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DEVELOPMENT OF METHODS AND TECHNOLOGIES OF INFORMATICS FOR PROCESS MODELING AND MANAGEMENT

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This book consists of papers describing applications of informatics in process modeling and management and in environmental engineering. Problems presented in the papers concern development of methods supporting process management, development of calculation methods for process modeling and development of technologies of informatics for solving some problems of environmental engineering. In several papers results of the research projects supported by the Polish Ministry of Science and Higher Education are presented.

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CHAPTER 3

Tools of informatics in environmental engineering

UNSUSTAINABLE LAND USE IN THE BALTIC SEA DRAINAGE BASIN FROM COMMON KNOWLEDGE TO COMMON PROJECTS AND RESPONSES*

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Abstract: *Author in this paper focuses on the unsustainable land use impacts of the Baltic Sea countries on environmental value of the Baltic Sea. The primary goal is to demonstrate that agriculture is still the main source of environmental problems, like eutrophication. In 1988 HELCOM adopted the so-called 50% goal which means a 50% reduction of phosphate and nitrogen inputs until 1995. Since agricultural activities continued being one of the main sources of pollution to the Baltic Sea, in 1995 this goal wasn't achieved. The author documents the present state of the Baltic Sea on the DPSIR framework basis.*

Keywords: Baltic Sea Drainage Basin, land use, DPSIR.

1. Introduction

Nine European countries (Figure 1, Tables 1, 2) have agreed to take joint actions to achieve a 50% reduction in the total load of nutrients to the Baltic Sea (HELCOM 1993). The severe eutrophication (overfertilization from non-point sources and ensuing water quality degradation and health hazards) and ecological collapse of the Baltic Sea has led to internationally-coordinated research activities seeking cost effective policies of pollutant reduction (EUROCAT; EEA; Gren, 2001; von Bodungen et al., 2001; Crossland et al., 2001; Żylicz et al., 1995; Ledoux et al., 2004; Turner et al., 1999; Miklewski, 1995; Miklewski et al., 1995; Editorial, 2004).

The Baltic Sea is a young sea, it started to develop since the last glacial period ca. 10 000 years ago and has gone through marine, freshwater and brackish water phases. Compared to the oceans or freshwater lakes, only few species have

* Project of the State Committee for Scientific Research (KBN) No PBZ-KBN-086/P04/2003 entitled "The Meteorological and Hydrological Extreme Events in Poland (Theirs Assessment for Human Environment)", BMBF Project of the German Federal Ministry Education and Research entitled "Integrated catchment management and risk- based resource allocation in urban and peri-urban areas" and Inner University Grant of the Agricultural University in Szczecin "Land Use Land Cover Change (LUCC) Models".

been able to adapt to live in the cold and brackish water conditions prevailing in the Baltic Sea. The simple food web is vulnerable to changes.

Since the 1800s, the Baltic Sea has changed from an oligotrophic clear-water sea into a eutrophic marine environment. Compared to pristine conditions, nitrogen inputs have more than doubled and phosphorus inputs are in average over three times higher. Agriculture contributes majority of the current water- and airborne nutrient inputs.

The Baltic Sea is one of the largest brackish water ecosystems of the world, situated in the temperate - sub-boreal climate. Its waters are a mixture of saline ocean waters from the North Sea and riverine freshwater from the catchment area. The Baltic Sea is semi-enclosed: the only connection to the oceans is through the narrow and shallow Danish Sounds. The waters of the Baltic Sea are shallow (the mean depth is only ca. 60 m) and the total volume small compared e.g. to the Mediterranean Sea. The water renewal time is long (ca. 30 years).

Strategic focus of ongoing research projects, in which author is engaged is documentation, evaluation, overcoming of obstacles and promotion of ongoing local interaction to achieve more sustainable rural development. The study will increase knowledge, competence and implementation of local, ecological recycling-based food chains to reduce consumption of limited resources, greenhouse gas emissions and eutrophication in the Baltic Sea Drainage Basin (BSDB) area.

Today, over 80 million people inhabit the catchment area. The use of the sea is intense. The 29 largest cities in the Baltic Sea drainage basin cover only 0.1% of the area of the drainage basin, but their inhabitants appropriate an ecosystem area about 1 000 times the city area (Folke et al., 1997). This "ecological footprint" is used for production of food (including seafood) and timber consumed inside the city, and for assimilation of waste emitted from the city (nutrients and carbon dioxide). Each city inhabitant depends on ecosystem work over an area of about 220,000-225,000 m^2, drawing on the work of nature from all over the planet. It is in the self-interest of the city inhabitants to sustain the capacity of ecosystems to supply this support, and not only within national boundaries but also in regions from where this support is derived (Folke et al., 2002).

Inputs of various substances as results of human activities, mainly unsustainable land use, in its catchment area (especially from agriculture), have changed the Baltic Sea ecosystem. Today the Baltic Sea is eutrophied and heavy blooms of toxic algae are common. Toxic substances, such as heavy metals and organochlorine compounds are accumulated in its fauna and sediment.

