# Cruise report hydroacoustic survey for blue whiting (*Micromesistius poutassou*) with F.R.V. "Tridens" (BWHTS) 23 March – 7 April 2015

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Report number 15.008

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## Contents

# 1 Introduction

This survey is part of the ICES coordinated international hydro acoustic survey for blue whiting which is carried out yearly in March/April. The other participating countries are the Faroe Islands, Ireland, Norway and Russia. IMARES, Institute for Marine Resources & Ecosystem Studies, part of Wageningen University and Research, has participated in the international North-East Atlantic hydro acoustic survey for blue whiting since 2004. The survey is part of the EU Data Collection Framework. The aim of this survey is to provide an abundance estimate of the whole North-East Atlantic blue whiting population and to determine the spatial distribution at this time of year. This estimate is used as a tuning index by the ICES Working Group on Widely Distributed Stocks (WGWIDE) to determine the size of the population. In this report the results are presented of the survey west of Ireland, carried out by FRV "Tridens". A secondary objective during the survey is to gather information on the distribution of non-commercial mesopelagic species.

# 2 Materials and Methods

## 2.1 Scientific staff

| | |
|---|---|
| *Kees Bakker* | *(Cruise leader, Technician, IMARES)* |
| *Ben Scoulding* | *(Acoustics, IMARES)* |
| *Thomas Pasterkamp* | *(Fish biologist, IMARES)* |
| *Dirk Burggraaf* | *(Technician, IMARES)* |
| *Eric Armstrong* | *(Acoustics, Marine Scotland, Scotland, UK)* |
| *Dirk Thijssen* | *(Fish biologist, DTU Aqua, Denmark)* |
| *Helen O'Neill* | *(Student, IMARES)* |
| *Stephanie Levesque* | *(Observer, Marine Institute, Ireland)* |
| *Simon Wieser* | *(Observer, TI, Germany)* |

## 2.2 Narrative (times are UTC)

The Tridens left Scheveningen two weeks prior to the start of the blue whiting survey on a test trip to trail the new drop-keel and acoustic equipment. During this time the EK60 echosounders were satisfactorily calibrated. Unfortunately time did not allow for calibration of the ME70 multibeam sonar. Also at the time of the survey the software was not available to calibrate the new EK80 broadband echosounders.

The remaining scientists joined the vessel in Galway on Sunday 22$^{nd}$ and the remaining crew arrived early Monday morning. On Monday 23$^{rd}$ March at 10:00 UTC the vessel departed Galway and steamed straight towards the first transect. We were informed of a change to the original cruise track as the Russians were unable to survey within British waters. As a result we swapped cruise tracks with the Russians. Rough seas delayed arrival on transect and we began surveying at 12:18 UTC on Tuesday 24$^{th}$ March (51°54'N 13°29'W).

As weather conditions were fairly rough throughout the survey hard spikes were observed on the echograms. Initially we were unsure of the cause for these spikes, however we now know it was because of waves crashing over the bow; resonating sound through the vessel. Additionally, ping dropouts were observed when the vessels bulbous bow forced air under the hull and consequently across the transducer faces. This problem was more obvious on the east to west transects as we were going against the swell.

Late on the 26th March we received news of another cruise track change with additional CTD stations. The Russian vessel had not received permission to enter the 200 nautical mile zone around the UK and so several of our transects had to be extended to help cover this area. The same applied for the Irish and Norwegian vessels. A broken winch on the 27th March prevented the net being hauled onboard, however after several hours of work the ships mechanics fixed the problem and the survey resumed.

Due to particularly bad weather on Saturday 28th March (6m + swell) progress on the western transects were slow, average speed of 4 knots. The estimated time to complete the next two transects was 30 hours. With little option we shorten these transects to make sure we were not out when the force 10 hit the following evening. Due to the expected bad weather and the need to take on fresh water we left transect on the morning of Sunday 29th March and headed for Loch Duich on the west coast of Scotland to do a second calibration of the acoustic equipment. Once successfully calibrated we stayed at anchor and spent the night in Loch Duich. On the morning of 30th March we steamed to Stornoway (Isle of Lewis) to wait out the bad weather and take on fresh water, arrival time 16:00 UTC. We left Stornoway at 08:00 UTC on 1st April and arrived back on transect at 18:39 UTC later that day (55°58'N 08°59'W).

The remainder of the survey continued without problems. The bad weather subsided and we finished the last transect on 7th April at 18:07 UTC (59°27'N 6°12'W) and streamed straight for Scheveningen, arriving at around 17:30 UTC.

### 2.3 Survey design

The survey was carried out from the 23rd March to the 7th of April 2015. The design covered an area west of Ireland from latitude 51.54º to 59.27º North and from longitude 6.12º to 16.0º West (Planned survey track: Figure 1). For various reasons the cruise track was changed several times. Namely because the Russian vessel was unable to get permission to enter UK waters during the survey period and therefore was only able to survey up until the 200 nmi EEZ.

