

R/V „Celtic Explorer“

Cruise 15013a, August 7th – 30th, 2015

Report of the Chief Scientist

ICES Cruise Id: 45CE15013a

CSRREF: 20153564

Holger Klein



Hamburg, September 28th, 2015

(CR-Celtic-Explorer-15013A.docx)

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Participants

Science Crew	Working Group	Ship Crew	Rank
Holger Klein	Marine Physics, Chief Scientist (BSH)	Antony Hobin	Master
Peter Löwe	Marine Physics (BSH)	Damien McCalling	Chief Engineer
Sören Joswig	Marine Physics (BSH)	Kenny Downing	Chief Officer
Dr. Christian Senet	Marine Physics (BSH)	Diarmuid Joyce	2 nd Officer
		David Stack	2 nd Engineer
Frank Oestereich	Nutrients (BSH)	Paul Taylor	ETO
Dr. Stefanie Schmied	Radioactivity (BSH)	Ken O'Neill	Bosun
		Tony Reck	Cook
André Seyler	Air Chemistry (University of Bremen)	Michelin Faherty	Bosun's Mate
		Philip Gunnip	AB Deckhand GP1
		Paddy Kenny	AB Deckhand GP1
		Michael Doogan	Assistant Cook
		Anthony English	Technician
		Jimmy Burke	AB Deckhand GP1
		Gerry Dirrane	AB Deckhand GP1



Fig. 1: The BSH Team: André Seyler (University of Bremen), Holger Klein, Christian Senet, Peter Löwe, Sören Joswig, Frank Oestereich, and Stefanie Schmied (from left to right).

Objectives and scientific background

The North Sea is a shallow shelf sea with a deep trough along the Norwegian coast with depth exceeding 700 m locally. Its physical status, primarily characterised by temperature and salinity, is to a large extent determined by the exchange of water masses with the Atlantic at its open northern boundary. There is also a link to the Atlantic via the English Channel which is important for the shallow southern North Sea. The Baltic Sea is linked to the North Sea via Skagerrak, Kattegat, Great and Little Belt, and The Sound. The Baltic outflow with its low saline water influences significantly the oceanographic conditions of the Skagerrak and Norwegian Coastal Current. Other drivers are inter alia continental river run-offs, the ocean-atmosphere heat exchange, and the rate of precipitation to evaporation.

All parameters exhibit a strong seasonal and/or inter-annual variability. Seasonal heating leads to the establishment of a seasonal thermocline between spring and end of August/midst of September with vertical gradients exceeding 3 K/m in most of the years. Strength and depth of the thermocline vary locally and from year to year. Near-bottom tidal mixing and wind induced mixing at the surface suppress stratification in areas shallower than 25 to 30 m. Stratified and vertically mixed areas are separated by so-called tidal mixing fronts.

In order to assess the summer state of the North Sea the BSH started its North Sea Summer Surveys (NSSS) in 1998. They cover the entire North Sea with seven coast to coast east-west sections between 54° and 60°N and additional stations between 54°N and the entrance of the English Channel. The surveys were realised at a time when thermal stratification is expected to be at its maximum and phytoplankton production has passed its maximum. With the exception of the first survey in 1998 all surveys served a fixed grid of vertical CTD casts (see red dots in Fig. 1). Between these fixed stations a towed CTD-system (1998-2008 the BSH *Delphin*, since 2009 an EIVA *MK2 ScanFish*) was deployed which oscillated between surface and bottom to record the distribution of relevant oceanographic parameters with high resolution in space and time (24 Hz). Both CTD-systems are recording temperature, salinity, fluorescence (chlorophyll-a, yellow substance), and oxygen concentration. Additionally, ship-mounted temperature-, salinity- and optical sensors provided data at about 4 m depth. In order to sample the transition area between North Sea and Atlantic the survey was expanded northwards to 62.5°N since 2010.

Due to technical problems and staff deficit there are no ScanFish measurements in 2015. This was compensated by about 40 additional vertical CTD stations marked with S in Fig. 1.

The objective of the NSSSs is the assessment of the oceanographic and chemical state of the North Sea, the calculation of heat and salt budgets, and the identification of changes due to climate change. The data are also used for the validation of operational and climate models and for the calibration of satellite-based ocean colour data and downstream products (Secchi depth, turbidity, CDOM, chlorophyll-a) which are used for assessments and MSFD reporting. All NSSSs are listed in Table 1. Most of the data are available via the German Oceanographic Data Centre (DOD) and the MERis MATCHup In-situ Database MERMAID.¹

¹ http://www.bsh.de/en/Marine_data/Observations/DOD_Data_Centre/index.jsp
<http://hermes.acri.fr/mermaid/home/home.php>

date of cruise	ship & cruise id
24.06.1998 – 16.07.1998	R/V Gauss 317
02.07.1999 – 22.07.1999	R/V Gauss 335
09.08.2000 – 23.08.2000	R/V Gauss 353
11.07.2001 – 02.08.2001	R/V Gauss 370
16.07.2002 – 31.07.2002	R/V Gauss 385
28.07.2003 – 13.08.2003	R/V Gauss 405
05.08.2004 – 20.08.2004	R/V Gauss 425
10.08.2005 – 29.08.2005	R/V Gauss 446
02.08.2006 – 20.08.2006	R/V Gauss 463
03.08.2007 – 17.08.2007	R/V Pelagia 273
21.07.2008 – 05.08.2008	R/V Pelagia 293
20.08.2009 – 09.09.2009	R/V Pelagia 311
04.08.2010 – 22.08.2010	R/V Pelagia 323
08.08.2011 – 28.08.2011	R/V Celtic Explorer 11010
07.08.2012 – 30.08.2012	R/V Celtic Explorer 12011
10.08.2013 – 04.09.2013	R/V Celtic Explorer 13012
01.08.2014 – 25.08.2014	R/V Celtic Explorer 14012
07.08.2015 – 30.08.2015	R/V Celtic Explorer 15013

Table 1: BSH North Sea Summer Surveys 1998-2015.

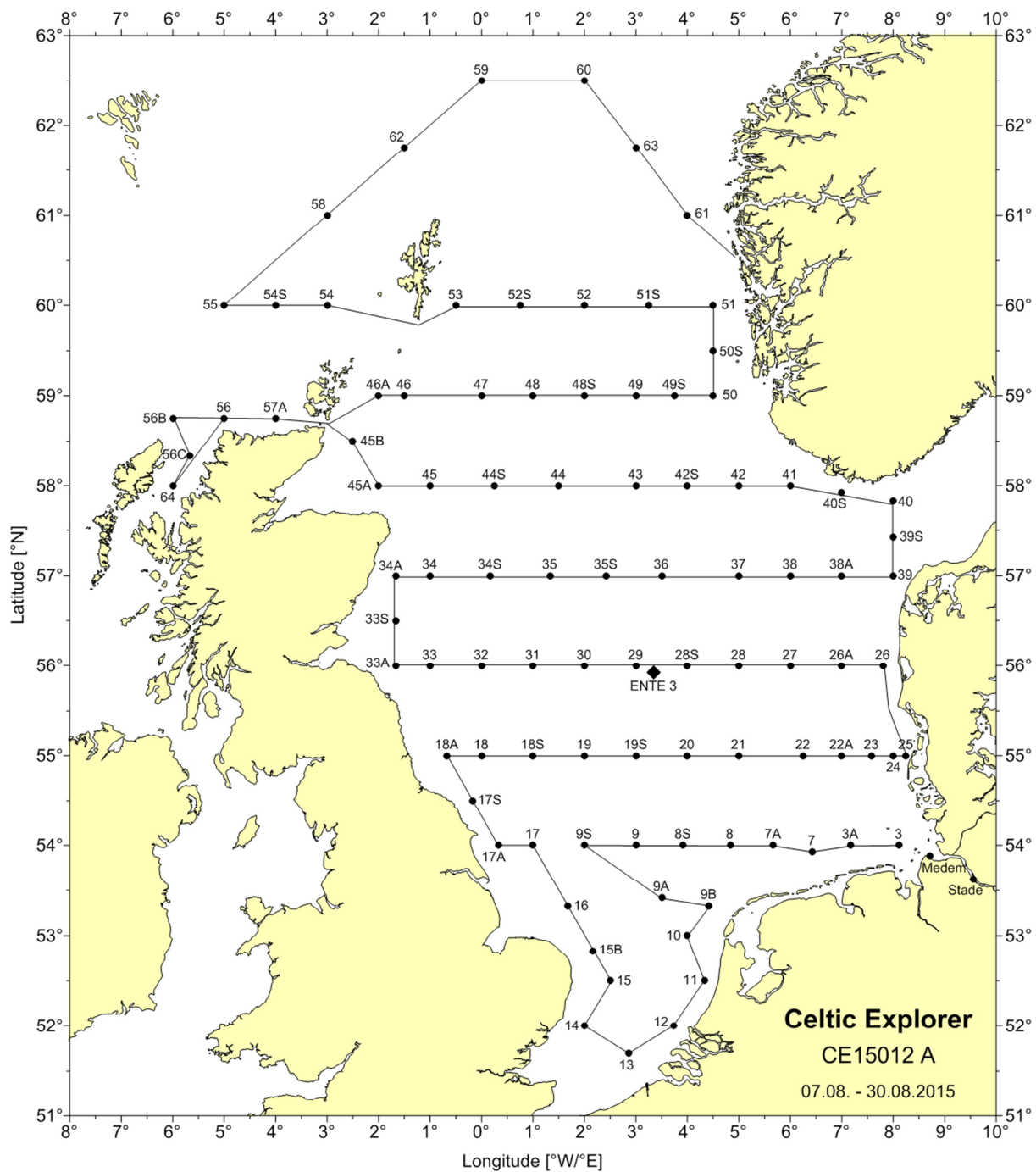


Fig. 2: Ship track and stations.

Equipment and Methods

Marine Physics:

- CTD 1 Seabird SBE 911+: SBE9, S/N 0577 (pressure); SBE3, S/N 2584 (temperature); SBE4, S/N 2886 (Conductivity); SBE 43, S/N 0180 (oxygen).
- WetLabs ECO fluorimeter, S/N FLNTURTB-3427 for turbidity and chlorophyll
- Rosette water sampler with twelve 10-liter bottles.
- Shipbased Seabird thermosal SBE 21 and Turner Fluorimeter for turbidity and chlorophyll.

Nutrients:

- Oxygen determination according to Winkler-Carpenter by means of a SIS Dissolved Oxygen Analyser (DOA) with photometric end point determination at selected depths.
- Continuous pH determination via the sea water pipe.
- Continuous phosphate, silicate (MiniMon), nitrite and nitrate determination via the sea water pipe and daily reference samples.
- Determination of the pH value (CTD samples).
- Determination of depth of visibility by means of a Secchi disk at daylight stations.
- Filtration of surface water samples and freezing of the glass fiber filters for the determination of chlorophyll according to Jeffrey and Humphrey after the cruise.
- Determination of alkalinity of sea water.
- Samples for the determination of $^{13}\text{C}/^{12}\text{C}$ at DIC (for IOW)
- Samples for the determination of $2\text{H}/1\text{H}$ and $^{18}\text{O}/^{16}\text{O}$ ratio (for IOW)

Radiochemistry:

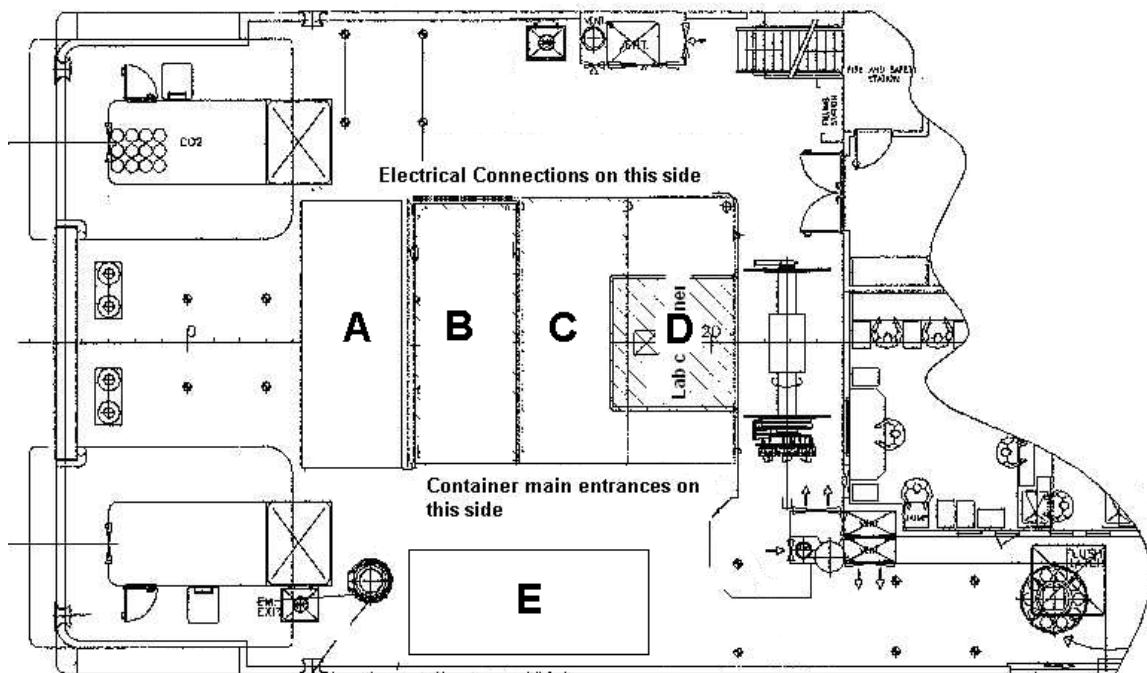
- 2 x 35 l surface water for the extraction of strontium 90 after the cruise.
- One liter surface samples for the analysis of tritium after the cruise.
- 100 l surface samples for the determination of plutonium und americium on board.
- 270 l samples taken at selected stations at great depths for the determination of strontium and tritium after the cruise and of cesium, plutonium, and americium on board.
- Three 600 l surface water samples for test purposes after the cruise.
- 100-150 l surface water samples for the on-board analysis of cesium-137 by means of a ion exchanger.

Atmospheric Chemistry

- Continuous trace gas analysis of nitric oxides (NO_x , NO und NO_2), of sulphur dioxide (SO_2), by ozone (O_3), and of carbon dioxide (CO_2) by means of Airpointer (Co. recordum/MLU).
- Remote sensing of NO_2 , SO_2 , and O_2 by MAX-DOAS measurements (Multi-axis Differential Absorption Spectroscopy, Institute of Environmental Physics, University of Bremen)

- Monitoring of current AIS signals in order to relate recorded emissions to ships passing.
- Collecting fine dust samples via a Riemer „High Volume Sampler“ Digital DHM-60 which will be analyzed for contaminants like sulfate and nitrate after the cruise.

Container Plan for leg a & b



	container type	weight	power supply	used on leg
A	Five 600 l drums for radioactivity and calibration lab			1
B	Bottom: 20" M33 lab container, height 3.1 m (HM)	9	2 x 32 A	2
B	Top: -			
C	Bottom: 20" Transport and store container	5 t	-	1&2
C	Top: -	-	-	-
D	Bottom: 20" M32 lab container for radioactivity, fresh- und sea water	5 t	32 A	1
D				
E	20" Transport container radioactivity	9 t	-	1
F	-			

F: Bow position

Diary

Time: UTC

↓ Specifications regarding fixed stations, ship stops for vertical CTD profiles and water sampling.

TN Tow of neuston net with 3 kn for sampling of micro plastics.

W&S Weather & Sea: T_A = air temperature, T_W = water temperature at 4 m depth
 T_W and salinity data are raw data from the ships thermosal SBE 21.

RA Radioactivity, sea water samples are taken for the following artificial nuclides:
Cs-137 = cesium-137; Sr-90 = strontium-90; Pu = plutonium, H-3 = tritium. If no samplers are used, samples are taken from the Seawater pipe.

Watch table Marine Physics:

00-04/12-16: Christian

04-08/16-20: Peter

08-12/20-00: Sören

Friday, August 7st, 2015

06:45: Arrival of the science crew at Celtic Explorer. Berth: Bützflethersand, Am Seehafen (BUSS Terminal Stade).

08:30: Arrival of containers and equipment and start of loading by use of the local crane.

Interview by Mrs. Volquardsen (NDR 90,3) and NDR Niedersachsen TV team (Mr. Schuch). Telephone interview by Mr. Junge (NDR Hörfunk Flensburg).

Preparation of the dry and wet lab and installation of sensor systems.

15:00: Security instructions by the second mate Diarmuid Joyce.

Saturday, August 8th, 2015

W&S 05:00: Bft. 1, 330°, 1018 hPa, T_A = 20.1 °C, overcast.

Klaus Becker must leave the vessel due to unexpected health problems.

07:10 Sailing.

↓ **07:37 – 07:49 Station STADE:**

RA: Cs-137, Sr-90, Pu, H-3.

W&S 08:00: Bft. 4, 360°, 1020 hPa, T_A = 20.5 °C, clear sky.

↓ **10:58 – 11:11 Station MEDEM:**

RA: Cs-137, Sr-90, Pu, H-3.

W&S 10:00: Bft. 4, 360°, 1021 hPa, T_A = 19.4 °C, clear sky.

- ↓ **13:10 - 13:31 Station GN003/ELBE1:**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients².
- W&S 14:00:** Bft. 4, 360°, 1024 hPa, $T_A = 18.0$ °C clear sky.
- ↓ **16:32 – 16:47 Station GN003A:**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients.
- TN 17:40 – 18:15:** Tow of the neuston net for micro plastics with 3 kn.
- W&S 18:15:** Bft. 2-5, 30°, 1024 hPa, $T_A = 16.2$ °C, clear sky.
- ↓ **20:03 – 20:19 Station GN007 (Borkumriffgrund):**
CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.
- ↓ **23:01 – 23:19 Station GN007A:**
CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.

Sunday, August, 9th, 2015

- ↓ **02:27 – 02:41 Station GN008:**
CTD profile with rosette sampler.
- W&S 05:00:** Bft. 4, 200°, 1021 hPa, $T_A = 17.7$ °C, clear sky.
- ↓ **06:18 – 06:27 Station GN008S:**
CTD profile with rosette sampler
- ↓ **09:33 – 09:48 Station GN009 (Outer Well Bank):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients.
- W&S 10:00:** Bft. 4, 200°, 1020 hPa, $T_A = 18.7$ °C, clear sky. $T_W = 16.6$ °C, 34.56 psu.
- ↓ **13:22 – 13:41 Station GN009S (Outer Silver Pit):**
CTD profile with rosette sampler
- W&S 14:00:** Bft. 4, 190°, 1019 hPa, $T_A = 18.2$ °C, coverd. $T_W = 17.3$ °C, 34.53 psu.
- TN 17:05 – 17:50:** Tow of the neuston net for micro plastics with 3 kn.
- W&S 20:00:** Bft. 2-3, 150°, 1019 hPa, $T_A = 18.7$ °C, cloudy. $T_W = 18.0$ °C, 34.47 psu.
- ↓ **20:07 – 20:18 Station GN009A:**
CTD profile with rosette sampler. RA: Cs-137. Nutrients.
- ↓ **23:48 – 00:05 Station GN009B:**
Secchi depth and CTD profile with rosette sampler.
RA: Cs-137, Sr-90, Pu, H-3.

