Science and Policy Integration for COastal System Assessment

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Water quality management in the Oder/Odra estuary (SSA3)

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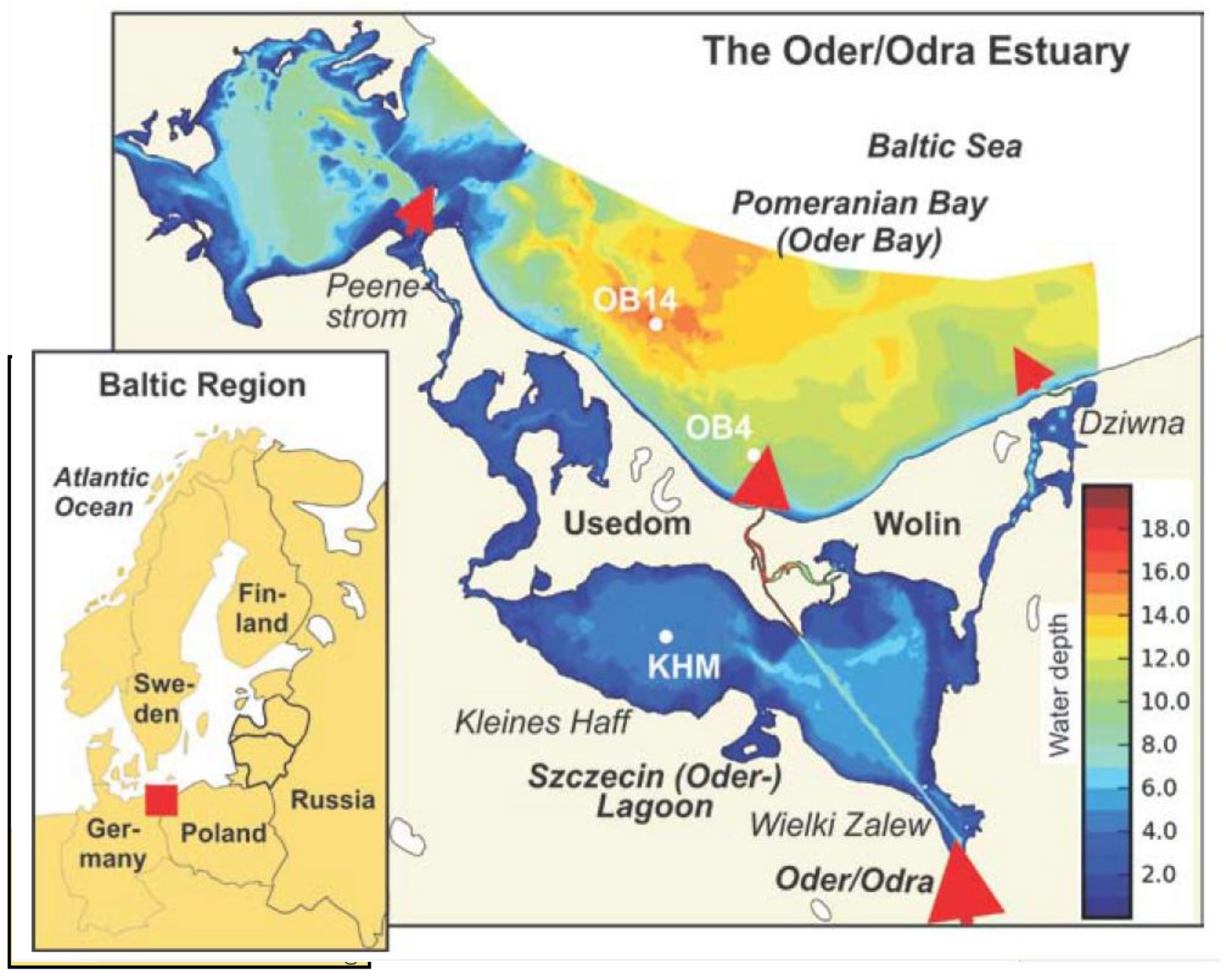

Policy issue:

Water quality improvement

Already for centuries, the river basin is under strong human influence. Agricultural land covers 70% of the upper river basin and 58 % of the middle basin. However the contribution of agriculture to the gross product is only 3.9 %. Several larger cities and many industries are located in the river basin (total population 15.4 millions). The nitrogen (N) and phosphorus (P) loads in the early 1960's were already high (N: 50,000 t/a; P: 6,000 t/a), increased further and reached its maximum during the 1980's (N: 116,000 t/a; P: 16,000 t/a). Due to economic changes, warm and dry years as well as improved sewage treatment a significant decrease of nutrient loads took place until the late 1990's (N: 94,000 t/a; P: 8,500 t/a). The Odra river flows through Szczecin and enters the large, shallow Szczecin (Oder) Lagoon. The river and its loads are responsible for the poor water quality in the lagoon and its highly eutrophic state. Temporary anoxia, fish kills, algae bloom and poor water transparency reflect the poor water quality state.