CTD stations were planned in advance, with approximately 50 nm between the stations. Additional CTD stations were added due to changes in cruise track design as the survey progressed. The survey cruise track and trawl positions are presented in Figure 2.

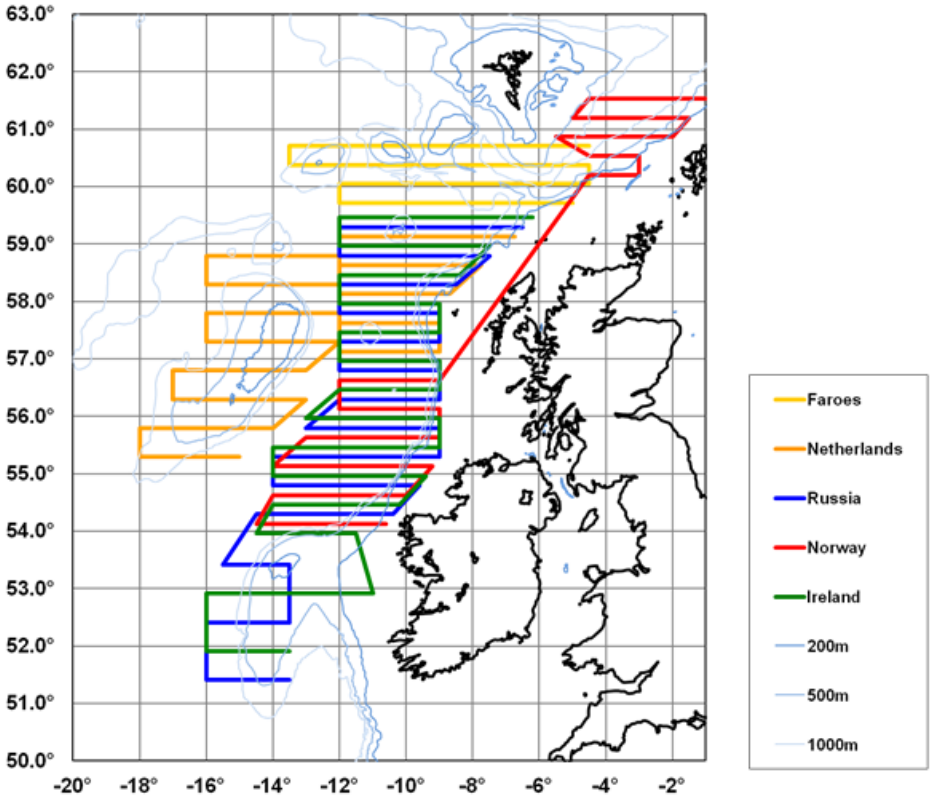


***Figure 1.*** *Original cruise track of Tridens (orange) for BWHTS 2015. Cruise track was swapped with Russia (blue) before start of the survey as the Russians were unable to survey within British waters as they did not acquire the necessary permissions.*

## 2.4 Acoustic calibrations

The EK60 echosounders with six frequencies were first calibrated during a test week before the survey in Bantry Bay, Ireland. A second mid-survey calibration in Loch Duich, Scotland, was also successfully executed. Results were not significantly different from the first calibration, indicating reliable transducer performance throughout the survey. In total, 10 calibrations were executed in Bantry bay. Each frequency was calibrated using the replay data from each of the 10 calibrations so that each transducer was calibrated 10 times (Table 1). Overall results were good to very good for 38, 70 and 120 kHz and fair to good for 18, 200 and 333 kHz. This is probably due to the size of the sphere used in the calibration. During the mid-survey break 5 calibrations were carried out in Loch Duich. The best calibration results from Bantry bay were used (see Appendix A).

***Table 1.*** *Calibration overview; the transducer no. 28887 was used during the survey. *Indicates a replay calibration.*

| | Frequency | Transducer ID | # calibrations | Final results |
|---|---|---|---|---|
| **Pre-calibration** | 18 kHz | | 10 | Fair |
| | 38 kHz | | 10 | Good |
| | 70 kHz | | 10 | Good |
| | 120 kHz | | 10 | Good |
| | 200 kHz | | 10 | Fair-Poor |
| | 333 kHz | | 10 | Fair-Poor |
| **Post-calibration** | 18 kHz | | 2 | Good |
| | 38 kHz | | 2 | Good |
| | 70 kHz | | 1 | Good |

## 2.5 Acoustic data collection

A Simrad EK60 echosounder operating at 18, 38, 70, 120, 200 and 333 kHz was used for acoustic data collection. Transducers were mounted close together on a newly fitted drop-keel which protruded 3.23 m below the vessel given a total transducer depth of around 9 m below the water surface. Acoustic raw data were logged and post-processed with Myriax Echoview (v 6.0) software. Due to the spikes caused by bad weather a spike removal algorithm was developed in Echoview. This successfully removed spike noise. The EK60 received position data and vessel speed from the ship's GPS. A variable ping rate was used near the shelf edge to avoid false bottom echoes. The data were logged in 1 nautical mile intervals. A typical vessel speed of 10 knots was used on one engine, to avoid interference with the acoustic data. Acoustic density values (NASC's) by log interval corresponding to blue whiting, based on school characteristics and trawl catch composition, were assigned to the category "blue whiting". All echoes were recorded with a threshold of -80dB up to a depth of 750 meters below the transducer.