Monday, August 10th, 2015

- ↓ **03:18 – 03:35 Station GN010 (west of Den Helder):**
CTD profile with rosette sampler.

² For details of nutrient sampling refer to Appendix 5.

- W&S 04:30:** Bft. 4, 200°, 1017 hPa, $T_A = 18.8$ °C, cloudy. $T_W = 18.6$ °C, 34.47 psu.
- ↓ **06:50 – 06:51 Station GN011 (west of Ijmuiden)**
Secchi depth, CTD profile with rosette sampler and nutrients.
Extended patches of red algae blooms between GN011 and GN012.
- ↓ **11:44 – 11:57 Station GN012 (west of Hoek van Holland):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients.
- W&S 14:00:** Bft. 3, 245°, 1017 hPa, $T_A = 19.4$ °C, cloudy. $T_W = 19.7$ °C, 34.43 psu.
- ↓ **16:00 – 16:15 Station GN013 (Rabsbank):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients.
- ↓ **19:57 - 20:08 Station GN014 (Outer Gabbard):**
CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.
- W&S 20:30:** Bft. 5, 220°, 1016 hPa, $T_A = 19.9$ °C, cloudy. $T_W = 18.9$ °C, 34.92 psu.
- ↓ **23:34 – 23:46 Station GN015 (east of Lowestoft):**
CTD profile with rosette sampler. RA: Cs-137.

Tuesday, August 11th, 2015

- ↓ **02:05 – 02:19 Station GN015B:**
Secchi depth and CTD profile with rosette sampler.
- W&S 05:00:** Bft. 3-4, 10°, 1017 hPa, $T_A = 17.7$ °C, clear sky. $T_W = 16.8$ °C, 34.15 psu.
- ↓ **06:08 – 06:18 Station GN016 (Haddock Bank):**
Secchi depth, CTD profile with rosette sampler and nutrients.
- W&S 10:00:** Bft. 3, 320°, 1020 hPa, $T_A = 16.9$ °C, clear sky. $T_W = 15.5$ °C, 34.61 psu.
- ↓ **10:44 – 10:55 Station GN017 (east of Flamborough Head):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137. Nutrients.
- ↓ **13:22 – 13:38 Station GN017A:**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients.
- W&S 14:00:** Bft. 3, 130°, 1021 hPa, $T_A = 17.9$ °C, cloudy. $T_W = 15.3$ °C, 34.03 psu.
- ↓ **17:10 – 17:23 Station GN0017S:**
CTD profile with rosette sampler.
- TN 17:35 – 18:10:** Tow of the neuston net for micro plastics with 3 kn.
- W&S 18:00:** Bft. 4, 150°, 1022 hPa, $T_A = 15.6$ °C, cloudy. $T_W = 15.6$ °C, 34.13 psu.
- ↓ **21:01 – 21:13 Station GN018A:**
CTD profile with rosette sampler. RA: Cs-137.
- ↓ **23:36 – 23:54 Station GN018 (Baymans Hole):**
CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.

Wednesday, August 12th, 2015

- ↓ **03:08 – 03:25 Station GN0018S:**
CTD profile with rosette sampler
- W&S 05:00:** Bft. 1, 230°, 1025 hPa, $T_A = 16.9$ °C, cloudy. $T_W = 17.1$ °C, 34.47 psu.
- ↓ **06:43 – 06:55 Station GN019 (Doggerbank):**
Secchi depth, CTD profile with rosette sampler and nutrients.
The CTD was covered with jellyfish and had to be cleared with sea water.
- W&S 10:00:** Bft. 0, -°, 1026 hPa, $T_A = 17.2$ °C, clear sky. $T_W = 17.1$ °C, 34.59 psu.
- ↓ **10:20 – 10:34 Station GN0019S:**
Secchi depth and CTD profile with rosette sampler.
- W&S 14:00:** Bft. 2, 70°, 1026 hPa, $T_A = 20.1$ °C, clear sky. $T_W = 17.6$ °C, 34.63 psu.
- ↓ **14:16 – 14:35 Station GN020 (east of Doggerbank):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137. Nutrients.
- TN 17:00 – 17:45:** Tow of the neuston net for micro plastics with 3 kn.
- W&S 18:00:** Bft. 3, 60°, 1025 hPa, $T_A = 19.8$ °C, clear sky. $T_W = 18.0$ °C, 34.44 psu.
- ↓ **18:30 – 18:42 Station GN021/AWZW2 (Nordschillgrund):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137. Nutrients.
- ↓ **23:06 – 23:18 Station GN022 (Weiße Bank):**
CTD profile with rosette sampler. RA: Cs-137.

Thursday, August 13th, 2015

- ↓ **02:09 – 02:21 Station GN022A:**
CTD profile with rosette sampler.
- ↓ **04:40 – 04:58 Station GN023:**
Secchi depth, CTD profile with rosette sampler and nutrients.
- W&S 05:30:** Bft. 5, 80°, 1024 hPa, $T_A = 15.5$ °C, clear sky. $T_W = 18.4$ °C, 31.42 psu.
- ↓ **07:19 – 07:31 Station GN025 (west of Sylt):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.
Nutrients.
- W&S 11:00:** Bft. 3, 70°, 1023 hPa, $T_A = 18.9$ °C, clear sky. $T_W = 18.5$ °C, 32.35 psu.

Between Horns Rev and GN026 strong red tides in form of patched and extended stripes along oceanic frontal zones known from ocean colour satellite data have been observed.



Fig. 3: *The Red Tide between Horns Rev and GN026.*

- W&S 14:00:** Bft. 5, 20°, 1022 hPa, $T_A = 19.2$ °C, clear sky. $T_W = 18.7$ °C, 32.23 psu.
- ↓ **14:58 – 15:14 Station GN026 (west of Lyngvik):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients.
- TN 17:00 – 18:00:** Tow of the neuston net for micro plastics with 3 kn.
- W&S 18:00:** Bft. 5, 50°, 1019 hPa, $T_A = 16.5$ °C, clear sky. $T_W = 18.7$ °C, 33.09 psu.
- ↓ **18:31 – 18:41 Station GN026A:**
CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.
- ↓ **21:57 – 22:10 Station GN027:**
CTD profile with rosette sampler. RA: Cs-137.
- W&S 22:00:** Bft. 4, 70°, 1017 hPa, $T_A = 16.4$ °C. $T_W = 17.5$ °C, 34.32 psu.

Friday, August 14th, 2014

- ↓ **01:31 – 01:46 Station GN028:**
CTD profile with rosette sampler.
- W&S 05:00:** Bft. 6, 100°, 1010 hPa, $T_A = 17.2$ °C, overcast. $T_W = 16.8$ °C, 34.73 psu.
- ↓ **04:56 – 05:19 Station GN0028S:**
CTD profile with rosette sampler.
- 07:22 – 07:28 Station ENTE3:**
600 liter sample of surface sea water for radioactivity.
- ↓ **08:54 – 09:06 Station GN029:**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients.
- W&S 10:00:** Bft. 5, 140°, 1006 hPa, $T_A = 16.7$ °C, overcast. $T_W = 16.9$ °C, 34.75 psu.

- ↓ **12:38 – 13:00 Station GN030:**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137. Nutrients.
- W&S 14:00:** Bft. 5, 140°, 1004 hPa, $T_A = 16.5$ °C, overcast. $T_W = 16.6$ °C, 34.70 psu.
- ↓ **16:28 – 16:42 Station GN031:**
CTD profile with rosette sampler. RA: Cs-137. Nutrients.
- TN 16:44 – 17:44:** Tow of the neuston net for micro plastics with 3 kn.
- W&S 18:45:** Bft. 3, 190°, 1002 hPa, $T_A = 16.4$ °C, fog. $T_W = 16.6$ °C, 34.59 psu.
- ↓ **21:00 – 21:12 Station GN032:**
CTD profile with rosette sampler. RA: Cs-137.

Saturday, August 15th, 2015

- ↓ **00:45 – 01:03 Station GN033 (east of Firth of Forth):**
CTD profile with rosette sampler.
- ↓ **03:29 – 03:47 Station GN033A:**
CTD profile with rosette sampler.
- W&S 05:00:** Bft. 4-5, 270°, 1006 hPa, $T_A = 11.8$ °C, rain. $T_W = 14.7$ °C, 33.96 psu.
- ↓ **06:55 – 07:05 Station GN0033S:**
CTD profile with rosette sampler.
- W&S 10:00:** Bft. 1-2, 150°, 1007 hPa, $T_A = 12.4$ °C, rain. $T_W = 13.3$ °C, 34.50 psu.
- ↓ **10:08 – 10:27 Station GN034A:**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients.
- ↓ **12:49 – 13:11 Station GN034 (Aberdeen Bank):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137. Nutrients.
Close to GN034 one or two long finned pilot whales and a bottlenose dolphin.
- W&S 14:00:** Bft. 3, 240°, 1009 hPa, $T_A = 14.0$ °C, overcast. $T_W = 14.1$ °C, 34.62 psu.
- ↓ **17:10 – 17:27 Station GN0034S:**
CTD profile with rosette sampler.
- TN 17:30 – 18:30:** Tow of the neuston net for micro plastics with 3 kn.
- W&S 21:30:** Bft. 3, 250°, 1013 hPa, $T_A = 15.6$ °C, cloudy. $T_W = 16.0$ °C, 34.81 psu.
- ↓ **22:05 – 22:24 Station GN035 (Coal Pitt):**
CTD profile with rosette sampler. RA: Cs-137.

Sunday, August 16th, 2015

- ↓ **01:59 – 02:22 Station GN0035S:**
CTD profile with rosette sampler.
- W&S 05:00:** Bft. 2, 270°, 1014 hPa, $T_A = 13.9$ °C, cloudy. $T_W = 16.2$ °C, 34.85 psu.
- ↓ **05:52 – 06:03 Station GN036:**
Secchi depth, CTD profile with rosette sampler and nutrients.

- W&S 10:00:** Bft. 3, 350°, 1016 hPa, $T_A = 16.2$ °C, cloudy. $T_W = 16.4$, 34.78 psu.
Close to GN037 a pod of breaching dolphins, however, too far away to determine species.
- ↓ **10:35 – 10:53 Station GN037 (Große Fischerbank):**
CTD profile with rosette sampler. RA: Cs-137. Nutrients.
- ↓ **14:04 – 14:20 Station GN038 (Kleine Fischerbank):**
CTD profile with rosette sampler. RA: Cs-137. Nutrients.
- W&S 15:00:** Bft. 2, 80°, 1016 hPa, $T_A = 16.1$ °C, overcast. $T_W = 16.6$ °C, 34.61 psu.
- TN 17:00 – 18:00:** Tow of the neuston net for micro plastics with 3 kn. In the net we found several buoy barnacles (*Dosima Fuscicularis*) which are normally not found in the North Sea.
- ↓ **18:18 – 18:29 Station GN038A:**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.
- W&S 18:30:** Bft. 4, 70°, 1015 hPa, $T_A = 16.6$ °C, overcast. $T_W = 16.9$ °C, 34.39 psu.
- ↓ **21:49 – 22:01 Station GN039 (E-lich Jyske Rev):**
CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.

Monday, August 17th, 2015

- ↓ **00:40 – 01:02 Station GN039S:**
CTD profile with rosette sampler.
- ↓ **03:53 – 04:21 Station GN040 (Skagerrak):**
CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.
- W&S 05:00:** Bft. 6, 60°, 1019 hPa, $T_A = 17.0$ °C, cloudy. $T_W = 17.9$ °C, 30.58 psu.
Station GN040S was cancelled due to strong tidal currents (>4.5 kn).
- W&S 10:00:** Bft. 4-5, 80°, 1018 hPa, $T_A = 17.6$ °C, overcast. $T_W = 17.4$ °C, 30.21 psu.
- ↓ **10:31 – 11:09 Station GN041 (west of Lindesnes):**
CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients.
- W&S 14:00:** Bft. 1-2, 100°, 1018 hPa, $T_A = 17.4$ °C, overcast. $T_W = 15.3$ °C, 34.82 psu.
- ↓ **14:19 – 14:40 Station GN042 (Eigersundbank):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137. Nutrients.
- TN 17:00 – 18:00:** Tow of the neuston net for micro plastics with 3 kn. Again some buoy barnacles in the net.
- W&S 18:00:** Bft. 5, 80°, 1017 hPa, $T_A = 16.9$ °C, overcast. $T_W = 15.8$ °C, 34.68 psu.
- ↓ **18:38 – 18:56 Station GN0042S:**
CTD profile with rosette sampler.
- ↓ **22:17 – 22:34 Station GN043 (Lingbank East):**
CTD profile with rosette sampler.

Tuesday, August 18th, 2015

- ↓ **03:16 – 03:36 Station GN044 (Lingbank West):**
CTD profile with rosette sampler.
- W&S 05:00:** Bft. 5, 110°, 1015 hPa, $T_A = 16.3$ °C, overcast. $T_W = 15.1$ °C, 34.98 psu.
- ↓ **07:37 – 07:53 Station GN0044S:**
CTD profile with rosette sampler.
- ↓ **11:55 – 12:14 Station GN045 (east of South Bank):**
Secchi depth, CTD profile with rosette sampler and nutrients.
- W&S 13:00:** Bft. 4, 100°, 1015 hPa, $T_A = 14.8$ °C, rain. $T_W = 14.1$ °C, 34.95 psu.
- ↓ **15:33 – 15:51 Station GN045A (Moray Firth):**
CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.
- TN 17:00 – 18:00:** Tow of the neuston net for micro plastics with 3 kn.
- ↓ **19:56 – 20:08 Station GN045B (east of Pentland Firth):**
CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.
- W&S 20:15:** Bft. 4, 90°, 1012 hPa, $T_A = 16.3$ °C, rain. $T_W = 13.3$ °C, 34.71 psu.
Passage of Pentland Firth westward bound

Wednesday, August 19th, 2015

- W&S 05:00:** Bft. 2, 140°, 1009 hPa, $T_A = 12.5$ °C, fog. $T_W = 13.7$ °C, 34.68 psu.
- ↓ **05:57 – 06:12 Station GN057A (W-lich Pentland Firth):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.
Nutrients.
- ↓ **09:20 – 09:35 Station GN056 (Cape Wrath):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.
Nutrients.
- W&S 10:00:** Bft. 4, 100°, 1008 hPa, $T_A = 12.5$ °C, cloudy. $T_W = 13.4$ °C, 34.65 psu.
- TN 14:50 – 15:50:** Tow of the neuston net for micro plastics with 3 kn.
- ↓ **12:52 – 15:45 Station GN056B (Butt of Lewis):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.
Two 270 l samples (bottom and 50 m) for RA. Nutrients.
- W&S 15:00:** Bft. 4, 100°, 1006 hPa, $T_A = 14.7$ °C, cloudy. $T_W = 14.2$ °C, 34.89 psu.
- ↓ **18:42 – 18:58 Station GN056C (North Minch):**
CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.
- W&S 19:00:** Bft. 4, 210°, 1007 hPa, $T_A = 14.8$ °C, rain. $T_W = 13.9$ °C, 34.58 psu.
- ↓ **21:23 – 21:44 Station GN064 (Shiant East Bank):**
CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3, and 2 x 600 liter
surface sea water.

Thursday, August 20th, 2015

- W&S 06:00:** Bft. 2, 80°, 1012 hPa, $T_A = 13.4$ °C, overcast. $T_W = 13.6$ °C, 34.66 psu.
Passage of Pentland Firth eastward bound.
- W&S 10:00:** Bft. 3-4, 140°, 1013 hPa, $T_A = 14.3$ °C, cloudy. $T_W = 13.3$ °C, 34.73 psu.
- W&S 14:00:** Bft. 4-5, 160°, 1014 hPa, $T_A = 13.5$ °C, fog. $T_W = 13.1$ °C, 34.81 psu.
- ↓ **14:00 – 14:19 Station GN046A:**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients.
- ↓ **16:29 – 16:46 Station GN046:**
Secchi depth, CTD profile with rosette sampler and nutrients.
- W&S 18:00:** Bft. 5-6, 170°, 1013 hPa, $T_A = 13.7$ °C, overcast. $T_W = 13.0$ °C, 35.06 psu.
Southerly swell.
- TN 16:50 – 18:50:** Tow of the neuston net for micro plastics with 3 kn.
- ↓ **22:32 – 22:49 Station GN047 (Fladengrund Rinne):**
CTD profile with rosette sampler.

Friday, August 21st, 2015

- ↓ **02:26 – 02:48 Station GN048:**
CTD profile with rosette sampler.
- W&S 05:00:** Bft. 5-6, 170°, 1015 hPa, $T_A = 15.4$ °C, overcast. $T_W = 15.0$ °C, 34.98 psu.
Southerly swell.
- ↓ **06:29 – 06:50 Station GN0048S:**
CTD profile with rosette sampler.
- W&S 10:00:** Bft. 5-6, 160°, 1017 hPa, $T_A = 15.7$ °C, overcast. $T_W = 14.9$ °C, 35.05 psu.
Strong southerly swell.
- ↓ **10:34 – 11:25 Station GN049 (Utsira Grund):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137. Nutrients.
- ↓ **14:26 – 15:02 Station GN0049S:**
Secchi depth and CTD profile with rosette sampler.
- W&S 15:00:** Bft. 6-7, 150°, 1019 hPa, $T_A = 16.3$ °C, overcast. $T_W = 15.0$ °C, 34.63 psu.
Strong southerly swell.
- W&S 18:00:** Bft. 7, 160°, 1020 hPa, $T_A = 16.4$ °C, overcast. $T_W = 16.5$ °C, 31.86 psu.
Strong southerly swell.
- ↓ **18:06 – 18:57 Station GN050 (Utsira Loch):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients.
- ↓ **21:45 – 22:19 Station GN0050S:**
CTD profile with rosette sampler.

Saturday, August 22nd, 2015

- ↓ **01:47 – 02:23 Station GN051 (west of Selbjørnsfjord):**
CTD profile with rosette sampler.
- W&S 05:30:** Bft. 7, 160°, 1018 hPa, $T_A = 15.1$ °C, overcast. $T_W = 14.6$ °C, 35.10 psu.
Strong southerly swell.
- ↓ **06:31 – 06:57 Station GN0051S:**
CTD profile with rosette sampler.
- W&S 10:30:** Bft. 5-6, 160°, 1017 hPa, $T_A = 15.3$ °C, overcast. $T_W = 15.0$ °C, 34.95 psu.
Strong southerly swell.
- ↓ **11:00 – 11:58 Station GN052 (Bergen Bank):**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137. Nutrients.
- W&S 10:30:** Bft. 4, 160°, 1018 hPa, $T_A = 14.7$ °C, fog. $T_W = 14.8$ °C, 35.06 psu.
- 15:47 – 16:03 Station GN0052S:**
CTD profile with rosette sampler and 2 × 600 l surface sea water samples for calibration lab.
- TN 16:10 – 17:10:** Tow of the neuston net for micro plastics with 3 kn.
- W&S 18:00:** Bft. 2-3, 200°, 1018 hPa, $T_A = 13.9$ °C, overcast. $T_W = 13.9$ °C, 35.14 psu.
- ↓ **20:35 – 20:51 Station GN053 (E-lich Shetlands):**
CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3.

