1130 Estuaries

Photo. 1. Site Piaśnica – estuary section of the river (H. Boniecka)

I. INFORMATION ON THE HABITAT

The habitat Estuary (1130) is defined by Warzocha (2004) as ‘lower part of the river limited by the brackish water boundary and subject to tidal action’.

In the Polish environmental conditions it refers to an area of river mouth. The habitat includes the lower part of the river's course under the influence of the sea caused by wind energy (so-called backwater). From the sea side, the boundary is the outline of the outermost morphological elements of the delta built of material transported by the river (sandbanks, shallows). In the absence of morphological forms built by the river, the seaward border should be taken as a straight line connecting points of the multi-annual average of contour line "0" of the sea shore, which are located on both sides of the river mouth. In the case of estuary sections of rivers in which the impact of sea waters extends beyond the reach of their bed, the area of the habitat covers adjacent areas. This is consistent with the definition of the coverage of the estuary habitat (1130) presented in the Interpretation Manual of the European Union Habitats (2013), which states that "the estuary forms

an ecological unit together with the surrounding types of land coastal habitats "(Michałek and Kruk-Dowgiałło 2014).

In Poland, the most complex estuaries form Odra and Vistula Rivers (Warzocha 2004). The mouths of rivers flowing into the sea are mostly regulated. This applies particularly to those rivers, in which the ports were built. Such regulated watercourses include: Rega, Parsęta, Wieprza, Słupia, Łeba, and Vistula (Warzocha 2004).

According to the literature, the criterion of the habitat estuary (1130) associated with marine areas is fulfilled by the following river mouth sections: Vistula Lagoon inflows: Wisła Królewiecka, Szkarpawa, Nogat and Elbląg, tributaries of the Gulf of Gdańsk: Wisła Przekop and Wisła Śmiała, tributaries of the Puck Bay: Gizdepka, Reda with Zagórska Struga, tributaries of the open sea: Piaśnica, Łeba, Słupia, Wieprza, Szczucza Canal, Czerwona, Rega, Resko Canal, Liwka Canal, Parsęta and Dziwna.

II. METHOD OF STUDIES AND ASSESSMENT OF THE CONSERVATION STATUS

1. Evaluation of the parameters of the habitat status and indices of the specific structure and function

The table (Table 1) presents a description of parameters, indices and components of indices for the assessment of the conservation status of the Estuaries (1130), while the table (Table 2) presents the valorisation of these parameters, indices and components of indices. The figure (Fig. 1) presents the method of aggregating assessment of the components of indices, indices and parameters to assess the status of this habitat.

Table 1. Description of parameters and indices with their components of the habitat Estuaries (1130)

Parameter/Indicator/ Indicator components	**Description of parameter, indicator or indicator components**
Area	The boundary of the habitat on the land side is the range of sea water inflows. The measure is the average of maximum monthly (SWW) sea levels determined on the basis of long-term results (last 25-year period). From the sea, the boundary of the habitat is the line between the sea and land intersecting the current (Piaśnica), and in the case of breakwaters going into the sea (Dziwna, Rega) a line connecting their ends, while in the case of delta (Reda) the outermost outline of its morphological forms. In case of Wisła Przekop the habitat border constitutes the border of PLH220044 Ostoja w Ujściu Wisły. For the mouth of the Nogat River, the extent of the habitat from the sea is determined by a line joining the embankment of this river in a place where it flows into the Vistula Lagoon. The range of the sea-side habitat is determined on the basis of available satellite images from the public GOOGLE website (Google Earth) and aerial photographs, including ortophotomap, originating from CODGiK and the Maritime Office in Gdynia (http://www.umgdy.gov.pl/?page id = 1667), as well as NMT taking into account the dynamics of their estuary section. In some cases, the area of the habitat was enlarged by flood plains that remain within the range of the impact of sea waters (Reda - Reserve Beka, Piaśnica - Piaśnickie Łąki). When determining the boundaries of the habitat, also hydrotechnical constructions were taken into account (to prevent backwater - Piaśnica, Rega, Nogat). In this case, the habitat border is not only the riverbed but also adjacent areas up to the base of flood embankments and hydrotechnical constructions limiting sea water inflows.
Specific structure and function	
The filling level of the	SNK is a relative measure of the flow section of the channel. It is calculated as

Parameter/Indicator/ Indicator components	Description of parameter, indicator or indicator components
channel (SNK)	the quotient of the cross-sectional area of the channel filled with water during the measurement, i.e. the flow cross-section (F), and the surface of this channel determined for the state of the shore water (F_{brz}). The flow cross-sectional area of the channel (F) is calculated on the basis of probing the channel during field measurements. The surface of the channel to the boundary state (F_{brz}) is determined as the sum of the surface of the flow channel (active surface of the channel) and the cross-sectional area in which no water occurs (passive surface of the channel), thus the surface bounded from the top by the height of the boundary state and from the bottom the water table. To calculate the surface of the "passive" channel you can use the formula for the surface of the trapezium. One base of the trapezium is the width of the channel filled with water, the second base in a cross-section has a constant value equal to the width between the coastal water of the left and right bank of the channel.
Water quality	
pH value	The pH value of natural waters depends primarily on following factors such as: (i) dissociation and hydrolysis of dissolved chemical compounds, (ii) carbonate system, (iii) soil structure, (iv) and pollutions (i.e. it may increase the amount of acids in water) (Dojlido 1995). The pH value is important for living organisms and for the course of biochemical processes.
oxygen [mg·dm^{-3}]	The content of oxygen is one of the most important indicators of water quality, since it is essential for the life of fish and other aquatic organisms. It is valuable indicator of water mass and additionally sensitive indicator of biological and chemical processes occurring in surface water (Bolałek and Falkowska 1999). Oxygen is also recognized as indicator of eutrophication (HELCOM 2014).
total nitrogen [mg·dm^{-3}]	The nitrogen compounds in surface water may be organic or inorganic origin. Total nitrogen is defined as the total amount of nitrogen occurring in any forms in the investigated material (Hermanowicz et al. 1999).
inorganic nitrogen [mg·dm^{-3}]	Dissolved inorganic nitrogen (DIN) refers to the sum of inorganic forms of nitrogen (i.e. nitrites, nitrates and ammonium ions). In surface water, nitrites determine the primary production. Therefore, they are considered to be growth-limiting substance of phytoplankton.
phosphate phosphorus [mg·dm^{-3}]	In surface water, in the absence of nitrogen compounds, phosphates may determine the amount of primary production. Therefore, they are classified also as the growth-limiting substance of phytoplankton.
total phosphorus [mg·dm^{-3}]	Total phosphorus is the sum of both organic and inorganic forms of phosphorus occurring in surface water. The concentration of phosphorus compounds undergo significant seasonal fluctuations, due to biogeochemical cycles and inflow of these substances from land.
transparency [m]	Water transparency (visibility) relates to the largest distance at which the object can be easily observed in the column of water. The Secchi disc depth (i.e. apparent transparency) is referred to the depth at which the object is no longer viewable. The result is considered to be a measure of the conventional transparency of water.
chlorides [mg·dm^{-3}]	The chlorides content in estuary is highly dependent on the seawater inlets (i.e. the input of seawater to the mouth of a watercourse that flows into the sea). There is no tides in the Baltic Sea, therefore areas of rivers mouth are freshwater and seawater mixing, due the storm surge phenomenon may occur , when the mass water is forced back up to the river (backwater).
Character and	The index presents the characteristics of the habitat in terms of transformations

Parameter/Indicator/ Indicator components	Description of parameter, indicator or indicator components
modification of banks	of natural conditions. The modification of the banks of the river in the estuary in the form of embankments, marinas, buildings, roads, parking lots, etc. in the belt with a width of 50 m from the water line on both banks of the river was assessed. The index is expressed as a percentage share of the total length of the banks modified to the total length of the river banks within the limits of the habitat.
Technical development	The index is based on an inventory of artificial barriers limiting the migration of organisms and transport of river debris in the river's current and their impact on the state of the habitat. Technical elements affecting the value of the indicator include: breakwaters, guide breakwaters, groynes, artificial troughs of the river bed (waterways) to obtain the river depth suitable for navigation. Valorisation of the indicator takes into account the number of technical development facilities present within the habitat borders.
Conservation prospects	Forecast of the conservation status of the habitat in the next 10–15 years. Expert judgement, which takes into account the current state of the habitat as a whole, the processes occurring in it and their intensity, as well as the effects of protective measures carried out and any identified impacts, and anticipated threats that may affect the future state of the habitat at the surveyed site.

