BONUS BaltCoast

SAF - application case study Vistula Lagoon

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A SYSTEM APPROACH FRAMEWORK FOR COASTAL RESEARCH & MANAGEMENT

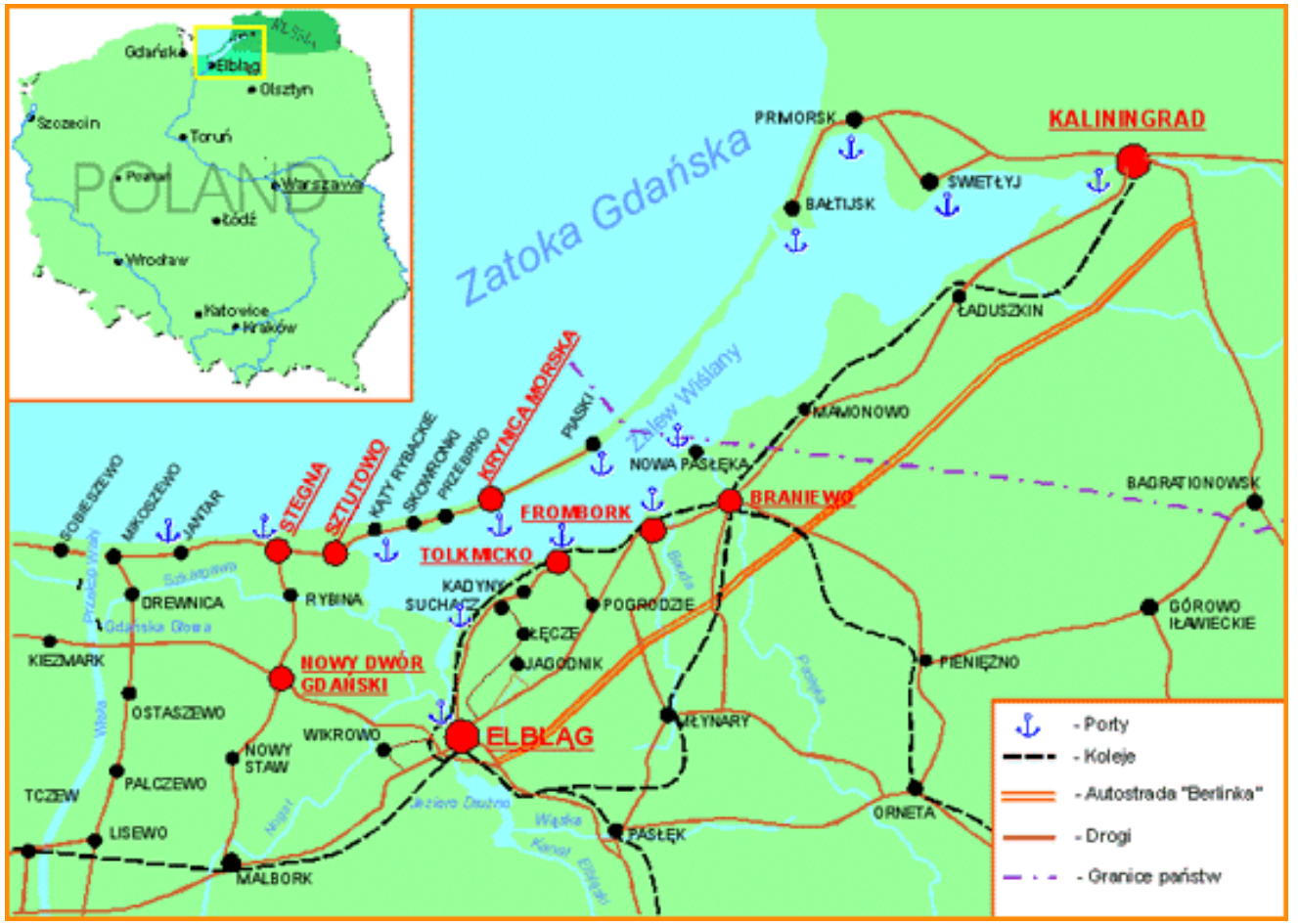
BONUS-BaltCoast received funding from BONUS (Art 185), funded jointly by the EU and Baltic Sea national funding institutions

BONUS Science for a better future of the Baltic Sea region

Case study site

Source: https://pl.wikipedia.org/wiki/Zalew_Wi%C5%9Blany

Photo by Konrad Kosacz/elblag.net



Source: http://www.zalew.org.pl/lagomar/index.htm

Vistula Lagoon (Polish: *Zalew Wiślany*; Russian: Калининградский залив or *Kaliningradskiy Zaliv*) is a brackish water lagoon on the Baltic Sea roughly 91 km long, 6.8 to 13 km wide and 2.7 m deep, max 5m, separated from Baltic Sea by the Vistula Spit.

Case study site

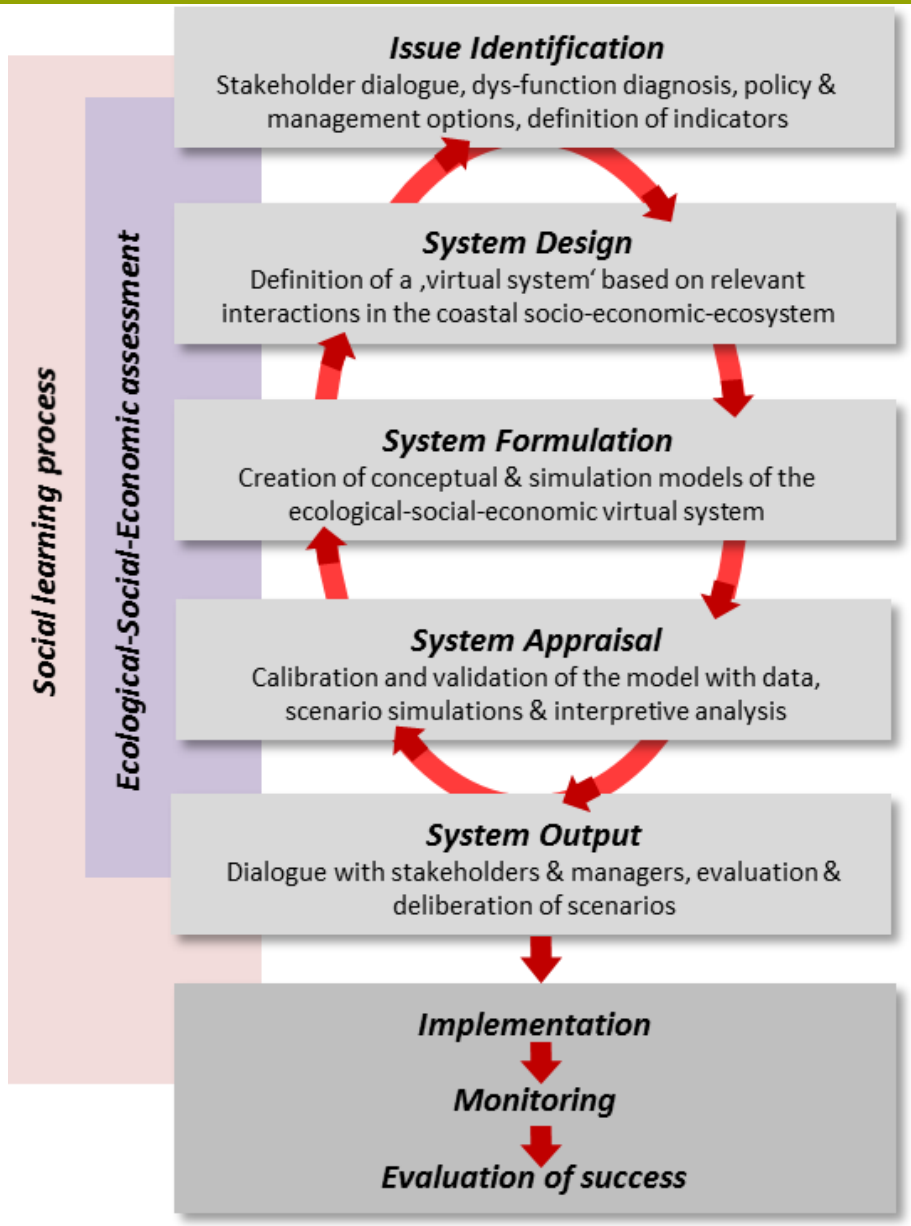
Source: petla-zulawska.pl

- Administrative division of the Polish part of the Lagoon between Pomeranian and Warmia-Masuria provinces – unfavourable in terms of communication and management
- Polish part – NATURA 2000 region

SAF

- **Issue identification**:

1. Key human activities
2. Stakeholder mapping
3. First stakeholder meeting to agree on Issue
4. Institutional mapping
5. Description of cause – effect chain (DPSIR and CATWOE)
6. Identification of social and economic components relevant for the Issue
7. List of main Ecosystem Goods and Services and Economic drivers relevant for the Issue



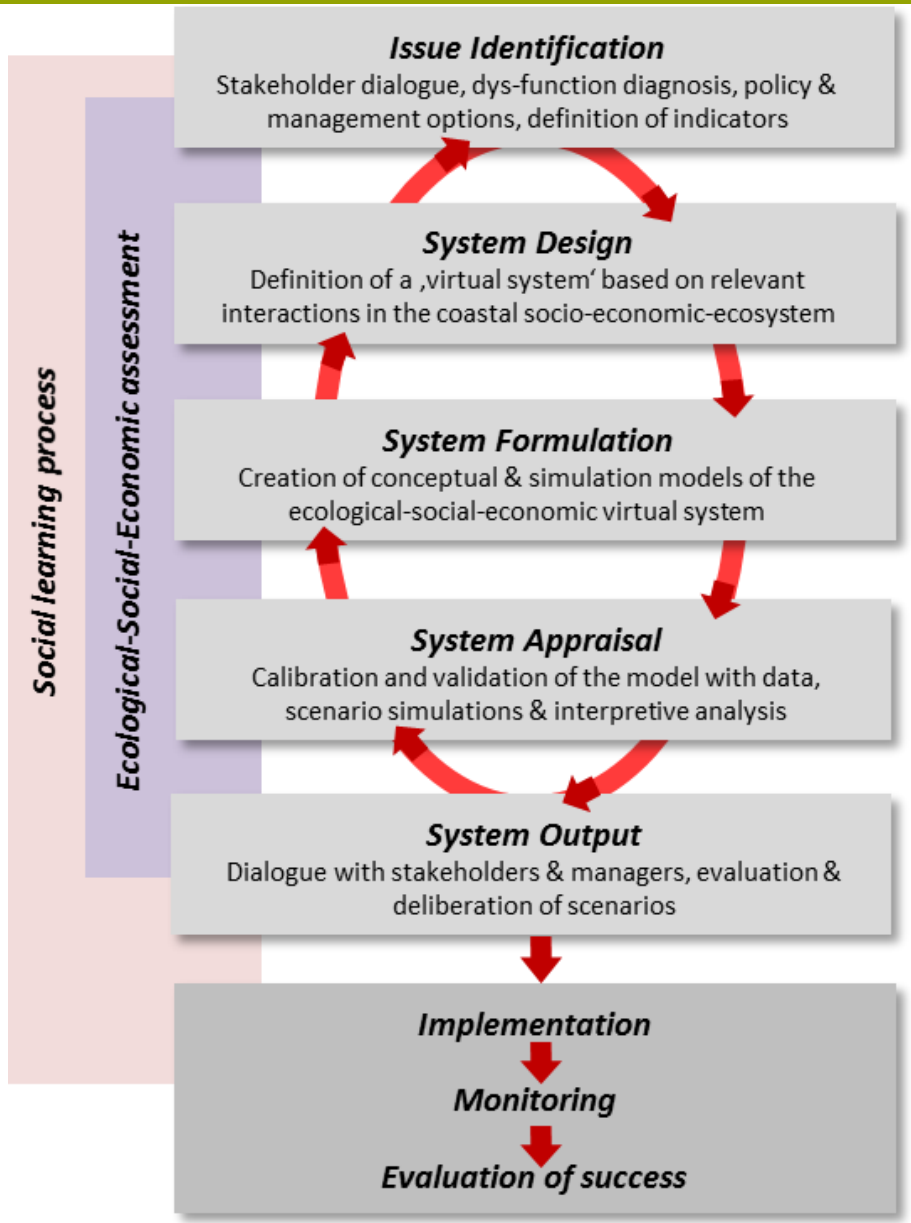
SAF

➢System Design

1. System definition
2. Conceptual model
3. Data and methods
4. Problem scaling

➢ System Formulation:

