Norwegian Financial Mechanism and Republic of Lithuania

Coastal Research and Planning Institute, Klaipėda University

Project: A system for the sustainable management of Lithuanian marine resources using novel surveillance, modelling tools and ecosystem approach

# Technical Report No. 9

# **Marine fishery resources model**

Project indicators:
1. Documented model for forecasting marine resources based on data for water quality, fish biomass, diet, physiology and prey biomass
2. Model based forecast of fish stocks and scenario assessment

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## SPECIFIC TERMS

**EWE** – ECOPATH with ECOSIM

**EE** - Ecological Efficiency

**Multi-stanza -** groups representing life history stages or stanzas for species that have complex trophic ontogeny

**NPZD model** - advanced biogeochemical model including nutrients, phytoplankton , zooplankton and detritus

**VBGF -** Von Bertalanffy Growth Function

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# INTRODUCTION

Fishery resources in the Lithuanian coastal zone (including the Curonian lagoon) has been investigated for decades providing the list of species and relative abundance estimates based on the gill net and trawling estimates. However, the exact population dynamics and growth parameters even of the dominant species are not so well known. Fisheries scientists and managers increasingly feel that proper management involves understanding the ecosystems in which fisheries operate. This concept is recognized in Baltic Sea fisheries, particularly with respect to food web. For example, cod prey on both sprat and herring, which in turn may feed on cod eggs and larvae (Köster and Möllmann, 2000). Intensive fishing thus occurs amid an array of complex species interactions. Understanding the effects of a fishery in the context of such interactions is key to responsible management of aquatic ecosystems.

Much of our understanding of how fisheries and food webs interact in the Baltic Sea comes from multispecies virtual population analysis (MSVPA) (Gislason, 1999; Collie and Gislason, 2001; Köster et al., 2001a, b). MSVPA is an age-structured model that estimates historic population sizes, fishing mortalities, and predation mortalities of several exploited, interacting fish stocks (Sparre, 1991). MSVPA links species to one another via predation, and thus explicitly accounts for variation in predation mortality, which single-species VPA assumes to be constant. Species that are in the food web but not targeted by fisheries are not explicitly incorporated into the analysis, but rather are pooled as ‘‘other food’’ if they are prey or as ‘‘other natural mortality’’ if they are predators. Thus, MSVPA focuses on how fishing affects targeted species, in the context of those species' direct predator–prey interactions. A different approach that simulates a wider range of species and ecosystem processes is ECOPATH with ECOSIM

(EwE; Christensen et al., 2000; Walters et al., 2000). Ecopath models represent a mass-balanced budget of production, consumption, and fishing in a food web, and may include all functional groups, including primary producers and consumers not targeted by fisheries. ECOPATH estimates are used to initialize ECOSIM, a model that simulates the dynamics of each biomass pool based on specified predator–prey relationships, recruitment processes, fishing, and physical forcing. Using ECOSIM, one can examine how a food web might respond to a perturbation, such as a change in fishing pressure or changes in the aquatic environment. Because EwE integrates predator–prey interactions, fisheries, and habitat effects across a broader range of functional groups, it can address questions that MSVPA cannot, including the importance of dynamic feedbacks between lower and upper trophic levels, the importance of bottom-up controls, and specific impacts of fishing on nontarget species such as marine mammals.

The Baltic Sea is a brackish water body which is connected with a freshwater Curonian Lagoon via Klaipėda strait. Due to periodical inflows of brackish water to the Curonian Lagoon, water salinity occasionally increases up to 6‰ in the Northern part of the Lagoon. More and more frequent influxes of the Sea water are observed in the Curonian Lagoon during the last two decades. The phenomenon is caused by: the increased water level in the Baltic Sea as in the rest of the world oceans, the reduced runoff of Nemunas River, intensified and lengthened periods of storms of Western direction during which the brackish water from the Baltic Sea is driven into the Lagoon and for the period of time overcome the pressure of freshwater opposite flow.

The decline in commercial fishermen' catches is observed in the areas of the Sea water inflow. According to Bukantis et al. (2007) the intensification of brackish water flow to the Lagoon is very harmful for the freshwater ecosystem: the plant and animal species adapted to the freshwater could be replaced by brackish water species. Bukantis et al. (2007) state that the negative impact is obvious and attribute to the declined catches in fishery, which is caused by escapement of fresh water fish species from the areas affected by the water from the Baltic Sea. However, authors do not provide any research based data to prove that the reduced fish catches are caused by the effect of water salinity. However, other factors related to water influx from the Baltic Sea as well as possible effect overfishing are not taken into account, despite overfishing is known as the most common and the main factor leading to the decline of catches in fishery in various regions of the World. Therefore, it is important and relevant task to assess the impact of periodical inflows of the water from the Baltic Sea on the freshwater fish species in the Curonian Lagoon based on scientific studies.

In order to provide a reliable, scientifically significant data on how the Baltic Sea water could affect freshwater fish in the Curonian Lagoon, series of the laboratory behavioural and growth experiments were performed. Perch (*Perca fluviatilis*) and roach (*Rutilus rutilus*) were used for the experiments as a model freshwater fish species.

# MATERIALS AND METHODS

## Experimental fish growth study

To assess the differences in growth of the Curonian lagoon fish species, which are known to migrate to the coastal zone of the Baltic for shorter or longer periods of time a set of laboratory experiments was conducted. Experiment were conducted with perch (*Perca fluviatilis*) specimens originated from two different sources (Curonian lagoon and non-connected freshwater ponds) and the roach (*Rutilus rutilus*) from the Curonian lagoon. All experiments have similar design. 10 randomly selected specimens were placed in each of the 15 experimental tanks, making 3 (3x5) independent experiments with 0‰, 3‰ and 6‰ salinities. All specimens were adapted for 7 days. The unrefined sodium chloride (NaCl) salt was used to reach the salinity. The water circulated in each batch of 5 experimental tanks was independently aerated and filtered. The temperature during the experiment was kept in the range of 15 to 19 °C. All the fish in each of experimental tanks were individually tagged and weighted at 0.1g accuracy. Each of the experiments lasted for 30 days.