Table 2. Valorisation of parameters and indices with their components of the habitat Estuaries (1130)

Parameter/Indicator/ Indicator components	Assessment		
	FV favourable status	**U1** unfavourable inadequate status	**U2** unfavourable bad status
Area	The area of the habitat is not reduced and it is not anthropogenically fragmented	The area of the habitat shows a slow downward trend compared to earlier studies or literature information or it is anthropogenically fragmented	The habitat area has a fast downward trend compared to earlier studies or literature information or it is strongly anthropogenically fragmented
Specific structure and function			
Filling level of the channel	Valorisation specific for particular sites (Table 3)		
Water quality			
pH value	if the value is in the range <7.0 – 8.8>	if the value is in the range <6.5 – 7.0) or (8.8 – 9.5>	if the value is >9.5 or <6.5
oxygen [mg·dm^{-3}]	if the value is >6.0	if the value is in the range <6.0 – 4.0>	if the value is < 4.0
total nitrogen [mg·dm^{-3}]	if the value is ≤2.7	if the value is in the range (2.7-5.0>	if the value is >5.0
	if the value is ≤4.0*	if the value is in the range (4.0-8.0>*	if the value is >8.0*
inorganic nitrogen [mg·dm^{-3}]	if the value is ≤1.5	if the value is in the range (1.5-3.0>	if the value is >3.0
	if the value is ≤3.0*	if the value is in the range	if the value is >5,0*

Parameter/Indicator/ Indicator components	Assessment		
	FV favourable status	**U1** unfavourable inadequate status	**U2** unfavourable bad status
		<3.0- 5.0>*	
phosphate phosphorus [mg·dm^{-3}]	if the value is <0.1	if the value is in the range <0.1 – 0.2>	if the value is >0.2
total phosphorus [mg·dm^{-3}]	if the value is <0.3	if the value is in the range <0.3 – 0.8>	if the value is >0.8
transparency [m]	If the value >1.0 or to the bottom, if the level of water is below indicated value	if the value is in the range <1.0 – 0.5>	if the value is <0.5
chlorides [mg·dm^{-3}]	if the value is >500**	if the value is in the range <500 – 200>**	if the value is <200**
	if the value is >50***	if the value is in the range <50 – 20>***	if the value is <20***
Character and banks modification	if the sum of the indicated lengths (strengthened and built-up) bank sections below 10% of their total length within the boundaries of the habitat	if the sum of the indicated lengths (strengthened and built-up) bank sections within the range 10-30% of their total length within the boundaries of the habitat	if the sum of the indicated lengths (strengthened and built-up) bank sections exceeds 30% of their total length within the boundaries of the habitat
Technical development	lack of technical development elements in the habitat	1 or 2 elements of technical development	3 or more elements of technical development
Conservation prospects	Conservation prospects for the habitat are good or excellent, no significant impact of threatening factors predicted, survival of the habitat in the perspective of 10–15 is very probable	Conservation prospects are medium rated, threatening factor impact expected	Conservation prospects poor, observed strong influence of threatening factors, the survival of the habitat in the perspective of 10–15 years can not be guaranteed

* limit value of nitrogen compounds for the site Wisła Przekop

** value for site: Dziwna

*** values for sites: Rega, Piaśnica, Reda, Wisła Przekop, Nogat

Table 3. Valorisation of index 'The filling level of the channel' for sites recommended for monitoring of the habitat Estuaries (1130)

Name of site	Name of station	Evaluation of index 'Filling level of the channel' (SNK)		
		FV	**U1**	**U2**
Dziwna	Dziwnów	SNK≥ 0,796	0,766 ≤ SNK< 0,796	SNK < 0,766
Rega	Mrzeżyno	SNK≥ 0,517	0,487 ≤ SNK< 0,517	SNK < 0,487

Name of site	Name of station	Evaluation of index 'Filling level of the channel' (SNK)		
		FV	U1	U2
Piaśnica	Dębki	SNK≥ 0,401	0,345 ≤ SNK< 0,401	SNK < 0,345
Reda	Beka	SNK≥ 0,318	0,270 ≤ SNK< 0,318	SNK < 0,270
Wisła Przekop	Świbno	SNK≥ 0,272	0,253 ≤ SNK< 0,272	SNK < 0,253
Nogat	Kępki	SNK≥ 0,426	0,399 ≤ SNK< 0,426	SNK < 0,399