The Baltic Sea is among the most thoroughly scientifically investigated sea areas in the world. In recent years extensive studies have been undertaken concerning the environmental conditions, issues and priorities in the drainage basin and coastal zone in relation to the Baltic Sea. Major programmes to address environmental management and ecological restoration of the Baltic Sea are under implementation through the complementary activities of the Helsinki Commission, Baltic 21 and other initiatives. However, the capability to survey, monitor, assess and manage the marine environment and its living resources, including fisheries, varies greatly among the coastal Baltic Sea States. The research and development (R&D) capacity, necessary for these purposes and to operationalize the ecosystem approach to management must be enhanced on a pan-Baltic scale. As the complexity of the issues is increasing, there is a strong need to build, mobilize and further integrate "core science" capabilities in order to underpin the sustainable development of the Baltic Sea as a whole with regard to ecosystem-based management. In this context, the States in economic transition require assistance in capacity building, both in terms of human resources development and facilities. In addition, research institutions should be encouraged to further coordinate their use of infrastructure, network building and collaboration with a view to enhancing capacity interchange in the region.

In the HELCOM Ministerial Declaration adopted on 25 June 2003 in Bremen (HELCOM, 2003) it is declared:

> *"WE RECOGNIZE that a main source of waterborne nitrogen input is related to intensive agricultural practices taking place within current EU Member States. Also, losses of phosphorus give rise to concern in several countries.*
> *WE CONSIDER that the EU enlargement process will bring large new areas of the Baltic Sea catchment under the EU Common Agricultural Policy and that this may lead to even higher nutrient inputs into the Baltic Sea Area."*

A different approach is used in the Baltic Sea Drainage Basin (BSDB): GIS, Maps and Statistical Database developed by United Nations Environmental Program (http://www.grida.no/prog/norbal/baltic/welcome.htm) - Global Resource Information Database (UNEP/GRID) Arendal (Norway) in collaboration with Institutes in Sweden. In this database there are only 81 sub-basins, in total forming the seven major catchments that define the Baltic Sea drainage area (Figure 1). The sub-basins all have an outlet to the sea or are coastal drainage areas (Table 1, 2); portions of the Baltic Sea are considered sub-basins. Therefore the sub-basins are numbered sequentially in clock-wise order beginning from the northern catchment (Bothnian Bay); jumping in the numbering scheme can occur when a portion of sea is encountered: a number ending by nine is always assigned to it. An additional parameter is linked to each sub-basin indicating the major catchment it belongs to.

The fundamental principle our investigations on the BSDB areas are:

1. Linking common knowledge of the many international scientific teams with actions (AWARE, BMBF, PBZ KBN projects), promoting the best agricultural practice, organic farming, wetland restoration and building, implementation of the agri-environmental support scheme.

2. DPSIR approach (conceptual Driving Forces – Pressures – State – Impacts – Response model) (Miklewski, 2001) (Figure 2).
3. Ecosystem approach and setting of ecological quality objectives (EcoQOs).

