Assessment of interannual variability of the dynamics of the Bering Sea water in the Chukchi Sea

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Problem	Interaction between the Arctic Ocean and the waters of the Pacific Ocean is one of the main factors shaping the hydrological regime of the region. Waters that inflow into the Arctic Ocean from the Pacific Ocean through the Bering Strait significantly contribute to the heat content of the Arctic Ocean and play a role in temporal variability of sea ice in the Chukchi Sea.
Objectives	Aim of the study was to calculate the volume, heat and salt influxes through the central part of the Chukchi Sea in a long-term average.
Data and methods	Mean monthly values for temperature, salinity and meridional component of current velocity for every 0.83° of a longitude from the CMEMS GLORYS12V1 reanalysis from Copernicus Marine Service were the main data sources used. Temporal resolution of the used data was from January 1993 to December 2020; values were retrieved at 19 depth checkpoints from 0 to 55.76 m.

Results

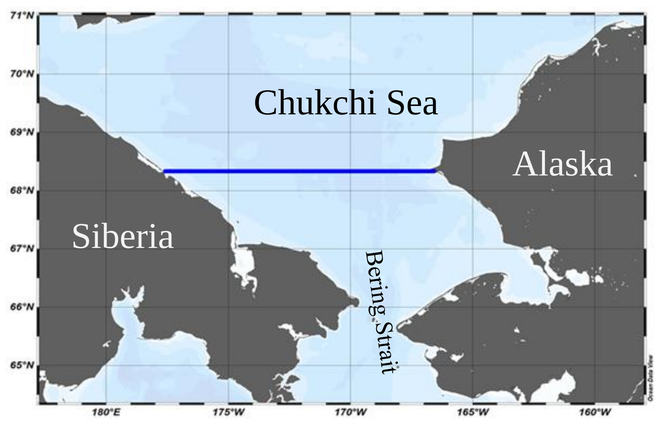

Fig. 1. Cross-section at the border of the Chukchi Sea

Calculation formulas

1. Volumetric flow rate

$$Q\ (Sv) = V * \Delta H * \Delta R * 10^{-6}$$

2. Heat flux

$$F_t\ (W) = Cp * p * (T-T_f) * V * \Delta H * \Delta R$$

3. Salt flux

$$F_s\ (kg/s) = p * Sw * V * \Delta H * \Delta R$$

V – flow velocity in the center of each cell, m/s;
ΔH – layer thickness, m;
ΔR – distance between stations, m;
Cp – specific heat capacity of water, 4200 J/(kg*s);
p – density of seawater, 1024 kg/m3;
T – seawater temperature, °C
Tf – minimum seawater temperature (-1.8°C);
Sw – salinity of seawater, kg/kg.

Linear trend for the studies variables was estimated in each cell of the studied section. Statistical significance of the linear trend coefficient was assessed using Student's t-test with a significance level of a=0.05.

Fig. 5 shows distribution of linear trend coefficients for the study period between January 1993 to December 2020 for the section across the Chukchi Sea (Fig. 1) for meridional current velocity (a), water temperature (b), and water salinity (c). The dotted lines indicate areas of significant linear trends.

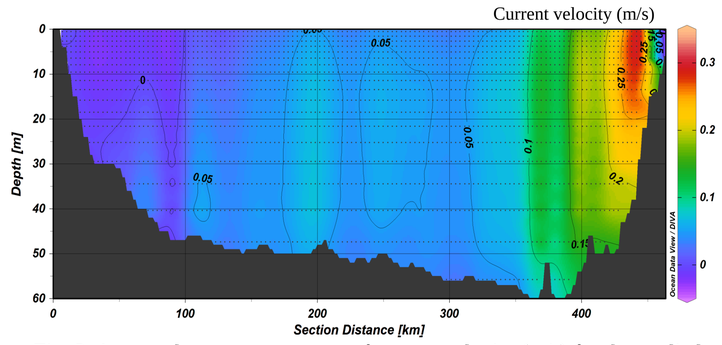

Fig. 2. Average long-term structure of current velocity (m/s) for the studied cross-section across the Chukchi Sea for Jan 1993 - Dec 2020

