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REPORTS

Managing the Baltic Sea

BaltCoast 2004 - Conference Proceedings

Editors:
G. Schernewski & N. Löser

EUCC

The Coastal Union

Die Küsten Union Deutschland

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Gerald Schernewski & Nardine Löser

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P r e f a c e

The conference BaltCoast 2004 - Managing the Baltic Sea took place in Rostock-Warnemünde, Germany, between 26th and 28th April 2004. The conference focused on research, planning and management of the Baltic Sea. Aim was to give a comprehensive overview on Baltic coastal zone management aspects, to enhance an exchange of information and to bridge the gap between coastal science and practice.
It was the fourth in a series of conferences in Rostock, Germany. The first symposium was held in 1992, entitled "The Future of the Baltic Sea Ecology, Economics, Administration and Teaching". The second event - "Sustainable Development in Coastal Regions a Comparison between North Atlantic Coast and Baltic Sea" - was in 1996 and the third was the workshop "Baltic Coastal Ecosystems Structure, Function and Coastal Zone Management" which took place in 2000.
BaltCoast 2004 - Managing the Baltic Sea is a conference within the project BaltCoast. Project and conference are funded by the EU program INTERREG III B. The conference was organised by the Baltic Sea Research Institute (IOW) in cooperation with the EUCC - Die Küsten Union Deutschland. We received additional support from the Wissenschaftsverbund Umwelt (WVU), LOICZ (Land-Ocean Interactions in the Coastal Zone) and the project "Integrated Coastal Zone Mangement in the Oder Estuary Region (ICZM-Oder)", which is funded by the National Ministry for Education and Research (BMBF).
We like to thank all participants for their contributions and active discussions. We further thank all who supported the organisation of this conference, especially Dr. Steffen Bock, Carsten Droste, Steffi Maack, Prof. Dr. Ulrich Schiewer and Ramona Thamm.
Informations on the conference and the proceedings are permanently available in the Internet, as well (http://www.eucc-d.de/baltcoast2004/papers.html).

Warnemünde, May 2004

Gerald Schernewski & Nardine Löser
- Baltic Sea Research Institute & EUCC-Germany -

EUCC - The Coastal Union Germany

"EUCC - Die Küsten Union Deutschland" (The Coastal Union Germany) is the independent German national branch of the international non-governmental organization "EUCC - The Coastal Union". It was founded as a non-profit association in 2002 with its office located in Rostock-Warnemünde.

Our main objective is to promote sustainable coastal management in Germany by integrating coastal sciences and practice. We further aim to raise international awareness of German initiatives of Integrated Coastal Zone Management (ICZM) . Our members are experts from fields such as spatial planning, research, nature protection, coastal engineering and other disciplines related to the coast. By linking together coastal practitioners, combining efforts and initiating joint projects we want to contribute to the implementation of ICZM in Germany and Europe . In pursuit if these goals, EUCC-Germany provides relevant information, hosts workshops and conferences, and runs demonstration projects.

More information is available in the Internet under http://www.eucc-d.de.

Baltic Sea Research Institute Warnemünde

The Baltic Sea Research Institute Warnemünde (abbreviated IOW for Institut für Ostseeforschung Warnemuende) is a non-university research institute, dedicated to interdisciplinary marine research in coastal and marginal seas with a special emphasis on the Baltic Sea ecosystem.

IOW is a member of the Science Association Gottfried Wilhelm Leibniz (WGL). Its basic funding is jointly covered by the federal government and the state of Mecklenburg-Vorpommern.

More information is available in the Internet under http://www.io-warnemuende.de.

Integrated Coastal Zone Management in the Oder Estuary Region (ICZM Oder)

As a consequence of the EC Recommendations on Integrated Coastal Zone Management (ICZM), the project ‘Research for an Integrated Coastal Zone Management in the Oder Estuary Region’ was initiated. It is one of the two large national German projects on ICZM, funded by the National Ministry for Education and Research (BMBF). The aims and tasks within the project result from the specific situation and demands of the region. At the same time the project tackles the aspects “Strategic Approach”, “Principles”, “National Status Quo” and “National Strategies” as recom-mended by the EC (EC 413/2002). The special challenge lies in carrying out science on an interna-tional level and, at the same time, to establish and support a regional initiative on ICZM. Major element for public participation and the involvement of authorities is the Regional Agenda 21 ‘Oder Lagoon’. The creation of sustainable perspectives and structures, exceeding the duration of the project, is the core of all activities.

More information is available in the Internet under: http://www.ikzm-oder.de.

Environmental Research Association (Wissenschaftsverbund Um-Welt, WVU)

The WVU is a research association formed by different institutes of Rostock University, which are concerned with environmental matters. Founded in 1990, the WVU became the first central scientific organization at Rostock University by resolution of the university’s Senate in 1996. The WVU unites all departments concerned with research and teaching of environmental matters ranging from philosophy, science, medicine, agriculture to engineering, economics, informatics and law. It is an organisation also open to all non-university research institutes and companies dealing with environmental problems. The WVU does not only focus on ecological aspects but also on social and economical matters according to the spirit of sustainable development. Above all, the WVU is concerned with supporting the necessary interdisciplinary approach to environmental research and teaching taking into consideration the practical needs. Most environmental problems e.g. contaminated land, water pollution or ozone depletion can only be understood and solved by scientists from different fields working together.

To find solutions to environmental problems on an interdisciplinary base, the WVU has three fields of activities: interdisciplinary communication, teaching and research. Further information under: http://www.uni-rostock.de/andere/wvu.

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National Integrated Coastal Zone Management strategy and initiatives in Poland

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Abstract

Integrated Coastal Zone Management in Poland is not existing so far. There are also no a clear legal background for this procedures, however there are a quite good law system connected with coastal management. The State plays still a significant role in decision making here, also because of financial instruments connected for example with coastal defence and protection against the erosion. Still valuable Polish coast, as a typical soft and young type of coast, is more and more popular for tourism and recreation and these kind of activities seams to be the most important sectors to realise ICZM. Boundaries changes till 1945, political changes and lack of democracy mechanisms in former time as well as lack of coastal education, actual short-time political influences make ICZM procedures very difficult. Still the spatial planning on the level of local communities is not clear in the coastal zone. There are some drastic examples illustrated the results of such a situation: wrong seawalls localisations, destruction of parts of valuable coasts because of too intensive tourism development. On the other hand there are some positive examples, where compromise is possible and NGOs (as EUCC-Poland) can be a good platform to realise many aspects of ICZM in Poland.

1 Introduction

In Poland, as in all CEEC end of the XX century has brought dramatically new situation in mostly from the sectors of human activities. In Poland economical crisis, political un-stabilities, lack of the experience of democratically functioning of the State had to be observed also in coastal zone management.

From the other hand should not to be forgotten, that after 1945 the “location” of the country has been significant changed. Poland lost its traditional eastern part, but new boundaries covered part from the former Prussian properties, including coastal zone. From less then 200 km before 1939 to more then 800 km in 1945 of coastline.

For creation national policy, administration structure and simple land using these aspects had and have a very important role.

Integrated Coastal Zone Management, understand as an on-going process, system of compromises, need a long-term procedures and common acceptation of the evident factor that for longer perspectives only the nature can regulate human activities and needs in this area.

2 Characteristic of the Polish coastal zone

2.1 General description of the Polish Coast

Since over one hundred years the Polish coast of Baltic Sea has been investigated by a number of scientists and scientific institutions, so the scientific recognising can be define as good, special in the light of coastal management needs.

Actually the total length of the coast is around 843 km, where about 500 km is an open sea coast, 241 km is coast if Szczecin Lagoon and 102 km is Vistula/Wisła Lagoon. This typical soft coast consists of about 52% of dune coast, about 28% of flat, organic coast and about 20% of cliff coast.

The Polish coast was formed at the end of the Pleistocene and modified up to now from Holocene period. For the shape of the landscape and current or on-going coastal processes the most important influence took place during Litorina transgression in the Atlantic period. As typical soft coast its shape is a result of numerous factors:

- hydrodynamics factors (as water level oscillations connected with air circulation)
- wind waves
- long shore currents and coastline exposure in connection with prevailing wind direction and velocity.

Of course morphology and geological structure has made a great impact to actual coast stage. The Polish coast includes:

- coastal dunes, partly with sandbars,
- coastal cliffs mostly active,
- delta plains,
- coastal lakes and lagoons,
- rivers estuaries
- urban areas

It is worth to mention, that nearly 90% of coast belt is covered by forests, of course out of the human developed areas.

According to existing data (f.e. published by Maritime Office) about 50% of dune area and more then 65 % of cliff shores as well as more then 70 % of other coastal formation have been changed and devastated thanks to the man activities.

Coast is protected against erosion with using traditional methods and techniques. On the total length of about 120 km can be found: groins, seawalls, bulkheads and in some parts (as popular summer villages and resorts) coast is protected by artificial beach nourishment.

From the other hand a very important part of Polish coast still represents a high biodiversity and landscape values characteristic for soft coast of un-tidies sea.

From XIX century human activities started to change and disturb natural balance and coastal dynamics. It is special clear to study near mouth of rivers as Wisła/Vistula, Łeba, Słupia, Parsęta, Rega and Odra (as a complex of Dziwna, Świna and Penne in German part of Szczecin Lagoon). Here are located not only harbours and shipyard industry (special active till late 80. of XX century), but the most popular and developed tourism centres.