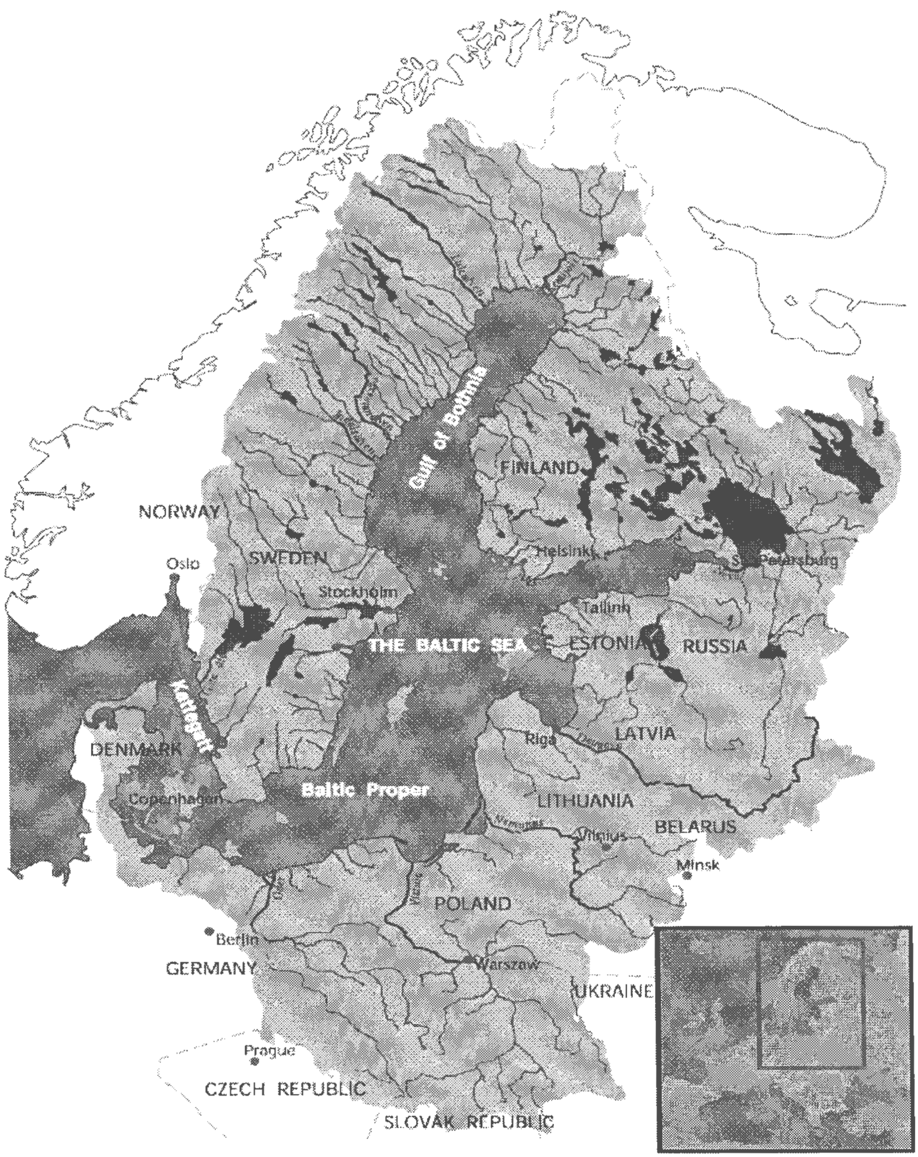

Figure 1. The Baltic Sea and its drainage basin. The Bothnian Bay is the northern and the Bothnian Sea the southern half of the Gulf of Bothnia. Source: Stockholm Marine Research Centre.

Table 1. Main Sub-catchments areas in the Baltic Sea Drainage Basin (HELCOM 2004).

Sub-basin	Gulf of Bothnia			Gulf of Finland	Gulf of Riga	Baltic Proper	Belt Sea and Kattegat			Total
Country	Bothnian Bay	Bothnian Sea	Archipelago Sea				Western Baltic	The Sound	Kattegat	
Catchments area riparian states (km^2) – Contracting Parties										
Denmark						1 200	12 340	1 740	15 830	31 110
Estonia				26 400	17 600	1 100				45 100
Finland	146 000	39 30	9 000	107 000						301 300
Germany						18 200	10 400			28 600
Latvia				3 600	49 600	11 400				64 600
Lithuania					11 140	54 160				65 300
Poland						311 900				311 900
Russia				276 100	23 700	15 000				314 800
Sweden	113 620	176 610				83 225		2 885	63 700	440 040
Total	259 620	215 910	9 000	413 100	102 040	496 185	22 740	4 625	79 530	**1 602 750**
Catchments area upstream states (km^2) – Non-Contracting Parties										
Belarus					25 800	58 050				83 850
Czech Rep.						7 190				7 190
Norway	1 055	4 855							7 450	13 360
Slovakia						1 950				1 950
Ukraine						11 170				11 170
Total Baltic Sea Basin area (km^2) – Contracting Parties and Non-Contracting Parties										
	260 675	220 765	9 000	413 100	127 840	574 545	22 740	4 625	86 980	**1 720 270**

Table 2. Total drainage area, area of arable land, population and total annual nitrogen load in the BSDB for the year 2000. Only the small part of Germany and Russia (Leningrad and Kaliningrad) that are located in the Baltic Sea Basin are covered by the statistics here and more detailed statistics were not available (HELCOM 2004).

	Arable land (1 000 ha)	Population (1 000)	Total N load (ta^{-1})	Total N load (kg capita^{-1}a^{-1})	% of total
Denmark	2 077	5 155	62 240	12	7.57
Estonia	1 160	1 595	32 990	21	4.01
Finland	2 387	4 938	146 560	30	17.82
Germany	2 051	3 300	31 510	10	3.83
Latvia	2 826	2 606	54 070	21	6.58
Lithuania	3 527	3 446	35 560	21	4.32
Poland	14 247	37 764	229 990	6	27.97
Russia	4 699	9 028	53 720	6	6.53
Sweden	2 698	8 500	175 610	21	21.36
Total	35 672	76 332	822 250		100.00

Runoff from agricultural land (Tables 3,4,5) means excessive nutrients, such as nitrogen and phosphorus, flow down to ocean waters causing eutrophication. Consequences of this are hypoxia (very low levels of oxygen in water), fish kills and harmful algal blooms. With world populations increasing food demand shall rise and hence more fertilizer use is predicted, so eutrophication of coastal waters will get progressively worse. Some countries have presented information on nutrient retention in river catchments and the net loads to the Baltic Sea (load-orientated approach). It should be highlighted that it is difficult to reliably estimate losses from agriculture into surface water, and that the models and methodologies used do not necessarily provide comparable and/or accurate estimates of these loads between different countries and time periods. The diffuse pollution from agriculture is very difficult to manage and it is difficult to judge if the present measures will be insufficient to reduce the loss of nutrients. Some time lag is expected between implementation of reduction measures and observed decrease in discharges.

2. DPSIR – holistic view on the Baltic Sea

Internal catchments processes, dominant pathways of pollutant load and hydromorphology are all important for the response of aquatic biological communities to pressures that arise within the catchments. Understanding these relationships is, further, restricted by the inherent complexity of Large Marine Ecosystems, like Baltic Sea. The simplification of that complexity through the identification of key variables and prediction of responses is a valuable tool as in DPSIR model (Figure 2).

The DPSIR framework is a system for scoping of complicated management issues and problems. It can make tractable the complexity of causes of water resources, habitat/species, degradation or losses and the links to socio-economic activities across the relevant spatial and temporal scales. It also provides the important conceptual connection between ecosystem change and effects of that change (Impacts) on people's economic and social wellbeing (Miklewski, 2001).

