Off-Range Beaked Whale Studies (ORBS): Baseline Data and Tagging Development for Northern Bottlenose Whales (*Hyperoodon ampulatus*) off Jan Mayen, Norway

Patrick Miller
Sea Mammal Research Unit
Scottish Oceans Institute
School of Biology
University of Saint Andrews
St. Andrews Fife, KY16 8LB UK
phone: (+44) 1334-463554 fax: (+44) 1334-463443 email: pm29@st-and.ac.uk

Award Number: N000141512533
http://www.smru.st-and.ac.uk

LONG-TERM GOALS

The question of how beaked whales are affected by naval sonar is important for the US Navy as information is required for accurate environmental assessments. A number of recent studies have reported behavioral responses of a small number of beaked whales to experimentally-presented sonar signals (Tyack et al., 2011; DeRuiter et al., 2013; Stimpert et al., 2014, Miller et al., 2015). These studies indicate that beaked whales do respond behaviorally to sonar, typically showing a combination of avoidance and cessation of feeding, with responses to simulated sonar starting at low received levels. These types of behavioral changes are confirmed by monitoring of vocal activity using Navy range hydrophones (Tyack et al., 2011; Moretti et al., 2014), and are consistent with longer-term movement of beaked whales around the AUTEC range (Tyack et al., 2011).

One concern with the current status of our scientific knowledge is that most of the information on beaked whale responses has been collected in areas directly on, or adjacent to, US Naval facilities. It is possible that animals which are resident in those areas may not be typical of beaked whales in the rest of the world's oceans. In 2013, the ONR-funded project $3S^2$ conducted a behavioral response study experiment with the beaked whale *Hyperoodon ampullatus*, the northern bottlenose whale, in a pristine environment near Jan Mayen using a 1-2 kHz sonar with a maximum source level of 214dB re 1µPa (see Related Programs). Results of that experiment indicated a clear and strong behavioral response with prolonged avoidance of the source and cessation of foraging, including a silent non-foraging dive which was the longest-duration and deepest dive recorded for the species (Miller et al., 2015). Other non-tagged whales in the experimentally-exposed area also moved away and/or ceased producing feeding-related vocalizations. The 3S experiment demonstrated that beaked whales far from a naval range responded to experimental presentation of sonar in a similar fashion as was observed in on-range studies. However, the severity of the response may have been stronger than has been reported for on-range studies, as the observed responses were ongoing until the tag detached from the whale more than 7 hours after the sonar exposure.

The work proposed here will contribute to our understanding of how beaked whales in pristine areas of the world's oceans respond to military sonar by refining methods that will be useful for future studies of how they respond to sonar. Specifically, baseline data collected by additional Dtag deployments, acoustic buoy recordings, and minimally-invasive satellite tags proposed here will enable us to more fully characterize the non-disturbed behavior of this beaked whale species. This wider suite of observation tools will make it possible to over longer-time and wider-spatial aspects of behavioral responses using multi-scale observations. The proposed killer whale and control playbacks will enable evaluation of the biological basis for the specific characteristics (deep and long silent dive) of the documented behavioral response to sonar (Miller et al., 2015), and will demonstrate our ability to conduct playback experiments with this species. Ultimately, the proposed testing and application of tagging and acoustic-recording systems will enable future studies of how sonar affects these animals in a relatively pristine body of water, far from ongoing naval sonar activities.

OBJECTIVES

The objectives of this short-duration project are: 1.) to test and use a pneumatically-launched tagging system (ARTS) with the version-3 Dtag; 2.) to deploy Dtags during a trial in June, 2015 off Jan Mayen to collect baseline data on the natural behavior of this species; 3.) to collect pilot data from passive acoustic buoys and longer-term SPLASH satellite tags; and 4.) to conduct 1-2 playbacks of killer whale and other control sounds to tagged-and-tracked bottlenose whales using a Lubell speaker. This fourth objective was a secondary objective not to interfere with the first 3 tasks.