2.2 Historical aspects

To understand actual problems with coastal management a glimpse to the historical aspects must be done. As has been mentioned, Polish coast in actual boundaries has existed since 1945. Before Second World War boundaries had been changed many times, according to historical and political changes in the country, wars and alliances. Generally however, there is no tradition reflected to the coastal management or rather lack of historical aspects.

Nearly revolutionary changes connected with economic development observed from the beginning of XX century, understand in the coastal zone also as a modern administration, till 1945 was reduced to the area of Gdańsk Gulf and about 50 km of the open sea area of the coast in Poland. Later, political system of communism did not got any chances for development of coastal management on local level administration and local individual initiatives. This aspect could have a positive reflection for actual situation.

2.3 Administration and responsibility authorities

Poland is from the administration point of view divided into 16 voivodships (provinces), from which 3 are located on the coastal area: West-Pomeranian, Pomeranian, Varmian-Masurian. The regional administration is represented by counties, which place a key role in self-governing system of Polish democracy. Among 370 counties 18 from them are connected with coastal areas.

For the coastal management a very important role should play local community. There are about 2.480 local communities, and 52 are located along Baltic Sea coast.

But according to existing law and because of actual state ownership of the coastline, and adjacent narrow strip there is one organisation responsibility for coastal zone management. On behalf of State and under Ministry of Infrastructure, Maritime Office is a body realising state policy and responsibility for administration, spatial planning protection and possible development here. Maritime Offices are located in Szczecin (west part of the coast and Szczecin Lagoon), Słupsk (middle coast) and Gdynia (east coast, Gdańsk Bay and Vistula Lagoon).

3 Basis for Coastal Zone Management: existing law

3.1 Definition of the coastal zone

There is no legal definition of the coastal zone, as well as there is no legal definition of ICZM. But in the group of Acts and State Regulations there are some definitions which can be very helpful in any kind of works connected with coastal zone management. The most important definition connected with coastal zone has been given in The Act on Marine Areas of the Polish Republic and Maritime Administration (1991). In this Act a protected coastal strip is established. It comprises:

- Technical Belt
- Protective Belt

Technical Belt extends up to 200 m inland. It depends of the type of coast and can be more narrow in active moraine cliffs, but also can be increased to 1.000 m in some from the flat part of the coast. The specific situation of urban areas forces to reduce Technical Belt to the area of beach and narrow strip of dunes (or rather in many places the rests from them). All kind of investments here must have approval from the Maritime Office, responsibility on behalf of State

Protective Belt can be wide up to 2.000 m inland and on some areas can be increased to 5.000 m. Of course in urban areas Protective Belt is significantly reduced or even practically is not existing. Here any kind of investments must be consult with Maritime Office.

3.2 Legislation

As there is no specific legal definition of the coastal zone and there is no separate national legislation for the ICZM. In that case any works connected with possible strategies and any from the planned and undertaken activities and initiatives must take into the consideration a group of Acts and Regulations. The list of the most important contains the following:

- The Act on Marine Areas of the Polish Republic and Maritime Administration (1991)
- The Act on Establishing Long-term Coastal Defence Programme (2003)
- The Act of Nature Conservation (1991, with changes made 2000 and new Act 2004)
- The Water Law Act (1974, under revision)
- The Environmental Law Act (2001)
- The Act on The Environmental Protection and Development (1994)
- The Act on The Forests (1991)
- The Act on the Protection of Agricultural and Forest Lands (1995)
- The Act on Access to Information on the Environment and its Protection and on Environmental Impact Assessments (2000)

- The Geological and Mining Law Act (1994)
- The Hunting Law (1995)

The other group of regulations and legislation is relevant to the spatial planning and it can have an important influence for ICZM. Here should be listed the following:

- The Act on Municipal Self-Government (1990)
- General Building Regulations (1997)
- The Physical Development Act (1994)
- The Concept of National Spatial Development Policy (2000).

4 Basis for the Coastal Zone Management: spatial planning in the coastal zone

The political changes in the beginnings of 90. of XX century have made a new possibilities to create “down – top” system of the spatial planning. However lack of financial sources and experiences among local stakeholders of local communities reduced these chances. For the coastal zone influence of the Maritime Office in the boundaries of urban area since about 1990 also has been thanks to the new law system reduced for the spatial planning on the local or county level.

The existing law as: The Act on Municipal Self-Government (1990), General Building Regulations (1997), The Physical Development Act (1994) and The Concept of National Spatial Development Policy (2000) regulated the system of planning, but in practise on the level of local communities has been usually not implemented yet. Local communities have prepared a basis for local spatial plans, called “Local Development Spatial Strategies” or “Studies and Conditions for Local Spatial Plans”. For the coastal zone the most important functions and development restrictions are described here. For some such a studies the zoning of the coastal area have been also prepared.

5 Basis for the Coastal Zone Management: coastal nature conservation

5.1 Structure and organisation of coastal nature conservation

Generally the provincial governor (“Wojewoda”) is on behalf of State responsible of the introduction of various forms of nature conservation and for their management. Only national parks are straight under management of Ministry of Environment. On the level of local community some forms (as ecological uses) can be held, but they must have a State approval.

Mostly from forests covering coastal zone are the property of State Treasury and for their management are responsible Regional Forests Authority. It is very important, that all forests in that zone are called as “protective forests”, what means reduces of their economical uses.

They will be also possibilities to create NGOs private protected areas, but legal position of this form is not described by law so far.

All protected areas should have their “Nature Conservation and Management Plan” and for mostly of the areas such documents have been prepared or they are under preparation. The plans for national parks must be approved by Ministry of Environment.

5.2 Protected areas in the coastal zone

Various forms of protected areas in the coastal zone in Poland cover in total more then 154.000 ha, what is almost 0,5 % of the country’s area.

There are two National Parks:

- Słowinski National Park with total area of nearly 33.000 ha, including 11.100 ha of the Baltic Sea waters,
- Woliński National Park with total area of nearly 11.000 ha, including 2.200 ha of the Baltic Sea waters.

There are five Landscape Parks:

- Szczeciński Landscape Park with total area of 9.000 ha
- Nadmorski Landscape Park with total area of 15.500 ha
- Trójmiejski Landscape Park with total area of 20.100 ha
- Vistula Spit Landscape Park with total area of 4.400 ha
- Elbląg Upland Landscape Park with total area of 13.500 ha

The other form of protection is Protected Landscape Area. There are 5 such areas in the coastal zone:

- Koszalin Coastal Belt (48.300 ha)
- Coastal Belt west of Ustka (7.500 ha)
- Coastal Belt east of Ustka (3.300 ha)
- Area of Protected Landscape of Vistula Lowlands (5.300 ha)
- Area of Protected Landscape of the River Bauda (2.100 ha)

Many nature reserves with different kind of flora and fauna species, as well as plant communities are also located in the coastal zone.

There is also planned to be established a first private protected area in Poland, called preliminary as "Odra Delta Nature Park" and covering approximately 2.000 ha on the east part of Szczecin Lagoon. The main owner of the grounds is EUCC-Poland.

6 New instrument for coastal zone management in Poland

In 1996 started a discussion connected with new strategy for the coastal protection, which should be an important law instrument in planned coastal zone management strategy.

At the beginning was planned that this document will describe relations between nature values, possible development and sources needed to coastal protection against erosion. After couple of years has been quite clear, that such a document will have only a technical character, as a long-term coastal technical guidelines.

In 2003 Parliament approved a new law called: "The Act on Establishing Long-term Coastal Defence Programme". Unfortunately this act is only for describing the investments which are necessary to realise protection of the coast only against erosion. It is very important that this "strategy" has been prepared for all-long Polish coast, but its weak point is, that is only a technical guidelines for many areas not sustainable at all. The artificial nourishment seems to be the most important method to reduce erosion, which is recommended by this guidelines. For many places however, there are not enough sandy material to be deposed on the destroyed beaches. There are too many heavy constructions planned in guidelines too. The places which have been left to the succession of natural processes covers about 200 km from the whole coastline, including the area of national parks of course. The planned financial sources for years 2004 - 2023 will come from National Budget and has been calculated on the range of 200.000.000 EURO.

This document has not be consulted with larger group of experts, as: nature conservation managers, scientists and practitioners connected with coastal zone.

7 Tourism and recreation

Even from the XVII century in some parts of Polish coast tourism and recreation have been known as a possible income generation for the local inhabitants. But as a part of local economy tourism and recreation have started to be understand as important element since late 50 of XX century. The rapidly growing of investments as hotels, summer houses, camping areas and all connected facilities have a significant influence for any kind of policy in local level and regional level. Till now sustainable development is as the last point to be discussed in spatial planning procedures. There are many examples that even Generals Architects from Provinces Offices trying to make changes in conservation and management plans connected with nature valuables area, where could be a good location for new hotels or pensions. The number of not legally built summer houses in the coastal zone is even every year higher.

As the result is worth to mention that about 30% of tourist investments in Poland are located in coastal zone and every year the open sea beaches of Polish coast (about 500 km) are visited by more then10 million guests, mostly between middle of June till end of August.

8 Case studies

Integrated Coastal Zone Management in Poland is not existing so far. Moreover: there is no clear strategy how to achieve ICZM as a long-term process. That is a result of first of all weak democracy mechanisms in decision making procedures, but also result of very low education which in practise is not given to the local actors and stakeholders. Some case studies can also illustrate how ICZM is realise in practise.