DPSIR assessments can be a useful management tool in assessing eutrophication. A step toward the implementation of a regional Baltic Sea specific ecosystem approach to the management of human activity was made at the Joint OSPAR and HELCOM Ministerial Meeting in June 2003, where it was agreed that the ecosystem approach and setting of ecological quality objectives (EcoQOs) are key to improving the protection of the North-East Atlantic and the Baltic Sea (Declaration of the First Joint Ministerial Meeting of the Helsinki and OSPAR Commissions, Bremen 25-26 June 2003). It was recognized that the ecosystem structure, process, functions and interactions (relevant to the development of policies) must be considered together in order to ensure the sustainable use of the seas, and the balance of interests between different sectors. The ecosystem approach was recognized as a key principle to maintain and restore ecosystem health, integrity and services. By incorporating

EcoQOs to the DPSIR framework a set of environmental Impacts and State changes (EcoQOs) can be identified. By working back through the DPSIR framework it will allow for an effective means to identify the environmental Pressures and related socioeconomic Drivers that need to be addressed by policy Response in order to achieve positive environmental impacts for society. It can further provide a means to link processes, composition, and functions with output of goods and services, allowing ultimately the assignment of monetary economic and/ or other value on reaching a set of EcoQOs. Figure 2 gives an overview of the DPSIR assessment framework for eutrophication. Several economic activities in society, especially industrial farming and unsustainable land use, form the driving forces and are responsible for substantial loads of nutrients in the environment. For instance, use of fertilizers and manure in agriculture.

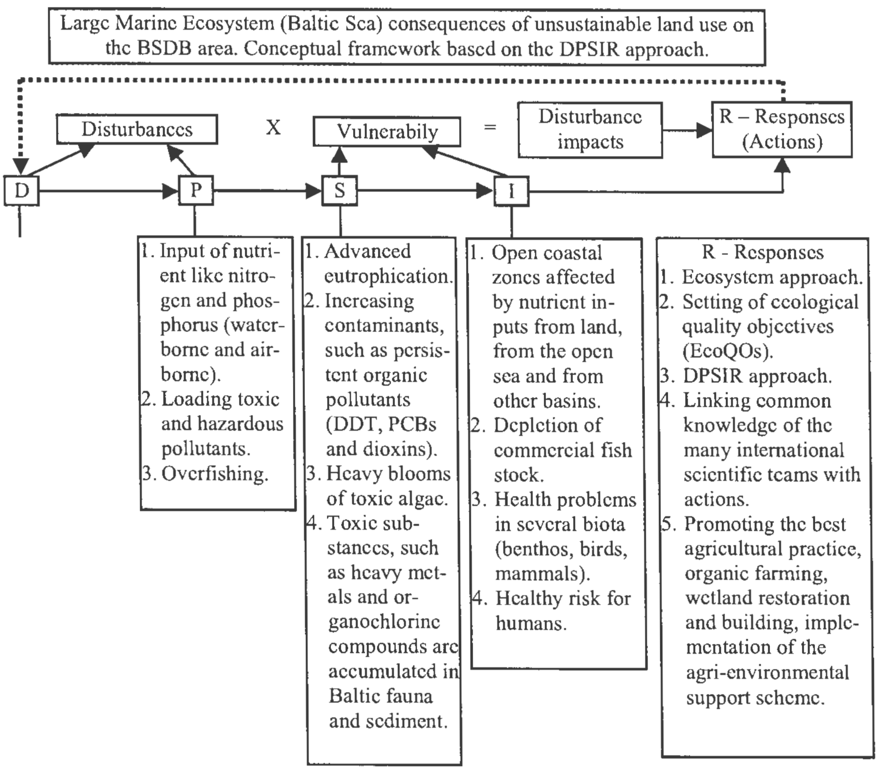

Figure 2. DPSIR approach for Baltic Sea Drainage Basin – conceptual framework from AWARE, BMBF, PBZ KBN projects.

3. D – Driving forces

The serious environmental situation in BSDB is driven by transboundary problems. Main driving forces are unsustainable land use in this region. Co-operation between states is a necessity to be able to handle environmental issues in the BSDB area. The quality of the environment in the Baltic Sea is a consequence of agricultural specialization, pollution from industries, incorrect waste management and the unsustainable lifestyle prevailing in the countries around the Baltic Sea (i.e. in its drainage basin).

A major geopolitical driving force has been the accession to the European Union (EU) in 2004 by Estonia, Latvia, Lithuania and Poland, leaving the Russian Federation as the sole non-EU coastal Baltic State. This enlargement of the EU has significant implications on the land, coastal and marine policies of the States of the Baltic Sea region, especially regarding the application of various policies and strategies concerning agriculture, transport, environment, fisheries, water resources and scientific research. The EU must face the challenge of developing and applying a more proactive strategy for collaboration with the Russian Federation in environmental management, research, and monitoring and assessment to achieve improved conservation and restoration of the environment and the living resources of the Baltic Sea, and to insure the sustainable development of the region (EU Marine Strategy).

4. P – Pressures

Input of nutrients (Pressures) like nitrogen and phosphorus to the sea is a natural prerequisite for life, not an environmental problem (Tables 3,4,5). It becomes a problem only when the input increases to such an extent that the original properties or functions of the ecosystem change. Eutrophication occurs when production and consumption of organic matter in the sea do no longer cancel each other out.

The natural cycle of accumulation and decomposition are no longer in reasonable balance. In addition, the semi-enclosed and brackish-water Baltic Sea, with its slow water exchange and built-in natural barriers, is in many respects particularly sensitive to eutrophication.