### 2.6 Biological data collection

Acoustic recordings were identified using a 5600 mesh pelagic trawl with 20 mm meshes in the cod-end. Fishing was carried out when large or dense recordings were observed on the echogram and to obtain biological samples of blue whiting. In general, after it was decided to make a tow with a pelagic trawl, the vessel turned and fished back on its track.

One deep haul (approx. 1000m) was carried out to collect mesopelagic species which successfully targeted the deep sea scattering layers..

Fish samples were divided into species by weight. Length measurements were taken to the 1.0 cm below for all species. For blue whiting, length representative samples were taken for sex, maturity, age (otolith extraction) and weight. This year 100 otolith samples were aged per trawl for blue whiting (with the exception of the first trawl, due to a communication error).

Specimens of non-target species were frozen and photographed for species determination in the lab. A total of 54 different mesopelagic species were identified. Hydrographical data were collected at 30 CTD stations with downcasts out to approximately 900 m or shallower (Figure 2). The hydrographic data will be verified at the lab and submitted to the ICES Oceanography database.

## 3 Results

### 3.1 Acoustics

The covered length of transects was 2157 nautical miles, which is only slightly longer than the length of the originally planned design (2075 nmi). The majority of blue whiting aggregations were encountered along the shelf edge, between 250 and 700m between 53 - 55ºN latitude (Figure 3). The largest NASC value by 1 nmi interval corresponding to blue whiting was 42800 m2/nmi2. Echotraces of blue whiting concentrations typically consisted of scattered aggregations at the shelf edge, becoming more dense and extending westwards off the shelf between 300 and 400 m (Figure 3). Results of the combined acoustic survey, including total blue whiting stock abundance and biomass estimation at age are reported in the combined survey report of ICES WGIPS 2016.