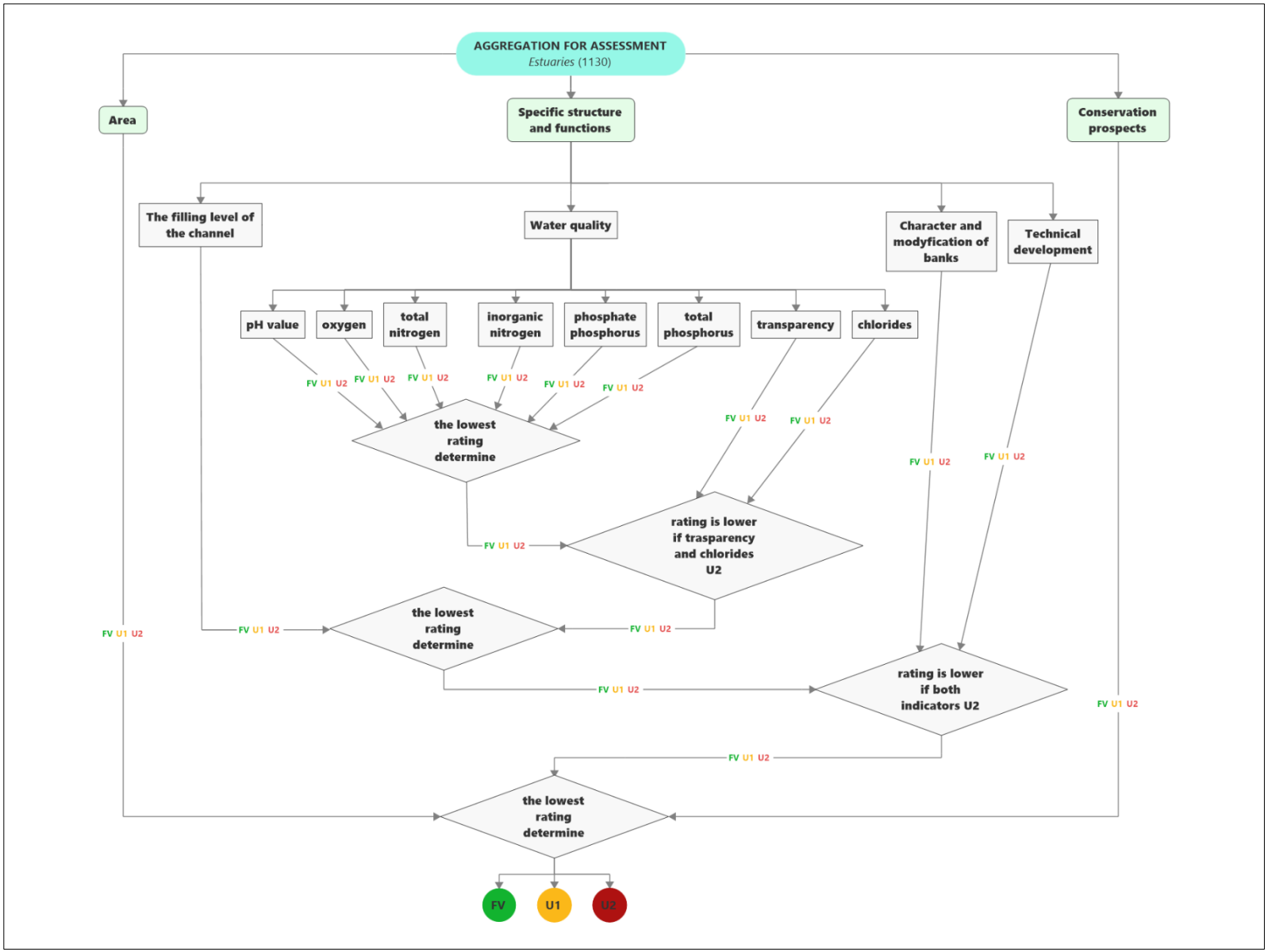

Fig. 1. Diagram of aggregation of indices and parameters to assess the state of protection of the habitat Estuaries (1130)

2. Methodology of monitoring studies

2.1. Selection of monitoring locations

A monitoring site is understood as the area of the habitat within its natural boundaries, within which research stations are located, on which samples for tests or measurements are collected.

The results of monitoring studies carried out in 2016–2018 have shown that in the following years the research should cover six sites representing all types of river estuaries (natural and fully anthropogenic), i.e.: Dziwna, Rega, Piaśnica, Reda, Wisła Przekop and Nogat (Fig. 2). In each outlet, a station is located where measurements of the channel filling level and water quality tests should be performed. The whole site should be investigated for the character and modification of the banks and technical development.

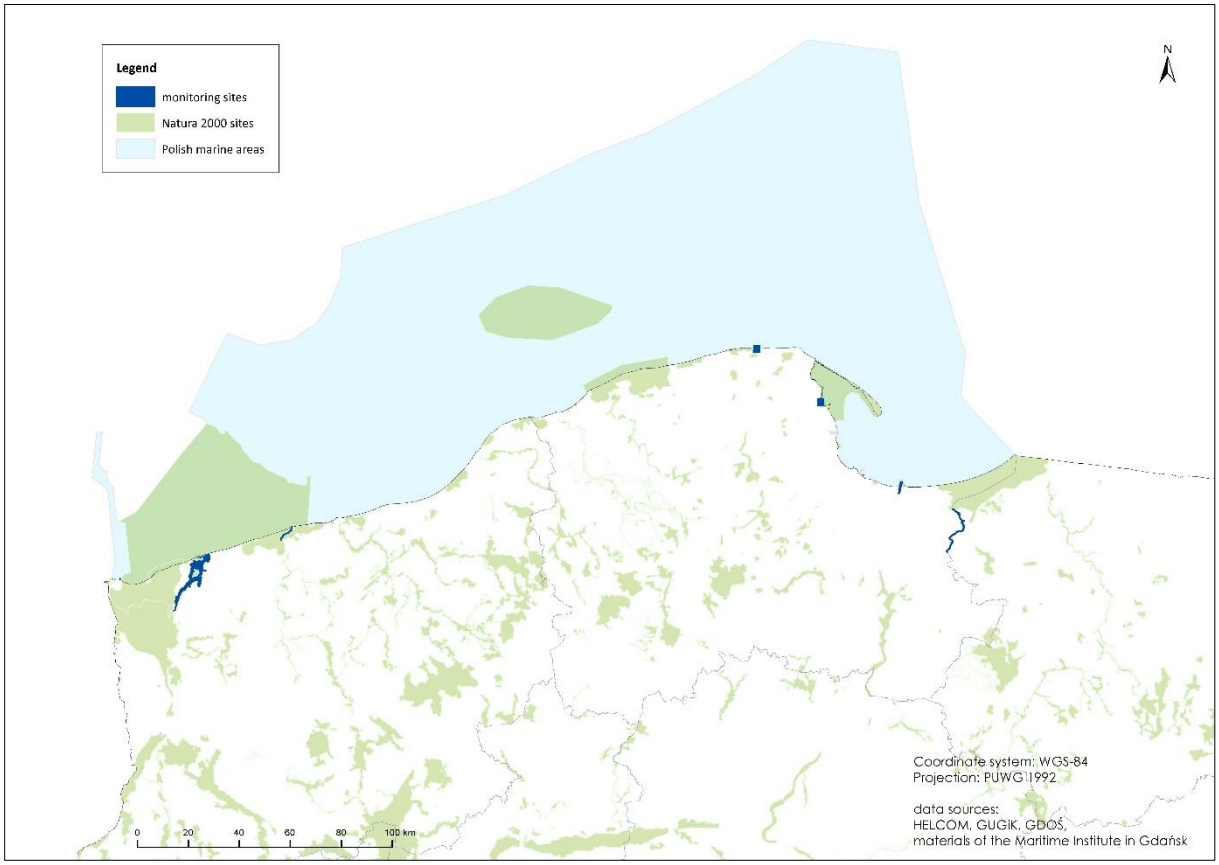

Fig. 2. Sites for monitoring habitat Estuaries (1130)

2.2. Study methods

Specification of the 'Surface' parameter

The borders of the Estuaries (1130) should be determined on the basis of a homogeneous numerical terrain model by a static determination of the range of sea impact in the estuary section of the river.

Determination of the area of the Estuaries (1130) requires the collection of appropriate source material (data) and conducting geospatial analyses. The following source data is necessary

- height data with a horizontal resolution not less than 1 m, vertical accuracy not less than 15 cm at a resolution of not more than 1 cm. On the basis of acquired altitude data, a uniform

(homogeneous) Digital Terrain Model (NMT) should be created in accordance with the diagram (Fig. 3);

- current ortophotomap;

hydrological data on the maximum monthly sea levels from each year of the last 25 years, obtained from mareographs closest to the site of the monitored habitat (

- Table 4). On the basis of these data, the sea level corresponding to the average of the maximum monthly water levels (SWWm) of the last 25 years should be calculated for each site.

On the basis of uniform NMT, for surveyed site of the habitat Estuaries (1130), simulation of flooding with sea waters should be performed, assuming that the sea level on the nearest mareograph corresponds to the average of monthly maximum water levels (SWW_m, i.e. average high monthly water) from the period of 25 years. This simulation can be done by reclassifying raster cells (pixels) of uniform NMT. This reclassification involves changing the value of the raster pixel in such a way as to unambiguously indicate those pixels whose value is less than or equal to the SWW_m value obtained from the mareograph closest to the analysed section of the estuary. In this way we obtain a new raster of the area of the estuary section of a given river, which will be flooded when the water level is increased by the value of SWW_m.

