CRUISE REPORT

Body Condition and 3S15 Projects: 2015 Jan Mayen Trial

A group of Northern bottlenose whales near Jan Mayen (Photo by T. Narazaki)

Jan Mayen, Norway, June 04 – July 05, 2015

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Cruise report with 17 figures and 10 tables. This research trial was co-funded by the US Office of Naval Research (ONR) grant N-00014-15-1-2533 and the Strategic Environmental Research and Development Program (SERDP) grant RC-2337, with additional support from the French Ministry of Defence (DGA) and in-kind support from the University of Oslo (participation of Rune Hansen). The authors wish to thank all other team members, and the dedicated ship's crew from North Sailing, Husavik, Iceland for making this field effort a success.

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EXECUTIVE SUMMARY

Using a similar sailboat platform as was trialled in 2014, we conducted a successful research trial off Jan Mayen, departing Husavik Iceland on 13 June, 2015 and returning on 03 July, 2015. We attached 9 Dtags (4 Dtag2 and 5 Dtag3) to northern bottlenose whales (*Hyperoodon ampullatus*), of which 6 deployments yielded useful data to the project. One Dtag2 failed to record any data, and two Dtag3 deployments were too short in duration. Six of the 9 deployments were accomplished using the ARTS launching system, while 3 were accomplished using a hand-pole from the bow-sprit of the sailboat. Biopsy samples were collected from 4/6 whales tagged using the ARTS system, but could not be obtained for 3 animals pole-tagged from the bowsprit. We attached 3 SPLASH-10 tags to good locations on or near the dorsal fin using the DanInject system. The ARGOS tracks indicated the whales moving south, suggesting that Jan Mayen may be a temporary seasonal habitat for northern bottlenose whales. We also successfully deployed two Loggerhead acoustic buoys at 2000m depth at the start of the trial. Recordings from one of the buoys were downloaded at the end of the trial, and it was re-deployed. Both buoys remained in the water for data collection until summer, 2016. We obtained several overhead images of animals tagged off the front half of the boat using a downward facing camera placed 22m above sea level on the main mast. Four CTD casts were made near Jan Mayen, and two CTD casts were made in Skjálfandi Bay near the locations where Dtags were deployed on a blue and humpback whale on the final day of the research trial.

Tracking of tagged whales was highly successful using VHF antennas mounted 25m above sea level at the top of the highest mast, and there was never any risk of tag loss. We conducted three sound playbacks to two tagged whales. The playbacks were only started after sufficient baseline data was collected to describe the body density and natural behaviour of those whales. Based upon initial inspection of the data, the playbacks seemed to elicit variable responses. An attraction response was apparent when a sequence of low level (120 dB re 1µPa m source level) 1-2 kHz sonar-control signals were played, but avoidance responses were recorded for playback of killer whale sounds to the same whale. Playback of a sequence of 1-2 kHz sonar sounds at a higher source level (~165-175 dB re 1µPa m) to a different tagged whale led to a strong avoidance reaction strikingly similar to that reported in Miller et al. (2015) in response to playback at greater distance using a source with maximum source level of 214 dB re 1µPa m. The whale was roughly 300m away from the speaker at the start of the playback and the response began soon after the first pulse was received at a sound pressure level of ~125-135 dB re 1 µPa. Interestingly, this received level (RL) matches the RL at which strong avoidance started during the 2013 bottlenose whale experiment (Miller et al., 2015), but the 2013 whale was further away (4.5 km). This result is useful to begin empirical evaluation of how received level and distance from a sonar source might interact to lead to behavioural effects, and demonstrates that we are capable of conducted controlled exposure experiments to tagged bottlenose whales from the sailboat platform.

In conclusion, we were able to effectively use the sailboat platform to deploy tags on northern bottlenose whales, collect biopsy samples, collect identification photographs, track whales, and deploy and recover bottom-mounted buoys. Effective tracking was largely enabled by high placement of VHF antennas at 25m above sea level and low levels of electronic interference. Effective tracking enabled us to experimentally expose tagged whale to sounds transmitted from a Lubell speaker deployed from the sailboat, as part of a BRS study. Further work is needed to develop a fully functional system to deploy version-3 Dtags using the ARTS system, but the ability to attach tags using a pole from the bowsprit offers additional options for tagging this difficult species using a sailboat platform.

PERSONNEL

Science crews:

Dr. Patrick Miller	Sea Mammal Research Unit, University of St Andrews, UK
Dr. Tomoko Narazaki	Sea Mammal Research Unit, University of St Andrews, UK
Dr. Saana Isojunno	Sea Mammal Research Unit, University of St Andrews, UK
Joanna Kershaw	Sea Mammal Research Unit, University of St Andrews, UK
Miguel Nerves Dos Reis	Sea Mammal Research Unit, University of St Andrews, UK
Hannah Wood	Sea Mammal Research Unit, University of St Andrews, UK
Rune Hansen	University of Oslo, Norway
Lars Kleivane	LKArts, Norway
Eva Hartvig	Sydney University, Australia
Dr. Stacy DeRuiter	Calvin College, USA (only joined for the preparation at Husavik)

Ship's Crew:

Christian Harboe-Hansen	(Skipper)
Kent Grundvad	(First Mate)
Tomasz Dulik	(Engineer)
Kaj Ravn	(Mate/Deckhand)
Sebinem Onagaclar	(Chef)

ITINERARY

05-13/06/2015	Preparation in Husavik
13/06/2015 20:36	Depart Husavik
16/06/2015 11:00	Arrive near Jan Mayen, Norway
16/06/2015 22:41	Deploy 1st acoustic buoy
17/06/2015 03:13	Deploy 2nd acoustic buoy and start research on northern bottlenose whales
25-26/06/2015	At anchor, poor weather
01/07/2015 03:00	Depart Jan Mayen
03/07/2015 19:00	Arrive Husavik
03/07/2015 21:15	Leave Husavik, research on baleen whales in Skjálfandi Bay, Iceland
04/07/2015 16:34	Arrive Husavik. End of Trial.

RESEARCH OBJECTIVES AND CRUISE TASKS

The main goals of this research trial was to: 1.) develop new systems to attach Dtag3 to cetaceans using an ARTS launching system; 2.) to collect baseline data of northern bottlenose whales off Jan Mayen, and 3.) to develop and ground-truth non-invasive methods to track the body condition of free-ranging cetaceans. This included attempting to understand their capacity to adjust foraging and anti-predator behaviors in response to their body condition, and to understand the consequences of fluctuations in body condition in terms of the reproductive status of individual animals. Primary tasks had a higher priority than secondary tasks. We tried to accomplish as many of the secondary tasks as possible, without interfering with our ability to accomplish the primary tasks.

Primary tasks:

1. Deploy Dtag2 and Dtag3 loggers on Northern bottlenose whales (*Hyperoodon ampullatus*) using suction cups with remote launching device (ARTS), taking a biopsy sample of the same whale during, or immediately after tag deployment. Photo-identify the tagged whale using photogrammetry.

2. Collect CTD profiles using a Valeport Mini-CTD to measure water density in the study area. Attempts should be made to lower the system to 600m on a line close to areas where tags are deployed, and near the acoustic buoy.

3. Observe tagged whales for presence or absence of calf.

4. Deploy SPLASH-10 satellite tags on northern bottlenose whales.

5. Deploy and re-deploy 2 EARS bottom-mounted buoys.

Secondary tasks:
1. Tag and conduct observations of 3S target species, including sperm, killer, long-finned pilot, humpback, and minke whales as well as blue whales (in Icelandic waters only). Biopsy samples can be taken in association with tag deployment on these species. Photo-identify the tagged whale using photogrammetry.

2. Collect sightings, photographs, and acoustic recordings of target species and other cetaceans encountered.

3. Take overhead and laser photogrammetry images of tagged whales and associated calves.

4. Conduct playback of killer whale sounds to bottlenose or pilot whales.

OPERATION AREA

The primary operating area was in the waters near Jan Mayen, but we did sight several bottlenose whales between Jan Mayen and Iceland (Fig. 1). Additionally, we worked during the final day of the research trial with coastal baleen whales in Skjálfandi Bay off Husavik, Iceland.

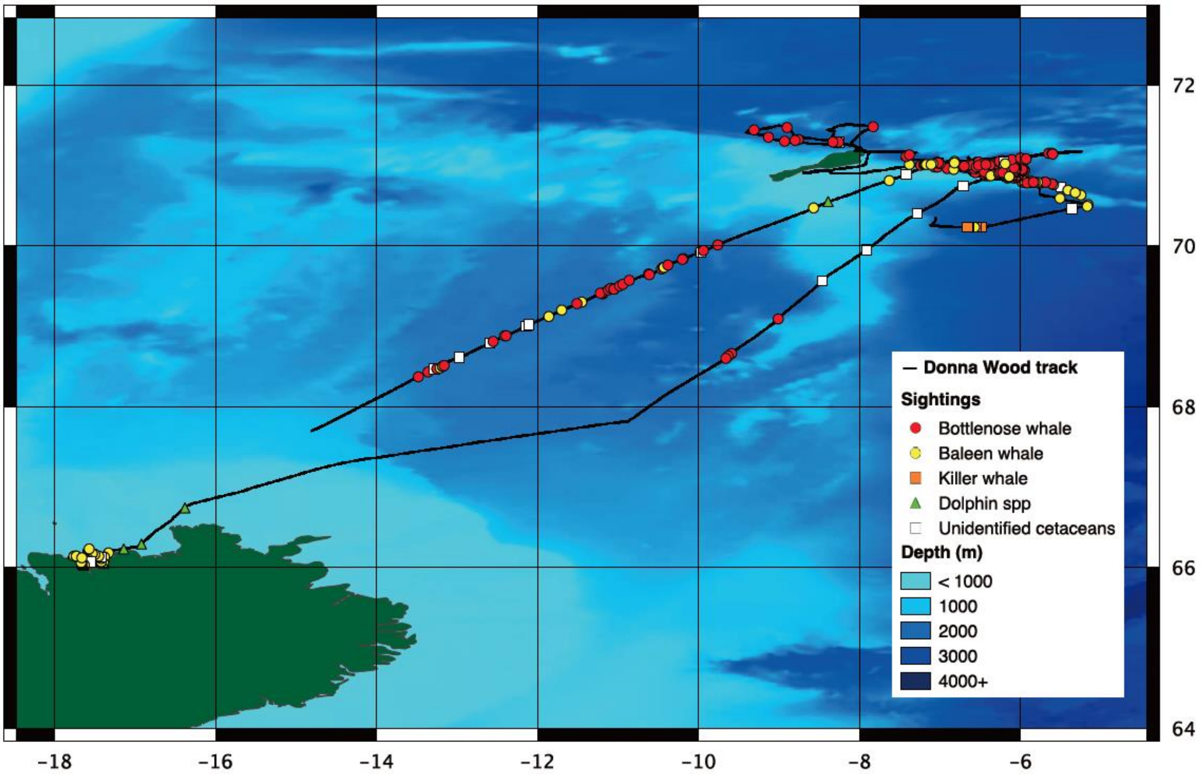

Figure 1. Map of study area with vessel track and species sightings overlaid. Missing vessel track intervals indicate unfavorable weather condition when we had no sightings effort.

EQUIPMENT AND PROCEDURES

Sailing Vessel Donna Wood

The 32m sailing boat Donna Wood (Fig. 2) was the base of operations and home to the crew for the entire period. Tagging was conducted from the deck of the sailboat using the ARTS system, and from the bowsprit using a hand-pole. VHF tracking antennas and the overhead camera were mounted near the top of the fore-sail.

 

Figure 2. Left: Sailing vessel Donna Wood at sea. Note the long bow-sprit from which tags were attached using a hand-pole. Right: using a crane to mount VHF antennas on top of the 25m high foremast. Two downward looking video cameras were also placed near the antennae.

Biologging research to study diving behaviour

This study made use of version-2 and version-3 Dtags provided by the Woods Hole Oceanographic Institution, and SPLASH10 satellite tags provided by Wildlife Computers (Table I).

Table I. Details of the three types of animal-attached tags used in the cruise.