## ECOPATH/ECOSIM model

For the model assessment of fish species and ecosystem dynamics the ECOPATH/ECOSIM software (version 6.1.1) was applied (Christensen et. al., 2005). The description of the ECOPATH/MODEL and its equations is widely available (Polovina & Ow, M., 1983; Christensen et. al., 2000; Christensen et. al., 2005) and, therefore is not presented here.

For the construction and linkage of fishery model 3 areas were primarily selected.

The whole Curonian lagoon - the whole area as there was impossible to model separate parts of the due to the unavailability of the spatially distributed reliable data on fish populations. The Lithuanian coastal zone was initially divided into two zones: the Northern and the Southern (Fig. 1). However, after consideration, both models were rather merged addressing the existing spatial heterogeneity as a proportion of different biotopes.
For the Curonian lagoon the following commercial and important fish species were included:

- Bream *(Abramis brama*), multi-stanza
- Pikeperch (*Sander lucioperca*), multi-stanza
- Perch (*Perca fluviatilis*), multi-stanza
- Ruffe (*Acerina cernua*), multi-stanza
- Roach (*Rutilus rutilus*), multi-stanza
- Silver bream (*Blicca bjorkna*), multi-stanza
- Vimba (*Vimba vimba*)
- Stickling (*Gasterosteus aculeatus*)

Initially it was planned to use the multi-stanza model for the Lithuanian part of the Baltic Sea. However, due to lack of data, that approach was dropped and the model was focused on the traditional data structure depicting only fish species spawning directly in the area of interest.

In the coastal part of the Baltic the following groups were included:

- Bream (*Abramis brama*) multi-stanza
- Pikeperch (*Sander lucioperca*) multi-stanza
- Perch (*Perca fluviatilis*) multi-stanza
- Vimba (*Vimba vimba*) multi-stanza
- Flatfish (*Platychthis flessus*) multi-stanza
- Smelt (*Osmerus eperlanus*) multi-stanza
- Lesser sandeel (*Ammodytes tobianus*) multi-stanza.

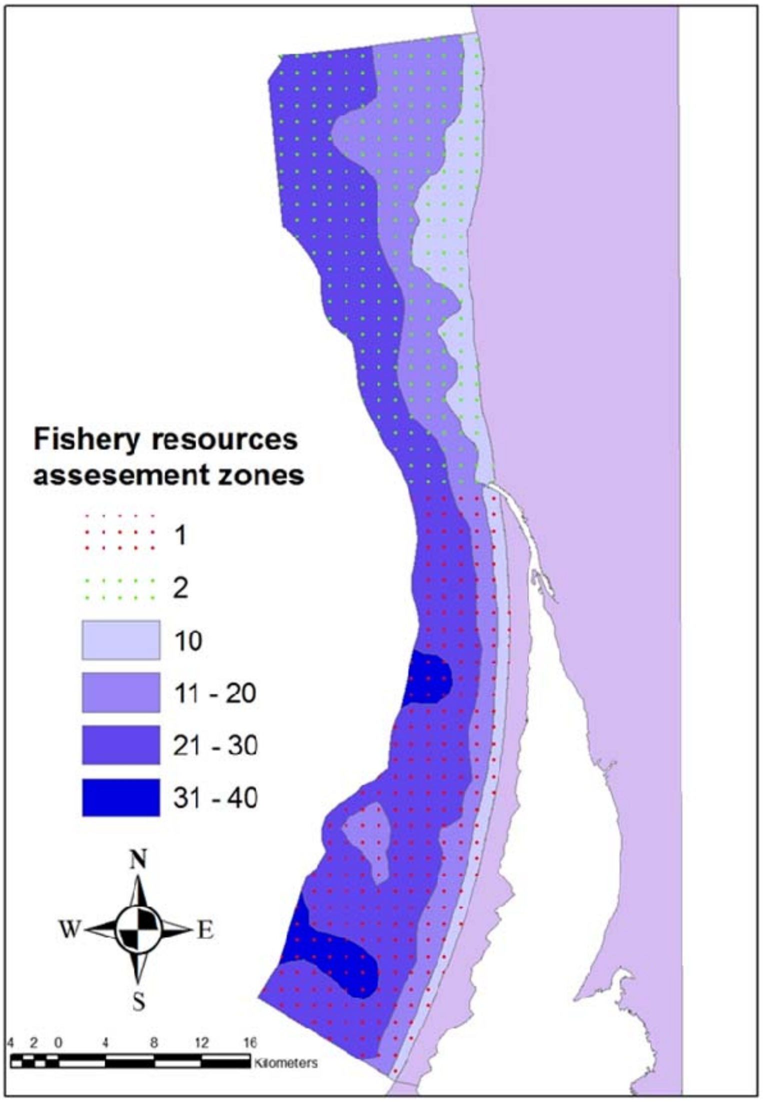


Fig. 1. Fishery assessment zones for the ECOPATH model and the bathymetry scheme.

Parameterisation data for the Curonian lagoon were mostly compiled from already existing sources (Razinkovas & Zemlys, 2000; Jankauskienė, 2001; Gasiūnaitė & Razinkovas, 2004; Pilkaitytė & Razinkovas, 2006; Pilkaitytė & Razinkovas, 2007) while data for Lithuanian coastal zone was compiled from the original trophology analysis and trawling data (Bacevičius et al., unpublished).