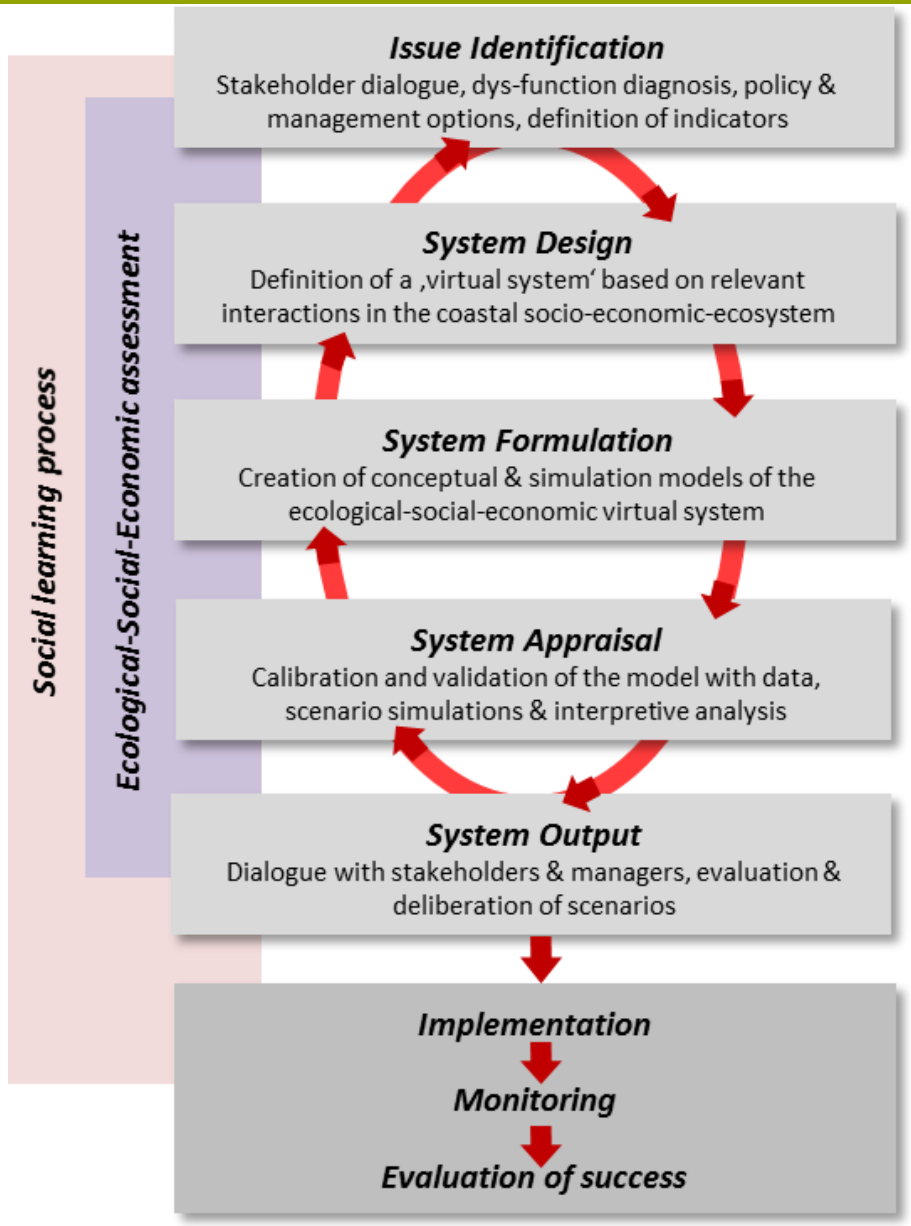
1. Data preparations (inputs)
2. Building and testing sub models
3. Documenting the model development



SAF

➢System Appraisal

1. Calibration and validation of the model with data
2. Scenario simulations and analysis
3. Conclusions

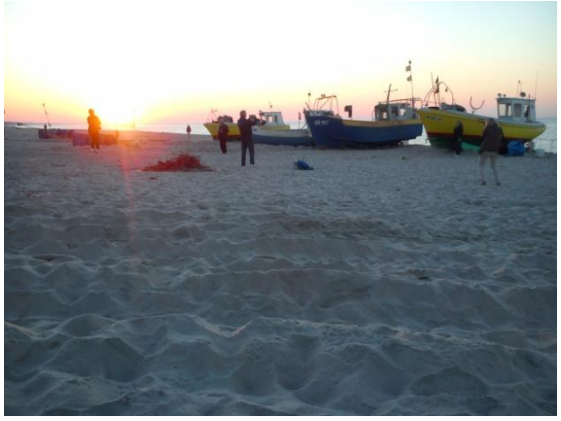


Key human activities

Human Activities	Associated stakeholder groups
Fisheries concentrated in VL harbors: (Nowa Pasłęka, Piaski, Frombork, Kąty Rybackie, Suchacz, Krynica Morska, Tolkmicko, Kamienica Elbląska).	Fishermen associations, harbor operator and users, Regional Inspectorate of Sea Fisheries in Gdynia, with branches in Frombork and Sztutowo.
Tourism – hotels, restaurants, harbors, transboundary tourism erratic due to political relations with Russia and isolation of the Lagoon from the rest of EU.	Hotel and restaurant operators, harbor operators, local authorities interested in tourism development.

Key human activities

Human Activities	Associated stakeholder groups
Commercial navigation: harbor in Elbląg (potential not fully used due to erratic trade with Kaliningrad Region).	Elbląg harbor operators, Elbląg authorities, shipping & logistics companies.
(Intensive) beach use on the Spit.	Tourism sector on the Spit (hotel, restaurant and camping operators).
Economic activities: prevalence of small shops and businesses with low creditworthiness- points to economic backwardness of the Lagoon area.	Shop owners.
Agriculture at south side of the Lagoon	Farmers, authorities



Key human activities

Human Activities	Associated stakeholder groups
Environmental protection: all Polish part is NATURA 2000 region (PLB280010, PLH280007). 	Ecologists, ecological organizations, institutions responsible for implementation of NATURA 2000 (Maritime Office in Gdynia, Regional Directorates of Environmental Protection in Gdańsk and Olsztyn).

Stakeholder mapping

Based on existing experience from other projects

- FP 7 cooperating projects:

  with common activities focused on stakeholders participation – joint workshops – contributing to socio-economic impact analysis (**LAGOON**S) and development of Management Plan (**ARCH**).

- LT-PL-RU Cross-border Cooperation Programme 2007-2013 **VILA** project: „The common benefits of the Vistula Lagoon potential development”

- South Baltic Programme **ARTWEI** project
- Żuławy Loop

Focus Groups to identify most accute problems of the area from a perspective of local communities – LAGOONS + ARCH projects.

Frombork:

Fishermen, hotel and gastronomy operators, teachers

Piaski:

Fishermen and hotel operators

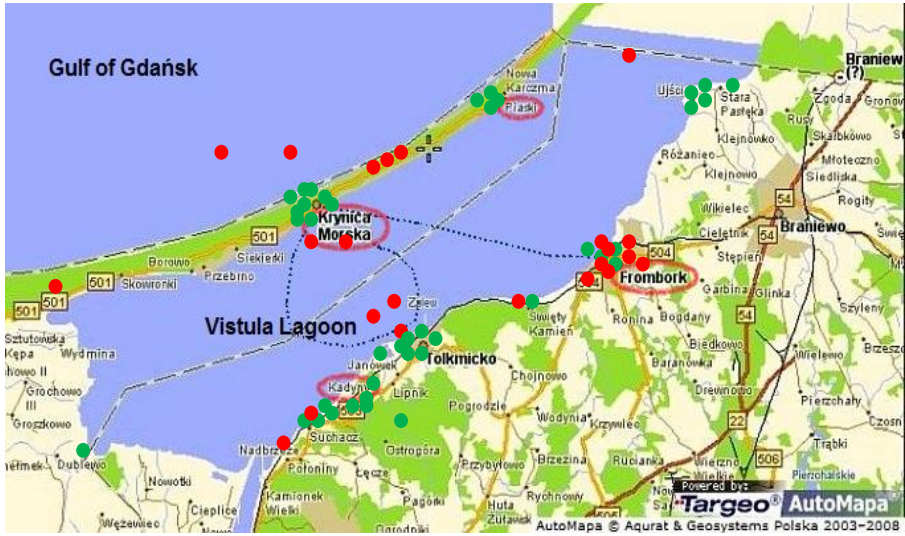
Kadyny:

Citizens and local authority

Krynica Morska:

Fishermen

Result: combined map indicating „best" and „worst" areas.



Citizens Jury as a next step allowing to refine insights and to formulate **recommendations** and **scenario of future lagoon development**.

