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Inter-annual variability of vertical distribution of temperature and salinity in the Gulf of Finland (Baltic Sea) in summer.

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The Gulf of Finland is a 400-km long and 80-120-km wide elongated sub-basin of the Baltic Sea. It has no sill at the entrance area separating the Gulf from the open Baltic Sea and its maximum cross-section depth decreases from $>$ 100 m at the entrance to $<$ 30 m in the eastern part. The salinity distribution in the surface layer is characterized by an increase from 1-3 in the east to 6 (on the practical salinity scale) in the west and by a slight decrease across the Gulf from south to north. The water column in the deeper areas of the Gulf reveals a three-layer vertical structure in summer – the upper mixed layer, the cold intermediate layer and a saltier and slightly warmer near bottom layer can be distinguished. These layers are separated by two pycnoclines – by seasonal thermocline usually situated at the depths of 10-20 m and by permanent halocline at the depths of 60-70 m.

According to the monitoring data a decrease of salinity in the deep layers of the Gulf observed from late seventies was replaced by a salinity increase in nineties. During the same period an average surface layer temperature increase has been observed. Main aim of the present study was to describe the vertical structure of temperature and salinity fields and its inter-annual variations in the Gulf of Finland in summer (June-August). We have analysed the data collected in 1987-2008 to show whether the suggested trends in salinity and temperature can be confirmed and what kind of changes did the pycnoclines experience.

CTD measurements were carried out onboard research vessels by Neil Brown Mark III and Seabird SBE-19 CTD profilers. Altogether data of 2145 CTD casts were used in the present study. Higher number of CTD casts was available in the western and southern part of the Gulf. The CTD data have been processed and stored as vertical profiles with a resolution of 0.5 m. Wind data for the corresponding period were obtained from the Kalbådagrund meteorological station (Finnish Meteorological Institute) located in the central part of the Gulf.

Upper mixed layer thickness as well as thermocline and halocline location, their thickness and steepness were estimated. Mean values on the basis of each profile, and monthly and seasonal mean values of temperature and salinity in the upper mixed layer and in the near-bottom layer were estimated.

On the basis of data from 1987-2008, the mean water temperature in the 5-m surface layer of the central Gulf of Finland in June was 12.3 $^{\circ}$C and the mean salinity – 4.5. Same parameters in July and August were, respectively, 16.8 $^{\circ}$C, 5.0 and 17.1 $^{\circ}$C, 4.9. A relatively high inter-annual variability of the surface layer and the near-bottom layer temperature and salinity, and the salinity gradient between the surface and the near-bottom layer was revealed. The highest salinity and temperature values were recorded at the 70-meter depth in the central Gulf in 1997 and 2006. These extreme T,S-values and strong vertical gradient of salinity were related to the exceptional wind pattern prevailed in the area – easterly winds were prevailing more than usually and a quite low average wind speed was measured.

The upper mixed layer thickness varied mostly between 4 and 18 m and its variability was the highest in August. A rough analysis was made to find a link between the average wind speed and the estimated upper mixed layer thickness. The results showed a significant correlation (r = 0.39) between the 3-day (a day when CTD cast was performed and 2 days before it) mean wind speed and the calculated mixed layer thickness.

The deeper border of thermocline was most probably found in a range 20-30 m. Similarly to the upper mixed layer thickness, the variability of the thermocline deeper border had the highest variability in August. The estimated thickness of thermocline in July-August varied mostly between 6 and 21 m. Mean vertical temperature gradient in the thermocline was 0.95 $^{\circ}$C m^{-1} and salinity gradient 0.09 m^{-1}.

The observed changes of the seasonal temperature and salinity values as well as the vertical structure of these fields was related to the general atmospheric circulation patterns and to the occurred salt water inflows from the North Sea to the deep layers of the central Baltic Sea. The possible influence of the variations in the vertical structure of the water column to the ecosystem of the Gulf of Finland is discussed.