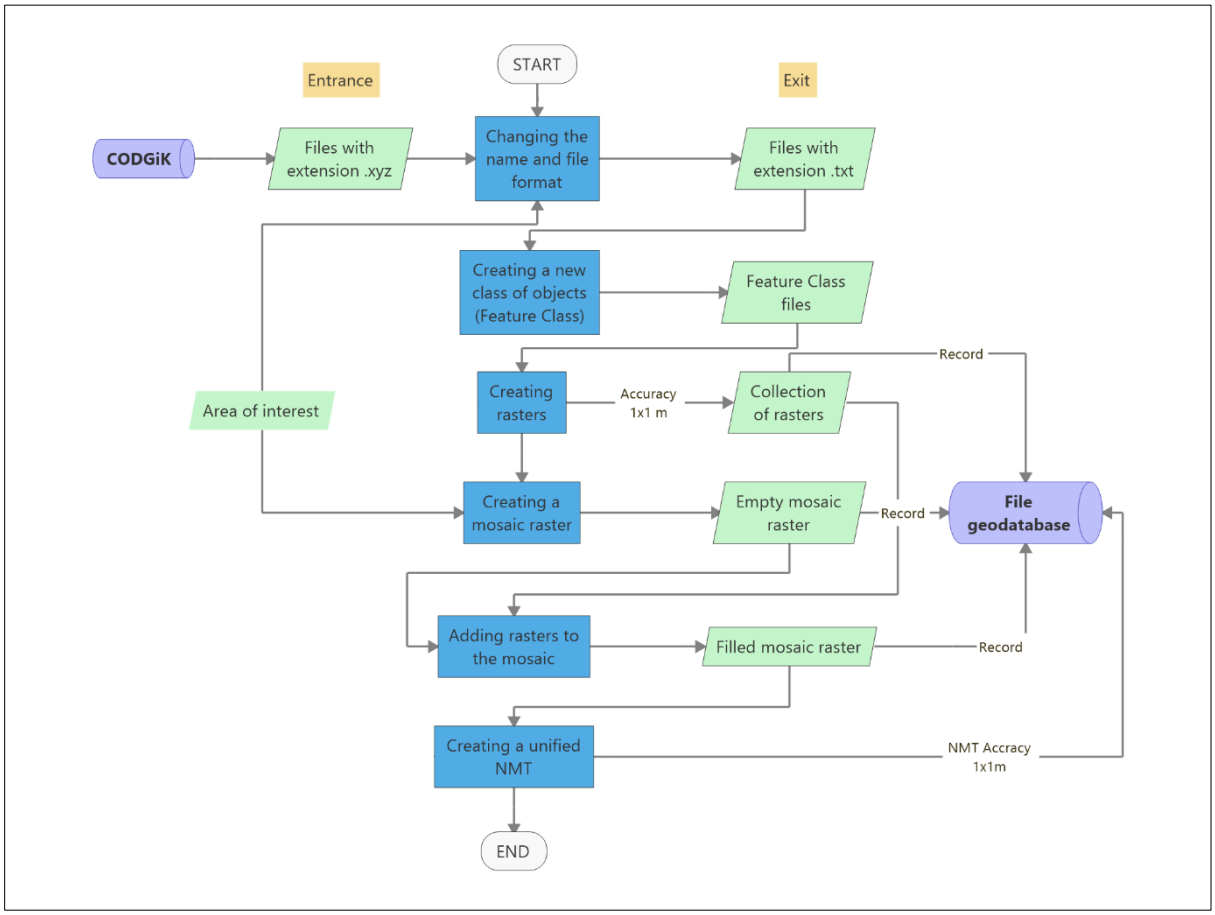

Fig. 3. Diagram of the data processing of the Numerical Terrain Model

Table 4. Examples of areas of the Estuaries (1130) and range of sea inlets at SWWm from 1991–2015

Site	Sea level				Length of river influenced by sea [km]	Area of habitat [km^2]
	Mareograph [-]	Zero of water gauge [m a.s.l.]	SWW_m (1991–2015) [cm]	The absolute altitude of the sea [m a.s.l.]		
Dziwna	Dziwnów	-5,08	542	0,340	32,228	50,577354
Reda	Puck	-5,08	541	0,330	1,500	1,386080
Piaśnica	Łeba	-5,08	543	0,350	0,985	0,062347
Rega	Kołobrzeg	-5,08	552	0,440	8,677	0,434041
Wisła Przekop	Gdańsk – Port Północny	-5,08	551	0,430	4,280	4,844486
Nogat	Osłonka	-5,08	556	0,480	23,150	4,142871

In the next stage, it is necessary to convert this part of raster data about flooding of the given area to the vector data format enabling the GIS package calculation of its area, e.g. shape file, class of objects (Feature Class). After converting the raster data to the vector data (polygons), the obtained area should be verified to eliminate the so-called holes / islands that appear inside a given area as a result of the static determination of sea inflows. In practice, this consists in removing polygons from the habitat area, which indicate that the area is not flooded and that the area of these areas is too small (expert judgement). In the final stage, the boundary area of the habitat from the sea should be determined in accordance with the adopted methodology and its course should be taken into consideration by modifying vector data.

Having the designated boundaries of the habitat, you can calculate its area. It should be remembered that the correct surface calculation is made at the geographical coordinate system defined for a given area. Therefore, this system should be a metric system (the mapping specified by the EPSG code: 2180 - ETRS89 / Poland CS92).

Filling level of the channel

SNK is a relative measure of the flow section of the channel. It is calculated as the quotient of the cross-sectional area of the channel filled with water during the measurement, i.e. the flow cross-section (F) and cross-sectional area of this channel determined for the state of the shore water (F_{brz}) (Fig. 4).

The flow channel cross-sectional area (F) is calculated on the basis of data obtained in the field, i.e. depth measurements (from water table to bottom) with simultaneous measurement of the probing point distance from the zero point, usually located on the left bank of the watercourse (Fig. 4).

When measuring the cross-section of a channel of the watercourse, the distance between the sounding points is determined according to the following principle (Bajkiewicz-Grabowska et al. 1993):

- if the river width B ≤ 5 m, the distance between the poles of soundings b ≤ 0,5 m;
- if the river width B ≤ 10 m, the distance between the poles of soundings b ≤ 1,0 m;
- if the river width B ≤ 200 m, the distance between the poles of soundings b ≤ 5,0 m;

- if the river width B > 200 m, the distance between the poles of soundings b ≤ 10,0 m.

Probing can be done with a weight probe or an echo sounder. In the case of echo sounder measurement - from the echogram, the depth should be read with an accuracy of 1 cm, similar to a measurement with a weight probe.

Each point in the section has the given distance ($B_{0, 1, 2, ..., n}$) and the depth ($h_{0, 1, 2, ..., n}$), (Fig. 4). Based on these coordinates, the cross-sectional area of the channel is calculated, i.e. the area of the flow cross-section (F).