Jurors from: *Krynica Morska, Piaski, Braniewo, Frombork, Kadyny*

Experts:

- *Quality of the Vistula Lagoon environment,*
- *Problems of the Vistula Lagoon fisheries,*
- *Problems of agriculture in the Vistula Lagoon region,*
- *Regulations and management in the Vistula Lagoon region,*
- *Transport and infrastructure in the Vistula Lagoon (maritime aspects),*
- *Environmental protection of the Vistula Lagoon,*
- *Tourism and recreation in the Vistula Lagoon region.*

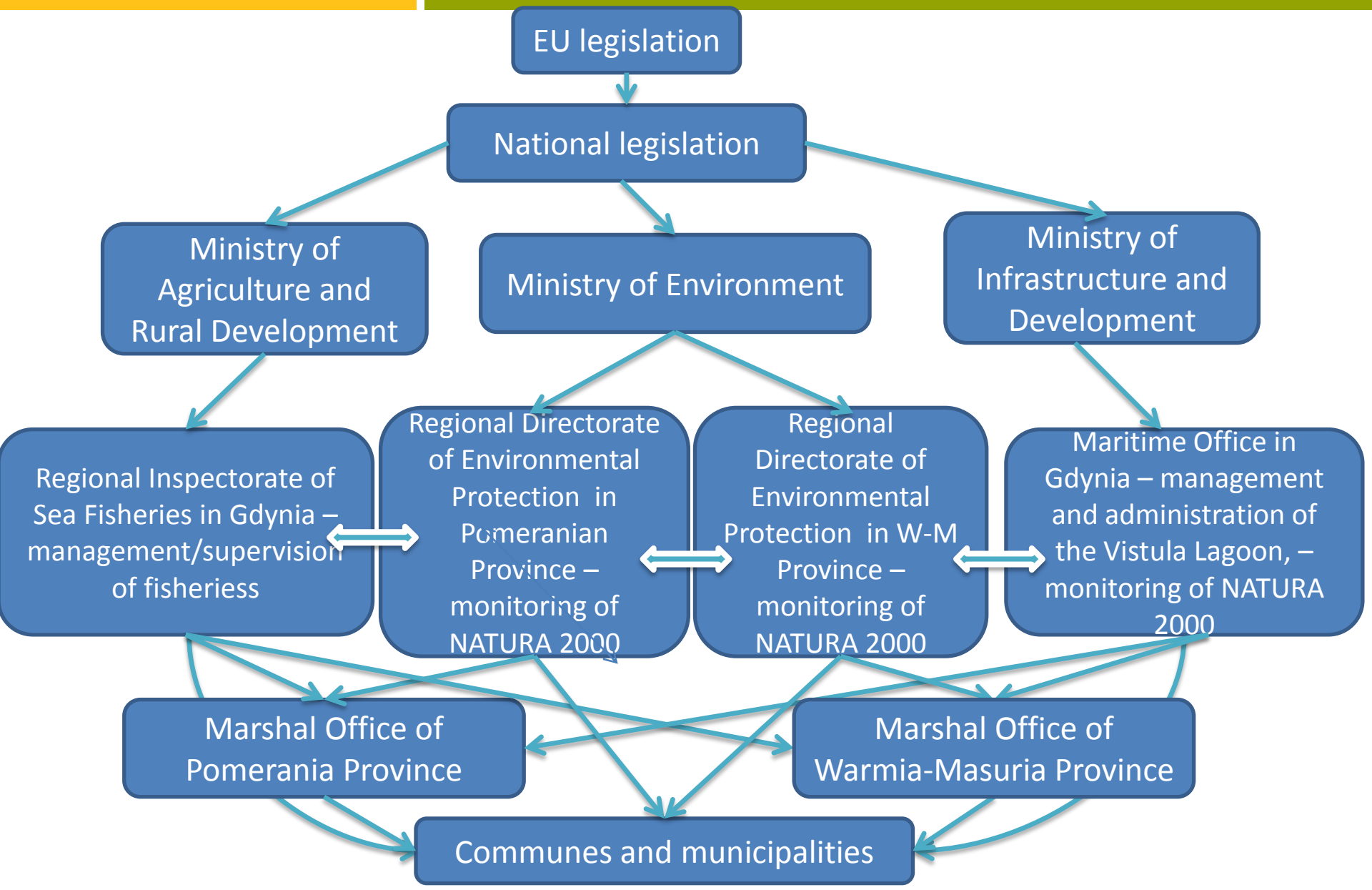
Stakeholder mapping

- **Public consultations in the framework of Żuławy Loop Project**

Program devoted to tourism development in the Gulfs of Gdańsk and Puck and the Vistula Lagoon, by modernization and development of marinas and harbors.

Pętla Żuławska (Żuławy Loop) waterway system

Institutional mapping



1st Stakeholder Meeting
Tolkmicko 26th Oct. 2015

Presentation of BaltCoast project

1st Stakeholder Meeting

Presentation ‘Natural and economic aspects of the functioning of Szczecin Lagoon in local scale’,

K. Rabski (EUCC Poland),

Presentation ‘Improvement of navigation in Vistula Lagoon - Żuławy Loop and Gulf of Gdańsk Programme’,

M. Górski, Żuławy Loop Manager, R. Wasil, Dept. of Infrastructure of Pomorskie Province Marshall Office,

1st Stakeholder Meeting

Moderated discussion on dredging of waterways in Vistula Lagoon and sustainable development of the Lagoon area, incl. questionnaire

1st Stakeholder Meeting

Participants:

- Office of Mayor of Tolkmicko (2 persons),
- Office of Mayor of Frombork (2 persons),
- Local Council at Krynica Morska (1 person),
- Maritime Office in Gdynia, (3 persons),
- Local Fishery Group, fishermen (3 persons),
- EUCC Poland (1 person),
- Żuławy Loop operator,
- Remontowa Holding Co. (1 person),
- Rotax Co. (1 person)
- Scientists from IBW PAN.

1st Stakeholder Meeting

Results of Questionnaire – present situation

A.1. For … (region/municipality) Environmental Quality compared to Economics is

Much less important	Less important	Slightly less important	Equally important	Slightly more important	More important	Much more important
☐	☐	2	7	☐	2	☐

A.2. For … (region/municipality) Environmental Quality compared to Social Well-being is

Much less important	Less important	Slightly less important	Equally important	Slightly more important	More important	Much more important
☐	☐	3	5	2	1	☐

A.3. For … (region/municipality) Environmental Quality compared to Governance is

Much less important	Less important	Slightly less important	Equally important	Slightly more important	More important	Much more important
☐	☐	2	7	2	☐	☐

A.4. For … (region/municipality) Economics compared to Social Well-being is

Much less important	Less important	Slightly less important	Equally important	Slightly more important	More important	Much more important
☐	☐	2	2	3	3	1

A.5. For … (region/municipality) Economics compared to Governance is

Much less important	Less important	Slightly less important	Equally important	Slightly more important	More important	Much more important
☐	☐	1	7	1	1	1

A.6. For … (region/municipality) Social Well-being compared to Governance is

Much less important	Less important	Slightly less important	Equally important	Slightly more important	More important	Much more important
☐	1	3	2	3	1	☐

1st Stakeholder Meeting

Results of Questionnaire – wish for future

B.1. For ... (region/municipality) Environmental Quality compared to Economics should be

Much less important	Less important	Slightly less important	Equally important	Slightly more important	More important	Much more important
☐	☐	4	**5**	2	☐	☐

B.2. For ... Environmental Quality compared to Social Well-being should be

Much less important	Less important	Slightly less important	Equally important	Slightly more important	More important	Much more important
☐	☐	**4**	2	2	1	☐

B.3. For ... Environmental Quality compared to Governance should be

Much less important	Less important	Slightly less important	Equally important	Slightly more important	More important	Much more important
☐	2	2	**5**	1	☐	☐

B.4. For ... Economics compared to Social Well-being should be

Much less important	Less important	Slightly less important	Equally important	Slightly more important	More important	Much more important
☐	☐	☐	**7**	3	1	☐

B.5. For ... Economics compared to Governance should be

Much less important	Less important	Slightly less important	Equally important	Slightly more important	More important	Much more important
☐	☐	☐	**6**	3	1	1

B.6. For ... Social Well-being compared to Governance should be

Much less important	Less important	Slightly less important	Equally important	Slightly more important	More important	Much more important
☐	☐	1	**4**	**4**	1	1

20

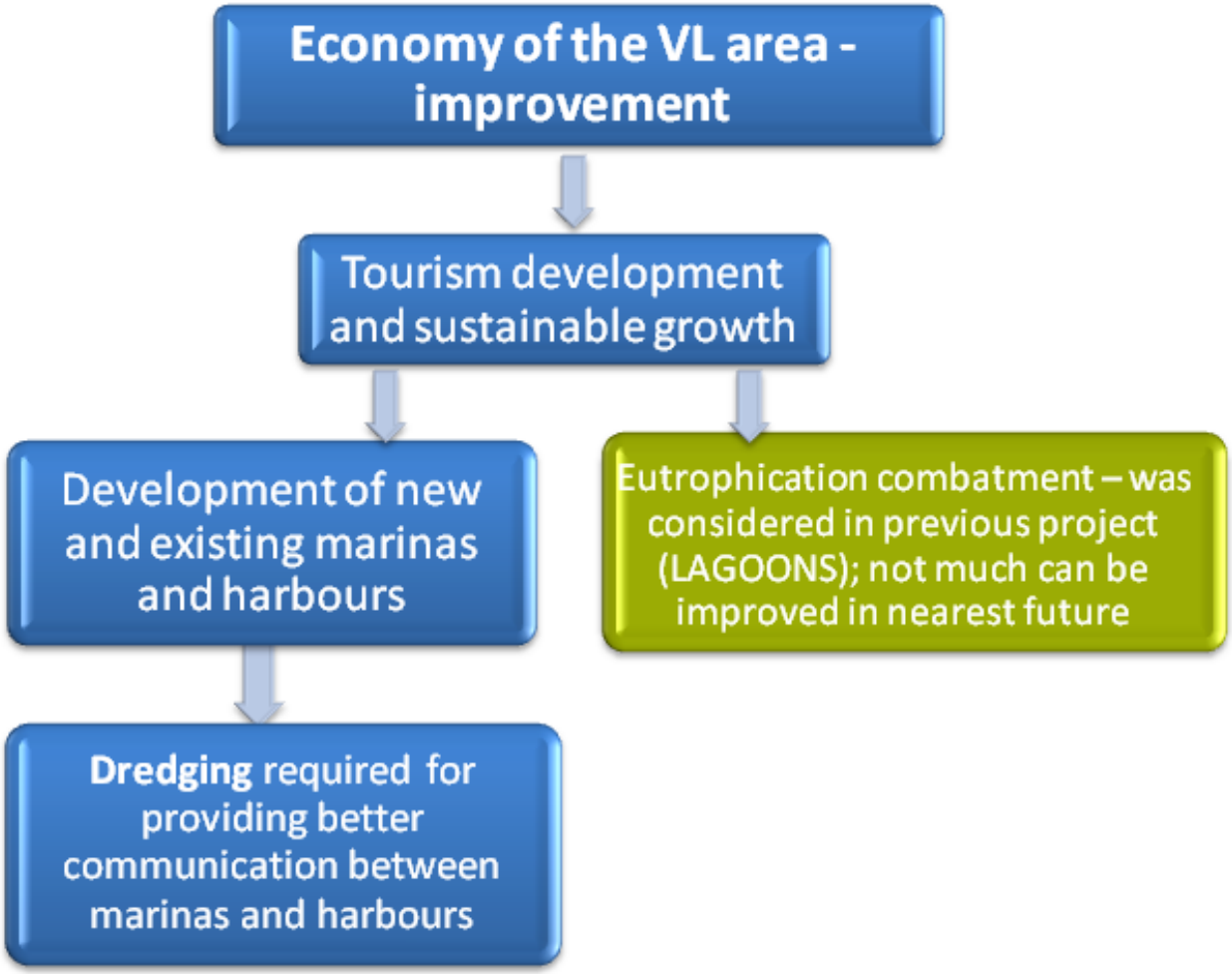
1st Stakeholder Meeting - Conclusions

- Need for ferry connections between Spit and hinterland: Tolkmicko - Krynica Morska and Frombork – Piaski.
- Need for integration of road and ferry traffic around Lagoon.
- Some of the waterways will need expansion in terms of depth and width (in case ferry connections are planned).
- Few scenarios of dredging activities will be elaborated based on the discussion and with Maritime Office assistance.