8.1 Heavy constructions and their influence for coastal zone management

There are some examples of investments realise during even last 10 years, when there have been started a lot of discussion around integrated coastal zone management. The most drastic is location of seawall in Jastrzębia Góra. Here is located a very interesting example of he moraine cliff, eroded since thousands years. Till late 90. of XX century a delicate compromise between nature and human development has been “established”. Some locations of the hotels however (special built between 1970 and 1980) was not sufficient prepared in the stage of collecting documentation or because of the political aspects have been realised without necessary permissions and morphological documentation. At the end of the day, after about 20 years one of the hotels (belongs to the Ministry of Treasure) found itself at the zone possible to be eroded by natural sea processes. There was no any discussion with specialist representing nature science and practise, there was no discussion with local community and there was no respectation to the existing law. The heave construction has been built, but probably it will not stop erosion at this place and for sure will increase erosion, special west from the built seawall.

The questions are: how far one institution can decide about such an incidents and how political influence can destructively influence for coastal management?

8.2 Active nature conservation a new challenge for ICZM

There are special areas located on Polish coastline zone with still very high nature values, but also very attractive to create new forms of local development in sustainable way. From 1996 EUCC-Poland has started a unique long-term project to protect the most valuable parts of Szczecin Lagoon (Odra Delta) and to promote ecologically sustainable development. The goal is to integrate environmental protection with economic development. For that reason the strategically located land have been bought (1.000 ha so far), which are representing typical coastal meadows and wetlands. For these areas a management visions and the backgrounds for management plans have been prepared, including nature inventory and feasibility studies for sectoral local economical development. Some parts of the areas have been actually prepared for extensive agriculture, what can be understand as re-vitalisation of the area. Here are again implemented various breeds of primitive cattle and wide horses and hay production was started. The area is under preparation for ecological tourism and education not forgetting about nature reserve places, special focused for wetland birds.

The plans and results are couple of time a year discussed with local stakeholders and local community managers, scientists and local inhabitants. The social actions is also provided to improve “post-colhos” life style.

It is important that area is designated to NATURA 2000 European Network.

9 Conclusions

The problems of Integrated Coastal Zone Management in Poland can be concluded in several points.

1. The historical importance of Maritime Office as responsible body for coastal conservation is undisputed. Thanks to activities lead by this institution many from the Polish coast is still valuable.
2. There are a good law background for nature conservation, special in the particular areas designated to be protected or which are protected.
3. Establishing "The Act on Establishing Long-term Coastal Defence Programme" State has got a very important financial document and technical guidelines to keep position of Maritime Offices as the most important actor for coastal zone management, however this act and guidelins can not be understand as ICZM document.
4. There are lack of coastal education on the level of local communities, which could be very helpful in implementation of integrated coastal zone management procedures.
5. The role of NGOs as a partner is still very low. Some of such a bodies as EUCC-Poland decided to create a model areas of sustainability as examples of ICZM in local scale, close to the particular types of the coasts.

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National ICZM strategy and initiatives in Lithuania

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Abstract

Lithuania has one of the shortest shoreline among European countries. Lithuanian coastal zone belongs to the southeast Baltic region of graded coasts, which took their present shape during Pleistocene and Holocene. The shoreline is relatively stable. From the administrative point of view it is very convenient that the entire coastal zone of Lithuania belongs to one (Klaipeda) county. There are no special agencies or institutions in Lithuania, which were responsible for planning, implementation and evaluation of ICZM. In recent years Lithuanian coastal zone management policy could be characterized by a very positive breakthrough. The Law of the Coastal Zone was adopted by the Lithuanian Parliament on July 2, 2002. It was followed by the National ICZM Programme, which was approved by the Ministry of Environment in September 2003. The Lithuanian mainland coastal zone between Klaipeda Seagate and the Latvian border is delimited by at least 100 m wide belt stretching from the mean water level mark landwards. This belt must definitely encompass the beach, the coastal cliff, the foredune and the hinterdune. The Lithuanian coastal zone also encompasses the entire Curonian spit from Klaipeda Seagate to the Russian border. The seaward boundary of the coastal zone is limited by the 20 m depth line. The main ICZM principles as described in the National Coastal Zone Management Programme are: 1. Conservation of natural coastal landscapes and coastal processes. 2. Integration of coastal conservation and coastal use objectives. 3. Littoral cells approach. 4. Differentiation of coastal management measures according to specific priorities for coastal conservation and wise use on a particular coastal strip. 5. Monitoring of coastal processes.

1 Introduction

Lithuania is located on the south-east coast of the Baltic Sea (Fig. 1).

Figure 1: Lithuanian Baltic coast can be described as a combination of microtidal sedimentary coastand soft rock coast. Within these major coastal types coastal formations and habitats of sandy beaches with bare and vegetated sand dunes prevail.

It is predominantly continental country with only 90 kilometres of the marine coastline. Only three other European countries - Montenegro, Slovenia and Belgium have a shorter marine coastline that the one of Lithuania.

In spite of the short length of the waterfront, the coastal zone of Lithuania encompasses a vast and very diverse coastal region with sand dunes, estuaries, large river delta and coastal lagoon. Therefore the integrated coastal zone management approach in the Lithuanian case covers a wide range of issues and target areas - from conservation and maintenance of pristine deltaic nature reserves located 60 kilometres inland from the coast to the development of industrial sea ports and seaside resorts.

2 Description of the Geographical Area

Lithuanian coastal zone belongs to the southeast Baltic region of graded coasts, which took their present shape during Pleistocene and Holocene. Within this strip of coasts, which stretches northwards from the Cape Taran in Sambian peninsula deposits of glacial and marine sand accumulation prevail.

Four different dynamic types of coasts could be distinguished along the Lithuanian Baltic coast.

- Slight accretion prevails between Nida and Juodkrante. Shoreline is relatively stable there. The beach is relatively wide, covered by medium-sized sand grains with admixture of gravel. It is framed by the 6 to 8 m high artificial foredune. Nearshore is relatively shallow. It has sandy bottoms with *Macoma baltica* communities. Glacial deposits appear on the bottom surface at the depth of 16-18 m, i.e., in the euphotic zone. The foredune is covered by marram grass, sea rocket and other perennial grasses, while the dune blow-outs are overgrown mainly by willows. The foredune was artificially created in the 19th century in order to protect coastal villages from the devastating sand drift. It stretches along the entire Lithuanian Baltic coast except few places north of Klaipeda.
- The coastal strip between Juodkrante and Melnrage is characterized by a relatively strong accretion. The average advance of the shoreline to the sea is up to 2 m there (except the places adjacent to the Seagate of the Klaipeda harbour). The beach is wide (50-70 m), covered by a well-sorted medium-sized sand. It is framed by a 12 to 14 m high artificial foredune. The nearshore is very shallow, it has sandy bottoms with *Macoma baltica* communities down to the 20-30 m depth.
- The coastal strip between Melnrage and Nemirseta is characterized by a moderate erosion and shoreline retreat up to 1 m annually. Glacial coastal scarps and bluffs prevail here covered with the sand of the Holocene Aeolian accumulation and forming coastal formations, which are unique for Lithuania. A steep ancient slope of the Holocene marine terrace formed by the Litorina sea transgression forms another important coastal landscape amenity with numerous coastal wetlands, rivulets and dense mixed old forest plantations. It gradually descends down northwards and southwards from the parabolic dune of Olando kepure, where it reaches 25-29 m altitudes. The height of the coastal cliff near the Olando kepure is up to 24,4 m high at Karkle. The cliff is active, not covered by vegetation, with numerous traces of landslides and landslips, fallen trees and sliding bushes. A relative height of the ancient slope of the Holocene marine terrace varies from 8 to 11 m. The beach in the strip between Melnrage and Nemirseta is relatively narrow, 15-25 m wide, covered by mixed sediments, where the gravel prevails with admixture of medium-sized sand, pebble and boulders. The nearshore is relatively steep, covered by fine sand, it has a hard bench of boulders, pebble and gravel. Here on the varied hard bottom sediments covered by the communities of *Mytilus edulis* with the sufficient penetration of sunlight the most favorable conditions form for the greatest biodiversity in the entire eastern Baltic Sea area. Therefore this area is one of the most important spawning places for the Baltic herring. Below the hard bottom area in the aphotic zone of 25-30 m depth the conditions for the marine life are much worse.
- North of Nemirseta the grading of the coast during the series of the Baltic Sea transgressions all through the Holocene created favorable conditions for sand accretion. The shoreline is relatively stable (except the places adjacent to the Palanga pier and Butinge wastewater discharge pipeline). The beach is relatively wide (50-90 m), covered by a well-sorted medium-sized sand. The beach is framed by the 3 to 6 m high artificial foredune. The foredune is covered by marram grass, sea

rocket and other perennial grasses, while the dune blow-outs are overgrown mainly by willows. The nearshore is relatively shallow, it has sandy bottoms with *Macoma baltica* communities. Glacial deposits appear at the bottom surface at the depth of 4-6 m, i.e., still in the photic zone. Here also on the varied hard bottom sediments covered by the communities of *Mytilus edulis* with the sufficient penetration of sunlight favorable conditions form for the biodiversity. Therefore this area is also among the most suitable spawning places for the Baltic herring. Behind the foredune there is an ancient coastal accumulative plain covered with the sand of the Holocene Aeolian accumulation. The terrace is covered by numerous coastal wetlands, rivulets, pine-forest plantations. The major landmarks of this area are two parabolic dunes: Birute hill and Nagliai hill reaching 20 m altitude.