**Nutrient reduction scenarios**

To assess the potential effects of changes in nutrient loading reduction toward the food web of the Curonian lagoon NPZD model was applied (Razinkovas et al. 2008). Since NPZD model predicted different Chlophyll a concentrations we decided to use in the ECOPATH model values derived from the scenarios resulting in three different Chlorophyll a values. Scenario S1 (N10) suggesting increase of Chlorophyll a as a result of 90% Nitrogen load reduction of, Scenario S2(P75) as intermediate Chlrophylla a decrease as a decrease of phosphorus loads by 25 % and an extreme scenario S3(P10) suggesting 90% reduction of total phosphorus load (Fig. 8). The chlorophyll a concentration was recalculated into the algae biomass, which further were used as a input parameters for the ECOPATH models.

## RESULTS

**Fish growth at different salinities**

The results of the laboratory experiments demonstrate that the salinities of 3‰ and 6 ‰ does not affect the growth of perch and roach. Therefore, the brackish water inflows from the Baltic Sea should not have any influence on juvenile or adult freshwater fish in the Curonian lagoon even during the long-term periods.

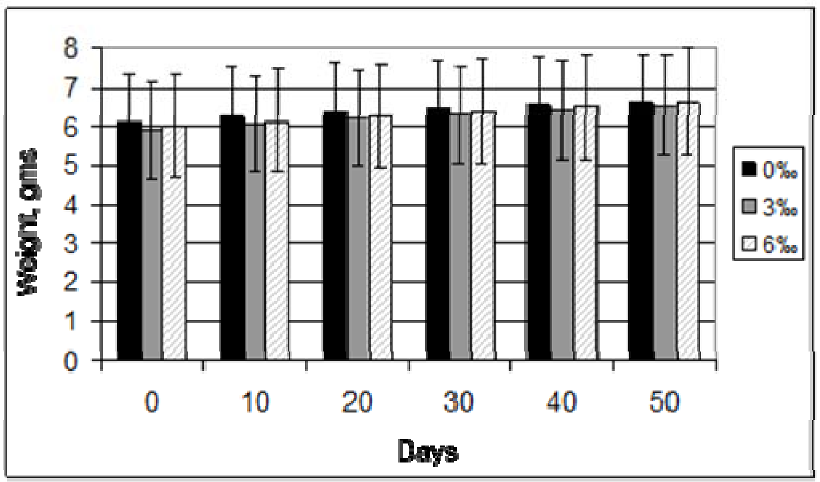


Fig. 2. Roach growth at different salinities

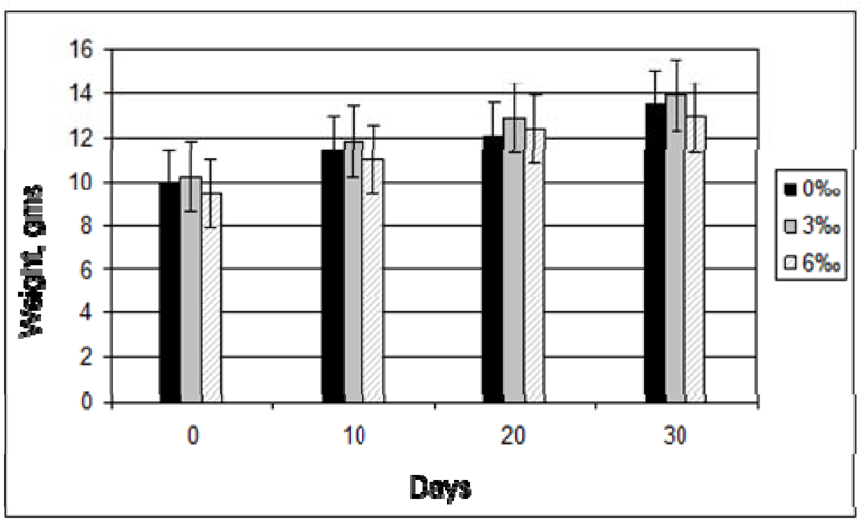


Fig. 3. Perch growth at different salinities.

Moreover, it was observed some improvement in growth under 3 ‰ and 6 ‰ treatments and identical feeding conditions. However, the improvement was statistically insignificant ($p>0.05$). This observation does not support the hypothesis that freshwater fish growth could improve in water of low salinity, which is close to the internal osmotic pressure of

fish plasma and makes the osmoregulation less energy demanding and the surplus of energy might be used for the growth.
The positive effect of water salinity on the growth of perch was observed if in the water concentration of the NO2-, NO3- and NH4+ ions increases. The improvement of perch growth under the both 3‰ and 6‰ salinity treatments was statistically significant compare to the growth in freshwater ($p<0,05$). This observation suggests that brackish water has positive effect on the species under conditions of deteriorating conditions of water environment and blocks toxic effect of the ammonia compounds.

**ECOPATH modelling results**

To assess population characteristics of the modelled fish species the monitoring data were analysed.

Table 1. Characteristics of the modelled fish species

| Group | Biomass of the last cohort, tons (as of 2007) | Mortality 0+ cohort | Mortality last cohort | Mortality intermediate cohorts | Fishery mortality |
|---|---|---|---|---|---|
| Bream | 30.535 | 0.5 | 1 | 0,2 | 0,5 |
| Pikeperch | 49.089 | 0,5 | 1 | 0,28 | 0,6 |
| Perch | 4.628 | 0,5 | 1 | 0,25 | 0,5 |
| Ruffe | 20.869 | 0,5 | 1 | 0,4 | - |
| Roach | 2.524 | 0,5 | 1 | 0,28 | 0,4 |
| Silver bream | 123.038 | 0,5 | 1 | 0,3 | - |

Landings (including ones from the Russian part of the lagoon) were recalculated from data presented by Švagždys (Švagždys, 2010).