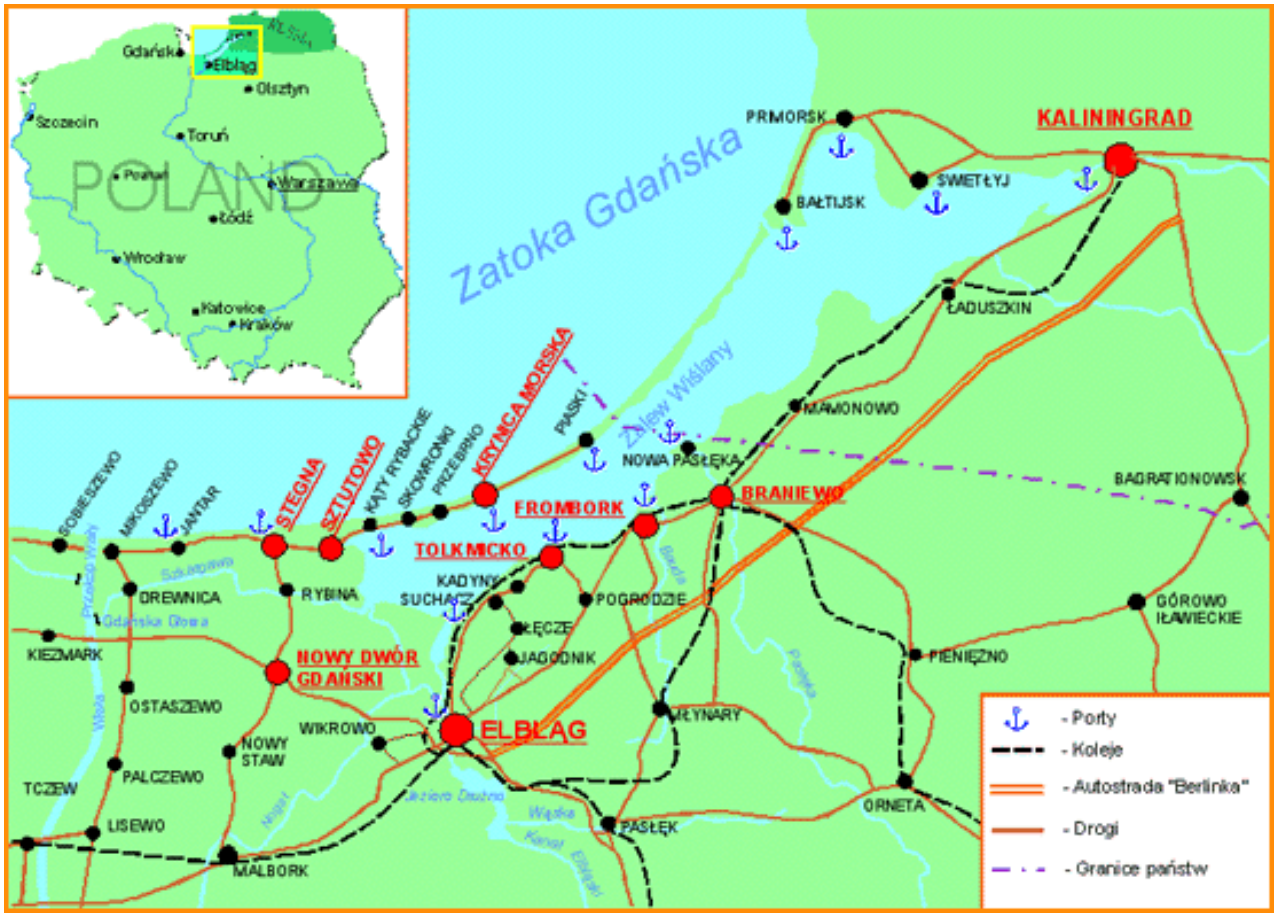


Issue for the Vistula Lagoon

Economy of the Vistula Lagoon area



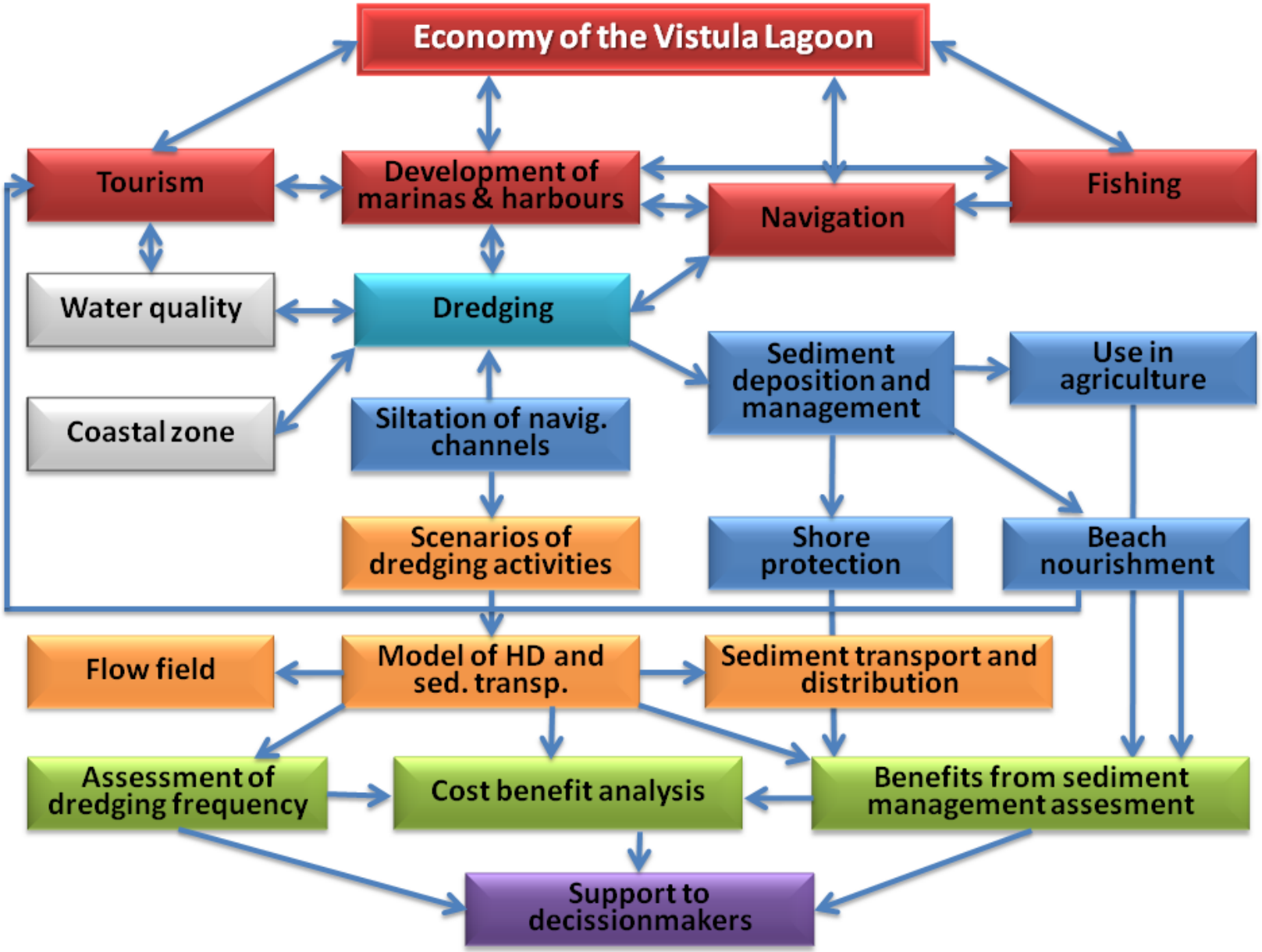
System Design



- System definition
- **Conceptual model**
- Data and methods
- Problem scaling

Source: http://www.zalew.org.pl/lagomar/index.htm

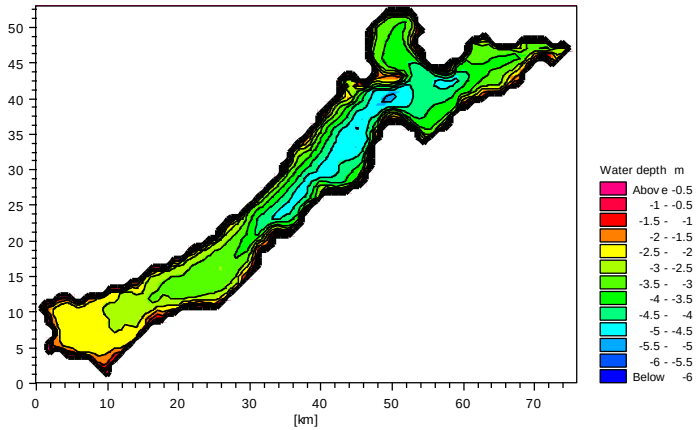
Conceptual model



System Formulation

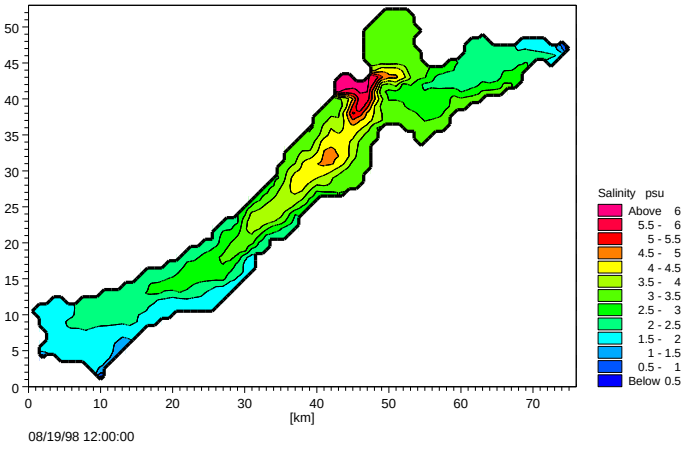
General description of applied model

- **Delft3D** is an integrated modeling suite, which simulates two-dimensional (in either the horizontal or a vertical plane) and three-dimensional flow, sediment transport, morphology change, wave parameters, water quality and ecology, and is capable of handling the interactions between these processes.