Sunday, August 23rd, 2015

- ↓ **04:18 – 05:07 Station GN054 (Otter Bank):**
Secchi depth, CTD profile with rosette sampler and nutrients.
- W&S 06:00:** Bft. 6, 110°, 1014 hPa, $T_A = 13.4$ °C, fog. $T_W = 14.0$ °C, 35.12 psu.
- ↓ **08:12 – 08:28 Station GN0054S:**
CTD profile with rosette sampler.
- W&S 10:00:** Bft. 6, 120°, 1011 hPa, $T_A = 15.0$ °C, fog. $T_W = 14.0$ °C, 35.17 psu.
- ↓ **11:32 – 12:11 Station GN055**
RA: Cs-137, Sr-90, Pu, H-3.
Secchi depth, CTD, and 270 l samplers could not be deployed due to strong currents and sea state. Several attempts for a CTD cast failed, because the wire was always torn under the hull of the vessel.
- W&S 18:00:** Bft. 5-6, 120°, 1012 hPa, $T_A = 15.0$ °C, cloudy. $T_W = 13.1$ °C, 35.15 psu.
- ↓ **20:14 – 21:07 Station GN058:**
CTD profile with rosette sampler. RA: Cs-137.

Monday, August 24th, 2015

- ↓ **03:15 – 04:25 Station GN062:**
CTD profile with rosette sampler.
- W&S 05:00:** Bft. 5, 90°, 1013 hPa, $T_A = 14.2$ °C, clear sky. $T_W = 13.5$ °C, 35.16 psu.
- W&S 10:00:** Bft. 3, 130°, 1014 hPa, $T_A = 15.1$ °C, clear sky. $T_W = 13.1$ °C, 35.06 psu.

- ↓ **10:28 – 11:52 Station GN059:**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients.
- ↓ **17:19 – 18:09 Station GN060:**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137. Nutrients.
- W&S 18:00:** Bft. 4, 80°, 1011 hPa, $T_A = 17.9$ °C, clear sky. $T_W = 14.2$ °C, 34.99 psu.
- TN 18:10 – 19:10:** Tow of the neuston net for micro plastics with 3 kn.

Tuesday, August 25th, 2015

- ↓ **23:58 – 00:33 Station GN063:**
CTD profile with rosette sampler.
- W&S 05:00:** Bft. 4, 70°, 1003 hPa, $T_A = 16.6$ °C, cloudy. $T_W = 16.2$ °C, 34.98 psu.
- ↓ **06:20 – 07:17 Station GN061:**
Secchi depth and CTD profile with rosette sampler. RA: Cs-137, Sr-90, Pu, H-3. Nutrients.

Wednesday, August 26th, 2015

Arrival in Bergen in the early afternoon (Festningskaaien 1).

Thursday, August 27th, 2015 and Friday, August 28th, 2015

Final processing of the last water samples for RA and nutrients. Arrangements for the second leg. Set-up of Clean-CTD for the next leg. Cleaning of the facilities.

Saturday, August 29th, 2015

16:00: Arrival of a new science crew for the second leg. Handover of chemistry labs and arrangements for the second leg. Arrangements for next day the crew change.

21:00: Change of the Celtic Explorer crew.

Sunday, August 30th, 2015

Crew change of BSH team and return flight to Hamburg via Copenhagen.

Preliminary findings

With the exception of statements concerning the area averaged North Sea sea surface temperature (SST), all assessments are basing on CTD raw data collected during the cruise. All temperature and salinity data will be processed and – if necessary – re-calibrated after the cruise.

In 2015 the monthly means of the area averaged North Sea SST started with positive anomalies of 0.9 K in January and 0.8 K March (reference period 1971-1993). Then the SST was dropping with negative anomalies of -0.3 and -0.2 in June and July. During August there was a strong heating due to increasing solar radiation, causing again a positive anomaly of 0.4 K and a monthly SST mean of 15.4 °C.³

SST is a reliable representative for the temperature of the seasonal mixed layer. Due to increasing solar radiation the North Sea established a seasonal stratification during spring over wide areas of the North Sea which last normally until end of August or beginning of September. Then the water column will be vertically mixed again by the first fall storms. The upper layer is separated from the colder bottom layer by a sharp thermocline with vertical gradients of the order of 3 K/m. While the oceanographic conditions in the upper layer are mainly determined by local radiation, the conditions in the bottom layer are influenced by the inflow of Atlantic Water (AW) with salinities >35 psu via the northern open boundary to the Atlantic and to a lesser degree via the English Channel. Only the knowledge of the hydrographic condition in both layers, determined by the spatial distribution of temperature and salinity, allows the calculation of heat and salt budgets.

The spatial structure of temperature distribution (see Figs. 4, 6, 8 and 9) corresponds largely to that of the reference period (RP) 2000-2010 with upper mixed layer depths between 20 and 30 m and the shallow south-eastern part of the North Sea vertically mixed. However, in 2015 the mixed layer temperatures of the 54° and 55°N sections correspond to the PR, while the northern section are 1-2 K cooler than the RP.

Atlantic Water >34 psu intrudes from the northern boundary (see Figs. 5, 7, 8 and 9) southward into the North Sea. The salinity sections along 58°, 59°, and 60°N show clearly the three main paths marked by the 35.25 isohalines: The western path through the Fair Isle Channel, the central path over the East Shetland Shelf and the eastern path at the western slope of the Norwegian Trench at depths between 250 and 450m. The tongue of Atlantic Water is traceable southward down to 56°N, 3°E reaching the north-westerly boundary of the German EEZ.

Concerning SST the summer 2015 was close to the climatological mean, this holds also for the volume temperature of the southern North Sea. The calculation of the total heat and salt contents will be possible not before the re-processing of the data at BSH.

³ http://www.bsh.de/en/Marine_data/Observations/Sea_surface_temperatures/index.jsp

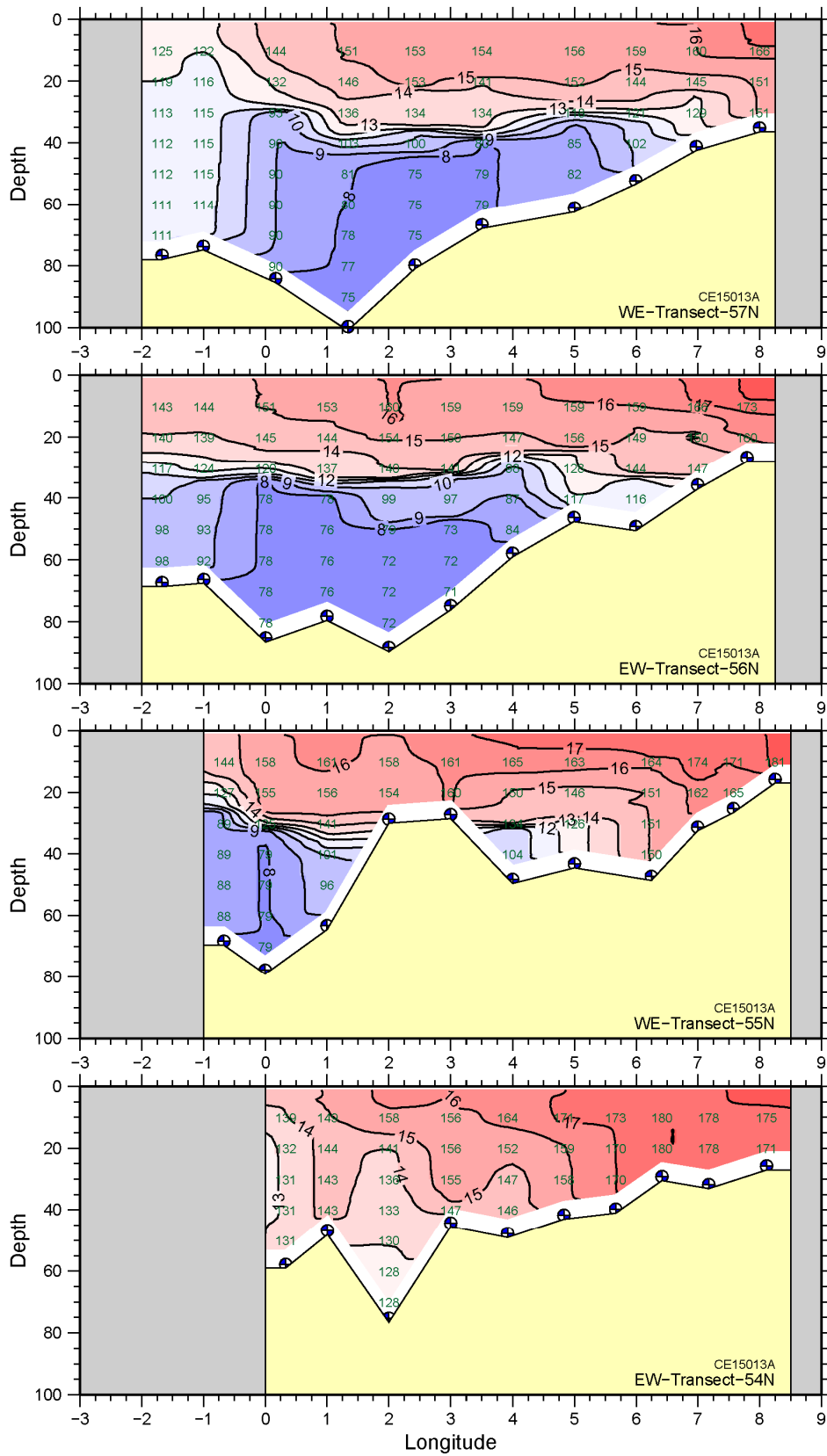


Fig. 4: Vertical temperature distribution along the 54°, 55°, 56°, and 57°N sections basing on CTD raw data. The numbers in the section give temperatures $\times 10$ for selected data points.

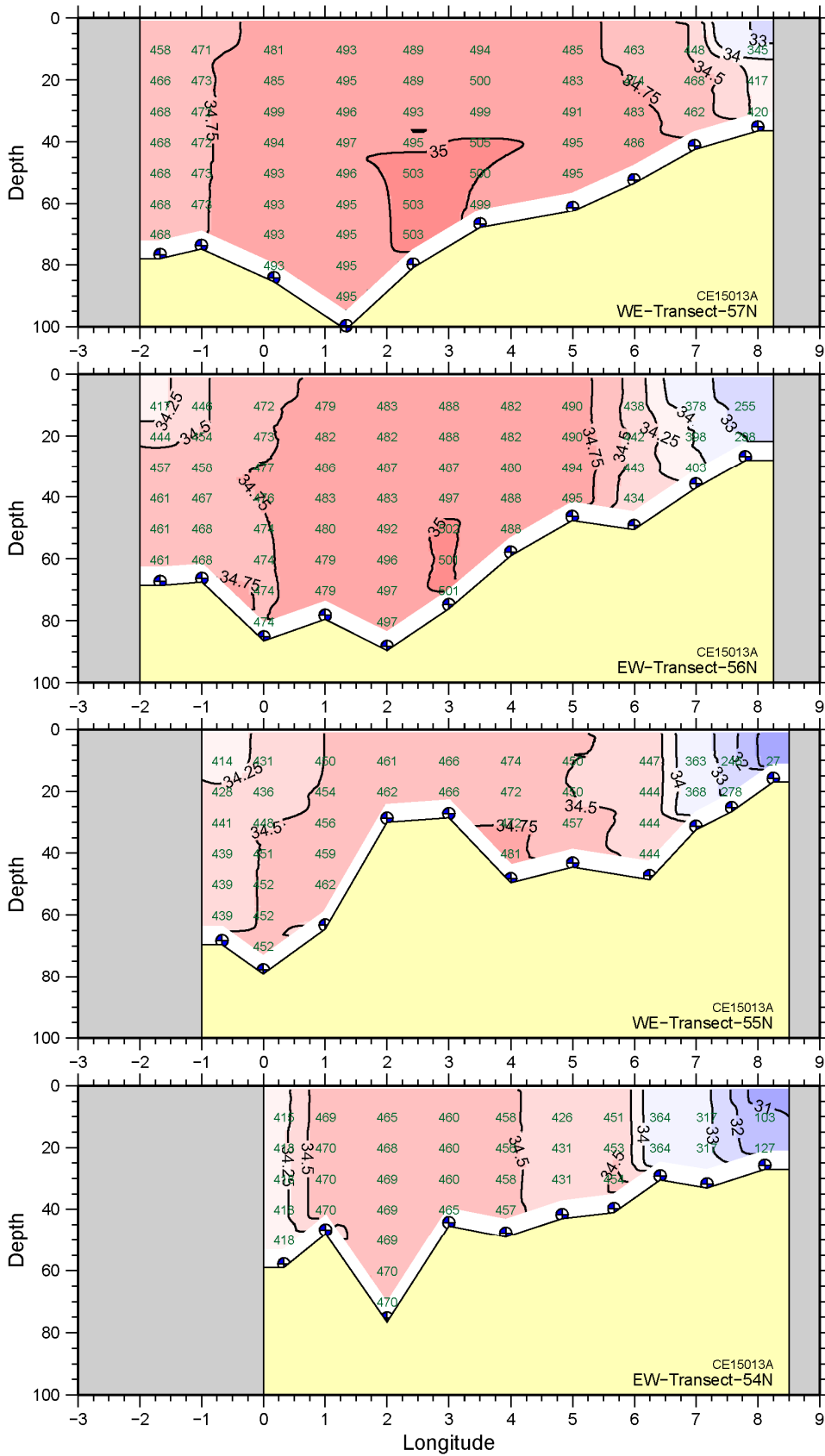


Fig. 5: Vertical salinity distribution along the 54°, 55°, 56°, and 57°N sections basing on CTD raw data. The numbers in the section give (salinities × 100) - 3000 for selected data points.

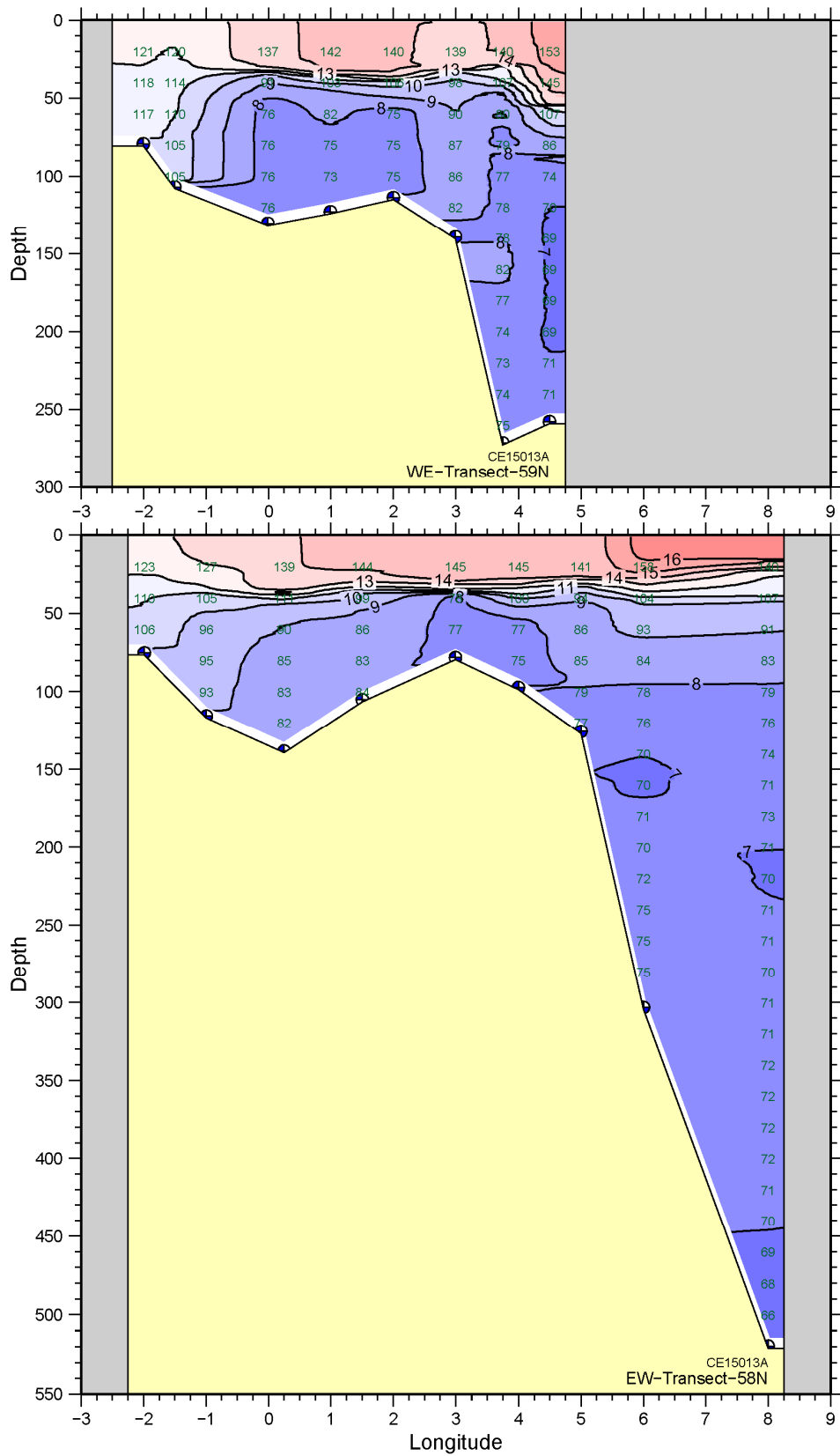


Fig. 6: Vertical temperature distribution along the 58° and 59°N sections basing on CTD raw data. The numbers in the section give temperatures $\times 10$ for selected data points.