Multi-stanza ECOPATH model consisting of 32 compartments was parameterized using manual calibration method while keeping intact the parameters defined as highly reliable in the pedigree (Fig. 4). Out of these 32 compartments 5 commercial fish species were represented as multi-stanza groups.

| | Group name | Trophic level | Habitat area (fraction) | Biomass in habitat area (g/m²) | Biomass (g/m²) | Z (/year) | Production / biomass (/year) | Consumption / biomass (/year) | Ecotrophic efficiency | Production / consumption |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grey heron | 4,335 | 1,000 | 0,000858 | 0,000858 | | 0,300 | 30,94 | 0,000 | 0,010 |
| 2 | Larus | 4,335 | 1,000 | 0,0159 | 0,0159 | | 0,300 | 12,38 | 0,000 | 0,024 |
| 3 | Goosander | 4,335 | 1,000 | 0,00181 | 0,00181 | | 0,300 | 45,35 | 0,000 | 0,007 |
| 4 | Great Crested Grebe | 4,335 | 1,000 | 0,00115 | 0,00115 | | 0,300 | 56,88 | 0,000 | 0,005 |
| 5 | Cormorants | 4,335 | 1,000 | 0,0137 | 0,0137 | | 0,300 | 15,84 | 0,000 | 0,019 |
| + | Pikeperch | | | | | | | | | |
| 6 | Pikeperch adults | 4,349 | 1,000 | 0,0620 | 0,0620 | 0,500 | | 2,500 | 0,908 | 0,200 |
| 7 | Pikeperch juvenile | 3,662 | 1,000 | 0,0947 | 0,0947 | 2,000 | | 5,105 | 0,748 | 0,392 |
| 8 | Pikerpech YOY | 3,384 | 1,000 | 0,0371 | 0,0371 | 3,000 | | 12,27 | 0,085 | 0,244 |
| + | Perch | | | | | | | | | |
| 9 | Perch adults | 4,126 | 1,000 | 0,356 | 0,356 | 0,500 | | 2,500 | 0,585 | 0,200 |
| 10 | Perch juveniles | 3,575 | 1,000 | 0,206 | 0,206 | 1,000 | | 4,297 | 0,688 | 0,233 |
| 11 | Perch YOY | 3,631 | 1,000 | 0,0265 | 0,0265 | 2,000 | | 10,51 | 0,194 | 0,190 |
| + | Ruff | | | | | | | | | |
| 12 | Ruff adults | 3,187 | 1,000 | 0,602 | 0,602 | 0,500 | | 2,710 | 0,877 | 0,185 |
| 13 | Ruff juveniles | 3,361 | 1,000 | 0,113 | 0,113 | 1,000 | | 5,647 | 0,016 | 0,177 |
| + | Bream | | | | | | | | | |
| 14 | Bream adults | 3,579 | 1,000 | 0,197 | 0,197 | 1,000 | | 2,000 | 0,652 | 0,500 |
| 15 | Bream juveniles | 2,769 | 1,000 | 0,114 | 0,114 | 2,000 | | 3,605 | 0,873 | 0,555 |
| 16 | Bream YOY | 2,779 | 1,000 | 0,0657 | 0,0657 | 3,000 | | 7,756 | 0,268 | 0,387 |
| + | Roach | | | | | | | | | |
| 17 | Roach adults | 2,952 | 1,000 | 0,782 | 0,782 | 0,900 | | 3,000 | 0,420 | 0,300 |
| 18 | Roach juveniles | 2,955 | 1,000 | 0,328 | 0,328 | 1,500 | | 5,184 | 0,017 | 0,289 |
| 19 | Roach YOY | 2,889 | 1,000 | 0,135 | 0,135 | 2,500 | | 10,81 | 0,143 | 0,231 |
| 20 | Other demersal fish | 3,388 | 1,000 | 0,200 | 0,200 | | 0,700 | 3,000 | 0,146 | 0,233 |
| 21 | Planktivorous fish | 3,528 | 1,000 | 0,0140 | 0,0140 | | 0,900 | 10,13 | 9,341 | 0,089 |
| 22 | Oligochets | 3,169 | 1,000 | 0,496 | 0,496 | | 8,000 | 15,40 | 0,900 | 0,519 |
| 23 | Meiobenthos | 2,375 | 1,000 | 1,081 | 1,081 | | 18,90 | 44,42 | 0,950 | 0,425 |
| 24 | Chironomids | 2,354 | 1,000 | 0,533 | 0,533 | | 10,80 | 59,40 | 0,576 | 0,182 |
| 25 | Mysids | 2,347 | 1,000 | 0,0678 | 0,0678 | | 8,000 | 14,50 | 0,929 | 0,552 |
| 26 | Filtrators bivalves | 2,150 | 0,240 | 10,44 | 2,506 | | 0,270 | 10,000 | 0,671 | 0,027 |
| 27 | Deposit feeders gastro | 2,000 | 1,000 | 0,153 | 0,153 | | 8,640 | 40,50 | 0,509 | 0,213 |
| 28 | Carnivorous zooplankt | 2,956 | 1,000 | 0,0800 | 0,0800 | | 37,80 | 237,6 | 0,916 | 0,159 |
| 29 | Grazing zooplankton | 2,100 | 1,000 | 0,370 | 0,370 | | 37,80 | 237,6 | 0,893 | 0,159 |
| 30 | Fitoplankton | 1,000 | 1,000 | 1,270 | 1,270 | | 196,4 | | 0,444 | |
| 31 | Bacteria | 2,000 | 1,000 | 0,110 | 0,110 | | 189,0 | 247,6 | 0,931 | 0,763 |
| 32 | Detritus | 1,000 | 1,000 | 35,20 | 35,20 | | | | 0,432 | |

Fig.4. Basic estimates for Curonian lagoon ECOPATH model

As it could be seen only the planktivorous fish group has not been balanced since it was mostly the migratory smelt (*Osmerus eperlanus*), which expected to be mostly imported due to the winter migrations. However, this species needed to be included in the calculations as very important in the total catches