Major questions:

- How do different stakeholders perceive water quality?
- What are their demands with respect to water quality?
- Would a "good" water quality (according to the Water Framework Directive) satisfy all stakeholders?
- Can a "good" water quality be reached in the entire estuary? If no, what would be the alternatives?
- Which measures in the river basin are necessary?
- Which nutrient sources have to be tackled preferably?
- On which nutrient (nitrogen or phosphorus) should the focus be?
- What are the costs for reaching a good water quality status?
- How would a cost-efficient approach look like?
- Which measures in the estuary would support a water quality improvement and how efficient will they be?
- How long would it take to reach a good status?

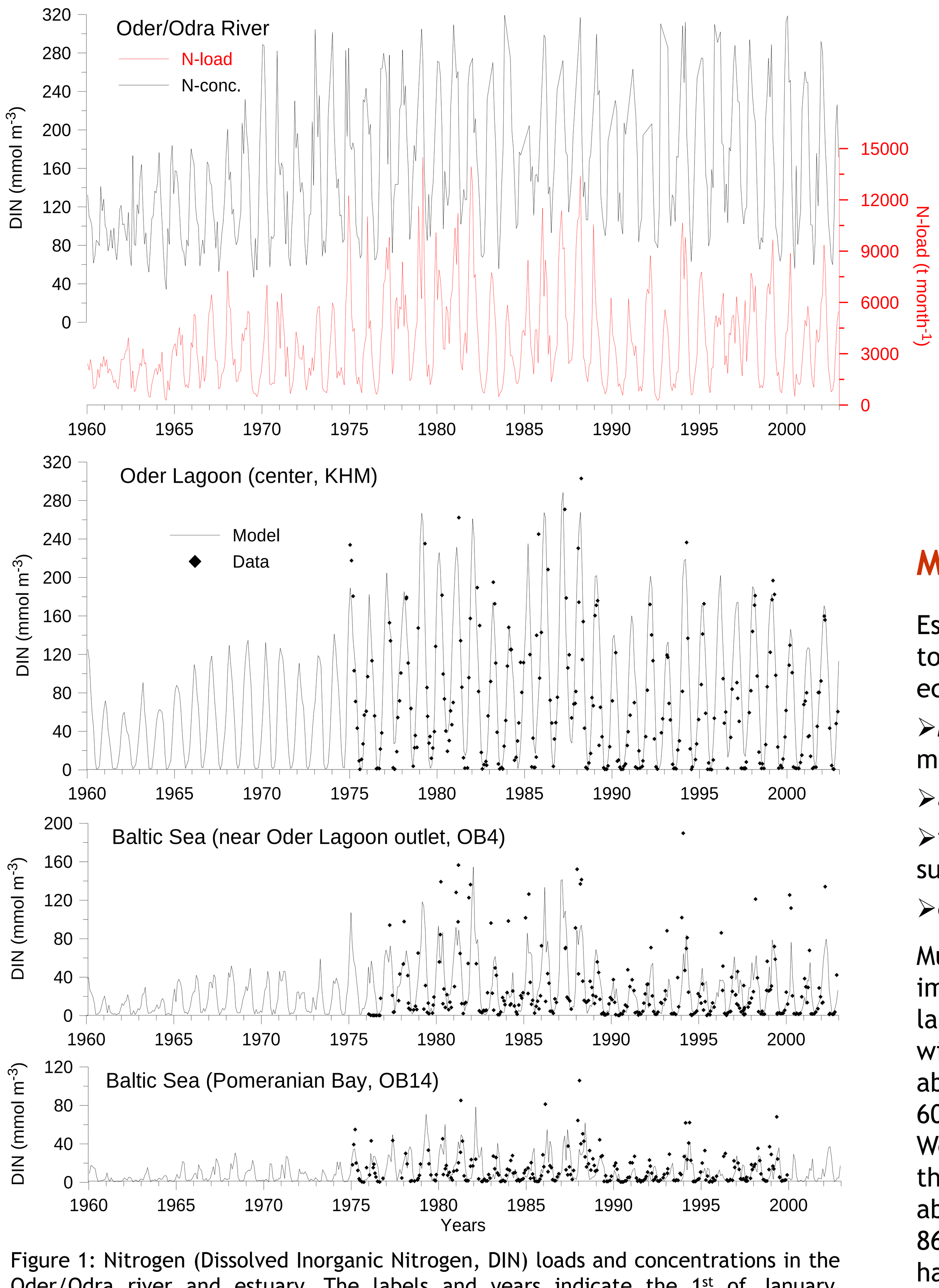

Figure 1: Nitrogen (Dissolved Inorganic Nitrogen, DIN) loads and concentrations in the Oder/Odra river and estuary. The labels and years indicate the 1st of January. Oder/Odra river loads are based on MONERIS model simulations. In the estuary, concentrations simulated with the ERGOM model are aggregated to monthly averages, while the measured data represents single samplings near the water surface (data source: LUNG).

River basin management: Possibilities and limits

Behrendt et al (2005) show that load reduction in the river basin above 35 % for nitrogen and 60 % for phosphorus are not realistic. The P-loads could be reduced from 12,180 t/a to 4,650 t/a. Basis for this calculation is the average load between 1993-1997. This is slightly below the loads of the early 1960's. The nitrogen loads can be reduced to the level of the late 1960's.

Lacking systematic changes in the nutrient limitation and ecosystem behaviour of the estuary between 1960 and 2002 and the suggested very low nutrient concentrations according to the Water Framework Directive clearly indicate that a nutrient load reduction significantly below the level of 1960 is required. The scenarios by Behrendt et al (2005) show, that this will be very difficult. Phosphorus mainly stems from point sources which can efficiently be managed. For nitrogen load reduction diffuse sources have to be tackled. This is much more complicated and during