**Annex 2.**

# Self-presentation

1. First name, last name **Jan Jędrasik**

2. Diplomas and degrees (type, place and year; PhD thesis title)

**1969, Higher education diploma (M.Sc.), Teachers' College, Gdańsk;**
**1976, Ph.D. in Geography, University of Gdańsk; thesis: „Internal wave action in trough lakes as exemplified by Raduńskie Lakes"**

3. Employment history (research institutions only)

**1 October-31 December 1969: research assistant, Department of Hydrography and Climatology, Faculty of Geography, Teachers' College, Gdańsk.**

**1 January 1970-30 September 1977: researcher, Limnological Station of University of Gdańsk, Borucino (Kashubian Lake District).**

**1 October 1977-30 September 1988: assistant professor, Department of Hydrology and Climatology, University of Gdańsk.**

**1 October 1988-30 September 2001: assistant professor, Department of Physical Oceanography, Institute of Oceanography, University of Gdańsk.**

**1 October 2001-30 September 2013: senior lecturer, Department of Physical Oceanography, Institute of Oceanography, University of Gdańsk.**

**1 October 2013-present: specific-task contract-based employment, Department of Physical Oceanography, University of Gdańsk.**

4. Scientific achievements, as defined by Art. 16 Para. 2, Act on Scientific Degrees and Titles of 14 March 2003 (Dz. U. No. 65, Issue 595 with alterations):

a) Title of achievement

**Jędrasik J., 2014, Modelling and forecasting of the Baltic Sea hydrodynamics, Wyd. Uniw. Gda., 1-190.**

The major achievement presented in the monograph is the elucidation of new mechanisms for exploring the Baltic Sea system through modelling and forecasting. Application of well-calibrated and comprehensively validated hindcast models capable of long-term simulations on the one hand, and of scenario-based prognostic modelling on the other makes it possible to gain new insights on attributes and characteristics of physical components of the marine environment, which would not have been possible to explore with other methods.

1. Achievements in modelling stemmed from determination of:
   - Trends and major topographic components of the Baltic Sea level changes;
   - Seasonal characteristics of surface and subsurface currents;
   - Long-term cyclic relationships between the Baltic hydrodynamics and the North Atlantic Oscillation;
   - Mechanisms of river plume formation and water exchange in the coastal zone with coastal waters and rivers.
2. In relation to forecasting, the monograph describes the development of implementation mechanisms for:
   - operational forecasts of the Baltic Sea hydrodynamics (on-line forecasts);
   - scenario-based forecasts of changes in the Baltic ecosystem.

The remaining achievements described in the monograph concern:

- presentation of new postulates regarding lines of research for the development of modelling and forecasting of the Baltic Sea hydrodynamics;
- ordering of concepts related to the development of modelling and forecasting of the Baltic Sea hydrodynamics, including guidelines for correct application of the concepts.

**Results of research on sea level changes**

Results of research on the Baltic Sea level changes emerged from two lines of earlier publications: the first focuses on decreasing trends determined by the Fennoscandian Plate isostatic uplift, whereas the other deals with the interrelationships between the sea level and atmospheric pressure changes as expressed by the NAO index.

Results of the transverse spectral analysis of the observed sea level changes showed cyclic similarities in two areas of the Baltic Sea: in the north-east and in the south-west (Jędrasik et al., 2004). The north-east showed decreasing trends, associated with the isostatic, postglacial uplift of the Fennoscandian Plate and a marine regression. In the south-west, the sea level changes showed an increasing trend, or a marine transgression due to the lowering of the Danish-Polish Trough (Rotnicki et al., 1995). The sea level decrease by as much as 5-8 mm $yr^{-1}$ in the Bothnian Sea and Bothnian Bay and a rising trend in the south-western part of the Baltic Sea by more than 2 mm $yr^{-1}$ were demonstrated. Thus, the already known N-S orientation of sea level changes was confirmed.

Analysis of trends in the changes modelled (disregarding geological changes) which were considered to depend on atmospheric effects (on the scale of four decades) and riverine runoff showed rising trends ranging from 1 to 3.5 mm $yr^{-1}$ at the west and east coast of the Baltic, respectively. The W-E oriented sea level changes and their values had not been known before.