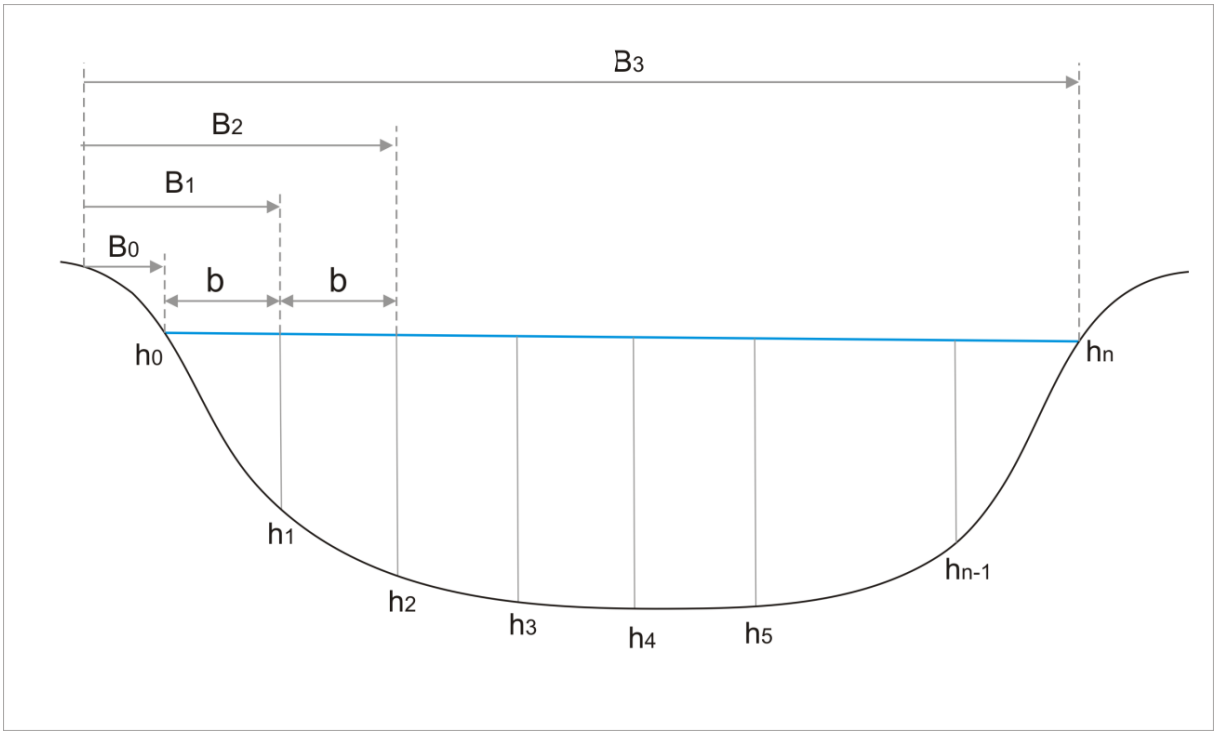

Fig. 4. Measurement of the flow section of the watercourse; h_0, h_1, h_2, … h_n - depth in probing, B_0, B_1, B_2, ... B - probing perpendicular distance from the beginning of the measuring tape, b - distance between probing sites

The cross-sectional area of the watercourse designated for the condition of the shore water is the sum of the area of the flow cross-section (F) and the cross-sectional area of the channel in which there is no water (F_o), (**Błąd! Nie można odnaleźć źródła odwołania.**). The cross-section of the channel without water (F_0) is limited from the top by the height of the boundary state and from the bottom the water table in the channel. The surface of this section is calculated from the formula on the surface of the trapezium. One foundation of this trapezium is the width of the channel filled with water (B_i), the second base in a given measurement cross-section has a constant value equal to the width between the coastal water of the left and right bank edge (B_{brz}). The height of the trapezium is the distance from the base of the coastal water to the water table in the channel (d_i), (Fig. 6). Coastal water conditions (H_{brz}) and the width of the channel between the shore waters of the left and right bank (B_{brz}) for the Estuaries (1130) recommended for monitoring are presented in the table (Table 5).

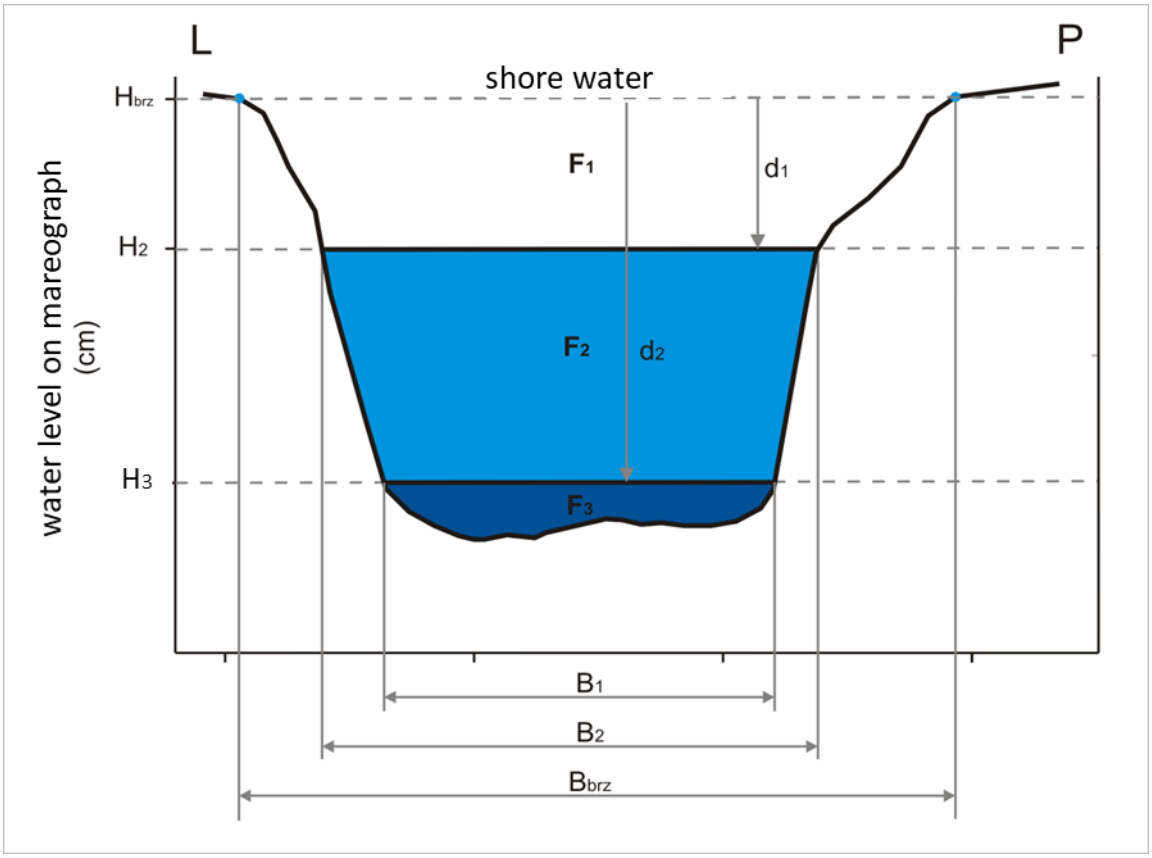

Fig. 5. Scheme for determining the cross-sectional area of a watercourse channel at the shore water state: F_3 - flow cross-section area at water level H_3, (F_2 + F_1) flow area at water level H_2, F_1 - cross-sectional area of the channel without water at water state H_2, (F_1+F_2) - area without water at H_3 water level. B_1 - width of watercourse at water level H_3, B_2 - width of watercourse at water state H_2, B_{brz} - width of riverbed at the state of coastal water, d_1, d_2 - distance to the water table from the state of shore water, L - left bank, P - right bank

Table 5. The state of the shore water and the width of the channel between the shore water of the left and right bank at the Estuaries (1130) sites recommended for monitoring

Site	**Statin**	**Mareograph**	**State of shoreline water (H_{brz})* [cm]**	**Width of channel at shore water state (B_{brz}) [m]**
Dziwna	Dziwnów	Dziwnów	608	201,0
Rega	Mrzeżyno	Kołobrzeg	678	87,0
Piaśnica	Dębki	Łeba	648	24,3
Reda	Beka	Puck	660	30,3
Wisła Przekop	Świbno	Gdańsk – Port Północny	1268	747,3
Nogat	Kępki	Osłonka	823	150,4

* The state of the shoreline water determined from NMT calculated from the sea level zero (508 cm)

The channel filling level (SNK) determines the filling of the river channel with water. It is the quotient of the flow cross-sectional area of the watercourse channel during the measurement (F) and the cross-sectional area of this channel to the state of shore water (F_{brz}), i.e. SNK = F / F_{brz}.