3 Results

3.1 Management of the Lithuanian Baltic coast

From the administrative point of view it is very convenient that the entire coastal zone of Lithuania belongs to one (Klaipeda) county, which consists of seven municipalities. Five of them (Klaipeda, Palanga, Neringa, Gargzdai and Silute) are located on the Baltic Sea and / or Curonian Lagoon coast.

There are no special agencies or institutions in Lithuania, which were responsible for planning, implementation and evaluation of ICZM. In the entire coastal zone of Lithuania, the interests of the state are represented by the Klaipeda County Governor's administration. Within their competencies, the territory of the coastal zone is administrated by the above mentioned five coastal municipalities.

Coastal (like any other) municipalities have the right to develop master and detailed spatial plans for their territory, which legally permit sectoral or integrated development in the coastal zone. However these two (master and detailed) spatial plans, and, through them, interests of municipality and private persons must be set in accordance with the state interests. These interests are pursued by the county administration and administrations of the state parks.

There are established three state parks in the coastal zone of Lithuania, i..e, protected areas with their own administrations, which are responsible to the Ministry of Environment (Kursiu nerija national park, Pajuris (Coastal) regional park and Nemunas delta regional park). They altogether cover app. 70% of the total coastal zone area. The administrations of the state parks in their activity must follow master plans of these protected territories, which have to be approved by the Government.

On the county level, integration of the coastal management through the supervision of spatial planning procedures is ensured by the spatial planning department of the Klaipeda County administration. Klaipeda County administration also arranges state and county planning process, which is the main legal tool for integration of coastal management, as well as for any other regulations, conservation and development related to the coast.

On the state level integration of coastal management is ensured by several departments at the Ministry of Environment. Of these Service Protected Areas, and the Department of Spatial Planning are the most relevant to the ICZM.

3.2 Legislation and policies of Lithuania relevant to coastal management and planning

In recent years Lithuanian coastal zone management policy could be characterized by a very positive breakthrough. The Law of the Coastal Zone was adopted by the Lithuanian Parliament on July 2, 2002. It was followed by the National ICZM Programme, which was approved by the Ministry of Environment in September 2003. Such radical measures were taken after series of devastating erosion events on the Lithuanian coast. Particularly devastating was the hurricane "Anatole" of December 1999 which had nearly swept away the beaches along the entire coastal zone of this country. The economic damage of "Anatole" upon the Lithuanian seacoast is given in Table 1.

Locality	Amount of damage	Description of damage
Smiltyne	120’000 EUR	Eroded seaward slope of the foredune on 5 km strip (200 thou. cub. m of sand washed away), destroyed stair and paths leading to the beach
Melnrage-Giruliai	100’000 EUR	Eroded seaward slope of the foredune on 4 km strip (150 thou. cub. m of sand washed away), destroyed stair and paths leading to the beach
Karkle	130’000 EUR	Eroded seaward slope of the foredune on 3 km strip (1 km of the foredune completely erased)), 50 thou. cub. m of sand and 15 thou. cub. m of till washed away, destroyed stair and paths leading to the beach
Palanga	430’000 EUR	Eroded seaward slope of the foredune on 10 km strip (1 km of the foredune completely erased)), 500 thou. cub. m of sand washed away, damaged promenade pier, destroyed stair and paths leading to the beach
Sventoji	170’000 EUR	Eroded seaward slope of the foredune on 14 km strip (350 thou. cub. m of sand washed away), destroyed stair and paths leading to the beach
TOTAL	950’000 EUR	Eroded seaward slope of the foredune on 36 km strip (2 km of the foredune completely erased), 1250 thou. cub. m of sand and 15 thou. cub. m of till washed away, damaged Palanga promenade pier, destroyed stair and paths leading to the beach

Table 1: Damage inflicted upon the Lithuanian coast by the December 4, 1999 storm

According to the Lithuanian Law of the Coastal Zone (2002) the objectives of the coastal zone management in Lithuania are the following: 1. To use wisely and to protect landscapes and rare species habitats of the Curonian spit (a World Heritage Site) and the Lithuanian mainland coast. 2. To ensure a sustainable use of the coastal zone for public and state needs. 3. To ensure conservation of coastal nature and culture heritage. 4. To provide favourable conditions for public use of coastal amenities for leisure purposes.

The Lithuanian coastal zone is delimited by at least 100 m wide belt of the mainland coast between Klaipeda Seagate and the Latvian border stretching from the mean water level mark landwards. This belt must definitely encompass the beach, the coastal cliff, the foredune and the hinterdune. The Lithuanian coastal zone, according to the Law also encompasses the entire Curonian spit from Klaipeda Seagate to the Russian border. The seaward boundary of the coastal zone is limited by the 20 m depth line. The land and the sea within the coastal zone is in the exclusive public property and belongs to the state, except those private lots of land, which have been established before the Law came into force. However these private lots should not be fragmented for sale, lease, mortgage or any other commercial use. The state has the priority right to buy those lots from the private owners.

An integrated management of the coastal zone, according to the Law, is ensured by the following spatial planning documents: 1. Special management plan of the “Kursiu nerija” national park. 2. Special management plan of the mainland coastal zone. 3. Master plans of Klaipeda and Neringa urban municipalities. Detailed plans of urban and rural settlements or parts of settlements within the following municipalities: Neringa, Palanga, Klaipeda urban and Klaipeda rural.

Any new exploitation of underground resources or new construction is fully forbidden within the entire Lithuanian coastal zone. Only reconstruction or regeneration of the existing buildings, or those buildings which are proved to exist in the past, or limited construction of small-scale seaside leisure amenities is allowed within the limits of the coastal zone. A permit for such intervention into the coastal zone can be issued by the Klaipeda Governor’s Administration only after the obligatory public hearings and environmental impact assessment. Every permit must be finally approved by the Lithuanian Government (sic!). Any intervention into the coastal zone must ensure, that there will be no changes in the bottom topography and sediment drift conditions, which might negatively affect neighbouring coastal strips. In order to assess long-term trends and changes in coastal zone development there should be introduced a comprehensive coastal monitoring system.

According to the National Coastal Zone Management Programme (2003), which was approved by the Ministry of Environment in September 2003, several important coastal management measures are anticipated, which are aimed to ensure introduction of ICZM principles.

The main ICZM principles as described in the National Coastal Zone Management Programme are: 1. Conservation of natural coastal landscapes and coastal processes. 2. Integration of coastal conservation and coastal use objectives. 3. Littoral cells approach. 4. Differentiation of coastal management measures according to specific priorities for coastal conservation and wise use on a particular coastal strip. 5. Monitoring of coastal development.

It is important to emphasize, that Lithuania is probably the only country in Europe, where the ICZM strategy for the whole seacoast within the national borders is based on a littoral cell approach. For that purpose the Baltic coastal zone of Lithuania is split into eleven management units and different ICZM measures are applied to various units. In all cases the priority is given to the conservation of natural coastal processes, following the HELCOM Recommendation 16/3 (1995).

The most opted coastal protection policy in Lithuania is limited intervention through coastal foredune and forest management, as well as through the submerged nourishment aimed to stabilize the coastal zone, particularly the recreational beaches. To fight coastal erosion, all forests and foredune ridges of the coastal zone have been classified as protected and preserved.

Coastal forests and dunes being the integral part of the coastal belt enjoy protection within the general nature conservation framework (Riepsas 1995; Stauskas 1995). They are, according to the Law on Forests, specifically regarded as a protected category. The foredune is regularly maintained and restored after every season of autumn and winter storms. Any new constructions in the coastal zone are allowed only behind the foredune. Maintenance of coastal foredune and forest plantations (restoration, fastening and revegetation of the foredune with marram grass and hybrid marram grass) is the principal technical coastal stabilization measure (Figure 2). It is a joint responsibility of local municipalities and administrations of Kursiu nerija national park and Pajuris regional park.

Application of sand, which is dredged from the Klaipeda Seaport gate for the submerged nourishment of the coastal zone in the nearshore is recommended as another important coastal stabilization measure applied at the mainland Baltic coast of Lithuania (Figure 3).

Figure 2: Eroded foredune fastened with fences and fascines in Pajuris regional park. Photo: E. Paplauskis, June 2001

Figure 3: Submerged nearshore nourishment at the Lithuanian mainland coast. Photo: V. Kaunas, April 2001

The only site along the entire Lithuanian Baltic coast, where “hard intervention” is recommended in the national Coastal Management Programme, is at the Palanga promenade pier, where the old jetty, which was removed in 1997, should be restored for shoreline and beach stabilization purposes.

4 Conclusion

Summarizing, we can claim that Lithuania currently possesses probably the most comprehensive ICZM policy instruments in the entire Baltic Sea region. Lithuania has relatively short coastline and rather well geographically expressed coastal region (or coastal zone in a broader sense). Therefore, its whole coastal management and planning system can serve as a good example of ICZM on the country level (Kavaliauskas 1995).