The proposed work will yield a tested system to deploy version-3 Dtags using the ARTS launching system, which should be of benefit to the entire field. Baseline data from all systems and response data from the killer whale playbacks will support the interpretation of existing CEE data on the species collected during the $3S^2$ project (see Related Programs, below). Finally, the project will represent a pilot study of multi-scale observation methods that could be utilized in future studies of beaked whale response to sonar signals in a location which is far from ongoing sonar activities.

APPROACH

Building upon previous work, an ARTS carrier system for Dtag3 will be built for field use with bottlenose whales (objective 1). Laboratory tests measure acceleration forces received by a dummy Dtag3 deployed using the ARTS system over a range of pneumatic pressure settings and target ranges. Measurements of forces involved in pole-tagging will be measured as a control. The system will be used in two trials to test and improve the effectiveness of the attachment system. Modifications will be made to the system after the first field trial, for further testing in a second lower-cost trial with easy-to-tag humpback whales. This objective will largely be accomplished by LKArts led by Lars Kleivane.

All objectives will be addressed during a 28-day research trial with *Hyperoodon* conducted in deep waters around Jan Mayen. This field trial will focus upon collecting baseline data using the proposed systems. During the field trial, Dtags provided by the Woods Hole Oceanographic Institution will be attached to northern bottlenose whales using the ARTS pneumatic launching system (objective 1). In addition to baseline Dtag recordings (objective 2), we will collect baseline data using a passive acoustic buoy and SPLASH-10 satellite tags (objective 3). Five SPLASH-10 tags and two Loggerhead Instruments: DSG-ST Ocean Acoustic Datalogger acoustic buoys were available to this project. IXSEA oceano 2500S universal acoustic releases for the acoustic data-loggers were provided by TNO, The Netherlands. While the primary focus of the trial is to develop tag systems and obtaining baseline

data, we will also conduct 1-2 sound playbacks of killer whale and control sounds to tagged whales (objective 4) as a secondary priority.

WORK COMPLETED

The contract for this grant started on 01 July, 2015. That timing made it possible for us to successfully accomplish the June 2015 trial with northern bottlenose whales off Jan Mayen, using pre-award spending. In that trial, we successfully addressed all four objectives, as detailed below. In addition, some measurements of shock forces experienced by Dtags in ARTS and pole deployments were measured by LKArts in Norway. A low-cost field trial with humpback whales that was originally proposed to take place in January, 2015 to further test use of the ARTS system with version-3 Dtags has been postponed to January, 2016.

Overall, as detailed below, substantial progress was made with all objectives. Further testing and refinement of the Dtag3-ARTS carrier system will be carried out prior to a January field trial with humpback whales in Norway. Data analysis of baseline data records collected using Dtags, acoustic buoys, and satellite tags is ongoing, and will continue through the duration of this short-duration project which is due to end on 31 March, 2016.

RESULTS

Objective 1: Test and use a pneumatically-launched tagging system (ARTS) with the version-3 Dtag
An ARTS carrier was built for the version-3 Dtag by LKArts. Testing in the lab using a 500g shock accelerometer found that impact forces from hand-pole deployments led to the tag experiencing forces of 158 ± 28g (st dev). Shock tests at 7.5 and 8.5 bars pressure using the ARTS launching system resulted in forces of 216 ± 28g and 253 ± 26g, respectively, at 10m range to the target. Thus, impact forces are predicted to be somewhat higher during ARTS launching than using a hand-pole, but it is unlikely that forces would be more than double that typically experienced during pole tagging.

During the research trial, significant testing with targets was accomplished prior to deployment attempts on bottlenose whales. Functionality of one version-3 Dtag was not affected by over 10 target practice launchings that landed on the sea surface. However, in a later missed deployment of that tag, we found that the VHF antenna of the version-3 Dtag had broken. The Dtag3-ARTS carrier is now being modified to provide more protection to the antenna during missed attempts, and will be tested in the January, 2016 field trial with humpback whales in coastal waters of Norway.

The version-3 Dtag was deployed twice onto *Hyperoodon* using the ARTS system. Both deployments were atypically short in duration, about 30s and 1.2 hrs. In contrast, all four deployments of version-2 Dtags using the ARTS system led to attachments that held until the scheduled 8-10 hour release time. Though this data sample is quite small, it indicates that the housing design of the version-2 Dtag is more suitable to ARTS deployment than the version-3 Dtag design. We therefore propose a simple long-term solution for use of version-3 Dtags with the ARTS system could be to build a Dtag2-style housing to carry the version-3 Dtag for ARTS deployment.