Despite measures taken nationally and internationally during the last decades, eutrophication continues to be a priority environmental problem of major concern in the BSDB. There are several reasons for that. A large proportion of the total load of waterborne and airborne nutrients to the sea originates from diffuse sources like agriculture, a sector where national legislation is not as efficient as for point sources, but where many of the measures to counteract eutrophication need to be taken.

There are also considerable time delays between measures taken in a drainage basin and detectable reductions in the input of nutrients to the sea. The long residence of nutrients (many years) means that outputs from one region are likely to affect other regions. The open coastal zones are not only affected by nutrient inputs from land but also from the open sea and thus also from other basins.

Since the effects of eutrophication are the result of nutrient transports and transformations in a number of different systems, management without understanding the links between the systems is likely to result in more costly mitigation programs than necessary. Currently, our understanding of this is large but highly fragmented. There is a need to utilize and synthesize scientific information pertinent to the relevant problem and management scale.

Table 3. Riverine, coastal and point source flow to the Baltic Sea of the 9 HELCOM countries in 1994-2004, m^3/s (HELCOM, 2004, NE – data not available).

Country	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Denmark	410.5	328.9	162.0	175.7	320.6	372.7	327.0	288.9	387.7	215.7	295.4
Estonia	710.8	761.1	431.2	622.2	827.0	756.4	538.5	636.6	558.0	482.6	808.6
Finland	2 078.4	2 406.8	1 982.8	2 091.3	2 931.1	2 198.2	2 884.5	2 260.4	1 760.4	1 503.7	2 515.9
Germany	184.8	146.6	82.3	82.7	151.3	134.2	114.6	113.7	188.7	77.8	84.0
Latvia	1 149.5	998.3	605.8	991.8	1 470.4	1 004.7	940.2	825.3	932.9	701.1	NE
Lithuania	1 047.4	787.7	642.8	598.2	886.4	828.5	644.5	638.3	702.8	285.9	525.1
Poland	1 952.6	1 884.2	2 045.5	2 236.7	2 431.7	2 346.3	2 103.1	2 182.4	2 279.1	1 474.1	1 527.4
Russia	2 411.7	2 612.3	2 036.6	2 077.2	2 308.6	2 576.9	2 347.1	2 493.7	2 261.4	1 672.1	NE
Sweden	5 111.1	6 124.8	3 891.8	5 105.8	7 075.2	6 285.8	7 575.1	7 179.0	5 332.2	4 027.7	5 339.3
Baltic Sea Basin	**15 056.8**	**16 050.7**	**11 880.8**	**13 981.6**	**18 402.3**	**16 503.7**	**17 474.6**	**16 618.3**	**14 403.2**	**10 440.7**	**11 095.7**

Table 4. Riverine, coastal and direct point and diffuse source inputs of N_{total} of the 9 HELCOM countries in 1994-2004 as t/year (HELCOM, 2004, NE – data not available).

Country	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Denmark	97 540.6	66 736.7	34 407.7	36 274.0	76 393.9	73 557.5	58 232.9	52 958.3	69 427.9	35 174.8	54 794.6
Estonia	24 400.9	32 401.1	16 813.1	25 737.6	38 787.8	30 965.3	26 948.7	36 192.3	30 430.1	22 327.6	39 027.6
Finland	60 364.5	68 416.9	65 842.0	64 239.4	86 406.8	67 227.6	101 368.0	74 573.4	51 021.8	52 934.6	82 288.9
Germany	43 556.3	27 192.2	12 081.5	12 173.2	30 622.9	24 774.3	18 600.9	17 530.5	32 417.3	9 950.7	16 080.6
Latvia	114 120.7	91 708.4	51 413.3	92 238.4	107 471.2	78 535.0	67 558.1	79 609.6	68 023.5	40 726.0	NE
Lithuania	64 922.6	36 041.9	39 608.9	53 567.3	78 034.6	64 722.6	47 874.0	32 956.1	42 156.8	22 791.7	39 037.1
Poland	266 068.5	220 514.8	218 888.4	221 599.1	278 452.7	221 943.9	191 737.3	204 341.4	252 334.0	137 028.6	156 579.5
Russia	NE	NE	NE	NE	NE	NE	72 465.5	72 872.3	87 854.4	95 966.5	NE
Sweden	113 957.8	130 781.8	72 001.5	83 519.1	145 303.0	132 465.7	150 981.8	127 721.1	118 961.5	79 354.1	114 439.4
Baltic Sea Basin	784 931.9	673 793.7	511 056.4	589 348.1	841 472.9	694 191.9	735 767.2	698 755.0	752 627.3	496 254.6	502 247.7

Table 5. Riverine, coastal and direct point and diffuse source inputs of P_{total} of the 9 HELCOM countries in 1994-2004 as t/year (HELCOM, 2004, NE – data not available).