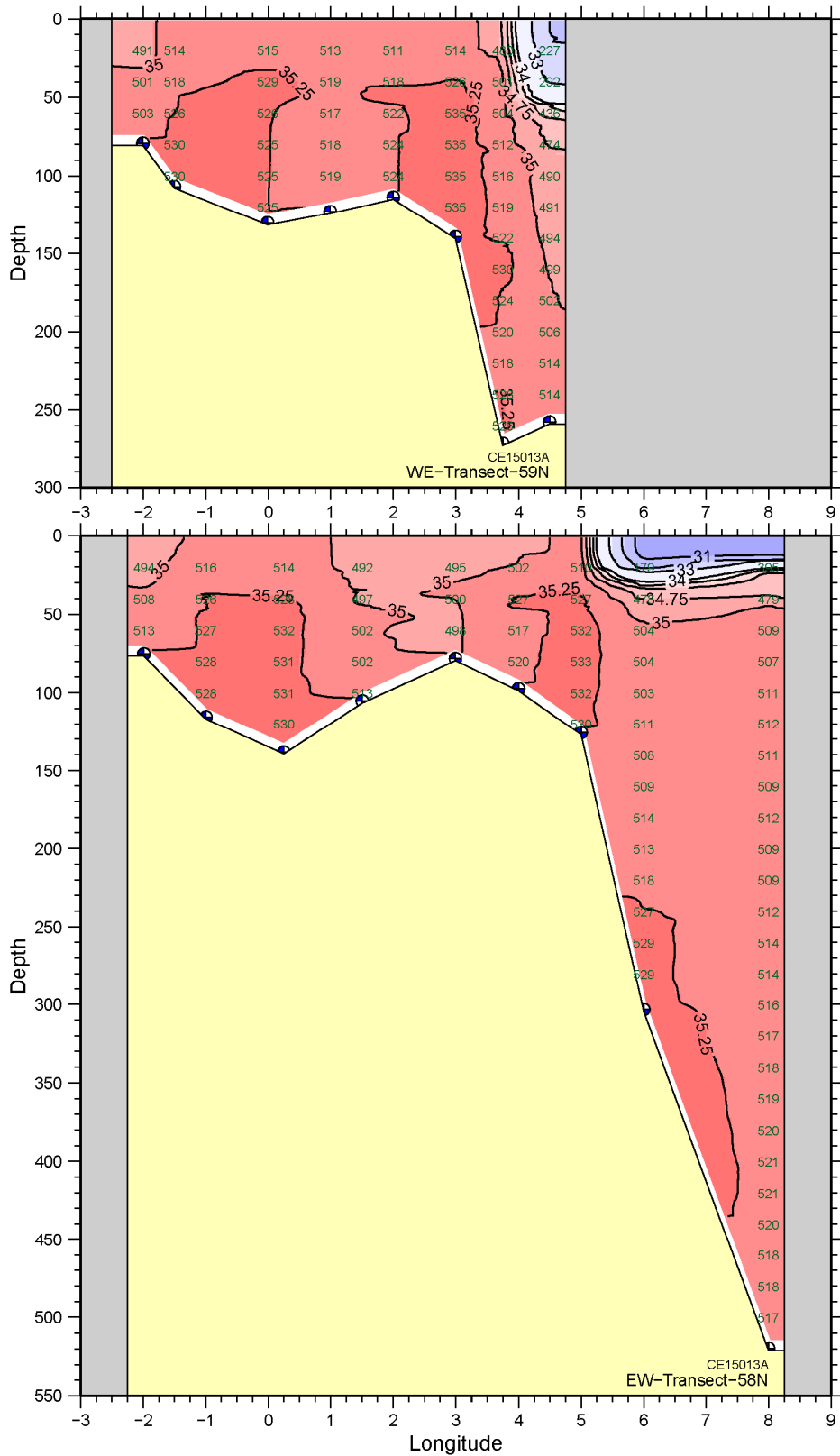


Fig. 7: Vertical salinity distribution along the 58° and 59°N sections basing on CTD raw data. The numbers in the section give (salinities × 100) - 3000 for selected data points

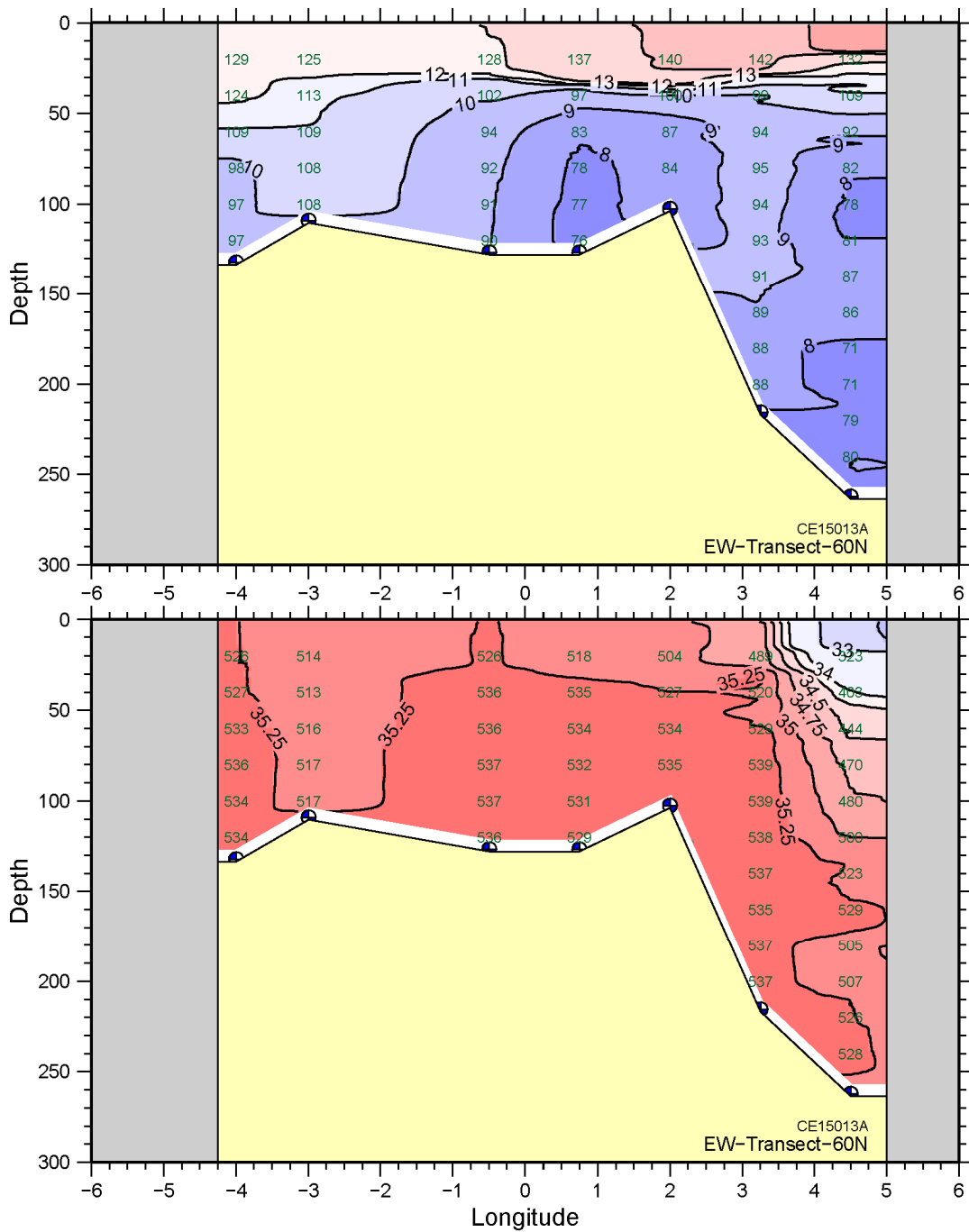


Fig. 8: Vertical temperature (top) and salinity (bottom) distribution along the 60°N section basing on CTD raw data. The numbers in the section give the temperatures $\times 10$ and (salinities $\times 100$) - 3000 for selected data points.

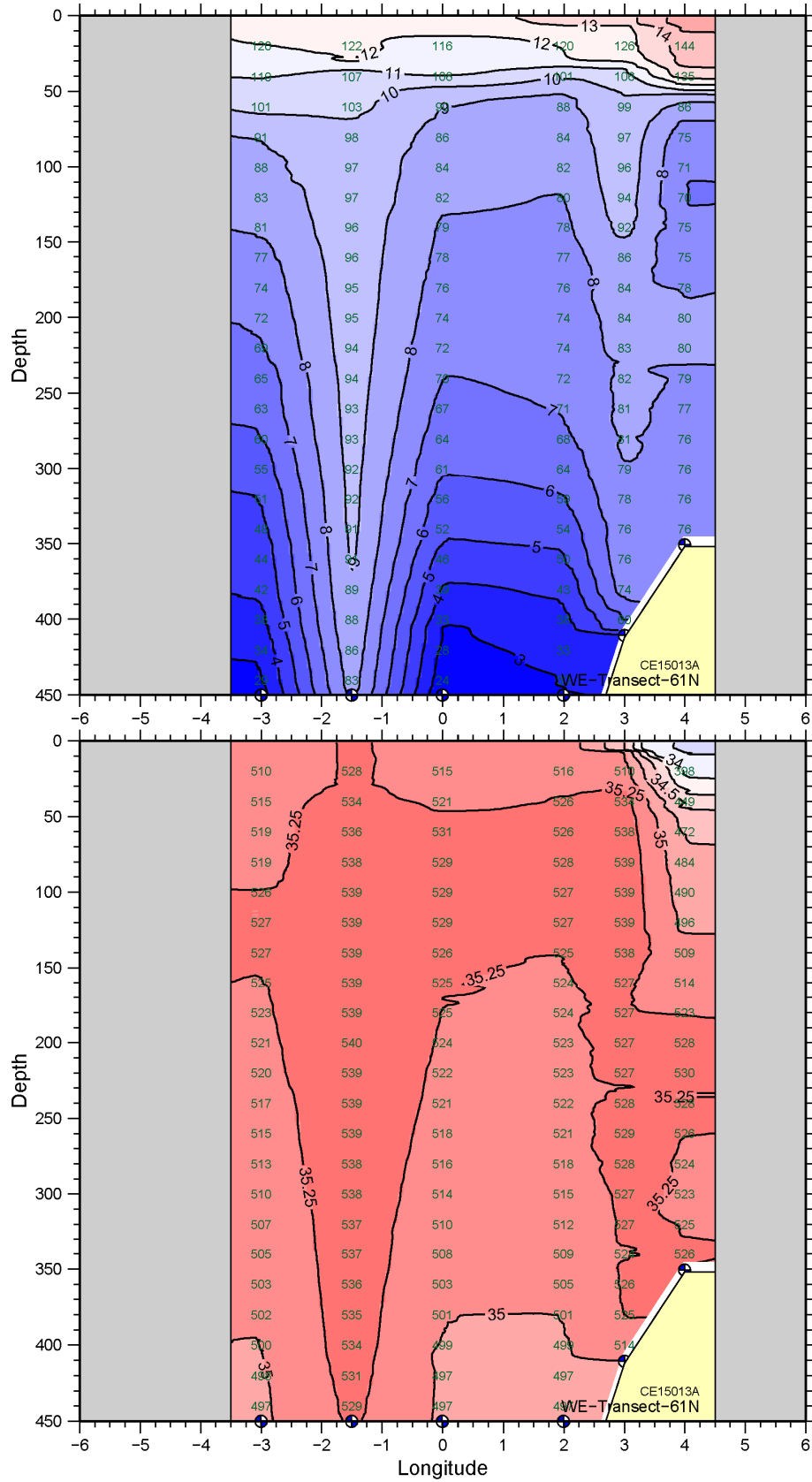


Fig. 9: Vertical temperature (top) and salinity (bottom) section from station GN058 (left) to GN061 (right) basing on CTD raw data. The numbers in the section give the temperatures $\times 10$ and (salinities $\times 100$) - 3000 for selected data points

Acknowledgement

All participants accomplished a big amount of work in a good temper and made the North Sea Summer Survey – despite the reduced head count – a big success! Thank you very much to all of you!

The help and professional support of captain Antony Hobin and his crew is gratefully acknowledged.

Holger Klein

Bergen, August 30th, 2015

Appendix 1: List of samples

CTD-profiles with rosette:	95 stations
Secchi depth:	35 stations (daylight stations only)
Salinity:	222 samples
Stations for radioactivity:	57 stations
Oxygen:	40 samples
pH-value:	40 samples
Chlorophyll:	37 samples
Alkalinity:	40 samples
d18O	40 samples
d13C	40 samples
Radioactivity (artificial nuclides):	36 samples à 2 35-l-drums Strontium-90 (pure) 36 samples 1-l-bottles Tritium (pure) 36 samples à 100 l Plutonium and Americium (concentrated) 57 samples à 150 l Caesium-137 (concentrated)

Appendix 2: Surface and bottom temperatures and salinities

The following tables are based on CTD raw data.

Station ID	Secchi depth [m]	water depth [m]	T _{sur} [°C]	T _{bot} [°C]	T _{sur} -T _{bot} [K]	S _{sur} [psu]	S _{bot} [psu]	S _{bot} -S _{sur} [psu]
GN003	3.5	31	18.3	16.9	1.4	30.49	31.39	0.90
GN003A	8.0	27	17.8	17.7	0.1	33.17	33.16	-0.01
GN007	-	37	17.9	18.0	-0.1	33.64	33.63	-0.01
GN007A	-	43	17.4	17.0	0.4	34.50	34.54	0.04
GN008	-	46	17.2	15.8	1.4	34.24	34.31	0.07
GN008S	-	42	16.5	14.6	1.9	34.58	34.57	-0.01
GN009	9.0	74	16.0	14.7	1.3	34.60	34.65	0.05
GN009S	-	28	16.2	12.8	3.4	34.65	34.70	0.05
GN009A	-	29	16.9	16.7	0.2	34.20	34.21	0.01
GN009B	-	31	17.5	17.3	0.2	34.97	34.95	-0.02
GN010	-	20	17.4	17.4	-	35.16	35.16	-
GN011	4.0	27	18.8	18.8	-	33.03	33.04	0.01
GN012	4.5	37	18.9	19.9	-	34.20	34.20	-
GN013	6.5	32	18.1	18.1	-	34.91	34.91	-
GN014	-	49	18.1	18.1	-	35.00	35.00	-
GN015	-	43	17.4	17.4	-	34.22	34.54	0.32
GN015B	-	32	17.1	17.1	-	34.00	34.00	-
GN016	12.5	44	15.4	15.4	-	34.46	34.46	-
GN017	10.5	55	15.1	14.3	0.8	34.69	34.70	0.01
GN017A	8.5	61	14.9	13.1	1.8	34.14	34.17	0.03
GN017S	-	67	15.3	9.6	5.7	34.19	34.29	0.10
GN018A	-	75	14.4	8.8	5.6	34.13	34.39	0.26
GN018	-	64	15.8	7.9	7.9	34.30	34.52	0.22
GN018S	-	26	16.1	9.6	6.5	34.50	34.62	0.12
GN019	13.5	25	15.9	15.4	0.5	34.61	34.61	-
GN019S	-	48	16.3	16.0	0.3	34.66	34.66	-
GN020	15.0	41	17.0	10.4	6.6	34.72	34.80	0.12
GN021	-	45	16.9	12.5	4.4	34.51	34.55	-0.01
GN022	-	31	17.0	15.0	2.0	34.45	34.44	-0.01
GN022A	-	32	17.4	16.2	1.2	33.62	33.67	0.05
GN023	7.0	25	17.2	16.4	0.8	32.39	32.78	0.39
GN025	5.0	14	18.1	18.1	-	30.27	30.27	-
GN026	4.5	27	18.1	16.0	-	32.05	33.00	0.95
GN026A	-	35	17.3	14.7	2.6	33.39	34.03	0.64
GN027	-	48	16.5	11.6	4.9	34.26	34.33	0.07
GN028	-	44	16.1	11.3	4.8	34.89	34.95	0.06
GN028S	-	57	15.9	8.4	7.5	34.81	34.88	0.07
GN029	15.0	71	15.9	7.1	8.8	34.88	35.01	0.13
GN030	14.0	75	16.0	7.2	8.8	34.82	34.99	0.17
GN031	-	86	15.5	7.6	7.9	34.78	34.79	0.01
2GN032	-	78	15.1	7.8	7.7	34.72	34.74	0.02
GN033	-	86	14.4	9.2	5.2	34.46	34.68	0.22
GN033A	-	65	14.3	9.8	4.5	34.16	34.61	0.45
GN033S	-	70	13.1	11.8	1.3	34.40	34.52	0.12
GN034A	9.0	50	12.5	11.1	1.4	34.57	34.68	0.11
GN034	11.5	75	12.6	11.3	1.3	34.68	34.73	0.05
GN034S	-	73	14.4	9.0	5.4	34.81	34.93	0.12
GN035	-	85	15.1	7.4	7.7	34.92	34.94	0.02
GN035S	-	99	15.3	7.5	7.8	34.88	35.03	0.15
GN036	16.0	81	15.4	7.9	7.5	34.94	34.99	0.05

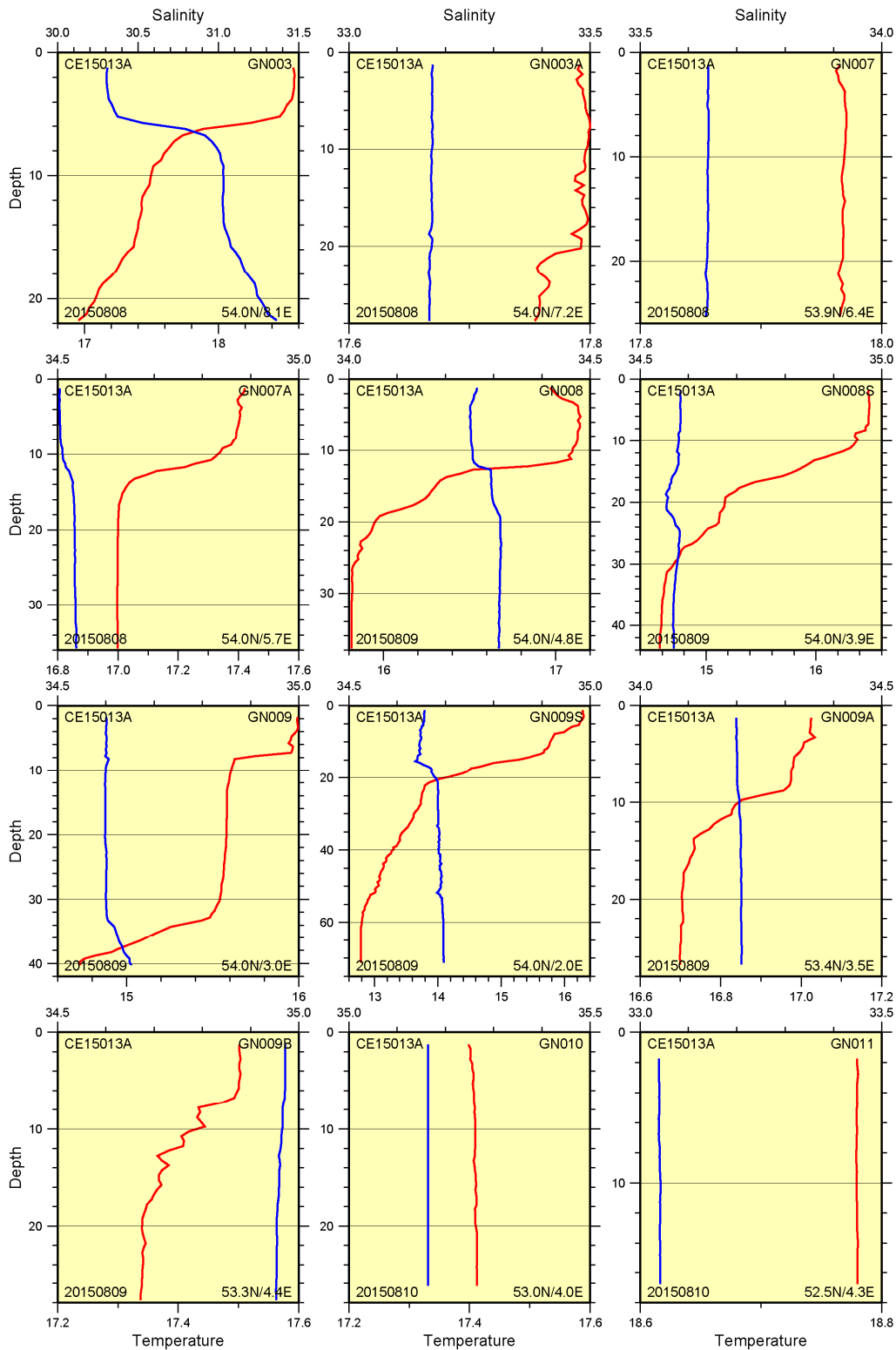
Station ID	Secchi depth [m]	water depth [m]	T _{sur} [°C]	T _{bot} [°C]	T _{sur} -T _{bot} [K]	S _{sur} [psu]	S _{bot} [psu]	S _{bot} -S _{sur} [psu]
GN037	13.5	65	15.6	8.2	7.4	34.85	34.95	0.10
GN038	-	59	15.9	10.0	5.9	34.63	34.88	0.25
GN038A	-	53	16.0	12.9	3.1	34.47	34.62	0.15
GN039	-	39	17.3	15.1	2.2	32.86	34.20	1.34
GN039S	-	93	15.7	7.8	7.9	33.92	35.11	1.19
GN040	-	524	16.8	6.5	10.3	30.16	35.17	5.01
GN041	-	309	16.4	7.5	8.9	30.45	35.29	4.84
GN042	14.0	128	14.1	7.7	6.4	35.07	35.30	0.23
GN042S	-	98	14.8	7.5	7.3	34.78	35.22	0.44
GN043	-	77	14.5	7.7	6.8	34.95	34.98	0.03
GN044	-	106	14.4	8.4	6.0	34.92	35.13	0.21
GN044S	-	139	13.9	8.1	5.8	35.13	35.30	0.17
GN045	10.0	115	13.3	9.3	4.0	35.06	35.28	0.22
GN045A	-	76	12.7	10.5	2.2	34.91	35.12	0.21
GN045B	-	72	12.1	12.0	0.1	34.82	34.90	0.08
GN057A	12.5	81	12.6	11.8	0.8	34.95	34.97	0.02
GN056	23.0	86	12.6	12.2	0.4	34.76	34.83	0.07
GN056B	10.0	118	13.4	10.6	2.8	34.97	35.17	0.20
GN056C	-	108	13.1	11.1	2.0	34.70	34.84	0.14
GN064	-	60	13.2	12.5	0.7	34.80	34.83	0.03
GN046A	13.0	80	12.2	11.6	0.6	34.91	35.10	0.19
GN046	8.5	106	12.0	10.5	1.5	35.14	35.30	0.16
GN047	-	129	13.7	7.6	6.1	35.15	35.25	0.10
GN048	-	123	14.2	7.3	6.9	35.13	35.19	0.06
GN048S	-	114	14.0	7.5	6.5	35.11	35.24	0.13
GN049	12.0	136	13.7	7.9	5.8	35.14	35.34	0.20
GN049S	-	271	14.1	7.5	6.6	34.75	35.26	0.51
GN050	8.5	258	15.2	7.1	8.1	31.98	35.15	3.17
GN050S	-	265	15.9	7.4	8.5	31.40	35.22	3.82
GN051	-	262	15.7	7.4	8.3	32.13	35.19	3.06
GN051S	-	215	14.2	8.8	5.4	34.88	35.37	0.49
GN052	14.5	100	14.1	8.3	5.8	35.03	35.35	0.32
GN052S	-	128	13.8	7.6	6.2	35.17	35.29	0.12
GN053	-	125	13.0	9.0	4.0	35.25	35.36	0.11
GN054	11.0	110	12.7	10.8	1.9	35.13	35.17	0.04
GN054S	-	132	12.9	9.7	3.2	35.25	35.34	0.09
GN058	-	724	12.0	-0.8	12.8	35.09	34.92	-0.17
GN062	-	829	12.2	-0.7	12.9	35.28	34.92	-0.36
GN059	8.5	1118	12.4	-0.8	13.2	35.15	34.92	-0.23
GN060	7.5	540	12.8	2.0	10.8	35.15	34.95	-0.20
GN063	-	409	13.1	6.9	6.2	34.75	35.13	0.38
GN061	11.5	350	15.5	7.6	7.9	32.73	35.25	0.52