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National ICZM strategies in Estonia

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Abstract

Problems connected with the protection and management of aquatic systems are of high priority in Estonia. Concerning aquatic environments, in the Estonian National Environmental Strategy (adopted in 1995) protection of surface water bodies and the coastal sea from pollution are the main goals. The legislation background has been created, several international projects completed or in progress. In general, the condition of the environment is good in Estonia. Compared to the 1980s, the discharge of nutrients has decreased more than twofold. The Environmental Strategy 2010 is based on the principles of sustainable development and corresponds to the EU recommendations. The strategic priorities are limitation of pollution of marine waters, conservation of biological diversity of aquatic organisms, implementation of means for protection of coastal sea, sustainable use of exploitable resources and development of their advanced investigations with integration of ecological factors in the final results.

1 Introduction

The length of Estonian coastline is 3794 km (Figure 1). In addition, there are 1200 lakes in Estonia, including Lake Peipsi, the most productive lake in fish in Europe. Therefore, problems concerning protection and management of aquatic systems are of high priority in Estonia. The Estonian zone in the Baltic Sea involves areas in the open part of the Baltic, in the Gulf of Finland and the Gulf of Riga. The species richness is the highest in the Väinameri area which involves a multitude of islands of various size and marine habitats of different depths and bottom types. Biological production in the Gulf of Riga, Väinameri and in some areas in the Gulf of Finland is high, partly due to anthropogenic eutrophication.

The Baltic Sea is a unique young brackish-water body in the stage of rapid development. Its biota has developed after the last glaciation, since 15 000 – 9000 years BP. Due to the shortness of the development no indigenous species have formed in the Baltic Sea. Therefore, the population level should be preferred in protection of biological diversity in this sea. In addition, exploitable resources should be assessed and managed by natural systems (local populations) to allow their sustainable management.

Estonian annual fish catches from the Baltic Sea have increased from below 20 000 tonnes before 1940 to over 50 00 tonnes in the middle of the 1950s and to the top catches exceeding 95 000 tonnes in 1976 and 1997 (Figure 2). They have consisted mainly of herring and sprat. Cod had a substantial part in landings during 1980-85. Other important species in Estonian fishery are flounder, smelt, pikeperch, perch and, in Lake Peipsi, lake smelt. The success of fishery in the Baltic Sea is important for Estonian economy. Fishery is the main engagement in many coastal regions. The importance of tourism and recreation is growing. In 1996 the Estonian Ecotourism Association was founded with the aim of propagation sustainable small-scale nature-friendly tourism and dissemination of corresponding knowledge. This form of tourism is thought to be the most acceptable in Estonia.

Figure 1: Estonian waters in the Baltic Sea.

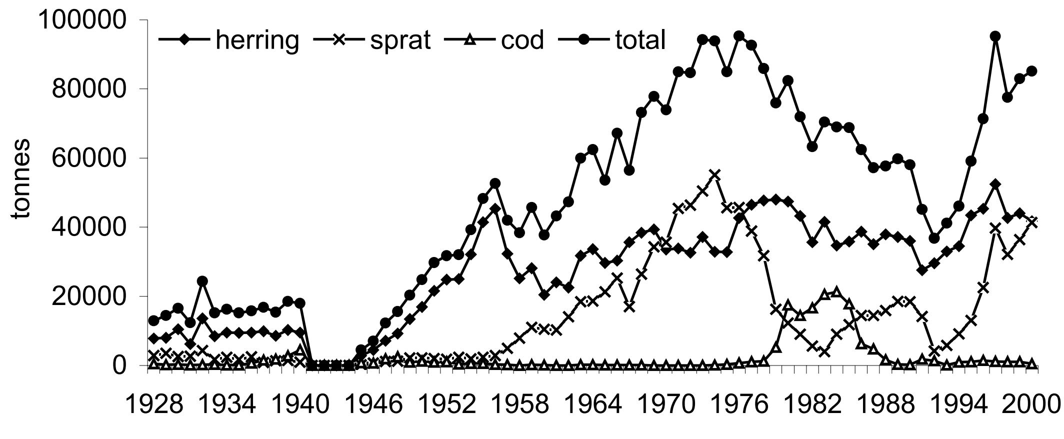

Figure 2: Estonian fish catches in the Baltic Sea.

2 ICZM in Estonia

2.1 General strategy

The Ministry of the Environment is responsible for the environmental and nature protection policy. The Estonian National Environmental Strategy has been adopted (1995). Concerning waters, the main goal has been protection of surface water bodies and the coastal sea from pollution, including combating oil spills.

For legislation background the following acts have been adopted: Act on Sustainable Development (1995), Water Act (1994), Pollution Charge Act (1999), Act on Protection of Marine and Freshwater Coasts, Shores and Banks and Act on Environmental Impact Assessment (2000).

As early as in 1989 the West Estonian Archipelago Biosphere Reserve was created. This has facilitated regional planning and the composition of nature protection programmes. Today more than 20% of Estonian coasts are protected as national parks, nature protection areas etc. Most of small islands have some protection status (HELCOM 2003).

2.2 Projects

- The following projects concerning ICZM have been completed (HELCOM, 2003):
- Establishment of the Tallinn Waste Water Treatment Plant (1998). The project was started in 1992 as the Finnish-Estonian joint project. It has resulted in a clear recovery in the algae belt (incl. bladder wrack) in Tallinn Bay. The situation in bathing beaches has considerably improved.
- The Environment Project of Haapsalu and Matsalu Bays that involved, *inter alia*, rehabilitation and expansion of the water and wastewater system of Haapsalu town.
- The project *Väinameri* was started in 1998. Its main objective was implementation of an integrated coastal zone management plan developed by a HELCOM working group for management of concrete areas.
- The Estonian Pilot Project: *the Hiiumaa Island*, with the main goal to test functioning of the ICZM model at county and municipal planning. As a result of this project the ICZM information centre was established at Kärdla town, Hiiumaa. This was estimated to be an important institutional achievement of the pilot project.
- The Water Constructed Infiltration Wetland System at Häädemeeste. The system created for about 1000 inhabitants village represents a sustainable way of reducing nutrients and pathogen load to the area of the Baltic Sea (the east coast of the Gulf of Riga) important for recreation and tourism.
- The ICZM Programme for the Baltic States and Poland (1997-2000) based on satellite image and GIS, for better management of coastal resources.

However, implementation of the six international projects listed below is continuing:

1. The *BEST Project* (Sustainable Tourism Development for B7 islands: Bornholm, Gotland, Hiiumaa, Saaremaa, Rügen, Aland and Öland) enchancing the exchange of experience for cooperation an sustainable development of tourism.
2. The *SUSWAT* (the project on the water supply in relation to environmental protection and sustainability, with a linkage to the *BEST* programme) facilitates the exchange of knowledge between the B7 islands in planning and management of water supply.
3. The *3 + 3 Local Agenda*, a part of a wider project between three counties both in Finland and Estonia. Concerning coastal areas, experience in planning and management of sustainable development of coastal regions and islands, are considered.
4. *The Narva Watershed Research Programme*, also participated by Sweden, Norway and Russia. The project is aimed at the development of the Narva River Watershed Management Plan.
5. The *Käina Bay Project* is supported by HELCOM. The main aim was to contribute to an ecologically sustainable development of the coastal region. It was agreed to consider this project under the framework of the Gulf of Riga Task Area (1994).
6. *The Joint Comprehensive Environmental Action Programme for the Baltic Sea* (JCP). The programme was adopted in 1992 to constitute a Strategic Acton Plan for the Baltic Sea region. The Global Environment Facility and World Bank as well as the countries of the region (including Estonia, Latvia, Lithuania, Poland and Russia as the recipients) and some other governments participating for restoration of the ecological balance of the Baltic Sea ecosystem (HELCOM 2003).

3 Estonian Environmental Strategy 2010

In this document the following strategic priorities have been listed, aiming at amelioration of the ecological status of the coastal sea and improvement of possibilities for reproduction of fish resources and aquatic organisms (Anon. 2003):

1. Limitation of marine water pollution,
2. Biological and chemical treatment of waste waters,
3. Collection of wastes from ships,
4. Conservation of biological diversity of aquatic animals,
5. Prevention of pollution of the coastal sea with dangerous compounds,
6. Limitation of nutrients input into the coastal sea.

It has been foreseen that up to the year 2010 the following should be achieved:

- establishment of water quality categories for the coastal sea,
- establishment of means for sustainable utilisation and protection of the coastal sea,
- application of environment-friendly technology,
- improvement and the increase of the efficiency of monitoring programmes,
- application of means for sustainable exploitation and protection of the coastal sea, achievement of good condition of the coastal sea,
- capability of fighting big disasters and environmental accidents.

Also,

- ecosystem-based management of fish resources should be introduced,
- habitats and spawning areas of fish and crayfish should be restored, access to spawning places established and the reproduction protected,
- abundance of protected fish species should be increased to create possibilities of their exploitation,

The strategic priorities in the protection and management of aquatic resources planned to implement up to 2010 are as follows (Anon., 2003):

- conservation of the diversity of aquatic organisms,
- optimum exploitation of fish resources,
- up to 30% decrease in fishing effort,
- integration of ecological factors into the results of investigations of fish resources,
- restoration of habitats and spawning areas of fish and crayfish,
- plantation of water bodies with endangered and valuable fishes,
- prevention of introduction and distribution of non-indigenous species in Estonia.