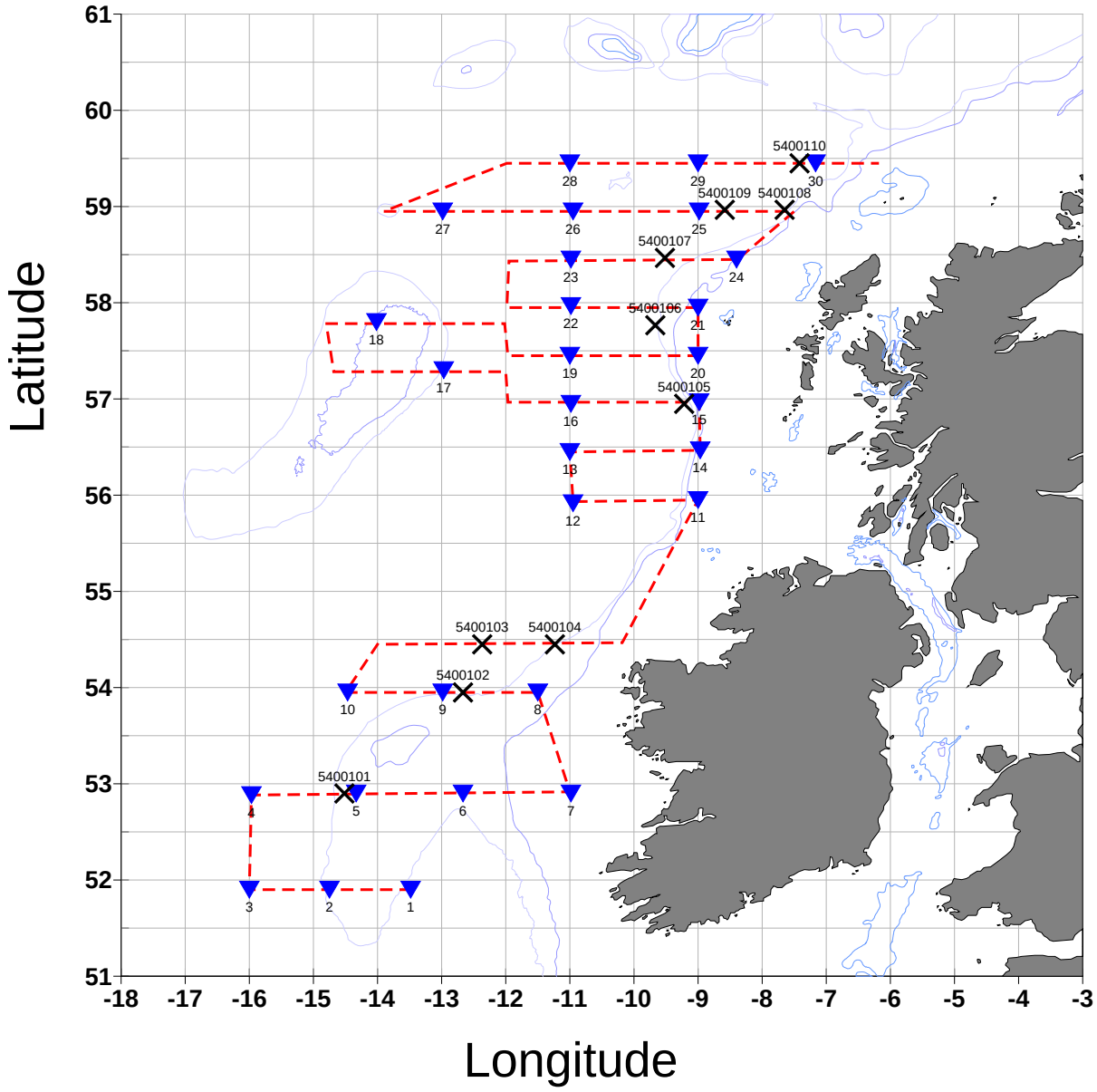


***Figure 2.*** *Realised cruise track, trawl positions and CTD stations of Tridens during BWHTS 2015.*

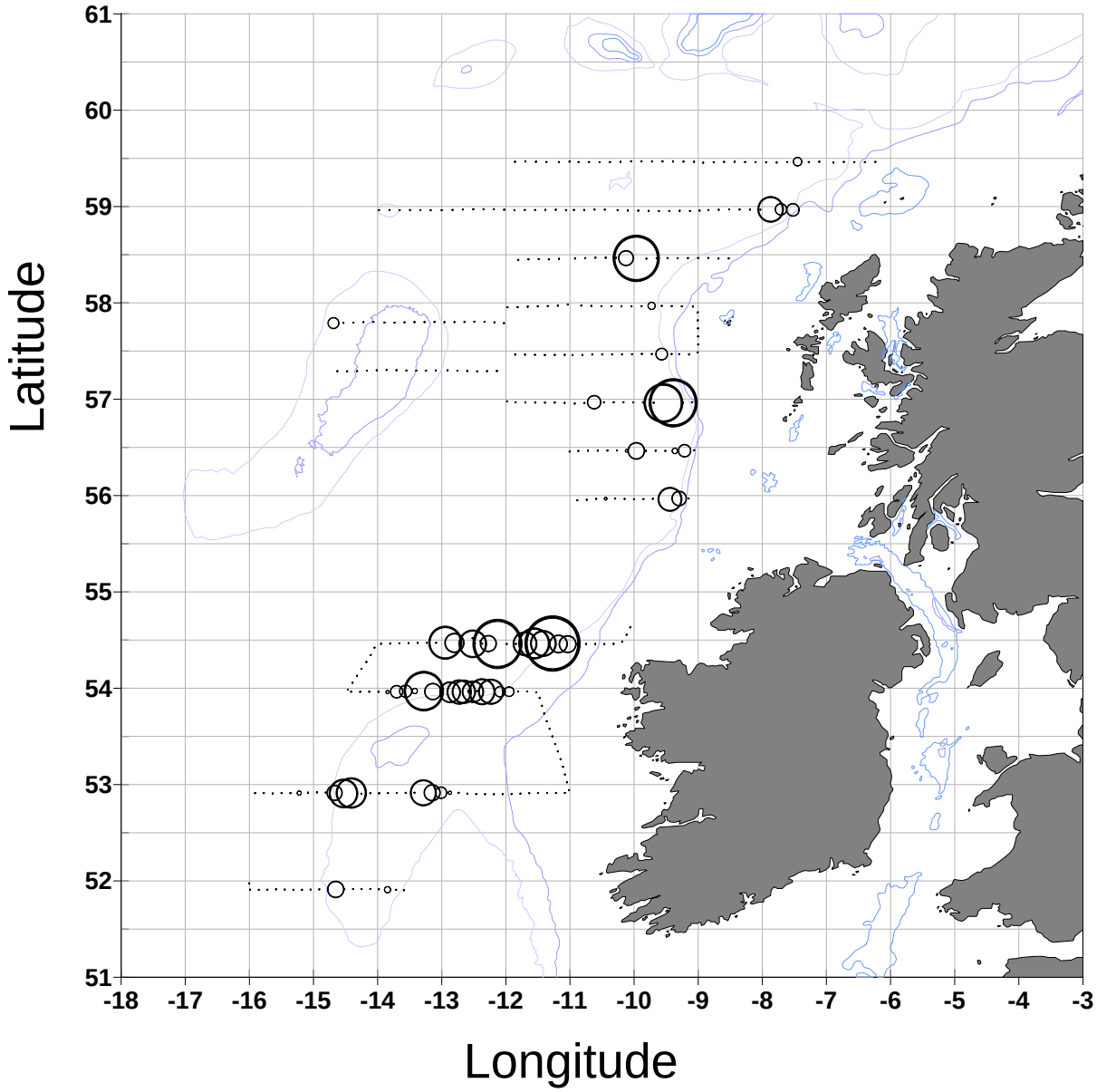


***Figure 3.*** *Bubble plot representing acoustic density (Nautical Area Scattering Coefficient, SA, in m2/nmi2) of blue whiting by 1 nmi intervals recorded by Tridens during BWHTS 2015. Values are square root scaled to make the area of the bubbles proportional to the recorded SA. the largest observation was 42800 m2/nmi2.*

