

## Supplementary Materials

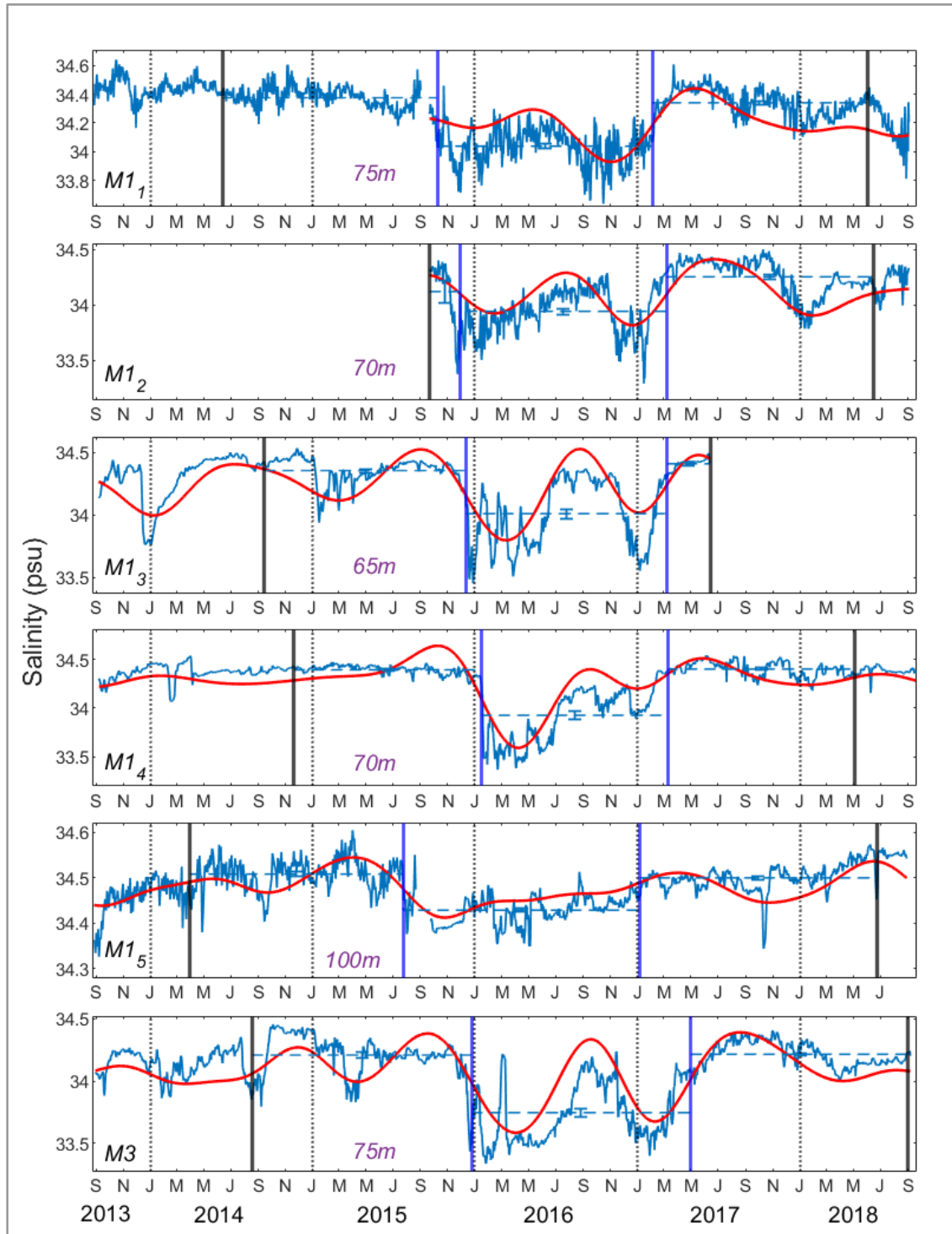


Figure S1: Daily salinity time series (blue lines) with seasonal signals (red line) derived from wavelet analysis for six mooring locations in the eastern Eurasian Basin. Vertical dark blue lines indicate the period of the freshening event; the vertical black lines mark the periods for pre- and post-event.