recent years, the diffuse loads did not show a decrease. On the opposite, a slight increase of nitrogen from diffuse sources is observed. The improvements during recent years were fairly easy to reach and at reasonable costs. Further nutrient load reductions face increasing marginal costs and increasing costs might hamper ongoing efforts. Further, Poland's membership in the European Community might cause a growing economy and intensified agriculture. The result could be an increased nitrogen load from diffuse sources, which would counteract load reduction measures. Therefore, it is uncertain whether a reduction of 35 % will be possible for nitrogen. These results call for additional management measures in the coastal waters itself.

Management measures in coastal lagoons

Especially in the Oder lagoon, several measures are possible to combat eutrophication, to remove nutrients and to improve ecosystem quality:

- Mussels farms, managed mussel beds and enlarged natural mussel beds,
- algal farms,
- increased reed belts (supported by pile rows) and extended submersed macrophyte areas and
- dredging of sediment and dumping on land.

Mussel farming might serve as an example to get an impression of the efficiency of these measures in the Oder lagoon. Dreissena polymorpha forms mussel beds in the lagoon with an estimated biomass according to Fenske (2008) of about 8,000 t in the western part (Kleines Haff) and about 60,000 t in the eastern part, the Maly Zalew (Woźniczka & Wolnomiejski 2005). In the Kleines Haff, 6.56 km² (2.4 % of the area) are covered with mussel banks, the average abundance in beds is 4000 mussels per m² (varying between 864 –10444 mussels m^{-2}), and a filtration rate of 1,083 l m^{-2} d^{-1} has been observed (Fenske 2008). Taking a volume of 1.026 km³ (only Kleines Haff), the existing mussel banks need 144 days to filter this water volume. This total filter capacity can be increased by supporting measures.

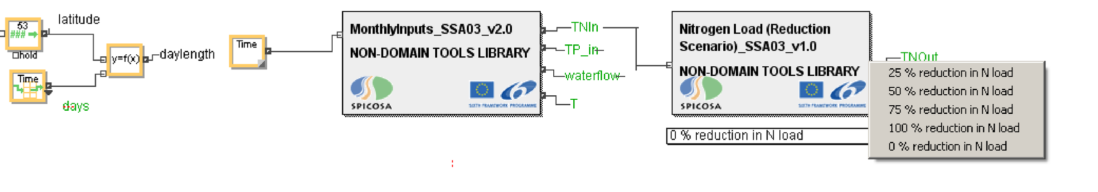

Figure 2a: Monthly inputs of N and P loads into the lagoon are given by the model MONERIS. In the Extend model nitrogen loads can be changed using five reduction options.
single samplings near the water surface (data source: LUNG).

