## SUPPLEMENTARY MATERIAL

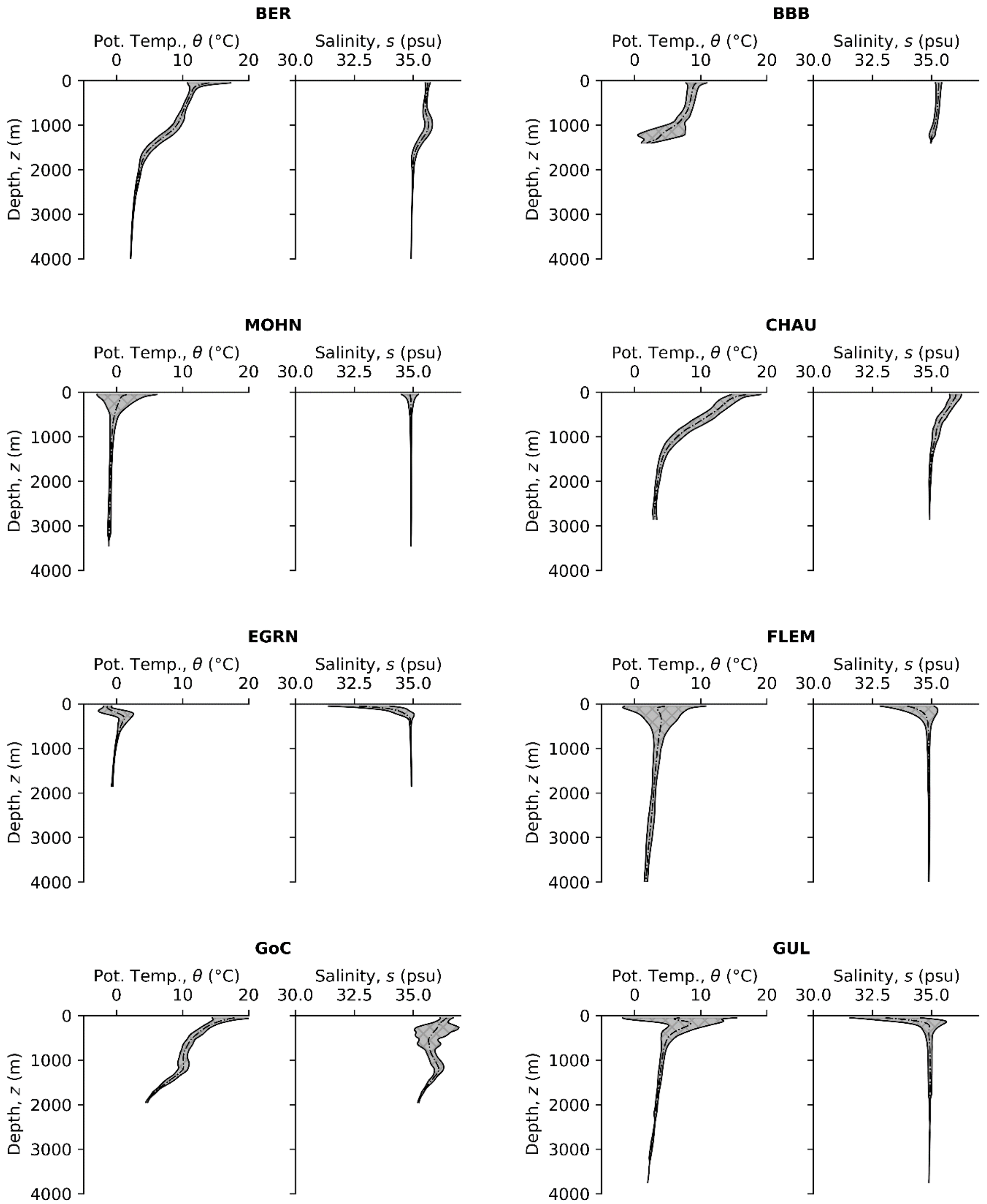


**Fig. S1** - Envelopes of potential temperature, $\theta$, and salinity, $s$, versus depth, $z$, for sites across the North Atlantic Ocean and Nordic Seas (site abbreviations as defined in Fig. 2). Climatological mean depth profiles are shown (dash-dotted lines) and envelope bounds (solid lines) represent mean values ± 2 SDs. Sites below the broken line (i.e. DAV, DEN, and FAR) were not included in the $\theta$-$s$ curvature analysis (see main text).