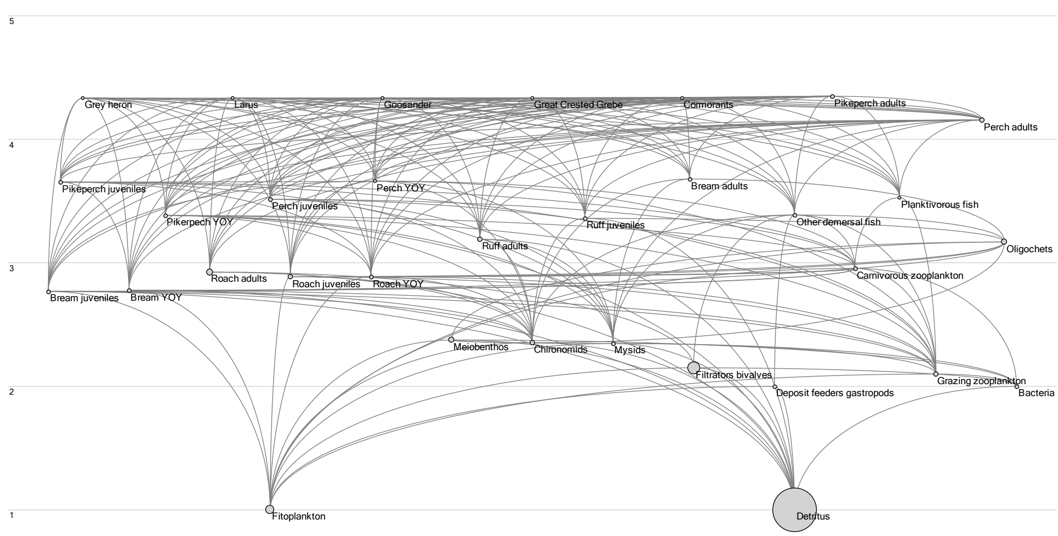


Fig.5 Trophic structure of the Curonian lagoon ECOPATH model

## ECOSIM linkage to NPZD model at the data level

Initial linkage of ECOPATH to NPZD model was performed using ALUKAS and the trophic network model used in this study for the Curonian lagoon contains 23 groups; 3 of them (The so called "greens", Diatoms and Cyanobacteria) being producers, 17 of them being consumers (bacteria, grazing zooplankton, carnivorous zooplankton, planktivorous fish, deposit feeder gastropods, chironomids, oligochets, filtrators bivalves, meiobenthos, mysids, demersal fish, predatory fish, grey heron, seagull, goosander, great crested grebe, cormorants) and the last 3 (POC, DOC and Detritus) being detritus. POC (particulate organic carbon) and DOC (dissolved organic carbon) groups represent the pelagic detritus (Ecopath does not differentiate between dissolved organic carbon and particulate detritus), while the group Detritus represents the benthic detritus. Initially no multi stanza groups were included. At that state ESTAS/ALUKAS was a dynamic model with 22 state variables, which include nutrients, detritus and plankton groups. ALUKAS state variables related to plankton groups (three phytoplankton groups and one zooplankton) are directly interfaced with Curonian Lagoon trophic network model. Curonian Lagoon trophic network model includes two groups for pelagic detritus compartment, the dissolved organic carbon (DOC) and the particulate organic carbon (POC), whereas ALUKAS contains 12 state variables, 6 of them for dissolved organic carbon and 6 more for particulate detritus carbon. Therefore; the sum of external labile dissolved organic carbon, external refractory dissolved organic carbon, so called "greens" based dissolved organic carbon, diatoms based dissolved organic carbon, cyanobacteria based dissolved organic carbon and zooplankton based dissolved organic carbon was defined as dissolved organic carbon, whereas the sum of external labile particulate detritus carbon, external refractory

particulate detritus carbon, so called "greens" based particulate detritus carbon, diatoms based particulate detritus carbon, cyanobacteria based particulate detritus carbon and zooplankton based particulate detritus carbon was defined as particulate organic carbon. The linkage between ESTAS/ALUKAS and Curonian Lagoon trophic network model is illustrated in Fig XX.

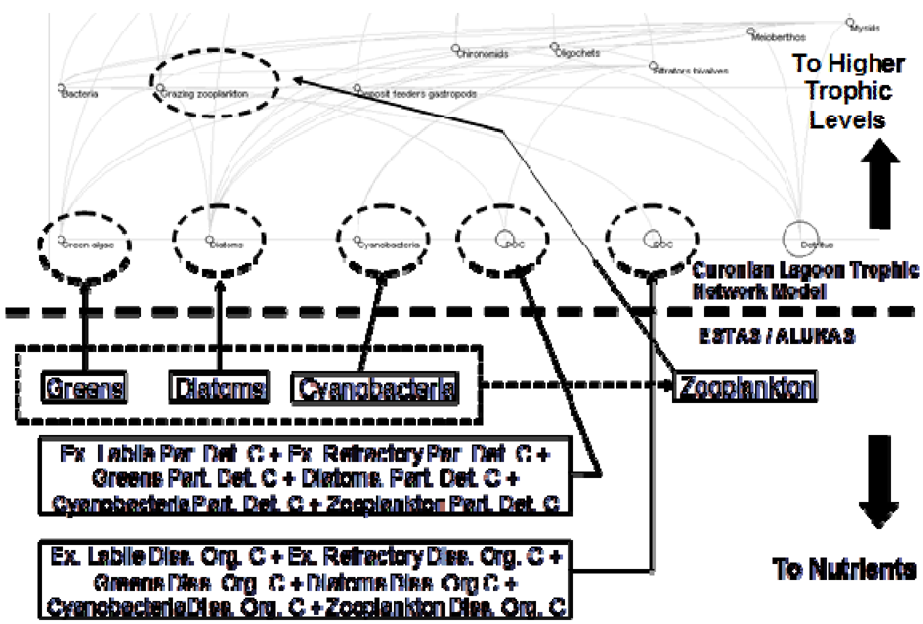


Fig. 6. Linkage between the NPZD model and ECOPATH/ECOSIM at the data level.