Bathymetry

- The **FLOW module** is the heart of Delft3D and is a multi-dimensional (2D or 3D) hydrodynamic (and transport) simulation programme which calculates non-steady flow and transport phenomena resulting from tidal and meteorological forcing on a curvilinear, boundary fitted grid or spherical coordinates.



Salinity

System Formulation - Scenarios

- The scenarios are based on information from the Maritime Office and governmental plans to construct a cross-cut through the Vistula Spit.
- The main goal is:
  - to estimate siltation rates of the channels,
  - dredging frequencies for each case,
  - perform cost-benefit analysis which will indicate most beneficial scenario.

System Formulation - Scenarios

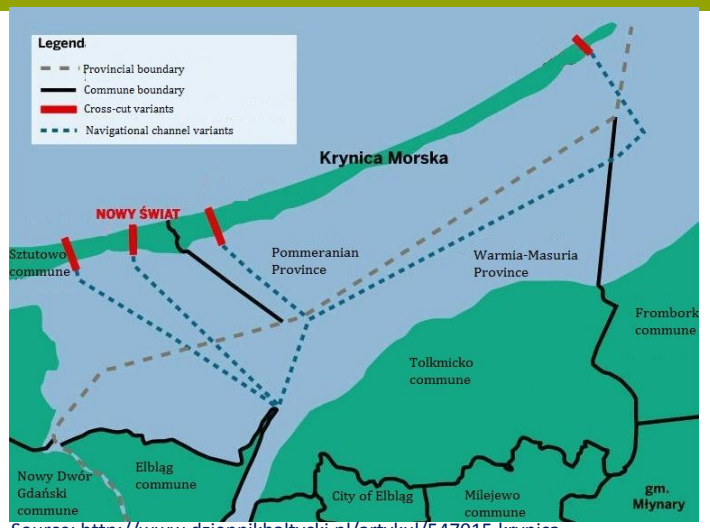
1. Modeling of hydrodynamics and siltation rate assuming **existing navigational channels** – reference conditions

2. Modeling of hydrodynamics and siltation rate assuming **existing navigational channels and including construction of new navigational channel** for the Vistula Spit cross-cut based on two assumptions:

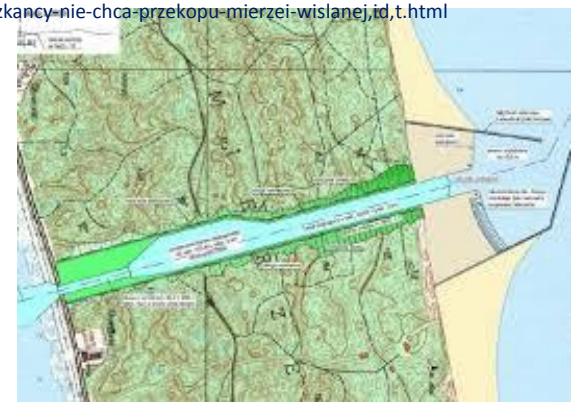
a) new navigational channel: 60 m wide and 5 m deep,

b) new navigational channel: 100 m wide and 5 m deep.

https://www.youtube.com/watch?v=Vhkk3iH3cec



Source: http://www.dziennikbaltycki.pl/artykul/547015,krynica-morska-mieszkancy-nie-chca-przekopu-mierzei-wislanej,id,t.html



Source: http://wiadomosci.gazeta.pl/wiadomosci/1,114871,19413609,pis-wraca-do-pomyslu-przekopu-mierzei-wislanej-jeden-z-priorytetow.html

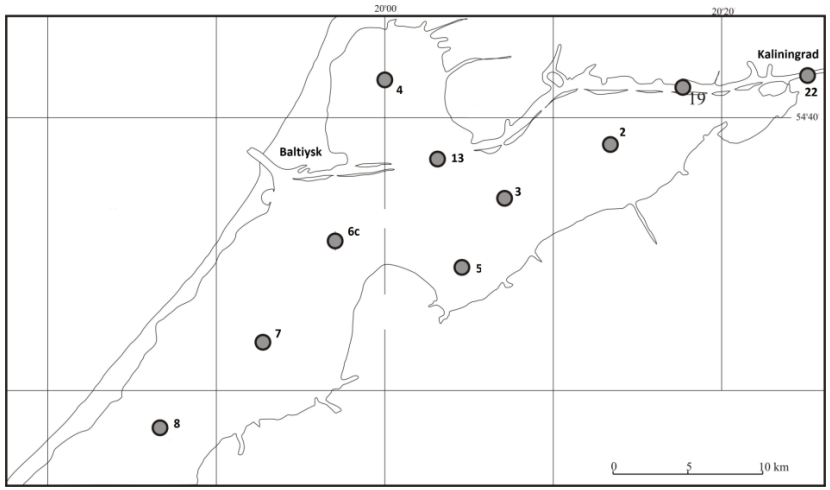
3. Modeling of hydrodynamics and siltation rate for **the existing navigational channels maintained at depth of 3.5 m** (which will require dredging of some parts of the channels) including construction of new navigational channel for the Vistula Lagoon cross-cut of the 60 m width (as in 2a).

System Formulation – sediment sampling

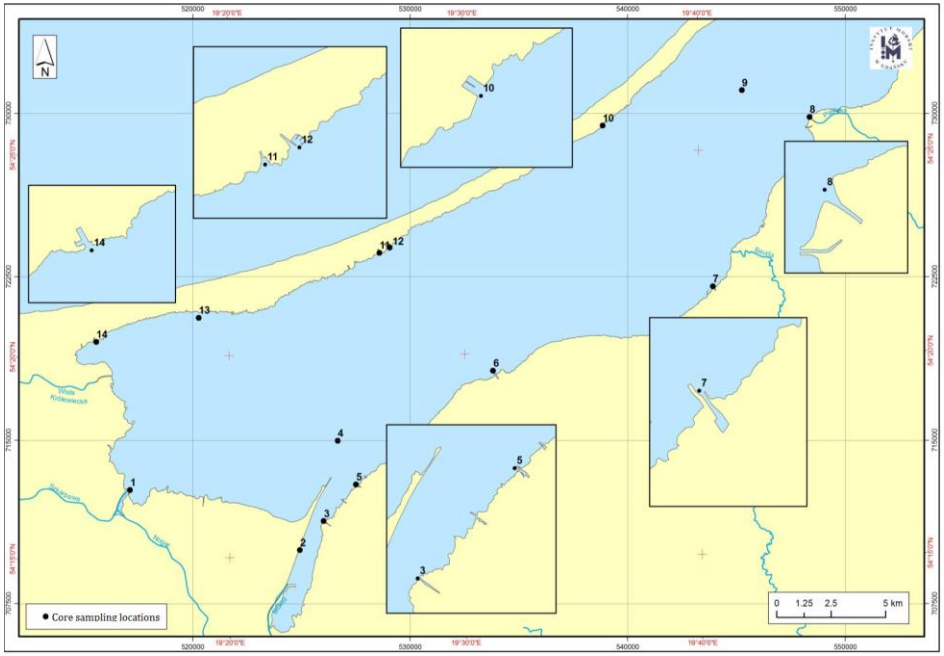
- Necessary for correct calibration of the modeling suite.
- Necessary for determination of sediment management methods (e.g. use for building artificial islands, depositing on land, beach nourishment, agriculture, others).

System Formulation – sediment sampling

- Sediment was sampled at 14 locations on Polish side in the vicinity of existing harbors, marinas and navigational channels and 10 locations on Russian side.