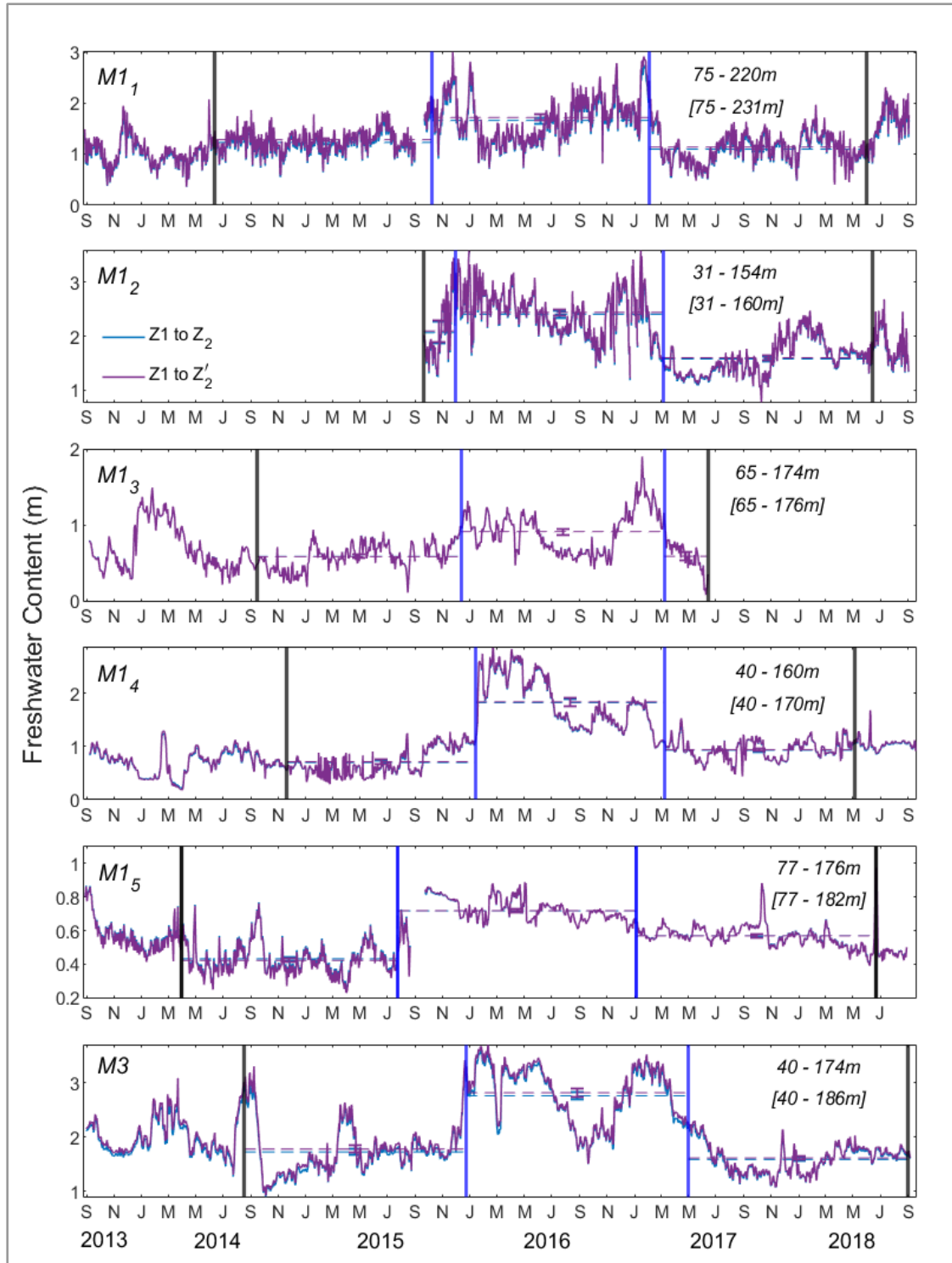


Figure S2: Time series of freshwater content (FWC, m) for six mooring locations in the eastern Eurasian Basin averaged over two depth ranges (blue and purple lines) defined by salinity anomaly criteria. The first range extends from the shallowest record to the depth where salinity anomalies drop below 3% (14% for  $M1_5$ ) of the reference salinity, whereas the second range extends to where anomalies approach 0% (11% for  $M1_5$ ). Horizontal dashed lines represent the mean, and error bars denote  $\pm 3$  standard errors. Vertical dark blue lines indicate the period of the freshening event; vertical black lines mark the periods before and after the event.