At the second stage ECOSIM Detritus represents the benthic detritus. Initially no multi stanza groups were included. At that state ESTAS/ALUKAS was a dynamic model with 22 state variables, which include nutrients, detritus and plankton groups.

**ECOSIM linkage to NPZD model at the code level**

For the further integration and possibility to link NPZD model to the ECOSIM directly a module ECOSIM in FORTRAN 90 was programmed following the conventions imposed of the present development framework the NPZD model. Direct integration and mass balance conservation procedures were implied. So far the ECOSIM model within NPZD model consists of two submodules one dedicated to the calculation of dynamic ECOSIM parameters , while other dealing with data structures and initialisation procedures (Fig. 4)

**Nutrient reduction scenarios**

To analyse the impact of the variation in nutrient loads on the Curonian lagoon ecosystem and food web several nutrient reduction scenarios were developed. All simulations were based on the year 1999, 2000. The year 2000 was much drier comparing to 1999, so two years with different climatic conditions were covered in these simulations. All considered scenarios are given in Table 2.

Table 2. Scenarios of decrease of nitrogen and phosphorus discharge from river Nemunas.

| Scenario | Total nitrogen discharge (t/year) | Total phosphorus discharge (t/year) | Relative amount of nitrogen and phosphorus in comparison with average of years1999-2000 |
|---|---|---|---|
| N10 | 5388.53 | 1938.07 | 10% nitrogen 100 % phosphorus |
| N20 | 10777.07 | 1938.07 | 20% nitrogen 100 % phosphorus |
| N50 | 26942.67 | 1938.07 | 50% nitrogen 100 % phosphorus |
| P1 | 53885.33 | 19.38 | 100% nitrogen 1 % phosphorus |
| P5 | 53885.33 | 96.90 | 100% nitrogen 5 % phosphorus |
| P10 | 53885.33 | 193.81 | 100% nitrogen 10 % phosphorus |
| P15 | 53885.33 | 290.71 | 100% nitrogen 15 % phosphorus |
| P50 | 53885.33 | 969.04 | 100% nitrogen 50 % phosphorus |
| P75 | 53885.33 | 1453.55 | 100% nitrogen 75 % phosphorus |
| P100N100 | 53885.33 | 1938.07 | Average from years 1999-2000 |
| P50N50 | 26942.67 | 969.04 | 50% nitrogen 50 % phosphorus |
| P40N40 | 21554.13 | 775.23 | 40% nitrogen 40 % phosphorus |
| P30N30 | 16165.60 | 581.42 | 30% nitrogen 30 % phosphorus |
| P20N20 | 10777.07 | 387.61 | 20% nitrogen 20 % phosphorus |
| P1N1 | 538.85 | 19.38 | 1% nitrogen 1 % phosphorus |
| P50N10 | 5388.53 | 969.04 | 10% nitrogen 10 % phosphorus |
| P50N100 | 53885.33 | 969.04 | 50% nitrogen 100 % phosphorus |
| P5N20 | 10777.07 | 96.90 | 5% nitrogen 20 % phosphorus |

The obtained concentrations of total nitrogen, phosphorus and chlorophyll a for two summers were compared to each other and to threshold concentrations good/average quality (Fig. 7, 8, 9).