Country	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Denmark	3 621.4	2 584.0	1 639.0	1 488.9	2 039.0	2 214.0	1 859.9	1 715.0	2 098.0	1 198.0	1 578.3
Estonia	1 425.9	1 316.0	735.6	937.5	1 240.7	1 748.1	965.0	1 346.0	1 237.4	1 023.4	1 500.0
Finland	3 507.5	3 586.9	3 194.8	3 040.4	4 475.1	3 437.6	4 835.4	3 407.0	2 239.3	2 001.5	3 434.9
Germany	955.4	685.9	447.2	417.9	716.9	567.9	486.4	454.1	751.7	345.6	418.4
Latvia	2 205.2	2 060.5	1 009.6	1 471.1	2 918.7	2 148.6	2 207.0	2 266.6	1 862.9	1 797.2	NE
Lithuania	3 819.9	1 372.7	1 445.5	2 330.4	3 132.2	3 529.9	1 894.1	2 565.6	2 992.0	1 294.4	2 530.4
Poland	13 344.9	14 265.4	13 936.3	16 882.8	16 833.9	14 740.1	12 555.4	13 589.5	12 957.5	8 458.4	9 689.2
Russia	4 192.9	9 264.8	4 189.4	3 811.9	4 050.4	3 868.5	6 198.0	3 148.8	5 834.8	4 572.5	NE
Sweden	3 664.9	4 714.9	1 883.7	3 523.2	4 250.5	4 224.5	4 943.8	3 840.2	3 154.6	2 249.5	3 341.6
Baltic Sea Basin	36 738.0	39 851.1	28 481.1	33 904.3	39 657.4	36 479.2	35 944.9	32 332.7	33 128.1	22 940.5	22 492.9

5. S – State of the Baltic Sea

Until about 1940, the Baltic Sea was a nutrient-poor (oligotrophic) water body with relatively low biological production and clear water (Jansson and Dahlberg, 1999). Since then, excessive inputs from human activities in the catchment area - combined with the long residence time in the system - have raised the loads of nutrients and toxic and hazardous pollutants, giving rise to symptoms of advanced "ecosystem pathology" (Leppäkoski and Mihnea, 1996). Overfishing has seriously depleted commercial fish stocks and also adversely affected vulnerable species and habitats in the ecosystem (HELCOM, 2002; Lääne et al., 2005). The impacts of pollution on coastal and marine ecosystems are all too evident, including the effects of advanced eutrophication, hazardous substances and oil spills (HELCOM, 1996, 2002). Contaminants, such as persistent organic pollutants (POPs such as DDT, PCBs and dioxins) and heavy metals, have inter alia accumulated via the food web causing health problems in several biota (e.g. benthos, birds and marine mammals), and levels of some pollutants in seafood (e.g. fatty fish and shellfish) may constitute a health risk for humans (Jensen et al., 1969; Helander et al., 1982; Blomqvist et al., 1993; Skerfving, 1995; Bengtsson et al., 1999; Backman et al., 2003; MacKenzie et al., 2004; Selin and VanDeever, 2004). These degradations in ecosystem health have resulted in detrimental socioeconomic impacts (Lääne et al., 2005).

Eutrophication is the gradual increase and enrichment of an ecosystem by nutrients such as nitrogen and phosphorus. Although traditionally thought of as enrichment of aquatic systems by addition of fertilizers into lakes, bays, or other semi-enclosed waters (even slow-moving rivers), there is gathering evidence that terrestrial ecosystems are subject to similarly adverse impacts (APIS, 2005; Miklewska, 1995). The increase in available nutrients promotes plant growth, favoring certain species over others and forcing a change in species composition. In aquatic environments, enhanced growth of choking aquatic vegetation or phytoplankton (that is, an algal bloom) disrupts normal functioning of the ecosystem, causing a variety of problems. Human society is impacted as well: eutrophic conditions decrease the resource value of rivers, lakes, and estuaries such that recreation, fishing, hunting, and esthetic enjoyment are hindered. Health-related problems can occur where eutrophic conditions interfere with drinking water treatment (Bartram et al., 1999).

To understand and project what is happening now and in the future, it is essential to understand the long-term cumulative effects of past human impact and the nature of specific environmental thresholds, particularly those that lead to reduced resilience. The degradation of terrestrial ecosystems by human activities is often linked to a shift beyond a threshold in a critical function, such as productivity.

The Baltic Sea has undergone similar reverberations of change due to human activities around its shores; over the past two centuries dense human populations have sufficiently increased nutrient supplies to the sea to cause a threshold to be passed. Eutrophication occurred, the depth to which light can penetrate decreased and the balance in diatom productivity shifted from benthic (bottom-dwelling) to plankton communities.

Enclosed seas, such as the Baltic Sea, have specific environmental characteristics. However, the environmental problems of the Baltic Sea are to a great extent also faced by the other seas of the world. Since the 1960s, the main threat to the Baltic Sea is eutrophication, which is also recognized as one of the major threats to coastal marine ecosystems on a global scale (Nixon, 1990). In the Baltic Sea, the increase of organic matter is largely caused by an increase of nutrient input followed by an increase in primary and secondary production (HELCOM, 1993; Bonsdorff et al., 1997b).

The ecological status of most parts of the Baltic Sea deviates from what is being considered an acceptable ecological structure and functioning. The factors behind this undesirable status are: fishing, pollution caused by inputs of nutrients and/or hazardous substances, physical modification of habitats, introduction for non-indigenous species and global change (Jackson et al., 2001).

6. I – Impact

The effects of eutrophication are serious, with both bio-diversity and people's health impacted. The increased cloudiness that it causes also affects the aesthetic value of the water environments, and effects on production capacity can have economic consequences. Bluegreen algae (cyanobacteria) flourish as a result of eutrophication and can harm people, pets and other organisms, giving rise not only to symptoms of poisoning and skin irritation, but reducing the quality of drinking and bathing water.