Tag type	VHF range	Tagging method	Recording parameters
Dtag 2, WHOI	148 MHz	ARTS	Depth, temperature, 3-axis magnetism, 3-axis accelerations, audio (192 kHz)
Dtag 3, WHOI	219 MHz	ARTS/pole	Depth, temperature, 3-axis magnetism, 3-axis accelerations, audio (220 kHz)
SPLASH10 (Wildlife computers)	N/A	Dan Inject	Satellite (ARGOS) up-linked positions and diving data

Version-2 Dtags have been successfully deployed using the ARTS tagging system since 2008 and were used again successfully in this trial (Fig. 3, left). As there are very few remaining version-2 Dtag units, we also deployed version-3 Dtags using the ARTS system. We identified the large bow-sprit of the vessel *Donna Wood* as a location with potential to tag whales using a 4-section handpole. Three version-3 Dtags were deployed using the handpole from this location (Fig. 3, right).

Figure 3. Left: Tagging attempt of a Dtag 2 on a Northern bottlenose whale using the ARTS launching system. The blue arrow points to the customized biopsy collection system attached to the ARTS carrier. Right: Tagging attempt of a Dtag 3 on a Northern bottlenose whale using the tag pole from the bowsprit.

Tagging systems

The ARTS (Aerial Rocket Tag System) is a pneumatic launcher system used for suction-cup tagging, as well as collecting biopsy samples using the LKDart. Additionally, a custom tag carrier (‘LKRBC’) was used in order to collect biopsy samples simultaneous with tag deployments.

The pole tagging system is a carbon fibre rod, using multiple sections, enabling tagging on close and semi close range animals. We used poles with 4 sections (~7m length) to tag from the bow-sprit of the research vessel.

VHF tracking systems

In addition to visual tracking, we used the processing radio direction finder, the DFHorten unit. The DFHorten is automatic direction finder device, which is connected to an array of 4 Yagi antennas in 4 different directions and further connected to a radio receiver. In addition to supporting visual tracking, the advantage of using the DFHorten becomes evident when the tagged whale is out of visual contact, in poor weather conditions, or even when it is dark. Additionally it is helpful to recovery floating tags.

Biopsy sampling systems

During ARTS tagging, biopsy samples were collected using the LKRBC custom biopsy collection system integrated into the ARTS launching system (Figure 2, left). Biopsy samples were also collected using LKDarts deployed from the ARTS launching system. For all systems, 60mm standard Finn-Larsen biopsy tips were used.

Photo-ID and photogrammetry systems

Digital cameras were used to take photographs of study animals. Photographs of dorsal fins were taken for identification, and photographs were taken during tagging and biopsy operations. One camera was equipped with a laser-dot system with two dots separated by 10cm to provide a reference indicator of the size animals.

Searching and line-transect survey

Visual sighting of Northern bottlenose whales and other cetaceans were collected from the deck of the operation vessel *Donna Wood* whenever weather conditions permitted. All sighting information was recorded using geo-referenced Logger software, provided by the International Fund for Animal Welfare.

CTD measurements

CTD profiles were measured near the acoustic buoy locations and tag retrieval locations using a 1.8 kg Valeport Mini-CTD probe.

Acoustic buoys

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. We sampled at 144kHz using X3 lossless compression. A 256Gb SD card enables us to sample 1 min of data every 5 min for the 28 day trial. For the 11-12 month deployments, we will record one minute of data every 30 minutes.

Overhead video clips

Overhead video recordings were made by two IR 37CSHR-IR 25m [Sony] cameras placed below the VHF antennas at the top of the main mast, recording onto a Samsung SRD-470DP 4 Channel CCTV DVR DVD Player Recorder With 2000GB 2TB HDD.

Sound playback system

Sounds were played from a Lubell LL9642T underwater loudspeaker driven by a Cadence Z8000 car-stereo amplifier. Monitoring of the playback was done using an HTI hydrophone, which was later calibrated at TNO.

CHRONOLOGICAL SUMMARY

05 June 2015

Science crews arrived in Husavik, installed gear and tested all systems

06 – 10 June 2015

Installed gear, set up the boat, tested all systems, target practice shooting.

10 June 2015

13:37 *Donna Wood* departed Husavik for test run
15:42 Returned to Husavik – end of test run

13 June 2015
20:36 *Donna Wood* departed Husavik to Jan Mayen.
No effort due to poor weather condition

15 June 2015
03:04 First sighting of bottlenose whales in transit to Jan Mayen.
18:35 Passed the border – entered Norwegian water

16 June 2015
11:00 Arrived near Jan Mayen
22:41 1st acoustic buoy (NIOZ) deployed at 71°01.917'N, 07°01.655'W

17 June 2015
03:13 2nd acoustic buoy (TNO) deployed at 70°51.026'N, 06°08.269'W
Started research on Northern bottlenose whales

20 June 2015
11:27 First Dtag deployment. Playback experiment conducted.
22:03 CTD conducted

21 June 2015
11:45 Fuel refilled from the supply ship (Seaworks; Fig. 4)

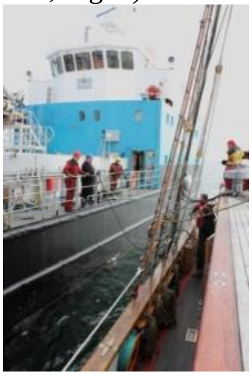

Figure 4. SEAWORKS vessel Moursund supplying Donna Wood with diesel fuel.

12:30 Resumed search phase. Spotted killer whales with minke whale carcass (Fig. 5).

Figure 5. An adult male killer whale handling a minke whale carcass inside northern bottlenose whale core habitat near Jan Mayen.

22 June 2015
All day Good weather, many encounters
13:52: Dtag 2 deployed using ARTS
14:45 SPLASH-10 satellite tag deployed using Daninject system
15:59 SPLASH-10 satellite tag deployed using Daninject system
17:27 Dtag 3 deployed using ARTS
20:28 Dtag 2 deployed using ARTS (no data was recorded)

23 June 2015
07:29 Dtag2 deployed using ARTS

08:34 Dtag3 deployed using hand pole from bow-sprit
20:42: SPLASH-10 satellite tag deployed using Daninject system

24 June 2015

02:47 CTD cast collected
Time? SPLASH-10 tagged whale was resighted in a group, approached boat

25 June 2015

Searched canyon NW of Jan Mayen. Several sighting of mother-calf pairs
20:07 Poor weather, moved to Jan Mayen Island

26 June 2015

Anchored at Jan Mayen Island due to poor weather. Visited Jan Mayen Station.

27 June 2015

Transit to the canyon NE of Jan Mayen. No effort due to poor weather.

28 June 2015

02:00 Weather condition improved. Started searching.
16:20 Dtag3 deployed from bow-sprit, detached early
21:45 Dtag3 deployed from bow-sprit, good tracking

29 June 2015

02:48 played control sound for killer whale playback, strong response
DFHorten direction measured at 4-6km estimated range. Refound whales
13:00 Recovered Dtag3 with data from sound playback
14:15 CTD measurement taken
19:32 1st acoustic buoy recovered. Data downloaded
20:03 CTD measurement

30 June 2015

Many minke whale sightings, some close to boat
23:02 Acoustic buoy re-deployed at 71°02.003'N, 07°01.981'W

01 July 2015

03:00 Departed Jan Mayen in worsening weather conditions
23:10 Passed the border – entered Icelandic water, rough conditions

02 July 2015

Some bottlenose whales sighted in rough conditions

03 July 2015

19:00 Arrived Husavik, went through customs
21:15 Departed Husavik, research on baleen whales in Skjálfandi Bay
23:25 Dtag2 attached to blue whale

04 July 2015

00:38 Dtag2 attached to humpback whale
06:14 Recovered blue whale tag, conducted CTD measurement
15:00 Recovered humpback tag, conducted CTD measurement
16:34 Arrived Husavik. End effort.

05 July 2015

Packed equipment for shipping, data backup

06 July 2015

Science crews departed from *Donna Wood*

DATA COLLECTED

Animal-attached tag data for Northern bottlenose whales

Archival-recording Dtag version 2 and version 3 were attached to four and five individual animals, respectively, but we could not download data from one Dtag 2 deployment (Table II; Figs. 6, 7). A total of six Dtag deployments (four Dtag 2 and two Dtag 3) were accomplished using the ARTS system from the deck of the *Donna Wood*. The tag carrier for the ARTS system contained a custom biopsy sample collection system ('LKRBC'), and samples were collected from four of the six tag deployments. Three Dtag 3 deployments were accomplished using the tag pole from the bowsprit of the *Donna Wood*. Biopsy sampling was attempted using LKDarts during tagging, but was not successful. We also made every effort, using LKDarts, to obtain a biopsy sample from the tagged whales for which biopsy sample were not collected by the tagging system. However, we could not collect any biopsy sample for any of the tagged whales after tags were attached.

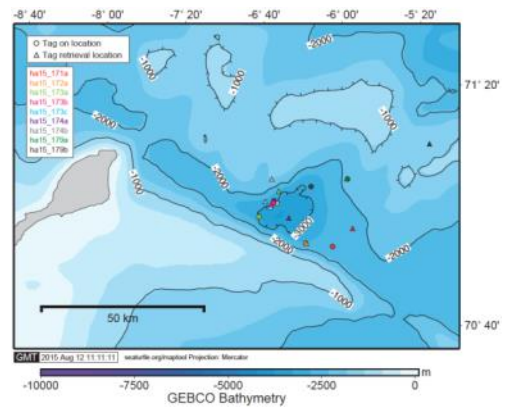

Figure 6. Location of Dtag deployment and recovery locations. Note that we only managed to tag whales near a deep water canyon SE of Jan Mayen.

Table II. Details of the Dtag deployments on northern bottlenose whales.

Dataset / sighting #	Tag on time (UTC)	Tag on location	Dur. (h)	Method	Tag type	Biopsy	reaction	Notes
ha15_171a (# 125)	20 Jun, 11:27	70°53.217'N, 06°04.885'W	4.7	ARTS	Dtag 2 (#242)	N	1	Playback (Sonar control, KW). Some audio data lost
ha15_172a (#165)	21 Jun, 17:37	70°53.817'N, 06°18.718'W	0.01	ARTS	Dtag 3 (D122)	Y	1	Skin sample
ha15_173a (#183)	22 Jun, 13:52	70°58.215'N, 06°42.605'W	8.9	ARTS	Dtag 2 (#245)	Y	1	
ha15_173b (#189)	22 Jun, 17:27	71°00.561'N, 06°35.057'W	1.2	ARTS	Dtag 3 (D122)	N	1	
ha15_173c (#191)	22 Jun, 20:28	70°59.801'N, 06°36.715'W	-	ARTS	Dtag 2 (#243)	Y	1	No data recorded
ha15_174a (#203)	23 Jun, 07:29	71°00.909'N, 06°34.804'W	11.6	ARTS	Dtag 2 (#246)	Y	1	
ha15_174b (#204)	23 Jun, 08:34	71°00.536'N, 06°33.491'W	12.9	Pole	Dtag 3 (D122)	N	2	
ha15_179a (#248)	28 Jun, 16:20	71°04.488'N, 05°57.132'W	0.4	Pole	Dtag 3 (D142)	N	2	
ha15_179b (#254)	28 Jun, 21:45	71°03.275'N, 06°15.958'W	14.4	Pole	Dtag 3 (D122)	N	2	Playback (Sonar control)

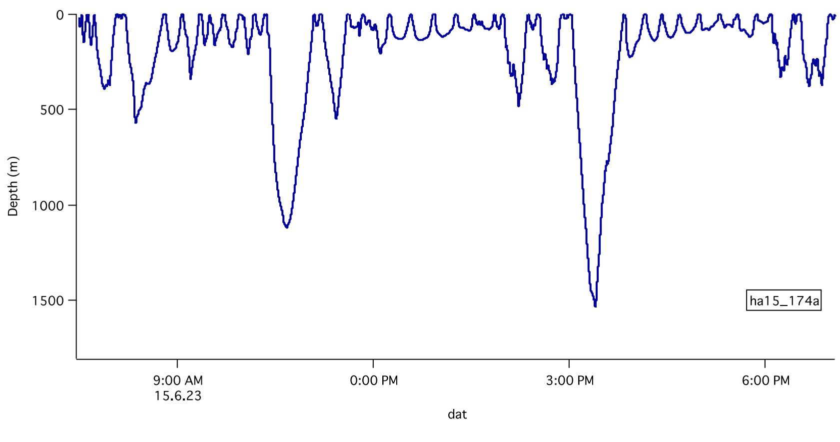

Figure 7. Example dive record of a Northern bottlenose whale tagged off Jan Mayen (Ha15_174a).