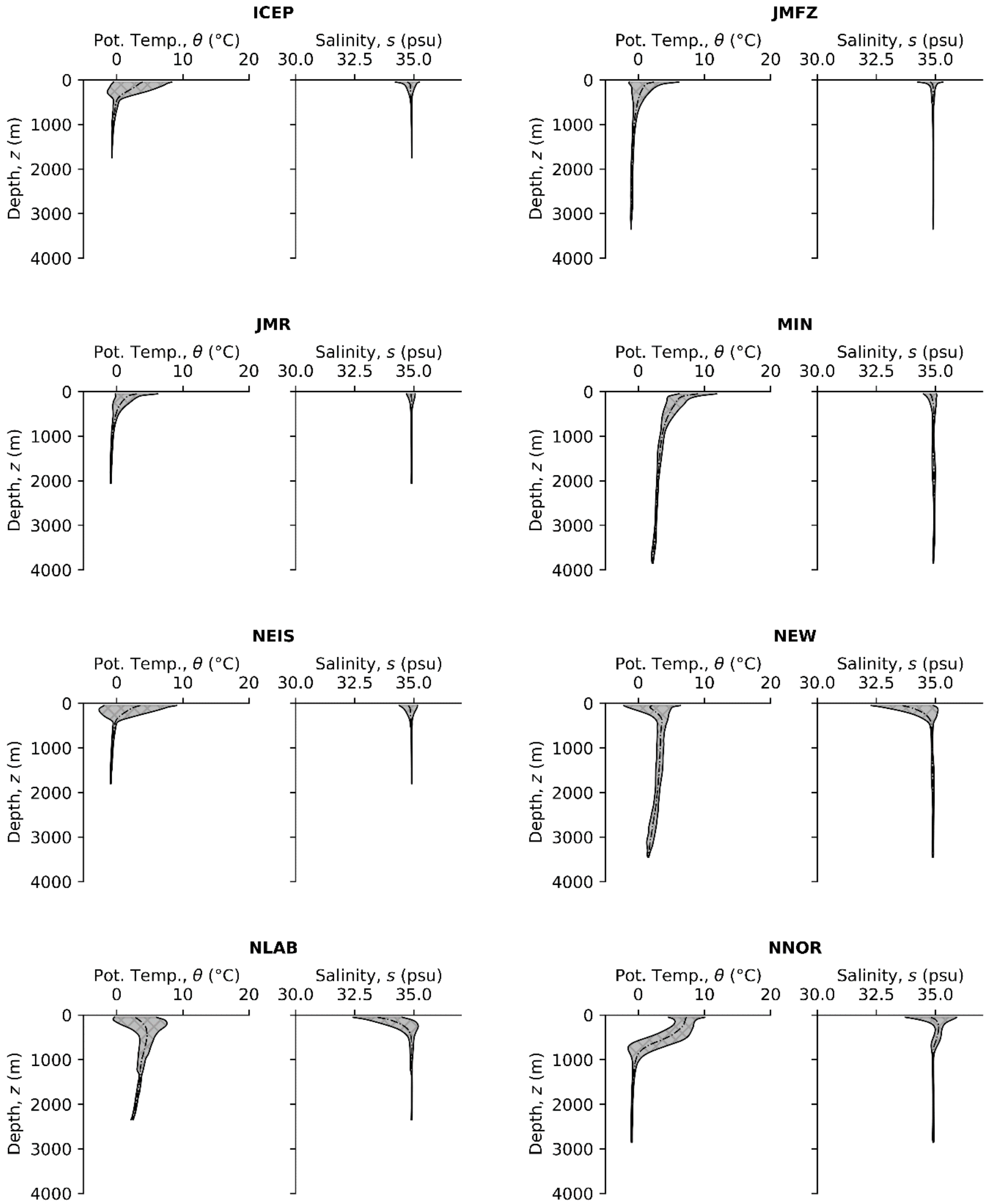


**Fig. S1** – (continued)

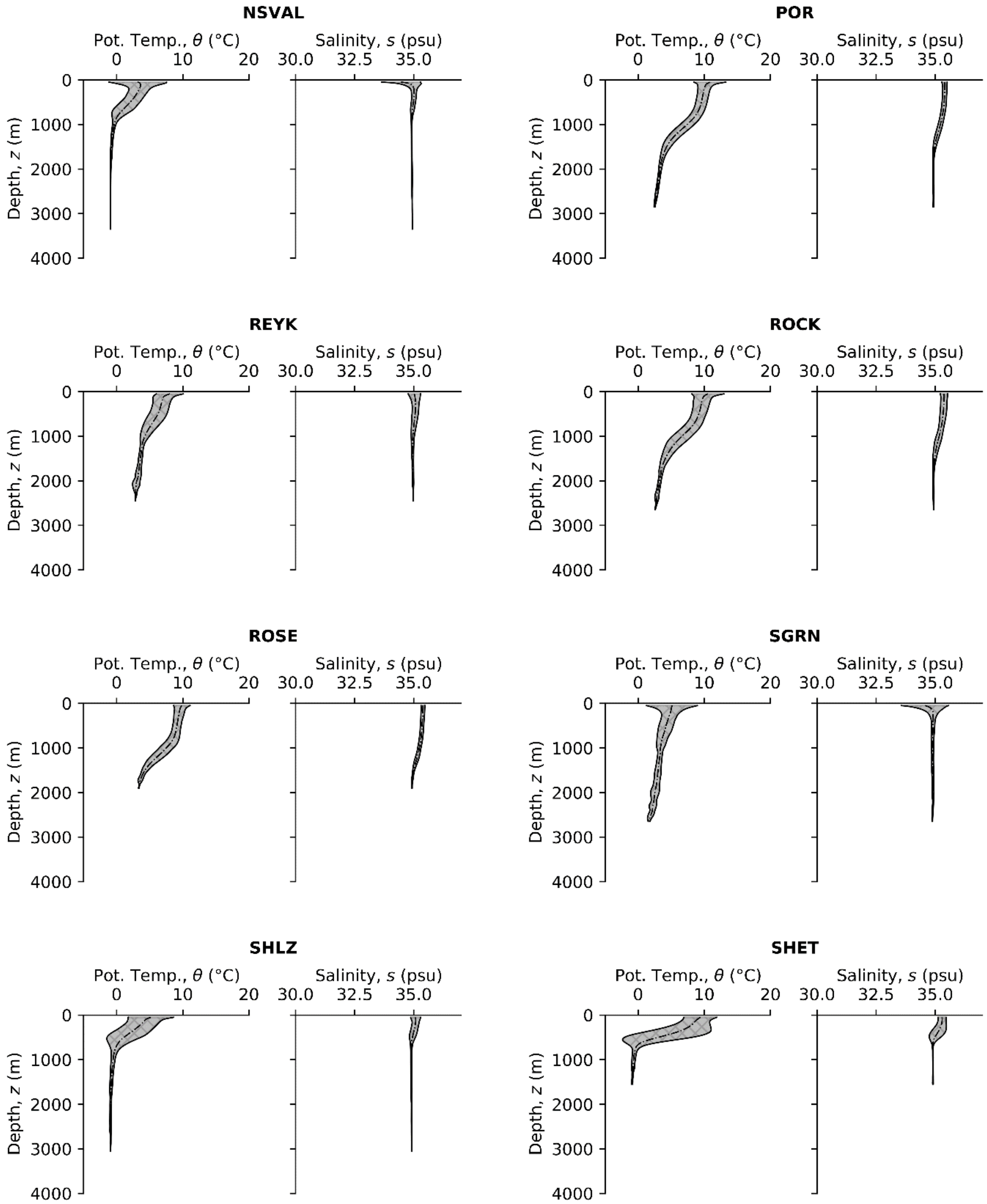


**Fig. S1** – (continued)

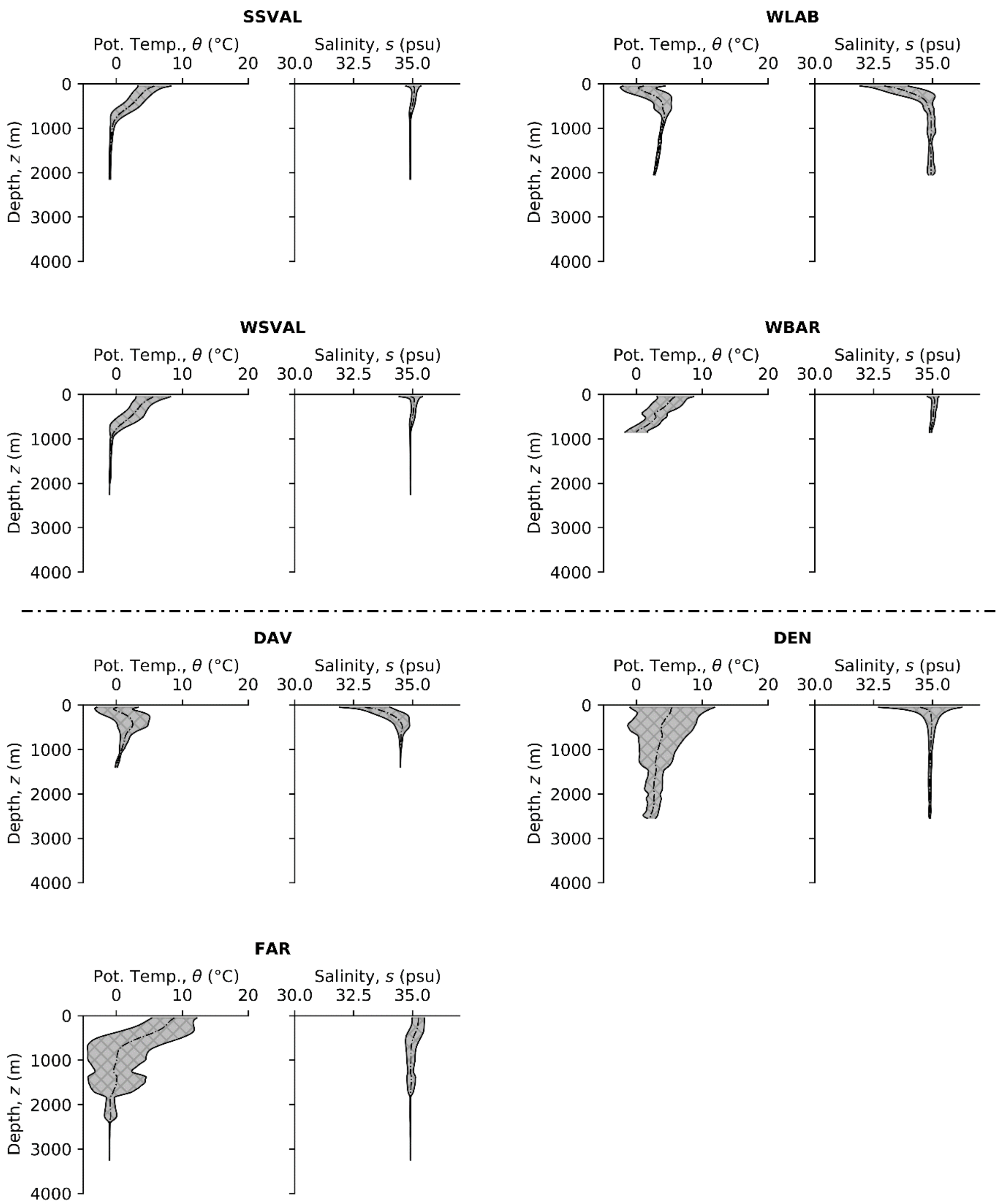


**Fig. S1** – (continued)

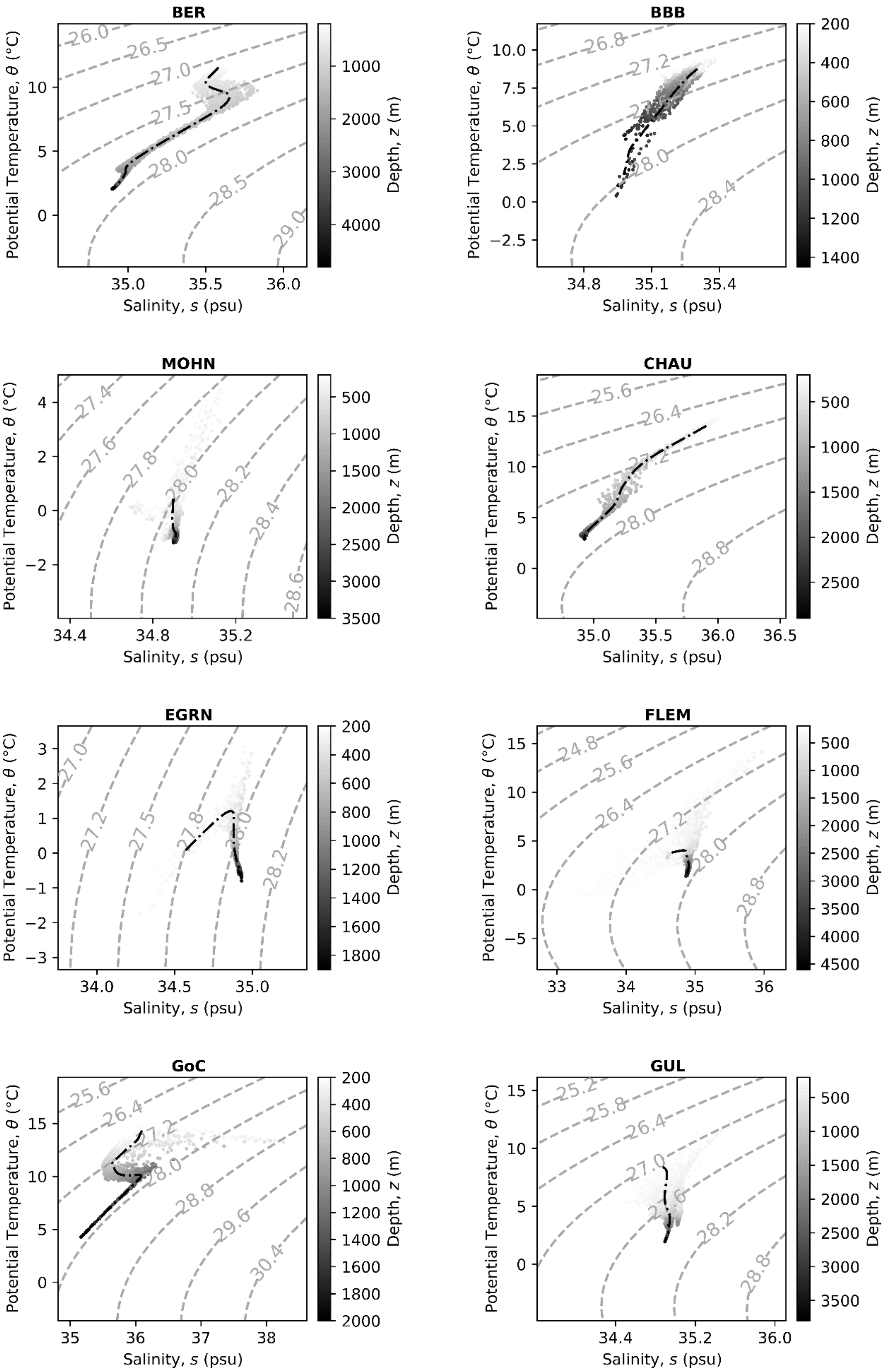


**Fig. S2** – Potential temperature–salinity ($\theta$-$s$) diagrams for sites across the North Atlantic Ocean and Nordic Seas (site abbreviations as defined in Fig. 2). Dash-dotted lines are climatological mean curves used in the curvature analysis. DAV, DEN, and FAR sites are not included, for reasons explained in the main text. Note the different scales applied for $\theta$, $s$, and depth, $z$, from panel to panel.