Objective 2. Deploy Dtags to collect baseline data on the natural behavior of Hyperdoodon
We attached 9 Dtags to *Hyperoodon* (4 Dtag2 and 5 Dtag3), of which 6 deployments yielded useful data to the project for a total recording time of over 60hrs. One Dtag2 failed to record any data, and two Dtag3 deployments were too short in duration to be useful. Six of the 9 deployments were

accomplished using the ARTS launching system (Figure 1, left panel), while 3 deployements of version-3 Dtags were accomplished using a hand-pole from the bow-sprit of the sailboat (Figure 1, right panel). This represents a slight improvement on our 2014 outcome during which 6 Dtags were deployed with 4 useful data-sets totalling over 40hrs were collected from *Hyperoodon* using a similar sailboat platform. Data from the deployments are currently being analysed (Figure 2).

Figure 1. Left: Tagging attempt of a version-2 Dtag on a Northern bottlenose whale using the ARTS launching system. Right: Tagging attempt of a Dtag 3 on a Northern bottlenose whale using the tag pole from the bowsprit. Both attempts were successful.

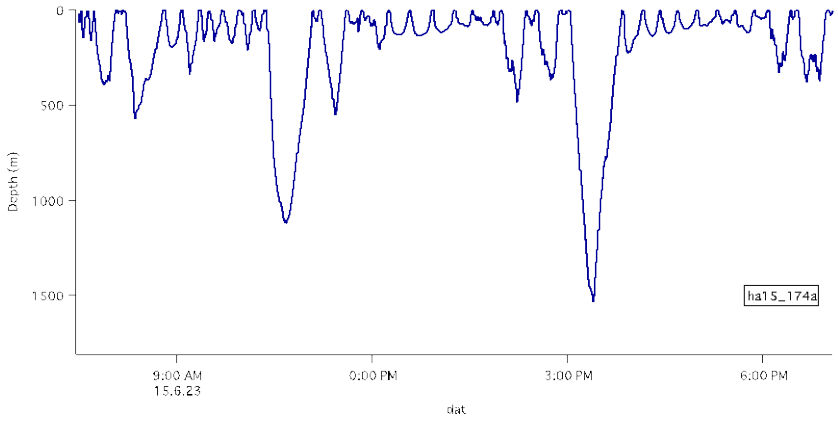

Figure 2. Example dive record of a Northern bottlenose whale tagged off Jan Mayen (Ha15_174a).

Objective 3. collect pilot data from acoustic buoys and SPLASH satellite tags
Two acoustic buoys were successfully deployed upon arrival at Jan Mayen on 16 and 17 June (Table I). Loggerhead Instruments DSG-ST Ocean Acoustic Datalogger with an aluminium housing were deployed using an IXSEA oceano 2500S universal acoustic release, provided by TNO, The Netherlands. From 16-29 June, sound was continuously recorded at 96 kHz on the SMRU buoy. After those data were downloaded and battery changed, the buoy was redeployed. For the 11-12 month deployments currently underway, the two buoys will record one minute of data every 30 minutes. Acoustic data from the recovered buoy have been inspected, and found to be of high sound quality. The next step is to detect clicks in the recordings using a *Hyperoodon* click detection algorithm developed by TNO.

Table I. Acoustic buoys deployed during the Jan Mayen trial.