The other line of research concerned interrelationships between changes in mean annual sea levels and atmospheric effects on the climatic scale. Statistical analyses involved sea level changes without the isostasy-driven decreasing trend. The significant correlation coefficient with respect to the annual NAO index was 0.41. Noteworthy are correlations of the sea level changes with the winter (December-

March) NAO indices, December-March (NAO_djfm) and January-March (NAO_jfm) of 0.63 and 0.7, respectively, indicating a strong correlation of sea level changes with the atmosphere in winter.

However, the major outcome concerned the interrelationship between sea level topographies and atmospheric effects on the climatic scale (four decades). The PCA applied to modelling of the free surface fields of the Baltic Sea showed certain spatial characteristics of the topography which had not been known earlier. Six new characteristics (spatial principal components) seem to be determined by atmospheric effects. The first principal component is related to multi-decadal distributions of atmospheric pressure and the dominant SW to NE winds. The tilt of the second principal component, from NW to SE repeatedly from November to March, was found to correlate with trajectories of low pressure systems in winter. The third principal component in the Baltic Sea proper retained the attributes of the second component, except that it was lowered at the NE and SW ends. Such a topography was found to be related to the anomaly in spring wind directions, NE to SW oriented. The fourth principal component showed double alternation of elevations and drops from SW to NE. The fifth and sixth principal components, although they were associated with the bottom topography and the presence of upwelling, respectively, were controlled by atmospheric effects as well.

New results stemming from the research on sea level changes presented are as follows:

- The W-E changes in the Baltic Sea level showed an increasing trend, from 1 mm $yr^{-1}$ at the western coast to 3.5 mm $yr^{-1}$ in the east.
- During four decades (1958-2001), the mean annual sea level changes were found to be significantly correlated with the mean annual North Atlantic Oscillation (NAO) indices, the correlation coefficient amounting to 0.63.
- The free surface topography of the Baltic Sea involved six spatial principal components dependent on atmospheric effects.

**Results of research on sea currents**

The currents modelled over the time span of four decades provided new knowledge on the Baltic Sea current system and confirmed the pattern of eddy circulation, known from earlier works spanning periods shorter than two decades (Lehmann, 1995; Lehmann and Hindrichsen, 2000a,b; Meier, 1999; Meier and Kauker, 2003). The first new characteristic of the circulation was a higher stability of subsurface currents (0.4-0.7) with respect to the ephemeral surface ones (0.2-0.5) as well as a distinct cyclonic circulation in the Arkona, Bornholm and Gotland Deeps and in the Bothnian Sea and Bothnian Bay. Flow rates were found to be intensified on shallows in the vicinity of islands and along the eastern Baltic coast. The subsurface circulation (at the depth of 20 m) was found to be less dependent on atmospheric effects and more heavily influenced by the bottom topography.

Another feature of Baltic currents is the opposition of seasonal circulations, spring and autumn, and a similarity between circulations in winter and summer. The spring circulations are characterized by an outflow of water from the Baltic at a lowered level of the free surface. This was confirmed by higher outflows in the water exchange with the North Sea. The autumn circulations, dominated by eastward currents, generated inflows to and a high infilling of the Baltic Sea.

The third feature of the surface current system was the wind speed-driven increased trend of current velocity (0.02 cm per 10 years). This result corresponds with increasing trends of significant waves in the Baltic (Cieślikiewicz et al., 2004), intensity of atmospheric pressure system passage over the Baltic (Sepp, 2009), and their positive correlation with the positive NAO index phase. An opposite relationship was reported at the same time from the Mediterranean Sea. All the trends were related to the NAO index fluctuations and their opposite effects in the Baltic and in the Mediterranean Seas. The significant and high correlation between the NAO index and the hydrographic parameters modelled (long-term changes in the sea level and surface current velocity) showed their dependence on atmospheric effects.

The relationship demonstrated for 1958-2001 was indicative of potentially similar effects in periods beyond the time covered by the modelling. Changes in the NAO index describe alterations of atmospheric conditions which determine the nature of the 3D water circulation, changes in the sea level, or the magnitude of oceanic inflow to the Baltic Sea. The NAO index past 2000 showed domination of negative values, the positive NAO phase dominating in the four preceding decades. During the domination of the positive NAO phase, the Baltic Sea was strongly affected by the atmosphere through an increased number of storms. The last decade (2000-2010), with the prevalence of the negative NAO index, featured severe winters with extensive ice cover and low water temperature. The negative NAO phase signifies a weaker hydrodynamics, reduced number of inflows, and thus extension of the water column stagnation, which may lead to deterioration of the environmental conditions in the Baltic Sea ecosystem. The reduced hydrodynamics will weaken the morphodynamic processes affecting the coast, but – on account of an increased number and intensity of ice phenomena – local ice effects in sheltered embayment's and lagoons will become more severe.