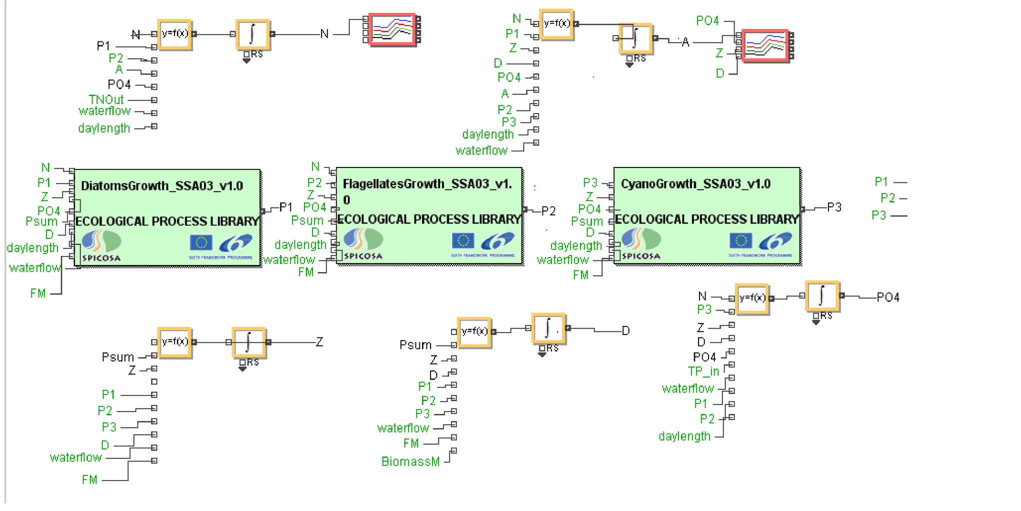

Figure 2b: The main part of the modelled ecosystem of the lagoon is based on the model ERGOM. It includes the dynamics of nutrients, phytoplankton, zooplankton and detritus and is linked with the dynamics of zebra mussels by their filtration activity (change in filtrated material (FM))

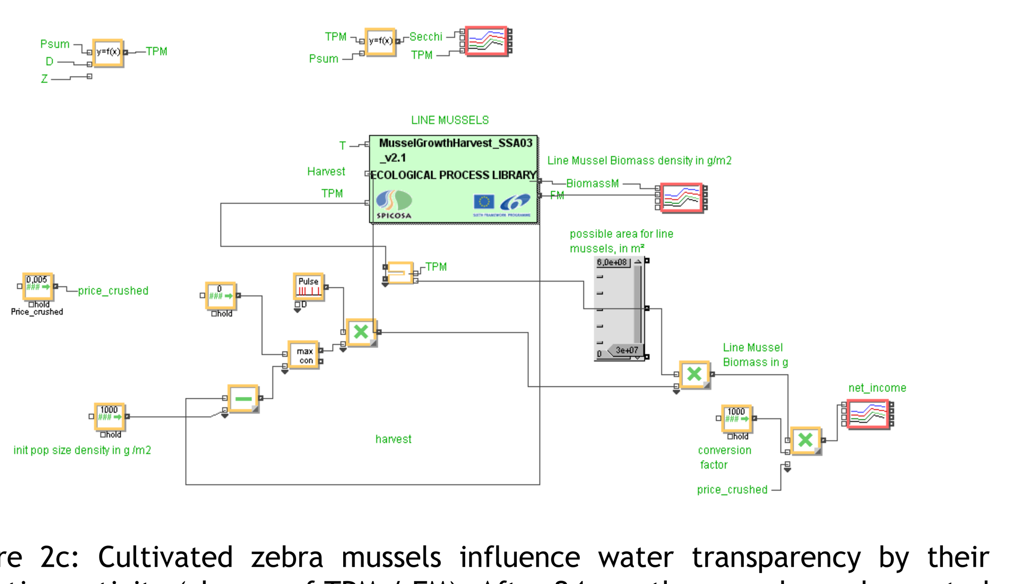

Figure 2c: Cultivated zebra mussels influence water transparency by their filtration activity (change of TPM / FM). After 24 months mussels are harvested and nutrients are removed out of the lagoon.