Russian part

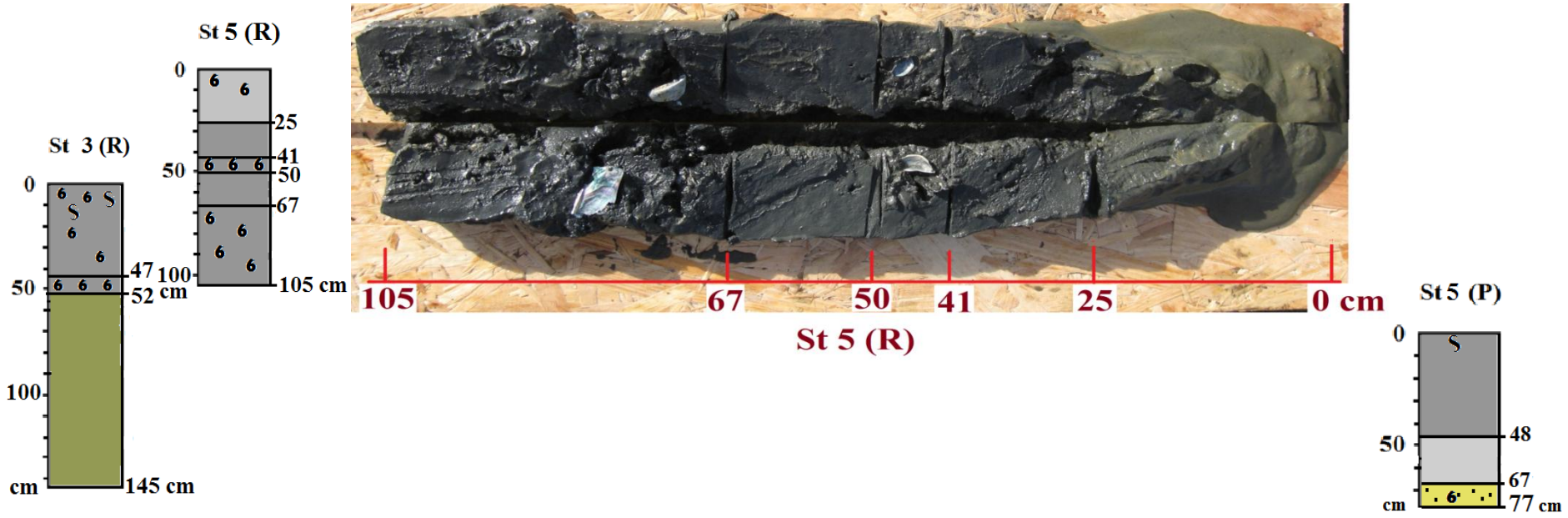


Polish part

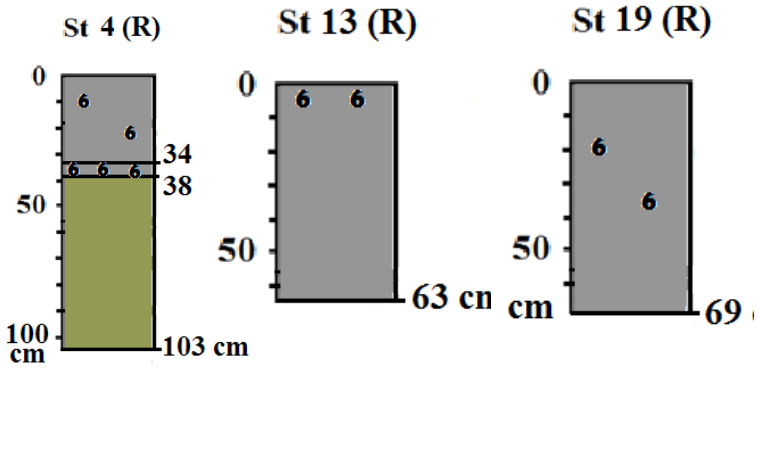
System Formulation – sediment sampling

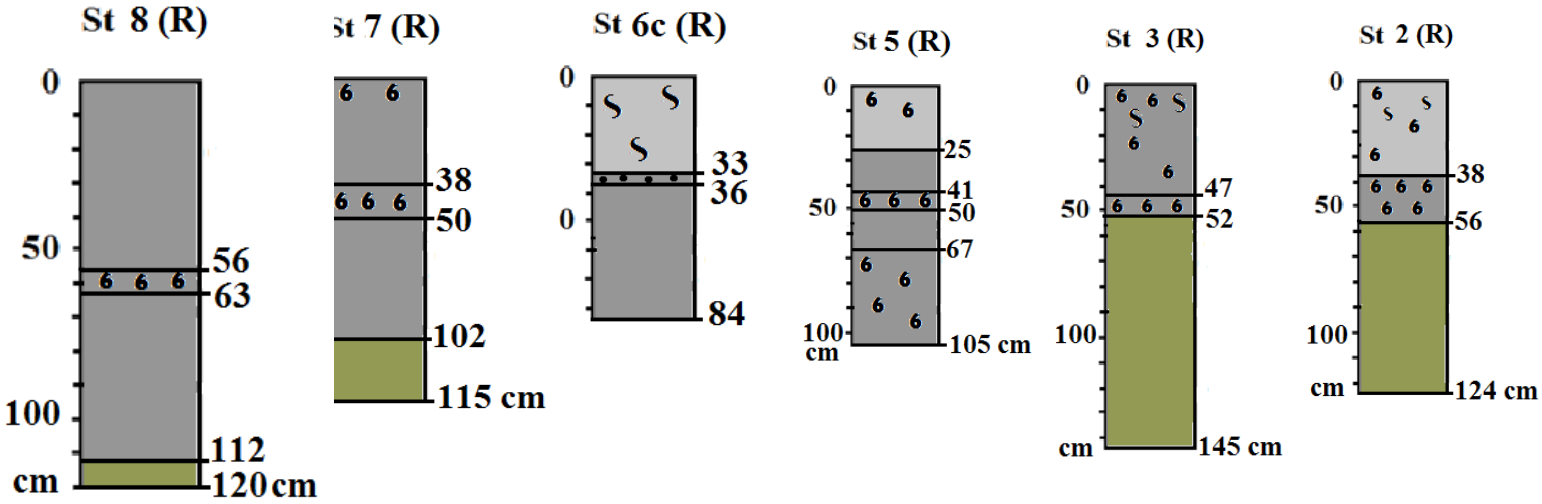
- Macroscopic analysis of sediment cores indicates that bottom is mostly made of various types of mud (usually soft plastic, sometimes semi-liquid in the upper part) and contain considerable amounts of organic matter. Sand deposits are present only occasionally.

- The samples were tested against the presence of heavy metals and persistent organic pollutants, such as PCB-s and PAH-s. All results are within acceptable limits.

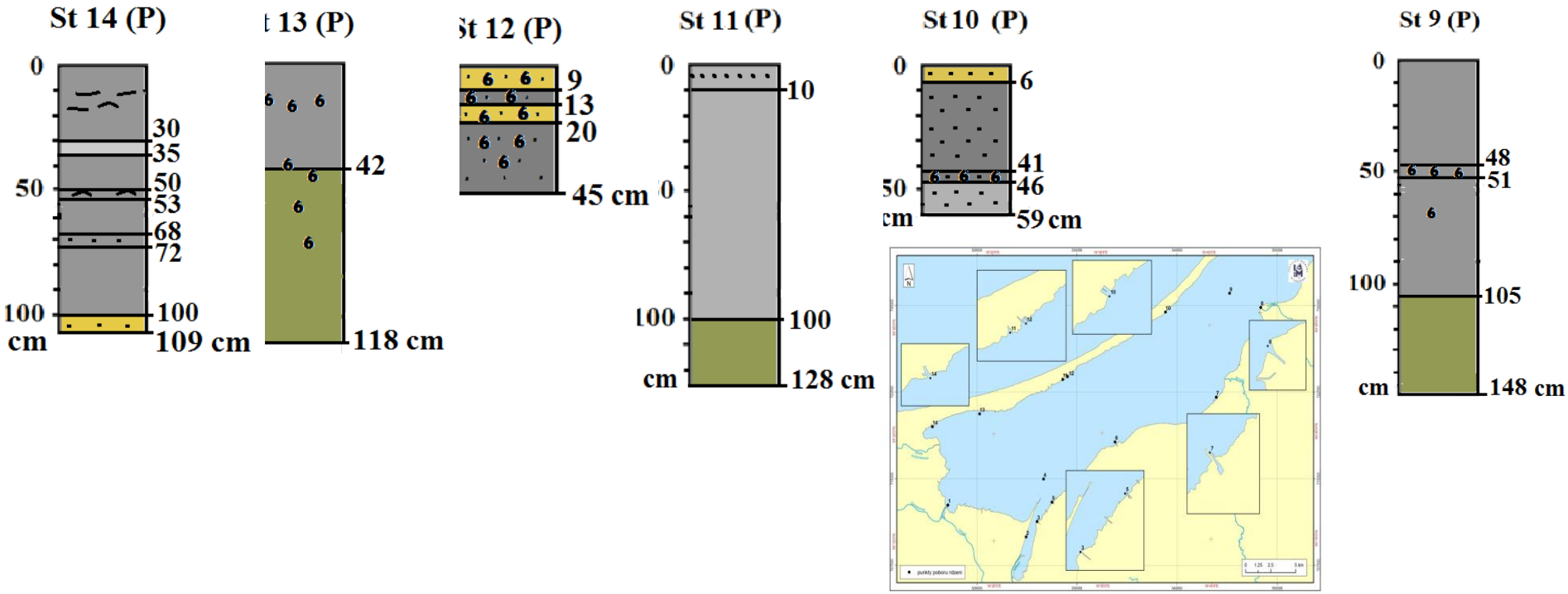


Sediment sampling – Russian part





Sediment sampling – Polish part



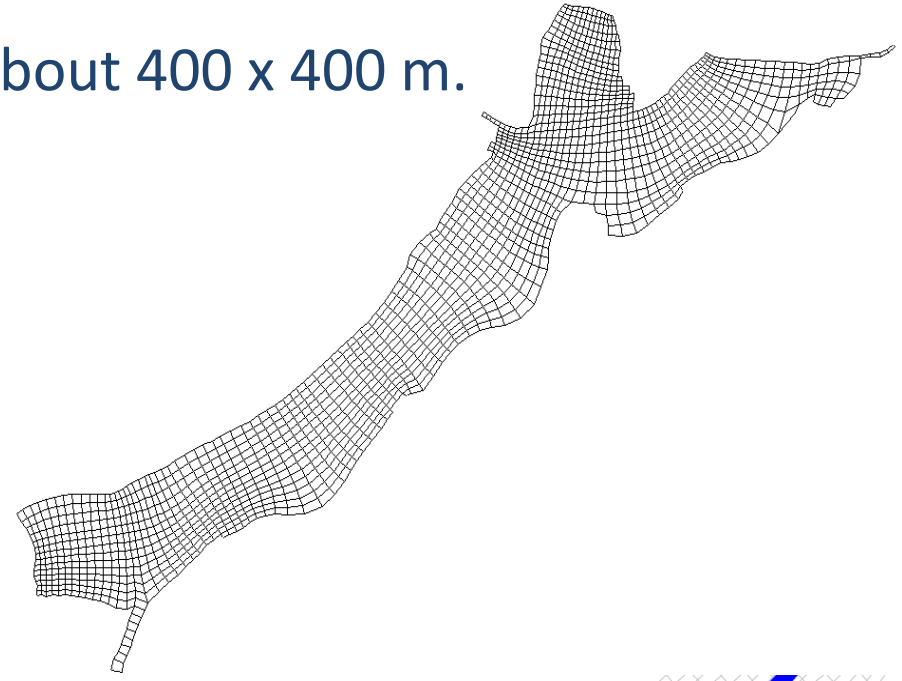
System Formulation – hydrodynamic modeling and grids

External conditions

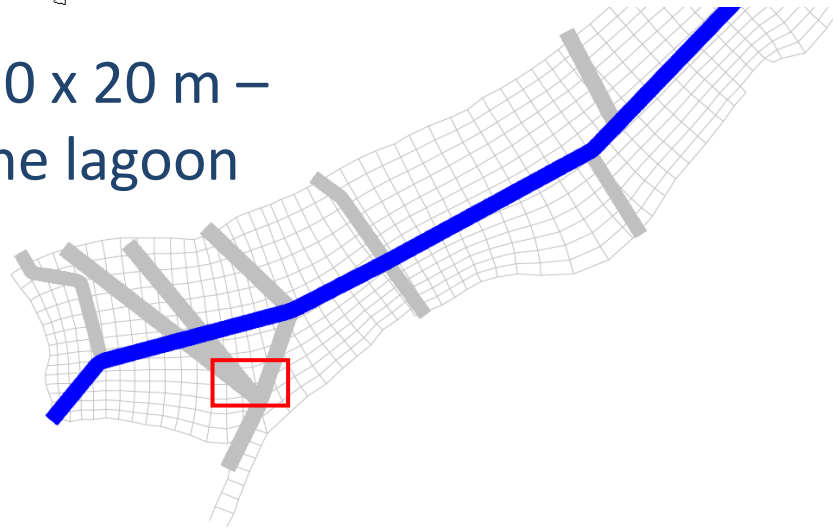
- rivers,
- water level,
- salinity,
- wind (currents and waves).

Hydrodynamic model currents, waves

Overall grid: about 400 x 400 m.