The state of the coastal water (H_{brz}) at the station of the given habitat site Estuaries (1130) is permanent (Table 5). It should be designated based on the numerical terrain model (NMT) obtained from measurements from aerial laser scanning (ASL). The water level in the watercourse channel at the station of the monitored site 1130 on the day of measuring its flow cross-section corresponds to the state of water on the nearest mareograph from the time when this measurement was performed (Table 5).

The table (Table 6) presents an example of calculation of the SNK index along with the assessment for the Nogat station (Kępki station, Osłonka mareograph). The threshold values are listed in the table (Table 3), while the state of the shore water and the width of the channel near the shore water state are summarized in the table (Table 5).

Table 6. An example of calculating the SNK index for the Nogat-Kępki station at the Nogat site in particular seasons

Season	**H [cm]**	**F_i [m^2]**	**B_i [m]**	**B_{brz} [m]**	**d_i [m]**	**F_o [m^2]**	**F_{brz} [m^2]**	**F_i/F_{brz} [-]**	**Assessment**
autumn	496	283,453	119,1	150,4	3,27	440,633	724,086	0,391	U2
winter	525	304,463	119,7	150,4	2,98	402,449	706,912	0,431	FV
spring	526	298,100	121	150,4	2,97	403,029	701,129	0,425	U1
summer	512	279,454	119,6	150,4	3,11	419,850	699,304	0,400	U1

Explanations:

H – water state in the Nogat river bed based on a reading on the Osłonka mareograph;

F_i – area of flow cross-section from measurements,

B_i – width of the water table in the flow channel from measurements,

B_{brz} – width of the riverbed at the state of peripheral water from the table (Table 5);

d_i – distance from the shore water to the water table on the day of the measurement, i.e. the difference in the state of the shore water and the state of the water in the channel;

F_o – surface of the watercourse without water when it is filled on the day of measurement: F0 = 0.5 (Bi + Bbrz) di, i.e. in autumn Fo amounted to 440.633 m^2 [0.5· (119.1 + 150.4) ·3, 27], in the winter 402.449 m2 [0.5· (119.7 + 150.4) ·2,98] etc.;

F_{brz} – cross-sectional area of the channel to the state of the boundary water on the day of measurement, ie the sum of the area of the measurement cross-section on the measurement day (F_i) and the cross-sectional area of the channel without water on the measurement day (F_o);

F_i/F_{brz} – troughhannel filling condition (SNK)

Threshold values for the assessment of the 'Filling level' of the Estuaries (1130) should be determined (Table 3) assuming that there is a relationship between the sea level recorded on the mareograph closest to the given site (H) and the degree of filling the riverbed (SNK) at the habitat site, calculated at sea level on the day of measurements of the flow cross-section of the channel (Table 6). The threshold values determine WSW_r, i.e. the high average annual water from the last 25 years, observed on the mareograph closest to the given position (Table 7) and zero sea level (508 cm), below which it does not affect habitat 1130.

If the relationship between sea levels recorded at the nearest station of the mareograph (H) and the SNK indicator calculated at a given sea level will be determined for any watercourse, it is enough to perform only the water level readings on the nearest for the given watercourse for the assessment of the habitat state 1130.

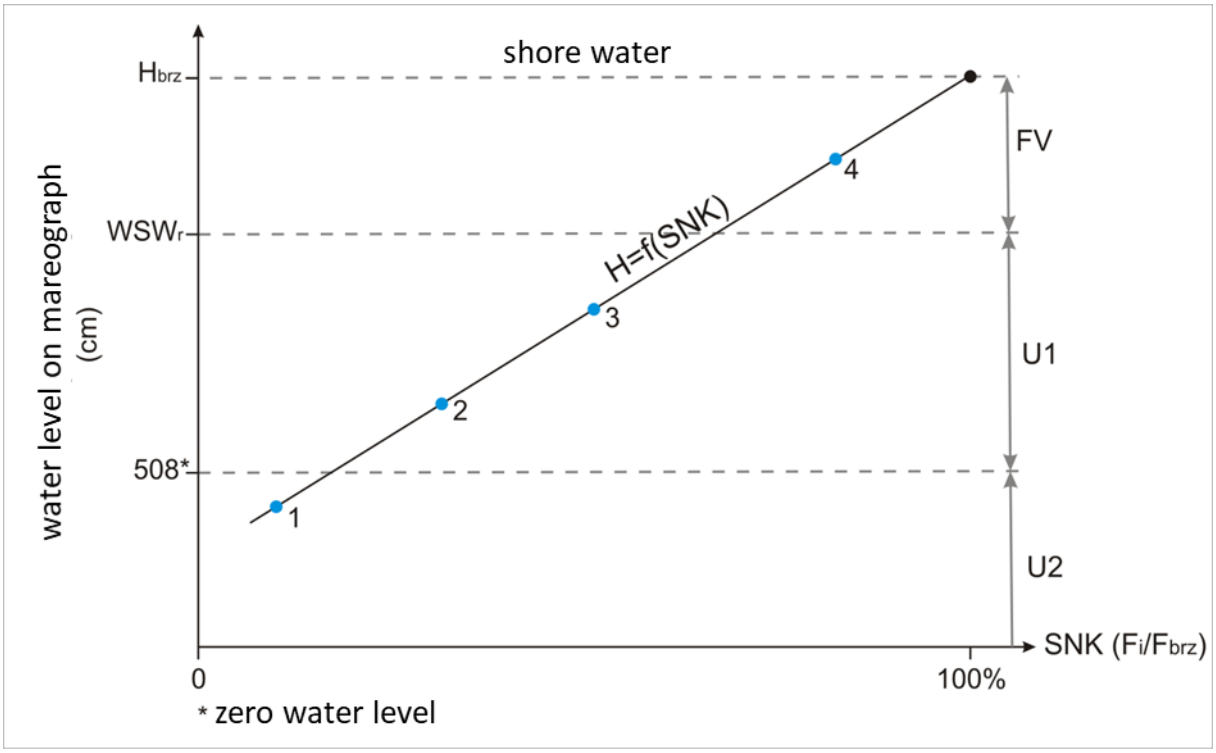

Fig. 6. Relationship between the state of water on the mareograph closest to habitat 1130 and the degree of filling the channel of the watercourse at the station of this habitat (SNK) with the indication of threshold values SNK determining the state of preservation of the habitat. Explanation: water state on the mareograph corresponding to the coastal water of the channel at the habitat station (Hbrz), high average annual water from the last 25 years (WSWr), zero sea level (508 cm), 1,2,3,4 - filling state at the habitat station on the day of the measurement (spring, summer, autumn, winter), FV - favourable, U1 - unfavourable inadequate, U2 - unfavourable bad

Table 7. Example of WSW$_r$ thresholds for the stations of Estuaries (1130)

Site	Station	Mareograph	Sea level [cm]	High average annual water (1991–2015), (WSW$_r$) [cm]
Dziwna	Dziwnów	Dziwnów	508	521
Rega	Mrzeżyno	Kołobrzeg	508	518
Piaśnica	Dębki	Łeba	508	520
Reda	Beka	Puck	508	518
Wisła Przekop	Świbno	Gdańsk – Port Północny	508	527
Nogat	Kępki	Osłonka	508	522

Research on water quality

In accordance with PN-EN ISO 7027 standard, the measurement of water transparency (Secchi depth) should be performed at each station. According to PN-ISO 5667-6 standard, the water samples for physicochemical properties should be collected from both surface and near bottom layers. The pH value is measured in situ. The water samples prepared in accordance with the PN-EN ISO 5667-3 standard (e.g. fixing, cooling) should be delivered to laboratory. The individual parameters should be

investigated in accordance with the reference methodologies given by the binding Regulation of the Minister of Environment on the forms and methods of monitoring of water bodies or equivalent methods.