SPLASH tags on Northern bottlenose whales

A total of three SPLASH10-292B limpet tags were deployed on different Northern bottlenose whales using the Dan Inject system (Table III, Figure 8a). A key improvement from the 2014 trial was achieving tag placements on the dorsal fin, or ridge, prompting longer attachment periods and increased time above water for the tags to accomplish data transmissions, thereby increasing the quantity and quality of received Argos locations and dive data (Figure 8b). The large scale movements of the three tagged whales demonstrated two distinct movement patterns, possibly indicating a switch in behavioral states from a period of concentrated foraging to southern migration. Initially whales were roaming around the deep-sea canyon complex northeast of Jan Mayen and the animal tracks display a non-directed pattern potentially indicative of prey search. Conversely, the subsequent movements away from Jan Mayen, and up until the final location fixes, were highly directed on a southern course for all three animals. The fact that one whale reached all the way to the Azores Archipelago (<3740 km in 38 days), represents a first confirmation of the linkage between animals in southern latitudes and the Jan Mayen habitat (Figure 8c).

Table III Deployments of SPLASH tags on Northern bottlenose whales

Serial No	Argos PTT	Tag on time (UTC)	Tag on location	Reaction	No of fixes	Last fix date	Tag position	Duration
15A0180	134670	22 June, 14:45	70°59.156’N, 06°40.416’W	1	573	04 August	Dorsal fin	41d 21h
15A0178	134669	22 June, 15:59	70°57.388’N, 06°45.571’W	1	162	02 July	Dorsal fin / ridge	8d 16h
13A0775	134668	23 June, 20:42	70°59.140’N, 06°33.914’W	1	573	21 July	Dorsal fin	26d 19h

Figure 8a. Deployment of SPLASH10 tags on the dorsal fin of a northern bottlenose whale (PTT 134668).

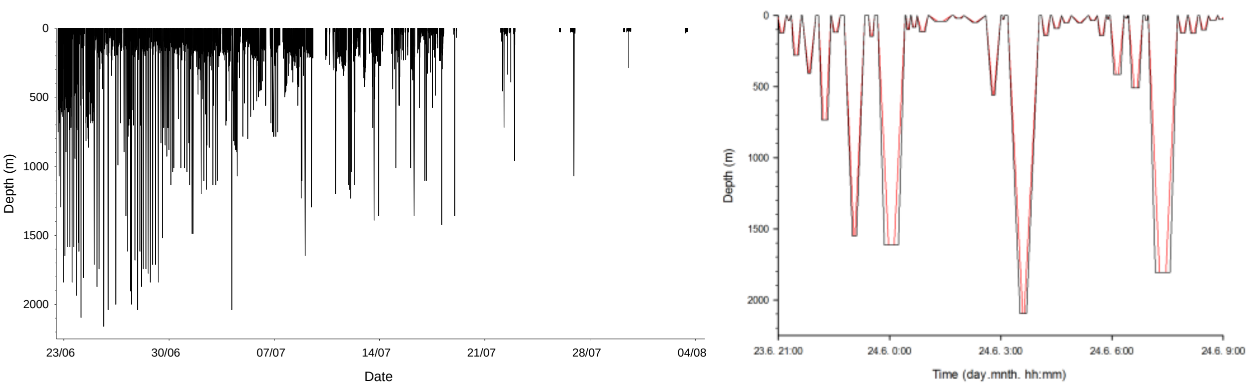

Figure 8b. Example of dive record for northern bottlenose whale acquired with the Behavior Log (BL) function of SPLASH10 tags. Left: The comprehensive dive record for the 42 days long deployment, PTT 134667, is shown in the left-hand plot. Right-: dive record for a 12 hours period illustrating the three general dive shapes provided by BL, i.e. V, U and square. (Dive shapes are classified according to the duration of bottom times, i.e. any depth reading >=80% of the maximum depth reading for the dive). Illustrations of dive profiles vary according to the bottom time applied; ranging from a maximal (black) to a minimal possible bottom time.

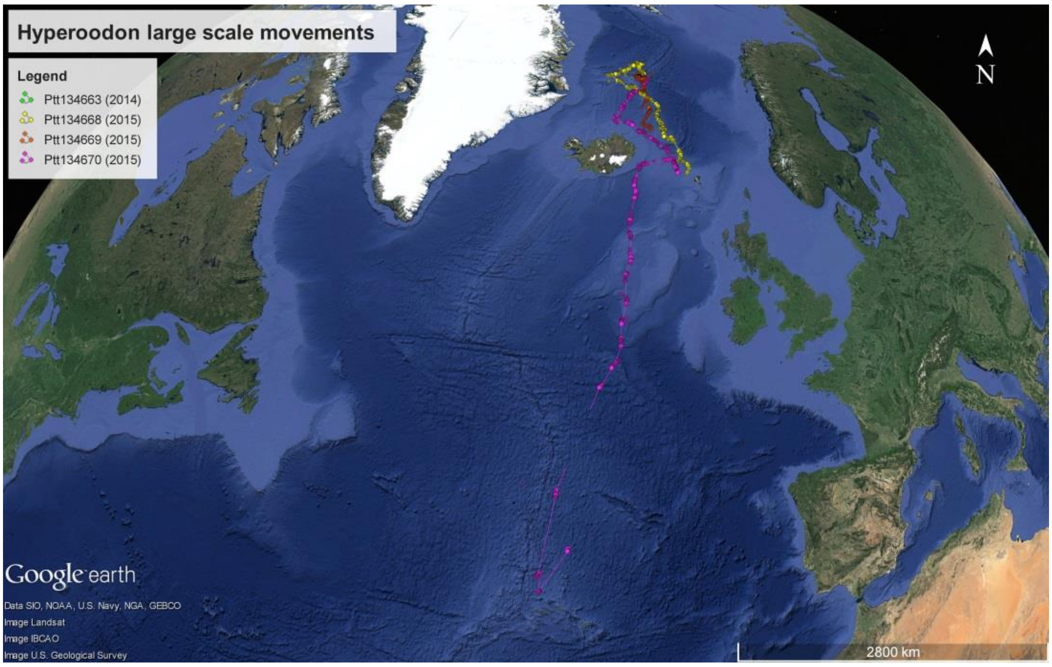

Figure 8c. Large-scale movements of northern bottlenose whales. All three tagged whales moved south from Jan Mayen. The yellow track is PTT 134668, the blue track is PTT 134669, and the red track is PTT 134670. Note that the animal with PTT 134760 was tracked moving to the Azores Archipelago.

Biopsy samples

A total of five biopsy samples were collected from Northern bottlenose whales, one from a humpback whale and one from a blue whale (Table IV). Four of the five Northern bottlenose whale biopsies were collected as the tag was attached using the LKRBC, while the other one consisted of a skin sample from the dorsal surface collected as the tag carrier missed the animal, but briefly made contact with it. All individuals showed a low level reaction to tagging and biopsy operations. Samples were all taken anterior to the dorsal fin, along the dorsal part of the body, but with variation between specific sites (Figure. 9)

Table IV Summary of biopsy samples collected during the Jan Mayen trial.

Sample Number	Species	Date	Skin Thickness (mm)	Blubber Thickness (mm)	Tag ID	Age Class	Reaction Category
LK-Ha-01	Ha	15/06/15	2-5	0	NA	Adult	1
LK-Ha-02	Ha	21/06/15	2	5	Dtag3 D122	Adult	1
LK-Ha-03	Ha	22/06/15	2	33	Dtag 245	Adult	1
LK-Ha-04	Ha	22/06/15	2	25	Dtag 243	Adult	1
SI-Ha-05	Ha	23/06/15	2	10	Dtag 245	Adult	1
LK-Bm-01	Bm	03/07/15	3	37	Dtag 245	Adult	1
RH-Mn-01	Mn	04/07/15	14-18	20-32	Dtag 246	Adult	1

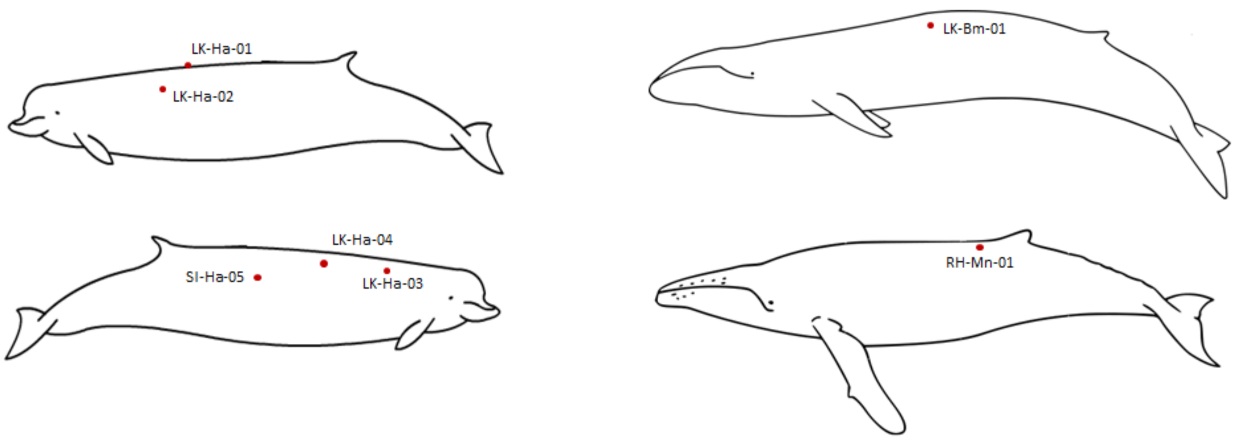

Figure 9. Northern bottlenose whale biopsy sampling sites with associated sample numbers (left), and blue whale and humpback whale biopsy sampling sites with associated sample numbers (right).

CTD measurements

A total of four casts were made with Valeport CTD off Jan Mayen (Table V, Fig. 10). Two casts were made in Skjálfandi Bay, Iceland after tagging study on baleen whales (Fig. 11).

Table V. Conductivity and temperature casts made during the trial.

CTD No	Date	Start time	Start location	End time	End location	Notes
1	20 Jun	22:03	70°56.019’N, 05°54.259’W	22:38	70°56.038’N, 05°54.135’W	After retrieving ha15_171a
2	24 Jun	02:47	71°03.034’N, 06°38.411’W	03:06	71°02.972’N, 06°38.743’W	After retrieving ha15_174b
3	29 Jun	14:15	71°10.175’N, 05°17.925’W	14:29	71°10.175’N, 05°17.925’W	After retrieving ha15_179b
4	29 Jun	20:03	71°01.726’N, 07°01.866’W	10:46	71°01.726’N, 07°01.866’W	3rd Acoustic buoy (NIOZ) location
5	04 Jul	06:14	66°12.506’N, 17°38.148’W	06:39	66°12.506’N, 17°38.148’W	In Skjálfandi Bay, after retrieving bm15_184a
6	04 Jul	15:34	66°02.374’N, 17°26.691’W	15:41	66°02.357’N, 17°26.687’W	In Skjálfandi Bay, after retrieving mn15_185a

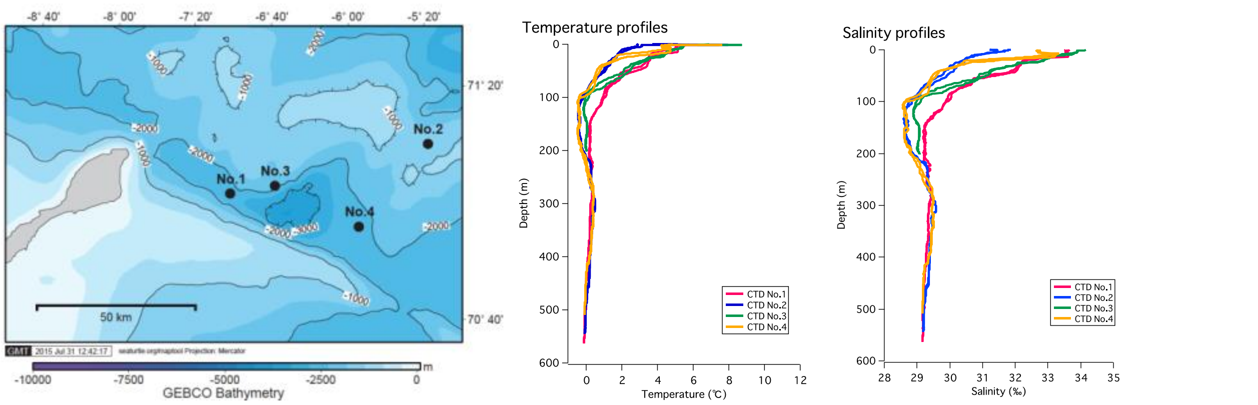

Figure 10. Location of CTD casts near Jan Mayen (left) and downcast and upcast temperature (middle) and salinity (right) profiles.