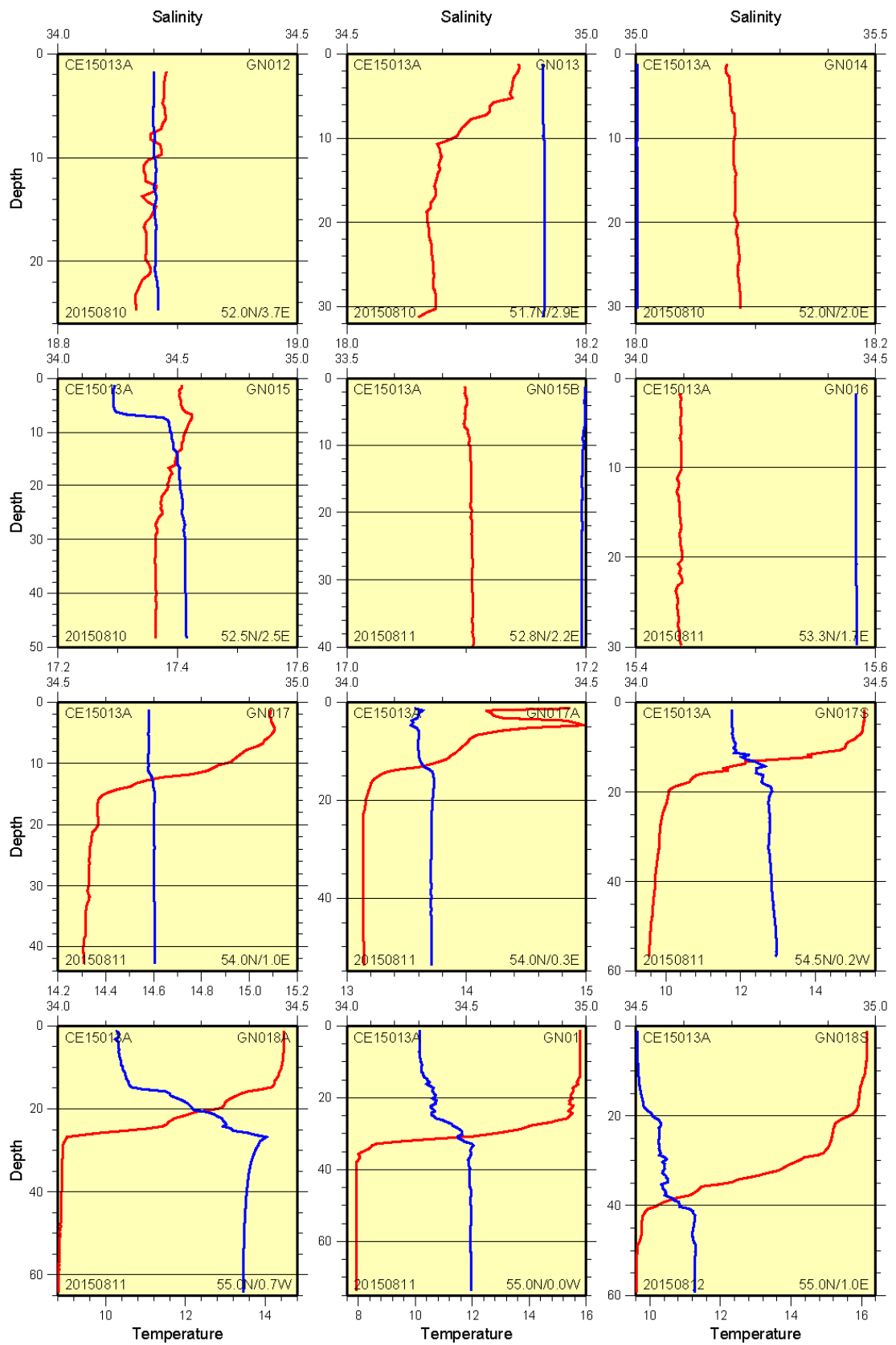
T_{sur}, T_{bot}: surface and bottom temperature.

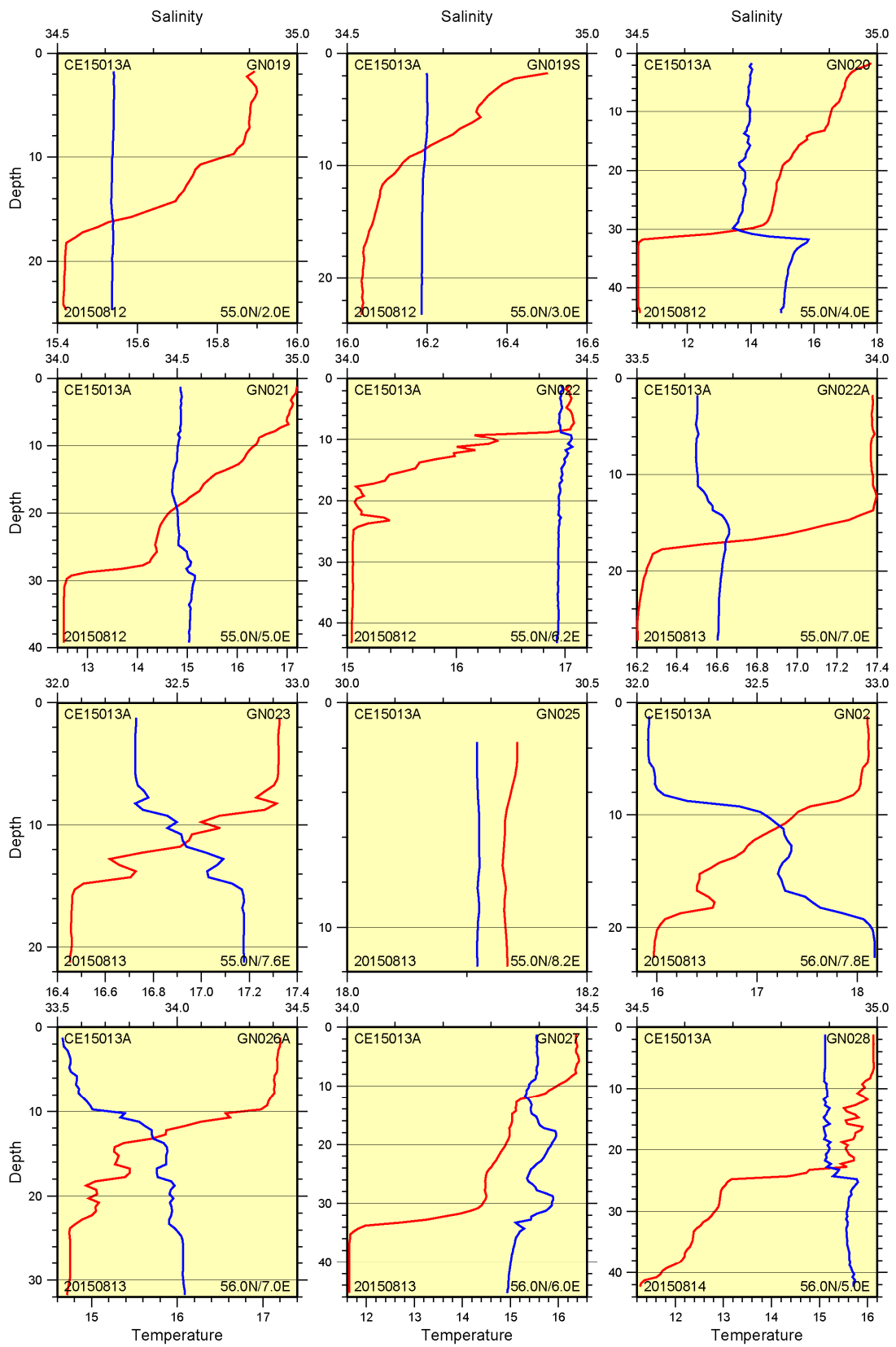
S_{sur}, S_{bot}: surface and bottom salinity. Blue: Coastal Water ≤34 psu, red: Atlantic Water ≥35 psu.

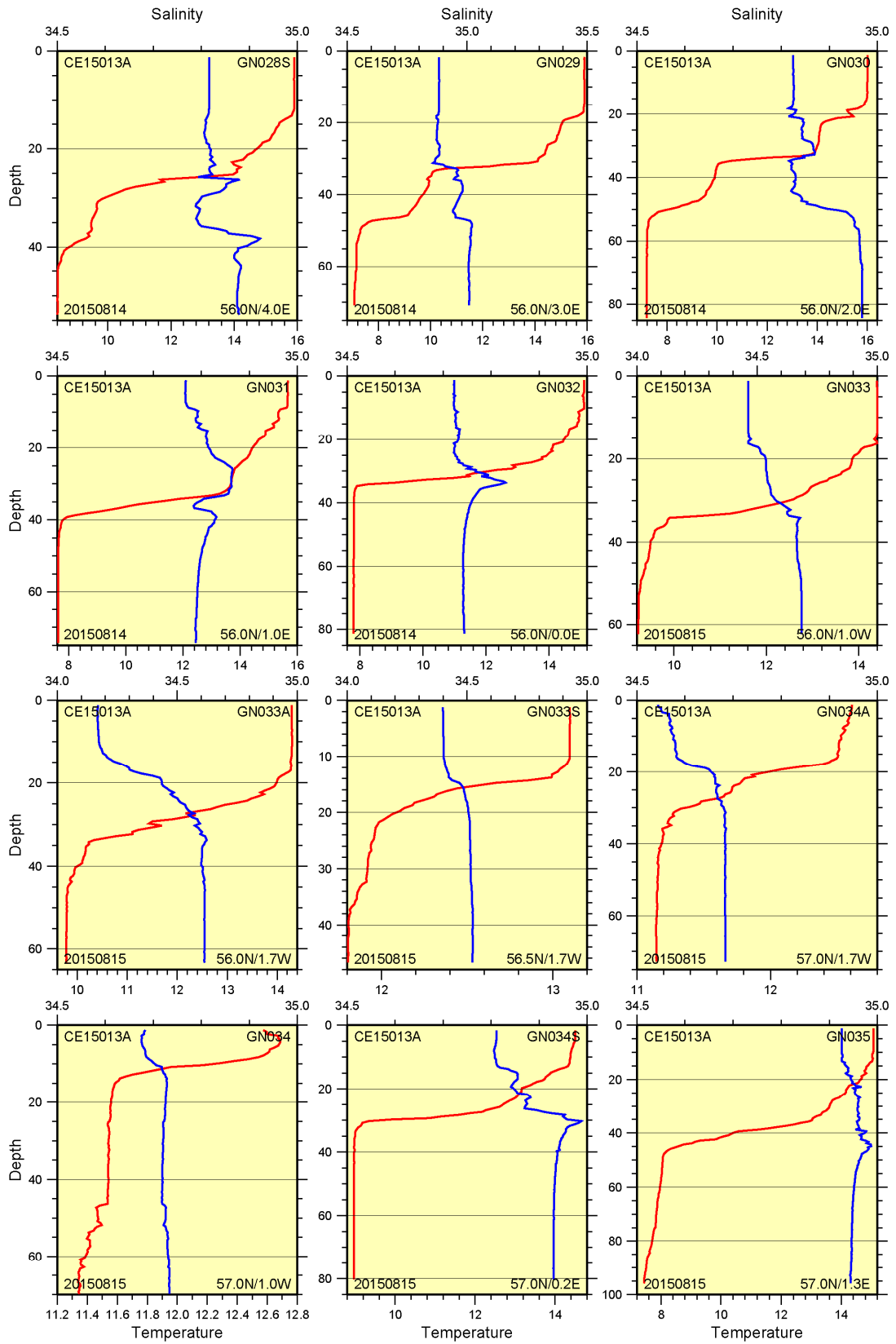
Appendix 3: T and S profiles, all stations

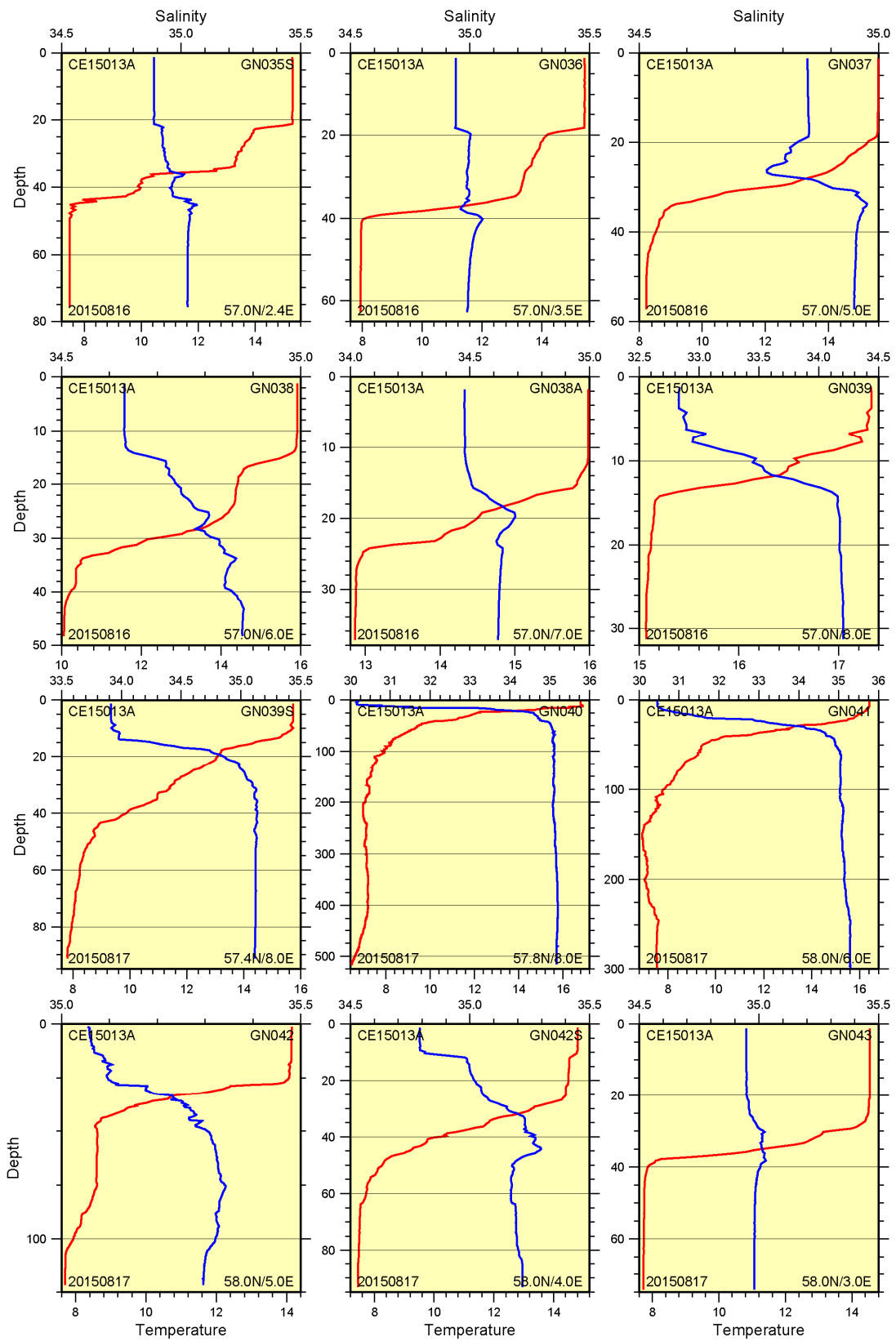
The following temperature and salinity profiles are based on CTD raw data.