4 Discussion

It has been estimated that in general, the condition of environment is good in Estonia. Compared to the 1980s, the discharge of nutrients from Estonia into the Baltic Sea has decreased more than twofold. As a result in the wastewater purification and restriction of pollution of marine waters from ships and other sources, ecological situation in Tallinn Bay and other areas of Estonian coasts has notably improved. A substantial part of macrovegetation has recovered and the biodiversity increased. The deviations in the Pärnu River and Pärnu Bay ecosystems induced by a long-term pollution of Pärnu River from a Soviet air base have gradually decreased. The smelt stock reproducing in Pärnu Bay and the Pärnu and Reiu Rivers, has steadily increased during the last decade. Presently Estonian beaches are much cleaner than in the past. These developments have had very favourable effect on tourism and recreation. But side by side with clean nature heavily polluted areas may occur. In general, such areas have the roots reaching back to the occupation time.

In Estonia a number of NGOs and private stakeholders have evolved who contribute to the ICZM activities (The Estonian Society for Nature Conservation, Estonian Fund for Nature, Coalition Clean Baltic, Estonian Green Movement, etc.). However, public awareness and participation in implementation of environmental projects aiming at sustainable development, are still insufficient and need dissemination of corresponding knowledge and know-how (cf. Pickaver, 2003).

The main environmental problems of coastal areas in Estonia are water pollution, deviations from the rational explitation of water bodies, decrease in reproduction potential of fish resources and decline in their quality. Despite of improvement in ecological situation in some areas, the danger to the biological diversity and habitats of aquatic organisms has not yet been removed.

The goal of the Estonian Environmental Strategy is graduaal solving of the problems. It is based on the principles of sustainable development and corresponds to the EU recommendations. Long-term plans have been composed for implementation of the strategic plan.

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National ICZM strategies in Germany: A spatial planning approach

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Abstract

Driven by a range of developments, German marine and coastal areas are facing profound change. Of particular importance is the rapid expansion of the offshore sector, which is characterised by the emergence of new permanent large-scale uses, the intensification of land-sea interactions and also new conflicts of use. In Germany, these developments have served as a starting point for the development of a national ICZM strategy. The Federal Office for Building and Regional Planning and the Ministry of Transport, Building and Housing are funding a project to develop suggestions for a national ICZM strategy from the point of view of spatial planning. The project attempts to design a framework suitable for the specific German context, with conflict minimisation and flexibility as its core concerns. So far, a comprehensive stocktake has identified significant trends and likely impacts on the coastal zone, and also pointed out a range of structural needs that a national strategy will need to address. Final results are expected in autumn 2004. Whilst it is clearly important to adapt spatial planning instruments to implement ICZM at a national level, it is equally important to take a more comprehensive and long-term view. In order to effectively deal with the expected changes, economic, ecological and social impacts of future trends need to be understood. Two large-scale research projects have recently been launched to provide this much needed information to supplement the development of the national strategy.

1 Introduction

Contrary to other parts of the globe, ICZM did not gain prominence in Europe until the mid-1990s. The conclusions of the EU Demonstration Programme on Integrated Coastal Zone Management led to recommendations of the European Parliament and Council that each coastal State develop a „national strategy or, where appropriate, several strategies, to implement the principles for integrated management of the coastal zone“ (European Community 2002). Strategies should be based on a comprehensive stocktake in the coastal and marine environment and carried out in partnership with relevant stakeholders. Based on recognised principles of good practice, this should for instance comprise:

- clarification of the tasks of different administrative levels,
- development of a combination of instruments to implement the principles set out in the recommendations, with special focus on bottom-up initiatives and public participation,
- implementation of appropriate legal systems,
- establishment of appropriate monitoring systems for the coastal zone.

(European Community 2002)

2 ICZM from the point of view of spatial planning

As a country with a long tradition in spatial planning, it is perhaps not surprising that one of the first efforts towards a national strategy in Germany is co-ordinated by the German Ministry of Transport, Building and Housing (BMVBW) and the Federal Office for Building and Regional Planning (BBR). In March 2003, a small project was launched to explore the potential of spatial planning in ICZM and develop suggestions for a national strategy from the point of view of spatial planning. The project explicitly focuses on the national level, although it does explore links to both international and regional ICZM. What key uses are expected to characterise German seas and coasts in the near future, and what conflicts are likely to ensue? How will the national and international policy context, for instance the European Water Framework Directive, influence the planning context on the coast? And how can the tasks of a national ICZM strategy, and with it the role of spatial planning, be delineated from regional or local approaches?

Geographically, the study area encompasses all German coasts and seas, extending from the West of Lower Saxony via the North Sea and Baltic coasts of Schleswig-Holstein to the Polish border of Mecklenburg-Pommerania. On the seaward side, the study area comprises all coastal and territorial waters including the EEZ. The landward boundary of the coastal environment is less easy to define. Here, administrative units such as coastal Federal States or local authority districts serve as structural boundaries, as does the extent to which specific impacts - ecological or social - can be traced back inland. In case of agriculture or water-borne pollution this might encompass entire catchment areas and therefore include large areas of Germany and neighbouring countries. The project is a co-operative effort, involving scientists from the Social Science Centre Berlin (WZB), the Research and Technology Centre West Coast (FTZ, Büsum) and the Institute of Geography at the University of Kiel.

2.1 Project structure

The approach of the project closely follows the requirements set out in the EU recommendations for the development of national strategies. In order to answer the above questions, a comprehensive stocktake of the coastal environment was a required first step. This snapshot vision of the coast included a description of basic environmental, economic and social parameters (e.g. population density, economic mainstays etc), as well as a description of current forms of use and future trends. The stocktake also included a description of the administrative, instituional and legal framework, as well as informal ICZM structures, networks, research and knowledge bases and monitoring programmes. The stocktake was completed in March 2004 and will shortly be available as a published report (Gee et al. 2003a – c; in German).

From this descriptive first phase, individual trends and spatial planning demands can be specified for different administrative levels. This was done by contrasting the snapshot picture of the coast with recognised international standards for ICZM. Forms of use and their trends were ranked and prioritised to ensure that the national ICZM strategy focuses on national hotspots rather than regional and local issues. A draft list of national priorities and theses for ICZM was presented and discussed at a national workshop in October 2003. These will now be developed into suggestions for a national strategy, with results expected in autumn 2004.

The following outlines the main results of the stocktake and methods used for selecting national hotspots. It will also discuss the implications of some of the results for providing a structural framework within which a national strategy will ultimately be implemented.

3 First results of the stocktake: A snapshot of current challenges

3.1 New key forms of use offshore

During the last 5 years, offshore wind energy, marine protected areas, oil and gas pipelines and access to major shipping ports have emerged as new key uses on the German coast. Offshore zones have become highly dynamic areas of development, characterised by increasing pressure on fragile ecosystems, increasing competition and growing complexity of land-sea interactions. At the same time, conflicts are preordained. Of particular concern are permanent and large-scale developments such as offshore wind farms, which are hotly debated in terms of their potential impact on wildlife, tourism and shipping security. It is clear that German territorial waters and the EEZ are set to become intensely contended spaces, with regulatory mechanisms urgently required to balance different interests.

3.2 Growing disparities on land

The notable dynamism of offshore developments is offset by contrasting developments on land. With most of Germany's coasts still classed as rural, the effects of structural changes continue to be felt in the decline of traditional industries such as agriculture and fisheries. Whilst some areas have benefitted from investments in European transport routes, other peripheral regions, most notably in Mecklenburg, are facing continuing recession and depopulation. Spin-offs from the wind energy sector have led to local investment, particularly on Schleswig-Holstein's West coast, and tourism continues to represent an economic mainstay in many coastal areas. Generally however, disparities between centres and peripheral regions are growing, as are disparities between urban centres and their peripheral regions.

3.3 Sea change in perception

Although the potential benefits of ICZM were recognised as early as the 1990s (Gee et al. 2000), ICZM was not a serious topic of debate until very recently. Reason for this is a sudden change of perception, largely due to the surge of interest in the economic potentials in the marine environment. National dynamics offshore are complemented by increasing international activity, evident in new networks of interest, transboundary initiatives and cross-sea alliances that span the North Sea and the Baltic. With both Seas turning into hubs of commerce, the traditional boundaries between land and sea are beginning to blur. Due to the increasingly complex interactions between land and sea, old mechanisms differentiating between land- and sea-based activities no longer apply. Germany too is beginning to see land and sea as a real continuum, emphasizing the need for integrated management.

3.4 Structural challenges

Despite some positive developments, Germany is still relatively ill equipped to deal with these rapid changes. In order to counter some of the above issues and provide effective ICZM in the process, clear structures need to be established to regulate the interchange between the federal level, the federal states and the regions. Competencies for decision-making need to be clearly communicated, not least in order to facilitate investment in offshore developments. Participation of local structures in national decision-making also needs to be regulated. Offshore, there have been some improvements in offshore construction and concessioning, but the system is far from being effective, streamlined and transparent. Partly, this is due to Germany's highly complex administrative structure, encompassing the Länder as additional and powerful regional players. Co-existing with these are specific development regions, such as the K.E.R.N. region in Schleswig-Holstein or the trilateral management schemes for the Wadden Sea, including their respective national, regional and local institutions and networks like the EUREGIO "Die Watten", the Interregional Wadden sea cooperation and the Common Wadden Sea Secretariat. This turns Germany into one of the most complex and multi-layered administrative landscapes ICZM will need to contend with (Tab. 1).