### 3.2 Catch results

From a total of 10 trawl hauls, 6 contained significant quantities of blue whiting (Table 2). One trawl was targeted, just below the 'blue whiting zone', to obtain samples of mesopelagic deep sea fish species. In total, 900 biological samples of blue whiting were collected for length, age, weight and maturity keys. A total of 65 different species was caught during the entire survey. Table 3 presents the species encountered in the trawls.

***Table 2.*** *Details of the trawl hauls taken during BWHTS 2015 on FRV "Tridens". All times are in GMT.*

| Haul nr | Station | Year | Month | Day | Hour | Min | Lat | Lon | WinDir | WinSpeed |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5400101 | 2015 | 3 | 25 | 12 | 3 | 52.94 | -14.52 | 270 | 9 |
| 2 | 5400102 | 2015 | 3 | 26 | 15 | 31 | 53.96 | -12.48 | 315 | 9 |
| 3 | 5400103 | 2015 | 3 | 27 | 11 | 10 | 54.49 | -12.39 | 225 | 4 |
| 4 | 5400104 | 2015 | 3 | 27 | 19 | 0 | 54.47 | -11.31 | 225 | 4 |
| 5 | 5400105 | 2015 | 4 | 1 | 19 | 54 | 56.93 | -9.15 | 225 | 12 |
| 6 | 5400106 | 2015 | 4 | 3 | 17 | 24 | 57.47 | -9.49 | 315 | 4 |
| 7 | 5400107 | 2015 | 4 | 4 | 21 | 24 | 58.32 | -9.52 | - | - |
| 8 | 5400108 | 2015 | 4 | 5 | 9 | 58 | 58.97 | -7.59 | 225 | 4 |
| 9 | 5400109 | 2015 | 4 | 5 | 15 | 14 | 58.97 | -8.48 | 203 | 4 |
| 10 | 5400110 | 2015 | 4 | 7 | 12 | 12 | 59.46 | -7.58 | 270 | 9 |

***Table 3.*** *Trawl catch species composition in kg for hauls taken during BWHTS 2015 on FRV "Tridens".*

| haul number *species* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Argentina silus* | 0.044 | | | | | 1.587 | | | | | *1.631* |
| *Micromesistus poutassou* | 4045 | 429 | 5698 | 5070 | 5175 | 7755 | | 2740 | 330 | *48* | *31290* |
| *Argyropelecus henigymnus* | | 0.006 | 0.005 | 0.001 | | | | | 0.004 | *0.008* | *0.024* |
| *Argyropelecus olfersi* | | 0.004 | 0.085 | 0.018 | | 0.018 | 0.048 | | 0.028 | *0.122* | *0.323* |
| *Maurolicus muelleri* | | 0.003 | | | | | 0.016 | | 0.056 | *0.012* | *0.087* |
| *Notoscopelus kroeyeri* | | 0.951 | 0.155 | 0.033 | | | | | 0.394 | *0.416* | *1.949* |
| *Myctophidae* | | 0.110 | 0.015 | 0.189 | | | 19.76 | | 6.843 | *0.896* | *27.813* |
| *Ommastrephes sagittatus* | | 0.002 | 0.315 | | 6.096 | 9.84 | 1.314 | 2.818 | 0.008 | *0.856* | *21.222* |
| *Scomber scombrus* | | | | | 1.965 | | | | | | *1.965* |
| *Eutrigla gurnardus* | | | | | | 34.77 | 0.596 | 2.752 | | | *38.118* |
| *Benthosema glaciale* | | | | | | | 1.6 | | | *0.944* | *2.544* |
| *Chauliodus sloani* | | | | | | | 1.08 | | | *0.06* | *1.14* |
| *Lamparyctus crocodilus* | | | | | | | 27.01 | | | *4.432* | *31.442* |
| *Nansenia groenlandica* | | | | | | | 0.252 | | 0.116 | *0.242* | *0.61* |
| *Merluccius merluccius* | 1.532 | | | | 14.63 | 5.289 | | | | | *21.451* |
| *Myctophum punctatum* | | | | | | | | | | *0.616* | *0.616* |
| *Argentine* | | | | | | | 28.92 | | | | *28.92* |
| *NRK* | | | | 0.036 | 0.165 | | 8.448 | | | *0.074* | *8.723* |
| *ZIK* | | | | | | | 0.048 | | | | *0.048* |
| *GFB* | | | | | | | 2.18 | | | | *2.18* |
| **Total** | *4047* | *430* | *5699* | *5070* | *5198* | *7807* | *91* | *2746* | *337* | *57* | *31481* |

# 4 Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

## Justification

Rapport 15.008
Project Number: 4311211007

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: Ingeborg de Boois
Project leader WOT surveys