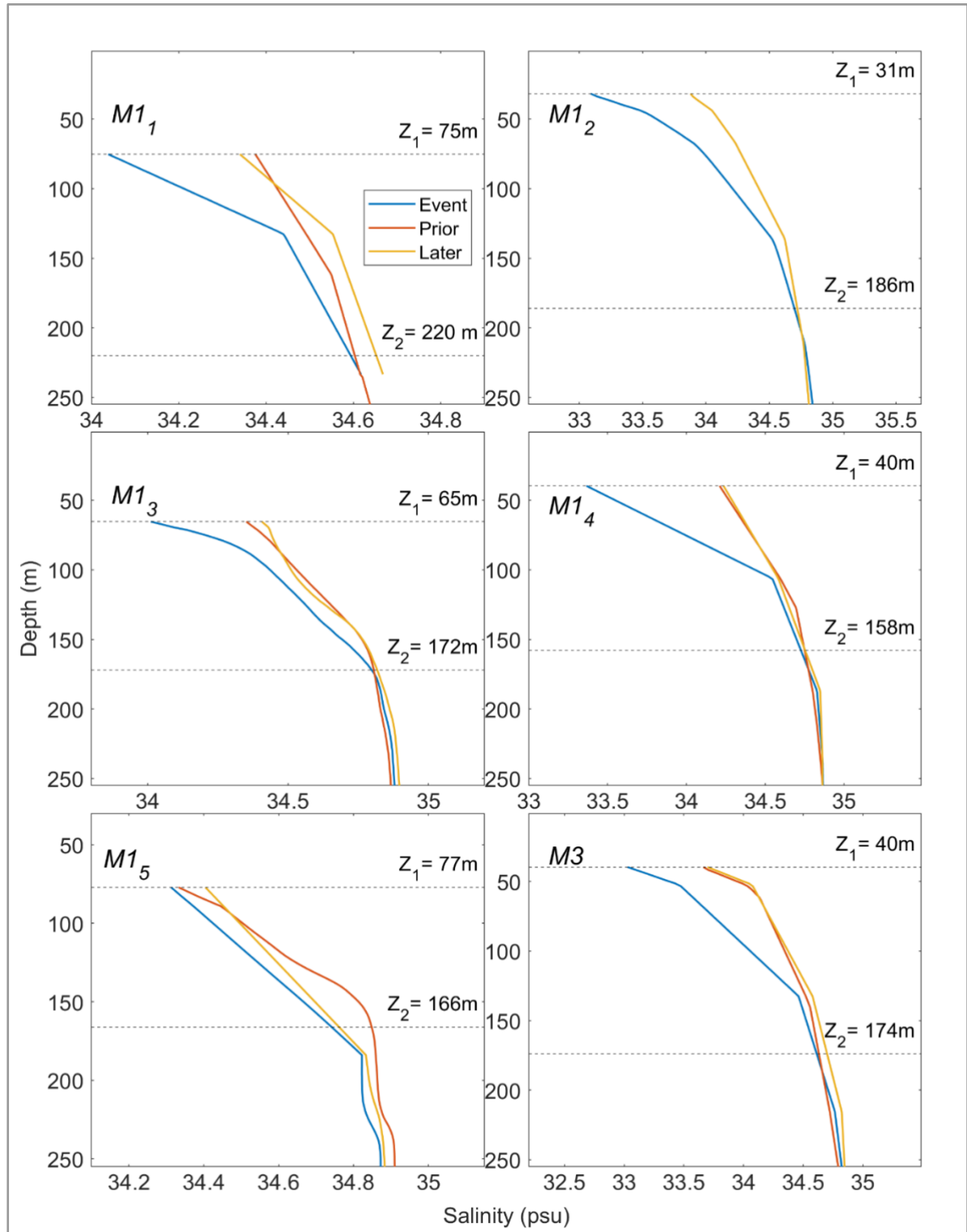


Figure S3: Salinity profiles averaged over the periods before (orange; pre-event), during (blue; Event), and after (yellow; post-event) the freshening event for six mooring locations in the eastern Eurasian Basin. Horizontal grey dashed lines mark freshening depth extent from  $Z_1$  (shallowest available salinity) and  $Z_2$  (determined by salinity anomaly threshold; see Methods for details).