Buoy owner	**Deployment time (UTC)**	**Deployment location**	**Recovery time**	**Notes**
SMRU	16 June, 22:41	No.1 (71°01.917'N, 07°01.694'W)	29 Jun, 19:32	Ranging code #08D1; releasing code #0803
TNO	17 June, 03:13	No.2 (70°51.029'N, 06°08.266'W)	To be recovered in 2016	Ranging code #0803; releasing code #0855
SMRU	30 June, 23:02	No.1 (71°02.003'N, 07°01.981'W)	To be recovered in 2016	Ranging code #08D1; releasing code #0803

In collaboration with Rune Hansen of the University of Oslo, a total of three SPLASH-10 tags were deployed on *Hyperoodon* using the Dan Inject system recommended by Wildlife Computers (Table II). Whale reactions to tagging were only minor short-duration responses in all cases, similar to typical responses of the species to biopsy sampling (Hooker et al., 2001). One tag was lost at sea following a miss, and another tag was not deployed. All three attached tags had transmission durations that were substantially longer than were achieved in the three tags deployed in the 2014 trial which had a maximum duration of 6days, 2hr. The longer-durations we achieved revealed larger scale movements by the tagged whales (Figure 3). All three tagged whales moved south in late June and July, with one whale tracked as far as the Azores archipelago. In addition to the novel large-scale movements, detailed movements of tagged whales near Jan Mayen were also recorded, and one animal was re-sighted near where it was tagged.

Table II Deployments of SPLASH tags on Northern bottlenose whales.

Serial No	Argos PTT	Tag on time (UTC)	Tag on location	Reaction	Last fix date
15A0180	134670	22 June, 14:45	70°59.156'N, 06°40.416'W	1	04 August
15A0178	134669	22 June, 15:59	70°57.388'N, 06°45.571'W	1	02 July
13A0775	134668	23 June, 20:42	70°59.140'N, 06°33.914'W	1	21 July

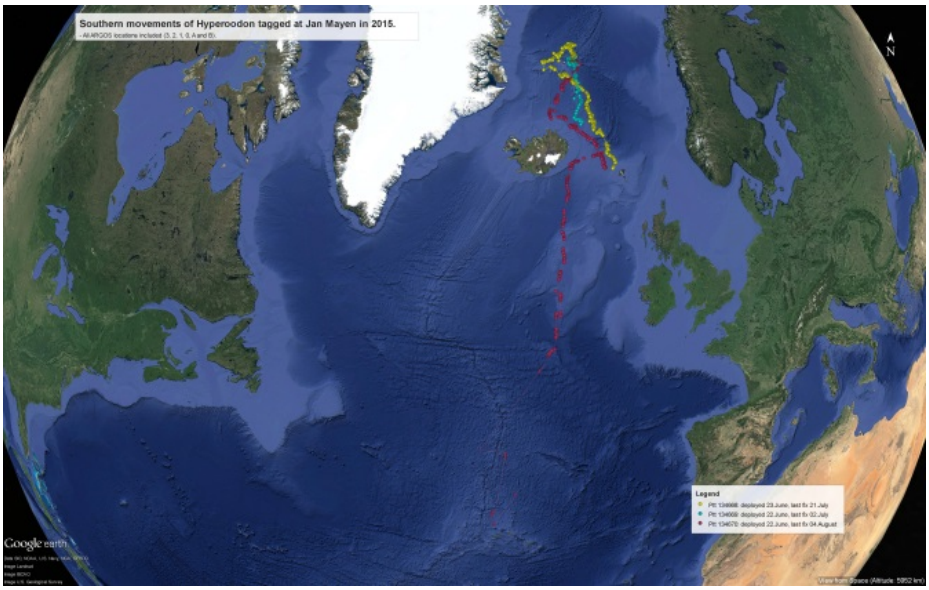

Figure 3. large-scale movements of northern bottlenose whales. All three tagged whales moved south from Jan Mayen. The yellow track is PTT 134668, the blue track is PTT 134669, and the red track is PTT 134670. Note that the animal with PTT 134760 was tracked moving all the way south to the Azores Archipelago. Figure courtesy of Rune Hansen.