Signature:

Date: 5th of August 2015

Approved: John Schobben
Head of department Fish

Signature:

Date: 5th of August 2015

## Appendix A. Calibration results

### 18 kHz calibration

```
#  Calibration  Version   2.1.0.12
#
#  Date:  3/11/2015
#
#  Comments:
#    cal 9 18 khz replay
#
#  Reference Target:
#    TS                  -42.73 dB       Min. Distance         29.80 m
#    TS Deviation          5.0 dB        Max. Distance         32.10 m
#
#  Transducer:  ES18-11  Serial No.   18
#    Frequency            18000 Hz       Beamtype                Split
#    Gain                 22.40 dB       Two Way Beam Angle   -17.0 dB
#    Athw. Angle Sens.       13.90       Along. Angle Sens.      13.90
#    Athw. Beam Angle    11.00 deg       Along. Beam Angle   11.00 deg
#    Athw. Offset Angle   0.00 deg       Along. Offset Angle  0.00 deg
#    SaCorrection          0.00 dB       Depth                 8.00  m
#
#  Transceiver:  GPT  18 kHz 00907208af40 1-1 ES18-11
#    Pulse Duration       1.024 ms       Sample Interval     0.190   m
#    Power                 2000  W       Receiver Bandwidth   1.57 kHz
#
#  Sounder Type:
#    EK60 Version  2.4.3
#
#  TS Detection:
#    Min. Value           -50.0 dB       Min. Spacing            100 %
#    Max. Beam Comp.        6.0 dB       Min. Echolength          80 %
#    Max. Phase Dev.           8.0       Max. Echolength         180 %
#
#  Environment:
#    Absorption Coeff.   2.8 dB/km       Sound Velocity     1487.5 m/s
#
#  Beam Model results:
#    Transducer Gain    = 22.48 dB       SaCorrection       = -0.72 dB
#    Athw. Beam Angle   =11.14 deg       Along. Beam Angle  =11.49 deg
#    Athw. Offset Angle =-0.02 deg       Along. Offset Angle=-0.13 deg
#
#  Data deviation from beam model:
#    RMS =    0.37 dB
#    Max =    0.96 dB  No. =   369  Athw. =  6.4 deg  Along = -4.4 deg
#    Min =   -1.22 dB  No. =    86  Athw. =  0.1 deg  Along = -6.9 deg
#
#  Data deviation from polynomial model:
#    RMS =    0.35 dB
```

```
#    Max =    0.80 dB  No. =   113  Athw. = -4.7 deg  Along =  3.0 deg
#    Min =   -1.25 dB  No. =   245  Athw. = -4.4 deg  Along =  5.6 deg
```

## 38 kHz Calibration

```
#  Calibration  Version   2.1.0.12
#
#  Date:  3/10/2015
#
#  Comments:
#    cal 3 38 kHz replay
#
#  Reference Target:
#    TS                  -42.38 dB       Min. Distance         23.80 m
#    TS Deviation          5.0 dB        Max. Distance         25.80 m
#
#  Transducer:  ES38B  Serial No.   38
#    Frequency            38000 Hz       Beamtype                Split
#    Gain                 26.50 dB       Two Way Beam Angle   -20.6 dB
#    Athw. Angle Sens.       21.90       Along. Angle Sens.      21.90
#    Athw. Beam Angle     7.10 deg       Along. Beam Angle    7.10 deg
#    Athw. Offset Angle   0.00 deg       Along. Offset Angle  0.00 deg
#    SaCorrection          0.00 dB       Depth                 8.00  m
#
#  Transceiver:  GPT  38 kHz 00907208a0bc 2-1 ES38B
#    Pulse Duration       1.024 ms       Sample Interval     0.190   m
#    Power                 2000  W       Receiver Bandwidth   2.43 kHz
#
#  Sounder Type:
#    EK60 Version  2.4.3
#
#  TS Detection:
#    Min. Value           -50.0 dB       Min. Spacing            100 %
#    Max. Beam Comp.        6.0 dB       Min. Echolength          80 %
#    Max. Phase Dev.          8.0        Max. Echolength         180 %
#
#  Environment:
#    Absorption Coeff.   9.9 dB/km       Sound Velocity     1487.5 m/s
#
#  Beam Model results:
#    Transducer Gain    = 26.26 dB       SaCorrection       = -0.57 dB
#    Athw. Beam Angle   = 6.87 deg       Along. Beam Angle  = 6.88 deg
#    Athw. Offset Angle = 0.06 deg       Along. Offset Angle=-0.09 deg
#
#  Data deviation from beam model:
#    RMS =    0.15 dB
#    Max =    0.48 dB  No. =   104  Athw. = -3.4 deg  Along =  2.8 deg
#    Min =   -0.63 dB  No. =   309  Athw. =  0.9 deg  Along = -4.5 deg
#
```

```
#  Data deviation from polynomial model:
#    RMS =    0.12 dB
#    Max =    0.46 dB  No. =   250  Athw. =  4.6 deg  Along = -1.4 deg
#    Min =   -0.61 dB  No. =   309  Athw. =  0.9 deg  Along = -4.5 deg
```