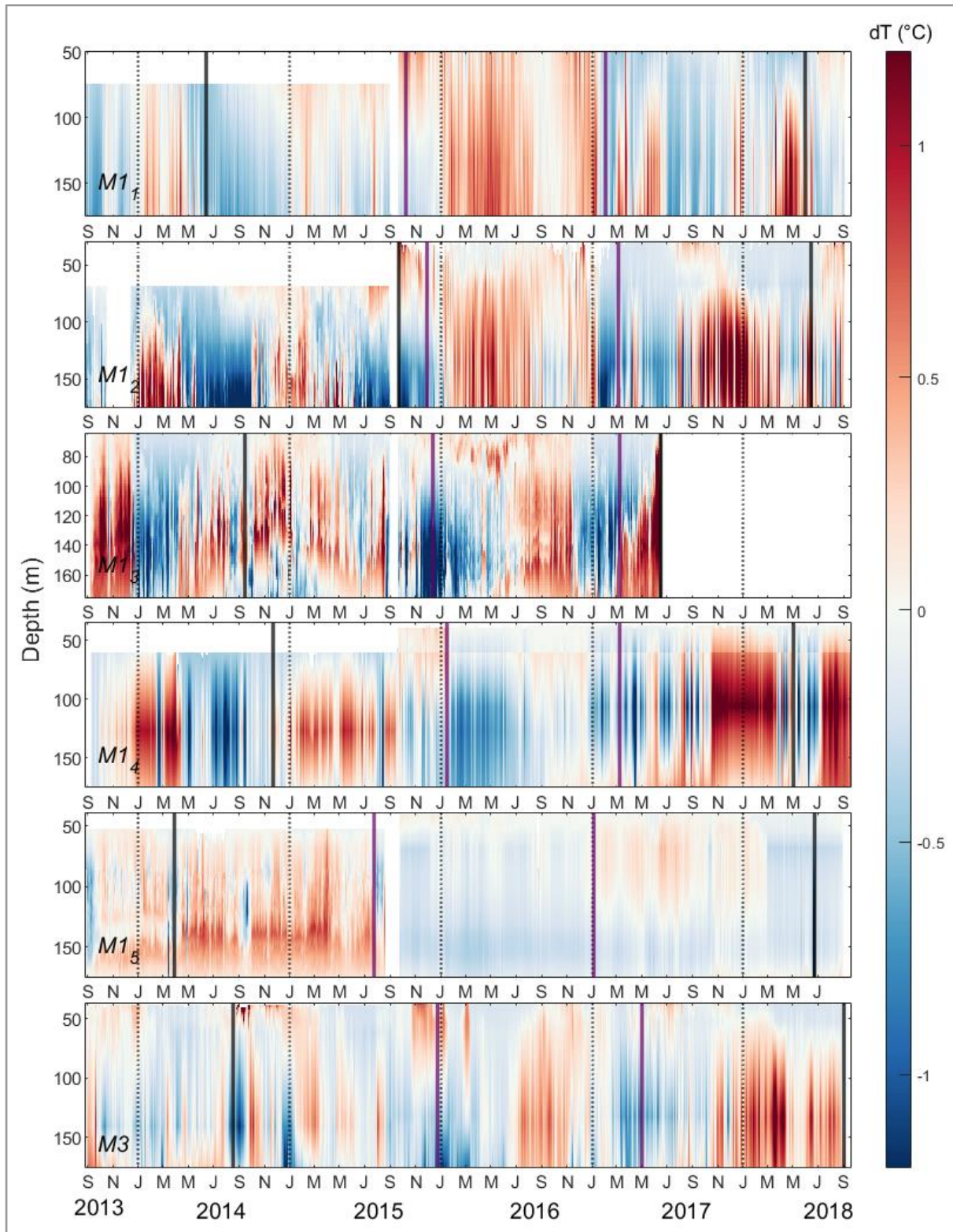


Figure S4: Depth–time distributions of anomalous temperature (relative to the 2013–2018 mean) for six mooring locations in the eastern Eurasian Basin at depths up to 175m (see their locations in Fig. 2.1) from 2013 to 2018. Vertical red dashed lines indicate the freshening event (2015–2017), and solid red lines mark the periods before and after the event, used for comparison. White gaps show missing data.