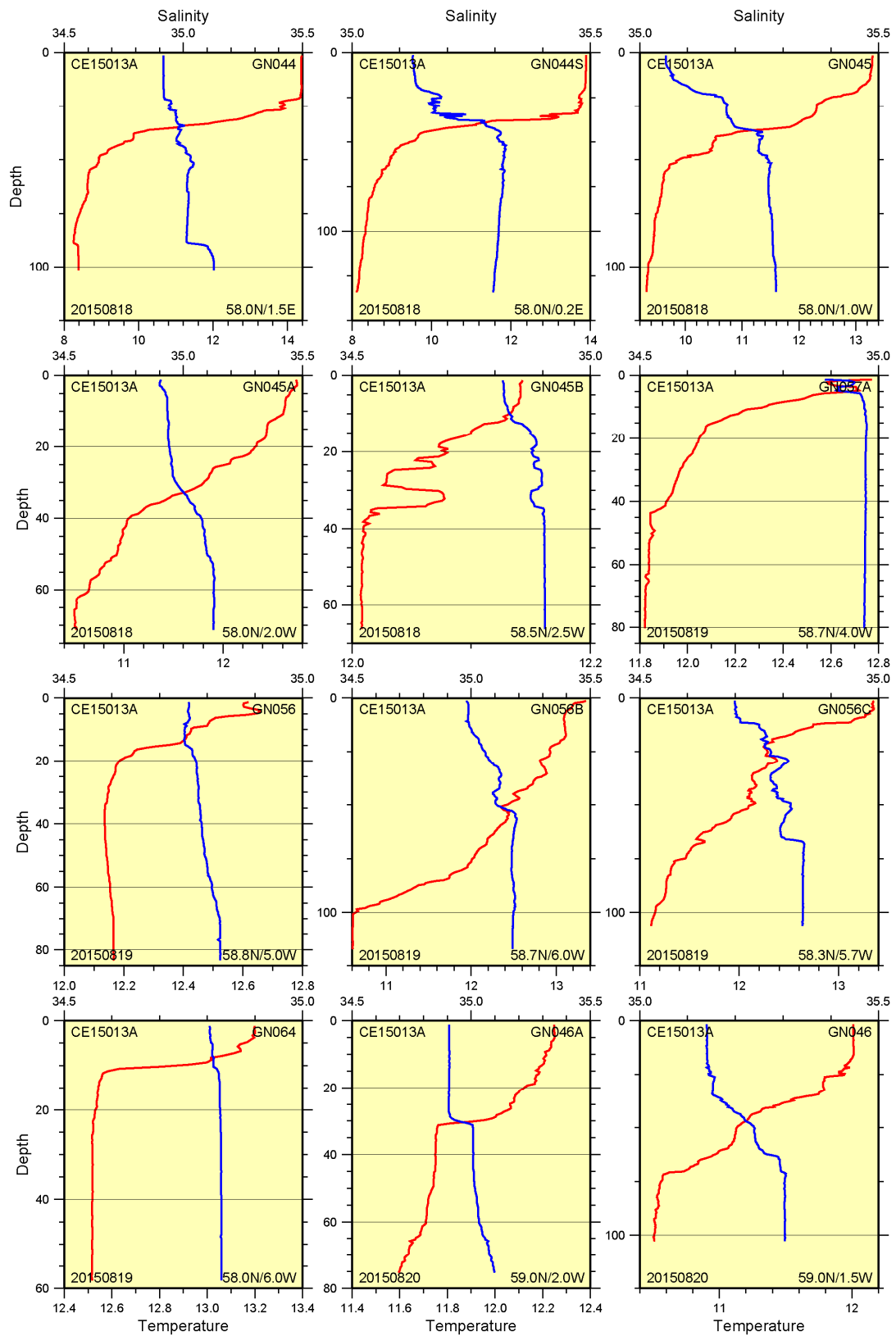


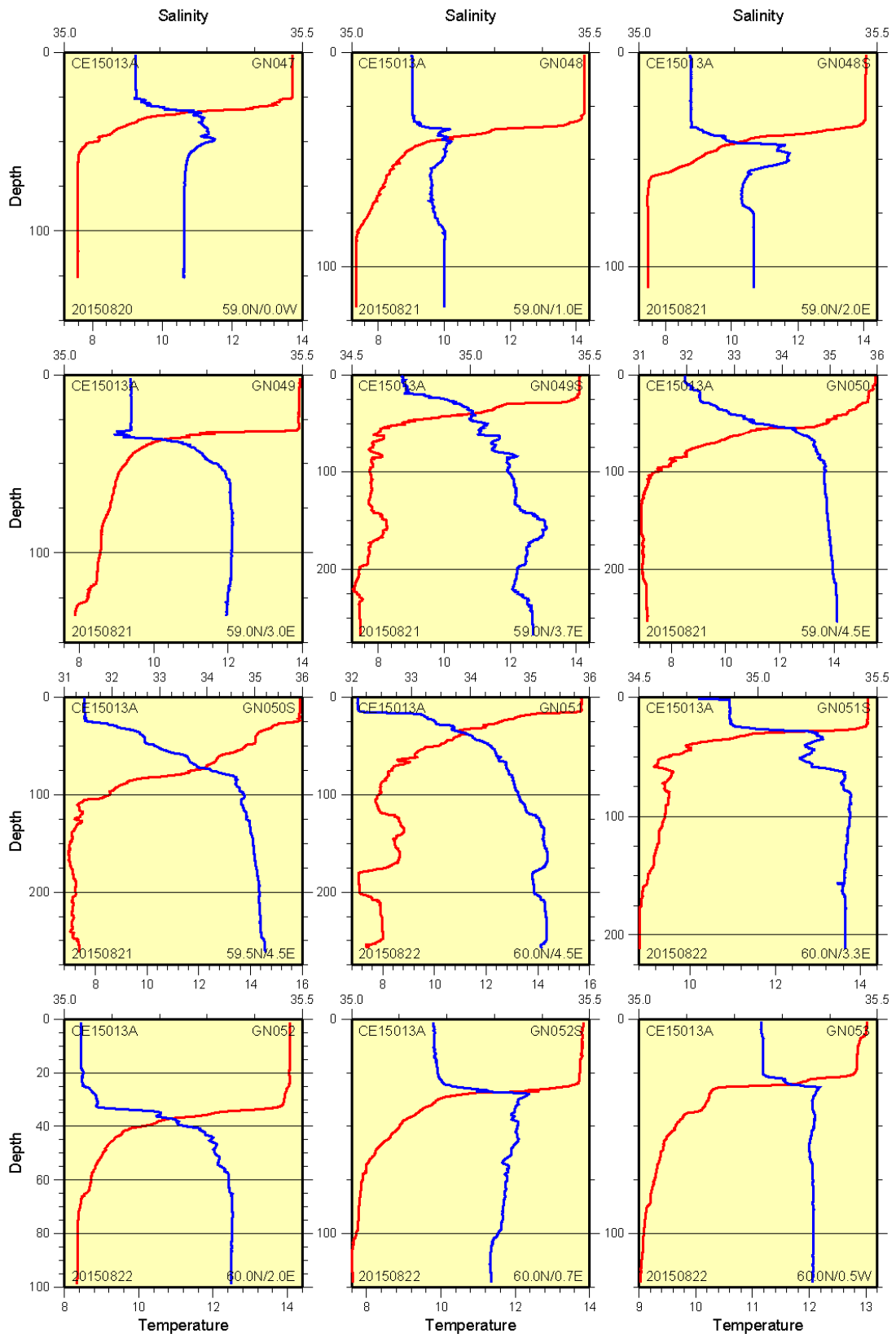


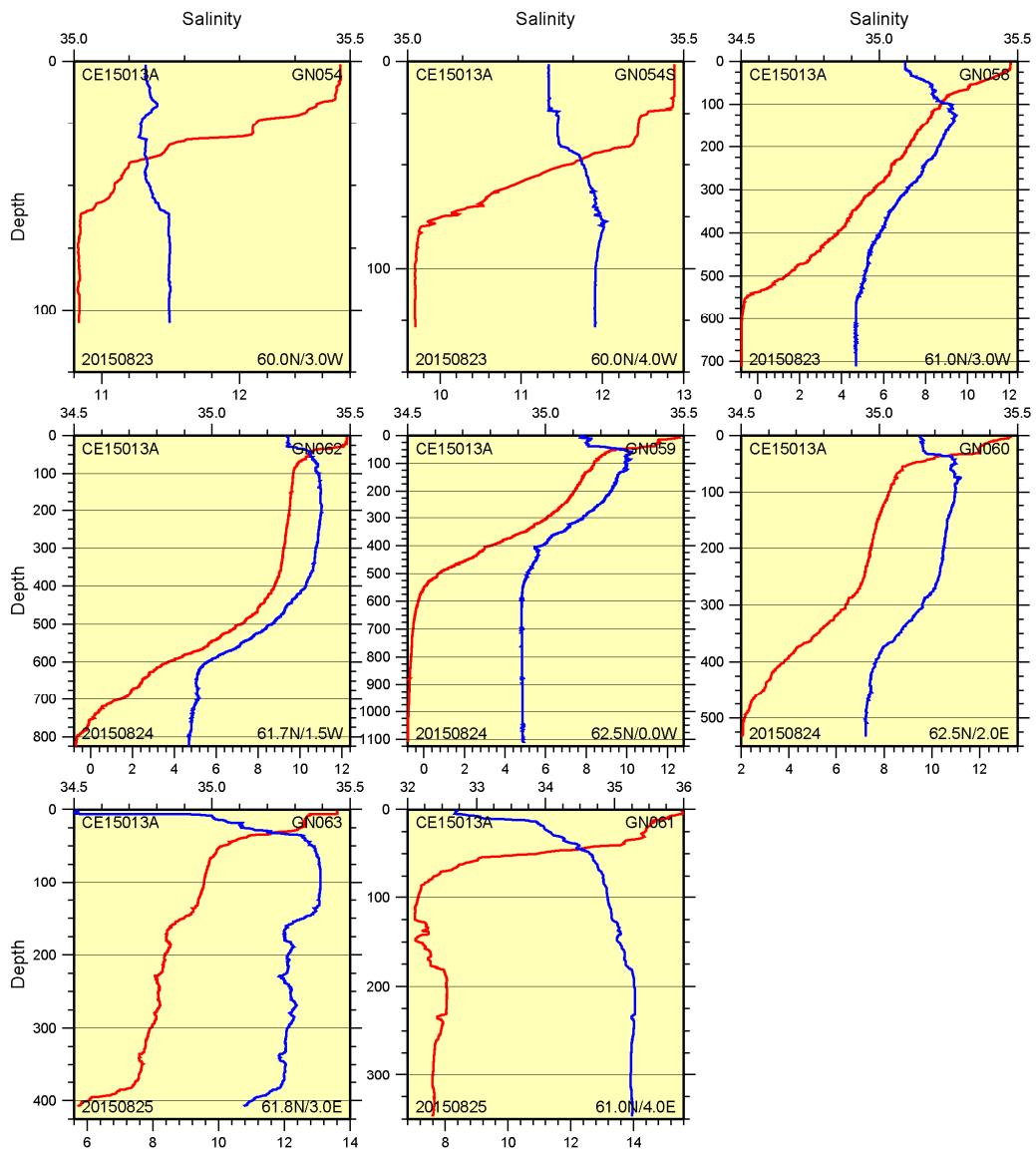






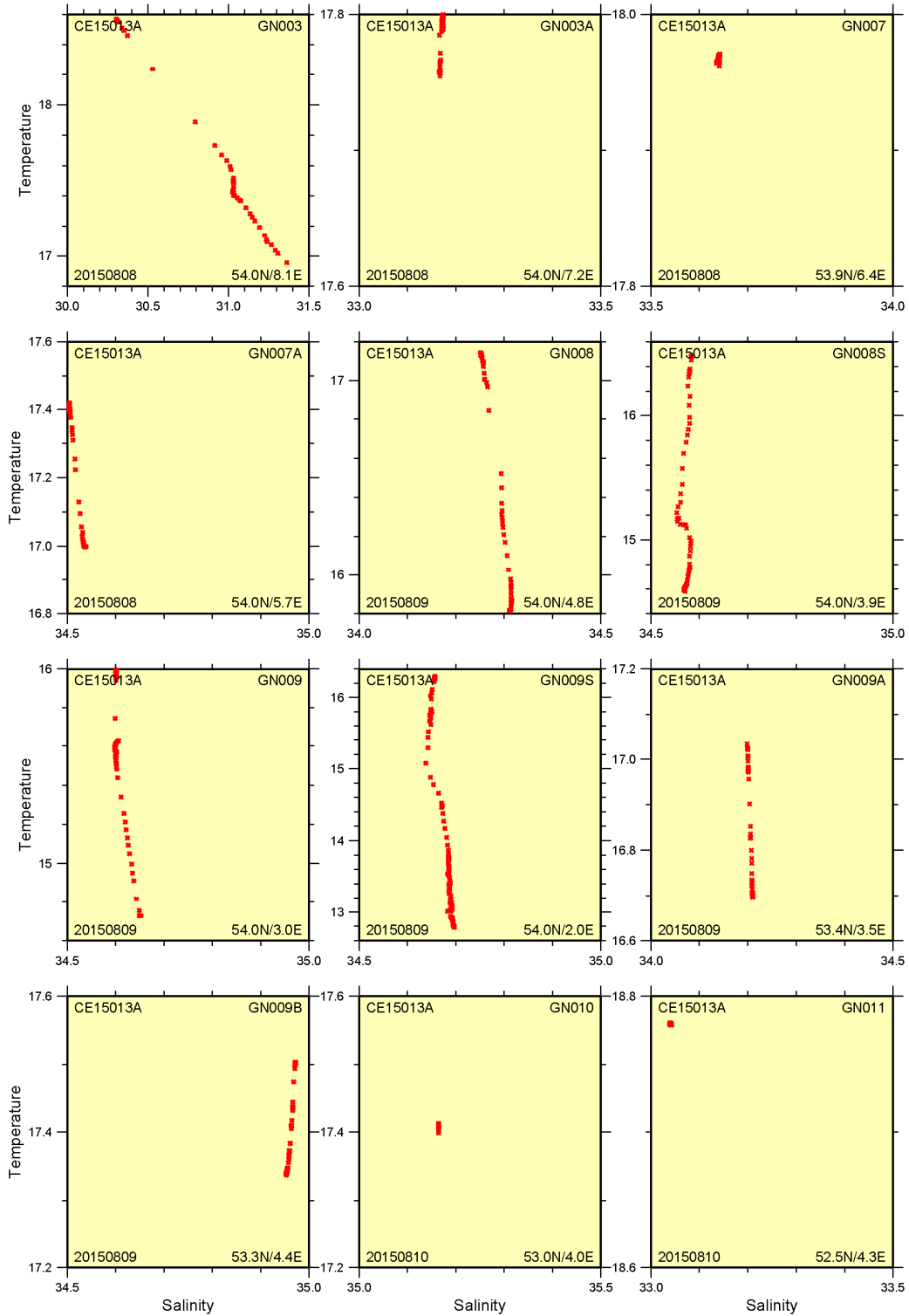


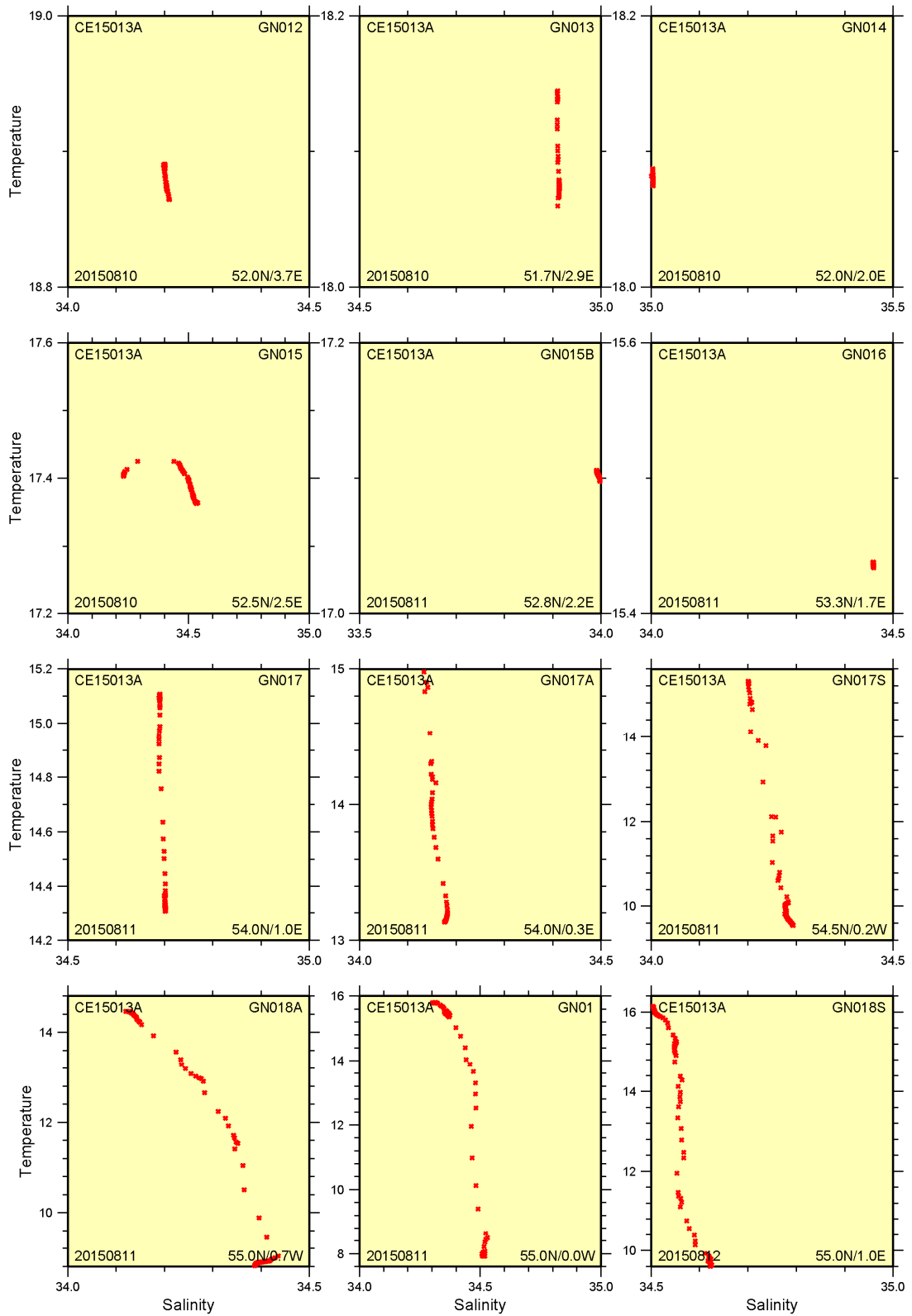