Eutrophication mainly affects birds indirectly by increasing the primary production in the sea (Beukema and Cadée, 1991; Pitkänen, 1994; Bonsdorff et al., 1997a). If eutrophication leads to an increase in the food resources of birds, it may allow their populations to increase, which can lead to their spread into new habitats (von Haartman, 1982, 1984). However, eutrophication may also change the species composition and function of aquatic animal communities (Leppäkoski, 1975; Viitasalo et al., 1990; Bonsdorff, 1992; Rumohr et al., 1996) or the vegetation structure in a way unbeneficial for birds. Thus, eutrophication may diminish the numbers and distribution of birds.

7. R – Responses

Main human responses are as follows: common research projects, ecosystem approach, ecosystem health approach, wetland restoration and building, promoting organic farming, implementation of the agri-environmental support scheme.

The Ecosystem Approach to management of human activities, adopted by the Joint HELCOM/OSPAR Ministerial Meeting in 2003, obliges HELCOM to assess the pressures of human activities as well as the resulting impacts on, and state of, the marine environment and to use the results of such assessments as the foundation for identifying priority actions. HELCOM assessments also aim to reveal how visions, goals and objectives set for the Baltic Sea marine environment are met and to link the quality of the environment to management.

Taking an ecosystem approach does not imply that we are managing the ecosystem, *per se*, but that we adopt an integrated and holistic view to the management of human impact on the environment. We will need to set targets that enable us to measure how effectively we are managing human activity. Within this process we will have to better recognize the complexity of ecosystems and the interconnections among its parts; humans are an integral part of ecosystems - our social and economic systems constantly interact with other physical and biological parts of systems (Kay et al., 2000).

The ecosystem approach is commonly defined as "the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity" (JMM, EU Marine Strategy). Ecosystem approach is a management principle. As such it builds on the recognition that the nature of nature is integrated and that we must take a holistic approach to nature management. The science to support ecosystem approach to management must also be integrated and holistic (DPSIR approach).

Adopting the ecosystem approach will require people within the Baltic Sea region to interpret its underling themes and what it means in everyday work. It is true that earlier management approaches have also been guided by ecological applications, but the ecosystem approach differs in several important ways:

- Conservation of ecosystem function, health and resilience; which include non-commodity values.
- It places management in the context of natural disturbance and long-term visions (change is inevitable).
- Appropriate temporal and spatial scale.
- Management within system limits, but taking a landscape perspective, moving beyond boundaries set by ownership and recognizing the reciprocal influence of neighboring ecosystems on the system being managed.
- Emphasis on sustainability and future generations, with an appropriate balance between conservation and use.
- Management objectives as societal choice.

EU ecosystem-based policy will result in an ecosystem-based management of the environment from land to the open sea (Apitz et al., 2005).

In the next step, scientific community set up the operational indicators for ecosystem health: the process of establishing ecological quality objectives (EcoQOs) for the Baltic Sea, for eutrophication, hazardous substances, impacts of fishing and loss of biodiversity (including xenodiversity and habitat destruction).

Ecological quality is an "...overall expression of the structure and function of the marine ecosystem taking into account the biological community and natural physiographical, geographic and climatic factors as well as physical and chemical conditions including those resulting from human activities" (OSPAR, 2002). Ecological Quality Elements are the individual aspects of overall ecological quality. EcoQOs are the desired level of ecological quality. This level can be set in relation to a reference level.

When setting EcoQOs it will be equally important to balance the interest between different sectors, including political, economic and social values. This needs to be done to guarantee that proposed solutions will be socially acceptable and that the approach can function in practice. To do this both the top-down (management) and the bottom-up (science) processes need to be incorporated in order to identify issues to be addressed in order to preserve ecosystem integrity and health, ensuring long-term sustainability of the Baltic Sea. This continuous interactive process of involvement between scientists and managers, throughout the policy cycle, will provide a "window of opportunity", where scientists gain a better appreciation of policy formulation and implementation, while managers/stakeholders gain a better understanding of the functioning and variability of natural systems and the consequences of socio-economic activity.

Wetlands have a capacity to reduce nutrients (nitrogen and phosphorus) in water by denitrification, sedimentation and plant uptake, though it seems to vary substantially between different wetland types, climatic conditions, etc. (Jansson et al., 1994; Leonardson, 1994). This capacity may be labeled as an ecosystem service provided by wetlands to society, since it contributes to mitigation of eutrophication effects in watercourses, lakes and seas. Natural and restored wetlands of the large-scale Baltic Sea drainage basin of Northern Europe annually retain an amount of nitrogen that corresponds to about 10-20% of the total emissions entering the Baltic Sea thereby counteracting eutrophication (Jansson et al. 1998). Investments in wetland functioning to gain one ecosystem service like nitrogen cleansing often generate several other valuable services like fodder for animals, bird watching, sport fishing and other recreational and tourism values, due to the multifunctional nature of ecosystems. This makes the total value of investments in Swedish wetlands at least twice as high as alternative investments (Green European Economic Review).