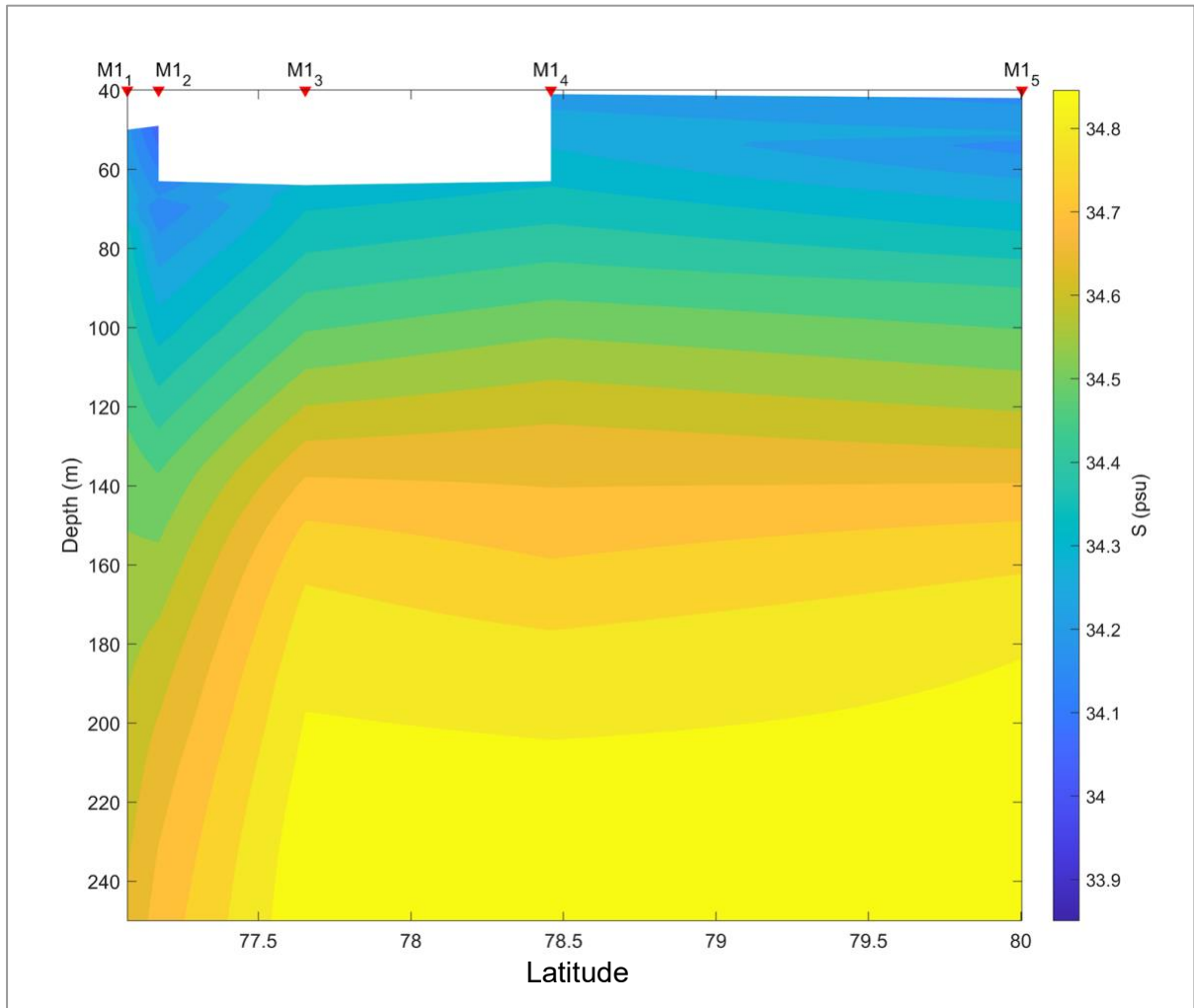


Figure S5: Vertical section of salinity (psu) from 40 to 250 m depth along the mooring array in the eastern Eurasian Basin, averaged from September 2015 to September 2018, excluding the freshening event. Red triangles at the top mark the mooring locations. White areas indicate data gaps.