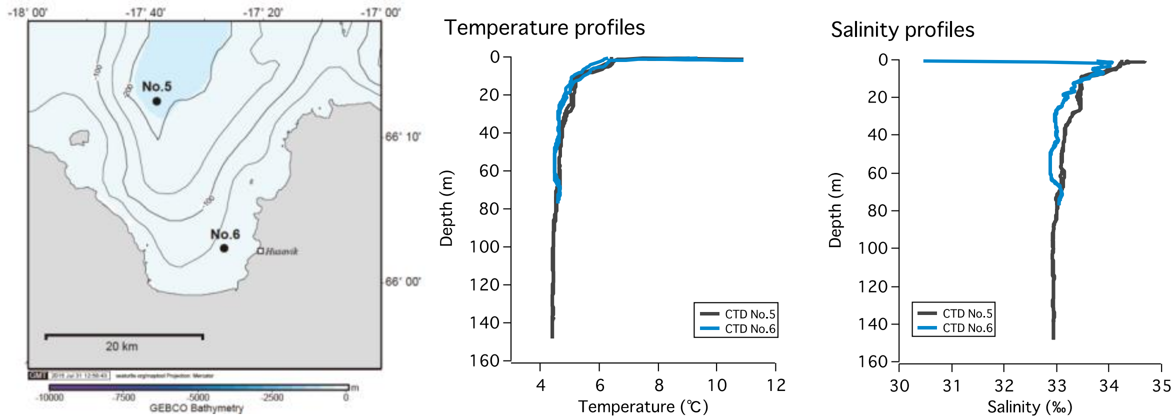

Figure 11. Location of CTD casts in Skjálfandi Bay near Husavik (left) and downcast and upcast temperature (middle) and salinity (right) profiles.

Photo Identification and photogrammetry images

A total of 14,231 photo-ID images were taken (Table VI), roughly half using photogrammetry camera outfitted with green laser dots spaced 10 cm apart.

Overhead video clips

Overhead video recordings were made during tagging and biopsy operations on most days (Fig. 12, Table VII). In many cases, the entire body of whales could be seen (e.g. Fig 12), but we recommend adjusting the pointing angle of the cameras to more effectively observe water somewhat further away from the vessel.

Figure 12. Image of whale taken from the overhead photogrammetry system.

Table VI. Number of photos taken by date.

Date	Time	No of photos	Notes
15 Jun	02:00 – 12:00	10	Transit toward Jan Mayen
15 Jun	12:00 – 22:00	361	Transit toward Jan Mayen
16 Jun	02:00 – 12:00	246	Transit toward Jan Mayen
16 Jun	12:00 – 23:00	0	Acoustic buoy deployment
17 Jun	02:00 – 12:00	45	
17-18 Jun	12:00 – 01:00	229	
18 Jun	02:00 – 12:00	351	
18-19 Jun	12:00 – 02:00	256	
19 Jun	02:00 – 12:00	0	
19 Jun	12:00 – 22:00	1393	Photos of killer whales
20 Jun	02:00 – 12:00	869	
20-21 Jun	12:00 – 02:00	375	
21 Jun	02:00 – 12:00	1209	
21 Jun	12:00 – 00:00	956	Photos of killer whales feeding on a minke whale
22 Jun	02:00 – 12:00	1109	
22-23 Jun	12:00 – 02:00	2492	
23 Jun	02:00 – 12:00	1090	
23-24 Jun	12:00 – 02:00	997	
24 Jun	02:00 – 12:00	103	
24-25 Jun	12:00 – 02:00	96	
25 Jun	02:00 – 12:00	0	
25 Jun	12:00 – 22:00	0	
26 Jun		0	Anchored at Jan Mayen due to poor weather; no effort.
27 Jun	02:00 – 12:00	0	Poor weather
27-28 Jun	12:00 – 02:00	0	
28 Jun	02:00 – 12:00	30	
28-29 Jun	12:00 – 02:00	432	
29 Jun	02:00 – 12:00	0	
29-30 Jun	12:00 – 02:00	0	
30 Jun	02:00 – 12:00	594	
30 Jun – 01 Jul	12:00 – 02:00	55	
01 Jul	02:00 – 12:00	0	Transit toward Iceland
01 Jul	12:00 – 22:00	54	Transit toward Iceland
02 Jul	02:00 – 12:00	136	Transit toward Iceland
02 Jul	12:00 – 22:00	0	Transit toward Iceland
03 Jul	04:00 – 12:00	0	Transit toward Iceland
03-04 Jul	21:00 – 02:00	734	Photos of blue and humpback whales in Skjálfandi Bay
04 Jul	02:00 – 12:00	9	Photos of humpback whales and dolphins in Skjálfandi Bay

Table VII. Duration of video clips recorded by date

Date	Start time	End time	Animals approached/Obs	filename (port cam)	filename (starboard cam)
17-Jun	05:06	06:11	N	17250100	17250200
17-Jun	08:09	08:30	N	17250101	17250201
17-Jun	08:45	09:03	N	17250102	17250202
17-Jun	14:34	15:27	N	17250103	17250203
17-Jun	18:11	18:53	N	17250104	17250204

17-Jun	19:58	20:23	N	17250105	17250205
17-Jun	20:41	20:50	N	17250106	17250206
17-Jun	21:03	21:26	N	17250107	17250207
17-Jun	23:01	23:06	N	17250108	17250208
17-Jun	23:12	23:14	N	17250109	17250209
17-Jun	23:53	00:16	N	17250110	17250210
18-Jun	00:38	00:45	N	17250111	17250211
18-Jun	01:50	02:30	N	17250112	17250212
18-Jun	02:38	02:53	N	17250113	17250213
18-Jun	03:31	05:02	N	17250114	17250214
18-Jun	05:10	05:20	N	17250115	17250215
18-Jun	05:31	06:01	Y	17250116	17250216
18-Jun	06:48	07:23	Y	17250117	17250217
18-Jun	07:26	08:11	N	17250118	17250218
18-Jun	13:33	14:13	target practice	17250119	17250219
18-Jun	15:54	16:06	N	17250120	17250220
18-Jun	17:15	17:30	Y (port 17:19:50)	17250121	17250221
18-Jun	17:30	17:34	N	17250122	17250222
18-Jun	18:53	19:12	Y (starboard 19:10:55)	17250123	17250223
18-Jun	19:35	19:41	N	17250124	17250224
18-Jun	19:54	20:01	N	17250125	17250225
18-Jun	20:44	20:50	N	17250126	17250226
18-Jun	21:02	21:06	N	17250127	17250227
18-Jun	23:23	23:30	N	17250128	17250228
19-Jun	13:15	14:21	killer whales	17250129	17250229
20-Jun	03:07	04:42	N	17250130	17250230
20-Jun	04:42	05:21	N	17250131	17250231
20-Jun	06:03	06:54	N	17250132	17250232
20-Jun	06:59	07:16	N	17250133	17250233
20-Jun	07:20	07:44	N	17250134	17250234
20-Jun	09:39	09:55	N	17250135	17250235
20-Jun	10:57	12:41	Y (starboard 11:27:20)	17250136	17250236
20-Jun	12:30	12:41	N	17250137	17250237
20-Jun	12:53	13:03	N	17250138	17250238
20-Jun	13:53	14:16	N	17250139	17250239
20-Jun	18:51	19:30	Y	17250140	17250240
20-Jun	20:35	20:51	N	17250141	17250241
20-Jun	20:56	21:20	N	17250142	17250242
21-Jun	01:25	01:28	N (out of frame - splash-tag)	17250143	17250243
21-Jun	03:59	04:51	Y	17250144	17250244
21-Jun	05:18	05:39		17250145	17250245
21-Jun	05:56	06:08		17250146	17250246
21-Jun	06:34	07:20	Y (starboard 07:00:10)	17250147	17250247
21-Jun	08:26	08:50	N	17250148	17250248
21-Jun	08:54	09:25	Y (09:18)	17250149	17250249
21-Jun	14:50	14:53	N	17250150	17250250

21-Jun	15:17	15:26	N	17250151	17250251
21-Jun	17:00	17:03	N	17250152	17250252
21-Jun	19:04	19:09	N	17250153	17250253
21-Jun	19:15	19:19	N	17250154	17250254
21-Jun	21:22	21:34	N	17250155	17250255
21-Jun	22:03	23:36	killer whales	17250156	17250256
21-Jun	23:36	00:04	killer whales	17250157	17250257
22-Jun	08:32	09:00	N	17250158	17250258
22-Jun	10:32	11:31	Y (11:11)	17250159	17250259
22-Jun	12:34	13:27	N	17250160	17250260
22-Jun	13:28	14:00	Y (13:52 - Dtag 2)	17250161	17250261
22-Jun	14:37	15:01	Y (14:45 - splash-tag)	17250162	17250262
22-Jun	15:11	15:29	N	17250163	17250263
22-Jun	15:36	17:07	not logged	17250164	17250264
22-Jun	17:10	18:43	Y	17250165	17250265
22-Jun	18:44	19:07	Y	17250166	17250266
22-Jun	19:19	19:41	N	17250167	17250267
22-Jun	20:20	21:53	not logged	17250168	17250268
22-Jun	21:53	23:08	not logged	17250169	17250269
22-Jun	23:09	23:11	not logged	17250170	17250270
23-Jun	00:54	01:20	not logged	17250171	17250271
23-Jun	01:54	02:43	Y	17250172	17250272
23-Jun	03:03	03:34	N	17250173	17250273
23-Jun	03:49	04:27	Y	17250174	17250274
23-Jun	04:36	05:06	Y	17250175	17250275
23-Jun	05:21	06:07	Y	17250176	17250276
23-Jun	06:21	06:34	Y (starboard 06:25:30)	17250177	17250277
23-Jun	06:50	06:54	N	17250178	17250278
23-Jun	06:56	07:02	N	17250179	17250279
23-Jun	07:15	07:57	Y (tag 07:25)	17250180	17250280
23-Jun	08:03	08:41	Y (tag ~08:37)	17250181	17250281
23-Jun	11:37	12:04	Y	17250182	17250282
23-Jun	20:04	21:03	Y (splash-tag miss)	17250183	17250283
23-Jun	23:57	02:39	Y	17250184	17250284
24-Jun	01:30	02:39	not logged	17250185	17250285
24-Jun	04:31	04:44	N	17250186	17250286
24-Jun	06:01	06:05	N	17250187	17250287
24-Jun	08:38	08:53	N	17250188	17250288
24-Jun	15:09	15:19	N	17250189	17250289
24-Jun	16:08	17:42	Y (calf?)	17250190	17250290
24-Jun	17:42	19:13	Y (calf?)	17250191	17250291
24-Jun	20:47	22:21	N	17250192	17250292
24-Jun	22:21	22:31	N	17250193	17250293
25-Jun	04:16	05:07	N	17250194	17250294
25-Jun	07:03	07:29	N	17250195	17250295
28-Jun	04:49	04:53	N	04490100	04490200

28-Jun	10:57	11:39	N	04490101	04490201
28-Jun	13:33	14:42	N	04490102	04490202
28-Jun	16:11	17:09	Y (Dtag 3)	04490103	04490203
28-Jun	17:24	17:40	N	04490104	04490204
28-Jun	17:44	17:55	N	04490105	04490205
28-Jun	19:30	19:53	N	04490106	04490206
28-Jun	20:23	20:50	not logged	04490107	04490207
28-Jun	21:38	22:46	Y	04490108	04490208
30-Jun	03:39	04:14	N	04490109	04490209
30-Jun	06:34	06:52	N	04490110	04490210
30-Jun	07:07	07:12	N	04490111	04490211
30-Jun	15:27	21:25	Y	not recording/no file	not recording/no file
03-Jul	10:09	not logged		not recording/no file	not recording/no file
04-Jul	10:32	not logged		not recording/no file	not recording/no file

Acoustic buoy deployments

Both acoustic buoys were successfully deployed upon arrival at Jan Mayen on 16 and 17 June (Table VIII, Fig. 13). The SMRU buoy which had been deployed on 16 June was received on 29 June. From 16-29 June, sound was continuously recorded at 144 kHz. After the data were downloaded and battery changed, the buoy was redeployed (using the same acoustic release system) in a location very near the first buoy deployment. Acoustic data from the buoy have been inspected, and found to be of high sound quality. Many instances of occurrence of clicks thought to be from bottlenose whales have been detected in the initial inspections of the data (Figure 14).