The new elements the study has brought to the knowledge of the Baltic Sea currents concern:

- a higher stability (0.4-0.7) of subsurface current eddies relative to the stability (0.2-0.5) of the ephemeral surface currents.
- an opposite nature of seasonal circulations in spring and autumn and the similarity between circulations in winter and summer; the spring circulation is accompanied by the dominant outflow from the Baltic Sea at a lowered sea level, the autumn circulation being accompanied by a strong inflow to and infilling of the Baltic resulting in a rise of the sea level.
- The period of more than four decades (1958-2001) witnessed an increasing trend in the surface and subsurface current velocity (by 0.02 and 0.006 cm per 10 years, respectively) associated with domination of the positive NAO index phase. Fluctuations of current velocity around the trend line correlated posi-

tively (R=0.63) with the NAO_djfm, a correlation identical to that between the index and the sea level changes.

**Results concerning ice phenomena**

The hindcast modelling of ice phenomena resulted in the assessment of the ice cover extent, timing of ice cover occurrence and disappearance, water and ice temperatures, and ice concentration in three winters of 2005–2008. The parameters modelled proved to be in adequate agreement with data obtained from in situ observations and satellite images.

- A novelty of the solution presented was the exploration of ice phenomena on a synoptic scale, as opposed to multi-annual changes described most frequently in the literature.

**Results concerning river plume and water exchange in the coastal zone**

New results of hindcast modelling with multi-step two-way dynamic downscaling include:

- a method allowing to determine the magnitude and frequency of seawater intrusions to coastal lakes, the method being first applied to Lake Gardno. Subsequently, the sea-lake exchange was described for the lakes Sarbsko and Jamno. The Sarbsko was affected by seawater intrusions and inflows of saline riverine waters of River Łeba, whereas water exchange in the Jamno proceeded directly via intrusions from the Baltic Sea. The earlier estimations of intrusion frequency and magnitude, based on the sea level gauge records and correlated wind directions were not sufficiently accurate and reliable.
- Results of hindcast modelling with downscaling provided, for the first time, a representation of river plume distributions, differentiated into three orders of flow rate, for the Vistula (1000 $m^3s^{-1}$) in the Gulf of Gdańsk and for Pomeranian rivers (100–10 $m^3s^{-1}$) at the central part of the Polish coast. The plume ranges, unknown earlier, were revealed for the first time, to reach to 3 km offshore for the Łupawa, up to 6 km offshore for the Parsęta, and 60 km offshore for the Vistula. The magnitudes of the plumes were dependent on the wind direction and speed and on the river flow rate. The plumes varied in size from 3 $km^2$ off the mouth of the Łupawa to 20 $km^2$ off the mouth of the Parsęta. A particularly high (3000 $km^2$) was the size of the Vistula plume in the Gulf of Gdańsk following spring thawing.

**Results concerning operational forecasts**

The second objective of the study was to present operational forecasts and a long-term forecast based on a scenario of expected changes. The results illustrate methodological implementation of operational forecasts at the regional level of the Baltic Sea and sub-regionally in the SE Baltic coastal zone. The forecasts were effected using the 3D hydrodynamic model of the Baltic Sea with 3 Nm resolution, with a 0.5 Nm resolution nested model of the SE Baltic sub-area. The regional and sub-regional models were equipped with data assimilation procedures based on the Cressman and optimal interpolation methods. Using an interface, the models collected ICM weather forecasts for the Baltic Sea area, data on flow rates of 150 rivers discharging into the Baltic Sea, the measured sea levels, 3D temperature and salinity distributions from the BOOS observation network as well as SST surface fields based on satellite images supplied by the Danish Hydraulic Institute. All the forecasts, including those for the preceding 48 and 24 h and for the 0:00 hours were validated online. The forecasts were assessed by evaluation of the model bias and statistical errors (standard deviations of differences between simulations and observations), correlations between simulations and observations, and simulation efficiency. The forecasts and their assessments were made available to users on-line via OpeNDAP servers. The forecasts were a product of an operational model integrated with the BOOS observation system. The forecasts were compatible and integrated with operational forecasts (primarily hydrodynamic at present) of the remaining European seas.

- The forecasts developed are the first Polish operational forecasts of the Baltic hydrodynamics.