For the long-term average, it was found that the main water flow direction is from the Pacific Ocean into the Arctic Ocean (Fig. 2). Maximum velocity values are observed in the eastern part of cross-section in the surface layer from 0 to 20 m (0.25-0.3 m/s). In the western part of the section, there is a reverse current flowing from the Chukchi Sea into the Pacific Ocean. The vertical distribution of velocities here is uniform and ranges from 0.0008 m/s to 0.01 m/s.

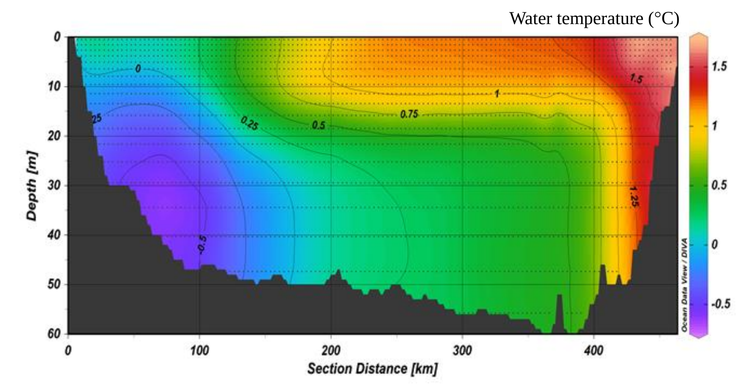

Fig. 3. Average long-term structure of water temperature (°C) for the studied cross-section across the Chukchi Sea for Jan 1993 - Dec 2020

Distribution of water temperatures (Fig. 3) has a visible warm core in the eastern part of the section and relatively warm water (1.5 °C) spreads westwards across the surface reaching a layer up to 20 m deep. In the surface and subsurface layers, water temperature reaches 1.67 °C. Relatively cold water is found from a depth of 8 m to the bottom of the western slope. The minimum water temperature here is –0.6 °C.

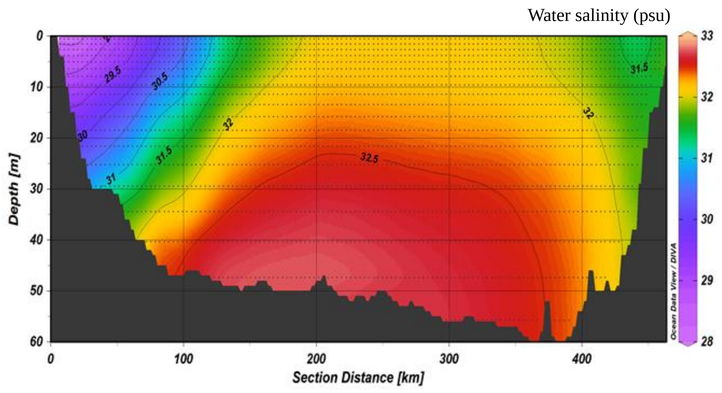

Fig. 4. Average long-term structure of water salinity (psu) for the studied cross-section across the Chukchi Sea for Jan 1993 - Dec 2020

Highest salinity values are situated in the middle of the section and reach their maximum in the bottom layer (up to 32.77 psu). Lowest salinity values are found in the western part of the section (28.32 psu). (Fig. 4)

Table 1. Average long-term (Jan 1993 – Dec 2020) values of flow rate Q, heat flux Fh, and salt flux Fs for the latitudinal section at 68°33'N

Flow	Total	Northbound flow	Southbound flow
Q, Sv	1.338	1.402	-0.064
Ft, TW	15.775	16.587	-0.814
Fs, t/s	44.464	46.35	-1.932