Table VIII. 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

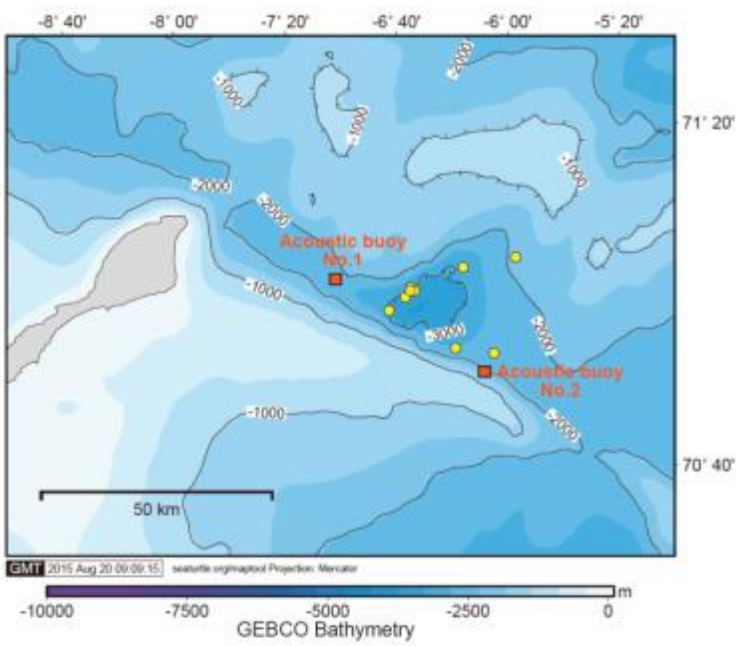

Figure 13. Acoustic buoy locations. Tag on locations (yellow dots) are overlaid as a reference.

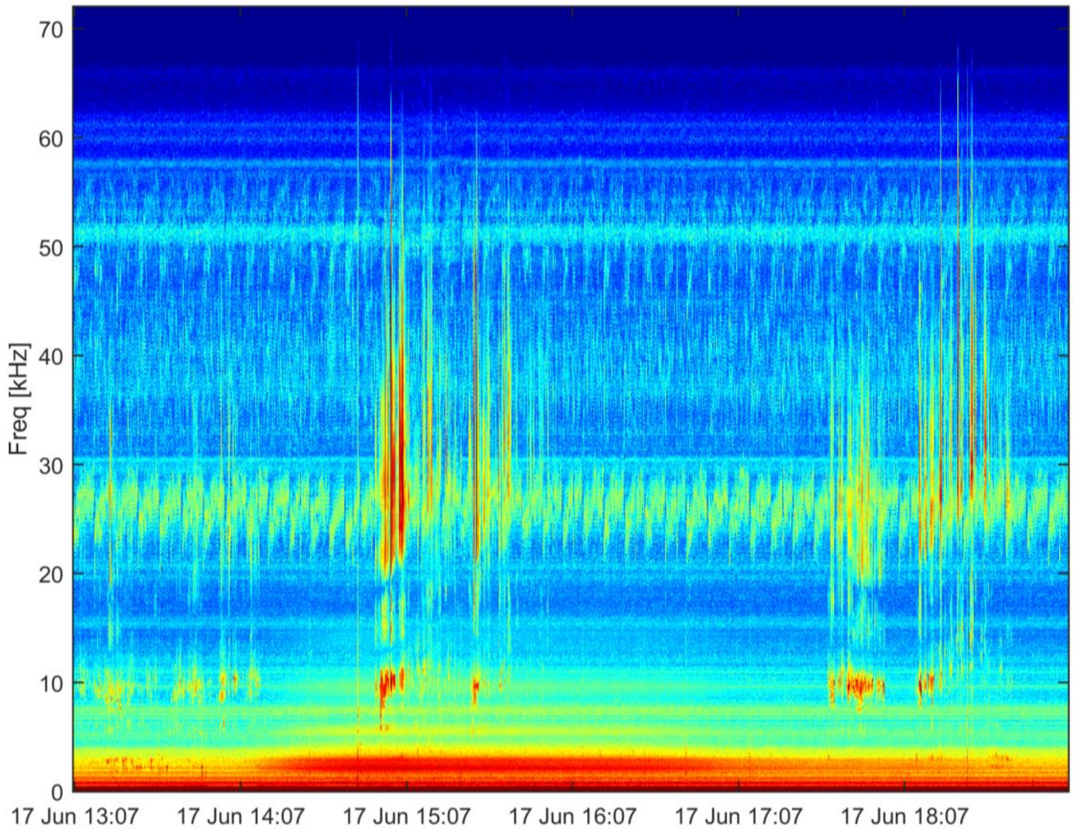

Figure 14. Spectrogram of likely bottlenose whales click series recording on the acoustic buoy. Spectrogram Y-axis is 0-72 kHz, and time X-axis is from 17 June 13:22 to 17 June 18:37.

Playback experiments

Two sets of playback experiments, consisting of three total playbacks were conducted with Northern bottlenose whales (Table IX). In the first experiment, tagged whale ha15_171a was first exposed to a sequence of 1-2 kHz sonar signals. Due to battery failure, the amplifier did not operate during that playback, and we estimate a rather low transmission source level for those signals. The second playback was of mammal-feeding killer whale sounds, during which the amplifier worked as normal. Tracking data indicated the tagged whale and its group moved away from the source boat position, though they were resighted later moving back toward the playback location. Unfortunately, Dtag audio recording stopped just prior to the start of the killer whale playback. Sensor data was recorded, but the file was corrupted, and has not been extractable to date.

Table IX Summary of playback experiments.

Date	Tag ID	1st exposure stimulus	1st stimulus observations	2nd exposure stimulus	2nd stimulus observations
20 Jun	ha15_171a	Sonar (110-120 dB re 1µPam source level) 15:13 – 15:27	- 7 to 9 animals initially attracted, spending several minutes around the boat - dove synchronously high arch	KW(orca1, 150-160 dB re 1µPam source level) 16:33 – 16:48	- no whales sighted during the KW playback. Whales moved away and sighted later moving toward playback location. Dtag data corrupted, no audio.
29 Jun	ha15_179b	Sonar (165-175 dB re 1µPam source level) 02:48 – 03:02	- Animals undertook a dive - No sighting of animals during the exposure - Animals travelled fast after the exposure	N/A	N/A

Due to the problems encountered with the first playback experiment, the treatments were to have been replicated in the second playback experiment. However, the tagged whale and its group responded very strongly to the playback of the amplified 1-2 kHz control sounds. The whale was not resighted during the playback period, but very faint VHF signals were detected at an estimated range of 4-6 km. Based upon those directional indications, we were able to re-sight the tagged whale ~12km away from the playback location (Fig 15). The whale continued to move in the same overall direction (away from the source playback location) throughout. No clicking by the tag group was observed for 6 hr 40 min after the playback, indicating a prolonged silencing response concordant with the avoidance movements. However, clicking during deep foraging dives started again before the tag detached from the whale.

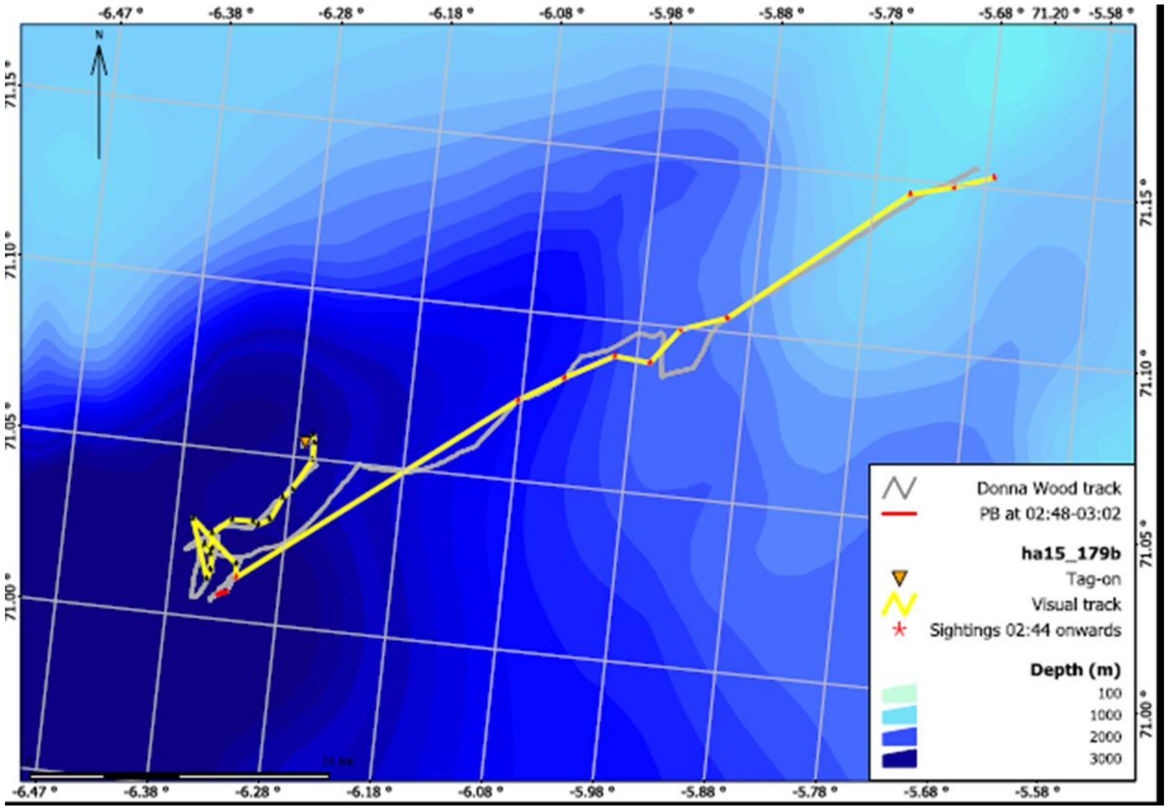

Figure. 15. Geometry of the movement of the tagged whale ha15_179b before, and after playback of 1-2 kHz sonar control signals. The whale track is shown in yellow with red symbols indicating whale sighting locations. The vessel track is shown in grey, with the vessel position during playback indicated with a red overlay. Note the strong turn (and continued movement) by the whale away from the location of the playback throughout the post-exposure period.