Table S1: Freshening layer limits and freshwater content (FWC) at six mooring locations in the eastern Eurasian Basin.  $z_1$  is the depth of the shallowest salinity record;  $z_2$  and  $z_2'$  are the lower bounds of the freshening layer where the mean salinity-anomaly profile falls to  $\leq 3\%$  ( $\leq 6\%$  for M15) of the event salinity magnitude and to  $\sim 0\%$  ( $\sim 3\%$  for M15), respectively. “Mean for  $z_1-z_2$ ” and “Mean for  $z_1-z_2'$ ” list the depth-integrated FWC (meters) as the mean  $\pm$  3 SE (standard error) of the time series. The correlation row gives the Pearson coefficient between the two FWC series at each mooring.

| <b>Moor</b>                                      | <b>M1<sub>1</sub></b> | <b>M1<sub>2</sub></b> | <b>M1<sub>3</sub></b> | <b>M1<sub>4</sub></b> | <b>M1<sub>5</sub></b> | <b>M3</b>       |
|--------------------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------|
| <b>Z<sub>1</sub> (m)</b>                         | 75                    | 31                    | 65                    | 40                    | 77                    | 40              |
| <b>Z<sub>2</sub> (m)</b>                         | 220                   | 186                   | 172                   | 158                   | 166                   | 174             |
| <b>Z<sub>2</sub>' (m)</b>                        | 230                   | 204                   | 174                   | 170                   | 184                   | 186             |
| <b>Mean for<br/>Z<sub>1</sub>-Z<sub>2</sub></b>  | 1.26 $\pm$ 0.01       | 0.89 $\pm$ 0.02       | 0.58 $\pm$ 0.01       | 0.75 $\pm$ 0.01       | 0.69 $\pm$ 0.00       | 1.95 $\pm$ 0.02 |
| <b>Mean for<br/>Z<sub>1</sub>-Z<sub>2</sub>'</b> | 1.30 $\pm$ 0.01       | 0.92 $\pm$ 0.02       | 0.57 $\pm$ 0.01       | 0.76 $\pm$ 0.01       | 0.68 $\pm$ 0.00       | 2.00 $\pm$ 0.02 |
| <b>Correlation</b>                               | 0.99                  | 0.99                  | 1.00                  | 0.99                  | 0.99                  | 0.99            |

Table S2: Properties averaged over 50–150 m for five mooring locations. Mean salinity ( $S$ , psu), the meridional salinity difference between adjacent moorings ( $\Delta S = S_{north} - S_{south}$ , psu), pair-mean meridional current velocity ( $\bar{V}$ , cm/s; averaged over adjacent mooring locations), and the proxy of advective term ( $\bar{V} \cdot \Delta S$ ) are averaged from September 2015 to September 2018 (excluding the freshening event).  $dS_{fresh}$  (psu) is the observed salinity anomaly during the freshening event.

| Mooring         | Mean S | $\Delta S$ | $\bar{V}$ | $\bar{V} \cdot \Delta S$ | $dS_{fresh}$       |
|-----------------|--------|------------|-----------|--------------------------|--------------------|
| M1 <sub>1</sub> | 34.42  | -0.10      | +3.4      | -0.32 ↔ salinification   | -0.14 ↔ freshening |
| M1 <sub>2</sub> | 34.32  |            |           |                          | -0.12 ↔ freshening |
| M1 <sub>3</sub> | 34.55  | +0.23      | +1.1      | +0.25 ↔ freshening       | -0.07 ↔ freshening |
|                 |        | -0.03      | +0.8      | -0.02 ↔ salinification   |                    |
| M1 <sub>4</sub> | 34.52  | -0.04      | +1.1      | -0.04 ↔ salinification   | -0.16 ↔ freshening |
| M1 <sub>5</sub> | 34.48  |            |           |                          | -0.05 ↔ freshening |