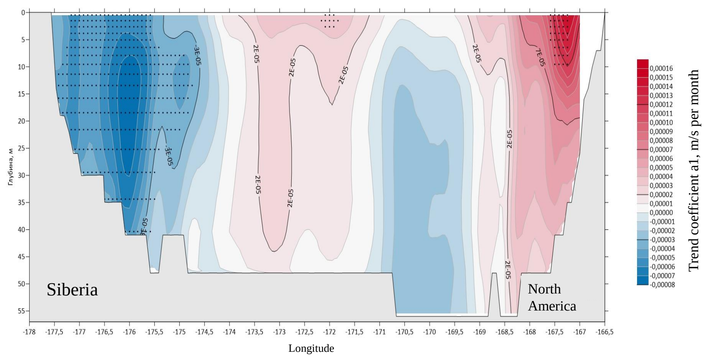

Fig. 5 (a). Distribution of linear trend coefficients (Jan 1993 - Dec 2020) for the studied cross-section across the Chukchi Sea for meridional velocity

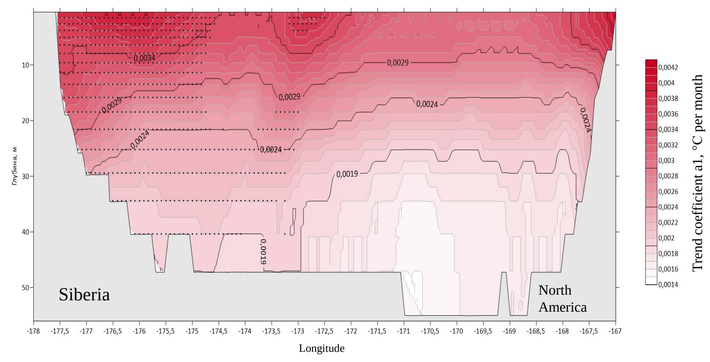

Fig. 5 (b). Distribution of linear trend coefficients (Jan 1993 - Dec 2020) for the studied cross-section across the Chukchi Sea for water temperature

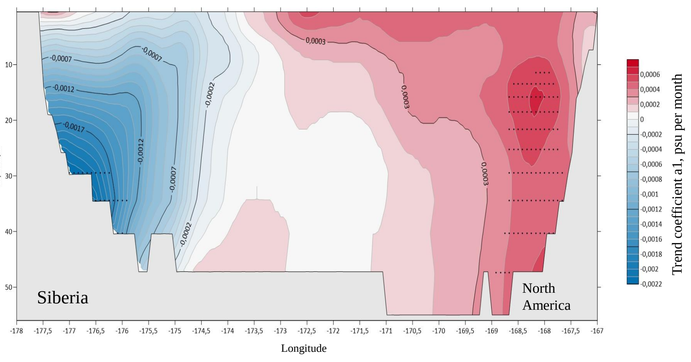

Fig. 5 (c). Distribution of linear trend coefficients (Jan 1993 - Dec 2020) for the studied cross-section across the Chukchi Sea for water salinity

Conclusions

- Average long-term (Jan 1993 - Dec 2020) values of volume, heat and salt influxes through the latitudinal section at 68°33'N are 1.3 Sv, 15.8 TW, and 44.5 **t/s**, respectively. Most of these fluxes flow from the Pacific Ocean into the Chukchi Sea with only a small portion flowing in the opposite direction.
- Distribution of hydrographic characteristics across the Chukchi Sea section shows presence of two main flows: the southern one (occupying most area of the studied cross-section) situated in the eastern part of the cross-section with maximum speeds and water temperature, and the northern one which is a narrow stream spreading along the western slope of the mainland with low speeds and relatively cold (-0.5 °C) and desalinated (28.5 psu) water.
- Salinity values distribution for the southern flow does not repeat the distribution of current velocities and temperatures and has maximum values at the bottom of the central part of the studied cross-section which decrease towards the opposite ends of the studies section.
- Temporal variability of temperature, salinity and current velocities exhibit a statistically significant linear trends which have higher values near the opposite ends of the cross-section – western and eastern coasts. This explains the increased dynamics in this region.

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