The behavioral response of whale ha15_179b to 1-2 kHz sonar sounds transmitted at ~300km range at a source level of 165-175 dB re 1µPa m were very similar to the response documented for whale ha13_176a (Miller et al., 2015, Royal Society Open Science 2: 140484). Similarities between the two experiments include an apparent switch from a shallow dive to a deep during the exposure period, a strong avoidance movement response that extended until the tag detached from the whale, cessation of foraging-related click sounds for over 6 hrs after the end of the exposure period, and significant changes in movement behaviour (quantified using Mahalanobis distance, Fig. 16) for a prolonged period of time after the exposure.

Though the similarities in behavioural responses between these two cases was striking, some differences were noted. Whale ha15_179b did not noted approach the sound source at the start of the playback, as was observed for whale ha13_176a, but moved away at the first ‘ping’ in the playback sequence. Another difference is that the deep dive by whale ha15_179b was neither striking long in duration nor of unusual depth, as was observed for whale ha13_176a. These differences are likely due to detailed differences in the manner in with the sound signals were presented to the whales, including lack of source level ramp-up and lower maximum source levels in the 2015 experiment.

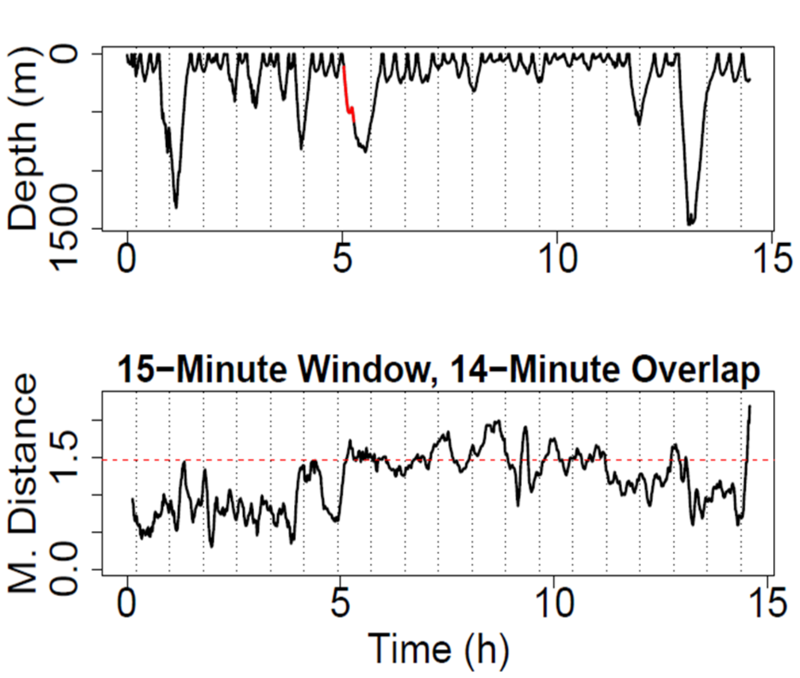

Figure. 16. Top: Dive profile of tagged whale ha15_179b. The exposure period is marked in red. Bottom: Preliminary Mahalanobis distance calculation for movement parameters, identical to the analysis reported in Miller et al., 2015, Royal Society Open Science. The 95% value during the pre-exposure period is indicated by a dashed red line. Note that Mahalanobis distance values rapidly deviated away from baseline values during the playback period, and generally remained above the 95% value range (with some dips below) for an extended period of time after the playback exposure period. Figure courtesy of S. DeRuiter, Calvin College.

Archival-recording tag data for Baleen whales in Skjálfandi Bay

On the final day of the research trial, two additional tags were attached to a blue and humpback whale in the coastal waters of Skjálfandi Bay near Husavik, Iceland (Table X. Fig. 17). Both tags were deployed by the ARTS system, with biopsy samples collected. The tag on the humpback whale slid down on the body shortly after tag deployment, and no more VHF beeps were heard. However, good tracking of the blue whale was conducted from 02:30 until the tag detached at roughly 06:00. The whale moved quite quickly around the bay during that tracking period.

Table X. Details of the Dtag deployments on baleen whales

Data name Sighting #	Species	Tag on time (local)	Tag on location	Duration (h)	Tag type	Biopsy
Bm15_184a (# 304)	Blue	03 Jul, 23:25	66°09.693'N, 17°31.508'W	6.2	Dtag 2 (#245)	Y
Mn15_185a (# 308)	Humpback	04 Jul, 00:38	66°07.126'N, 17°33.276'W	10.8	Dtag 2 (#246)	Y

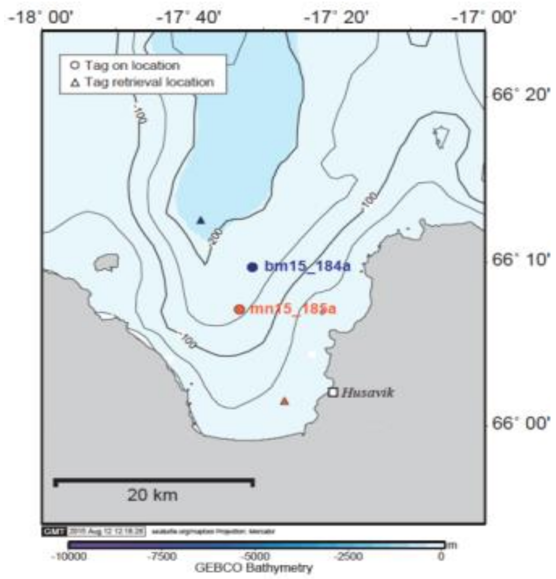

Figure 17 Tag deployment and retrieval locations in Skjálfandi Bay, Iceland.

SUMMARY OF ACCOMPLISHMENTS (RELATED TO CRUISE TASKS) AND RECOMMENDATIONS FOR FUTURE RELATED EFFORTS

Overall, the research trial was a successful effort in which all of the primary and secondary tasks were addressed, and novel data were collected.

Primary tasks:

1. Deploy Dtag2 and Dtag3 loggers on Northern bottlenose whales (*Hyperoodon ampullatus*) using suction cups with remote launching device, taking a biopsy sample of the same whale during, or immediately after tag deployment. Photo-identify the tagged whale using photogrammetry.

We were successful in deploying 9 tags on northern bottlenose whales, 6 of which collected usable data. The ARTS system was successful in attaching version-2 Dtags, following the established track record. However, one of the tags (ha15_173c) didn't record usable data, and tag ha15_171a stopped recording audio after 4hr 47 min of recording time. This meant that there was no audio recording on the Dtag during and after the killer whale playback, and sensor data were corrupted and have not been analyzable to date. Audio also stopped recording early on two other Dtag2 deployments, after 10 and 12 hours. We were able to deploy version-2 Dtags very successfully, but the tags themselves appear not to have functioned perfectly.

With version-3 Dtag, two deployments were made using the newly built Dtag3-ARTS carrier, before the carrier was lost at sea during a successful Dtag deployment. Both deployments were very short (0.01 and 1.2 hrs), indicating that the suction-cup attachments were not ideal. One version-3 Dtag had a broken antenna after a missed shot, indicating potential damage from contact of the tag with the sea surface. Three version-3 Dtags were deployed from the bowsprit using a tag-pole. One of those detached after only 0.4 hr, but the other 2 remained attached until the scheduled release time.

Based upon this result, we recommend two actions related to ARTS use with Dtags. First, there appears to be a risk that standard Dtag3 antennas can be damaged from impacts, and that missed attempts may be a risk factor. Therefore, the Dtag3-ARTS carrier should be modified to offer greater protection to the Dtag3 antenna. Second, given the poor attachment durations with version-3 Dtag versus excellent durations with version-2 Dtags with the ARTS system, we recommend that a new tag housing be produced which can carry the version-3 Dtag within a housing that more closely resembles the Dtag2 housing. The additional space provided by such a package can also be used for additional shock-absorption and an additional sensor.

Biopsy samples were collected for 4/6 tag deployment using the custom LKRBC biopsy collected attached to the ARTS carrier, but none could be collected using LKDarts when tags were deployed by pole from the bow-sprit. Despite intensive effort, we were also not able to collect biopsy samples from any tagged whale after tagging. Therefore, we recommend that the LKRBC be modified to increase the rate of biopsy samples collected when tags are deployed using the ARTS system. Additionally, we recommend that an integrated biopsy collection system be developed to collect biopsy samples when tags are deployed using hand-poles, as was possible from the bow-sprit.

2. Collect CTD profiles using a Valeport Mini-CTD to measure water density in the study area. Attempts should be made to lower the system to 600m on a line close to areas where tags are deployed, and near the acoustic buoy.

CTD casts were successfully made as needed. We recommend that a new battery should be inserted before the first use of each field season.

3. Observe tagged whales for presence or absence of calf.

This objective was also successfully accomplished, though very few calves were observed in groups which approached the vessel and were thereby available for tagging. More systematic descriptions of groups that do or do not approach the vessel would be helpful to identify whether or not any systematic sampling bias results from the inability to tag any whales other than those that are actively attracted to the tagging boat.

4. Deploy SPLASH-10 satellite tags on northern bottlenose whales.

This objective was accomplished, with 3 tag deployments providing novel information on long-distance migrations of northern bottlenose whales southward from Jan Mayen as far as the Azores. One tag was lost following a miss, and another tag was not deployed. Tag durations were longer than were achieved in 2014, so the 2015 tagging systems and procedures are recommended. One tag was successfully deployed from the work-boat (Fig. 8a), so this might be an effective platform for deploying SPLASH tags in future efforts. A second SPLASH tagger is recommended to enable 24-hr effort to attach this type of tag.

5. Deploy and re-deploy 2 EARS bottom-mounted buoys.

This objective was accomplished successfully, and will provide novel data. Analyses of sub-sampled data will explore when bottlenose whales appear to leave and return to the Jan Mayen habitat. The locations of the buoys were on both sides of the deep canyon where most successful tagging took place (Fig. 13). More detections might be made if an additional buoy were placed closer to the deepest part of the canyon.

Secondary tasks:

1. Tag and conduct observations of 3S or other target species. Photo-identify the tagged whale using photogrammetry.

We successfully tagged and collected a biopsy sample from one humpback whale and one blue whale in the coastal waters near Iceland. Humpback whales are also a target species of the SERDP body condition project, so this record will be included in that overall data-set. Though blue whales have not been a 3S target species, body condition of blue whales tagged off California has been successfully quantified in a pilot-study analysis by Dr. Tomoko Narazaki, so that data-set could be useful to contrast body density with whales tagged off California. Skin samples were provided to HAFRO, c/o Dr. Gisli Vikingson.

2. Collect sightings, photographs, and acoustic recordings of target species and other cetaceans encountered.

This secondary task was also accomplished. Killer whales were sighted near Jan Mayen on two different occasions. One large aggregation appeared to be feeding on herring, based upon its behavior and the presence of surface-feeding birds. Another group sighted within the deep canyon core area of northern bottlenose whales was handling a minke whale carcass. These sightings clearly indicated that marine mammal-feeding killer whales are a part of the species composition off Jan Mayen, and affect the ecology of northern bottlenose whales as potential predators. In future efforts, it would be useful to tag killer whales with Dtags to further document their feeding behavior and interactions with other species.

3. Take overhead and laser photogrammetry images of tagged whales and associated calves.

We obtained images using this method, and it is a potentially-effective method to capture overhead images of whales that can be used to measure their body dimensions. However, the view of the cameras was too close to the boat, and didn't include the entire body of whales in many cases. So, the cameras should be placed higher on the mast, and their pointing direction carefully checked before fixing their position. This will require building a new mount that could be attached directly to the VHF antenna mast.

4. Conduct playback of killer whale sounds to bottlenose or pilot whales.

We conducted 3 playback sessions with two different tagged bottlenose whales. These were intentionally timed for the start and end of the trial in order to avoid interfering with baseline data collection during the middle part of the trial. Given the excellent VHF-tracking capability we experienced, we could have accomplished two more experiments on 22 and 23 June, had playbacks been the priority.

Results were consistent with previous findings that northern bottlenose whales are sensitive to disturbance from acoustic noise, and that details of signal presentation might influence how whales respond to playbacks. Whales appear to have been attracted to 1-2 kHz hyperbolic upsweep signals when they were played at low source levels (110-120 dB re µ1 Pa m), but strongly avoided the same signals played at a somewhat higher source level (165-175 dB re µ1 Pa m). We recommend careful checking of sound sources prior to use to avoid failure of the amplifier or other components. To achieve higher source level playbacks than was possible using the Lubell speaker, the non-towed system used in the SOCAL study (Southall et al., 2012, Marine Technology Society Journal) could be deployed and operated from the sailboat platform.