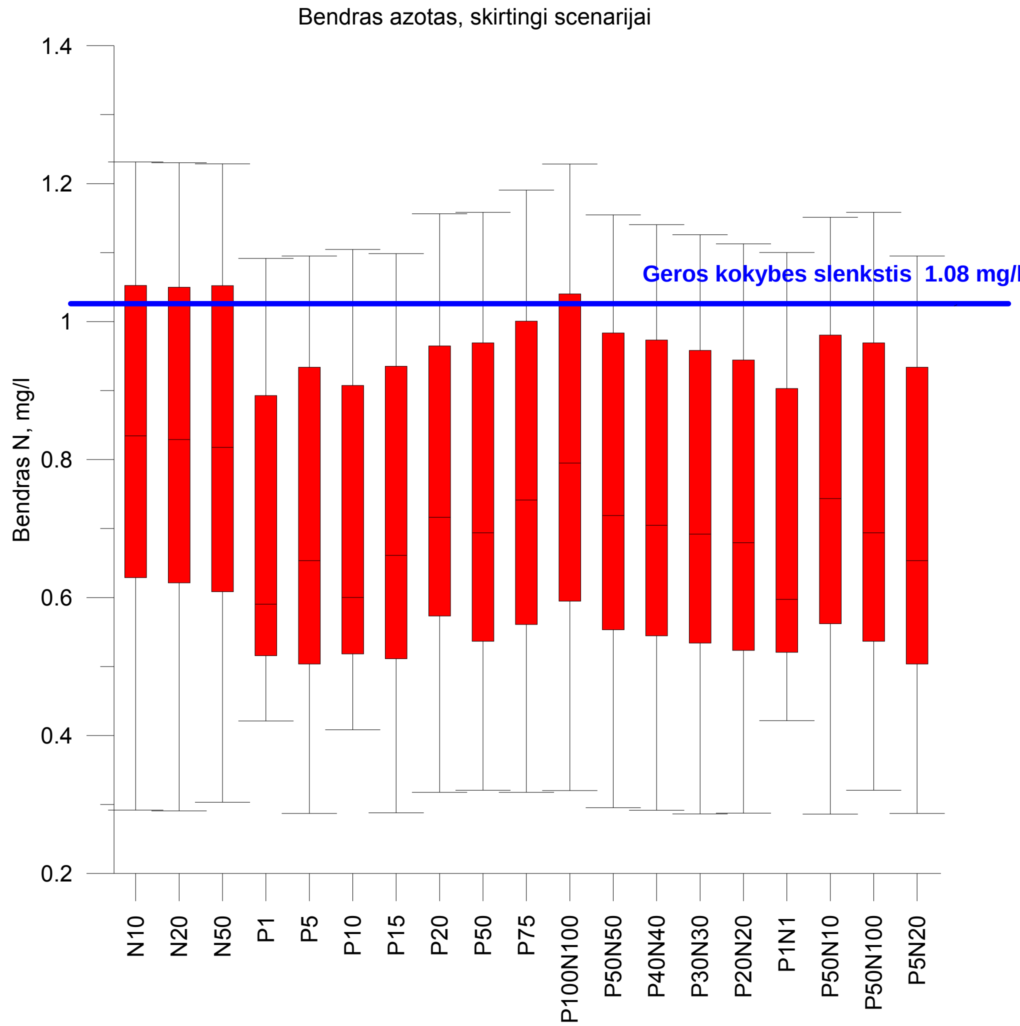


Fig. 7. Average concentrations and 65%, 95% concentration variations of total nitrogen in the Curonian for summer months in different scenarios.

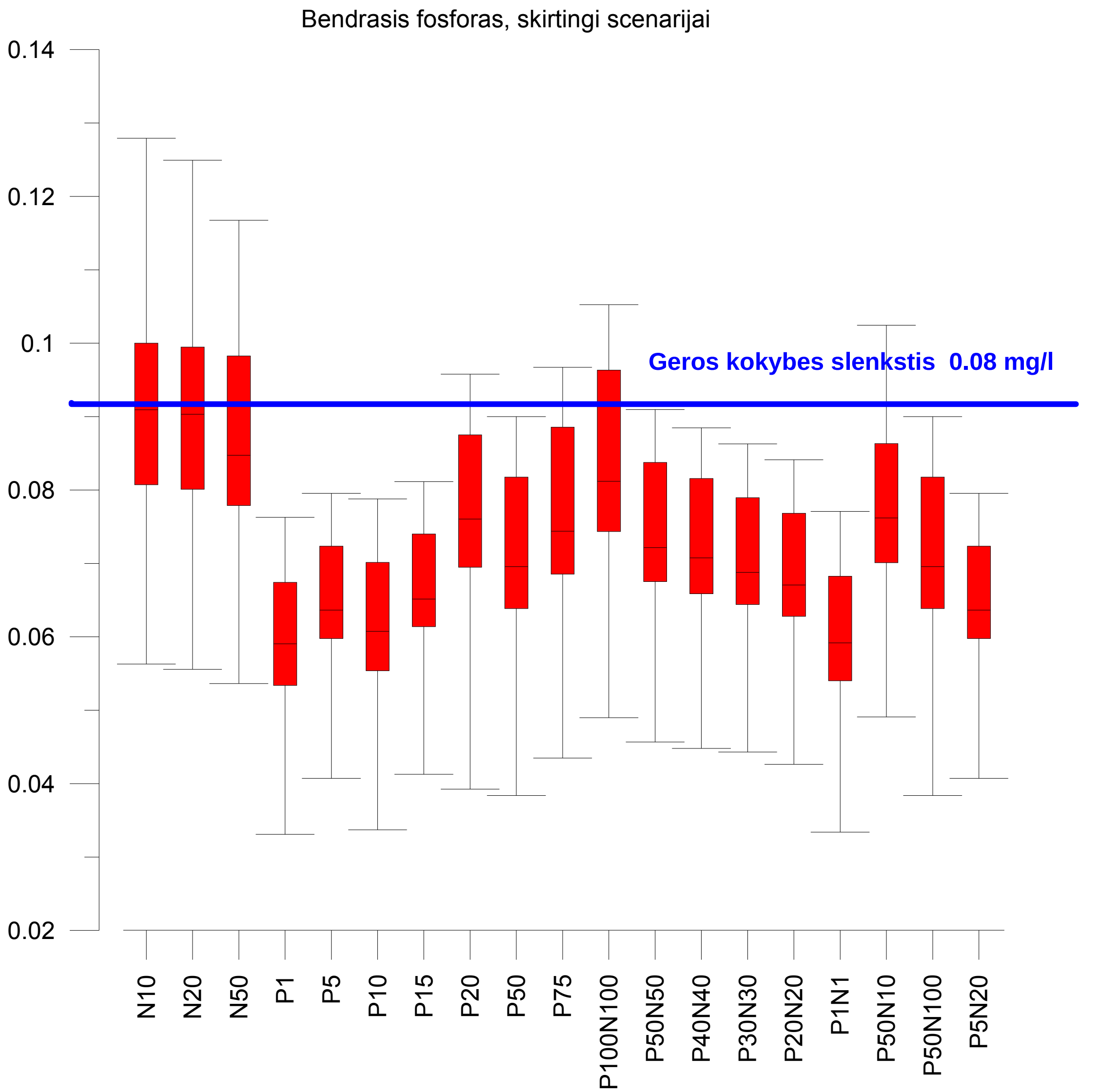


Fig. 8. Average concentrations and 65%, 95% concentration variations of total phosphorus in the Curonian for summer months in different scenarios.