International	= North and Baltic Seas (Regional Seas)
National	= federal level
Länder	= federal State level
Regional	= partial federal State level, some transboundary (e.g. K.E.R.N. – Region in SH)
Local	= communal level

Table 1: German interpretations of international spatial categories

The need for additional regulatory mechanisms is gradually being recognised at political level too. Schleswig-Holstein and Lower Saxony have responded to increasing spatial competition and conflicts offshore by providing a strategic framework for ICZM (SH) and extending their spatial planning competencies to the 12 sm territorial waters (LS). The federal level has also responded, recently amending the Federal Spatial Planning Act to extend national sectoral competencies to the EEZ.

4 Basic parameters of a national ICZM strategy

The list of challenges drawn up above suggests that spatial planning in the context of ICZM primarily needs to facilitate constructive management of change. This is a continuous and adaptive process that should aim to create multifunctional spaces on coasts and seas. Rather than prescribing particular functions or forms of use, ICZM – and with it, spatial planning – should serve to weigh up risks and opportunities inherent in different forms of use as part of a wider process of social consensus-building. ICZM however is not just about conflict management, but also about improving co-ordination and communication and developing common visions. In this context, the task of the national level can be summarised as:

- maintaining the integrity of ecological and socioeconomic systems,
- providing indicators and threshold values,
- formulating political aims,
- developing appropriate processes and instruments.

How can such a framework be achieved in the German coastal context? Looking at some of the peculiarities of the German situation, the following general theses are suggested.

Firstly, Baltic and North Sea are highly distinct ecosystems, guided by different physical and biological parameters. Each comprises a range of habitats with specific threats and management needs, linked together in complex systems of interchange. Due to the inherent fragility of ecological systems, maintenance of key ecosystem functions should constitute a primary objective against which other perspectives need to be weighed.

Individual habitat needs, pressure of use and levels of threat are coupled with the complexities of the German administrative system. Together they demand differentiated and tailor-made approaches to ICZM in specific spatial units of the coast. It follows that a national strategy should explicitly support the growth of smaller ICZM regions below the federal level. These could be made of local authorities, Federal State authorities, scientific institutes and NGOs working together to guide and implement ICZM and make the national strategic framework come alive.

Secondly, although it is a useful instrument for balancing different demands of use, spatial planning needs to adapt to the special complexity of the coastal zone. As an instrument within a national strategy, spatial planning needs to be flexible enough to respond to the high degree of variability on the coast. Rather than a fixed corset, planning in the coastal and marine environment needs to act as an enabling environment within which different developments can take place. The enabling environment is held together by standards of good practice in ICZM and the principles of sustainability. Spatial planning can assist in providing an enabling environment through making available measures and instruments improving co-ordination and co-operation between the national, Länder and regional level.

5 Setting national thematic priorities

During the stocktaking exercise, a total of 16 forms of use were identified for both land and sea (Tab. 2).

Offshore wind farms
Marine protected areas
Fisheries
The sea as a public good
Sea cables
Tourism
Ports and harbours
Agriculture
Dredging
Oil and gas exploration
Dumping
Aqua- and mariculture
Military use
Coastal service centres
Nature conservation
Coastal protection

Table 2: Current significant forms of use on the German coast

But which of these should be dealt with at a national level, and which are better left to regional or local levels? One way to identify nationally significant trends is to draw up a list of thematic priorities. This essentially means ranking current forms of coastal use according to predetermined criteria, which is not an easy task. Criteria form a much debated topic within ICZM as part of discussions on quality standards. At present, Germany at least still lacks an agreed set of ICZM criteria that could be applied in the context of a national strategy. Available suggestions rarely differentiate between the political and normative level on the one hand and the descriptive-analytical level on the other, leading to an arbitrary potpourri of evaluation criteria applied to a variety of contexts. In most cases, these are not even criteria in the scientific sense because they do not include any measurable variables or scales according to which 'good' or 'bad' could be determined. This is clearly a field of research that will need to be addressed if a national strategy is to be a success (Daschkeit & Sterr 2002).

Naturally, the remit of this project does not include the development of indicators that would meet the criteria of proper science. Instead, it chose to pursue a rather more pragmatic approach, in which a set of common sense 'dimensions' was drawn from the EU ICZM criteria and used to rank the above 16 uses. The choice of term is a conscious one to mark the differentiation from criteria. The following sets out the reasoning behind choosing these dimensions and presents the results of the ranking exercise.

5.1 Basic parameters

Ranking forms of use is based on the – obvious - recognition that different forms of use have different potential to affect the coastal and marine environment. This so-called potential impact can be measured in terms of spatial extent and intensity of impact. The impact of large-scale and permanent offshore wind farms for example is more significant on both counts than, say, a sea cable, although laying a sea cable certainly implies intense short-term localised impacts. As a measure, potential impact comprises both direct and indirect effects and can be determined through ecological, spatial and aesthetic criteria. What matters in the context of a national strategy is the severity of potential impact, which can be expressed on a scale from slight to severe for intensity and from local to national for spatial extent.

Whilst this makes intuitive sense, it is clear that potential impact is no absolute measure. Rather, it is influenced by the underlying systems, and in particular their innate susceptibility to change. Sensitive systems – whether ecological, economic or social – are more likely to be negatively affected by internal or external change than their more robust counterparts. Other factors influencing potential impact include the possible cumulation of effects, the presence of management measures or technological developments that could mitigate the intensity and extent of impact (e.g. pollution).

It is argued here that a national strategy should primarily focus on large-scale forms of use with significant – i.e. notable ecological, economic or social - impact on the North Sea and Baltic Sea. The need to maintain the ecological and social integrity of both systems and constituting sub-systems should act as a guiding principle, so that all those forms of use become national priorities that could threaten the inherent integrity of large-scale ecological, social or economic systems. This essentially reflects the principle of sustainable development, which is a central vision for a national ICZM strategy.

Spatial significance and threat to systemic integrity alone however is not enough to determine which issues should form national priorities. A national strategy must also include all those forms of use that are of federal political significance, as well as those where the federal level bears exclusive administrative responsibility. These are issues that simply cannot be decided on any other than the national level. An example for the federal political significance is offshore wind energy development, which is currently receiving strong political support in terms of subsidies and new renewable energy legislation. An example of the federal level political responsibility is EU legislation (eg. implementation of the Water Framework Directive and Marine Protected Areas) or more recently, spatial planning competencies for the EEZ. The latter also includes representation of German coastal interests at the international level.

5.2 Refining national priorities

The following four ICZM dimensions are suggested to narrow down the spectrum of potential national hotspots.

- **Dynamics of development**, which is a measure of the speed and intensity of development in individual sectors. The more dynamic a form of use and the more significant its potential impact, the closer the compatibility of the sector with other forms of use and the need to analyse its potential knock-on effects on ecological and socio-economic systems. Since dynamics of development depend on external conditions, any evaluation of dynamics can only be a snapshot, underlining the need for continuous monitoring.
- **Interconnectivity**, which is a measure of interaction with other forms of use and possible knock-on effect on surrounding systems;
- **Compatibility** of forms of use with each other, which essentially measures potential for conflict (see below),
- **Absolute significance,** which recognises that individual forms of use can be of high local significance, although they may no longer be dynamic on the national level. An example could be coastal tourism in Schleswig-Holstein, which has recently shown some signs of stagnation but still represents the most significant form of income for local communities on the Schleswig-Holstein West coast. Absolute significance also includes the emotional significance of particular forms of use for the local population, for instance fishery.

National hotspots therefore comprise all themes, trends and uses that:

- are of high spatial significance,
- show highly dynamic development on a national or regional level,
- have significant knock-on effects on other forms of use,
- are of high political significance,
- are strongly incompatible with other forms of use/have high potential for conflict, and
- are of high emotional value.

5.3 Analysing compatibility

Although it is linked to other measures such as interconnectivity, compatibility is essentially a measure of potential conflict. It stands apart from the other dimensions in that it directly affects spatial planning or the allocation of space. Spatial planning needs to maximise compatibility, avoiding an overlap of incompatible uses in order to achieve multifunctional, sustainable coasts and seas. Two strongly incompatible forms of use that both enjoy national priority status will require stronger regulation and management and careful allocation of space than two compatible forms of use.

Compatibility can be divided into the following categories:

- directly incompatible uses,
- indirectly incompatible uses,
- neutral uses,
- compatible uses.

Directly and indirectly incompatible uses have strong potential for conflict, whereas compatible forms of use might even enhance one another or yield double benefits (eg. the secondary use of offshore wind farms through mariculture). Indirectly incompatible uses comprise more remote effects where two forms of use are not directly connected, such as long-range water- or airborne pollution of coastal seas (eg. riverine inputs). It is important to note in this context that perceived conflicts can be just as significant as actual compatibility. This is the case in most issues affecting aesthetic qualities of the landscape, the sense of identity of local communities or traditional communal structures on the coast. The installation of offshore wind farms for example might be classed as highly incompatible with life on the coast or tourism by local residents, whereas this is not necessarily the view of tourists themselves. Other conflicts result from the disappearance of significant elements of the landscape, such as working fishing boats or traditional cultural landscapes.

The following matrix is a first attempt at analysing the mutual compatibility of the existing 16 uses on the North and Baltic Sea. For ease of analysis, it only considers spatial compatibility and does not take account of social or aesthetic criteria. As such, incompatibility simply indicates that two forms of use cannot occupy the same coastal or marine space and does not exclude co-existence per se, for instance as ‘peaceful neighbours’. The matrix attempts to pinpoint decision-making priorities for spatial planning. Checked against the thematic list of priorities it can serve to refine the list of national priorities. It is also a helpful way of identifying areas in need of specific management measures and instruments.