APPENDIX: SIGHTING DATA

Sightings of marine mammals during the 2015 Jan Mayen Trial. Sightings within Icelandic waters are colored in blue. Missing sighting numbers are due to data entry processing, and do not represent missing sightings. Species codes are: BA: *Balaenoptera acutorostrata* minke whale; BB: *Balaenoptera borealis* sei whale; BM: *Balaenoptera musculus* blue whale; BP: *Balaenoptera physalus* fin whale; HA: *Hyperoodon ampullatus* northern bottlenose whale; LAl: *Lagenorhynchus albirostris* white-beaked dolphin; MN: *Megaptera novaeangliae* humpback whale; OO: *Orcinus orca* killer whale; PGr: *Pagophilus groenlandicus* harp seal; PM *Physeter macrocephalus* sperm whale; PP: *Phocoena phocoena* harbour porpoise. Unidentified sighting codes are: B?: unidentified large cetacean; S?: unidentified small cetacean; SL?: unidentified seal; U?: unidentified dolphin; W?: unidentified whale.

Sighting Number	Date	Time	Vessel Latitude	Vessel Longitude	Species	Estimated Number	Calves
6	15-Jun	2:14:22	68.37	-13.48	HA	3	0
7	15-Jun	3:04:42	68.43	-13.36	HA	3	0
8	15-Jun	3:32:42	68.47	-13.28	B?	1	0
9	15-Jun	3:39:17	68.47	-13.25	HA	2	0
10	15-Jun	3:52:42	68.48	-13.21	BP	1	0
11	15-Jun	4:06:27	68.50	-13.18	HA	3	0
12	15-Jun	4:07:57	68.50	-13.18	BA	1	0
13	15-Jun	4:15:42	68.51	-13.16	HA	3	0
14	15-Jun	5:50:27	68.61	-12.97	W?	3	0
15	15-Jun	8:12:22	68.79	-12.59	B?	1	0
16	15-Jun	8:27:02	68.81	-12.55	HA	3	0
17	15-Jun	9:34:47	68.88	-12.41	BP	1	0
18	15-Jun	9:39:47	68.88	-12.39	HA	2	0
19	15-Jun	11:17:52	69.00	-12.14	B?	2	0
20	15-Jun	11:30:37	69.02	-12.11	B?	2	0
21	15-Jun	12:58:27	69.12	-11.86	BA	1	0
22	15-Jun	14:01:19	69.20	-11.70	BB	1	0
23	15-Jun	15:07:02	69.28	-11.51	HA	4	0
24	15-Jun	15:35:27	69.30	-11.45	BA	1	0
25	15-Jun	17:10:47	69.41	-11.20	HA	2	0
26	15-Jun	17:25:17	69.41	-11.19	HA	3	0
27	15-Jun	17:29:17	69.40	-11.19	HA	3	0
28	15-Jun	17:58:57	69.41	-11.22	HA	3	0
29	15-Jun	18:47:37	69.45	-11.12	HA	3	0
30	15-Jun	18:57:32	69.47	-11.09	HA	4	0
31	15-Jun	19:20:37	69.46	-11.05	HA	3	0
32	15-Jun	19:32:47	69.46	-11.05	HA	3	0
33	15-Jun	20:02:37	69.46	-11.05	HA	2	0
34	15-Jun	20:40:37	69.50	-10.98	HA	2	0
35	15-Jun	20:53:02	69.52	-10.94	HA	3	0
36	15-Jun	22:06:07	69.57	-10.86	HA	3	0

37	15-Jun	23:16:42	69.65	-10.62	HA	1	0
38	15-Jun	23:33:52	69.64	-10.61	HA	2	0
39	16-Jun	0:31:42	69.71	-10.46	HA	4	0
40	16-Jun	0:57:32	69.73	-10.44	HA	6	0
41	16-Jun	1:12:47	69.73	-10.43	BA	1	0
42	16-Jun	1:47:37	69.76	-10.38	HA	3	0
43	16-Jun	2:46:07	69.83	-10.20	HA	3	1
45	16-Jun	5:20:42	69.92	-9.98	BA	0	0
46	16-Jun	5:26:47	69.92	-9.97	W?	1	0
47	16-Jun	5:41:32	69.94	-9.94	HA	3	0
48	16-Jun	6:31:12	69.99	-9.81	SL?	1	0
49	16-Jun	6:50:07	70.01	-9.76	HA	2	0
50	16-Jun	10:31:57	70.28	-9.06	SL?	1	0
51	16-Jun	13:01:47	70.47	-8.57	MN	1	0
52	16-Jun	14:02:57	70.55	-8.39	PP	1	0
53	16-Jun	17:47:57	70.81	-7.63	MN	1	0
54	16-Jun	18:49:37	70.89	-7.42	B?	1	0
57	17-Jun	4:52:27	70.92	-6.19	S?	1	0
58	17-Jun	4:56:47	70.92	-6.20	HA	0	0
59	17-Jun	5:30:02	70.92	-6.20	W?	3	0
60	17-Jun	5:50:12	70.92	-6.20	HA	3	0
61	17-Jun	7:35:32	71.00	-6.28	W?	0	0
62	17-Jun	7:44:57	71.01	-6.32	MN	1	0
63	17-Jun	7:54:37	71.01	-6.37	HA	2	0
65	17-Jun	8:22:57	71.01	-6.40	HA	2	0
66	17-Jun	12:52:07	71.01	-7.38	MN	1	0
67	17-Jun	14:30:37	70.98	-7.07	HA	4	0
68	17-Jun	14:57:17	70.98	-7.04	HA	2	0
69	17-Jun	15:17:22	70.98	-7.03	HA	6	0
70	17-Jun	16:06:27	70.96	-6.91	HA	2	0
71	17-Jun	16:24:57	70.95	-6.83	BA	1	0
72	17-Jun	17:42:12	70.91	-6.56	HA	4	0
73	17-Jun	20:20:12	70.87	-6.44	HA	2	0
74	17-Jun	21:01:02	70.88	-6.44	HA	2	0
75	17-Jun	21:19:32	70.87	-6.40	HA	1	0
76	17-Jun	22:29:47	70.84	-6.16	BA	1	0
77	17-Jun	22:35:17	70.85	-6.15	HA	1	0
78	17-Jun	22:52:57	70.85	-6.13	HA	3	1
79	17-Jun	23:08:57	70.85	-6.12	BA	1	0
80	18-Jun	1:39:33	70.82	-5.97	HA	7	0
81	18-Jun	3:22:33	70.79	-5.95	HA	7	1
82	18-Jun	3:36:53	70.79	-5.94	HA	1	0
83	18-Jun	4:32:23	70.79	-5.94	HA	2	1
84	18-Jun	5:27:43	70.80	-5.87	HA	3	0
85	18-Jun	6:32:33	70.78	-5.75	HA	4	0
86	18-Jun	7:30:03	70.79	-5.71	HA	3	0
87	18-Jun	7:42:48	70.79	-5.70	SL?	1	0
88	18-Jun	9:28:08	70.73	-5.50	W?	1	0
89	18-Jun	10:07:58	70.69	-5.41	BA	2	0
90	18-Jun	11:10:53	70.63	-5.25	BA	1	0
91	18-Jun	11:44:03	70.66	-5.32	BA	1	0
92	18-Jun	13:21:13	70.76	-5.59	BA	1	0
93	18-Jun	14:37:58	70.77	-5.61	HA	5	0

94	18-Jun	15:52:13	70.79	-5.69	BA	1	0
95	18-Jun	15:52:48	70.79	-5.69	HA	2	0
96	18-Jun	16:45:48	70.79	-5.79	BA	1	0
97	18-Jun	16:52:18	70.79	-5.82	BA	1	0
98	18-Jun	17:10:33	70.79	-5.88	W?	0	0
99	18-Jun	17:14:28	70.79	-5.89	HA	2	0
100	18-Jun	17:50:48	70.80	-5.91	HA	1	0
101	18-Jun	18:35:03	70.79	-5.95	HA	3	0
102	18-Jun	19:18:18	70.79	-5.98	HA	3	0
103	18-Jun	21:45:56	70.80	-5.95	BA	1	0
104	18-Jun	22:10:46	70.78	-5.92	HA	4	0
105	19-Jun	0:14:16	70.80	-5.87	BA	1	0
106	19-Jun	0:15:11	70.80	-5.87	HA	2	0
107	19-Jun	1:15:52	70.79	-5.84	HA	3	0
109	19-Jun	4:56:32	70.59	-5.51	BA	1	0
110	19-Jun	6:34:57	70.51	-5.16	BA	2	0
111	19-Jun	7:02:12	70.49	-5.17	BP	1	0
112	19-Jun	7:44:52	70.46	-5.36	W?	1	0
113	19-Jun	12:33:37	70.23	-6.48	OO	5	0
114	19-Jun	13:17:32	70.23	-6.55	OO	40	0
115	19-Jun	13:39:02	70.23	-6.57	BP	1	0
116	19-Jun	14:56:42	70.23	-6.64	OO	10	0
117	19-Jun	15:01:52	70.23	-6.66	OO	1	0
118	20-Jun	2:55:43	70.84	-6.08	HA	6	0
119	20-Jun	3:22:03	70.85	-6.07	HA	2	0
120	20-Jun	4:30:58	70.85	-6.05	HA	4	0
121	20-Jun	5:52:48	70.86	-6.03	HA	9	0
122	20-Jun	8:20:58	70.88	-6.06	HA	2	0
123	20-Jun	8:23:18	70.88	-6.06	HA	1	0
124	20-Jun	9:38:58	70.88	-6.03	HA	2	0
125	20-Jun	10:57:08	70.88	-6.09	HA	2	0
126	20-Jun	13:49:32	70.92	-6.06	HA	1	0
127	20-Jun	14:03:27	70.92	-6.06	W?	1	0
128	20-Jun	14:23:37	70.92	-6.06	W?	2	0
129	20-Jun	14:43:52	70.93	-6.03	HA	3	0
130	20-Jun	15:36:12	70.93	-6.04	HA	2	0
131	20-Jun	15:36:12	70.93	-6.04	HA	3	0
132	20-Jun	15:37:32	70.93	-6.03	HA	4	0
134	20-Jun	16:52:47	70.97	-6.05	HA	2	0
135	20-Jun	17:01:07	70.96	-6.02	HA	7	0
136	20-Jun	17:12:27	70.95	-6.00	HA	5	0
137	20-Jun	17:26:17	70.94	-5.97	HA	1	0
138	20-Jun	18:00:02	70.94	-5.95	HA	4	0
140	20-Jun	18:15:42	70.94	-5.98	HA	3	0
141	20-Jun	18:38:57	70.94	-6.00	HA	6	0
142	20-Jun	18:45:37	70.94	-6.00	HA	3	0
144	20-Jun	19:13:37	70.94	-6.00	HA	7	0
145	20-Jun	20:04:37	70.94	-5.98	HA	4	0
146	20-Jun	22:59:22	70.93	-5.95	HA	2	0
147	21-Jun	0:14:07	70.94	-5.98	HA	3	0
148	21-Jun	1:01:08	70.94	-5.97	HA	5	0
149	21-Jun	1:06:18	70.94	-5.97	HA	4	0
150	21-Jun	1:24:23	70.95	-5.98	HA	4	0