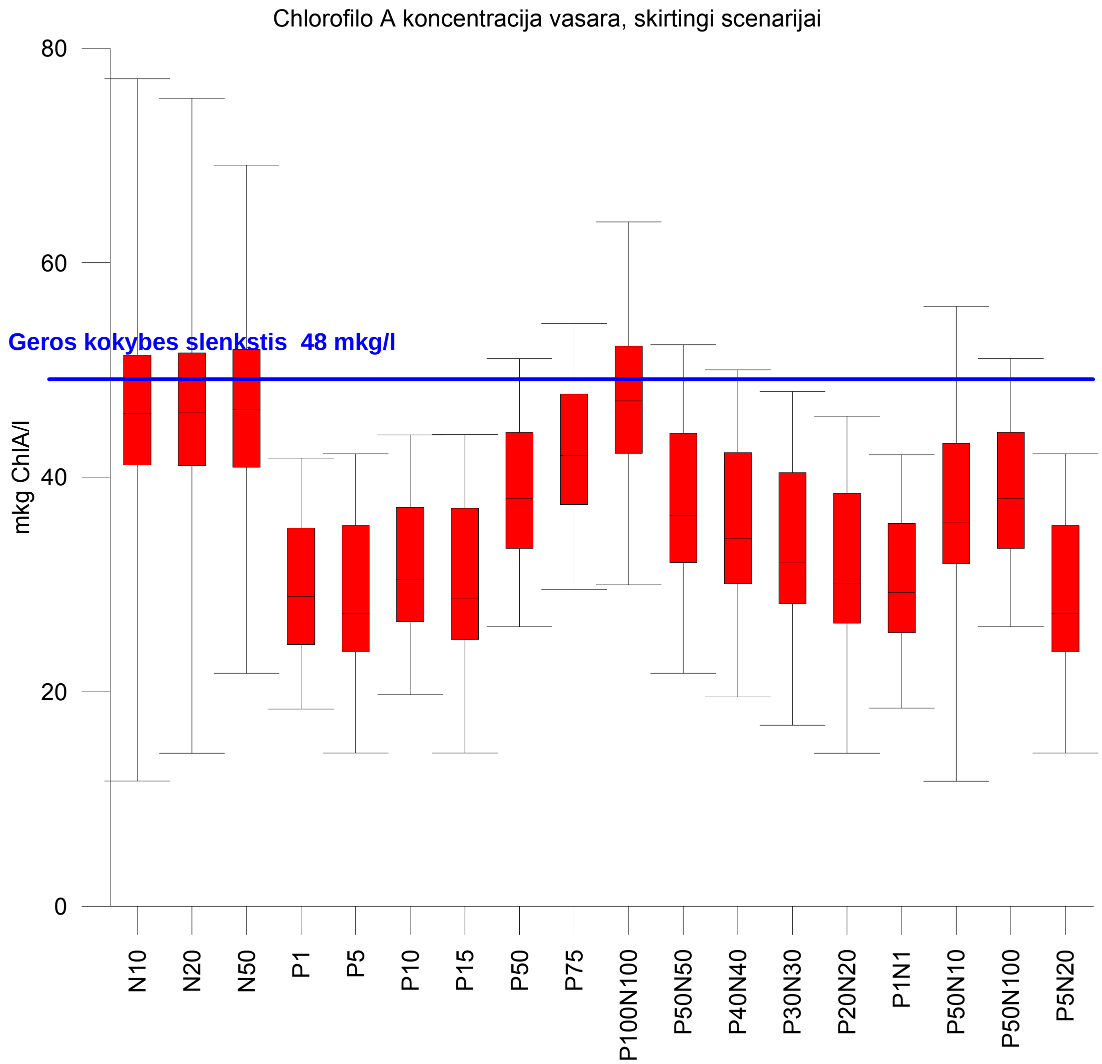


Fig. 9. Average concentrations and 65%, 95% concentration variations of chlorophyll in the Curonian for summer months in different scenarios.

As one can see from figure above the minimum efforts requiring scenario that lets not to exceed good quality threshold is scenario P75 that means decrease of total phosphorus discharge by 25% leaving the total nitrogen on the same level. This corresponds to the decrease phosphorus by 240 t/year.

Estimated from the NPZD model 3 different phytoplankton biomass values (0.092, 0.072 and 0.065 mgChlA/l) were recalculated into the carbon units using the equation as described in Qian et al. (2010). Resulting 3 models were well balanced, but the differences were visible only in the EE (ecotrophic efficiency) of two compartments – phytoplankton and detritus. However , even the largest differences ( between S1 and S3 scenarios) were still in the range of 6 and 5 % respectively.

## DISCUSSION

According to the growth experiments under laboratory conditions, it could be concluded that driving factor of the decline in freshwater fish species abundance in the Northern part of the Lagoon during the periods of water influx from the Baltic Sea is water temperature, while the low water salinity (up to 6‰) is of minor importance or even might have some attractive effect. In any case the negative effect of Baltic Sea water should have temporal effect until the Sea water temperature equilibrates to temperature of the Lagoon water. On the other hand, if the temperature of the Sea water is equal or higher compare to freshwater, the negative behavioural reactions of freshwater species should not be observed. These experimental tests well explain seasonal migrations of freshwater fish species to the coastal waters, which start at the end of spring or the beginning of summer after water temperature in the coastal areas increases enough. The other driving factor of such freshwater fish species seasonal migrations from the Curonian Lagoon might be increase of ammonia and other toxic compounds in the water due to mass algal blooms and algae decomposition in the Lagoon during summer time.

Present development introduces a new dimension in the biological resource modelling effort in both Curonian lagoon and the Lithuanian coastal zone of the Baltic Sea. However, present parameterisation of both NPZD and fishery models is still far from the perfection. The fish stock assessment in the Curonian lagoon is far more advanced that one along the Lithuanian coastal zone, providing the multi-cohort compartments based on the fish population studies. Due to the present limitation in the reliable stock assessment in the Lithuanian coastal zone so far only ECOPATH model was constructed. However, the level of details of the present model is far more advanced than it was presented in previous studies (Tomczak et.al., 2009) in this region. The three developed nutrient reduction scenarios applied to assess the effect in the Curonian lagoon food web showed no significant consequences in the organic material cycling in the Curonian since the dominant detritus pathway is pretty stable and is not affected by the produced variation in primary production.

## FUTURE DEVELOPMENTS

Future work should include further integration of EWE (at the code level) with the rest of modelling tools allowing two-way interaction between NPZD and ECOSIM models. Second direction is the improvement of the already existing ECOPATH/ECOSIM models.

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