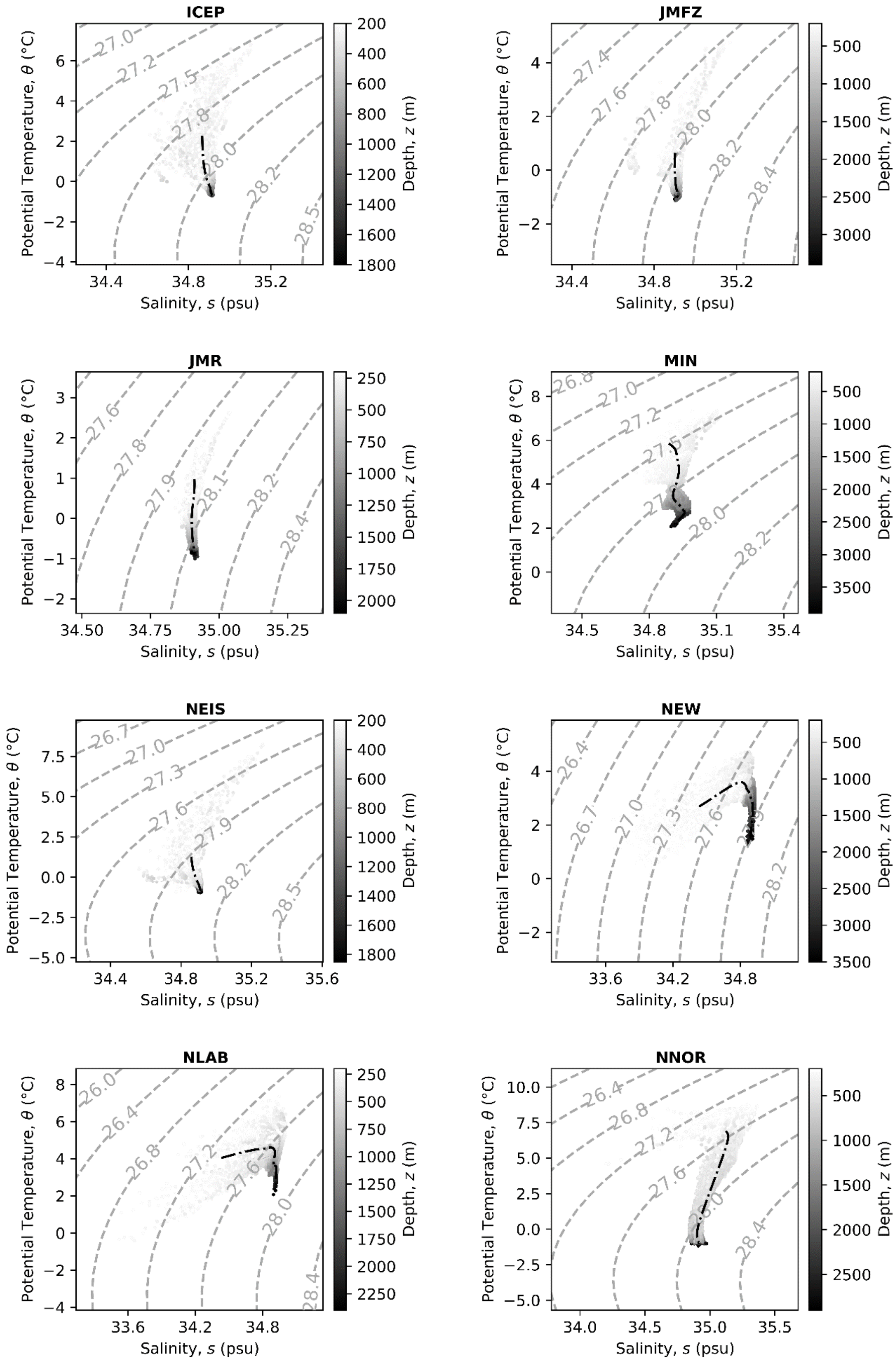


**Fig. S2** – (continued)

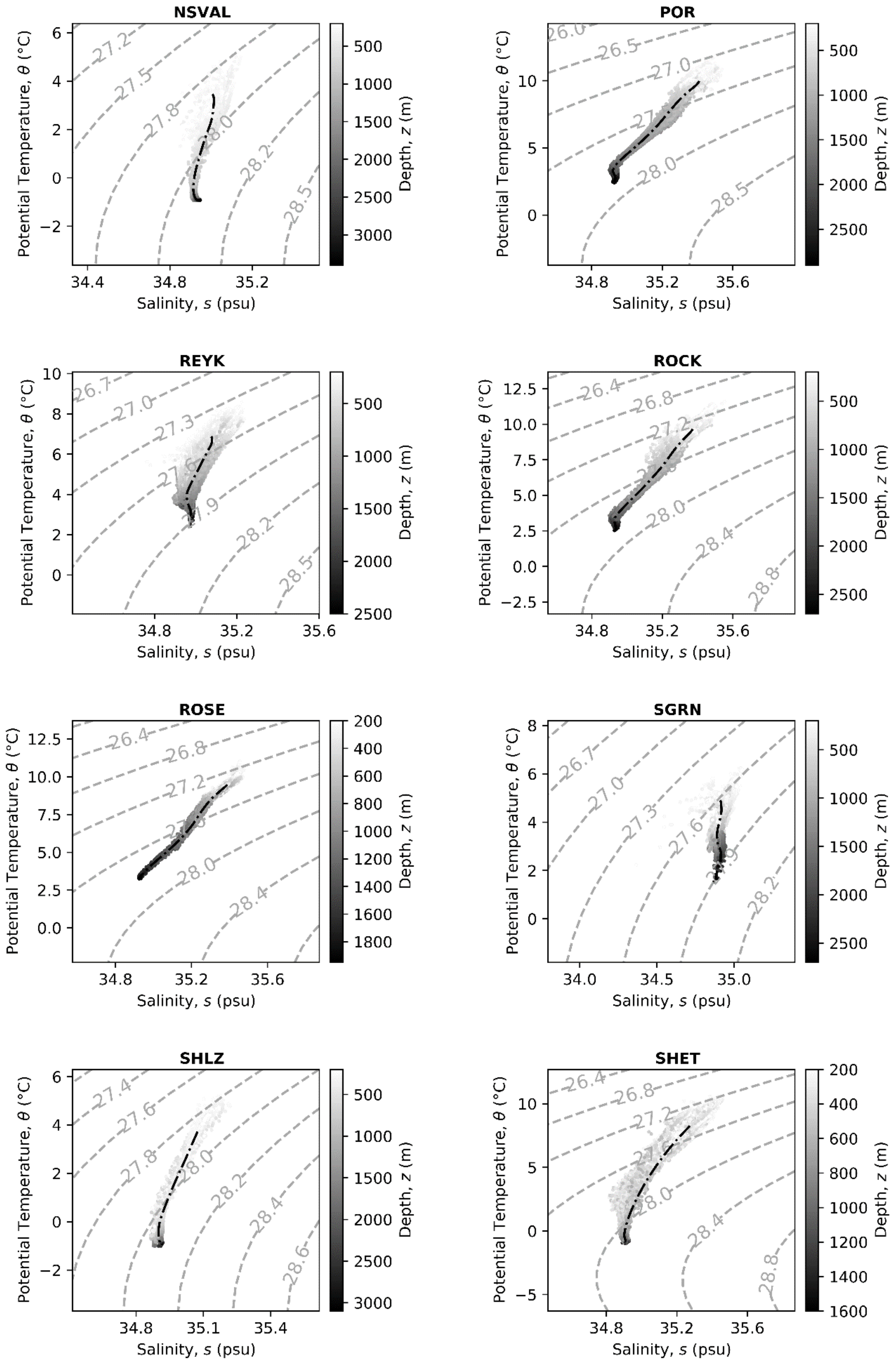


**Fig. S2** – (continued)

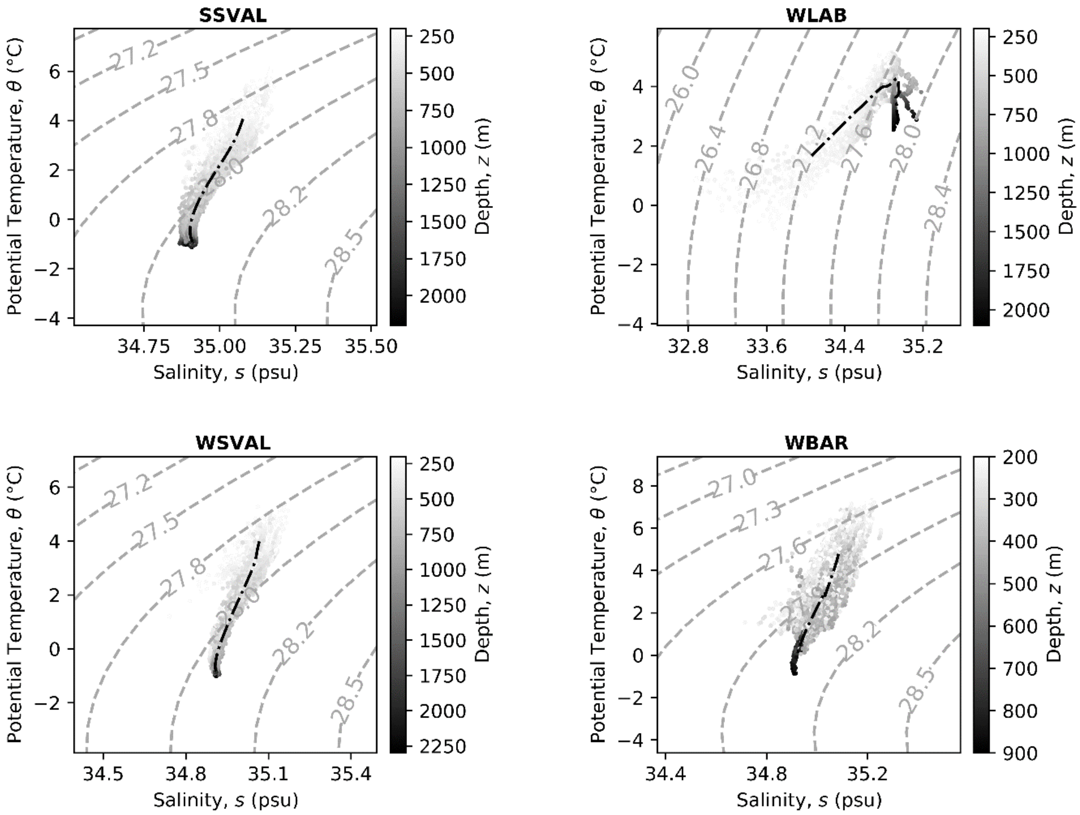


**Fig. S2** – (continued)

**Table S1** – Full names relating to water mass abbreviations used in this study, and comments on water mass distributions and/or origins.