## 70 kHz Calibration

```
#  Calibration  Version   2.1.0.12
#
#  Date:  3/10/2015
#
#  Comments:
#    cal 4 70 kHz replay
#
#  Reference Target:
#    TS                  -41.24 dB       Min. Distance         23.80 m
#    TS Deviation           5.0 dB       Max. Distance         25.80 m
#
#  Transducer:  ES70-7C  Serial No.   70
#    Frequency            70000 Hz       Beamtype                Split
#    Gain                 27.00 dB       Two Way Beam Angle   -21.0 dB
#    Athw. Angle Sens.       23.00       Along. Angle Sens.      23.00
#    Athw. Beam Angle     7.00 deg       Along. Beam Angle    7.00 deg
#    Athw. Offset Angle   0.00 deg       Along. Offset Angle  0.00 deg
#    SaCorrection          0.00 dB       Depth                 8.00  m
#
#  Transceiver:  GPT  70 kHz 00907208a0bf 3-1 ES70-7C
#    Pulse Duration       1.024 ms       Sample Interval     0.190   m
#    Power                  750  W       Receiver Bandwidth   2.86 kHz
#
#  Sounder Type:
#    EK60 Version  2.4.3
#
#  TS Detection:
#    Min. Value           -50.0 dB       Min. Spacing            100 %
#    Max. Beam Comp.        6.0 dB       Min. Echolength          80 %
#    Max. Phase Dev.           8.0       Max. Echolength         180 %
#
#  Environment:
#    Absorption Coeff.  22.1 dB/km       Sound Velocity     1487.5 m/s
#
#  Beam Model results:
#    Transducer Gain    = 27.00 dB       SaCorrection       = -0.34 dB
#    Athw. Beam Angle   = 6.40 deg       Along. Beam Angle  = 6.42 deg
#    Athw. Offset Angle =-0.01 deg       Along. Offset Angle=-0.09 deg
#
#  Data deviation from beam model:
#    RMS =    0.17 dB
#    Max =    0.60 dB  No. =    36  Athw. = -2.4 deg  Along =  4.5 deg
```

```
#    Min =   -0.97 dB  No. =   404  Athw. =  1.2 deg  Along = -4.8 deg
#
#  Data deviation from polynomial model:
#    RMS =    0.14 dB
#    Max =    0.50 dB  No. =    36  Athw. = -2.4 deg  Along =  4.5 deg
#    Min =   -0.77 dB  No. =   404  Athw. =  1.2 deg  Along = -4.8 deg
```

## 120 kHz Calibration

```
#  Calibration  Version   2.1.0.12
#
#  Date:  3/11/2015
#
#  Comments:
#    cal 10 120 khz replay
#
#  Reference Target:
#    TS                  -39.48 dB       Min. Distance         29.80 m
#    TS Deviation           5.0 dB       Max. Distance         32.10 m
#
#  Transducer:  ES120-7C  Serial No.   120
#    Frequency           120000 Hz       Beamtype                Split
#    Gain                 27.00 dB       Two Way Beam Angle   -21.0 dB
#    Athw. Angle Sens.       23.00       Along. Angle Sens.      23.00
#    Athw. Beam Angle     7.00 deg       Along. Beam Angle    7.00 deg
#    Athw. Offset Angle   0.00 deg       Along. Offset Angle  0.00 deg
#    SaCorrection          0.00 dB       Depth                 8.00  m
#
#  Transceiver:  GPT 120 kHz 009072088a6a 4-1 ES120-7C
#    Pulse Duration       1.024 ms       Sample Interval     0.190   m
#    Power                  250  W       Receiver Bandwidth   3.03 kHz
#
#  Sounder Type:
#    EK60 Version  2.4.3
#
#  TS Detection:
#    Min. Value           -50.0 dB       Min. Spacing            100 %
#    Max. Beam Comp.        6.0 dB       Min. Echolength          80 %
#    Max. Phase Dev.           8.0       Max. Echolength         180 %
#
#  Environment:
#    Absorption Coeff.  35.1 dB/km       Sound Velocity     1487.5 m/s
#
#  Beam Model results:
#    Transducer Gain    = 27.04 dB       SaCorrection       = -0.36 dB
#    Athw. Beam Angle   = 6.49 deg       Along. Beam Angle  = 6.47 deg
#    Athw. Offset Angle = 0.01 deg       Along. Offset Angle= 0.01 deg
#
#  Data deviation from beam model:
```

```
#    RMS =    0.21 dB
#    Max =    0.68 dB  No. =   238  Athw. = -3.7 deg  Along = -2.9 deg
#    Min =   -0.68 dB  No. =   306  Athw. =  2.1 deg  Along = -4.6 deg
#
#  Data deviation from polynomial model:
#    RMS =    0.19 dB
#    Max =    0.70 dB  No. =   238  Athw. = -3.7 deg  Along = -2.9 deg
#    Min =   -0.69 dB  No. =   280  Athw. = -3.1 deg  Along = -2.1 deg
```