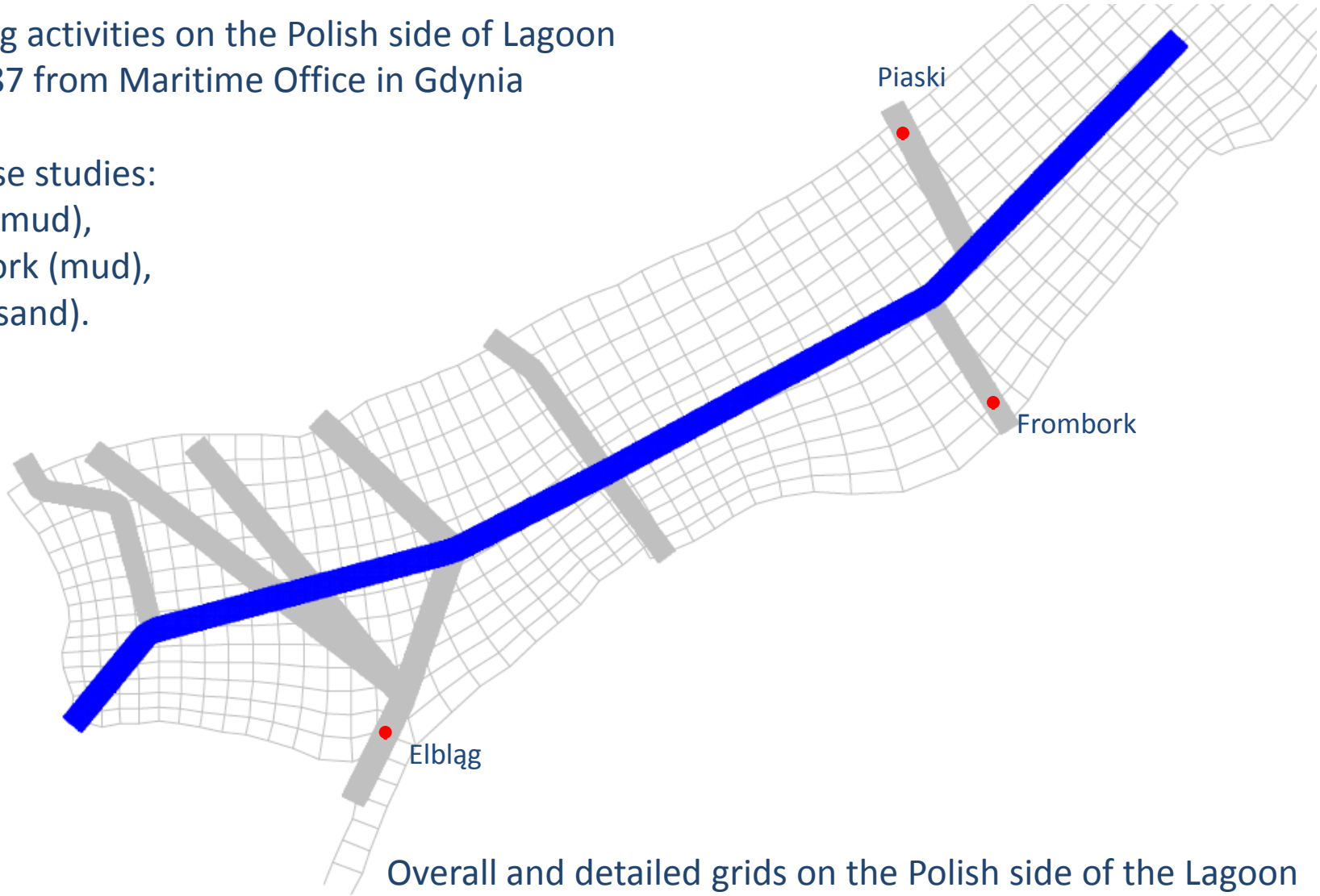
Detailed grid: 20 x 20 m – Polish side of the lagoon



System Formulation – calibration of sed. transport

Dreadging activities on the Polish side of Lagoon since 1987 from Maritime Office in Gdynia

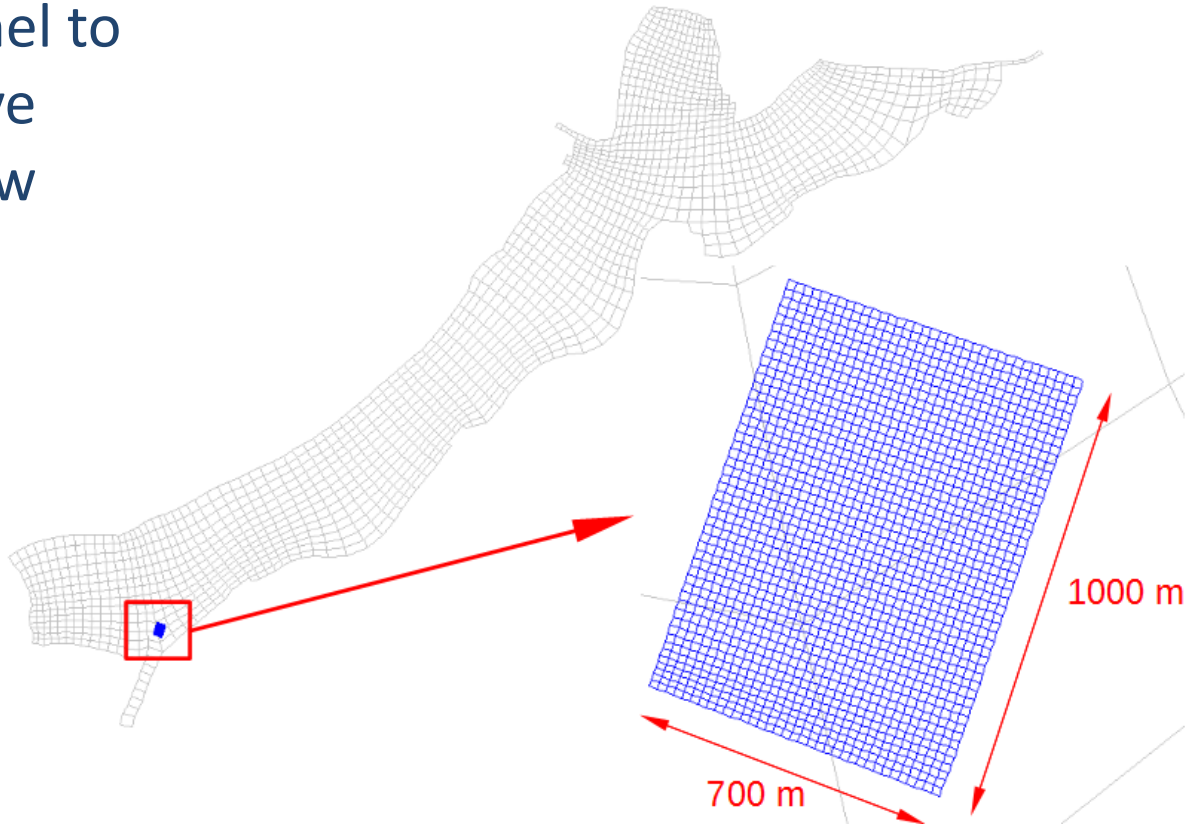
Three case studies:
- Elbląg (mud),
- Frombork (mud),
- Piaski (sand).



Overall and detailed grids on the Polish side of the Lagoon

System Formulation: hydrodynamic modeling – local grids

Calibration area: channel to Elbląg harbor – cohesive sediments with very low angle of repose and residual cohesion.



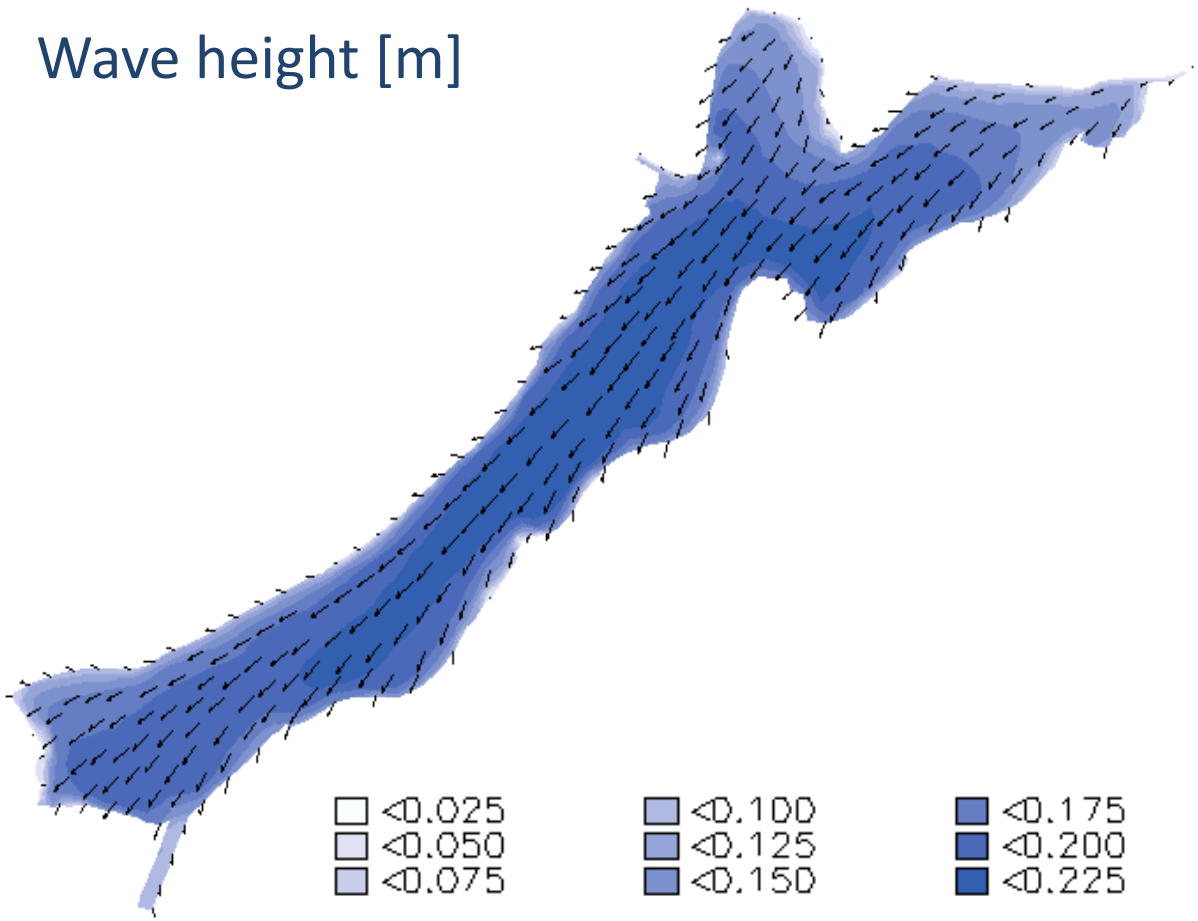
System Formulation – hydrodynamic modeling

External conditions

- rivers,
- water level,
- salinity,
- wind (current and waves).