| Abbreviation | Full name | Comment |
|---|---|---|
| **(C)ArW** | (Canadian) Arctic Water | Arctic Ocean outflow to Baffin Bay through the Canadian Arctic Archipelago. |
| **(IC)IrAW** | (Irminger Current) Irminger Atlantic Water | In this study, intended to represent Irminger Sea water carried northwards through the Denmark Strait by the North Icelandic Irminger Current (NIIC). |
| **(NS)ArW** | (Nordic Seas) Arctic Water | Water from the basins of the Nordic Seas contributing to DSOW via the North Icelandic Jet (NIJ). |
| **(WG)IrAW** | (West Greenland) Irminger Atlantic Water | Component of the northwards-flowing West Greenland Current (WGC), concentrated on the continental slope and carrying water from the Irminger Sea. |
| **ArIW** | Arctic Intermediate Water | Intermediate waters formed in the convective gyres of the Greenland and Iceland Seas or (in the case of the Norwegian Sea) fed by the advection of other intermediate waters (see NwArIW). |
| **ArODW** | Arctic Ocean Deep Water | Bracket term incorporating deep waters of the Arctic (Polar) Ocean (see EBDW and CBDW). |
| **ArSW** | Arctic Surface Water | Surface waters of the Nordic Seas (particularly the Greenland and Iceland Seas) not otherwise specified. |
| **BBDW** | Baffin Bay Deep Water | Deep water found in Baffin Bay, the origin/formation of which is still debated. |
| **CBDW** | Canadian Basin Deep Water | Deep water in the Canadian Basin of the Arctic Ocean; originates largely from the Eurasian Basin, where it was modified (to become warmer and more saline) by interactions with shelf plumes and Atlantic-derived water. |
| **DSOW** | Denmark Strait Overflow Water | Dense water overflowing the sill of the Denmark Strait into the deep North Atlantic. Sources are the East Greenland Current (EGC) and (NS)ArW carried by the North Icelandic Jet (NIJ). DSOW forms the densest component of North Atlantic Deep Water (NADW) and contributes significantly to the Deep Western Boundary Current (DWBC). |
| **EBDW** | Eurasian Basin Deep Water | Deep water in the Eurasian Basin of the Arctic Ocean; a mixture of dense plumes formed on the Arctic Ocean shelves and deep water from the Nordic Seas entering through the Fram Strait. |
| **ENACW** | East North Atlantic Central Water | Characterised by a nearly straight line in $\theta$-$s$ diagrams, ENACW occupies the upper layer in the Northeast Atlantic and is formed by winter mixing and subduction over an area from the northeast Azores to the European margin, bounded by the North Atlantic Current (NAC) and Azores Current (AC). |

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| **FSAW** | Fram Strait Atlantic Water | Atlantic-origin water entering the Nansen Basin of the Arctic Ocean via the Fram Strait / West Spitsbergen Current (WSC). |
| **GDW** | Greenland Sea Deep Water | Deep water mass historically formed by deep winter convection in the Greenland Sea (NB: convective activity in the Greenland Sea has changed in recent decades and ArODW is having a greater influence). |
| **GFZW** | Gibbs Fracture Zone Water | Deep water mass entering the western North Atlantic largely through the Charlie-Gibbs Fracture Zone (CGFZ). GFZW describes the admixture of ISOW and NEADW, which contributes to the deep waters and boundary currents of the Northwest Atlantic. |
| **ISOW** | Iceland-Scotland Overflow Water | Dense water flowing from the Norwegian Sea into the North Atlantic over the Iceland-Scotland Ridge and through Faroe Bank Channel. |
| **IW** | Intermediate Water | Intermediate water mass above Charlie-Gibbs Fracture Zone (CGFZ), as identified in Racapé et al. (2019). |
| **LDW (AABW)** | Lower Deep Water (Antarctic Bottom Water) | Abyssal water mass found throughout the Northeast Atlantic, derived from Antarctic Bottom Water (AABW) entering the area at the Vema and Romanche Fracture Zones. AABW is formed by deep convection associated with sea ice formation in the Ross and Weddell Seas. |
| **LSLW** | Labrador Slope Water | A water mass found along the Newfoundland/Scotian Slopes, flowing to the southwest as a component of the Labrador Current (LC). It is found shoreward of and beneath WSW (see below). |
| **LSW** | Labrador Sea Water | Water mass formed in the Labrador Sea by deep convection caused by winter surface cooling. It is found at mid-depths nearly everywhere in the northern North Atlantic, but extends further south along the western boundary of the North Atlantic. |
| **MW** | Mediterranean Water | Intermediate water mass formed in the Gulf of Cádiz as the outflow of sub-surface Mediterranean water (Mediterranean Overflow Water; MOW) over the sill of the Strait of Gibraltar entrains ENACW in particular. MW spreads at intermediate depths to the north, along the western European margin, and west, towards the Azores (primarily as anticyclonic eddies, or ‘meddies’). |
| **NEADW** | Northeast Atlantic Deep Water | A deep water mass in the Northeast Atlantic (but also influencing the north-western basins), defined by the mixing of four water types (ISOW, LSW, MW, and LDW). In the Northeast Atlantic, the core of NEADW is found beneath LSW and above LDW, and generally moves southwards (although it also crosses the Mid-Atlantic Ridge heading west at the Charlie-Gibbs Fracture Zone (CGFZ)). |