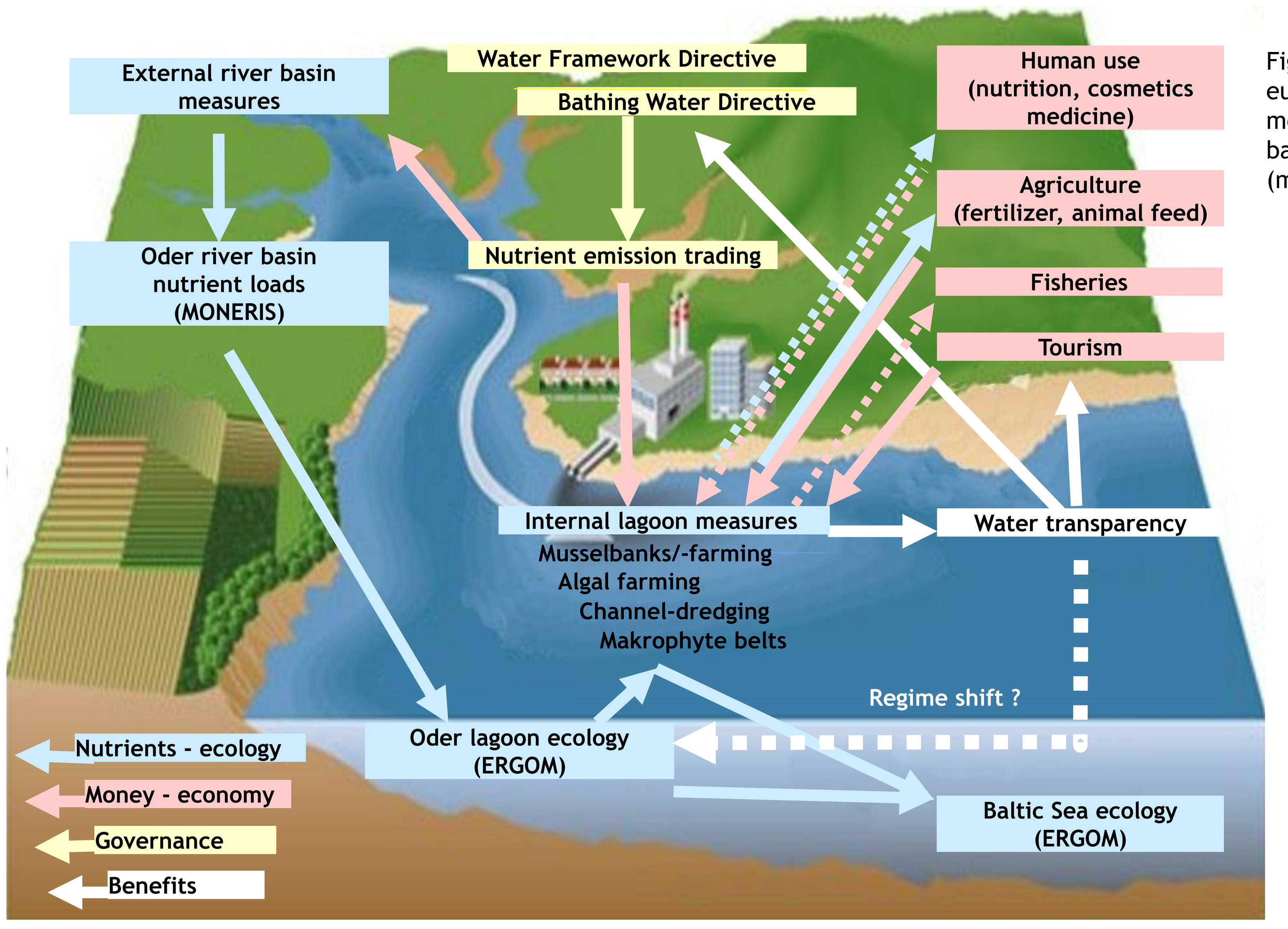

Figure 3: Conceptual model for a comprehensive eutrophication management of the Oder estuary. Internal measures in the lagoon and external measures in the river basin are linked to economic and governance aspects (modified background picture after LOICZ, 2000).

Towards a comprehensive management approach

The Oder/Odra example shows that nutrient management between land and sea requires a comprehensive approach, has to link external and internal management measures and has to follow guiding principles. Firstly, the application of nutrients on terrestrial systems and their loss to the sea has to be minimized. Secondly, nutrient cycles have to be established and/or strengthened. Figure 3 shows an example: Nutrients are used as fertilizer in agriculture and are partly lost to ground and surface waters and end up in the river and finally in the sea. The application of fertilizer and agricultural practice has to be optimized, to reduce the loss. Measures in the river basin can increase the retention of nutrients. Denitrification in wetlands and tile drainage systems is one example. Vegetated strips along watercourses to reduce runoff and sediment input are another example. Measures in coastal waters, like the mentioned mussel or algal farms are another option. With the mussel or algal harvest, the nutrients are removed back to the land and end up as fertilizer in agriculture. The cycle is closed and protects the coastal waters and the sea from eutrophication.

Behrendt H, Dannowski, R (eds) (2005) Nutrients and heavy metals in the Odra river system, Weißensee Verlag Berlin

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