## 200 kHz calibration

```
#  Calibration  Version   2.1.0.12
#
#  Date:  3/11/2015
#
#  Comments:
#    cal 9 200 khz replay
#
#  Reference Target:
#    TS                  -39.30 dB       Min. Distance         29.80 m
#    TS Deviation           5.0 dB       Max. Distance         32.10 m
#
#  Transducer:  ES200-7C  Serial No.   200
#    Frequency           200000 Hz       Beamtype                Split
#    Gain                 27.00 dB       Two Way Beam Angle   -20.7 dB
#    Athw. Angle Sens.       23.00       Along. Angle Sens.      23.00
#    Athw. Beam Angle     7.00 deg       Along. Beam Angle    7.00 deg
#    Athw. Offset Angle   0.00 deg       Along. Offset Angle  0.00 deg
#    SaCorrection          0.00 dB       Depth                 8.00  m
#
#  Transceiver:  GPT 200 kHz 00907208a0b6 5-1 ES200-7C
#    Pulse Duration       1.024 ms       Sample Interval     0.190   m
#    Power                  150  W       Receiver Bandwidth   3.09 kHz
#
#  Sounder Type:
#    EK60 Version  2.4.3
#
#  TS Detection:
```

```
#    Min. Value           -50.0 dB       Min. Spacing            100 %
#    Max. Beam Comp.        6.0 dB       Min. Echolength          80 %
#    Max. Phase Dev.           8.0       Max. Echolength         180 %
#
#  Environment:
#    Absorption Coeff.  49.3 dB/km       Sound Velocity     1487.5 m/s
#
#  Beam Model results:
#    Transducer Gain    = 26.77 dB       SaCorrection       = -0.39 dB
#    Athw. Beam Angle   = 6.49 deg       Along. Beam Angle  = 6.82 deg
#    Athw. Offset Angle =-0.00 deg       Along. Offset Angle=-0.18 deg
#
#  Data deviation from beam model:
#    RMS =    0.33 dB
#    Max =    0.81 dB  No. =   171  Athw. = -1.9 deg  Along = -1.8 deg
#    Min =   -1.49 dB  No. =    74  Athw. = -0.4 deg  Along =  2.2 deg
#
#  Data deviation from polynomial model:
#    RMS =    0.31 dB
#    Max =    0.81 dB  No. =   352  Athw. =  0.7 deg  Along =  1.2 deg
#    Min =   -1.40 dB  No. =    74  Athw. = -0.4 deg  Along =  2.2 deg
```

## 333 kHz calibration

```
#  Reference Target:
#    TS                  -36.77 dB       Min. Distance         27.80 m
#    TS Deviation           5.0 dB       Max. Distance         30.10 m
#
#  Transducer:  ES333-7C  Serial No.   333
#    Frequency           333000 Hz       Beamtype                Split
#    Gain                 24.00 dB       Two Way Beam Angle   -20.7 dB
#    Athw. Angle Sens.       23.00       Along. Angle Sens.      23.00
#    Athw. Beam Angle     7.00 deg       Along. Beam Angle    7.00 deg
#    Athw. Offset Angle   0.00 deg       Along. Offset Angle  0.00 deg
#    SaCorrection          0.00 dB       Depth                 8.00  m
#
#  Transceiver:  GPT 333 kHz 00907208a0c8 6-1 ES333-7C
#    Pulse Duration       1.024 ms       Sample Interval     0.190   m
#    Power                   50  W       Receiver Bandwidth   3.11 kHz
#
#  Sounder Type:
#    EK60 Version  2.4.3
#
#  TS Detection:
#    Min. Value           -50.0 dB       Min. Spacing            100 %
#    Max. Beam Comp.        6.0 dB       Min. Echolength          80 %
#    Max. Phase Dev.           8.0       Max. Echolength         180 %
#
#  Environment:
#    Absorption Coeff.  75.2 dB/km       Sound Velocity     1487.5 m/s
#
```

```
#  Beam Model results:
#    Transducer Gain    = 24.27 dB       SaCorrection       = -0.37 dB
#    Athw. Beam Angle   = 7.06 deg       Along. Beam Angle  = 7.01 deg
#    Athw. Offset Angle = 0.04 deg       Along. Offset Angle= 0.01 deg
#
#  Data deviation from beam model:
#    RMS =    0.65 dB
#    Max =    1.10 dB  No. =   207  Athw. = -1.8 deg  Along = -0.6 deg
#    Min =   -1.31 dB  No. =   408  Athw. =  0.4 deg  Along =  2.4 deg
#
#  Data deviation from polynomial model:
#    RMS =    0.63 dB
#    Max =    1.41 dB  No. =   263  Athw. = -3.1 deg  Along = -3.9 deg
#    Min =   -1.40 dB  No. =   248  Athw. =  1.0 deg  Along = -1.3 deg
```