The EU Rural Development Regulation 1257/1999 (the "second pillar" of the CAP) makes provision for Member States to encourage more environmentally-friendly farming methods, including practices and actions that reduce the risk of agricultural pollution. EU introduces EU good agricultural practice and co-financed schemes that introduce agri-environment schemes that offer area payments to support the adoption of organic farming, the creation of uncultivated buffer strips, conversion of arable to pasture land and the introduction of more diverse crop rotations. Another useful tool will be the "verifiable standards of Good Farming Practice (GFP)" that all farmers receiving payments from agri-environment and less-favoured area schemes funded by the Rural Development Regulation - the so-called CAP 'Second Pillar' - must comply with across the whole of their farm.

Table 6. Organic Farming in the BSDB.
http://www.organic-europe.net/default.asp.

	Year	Organic Area		Organic Fams	
		ha	%	ha	%
Bielarus					
Czech Rep.	31.12.2004	260 120	6.09	836	2.2
Denmark	31.12.2004	154 921	5.81	3 166	5.5
Estonia	31.12.2004	46 016	6.59	810	2.0
Finland	31.12.2004	162 024	7.27	4 887	6.0
Germany	31.12.2004	767 891	4.53	16 603	4.1
Latvia	31.12.2004	43 902	1.77	1 043	
Lithuania	31.10.2005	64 545	1.85	1 811	2.7
Poland	31.12.2004	82 730	0.45	3 760	0.2
Russia					
Slovakia	30.08.2005	93 943	4.19	218	2.9
Sweden	31.12.2004	206 579	6.59	3 138	3.9
Ukraine	31.10.2005	241 980	0.58	72	

Organic farming is also considered by Baltic Countries (Table 6). This type of production system is defined by EU regulation 2092/91 which restricts the use of fertilizers and ban pesticides. Is clear that to reach the 50% nutrient reduction goal all agriculture in the entire Baltic Sea region would have to convert to organic farming, but it would still obtain 75% of the yield gained with conventional farming. On the other hand to reach the 50% reduction with conventional farming and without changing intensity would require setting aside 50% of the land resulting in a 50% reduction of the yield. Such a situation is not realistic, but organic farming may contribute to reduce nutrient losses and at least to reduce the environmental impact of pesticides.

8 Conclusions

What is needed, in BSDB protecting process, is the expansion of local research projects so as to address the sustainability of all resources at a particular location at once. Such projects are beginning to emerge (for example: BONUS, BMBF, PBZ KBN). We saw the launch of the Millennium Ecosystem Assessment (MEA) - an ambitious endeavor to assess the impact of factors such as shifts in land use and loss of biodiversity on the Earth's ecosystems (Gewin, Nature, 417, 112-113, 2002). Information on everything from fish stocks to nitrogen cycles will be produced, but the data generated are not just for ecologists. "The MEA focuses on things coming out of those ecosystems that people actually care about," says Lubchenco.

In 1999 (Jansson et al.), a Swedish team, looking at the ecological footprint of the Baltic Drainage Basin, distinguished between "liquid water appropriation" - the water directly consumed by humans - and "water vapor dependence" - the water supporting other natural systems on which the human population depends. By their estimates, total human freshwater needs may be up to 50 times larger than the amount used for direct consumption.

“Maritime research is (an area) which will benefit significantly from research co-operation, such as the joint use of research vessels, equipment and other research infrastructure,” says Kaisa Kononen of the Academy of Finland, one of the BONUS project’s partners.

EU Research Commissioner Philippe Busquin said the international projects will improve the effectiveness of environmental and sustainable development policies for the entire Baltic region. He also noted that the Baltic region “needs decisive action based on solid scientific knowledge. A coherent transnational strategy is essential to ensure that research is cost-effective, of high scientific quality, and addresses the real needs of policy-makers and of the Baltic region's economy and citizens.” Recent debates over issues such as fishing rights and the pollution of coastlines by oil spills have, however, emphasized the importance of increased international scientific collaboration and strategic planning. Following preparatory activities in the initial stage of the project, joint research programs will be established, procedures for the management and shared use of research facilities agreed, and a joint postgraduate training program set up. This, in turn, will lead to the definition of management and decision-making systems for long-term cooperation.

A common language for communication between scientists and managers, and a consensus about scales, problems and causes, needs to be established. Such a holistic approach takes into account e.g. the entire hydrological and biogeochemical cycles.

Development of the Driving Forces-type indicators within above mentioned projects should be connected to the already developed EcoQOs and PSR indicators. This will enable to achieve the full DPSIR framework of indicators. Therefore, socio-economic indicators should be developed for the most important Baltic concerns identified by the projects:

- Effects of Eutrophication.
- Effects of Hazardous Substances.
- Effects of Fishing Activities.
- Habitat Destruction and Loss of Biodiversity.

It is proposed to adopt so called "casual-chain analysis" (DPSIR) for the above mentioned Baltic concerns.

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Jan Studzinski, Olgierd Hryniewicz (Editors)

DEVELOPMENT OF METHODS AND TECHNOLOGIES OF INFORMATICS FOR PROCESS MODELING AND MANAGEMENT

The purpose of this publication is to popularize application of informatics in process modeling and management and in environmental engineering. The papers published are thematically selected from the works presented during the conference '*Multi-accessible Computer Systems*' organized by the Systems Research Institute and the University of Technology and Agriculture in Bydgoszcz for several years already in Ciechocinek. Problems presented in the papers concern: development of quality and quantity methods supporting the process management, development of quantity methods for process modeling and simulation, development of technologies of informatics for solving problems of environmental engineering. In several papers results of research projects supported by the Polish Ministry of Science and Higher Education are presented.

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