**Results concerning scenario-based forecasts**

The long-term (2000-2030) forecast was developed based on the Baltic Sea Action Plan (BSAP) scenario assuming reduction of nitrogen and phosphorus input to the Baltic Sea in 2000-2021. The forecast provided a new solution for the expected future changes of the Baltic Sea ecosystem once the BSAP has been implemented. The BSAP scenario-based simulation mimicked the annual cyclicity and seasonality, but with a decreasing trend of nutrient concentrations. Lower concentration of nitrogen and phosphorus compounds will result from their reduced input to the Baltic Sea, and thus less nutrients will be involved in biogeochemical processes. Past 2021, the riverine runoff will supply nitrogen and phosphorus amounts lower by 140 thou. and 13.3. thou. tones, respectively. The total nitrogen and phosphorus contents in the Baltic Sea will be reduced by more than 360 thou. and 100 thou. tones, respectively. The BSAP effect will be more pronounced in changes involving phosphorus. A comparison of patterns produced by the simulation of BSAP scenario-based surface fields of nitrogen and phosphorus concentrations with reference simulations after each decade showed the surfaces with decreasing concentrations to increase. The most effective reduction would occur in the southern Baltic Sea. Consequently, the BSAP seems to be an appropriate and effective measure.

- The long-term (3 decades) HELCOM scenario-based forecast is the first forecast of quantitative changes in the Baltic Sea ecosystem.

**Results concerning the postulated lines of research in modelling and forecasting**

The postulated new lines of research in modelling and forecasting include:

- development of long-term hindcast models with descriptions of effects of the crustal isostasy and epeirogeny as well as eustasy, resulting from ocean-atmosphere system's water circulation budget, on the marine hydrodynamics;
- development of methods for: hindcasting to replace the currently used hindcast models; short-term forecast transformation into long-term forecast; downscaling and upscaling without aliasing;

- basing the operational forecasting system, aimed at globalization as a mega-, or possibly a giga-, system, on three-dimensional operational prognostic models (an ecohydrodynamic model for the sea and atmospheric circulation, hydrological model for the sea catchment areas); the mega-/giga-system postulated will be integrated with satellite-based monitoring as well as marine and land-based observation network systems; the forecast system should involve synchronization and succession of short-term forecasts into long-term ones; similarly, local forecasts should evolve into large-scale ones.

**Results concerning ordering of concepts used in modelling and forecasting**

Concepts concerning hindcast and forecast modelling as well as operational and scenario-based forecasting were ordered and systematized. A path from hindcast modelling to forecasting was presented, as were stages involved in the development of a hindcast model, operational forecasting, and scenario-driven forecasting. The functioning of a hydrodynamic model as a hindcast, operational, and prognostic one was illustrated from the viewpoint of temporal integration and with the embedded two-way spatial dynamic downscaling.

Modern research programmes involving modelling and forecasting of sea hydrodynamics were reviewed. The programs targeting the ocean were presented, as were the projects concerning operational oceanography in the European seas and the Baltic Sea synchronized with the European and global programs.

**Results concerning the author's contribution to the development of the ecohydrodynamic model development (M3D + ProDeMo) and the Baltic operational system at the Institute of Oceanography, University of Gdańsk**

The model was developed in response to the research needs of the marine environment research community with respect to physical, chemical, and biological aspects. The model contains two components: hydrodynamic (M3D) and ecosystem-based (ProDeMo). The first, multi-module, component (Jędrasik, 1997a) functions independently to describe hydrodynamics of the entire Baltic Sea or a selected area. The other component describes changes in the marine ecosystems in conjunction with the first. The model had been under development for a number of years based on projects supported by the Polish National Committee for Scientific Research and by the European Commission. The author participated in developing the structure and architecture of the hydrodynamic model (Jędrasik et al., 1997a) and formulation of the surface energy flux module (Jędrasik, 1997b). At the stage of intensive development of the ecosystem component, the author's involvement focused on the formation of the ecosystem part of the ProDeMo (Ołdakowski et al., 2005) and the optimization of procedural steps, particularly validation of both the hydrodynamic (Jędrasik, 2005) and the ecosystem part (Jędrasik and Szymelfenig, 2005).

Another contribution concerned validation of the M3D hindcast model using 3D distributions of seawater temperature and salinity and long-term sea level gauge records (Jędrasik et al., 2008). The M3D model was first validated off-line based on 1993-2001 $SSH_{SAT}$ observations in the Baltic Sea supplied by the satellite Poseidon (Jędrasik et al., 2004).

