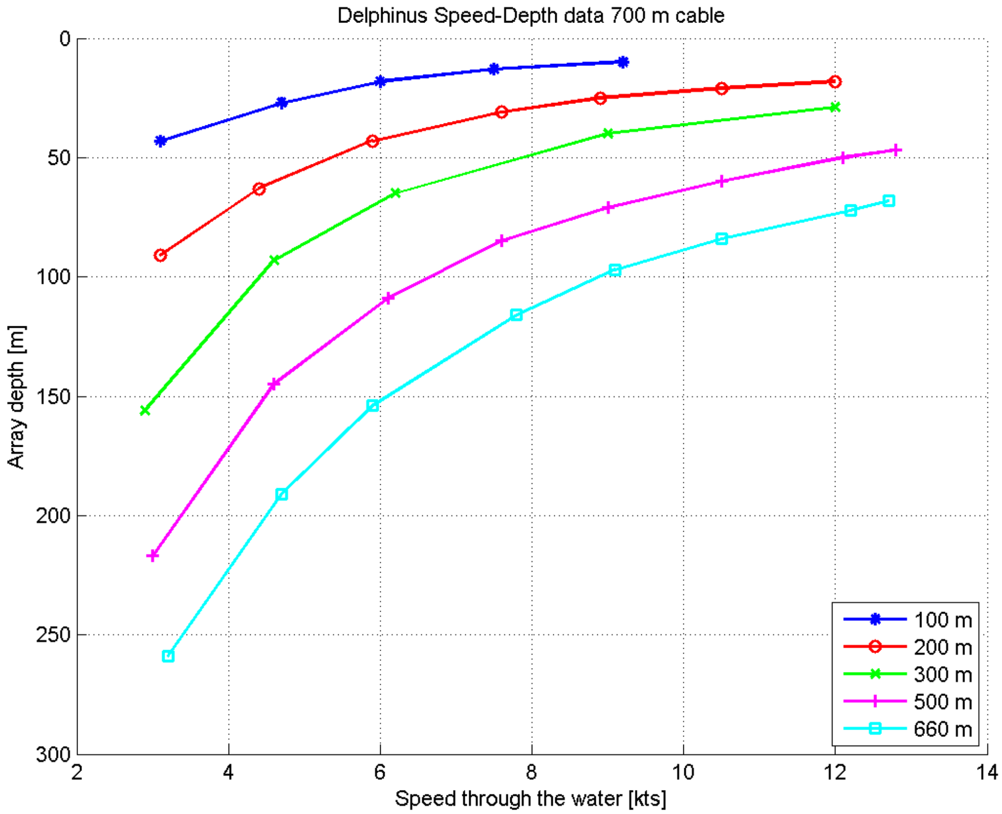
Data Sheet

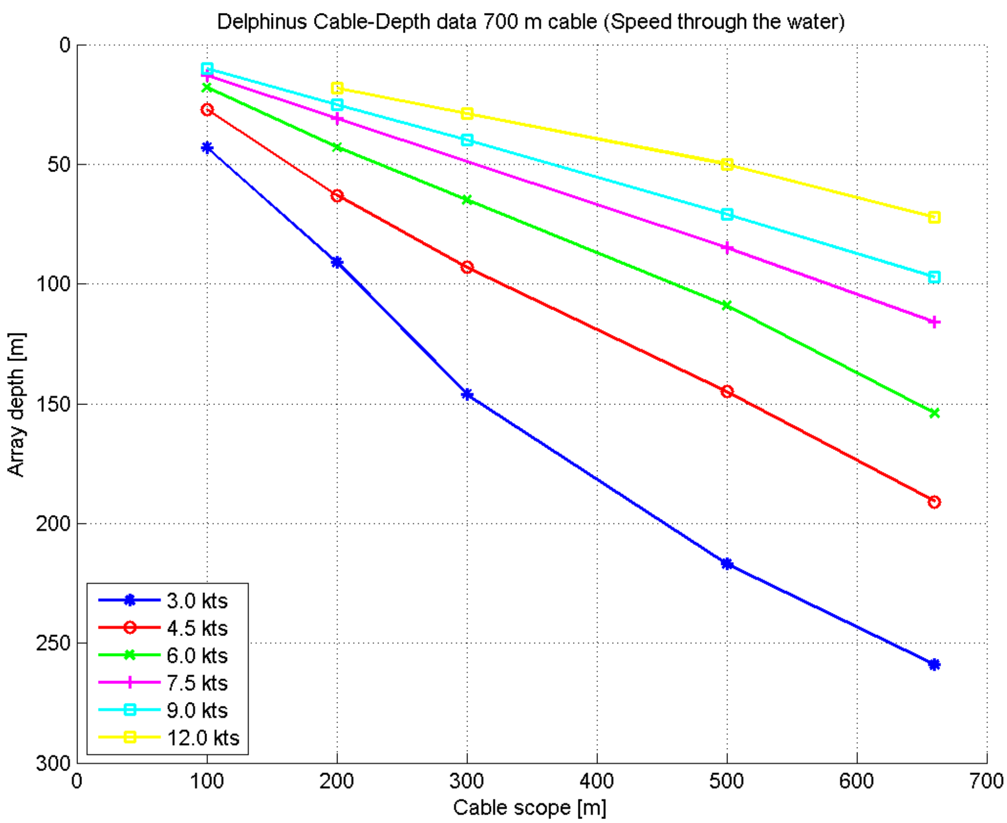
The operational limitations and additional information for H.U. Sverdrup II while towing are presented below:

Item	min	max	Remarks
SOCRATES 2 weight [kg (daN)]	430	750	Weight in water/air
SOCRATES 2 tow length [m]	100	950	
Bottom Vertical Safety Separation [m]	20		
Upper Vertical Safety Separation [m]	15		When not transmitting
Upper Vertical Safety Separation [m]	40		When transmitting
Array depth [m]	10	400	
Array tow length [m]	100	660	
Speed brackets [kts]	4	12	SOCRATES + array
Sea state	-	5	SS 5 during towing, SS 4 deploy/recovery

Speed-Depth Graphs




Delphinus Speed-Depth data 700 m cable
Array depth [m]
Speed through the water [kts]
0
50
100
150
200
250
300
2
4
6
8
10
12
14
100 m
200 m
300 m
500 m
660 m


Delphinus Cable-Depth data 700 m cable (Speed through the water)
Array depth [m]
Cable scope [m]
0
50
100
150
200
250
300
0
100
200
300
400
500
600
700
3.0 kts
4.5 kts
6.0 kts
7.5 kts
9.0 kts
12.0 kts