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| **NwArIW** | Norwegian Sea Arctic Intermediate Water | ArIW beneath the upper Atlantic-derived layer (i.e. NwAW) in the Norwegian Sea. Unlike ArIW in the Iceland and Greenland Seas, NwArIW is not formed by convection locally, but is rather fed by advection of adjacent intermediate waters. NwArIW forms a major component of ISOW. |
| **NwAW** | Norwegian Sea Atlantic Water | Upper layer waters of the various branches of the Norwegian Atlantic Current in the Norwegian Sea. |
| **NwDW** | Norwegian Sea Deep Water | Deep water mass of the Norwegian Sea; a mixture of ArODW and GDW. |
| **PW** | Polar Water | Cold, fresh upper water masses from the Arctic Ocean, influenced there by river runoff, positive net precipitation, relatively fresh Pacific inflow, and seasonal ice melt. PW leaves the Arctic Ocean travelling equatorward (e.g. in the East Greenland Current (EGC)). |
| **RAW** | Re-circulating Atlantic Water | Atlantic water from the West Spitsbergen Current (WSC) that has re-circulated in the Fram Strait area and submerged beneath less dense PW to the west to augment the East Greenland Current (EGC). This is joined in the EGC by (amongst other components) Atlantic water that has been modified inside the Arctic Ocean (Modified Atlantic Water; MAW), but we do not differentiate between these 2 Atlantic water masses in the present work. |
| **SPMW** | Subpolar Mode Water | Subpolar Mode Waters are thick, near-surface layers in the sub-polar North Atlantic with almost vertically uniform properties. SPMWs are associated with the warm sides of the main branches of the North Atlantic Current (NAC)/subpolar gyre. |
| **UPDW** | Upper Polar Deep Water | Water mass originating in the Arctic Ocean, where it is found between the upper, Atlantic-derived layer and ArODW. In the Canadian Basin, it is the product of shelf-slope convection. In the Eurasian Basin, it is fed by colder, less saline Atlantic water inflow from the Barents Sea at intermediate depths. |
| **WSW** | Warm Slope Water | Sub-surface water over the Scotian Slope. It is the product of mixing between the Gulf Stream, North Atlantic Central Water (NACW), and coastal (shelf) waters, and flows to the northeast, adjacent to the Gulf Stream and offshore relative to LSLW. |

**Table S2** – Literature sources consulted when interpreting site-specific water mass structure from the potential temperature-salinity ($\theta$-$s$) diagrams shown in Figure A1 (above the dash-dotted line) and Figure 6 (below the dash-dotted line). Full references are provided at the end of the supplementary material.

| Site name | Abbreviation | Literature source(s) for water mass interpretation |
|---|---|---|
| Berthois Spur | **BER** | Pollard et al. 1996; Lavín et al. 2004; González-Pola et al. 2005; Porter et al. 2016 |
| Bill Bailey Bank | **BBB** | Harvey 1982; Turrell and Sherwin 2003; Johnson et al. 2010 |
| Central Mohn's Ridge | **MOHN** | Swift and Aagaard 1981; Blindheim and Rey 2004; Le Moine Bauer et al. 2018 |
| Chaucer Seamount | **CHAU** | Tychensky et al. 1998; Søiland et al. 2008; Palma et al. 2012; Caldeira and Reis 2017 |
| East Greenland Shelf | **EGRN** | Rudels et al. 2002; Amon et al. 2003; Langehaug and Falck 2012 |
| Flemish Cap | **FLEM** | Lee and Ellett 1967; Kieke and Rhein 2006; van Sebille et al. 2011 |
| Gulf of Cadiz | **GoC** | Alves et al. 2011; Carracedo et al. 2012; Carracedo et al. 2016 |
| Gully Canyon | **GUL** | Greenan et al. 2014; MacIsaac et al. 2014; Dever et al. 2016; Filippova et al. 2017 |
| Icelandic Plateau | **ICEP** | Malmberg et al. 1996; Buch et al. 1996; Blindheim and Østerhus 2005 |
| Jan Mayen Fracture Zone | **JMFZ** | Buch et al. 1996; Rudels et al. 2003; Mork et al. 2014 |
| Jan Mayen Ridge | **JMR** | Buch et al. 1996; Rudels et al. 2003; Mork et al. 2014 |
| Minia Seamount / Charlie-Gibbs Fracture Zone | **MIN** | Racapé et al. 2019 |
| Newfoundland-Labrador Slope | **NEW** | Lee and Ellett 1967; Kieke and Rhein 2006; van Sebille et al. 2011 |
| North Labrador Sea | **NLAB** | Lee and Ellett 1967; Kieke and Rhein 2006; van Sebille et al. 2011 |
| North Norwegian Shelf | **NNOR** | Buhl-Mortensen et al. 2012 |
| North of Svalbard | **NSVAL** | Schauer et al. 1997; Cokelet et al. 2008; Rudels et al. 2013; Våge et al. 2016; Pérez-Hernández et al. 2017 |
| Northeast Iceland Shelf | **NEIS** | Read and Pollard 1992 |
| Porcupine Bank / Malin Slope | **POR** | McGrath et al. 2012 |

| | | |
|---|---|---|
| Reykjanes Ridge | **REYK** | Yashayaev et al. 2007; Kanzow and Zenk 2014; Castrillejo et al. 2018; Fröb et al. 2018; Petit 2018 |
| Rockall Bank | **ROCK** | McGrath et al. 2012 |
| Rosemary Bank | **ROSE** | Johnson et al. 2010 |
| Schulz Bank | **SHLZ** | Roberts et al. 2018 |
| Shetland Islands | **SHET** | Hansen and Østerhus 2000; McKenna et al. 2016 |
| South of Greenland | **SGRN** | Kieke and Rhein 2006; de Jong et al. 2009; Castrillejo et al. 2018 |
| South of Svalbard | **SSVAL** | Langehaug and Falck 2012 |
| West Labrador Sea | **WLAB** | Lee and Ellett 1967; Kieke and Rhein 2006; van Sebille et al. 2011 |
| West of Svalbard | **WSVAL** | Langehaug and Falck 2012 |
| Western Barents Sea | **WBAR** | Buhl-Mortensen et al. 2012; Oziel et al. 2016 |
| Davis Strait | **DAV** | Tang et al. 2004; Azetsu-Scott et al. 2012 |
| Denmark Strait | **DEN** | Harden et al. 2016; Mastropole et al. 2017 |

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