The author contributed substantially to the M3D model development during his involvement in the ECOOP project he coordinated in 2007-2010. The model was then enlarged by incorporation of assimilation procedures (Jankowski et al., 2008; Kowalewski et al., 2009a), data collection interfaces with in situ observation systems (Piotrowski, 2008), and the real-time SST satellite images (Zdroik, 2009) as well as procedures of on-line validation (Zdroik and Jędrasik, 2009) and operational forecast distribution (Zdroik, 2009). The M3D model functioned operationally for the first time in 2009; it assimilated – in real time – in-situ data on three-dimensional temperature and salinity distributions, sea level changes, and SST satellite images, and was validated on-line using the SST observations. Owing to the M3D model's participation in the operational regional forecasting of the Baltic Sea hydrodynamics regionally and the south-eastern Baltic sub-regionally during the TOP experiment in five European shelf seas (1 February 2009-31 July 2009), the model was incorporated into a system of the European operational models. It is one of the five operational models[1] in the Baltic Sea functioning at present (Leth et al., 2009).

The ecohydrodynamic pre-operational model (M3D coupled with ProDeMo) functioned as a hindcast one (Kowalewski et al., 2009b); enlarged by including a management-type scenario with meteorology and hydrology, it became a prognostic long-term model (Jędrasik et al., 2009).

**b) Discussion of the scientific objective of the work described above and its results, including discussion of their application potential**

The results presented above form a part of the scientific output of a research team based at the Institute of Oceanography, University of Gdańsk. The team has developed an operational system of hydrodynamic forecasts for the Baltic Sea. At present, the second part of the system, addressing the ecological aspects, is being brought to the operational level. The new knowledge, experience, and infrastructure makes it possible to establish a new unit within the Institute, mandated with forecasting the hydrodynamics and ecosystem changes in the Baltic Sea, with a particular focus on the southern Baltic. Hydrodynamic forecasts with downscaling to coastal areas would contribute to increased safety of the present and future multi-aspect human activities in the Polish coastal areas. The ecosystem operational forecasts would prevent further deterioration of the marine environment and would enable its management towards the desired status.

The already achieved European standard of the forecasts and their compatibility with forecasts for the Baltic Sea and other European seas provide sound evidence that the time is ripe to make the decision of establishing such a unit in the form of, e.g., Interdisciplinary Modelling and Forecasting Centre at the University of Gdańsk (IMFC-UG). The new modelling and forecasting centre would develop operational and long-term forecasts, both hydrodynamic and ecosystem-wide, for national and

[1]The operational models functioning in the Baltic Sea: BSH - BSHcmod V4; DMI - DMI-BSHcmod; SMHI – HIROMB; FIMR - BalEco v2; IOUG - M3D.

foreign end-users. There is a need to prepare a proposal for the establishment of IMFC-UG, and to determine its structure and terms of reference. The Institute of Oceanography, University of Gdańsk (IOUG) would provide a pool of scientific resources for the centre, developing new modelling and forecasting methods. The new centre would initiate the formation of the Polish Coastal Operational System (POLCOS) with three regions of interest, from the Pomeranian Bay to the central part of the Polish coast to the Gulf of Gdańsk. POLCOS would constitute a component of the future Baltic Coastal Operational System (BALTCOS) cooperating with the currently operating COSYNA system in the North Sea.

## 5. Description of remaining research achievements

My research interests were focused on limnology and physical oceanography. My initial research in limnology concerned mathematical description of summer stratification stability and were based on field observations on the thermal cycle of Chmieleńskie lakes in the Kashubian Lake District (Jędrasik and Lange, 1972). An almost unknown phenomenon of thermal anomalies beneath the ice cover (increase in water temperature up to 6°C) and spatio-temporal variability of the effect in the lake was described in Jędrasik (1973). While exploring the problem of seiche-type dynamics of the free surface of Lake Raduńskie, I developed a 1D hydrodynamic model of the lake, whereby the simulated changes were in agreement with observational data (Jędrasik and Kowalik, 1973). I analyzed time series of vertical water temperature by applying then novel spectral analysis used in signal studies. The application supplied new knowledge on rhythms in lacustrine water thermal fluctuations (Jędrasik and Kowalik, 1976). Subsequent research based on field observations involved exploration and mathematical description, with 1D two-layer model, of internal waves in deep trough lakes (Jędrasik, 1976). The study involved description of internal wave characteristics (changes in the surface of seasonal density stratification) dependent on the horizontal dimensions of the lake, its stratification with respect to depth, temperature gradient in the thermocline, and fluctuations of wind speed and directions in the Pomerania on the synoptic scale. The paper by Jędrasik and Simons (1983) was a continuation of the study on geometry-driven internal seiches in Lake Raduńskie.