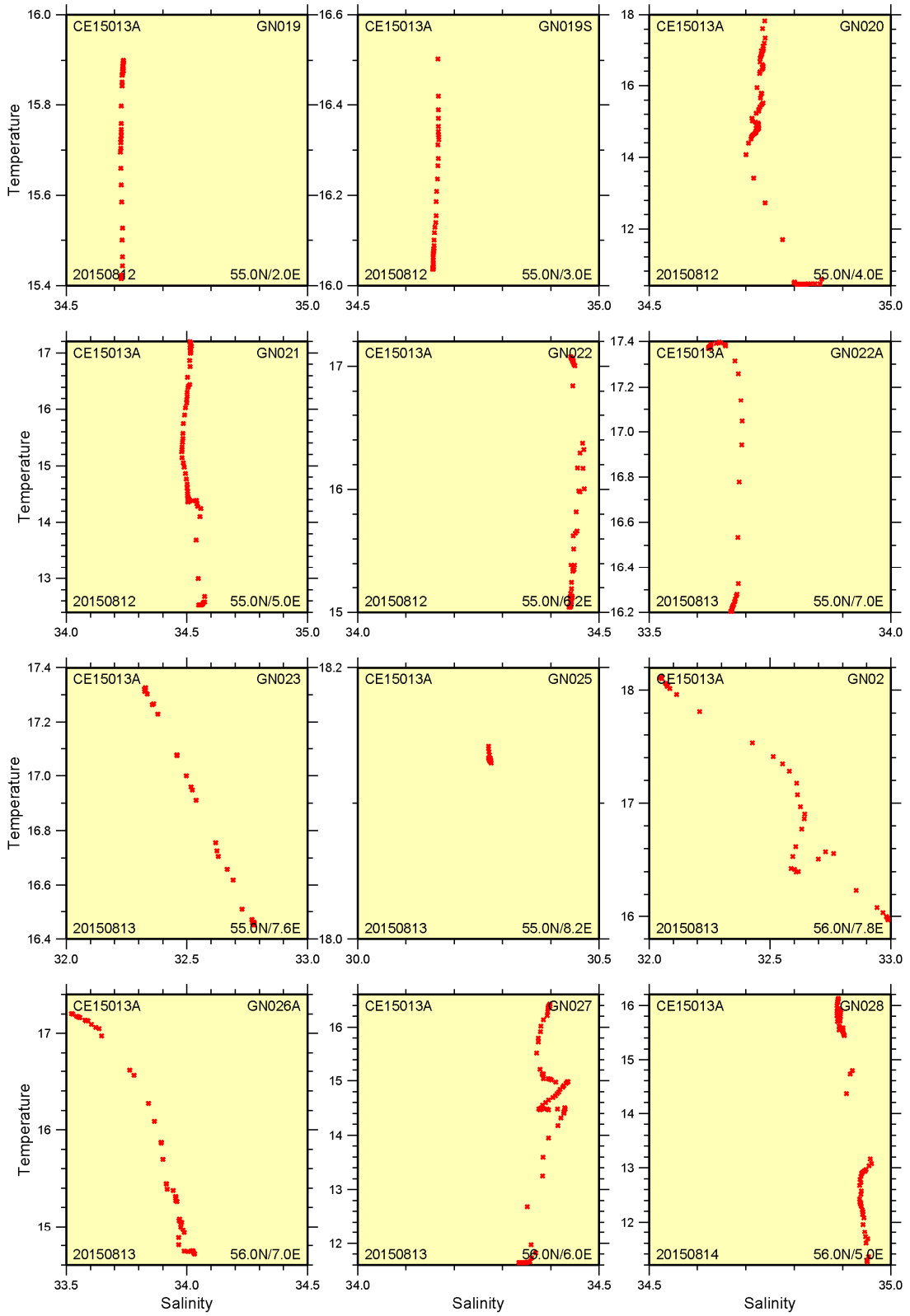


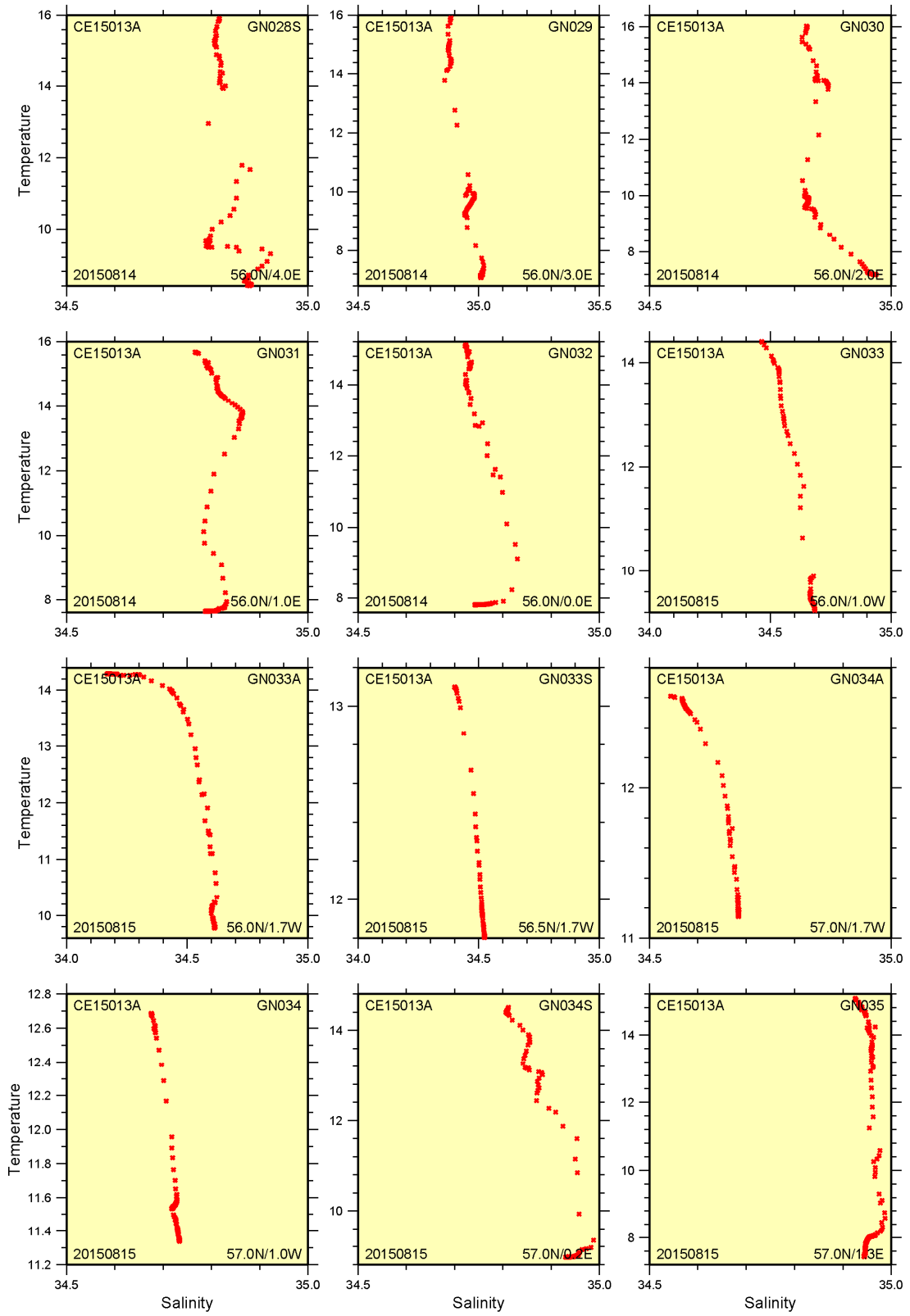
Appendix 4: T/S diagrams, all stations

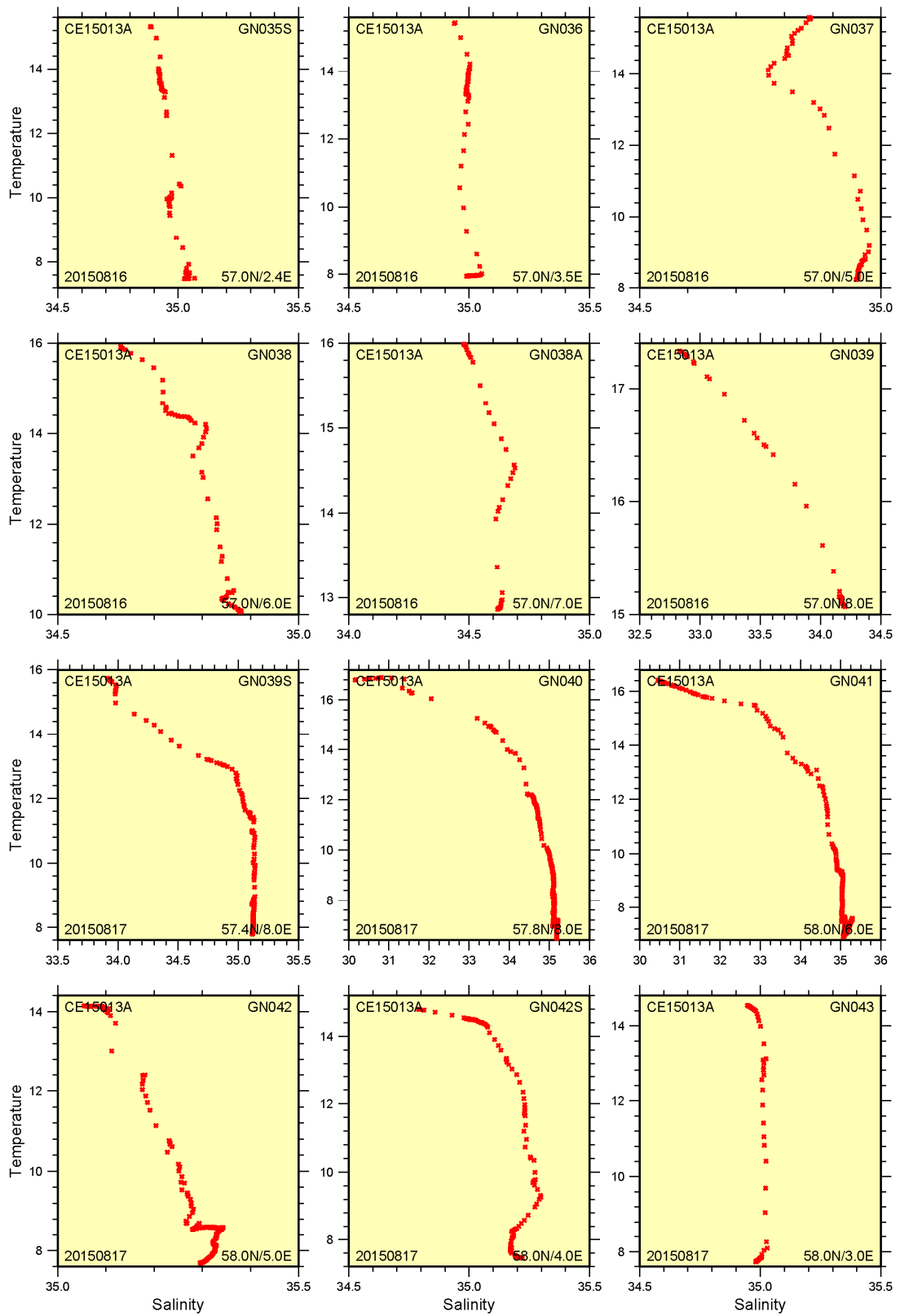
The following diagrams are based on CTD raw data.