Sampling, all measurements as well as the physicochemical analyses should be performed by the accredited laboratory in the above-mentioned range.

Character and banks modification

Field studies of the habitat for banks modification are difficult methodically. On some sections of the banks of rivers and their nearby facilities due to unstable subsoil, extensive reed beds, crops, marshlands, backwaters, wetlands, closed areas (Dziwna) or private areas and lack of access roads it is impossible to conduct direct survey and make accurate measurements. Therefore, first of all, study works should be performed using the current ortophotomap. Verification of data in the field is necessary in case of difficult identification on the maps of the beginning and end of the object or type of development. In the case of Piaśnica, it is not possible to use ortophotomap, as the site is located in the forest, which means that the facilities and shore management are not identifiable. Field syrveys will also be necessary, if there are no current ortophotomap covering a given site in a given measurement cycle. An ortophotomap can be a source of information only if its quality allows to obtain data in the field of character and modification of banks and technical buildings. Maps should be obtained from the resources of the Head Office of Geodesy and Cartography, from the Geoportal.gov.pl website and Maritime Offices

Both studio and field works should be implemented in the division into the left and right banks of the river.

In the case of Piaśnica, the left bank is also Białogórska Struga, whereas in the Dziwna station, measurements should also be made for the Chrząszczewska island, as a separate station.

To determine the places of occurrence of objects and various forms of development of the river bank facilities in the area, a satellite navigation system (GPS) should be used. Information acquired during the study and field studies of the 'Character and shore modification' index should contain geographical coordinates of the starting and ending section (ID) occupied by the object or other forms of river bank facilities up to 50 m from the waterline. In cases of section breaks, this break should also be indicated as an intermediate point (characteristic). An object with a width of <2 m is treated as a point object with a coordinate determined in the middle of its width. To calculate the value of the index, the length of each segment should be obtained from its starting point to the ending point.

At the Reda site, there is a naturalized section of flood embankment, which does not affect the condition of the habitat, therefore it is not subject to inventory.

In order to assess the state of the coastal zone in the vicinity of rivers flowing into the sea, using the tape measure should be measured the width of the beach, and the expert method to assess the effect of erosion or accumulation at border and characteristic points. If there are beaches along the banks of the river, proceed in the same way. Additionally, photographic documentation should be prepared at the measurement points and between them.

In the research on the character and modification of the banks of river estuaries one should use the symbols listed in the tables (Table 8 – Table 10).

Table 8. List of object symbols

Symbol	Object
nk	rip-rap (crushed stones)
mż	reinforced concrete wall
moż	reinforced concrete retaining wall
mog	gabions retaining wall
ś	sheet pile wall
o	slope revetment
p	palisade
po	palisade with slope revetment above
pnk	palisade with rip-rap foot
opm	sea wall of composit structure
pj	single or multi-row palisade
gk	stone causeway
km	composite structure
nsz	bank - artificial nourishment effect
wpp	embankment (longshore, soil core)
ws	shipwreck
nb	quay
prz	landing stage
ma	marine
pom	stage
mo	pier/jetty
kł	mattress, footbridge
pirs	pier
m	bridge
r	outlet pipe
ur	drainage ditch outtake

Table 9. List of object symbols of the erosion or accumulation effects

Symbol	Erosion or accumulation effect
wb	coastal berm
ps	wide beach
psk	undercutting cliff toe
ppw	undercutting dune toe
os	landslide

Symbol	Erosion or accumulation effect
ob	rock fall
osy	avalanche
pw	narrow beach

Table 10. List of symbols for the development of the river bank facilities

Symbol	Way of development of the river bank facilities
zz	dense urban development
bp	single buildings
tprz	industrial area
tp	harbour area
ps	parking area
c	camping place (campsite)
s	stadium, playing field
pz	playground, recreation place
l	helicopter landing pad
pu	farmlands
os	garden, orchard
p	park
o	area for development
tw	military area
sr	bicycle path
du	paved road
dg	dirt road/field road/forest road
tk	railway (track)
zs	temporary development

Technical development

In the case of the index 'Technical development' (existence of waterways, dredging, underwater thresholds, etc.), field surveys are only a supplementary source of information used to assess this index. Data for the assessment of the index must be based on information obtained from bodies responsible for conducting activities related to the construction and maintenance of waterways and hydro-technical structures in the riverbed, ie Regional Water Management Boards and Maritime Offices.

The table (Table 11) lists the symbols used to assess the technical development elements found in the habitat.

Table 11. Lists of symbols of technical development

Symbol	Technical development item
fu	detached breakwater
ku	guide groins
pp	underwater sill, submerged breakwater
tw	waterway
os	groin
sl	sluice

2.3. The date and frequency of surveys

The measurements of the channel filling level (SNK) should be carried out in April (the end of the hydrological winter half-year) and October (the end of the hydrological summer half-year).

Research aimed at assessing the 'Water quality status' index should be carried out in four periods: January – February, April – May, July – August and October – November.

Field surveys aimed at assessing the indices 'Character and bank modification' and 'Technical development' should be carried out in the period from June to September.

2.4. Equipment and materials for survey

For the measurements of the channel filling degree (SNK), depending on the size of the watercourse and access to the research profile, a weight probe or echo sounder as well as a measuring tape are necessary.

For the collection of water samples and for in situ measurements, a bathometer or beaker, a Secchi disc, a thermometer and a pH meter are needed. To perform laboratory analyses: spectrophotometer, ion chromatograph, burette and chemical reagents for particular determinations according to the applied research method are necessary.

For field studies and studies on the 'Character and shore modification' index and 'Technical development', you need: an ortophotomap, a GPS receiver, a measuring tape and a camera.

2.5. Examples of field forms

FORM OF RIVER CROS SECTION MEASUREMENT		
Institution: *Maritime Institute in Gdańsk*		
Site name: *Czerwona*	Station: *Ujście*	
Coordinates of the initial point: *54°13'39,065"" N; 15°47'56,522'' E*		
Bank: left □ right X		
Date (yyyy-mm-dd): *2017-06-09*		
Hour/start UTC (hh-mm): *15:40*	Hour/ end UTC (hh-mm): *16:10*	
Device: weight probe	Way of survey: *from bridge*	
Sea level [cm]: *501 (Kołobrzeg)*	Water level on the nearest water gauge [cm]: -	Relation to water [cm]: *172**
Habitat threats: -		
Remarks: ** water gauge on the left just above the measurement station*		
Page 1 of *2*		

No	**Distance from bank (zero tape)**	**Distance to water**	**Distance to bottom**	**Depth**
[-]	**b [m]**	**h_1 [m]**	**h_2 [m]**	**h_p [m]**
1.	*5,10*	*3,90*	*3,90*	*1.*
2.	*6,00*	*3,90*	*4,35*	*2.*
3.	*7,00*	*3,90*	*4,95*	*3.*
4.	*8,00*	*3,90*	*5,00*	*4.*
5.	*9,00*	*3,90*	*5,18*	*5.*
6.	*10,00*	*3,90*	*5,13*	*6.*
(…)				

d - distance from the left bank (zero tape), bn- distance, h - depth in the measurement vertical, hśr - mean depth in the field between the vertical, fi - partial surface areas between the vertical, F - cross-section area
Unshaded columns are filled in the field (d, h) the remaining columns are calculated during office works

Compiled by:	**Checked by:**	**Approved by:**
Date:	Date:	Date:
Full signature:	Full signature:	Full signature:

WATER SAMPLING FORM	
Site name: *Wisła Przekop*	
Institution: *Maritime Institute in Gdańsk*	
Method of sampling: *PN-EN ISO 5667-6:2016*	
Sampling gear/sample volume: *beaker*	
Scope of research: *pH, oxygen, N tot, inorganic nitrogen, Cl, P_{org}, transparency*	
Way of preserving : *PN-ISO 5813, 1997 / cooling*	
Weather: *6/8; 4-5 m/s (3B)*	Water level on the water gauge [cm]: *555*
Threats: -	

No.	Station	Symbol of sample	Date	Hour (UTC)	Location in trans section*	Depth [m]	Temp. [°C]	pH	Transparency [m]	Remarks
1.	*Wisła Przekop*	*pow.*	*2017-03-09*	*10:18*	*lewy brzeg*	*0 – 0,5*	*4,6*	*8,10*	*0,60*	

* Left bank, right bank, middle point

Compiled by:	**Checked by:**	**Approved by:**
Date:	Date:	Date:
Full signature:	Full signature:	Full signature:

FORM OF LABORATORY ANALYSIS OF WATER SAMPLE
Site: *Piaśnica*
Institution: *Maritime Institute in Gdańsk*
Station: *Dębki*
Sample: *Dębki pow.*
Date: *2017-08-12*
Date of delivery to laboratory: *2017-08-12*
Method of sampling: *PN-EN ISO 5667-6:2016-12*

No.	Analysis	Unit	Result		Method	Remaarks
			value	uncertainty		
1.	*odczyn*	*pH*	*7,71*	*0,44*	*Potentiometric method according to PN-EN ISO 10523:2012*	
2.	*tlen rozpuszczony*	*$mg \cdot dm^{-3}$*	*6,50*	*0,58*	*Method according to PN-EN 25813:1997*	
3.	*fosfor fosforanowy*	*$mg \cdot dm^{-3}$*	*0,037*	*0,007*	*Spectrophotometric method, research procedure PB-32, ed. 3 of on 15/03/2017*	
4.	*fosfor ogólny*	*$mg \cdot dm^{-3}$*	*0,049*	*0,003*	*Spectrophotometric method, research procedure PB-31, ed. 3 of on 15/03/2017*	
5.	*chlorki*	*$mg \cdot dm^{-3}$*	*30,2*	*6,0*	*The ion chromatography method according to PN-EN ISO 10304-1:2009/AC:2012*	
6.	*azot ogólny*	*$mg \cdot dm^{-3}$*	*0,50*	*0,17*	*Spectrophotometric method, research procedure PB-03, ed. 2 of on 10.05.2007*	
7.	*azot mineralny*	*$mg \cdot dm^{-3}$*	*0,155*	*0,054*	*Calculation method according to I-16, ed. 1 of on 9.01.2017*	

p. - below the limit of quantification

* the result was given with expanded uncertainty, the expansion factor k = 2; with 95% probability

Compiled by:	**Checked by:**	**Approved by:**
Date:	Date:	Date:
Full signature:	Full signature:	Full signature:

FORM OF FIELD SURVEY – CHARACTER AND BANK MODYFICATION		
Institution: *Maritime Institute in Gdańsk*		
Site: *Piaśnica*		
Date: *2017-09-08*	Hour /start (UTC): *6:25*	Hour /end (UTC): *8:03*
Device: *GPS*		
State of the sea: *2*	Sea level [cm]: *518 (Władysławowo)*	
No of Form page: 1 of *2*		

Hour (UTC)	Section ID	Left Bank/ Right L/R	Coordinates		Symbol			Beach width [m]	Photo [Y/N]	Remarks
			Longitude	Latitude	object *	erosion/ accumulation*	development of the bank			
6:26	*1*	*P*	*54°49'52,7''*	*18°03'45,8''*	*M*			*0*	*Y*	*Wooden bridge*
6:27	*1*	*P*	*54°49'52,5''*	*18°03'45,7''*	*M*			*0*	*Y*	*Wooden bridge*
6:29	*2*	*L*	*54°49'52,7''*	*18°03'44,6''*	*M*			*0*	*Y*	
6:30	*2*	*L*	*54°49'52,6''*	*18°03'44,5''*	*M*			*0*	*Y*	

* symbol in the table (Table 8, **Błąd! Nie można odnaleźć źródła odwołania.**Table 9, Table 10)

Compiled by:	Checked by:	Approved by:
Date:	Date:	Date:
Full signature:	Full signature:	Full signature:

FORM OF FIELD SURVEY – TECHNICAL DEVELOPMENT		
Institution: *Maritime Institute in Gdańsk*		
Site: *Rzeka Elbląg*		
Date: *2017-08-22*	Hour /start (UTC): *6:25*	Hour /end (UTC): *12:03*
Device: *GPS*		
State of the sea: *2*	Sea level [cm]: *518 (Władysławowo)*	
No of Form page: 1 of ……		

Hour UTC	**Object ID**	**Left/Right bank L/R**	**Coordinates**		**Object symbol***	**photo [Y/N]**	**Remarks**
			longitude	**latitude**			
6:52	*1*	-	*54°15,162'*	*19°22,879*	*tw*	*N*	*deepening of the waterway*
12:30	*1*	-	*54°09,600'*	*19°23,511*	*tw*	*N*	

* symbol in the table (Table 11)

Compiled by:	**Checked by:**	**Approved by:**
Date:	Date:	Date:
Full signature:	Full signature:	Full signature:

3. References

Bajkiewicz-Grabowska E., Mikulski Z. 1993. Hydrologia ogólna. Wydawnictwo Naukowe PWN, Warszawa, ISBN 8301112662.

Bolałek J., Falkowska L. 1999. Analiza chemiczna wody morskiej. Część 1 – Makroskładniki i gazy rozpuszczone w wodzie morskiej. Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk, ISBN 83-7017-872-3, s. 91

Dojlido R.J. 1995. Chemia wód powierzchniowych. Wydawnictwo Ekonomia i Środowisko, Białystok, ISBN 83-85792-22-8, s. 342

HELCOM 2014. Manual for Marine Monitoring in the COMBINE Programme of HELCOM. Online: http://www.helcom.fi/Lists/Publications/Manual%20for%20Marine%20Monitoring%20in%20the%20COMBINE%20Programme%20of%20HELCOM.pdf

Hermanowicz W., Dożańska W. Dojlido J., Koziorowska B. 1999. Fizyczno-chemiczne badanie wody i ścieków. Warszawa, Arkady, ISBN 83-213-4067-9, s. 556

Interpretation manual of European Union Habitats 2013. EUROPEAN COMMISSION DG ENVIRONMENT Nature ENV B.3, EUR 28, April 2013, 144 s.

Michałek M., Kruk-Dowgiałło L. (red.) 2014. Zbiorcze sprawozdanie z analizy dostępnych danych i przeprowadzonych inwentaryzacji przyrodniczych (zebranie i analiza wyników inwentaryzacji, materiałów niepublikowanych i opracowań publikowanych, przydatnych do sporządzenia projektów planów) Ostoja w Ujściu Wisły (PLH220004). Projekt rozporządzenia Ministra Środowiska ws. planu ochrony obszaru PLH220004.

Warzocha J. 2004. Ujścia rzek (estuaria). [w:] J. Herbich (red.) Siedliska morskie i przybrzeżne, nadmorskie i śródlądowe solniska i wydmy. Poradniki ochrony siedlisk i gatunków Natura 2000 - podręcznik metodyczny Ministerstwo Środowiska, Warszawa, t. 1, 31-36.

Authors: Bajkiewicz-Grabowska E., Markowski M., Barańska A., Opioła R., Boniecka H., Gajda A., Dembska G., Michałek M.