My limnological research was synthesized in a paper (Jędrasik, 1995) in which mechanisms responsible for thermal structures were described and a hierarchy of constraints affecting those mechanisms was determined. In addition, I described the thermal structures in a lake which correspond with those in a land-locked sea and/or an estuary.

In the paper referred to I defined a thermogram as a representation of water temperature distribution in function of time and space, with superimposed effects of various large-scale mechanisms. A sequentional rhythm of variations in the thermogram characteristics represented the thermal regime and allowed to identify mechanisms shaping it. I distinguished between a number of mechanisms generating thermal structures in lakes. The first was the **wind-induced mixing** (stirring) when the friction velocity reached the thermocline at a time shorter than one-fourth of the internal seiche period. Stratification was broken down when the friction velocity reached the bottom at a time shorter than one-fourth of the internal seiche period. This was then the **shearing**. The **Langmuir circulation**, resulting from fusion of non-linear effects of wind-induced wave action and drift currents, was an effective mechanism of heat transfer. As a result of the energy budget, positive (from atmosphere towards the lake/sea surface) or negative (from lake/sea towards the atmosphere) fluxes initiate convection, **free** or **penetrating mixing**, respectively. The convection significantly affects the vertical temperature distribution. The vertical distribution was disturbed by horizontal advection of rivers or lateral inflows via straits, or via open boundaries in general. The next mechanism affecting the so-called subtle thermal and salinity structures was the differential diffusion related to heat and diffusion of salt (salt fingers). The first occurs in thermoclines of lakes, both mechanisms operating in the permanent pycnocline in the sea.

The major constraint in the thermal structure formation was the climatic heat and momentum advection through the free surface of a lake/sea. In the positive energy budget climate, dominant are stratified lakes and seas. The negative budget brings about homogenous, or periodically stratified, structures. Strong heat deficits produce ice cover and inverse stratification. Another type of constraints is the hydrographic lateral supply: an inflow of oceanic water to the sea, influx of sea water to an estuary, and a riverine inflow and infiltration from water-logged layers to a lake. Their role results from the ratio of fluxes through lateral boundaries and through the free surface. The third major constraint is the basin geometry which controls the access of external energy generating turbulent heat transfer in the water column of a lake/sea. The topography of the area surrounding the lake becomes a constraint due to the restricting role of barriers to the supply of short-wave radiation and to the reduction of the momentum-atmosphere exchange field. I developed a method for determining the illumination field (a "sun ruler") and a wind field restricted by orographic barriers. Geometric (morphometric) constraints control, and even select, the types of mechanisms which are directly responsible for temperature distributions in a lake. Horizontal dimensions control rotational effects, e.g., current and wave action inertion. When the lake size precludes the occurrence of such effects internal oscillations dominate, the length to depth ratio determining the velocity of structure evolution by wind-driven mixing or internal friction.

Incorporation of lake/estuary/sea-characteristic scales to the heat turbulent diffusion equation made it possible to determine the weighting and manner of heat transfer. Scaling showed how constraints select the mechanisms controlling thermal structures. The approach was verified by model simulations of thermal structures in selected lakes of the Kashubian Lake District, the Vistula Lagoon, and the Gulf of Gdańsk. The most important mechanism in a deep lake and in the Gulf of Gdańsk was the vertical turbulent diffusion on the scale of a season and a year for the lake and for the Gulf of Gdańsk, respectively. In the shallow, extensive Vistula Lagoon, the vertical turbulent diffusion effected a homogenous structure within two days. Simulations of thermal structures in the upper layer of the Gulf of Gdańsk showed their similarity to those structures in the lake and proceeded like those in a non-saline water. Salinity stabilizes the density distribution in deep layers. The similarity between stratified thermal structures in deep estuaries and deep lakes as well as in shallow estuaries and shallow lakes supports the notion of common causes of the structures' formation and a possibility of applying identical research methods. However, the processes in lakes are less complex and easier to verify by in situ measurements. Therefore, in my opinion, lakes should be used as field test areas in marine research.

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