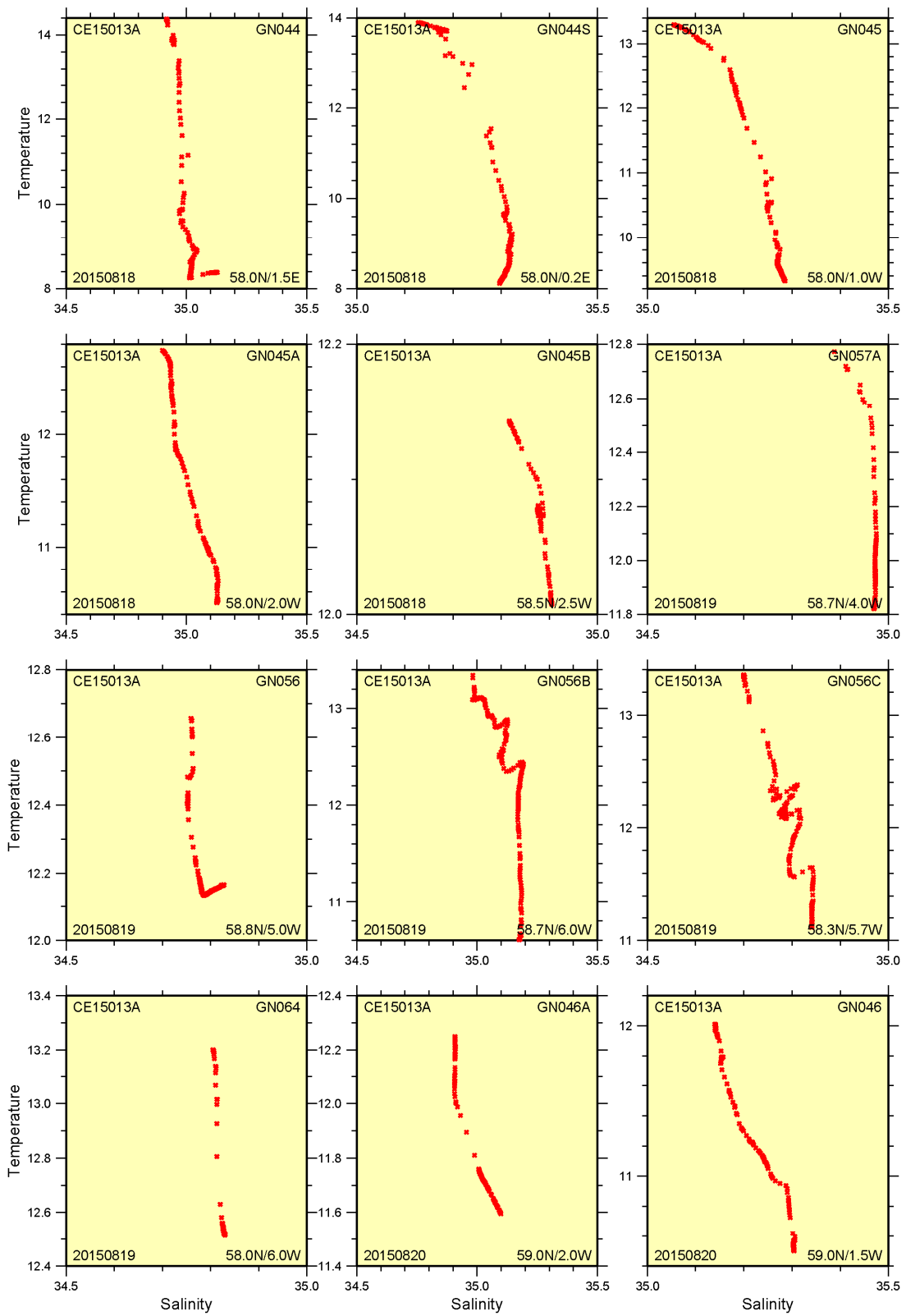


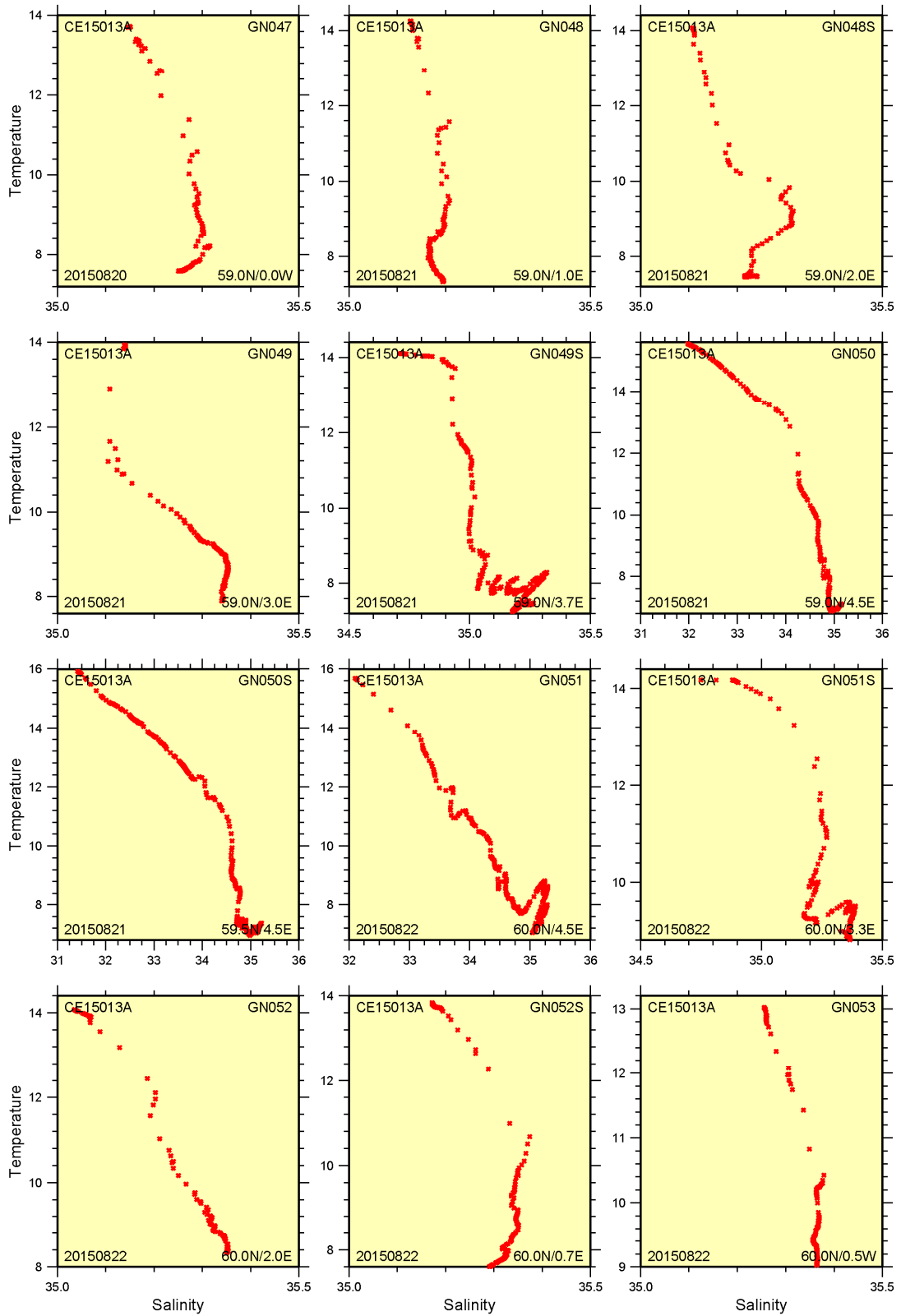


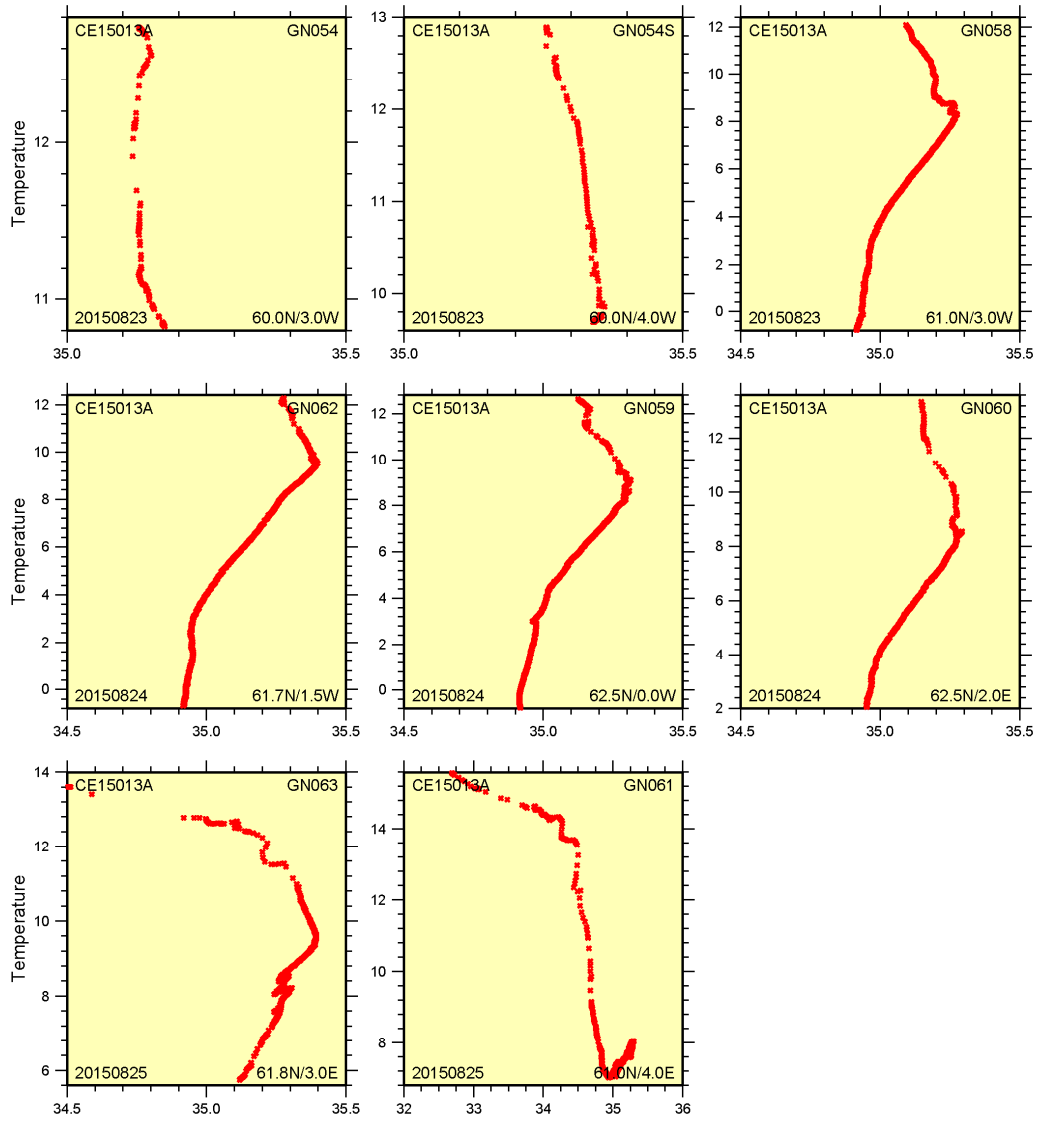












Appendix 5: Station list for chemical analysis

Station ID	Secchi-depth	Oxygen	pH	Alkalinity	Chlorophyll	d 18O1 (for IOW)	d 13C (for IOW)
GN003	X	X	X	X	X	X	X
GN003A	X	X	X	X	X	X	X
GN009	X	X	X	X	X	X	X
GN009A	-	X	X	X	X	X	X
GN011	X	X	X	X	X	X	X
GN012	X	X	X	X	X	X	X
GN013	X	X	X	X	X	X	X
GN016	X	X	X	X	X	X	X
GN017	X	X	X	X	X	X	X
GN017A	X	X	X	X	X	X	X
GN019	X	X	X	X	X	X	X
GN020	X	X	X	X	X	X	X
GN021	-	X	X	X	-	X	X
GN023	X	X	X	X	X	X	X
GN025	X	X	X	X	X	X	X
GN026	X	X	X	X	X	X	X
GN029	X	X	X	X	X	X	X
GN030	X	X	X	X	X	X	X
GN031	-	X	X	X	-	X	X
GN034A	X	X	X	X	X	X	X
GN034	X	X	X	X	X	X	X
GN036	X	X	X	X	X	X	X
GN037	X	X	X	X	X	X	X
GN038	-	X	X	X	-	X	X
GN041	-	X	X	X	X	X	X
GN042	X	X	X	X	X	X	X
GN045	X	X	X	X	X	X	X
GN045A	X	X	X	X	X	X	X
GN057A	X	X	X	X	X	X	X
GN056	X	X	X	X	X	X	X
GN056B	X	X	X	X	X	X	X
GN046A	X	X	X	X	X	X	X
GN046	X	X	X	X	X	X	X
GN049	X	X	X	X	X	X	X
GN050	X	X	X	X	X	X	X
GN052	X	X	X	X	X	X	X
GN054	X	X	X	X	X	X	X
GN059	X	X	X	X	X	X	X
GN060	X	X	X	X	X	X	X
GN061	X	X	X	X	X	X	X

Appendix 6: Station List

Positions are taken at the beginning of the stations! Radioactivity: Cs = Cesium-137; Strontium-90 = Sr; Plutonium = Pu; Tritium = H3

station name	latitude	longitude	water depth [m]	water sampling CTD [m]	Secchi-depth [m]	radio-activity	Bedford-Nr. 155nnn	date dd.mm.yy	time [UTC]
STADE	53° 36.94' N	009° 32.80' E	14	-	-	Cs/Sr/Pu/H3		08.08.15	07:37 – 07:49
MEDEM	53° 52.94' N	008° 43.00' E	17	-	-	Cs/Sr/Pu/H3		08.08.15	10:58 – 11:11
GN003 ELBE1	54° 00.07' N	008° 06,67' E	24	bottom, 5	3.5	Cs/Sr/Pu/H3	001-002	08.08.15	13:10 – 13:31
GN003A	54° 00.02' N	007° 10.52' E	31	Bottom, 5	8	Cs/Sr/Pu/H3	003-004	08.08.15	16:32 – 16:47
GN007	53° 56.97' N	006° 25.08' E	27	bottom, 5	-	Cs/Sr/Pu/H3	005-006	08.08.15	20:03 – 20:19
GN007A	54° 00.15' N	005° 40.08' E	37	Bottom, 5	-	Cs/Sr/Pu/H3	007-008	08.08.15	23:01 – 23:19
GN008	54° 00.15' N	004° 49.89' E	43	bottom, 5	-	-	009-010	09.08.15	02:27 – 02:41
GN008S	54° 00.03' N	003° 55.08' E	46	bottom, 5	-	-	011-012	09.08.15	06:18 – 06:27
GN009	53° 59.99' N	003° 00.16' E	42	bottom, 5	9.0	Cs/Sr/Pu/H3	013-014	09.08.15	09:33 – 09:48
GN009S	53° 59.96' N	002° 00.18' E	74	bottom, 5	-	-	015-016	09.08.15	13:22 – 13:41
GN009A	53° 25.22' N	003° 29.73' E	28	bottom, 5	-	Cs	017-018	09.08.15	20:07 – 20:18
GN009B	53° 19.84' N	004° 25.35' E	29	bottom, 5	-	Cs/Sr/Pu/H3	019-020	09.08.15	23:48 – 00:05
GN010	52° 59.97' N	004° 00.07' E	31	bottom, 5	-	-	021-022	10.08.15	03:18 – 03:35
GN011	52° 30.63' N	004° 19.36' E	20	bottom, 5	4.0	-	023-024	10.08.15	06:50 – 06:59
GN012	52° 00.10' N	003° 44.15' E	27	bottom, 5	4.5	Cs/Sr/Pu/H3	025-026	10.08.15	11:44 – 11:57
GN013	51° 42.00' N	002° 51.33' E	37	bottom, 5	6.5	Cs/Sr/Pu/H3	027-028	10.08.15	16:00 – 16:15
GN014	51° 59.95' N	002° 00.11' E	32	bottom, 5	-	Cs/Sr/Pu/H3	029-030	10.08.15	19:57 – 20:08
GN015	52° 30.20' N	002° 30.12' E	49	bottom, 5	-	Cs	031-032	10.08.15	23:34 – 23:46
GN015B	52° 49.75' N	002° 10.46' E	43	bottom, 5	-	-	033-034	11.08.15	02:05 – 02:19
GN016	53° 19.77' N	001° 40.26' E	32	bottom, 2 x 5	12.5	-	035-037	11.08.15	06:08 – 06:18
GN017	53° 59.86' N	001° 00.12' E	44	bottom, 2 x 5	10.5	Cs	038-040	11.08.15	10:44 – 10:55
GN017A	54° 00.02' N	000° 20.04' E	55	bottom, 5	8.5	Cs/Sr/Pu/H3	041-042	11.08.15	13:22 – 13:38
GN017S	54° 29.92' N	000° 10.16' W	61	bottom, 5	-	-	043-044	11.08.15	17:10 – 17:23
GN018A	55° 00.01' N	000° 40.27' W	67	bottom, 5	-	Cs	045-046	11.08.15	21:01 – 21:13
GN018	55° 00.05' N	000° 00.15' W	75	bottom, 5	-	Cs	047-048	11.08.15	23:36 – 23:54
GN018S	54° 59.95' N	001° 00.03' E	64	bottom, 5	-	-	049-050	12.08.15	03:08 – 03:25
GN019	55° 00.00' N	001° 59.85' E	26	bottom, 2 x 5	13.5	-	051-053	12.08.15	06:43 – 06:55
GN019S	55° 00.00' N	002° 59.86' E	25	bottom, 5	-	-	054-055	12.08.15	10:20 – 10:34
GN020	55° 00.03' N	003° 59.96' E	48	bottom, 2 x 5	15.0	Cs	056-058	12.08.15	14:16 – 14:35
GN021 AWZW2	55° 00.10' N	005° 00.00' E	41	bottom, 5	-	Cs	059-060	12.08.15	18:30 – 18:42
GN022	54° 59.97' N	006° 14.66' E	45	bottom, 5	-	Cs	061-062	12.08.15	23:06 – 23:18

station name	latitude	longitude	water depth [m]	water sampling CTD [m]	Secchi-depth [m]	radio-activity	Bedford-Nr. 155nnn	date dd.mm.yy	time [UTC]
GN022A	55° 00.04' N	006° 59.97' E	32	bottom, 5	-	Cs	063-064	13.08.15	02:09 – 02:21
GN023	55° 00.00' N	007° 34.73' E	25	bottom, 5	-	-	065-066	13.08.15	04:40 – 04:58
GN025	54° 59.96' N	008° 14.96' E	14	bottom, 5	5.0	Cs/Sr/Pu/H3	067-068	13.08.15	07:19 – 07:31
GN026	56° 00.00' N	007° 47.87' E	27	bottom, 5	4.5	Cs/Sr/Pu/H3	069-070	13.08.15	14:58 – 15:14
GN026A	55° 59.97' N	006° 59.76' E	35	bottom, 5	-	Cs/Sr/Pu/H3	071-072	13.08.15	18:31 – 18:41
GN027	55° 59.95' N	006° 00.00' E	48	bottom, 5	-	Cs	073-074	13.08.15	21:57 – 22:10
GN028	56° 00.13' N	004° 59.89' E	44	bottom, 5	-	-	075-076	14.08.15	01:31 – 01:16
GN028S	55° 59.99' N	004° 00.05' E	57	bottom, 5	-	-	077-078	14.08.15	04:56 – 05:19
ENTE3	55° 55.00' N	003° 21.02' E	71	600 l sea water for RA	-	-	-	14.08.15	07:22 – 07:28
GN029	56° 00.03' N	002° 59.92' E	75	bottom, 2x5	15.0	Cs/Sr/Pu/H3	079-081	14.08.15	08:54 – 09:06
GN030	55° 59.92' N	001° 59.99' E	86	bottom, 2x5	14.0	Cs	082-084	14.08.15	12:38 – 13:00
GN031	55° 59.99' N	000° 59.99' E	78	bottom, 5	-	Cs	085-086	14.08.15	18:28 – 18:42
GN032	55° 59.96' N	000° 00.29' W	86	bottom, 5	-	Cs	087-088	14.08.15	21:00 – 20:12
GN033	55° 59.96' N	000° 59.69' W	65	bottom, 5	-	Cs	089-090	15.08.15	00:45 – 01:03
GN033A	55° 59.97' N	001° 40.18' W	70	bottom, 5	-	-	091-092	15.08.15	03:29 – 03:47
GN033S	56° 30.02' N	001° 40.20' W	50	bottom, 5	-	-	093-094	15.08.15	06:55 – 07:05
GN034A	56° 59.99' N	001° 40.18' W	75	bottom, 5	9.0	Cs/Sr/Pu/H3	095-097	15.08.15	10:08 – 10:27
GN034	56° 59.85' N	001° 00.39' W	73	5 x bottom, 2x5	11.5	CS	098-104	15.08.15	12:49 – 13:11
GN034S	57° 00.01' N	000° 10.09' E	85	bottom, 5	-	-	105-106	15.08.15	17:10 – 17:27
GN035	56° 59.71' N	001° 20.13' E	99	bottom, 5	-	Cs	107-108	15.08.15	22:05 – 22:24
GN035S	57° 00.00' N	002° 25.16' E	81	bottom, 5	-	-	109-110	16.08.15	01:59 – 02:22
GN036	57° 00.01' N	003° 30.40' E	65	bottom, 2x5	16.0	-	111-113	16.08.15	05:52 – 06:03
GN037	57° 00.04' N	005° 00.13' E	59	bottom, 5	13.5	Cs	114-116	16.08.15	10:35 – 10:53
GN038	56° 59.96' N	005° 59.83' E	53	bottom, 5	-	Cs	117-118	16.08.15	14:04 – 14:20
GN038A	57° 00.12' N	006° 58.13' E	39	bottom, 5	-	Cs/Sr/Pu/H3	119-120	16.08.15	18:18 – 18:29
GN039	57° 00.03' N	007° 59.78' E	33	bottom, 5	-	Cs/Sr/Pu/H3	121-122	16.08.15	21:49 – 22:01
GN039S	57° 25.11' N	007° 59.95' E	93	bottom, 5	-	-	123-124	17.08.15	00:40 – 01:02
GN040	57° 49.81' N	007° 59.98' E	524	bottom, 5	-	Cs/Sr/Pu/H3	125-126	17.08.15	03:34 – 04:21
GN041	58° 00.21' N	006° 00.19' E	309	bottom, 5	-	Cs/Sr/Pu/H3	127-129	17.08.15	10:31 – 11:09
GN042	57° 59.99' N	005° 00.09' E	128	bottom, 5x5	14.0	Cs	130-135	17.08.15	14:19 – 14:40
GN042S	58° 00.11' N	004° 00.10' E	98	bottom, 5	-	-	136-137	17.08.15	18:38 – 18:56
GN043	58° 00.22' N	002° 59.73' E	77	bottom, 5	-	-	138-139	17.08.15	22:17 – 22:34
GN044	57° 59.98' N	001° 29.90' E	106	bottom, 5	-	-	140-141	18.08.15	03:16 – 03:36
GN044S	58° 00.04' N	000° 14.96' E	139	bottom, 5	-	-	142-143	18.08.15	07:37 – 07:53
GN045	58° 00.02' N	001° 00.02' W	115	bottom, 2x5	-	-	144-146	18.08.15	11:55 – 12:14

station name	latitude	longitude	water depth [m]	water sampling CTD [m]	Secchi-depth [m]	radio-activity	Bedford-Nr. 155nnn	date dd.mm.yy	time [UTC]
GN045A	57° 59.92' N	001° 59.58' W	76	bottom, 2x5	-	Cs/Sr/Pu/H3	147-149	18.08.15	15:33 – 15:51
GN045B	58° 29.97' N	002° 30.00' W	72	bottom, 5	-	Cs/Sr/Pu/H3	150-151	18.08.15	19:56 – 20:08
GN057A	58° 44.97' N	004° 00.03' W	81	bottom, 2x5	12.5	Cs/Sr/Pu/H3	152-154	19.08.15	05:57 – 06:12
GN056	58° 45.05' N	004° 59.95' W	86	bottom, 2x5	23.0	Cs/Sr/Pu/H3	155-157	19.08.15	09:20 – 09:35
GN056B	58° 44.97' N	005° 59.80' W	118	bottom, 2x5 2x270 l for RA (50&bot.)	-	Cs/Sr/Pu/H3	158-160	19.08.15	12:52 – 15:45
GN056C	58° 19.68' N	005° 40.37' W	108	bottom, 5	-	Cs/Sr/Pu/H3	161-162	19.08.15	18:42 – 18:58
GN064	58° 00.18' N	005° 59.83' W	60	bottom, 5 2x600 l sea water for RA	-	Cs/Sr/Pu/H3	163-164	19.08.15	21:23 – 21:44
GN046A	58° 59.86' N	002° 00.29' W	80	bottom, 2x5	13.0	Cs/Sr/Pu/H3	165-167	20.08.15	14:00 – 14:19
GN046	59° 00.01' N	001° 30.06' W	106	bottom, 5	8.5	-	168-169	20.08.15	16:29 – 16:46
GN047	59° 00.10' N	000° 00.56' E	129	bottom, 5	-	-	170-171	20.08.15	22:32 – 22:49
GN048	59° 00.08' N	000° 59.57' E	123	bottom, 5	-	-	172-173	21.08.15	02:26 – 02:48
GN048S	59° 00.07' N	001° 59.83' E	114	bottom, 5	-	-	174-175	21.08.15	06:29 – 06:50
GN049	59° 00.08' N	002° 59.73' E	136	bottom, 2x5	12.0	Cs	176-178	21.08.15	10:34 – 11:25
GN049S	59° 00.03' N	003° 44.82' E	271	bottom, 5	-	-	179-180	21.08.15	14:26 – 15:02
GN050	59° 00.09' N	004° 29.76' E	258	bottom, 5	8.5	Cs/Sr/Pu/H3	181-182	21.08.15	18:06 – 18:57
GN050S	59° 30.17' N	004° 30.18' E	265	bottom, 5	-	-	183-184	21.08.15	21:46 – 22:19
GN051	60° 00.08' N	004° 30.24' E	262	bottom, 5	-	-	185-186	22.08.15	01:47 – 02:23
GN051S	60° 00.04' N	003° 15.15' E	215	bottom, 5	-	-	187-188	22.08.15	06:31 – 06:57
GN052	59° 59.88' N	001° 59.95' E	100	bottom, 5x5	14.5	Cs	189-194	22.08.15	11:00 – 11:58
GN052S	60° 00.02' N	000° 44.93' E	128	bottom, 5 2x600 l sea water for CL	-	-	195-196	22.08.15	15:47 – 16:03
GN053	60° 00.00' N	000° 29.83' W	125	bottom, 5	-	Cs/Sr/Pu/H3	197-198	22.08.15	20:35 – 20:51
GN054	59° 59.95' N	002° 59.75' W	110	bottom, 2x5	11.0	-	199-201	23.08.15	04:18 – 05:07
GN054S	60° 00.03' N	003° 59.99' W	132	bottom, 5	-	-	202-203	23.08.15	08:12 – 08:28
GN055	60° 00.09' N	005° 00.18' W	423	-	-	Cs/Sr/Pu/H3	-	23.08.15	11:32 – 12:11
GN058	60° 59.98' N	003° 00.02' W	724	bottom, 5	-	Cs	204-205	23.08.15	20:14 – 21:07
GN062	61° 44.94' N	001° 30.12' W	829	bottom, 5	-	-	206-207	24.08.15	03:15 – 04:25
GN059	62° 29.95' N	000° 00.28' W	1124	bottom, 2x5	8.5	Cs/Sr/Pu/H3	208-210	24.08.15	10:28 – 11:52
GN060	62° 30.05' N	001° 59.81' E	540	bottom, 2x5	7.5	Cs	211-213	24.08.15	17:19 – 18:09
GN063	61° 45.06' N	003° 00.06' E	410	bottom, 5	-	-	214-215	25.08.15	23:58 – 00:33
GN061	60° 59.95' N	004° 00.03' E	349	bottom, 6x5	11.5	Cs/Sr/Pu/H3	216-222	25.08.15	06:20 – 07:17

Water depth corrected for draft (5 m)!