151	21-Jun	2:58:06	70.96	-6.05	HA	3	0
152	21-Jun	3:57:36	70.93	-6.27	HA	3	0
153	21-Jun	5:00:16	70.92	-6.30	HA	5	0
154	21-Jun	6:31:36	70.90	-6.42	HA	3	0
155	21-Jun	7:28:11	70.89	-6.40	HA	2	0
156	21-Jun	7:58:01	70.90	-6.32	HA	2	0
157	21-Jun	8:43:11	70.88	-6.36	HA	2	0
158	21-Jun	8:44:06	70.88	-6.36	HA	7	0
159	21-Jun	13:38:21	71.01	-6.34	HA	2	0
160	21-Jun	14:47:21	70.93	-6.33	HA	2	0
161	21-Jun	14:57:51	70.93	-6.33	HA	2	0
162	21-Jun	15:16:46	70.93	-6.32	HA	4	0
163	21-Jun	16:37:51	70.88	-6.30	HA	7	1
165	21-Jun	17:15:16	70.89	-6.32	HA	7	0
166	21-Jun	17:22:51	70.89	-6.31	HA	2	0
167	21-Jun	18:46:46	70.89	-6.35	HA	5	0
168	21-Jun	19:09:01	70.89	-6.38	HA	4	0
169	21-Jun	19:26:31	70.89	-6.37	HA	5	1
170	21-Jun	19:44:21	70.89	-6.34	HA	8	0
171	21-Jun	21:32:31	70.91	-6.18	OO	10	0
172	22-Jun	8:23:21	71.00	-6.38	HA	3	0
173	22-Jun	10:13:51	71.00	-6.56	BA	1	0
174	22-Jun	10:29:46	71.00	-6.58	HA	2	0
175	22-Jun	10:51:21	70.99	-6.57	HA	2	0
176	22-Jun	12:09:01	70.99	-6.66	HA	1	0
177	22-Jun	12:13:36	70.99	-6.67	HA	3	0
178	22-Jun	12:16:21	70.99	-6.68	HA	1	0
179	22-Jun	12:18:21	70.99	-6.68	HA	3	0
180	22-Jun	12:32:21	70.99	-6.70	HA	2	0
181	22-Jun	12:45:31	70.99	-6.70	HA	0	0
183	22-Jun	12:52:41	70.98	-6.71	HA	9	0
184	22-Jun	14:18:56	70.97	-6.69	HA	4	0
185	22-Jun	15:04:56	70.98	-6.66	BA	4	0
186	22-Jun	15:07:41	70.98	-6.65	HA	8	0
187	22-Jun	16:43:31	70.99	-6.61	HA	3	0
188	22-Jun	16:44:31	71.00	-6.61	HA	3	0
189	22-Jun	16:46:11	71.00	-6.61	HA	5	0
190	22-Jun	19:45:46	71.00	-6.61	BA	1	0
191	22-Jun	21:12:31	70.98	-6.63	HA	5	0
192	22-Jun	21:37:16	70.97	-6.63	HA	10	0
193	22-Jun	22:56:57	70.97	-6.62	HA	3	0
194	22-Jun	23:10:06	70.97	-6.62	HA	6	0
195	22-Jun	23:34:31	70.99	-6.64	HA	7	0
196	23-Jun	0:53:01	71.04	-6.54	HA	8	0
197	23-Jun	1:43:21	71.04	-6.54	BA	1	0
198	23-Jun	2:04:31	71.04	-6.53	HA	0	0
199	23-Jun	2:58:52	71.00	-6.65	HA	1	0
200	23-Jun	4:20:46	71.00	-6.64	HA	5	0
201	23-Jun	5:43:56	70.99	-6.60	HA	3	0
202	23-Jun	7:06:41	71.01	-6.57	HA	3	0
203	23-Jun	8:06:21	71.01	-6.57	HA	8	0
204	23-Jun	9:32:26	71.00	-6.55	HA	3	0
205	23-Jun	13:52:41	70.97	-6.54	HA	1	0

206	23-Jun	14:50:26	70.98	-6.52	HA	2	0
207	23-Jun	18:18:56	70.98	-6.54	HA	6	0
208	23-Jun	18:36:21	70.96	-6.55	HA	0	0
209	23-Jun	18:45:16	70.96	-6.58	HA	3	0
210	23-Jun	19:17:46	71.00	-6.60	HA	2	0
211	23-Jun	19:43:21	70.98	-6.53	HA	0	0
212	23-Jun	19:49:42	70.98	-6.55	HA	5	0
213	23-Jun	23:58:26	71.04	-6.52	HA	4	0
214	24-Jun	4:04:31	71.04	-6.82	HA	3	0
215	24-Jun	5:24:21	71.03	-7.02	W?	1	0
216	24-Jun	5:59:52	71.04	-7.03	HA	3	0
217	24-Jun	8:29:26	71.11	-7.42	HA	5	0
218	24-Jun	9:10:21	71.13	-7.38	HA	3	0
219	24-Jun	14:21:21	71.28	-8.27	HA	2	0
220	24-Jun	14:31:21	71.29	-8.26	W?	1	0
221	24-Jun	14:47:46	71.29	-8.26	HA	2	0
222	24-Jun	15:57:36	71.29	-8.33	HA	1	0
223	24-Jun	18:09:36	71.33	-8.76	PGr	1	0
224	24-Jun	18:13:01	71.32	-8.76	HA	2	1
225	24-Jun	18:35:41	71.32	-8.76	HA	2	1
226	24-Jun	19:11:51	71.31	-8.80	HA	3	1
227	24-Jun	20:49:51	71.30	-8.93	HA	4	1
228	25-Jun	0:40:52	71.35	-9.13	HA	2	0
229	25-Jun	4:14:21	71.44	-9.31	HA	4	0
230	25-Jun	6:52:52	71.47	-8.90	HA	3	0
231	25-Jun	11:01:11	71.27	-8.49	SL?	1	0
232	25-Jun	16:18:42	71.48	-7.83	HA	2	0
233	27-Jun	6:55:42	71.00	-7.24	HA	2	0
234	27-Jun	10:45:17	70.99	-6.70	HA	1	0
235	27-Jun	13:51:39	71.02	-6.47	HA	3	0
236	28-Jun	0:55:49	70.94	-6.45	HA	3	0
237	28-Jun	3:56:09	71.03	-7.03	HA	3	0
239	28-Jun	4:44:59	71.02	-7.00	HA	3	0
240	28-Jun	7:59:04	70.89	-6.32	W?	2	0
241	28-Jun	9:23:14	70.85	-6.14	HA	2	0
242	28-Jun	10:11:09	70.90	-6.14	W?	1	0
243	28-Jun	10:56:04	70.95	-6.13	HA	2	0
244	28-Jun	13:16:04	70.97	-6.08	HA	3	1
245	28-Jun	14:13:39	70.98	-6.07	HA	4	0
246	28-Jun	15:47:29	71.07	-6.01	HA	3	0
247	28-Jun	16:02:54	71.07	-5.96	HA	1	0
248	28-Jun	16:06:49	71.07	-5.95	HA	7	0
249	28-Jun	16:06:49	71.07	-5.95	HA	2	0
250	28-Jun	16:42:59	71.07	-5.95	HA	7	0
251	28-Jun	17:42:49	71.07	-5.99	HA	4	0
252	28-Jun	20:19:49	71.07	-6.11	HA	2	0
253	28-Jun	21:25:49	71.06	-6.23	HA	4	0
254	28-Jun	21:35:44	71.05	-6.26	HA	4	0
255	28-Jun	22:12:14	71.05	-6.26	HA	3	0
258	29-Jun	4:14:09	71.04	-6.21	W?	1	0
259	29-Jun	5:23:59	71.09	-6.00	HA	3	0
260	29-Jun	5:57:19	71.08	-5.93	HA	2	0
261	29-Jun	8:10:19	71.15	-5.65	HA	2	0

262	29-Jun	8:22:49	71.15	-5.61	HA	3	0
263	29-Jun	14:36:19	71.14	-5.60	HA	1	0
264	29-Jun	17:53:19	71.05	-6.82	BA	1	0
265	29-Jun	18:54:59	71.03	-7.02	HA	1	0
266	30-Jun	2:51:44	70.92	-6.45	HA	4	0
267	30-Jun	5:36:29	70.87	-6.37	BA	1	0
268	30-Jun	6:26:54	70.90	-6.27	HA	3	0
269	30-Jun	7:19:14	70.91	-6.25	HA	2	0
270	30-Jun	7:32:04	70.91	-6.22	HA	2	0
271	30-Jun	8:55:39	70.86	-6.14	BA	1	0
272	30-Jun	11:46:44	71.02	-6.19	BA	0	0
273	30-Jun	14:09:49	71.00	-6.52	HA	5	0
274	30-Jun	14:52:49	71.00	-6.42	PGr	1	0
275	30-Jun	15:16:39	71.01	-6.43	HA	4	0
276	30-Jun	18:41:49	71.03	-6.82	BA	1	0
277	30-Jun	19:37:49	71.02	-7.09	BA	1	0
278	30-Jun	20:03:20	71.02	-7.19	BP	1	0
279	30-Jun	20:07:14	71.01	-7.20	BA	1	0
280	30-Jun	20:31:39	71.01	-7.19	BA	1	0
281	30-Jun	20:34:59	71.01	-7.18	BA	1	0
282	30-Jun	20:49:49	71.01	-7.17	BA	1	0
283	30-Jun	20:57:49	71.01	-7.15	PGr	1	0
284	30-Jun	21:11:34	71.01	-7.11	BA	1	0
286	1-Jul	5:49:14	70.74	-6.71	W?	1	0
287	1-Jul	9:08:34	70.40	-7.28	B?	2	0
288	1-Jul	13:27:34	69.95	-7.91	PM	1	0
289	1-Jul	17:15:04	69.56	-8.46	B?	2	0
290	1-Jul	21:50:14	69.09	-9.01	HA	2	0
291	2-Jul	2:42:59	68.66	-9.59	HA	4	0
292	2-Jul	3:11:29	68.63	-9.63	HA	1	0
293	2-Jul	3:27:04	68.60	-9.66	HA	3	0
294	3-Jul	10:11:50	66.74	-16.38	LAl	3	0
295	3-Jul	15:03:15	66.29	-16.92	U?	4	0
296	3-Jul	16:01:40	66.23	-17.14	LAl	2	0
297	3-Jul	16:51:55	66.18	-17.33	MN	1	0
298	3-Jul	17:21:30	66.13	-17.38	LAl	2	0
299	3-Jul	17:23:15	66.13	-17.38	MN	2	0
300	3-Jul	18:31:00	66.05	-17.39	BA	1	0
301	3-Jul	18:31:10	66.05	-17.39	PP	1	0
302	3-Jul	21:39:35	66.07	-17.42	MN	1	0
303	3-Jul	22:02:06	66.11	-17.42	MN	1	0
304	3-Jul	22:11:25	66.13	-17.42	B?	1	0
305	3-Jul	22:22:00	66.14	-17.45	MN	1	0
306	3-Jul	22:38:25	66.16	-17.50	MN	1	0
307	4-Jul	0:42:10	66.12	-17.55	BM	1	0
308	4-Jul	1:01:30	66.11	-17.55	MN	2	0
309	4-Jul	3:08:35	66.16	-17.55	MN	1	0
310	4-Jul	3:20:35	66.17	-17.53	BM	1	0
312	4-Jul	5:07:15	66.23	-17.57	MN	1	0
313	4-Jul	7:45:10	66.10	-17.58	BM	1	0
314	4-Jul	7:46:00	66.10	-17.58	LAl	2	0
315	4-Jul	8:02:55	66.07	-17.55	W?	1	0
316	4-Jul	9:31:25	66.03	-17.63	MN	1	0

317	4-Jul	9:33:50	66.03	-17.64	PP	2	0
318	4-Jul	9:38:30	66.03	-17.64	LAl	1	0
319	4-Jul	9:44:30	66.04	-17.64	LAl	1	0
320	4-Jul	9:48:25	66.04	-17.65	LAl	2	0
321	4-Jul	9:54:40	66.05	-17.65	LAl	5	0
322	4-Jul	9:57:55	66.05	-17.66	BM	1	0
323	4-Jul	10:05:50	66.06	-17.67	LAl	8	0
324	4-Jul	10:09:50	66.06	-17.67	BA	1	0
325	4-Jul	12:31:30	66.14	-17.76	MN	1	0
326	4-Jul	12:45:45	66.14	-17.73	MN	1	0
327	4-Jul	12:48:00	66.14	-17.73	MN	1	0
328	4-Jul	13:09:10	66.12	-17.66	BM	1	0