Objective 4. conduct playbacks of killer whale and control sounds to tagged-and-tracked Hyperoodon
We conducted 3 playback sessions with two different tagged *Hyperoodon*. These were intentionally timed at the start and end of the trial in order to avoid interfering with baseline data collection during the middle part of the trial. In the first experiment with two playback sessions, we first conducted a 15-minute control playback of a 1-2 kHz upweep tone (similar to the sonar signal used in the BRS experiment reported in Miller et al., 2015), followed by a 15-minute playback of mammal-eating killer whale sounds. Visual tracking was strong until the killer whale playback when the animals were not sighted after an apparently strong behavioral response to the playback. Direction to the tagged whale was consistently visible using the DFHorten automatic direction finder (ADF) system connected to quad antennas mounted at 25m above sea level at the top of the mast, and we were able to reacquire the animals. In the second experiment we conducted a 15-minute control playback of the 1-2 kHz upsweep tone. The whales were not seen immediately after that playback, but directions to the whale were obtained from the DFHorten ADF system at an estimated range of 5-10km. The animals moved consistently away to the northwest, and we reacquired the whales after moving in that direction. The strong reaction to the control signal meant we did not conduct the playback of killer whale sounds. Tags deployed during both experiments were successfully recovered but audio data was not recorded during the killer whale playback due to low battery levels in the Dtag2. Analysis of the outcome of these playback experiments is ongoing.

In summary, we were able to conduct two carefully-planned and controlled exposures of *Hyperoodon* using a Lubell speaker deployed from the sailboat. Given the excellent VHF-tracking capability, we could have accomplished two more experiments had playbacks been the priority of the research trial. Combined with the successful deployment of acoustic buoys and SPLASH-10 satellite tags, this effort has demonstrated our capability to conduct multi-scale observations of natural behavior and to study

the behavioral response of the beaked whale *Hyperoodon* to experimentally-presented sounds within this pristine habitat far from regular naval sonar activities.

RELATED PROJECTS

This study is a continuation of two projects "Cetaceans and naval sonar: behavioral response as a function of sonar frequency" award number N00014-08-1-0984, which expired in 2011 and "$3S^2$: Behavioral response studies of cetaceans to navy sonar signals in Norwegian waters" which expired in 2014. Fieldwork under this project has been co-funded by SERDP award RC-2337 entitled 'Behavioral ecology of cetaceans: the relationship of body condition with behavior and reproductive status'. Additional support has been provided by French Ministry of Defence, and the University of Oslo.

REFERENCES

DeRuiter SL, Southall BL, Calambokidis J, et al. (2013) First direct measurements of behaviour responses by Cuvier's beaked whales to mid-frequency active sonar. Biology Letters 9, doi: 10.1098/rsbl.2013.0223

Hooker, S.K., Baird, R. W., Al-Omari, S., Gowans, S. and Whitehead, H. 2001. Behavioral reactions of northern bottlenose whales (Hyperoodon ampullatus) to biopsy darting and tag attachment procedures. Fish. Bull. 99: 303-308

Miller P. J. O., Kvadsheim, P. H., Lam, F. P. A., Tyack, P.L., Curé, C., DeRuiter, S. L., Kleivane, L., Sivle, D. L., van IJsselmuide, S. P., Visser, F., Wensveen, P. J., von Benda-Beckmann, A. M., Martin López, L. M., Narazaki, T., Hooker, S. K. (2015). First indications that northern bottlenose whales are sensitive to behavioural disturbance from anthropogenic noise. *R. Soc. open sci.* 2: 140484. http://dx.doi.org/10.1098/rsos.140484

Moretti, D., Thomas, L., Marques, T., Harwood, J., Dilley, A., Neales, B., Shaffer, J., McCarthy, E., New, L., Jarvis, S.*, et al.* 2014 A risk function for behavioral disruption of Blainville's beaked whales (*Mesoplodon densirostris*) from mid-frequency active sonar. *PLoS One*. 9, e85064. (10.1371/journal.pone.0085064)

Stimpert, A. K., DeRuiter, S. L., Southall, B. L., Moretti, D. J., Falcone, E. A., Goldbogen, J. A., Friedlaender, A., Schorr, G. S., Calambokidis, J. 2014 Acoustic and foraging behavior of a Baird's beaked whale, *Berardius bairdii*, exposed to simulated sonar. *Sci. Rep.* 4, 7031. (10.1038/srep07031)

Tyack PL, Zimmer WMX, Moretti D, Southall BL, Claridge DE, Durban JW, Clark CW, D'Amico A, DiMarzio N, Jarvis S, McCarthy E, Morrissey R, Ward J, Boyd I. 2011. Beaked whales respond to simulated and actual navy sonar. PLOS One 6(3):e17009