Hydrodynamic model currents, waves

Wave height [m]



System Formulation – hydrodynamic modeling

External conditions

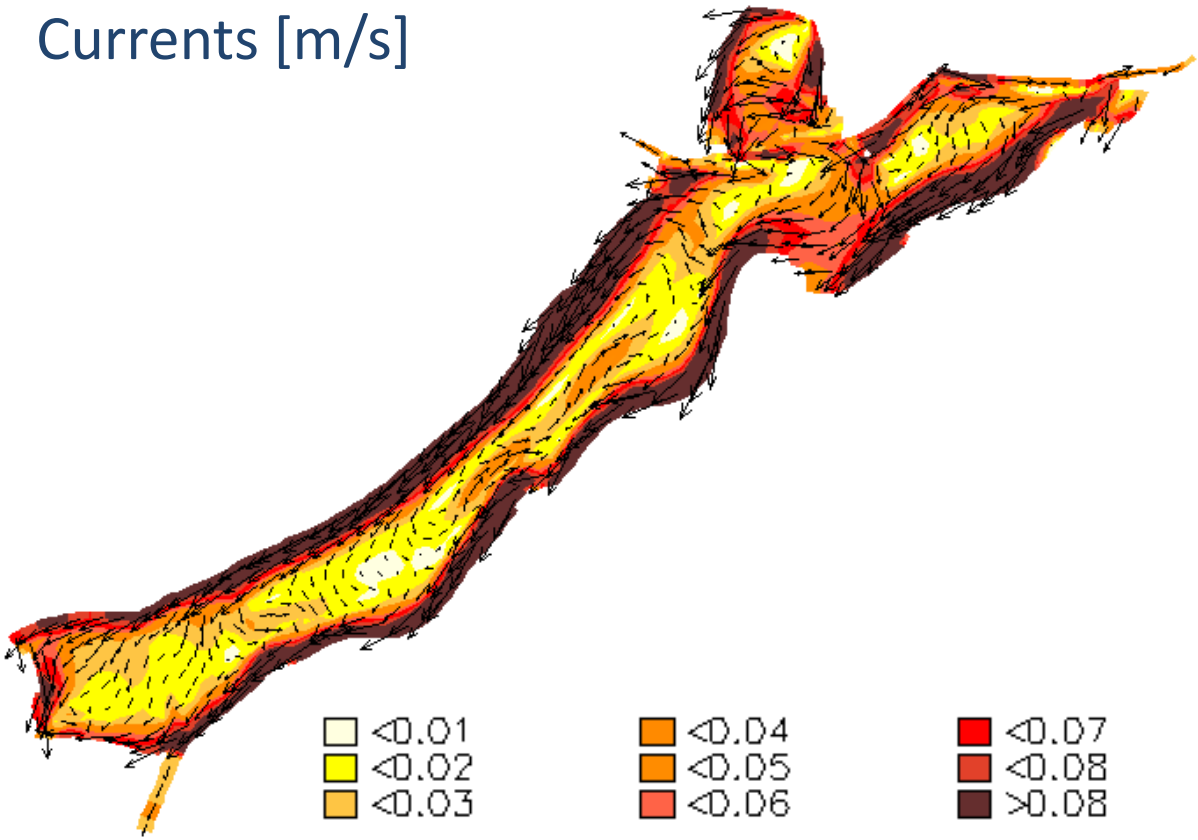
- rivers,
- water level,
- salnity,
- wind (currents and waves).

Hydrodynamic model currents, waves

Sediment transport sand, mud

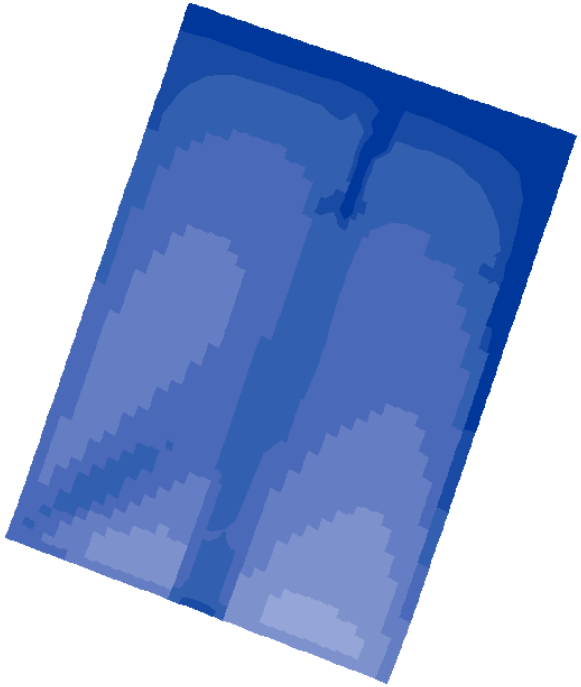
- material parameters,
- calibration.

Currents [m/s]



System Formulation – sediment transport

- Rivers have local effect.
- Salinity gradient generates negligible flows.



- Key factors affecting sediment transport:
  - wind currents,
  - wind waves,
  - water level,
  - water level changes (gradient currents).

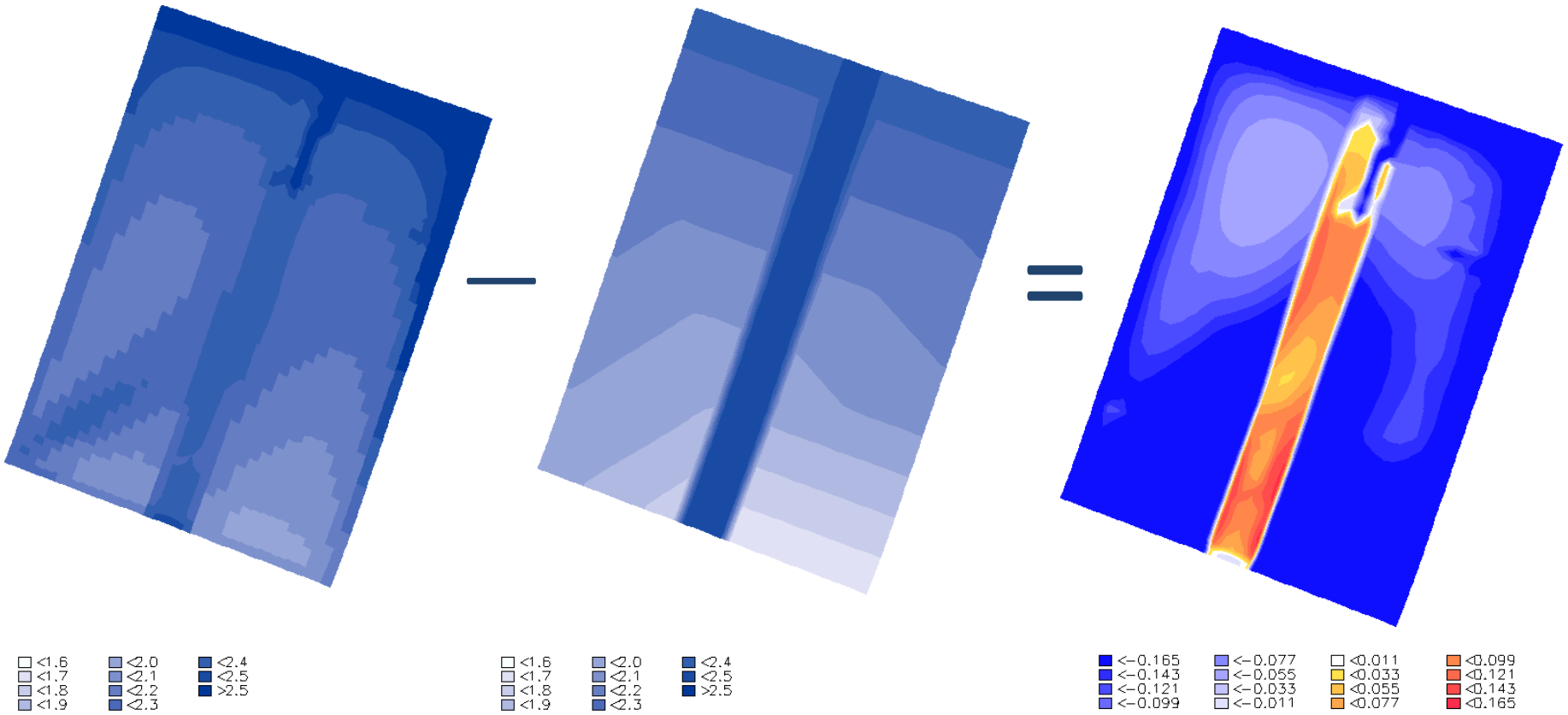
- **1999 year as a representative, statistical year.**

- **Sediment transport model provides information on siltation rates which are converted into sediment volume deposited in the case area**

System Appraisal – calibration results

Example of the siltation results for Elbląg case study made based on the calculated sediment siltation volume and compared to the volume of actually dredged sediment (data from Maritime Office in Gdynia)

Final bathymetry — Initial bathymetry = Differential bathymetry



System Appraisal – calibration results

Background information:

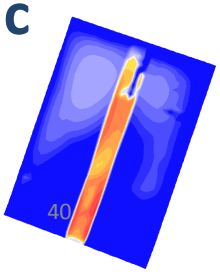
Observed siltation in a 1000 m long segment, channel width 60m and depth 2.4 m:

- 3500 m3/year;
- the resultant siltation layer 3500/1000/60 = **5.8 cm**.

Modeling results of siltation for the same configuration:

- 2250 m3/year;
- the resultant siltation layer: 2250/1000/60 = **3.75 cm.**

Conclusion: 3.75/5.8 = 64% of siltation due to hydrodynamic forces, 36% due to sliding of channel slopes.

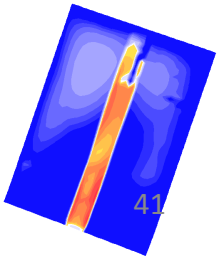


System Appraisal – scenario results

Modeling results for 1000 m long channel segment, 100 m wide and 5 m deep:

- The modeled siltation of **15000 m3/year** corresponds to the layer of 15000/1000/100 = **15 cm**.
- Adding the sliding component yields: 15000/0.64 = **23440 m3/year**, or the siltation layer of 15/0.64 = **23.4 cm**.
- Ratio of both siltations for both situations: 23.4/5.8 = **4**.

Conclusion: deepening of a channel from 2.4 to 5 m in cohesive sediments produces quadrupling of siltation – this will have significant consequences for maintenance costs of new channels.



Discussion

Experiences/recommendations so far:

- Well investigate all initiatives going around linked to the Issue.
- Participate in public consultations organized at the time on related issues.
- Invite all managers involved in the region.
- Invite different groups of stakeholders – representatives of major business, groups, regular people.
- Stakeholder meetings as mean of providing dialog of stakeholders, preliminary conflict solving, cooperation building, data / valuable information provision.

Discussion

- Modelling of cohesive sediment is troublesome and creates lots of uncertainties.
- Scarce monitoring data to calibrate sediment transport and siltation adds to the above.
- Political decisions (cross-cut construction) determine direction of SAF development for the Vistula Lagoon.
- Cross-cut construction exerts profound impacts on the economy of the Vistula Lagoon (large cost of cross-cut vs lower costs of maintenance of the existing and development of new marinas)

Conclusions

- Continuity of research efforts in Vistula Lagoon area over last decades was highlighted,
- Eutrophication of water column and cohesive sediments are key obstacles against 'traditional' beach uses in the lagoon,
- Concentration on water tourism, transport and fishing development was correctly selected as the central issue supported by navigation channels and marinas expansion, and were highlighted in the system design diagram as a way to economic recovery of the lagoon,
- Cohesive sediments are very difficult for the modelling of sediment transport and rates of silting-up of navigation channels; this is the most challenging modeling issue.
- Modeling results suggest that deepening of channels from 2,4 to 5 m results in 4 times greater siltation rates: it will have economic implications for future channel maintenance.

BONUS BaltCoast

Thank you!

A SYSTEM APPROACH FRAMEWORK FOR COASTAL RESEARCH & MANAGEMENT

BONUS-BaltCoast received funding from BONUS (Art 185), funded jointly by the EU and Baltic Sea national funding institutions

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