Dynamic developments on coasts and seas require continuous monitoring of trends and compatibilities of individual forms of use. ICZM needs to be understood as a proactive, iterative tool box that can only succeed in the context of a long-term planning horizon and comprehensive ecological, economic and social monitoring system.

	Offshore wind farms	Marine protected areas	Fisheries	The sea as a public good	Cables	Tourism	Shipping routes	Harbours and ports	Agriculture/run-off	Sand an gravel extraction	Oil and gas exploration	Dumping of dredged material	Aqua- and mariculture	coastal service centres	nature conservation	coastal protection	Military use
Offshore wind farms	0	**x**	**x**	**x**			**x**			**x**	**x**	**x**					**x**
Marine protected areas	**x**	0	**x**	x	**x**	x	**x**	x	**x**	**x**	**x**	**x**	**x**				**x**
Fisheries	**x**	**x**	0	x	x		**x**		x	x			**x**				**x**
The sea as a public good	**x**	x	x	0			x			**x**	**x**	**x**	**x**				**x**
Cables		**x**	x		0		x		x	**x**	**x**	**x**			**x**		
Tourism		x				0									x	x	**x**
Shipping and shipping routes	**x**	**x**	**x**	x	x		0			**x**	**x**	**x**	**x**				**x**
Harbours and ports		x						0					x		**x**		
Agriculture/run-off		**x**	x	x					0				x		**x**		
Sand and gravel extraction	**x**	**x**	x	**x**	**x**		**x**			0	**x**	**x**	**x**		**x**	x	
Oil and gas exploration	**x**	**x**		**x**	**x**		**x**			**x**	0	**x**	**x**				**x**
Dumping of dredging material	**x**	**x**		**x**	**x**		**x**			**x**	**x**	0	**x**				
Aqua- und mariculture		**x**	**x**	**x**			**x**	x	x	**x**	**x**	**x**	0		x		**x**
Coastal service centres														0	x		
Nature conservation					**x**	x		**x**	**x**	**x**			x	x	0	x	x
Coastal protection						x				x					x	0	x
Military use	**x**	**x**	**x**	**x**		**x**	**x**				**x**		**x**		x	x	0

Table 3: Estimates of compatibility of individual forms of use on coasts and seas

X = incompatible; X = conditionally compatible; Blank field = compatible; 0 = not applicable

5.4 First selection of nationally relevant themes

Based on the stocktake and the ICZM dimensions described above, a matrix was compiled to rank each individual form of use as either high, medium or low. Spatially, they were also ranked, using local, regional or national importance as basic criterium (i.e. affecting sub-regions of the North Sea and Baltic Sea, the entire North or Baltic Seas or both seas). The following uses and developments emerged as national priorities:

- **Offshore wind farms** (highly dynamic developments, strong interaction between land and sea, federal administrative responsibility in the EEZ, high political relevance, and influence on shipping safety);
- **Marine protected areas** (highly dynamic developments, international responsibilities of the federal Government, federal administrative responsibility within the EEZ)
- **Fisheries** (high political significance, federal political responsibility internationally and nationally)
- **The sea as public good** (federal responsibility for establishing an administrative framework within the EEZ, federal responsibility for legal issues, high potential for conflicts)
- **Port development** and **access to ports** (responsibility of the federal level for developing transport infrastructure, high local potential for conflict, locally highly dynamic developments),
- **Shipping safety** (high risk potential for other forms of use, federal responsibilities within the EEZ and German shipping lanes, international networks)

6 Structural priorities on a national level

Acceptance of thematic national priorities needs to be matched by appropriate changes at the structural level. "Compatibility" for instance is also relevant in terms of administrative structures, where it can act as a measure for co-ordination and integration of decision-making. The following structural demands can be distilled from EU ICZM requirements:

- **Transparency** (incorporating vertical, horizontal and territorial integration as well as open structures of decision-making, participation and information flow between relevant actors and the public),
- **Legitimacy** (focusing on the role of informal and formal decision-making processes and structures, in particular processes that are not legally binding)
- **Efficiency** (i.e. the relationship between investment in planning processes and tangible results)
- **Flexibility** (i.e. the ability of individual processes to deal with uncertainty and changing framework conditions, which is considered a prerequisite for setting priorities and developing new instruments of management).
- **Holistic, systematic view** (i.e. a comprehensive understanding of ecological and social processes irrespective of the land-sea boundary, incorporating scientific as well as ‚soft' knowledge)
- **Integrated criteria for assessment** in the process of achieving consensus (ensuring that decision-making is based on clearly documented and transparent criteria).

7 Structural measures required to meet these demands

At a structural level, the following categories and areas of responsibilities exist in Germany:

- Regional Seas (administrative framework: OSPAR, HELCOM, VASAB, EU, federal responsibility)
- Federal level (relevant for federal policy and decision-making, e.g. Renewable Energy Act, national legislation, spatial and sectoral planning within the EEZ)
- Federal States (responsible for spatial and sectoral planning within 12 sm and inland)
- Regions and local areas (responsible for implementation and local ICZM projects).

In view of the authors, the following structural measures are required to ensure effective ICZM at a national level:

(1) **Institutionalisation**. ICZM should be institutionalised based on the above spatial categories without creating new formal structures. Suggestions include the creation of a hierarchy of forums, tasked with networking between existing structures, facilitating horizontal and vertical communication, overcoming institutional barriers and achieving greater transparency at all levels. Willingness to co-operate, as well as agreement on mechanisms for channelling informal decisions into legitimate frameworks, form pre-conditions for success.

(2) **Management offshore**. Within the EEZ, a clear allocation of spatial planning responsibilities is required. This includes cross-sectoral exchange and transparent decision-making systems that view land and sea as a continuum. A central co-ordinating unit could be useful to act as a national centre and first port of call or contact point for all matters relating to the EEZ and the coastal waters.

(3) **International tasks**. For Germany to be an international player in ICZM, the federal level needs to become more proactive, taking on more international tasks and showing increased presence at the international level. This must however be matched by support for national research and regional initiatives for implementing ICZM, with appropriate feedback systems to ensure a free flow of information.

(4) **Monitoring**. As a continuous process, ICZM requires continuous monitoring of the coastal and marine environment on an ecological, socioeconomic and institutional level. This requires the establishment of scientifically sound criteria which are able to integrate these three levels.

Institutionally, the implementation of ICZM recommendations might serve as an initial stepping stone for process-oriented monitoring.

8 Where next?

The way ahead for a national ICZM strategy in Germany and the role of spatial planning within ICZM strongly depends on the fundamental understanding of ICZM either as a planning and decision-making tool or a holistic ‚philosophy' of thought (Kannen et al. 2004). If we take the philosophy line of thought, implementation of ICZM will primarily be based on enabling a national strategy to act as a guiding framework within which integrative spatial and sectoral planning can take place. In this scenario, the strategy is focussing on a high degree of flexibility, which will enable measures to respond to regional developments and new trends. Spatial planning is one of the instruments to implement this philosophy throughout its various tools and methods. Meeting developing societal visions, as well as continuous adaptation to social developments and technological innovation are prerequisites for success, as is the international integration of the national strategy. The development of the national strategy should therefore be based on:

- specifying levels of activity,
- identifying responsible actors and key contacts,
- naming intersections between spheres of activity and instruments to ensure information flow between the intersections
- documenting the specific tasks and challenges facing spatial planning, sectoral planning, politics and civil society actors.

The national strategy thus:

- provides principles,
- outlines tasks of spatial and sectoral planning,
- specifies communication and information needs and recommends ways to meet these,
- recommends instruments and concepts including decision-making tools, evaluation criteria and monitoring.

At the same time, a national strategy requires a transdisciplinary and above all universally agreed visions for coasts and seas. These should include visions of development as well as socially accepted evaluation criteria and indicators, which in turn are based on societal visions and objectives. Essentially, this means taking a more comprehensive and long-term view than the horizon of the present project. Two large-scale research projects have recently been launched to probe the wider impacts of new trends on the coast, with focus on offshore wind energy on the West coast of Schleswig-Holstein and the Oder estuary on the Mecklenburg-Pommeranian coast. Both projects are now being launched and will significantly contribute to the development of the national strategy.

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Towards a Typology for the Baltic Sea

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Abstract

The Water Framework Directive (WFD) establishes a comprehensive framework for European Community actions in the field of water and introduces new principles of modern water management based on long-term protection of water resources. It requires from all EU Member States to protect and enhance the status of water quality of all types of waters, including coastal zone of the sea. For the purpose of the WFD implementation all water bodies must be classified into types of similar characteristics based on the physical factors. This classification scheme is called typology and forms a universal basis for all other activities within the WFD implementation such as: management or monitoring. The implementation of the WFD as well as the development of a national typology are a responsibility of national authorities and are due to be operational in a few years time. As a result, every country develops or has already developed an independent typology. The WFD defines the Baltic Sea as one Ecoregion. The coastal waters have an international character but national typologies will cause interceptions at country borders and different national typologies will complicate large scale comparisons across the Baltic Sea. Further, the definition of coastal waters (1 nm off the baseline) is artificial. The division between coastal waters and open waters is not in agreement with morphological, physical, chemical or biological parameters. Therefore, a joint typology approach, not only for the Baltic coastal waters, but the entire Baltic Sea is needed. Within the EU-project CHARM (Characterization of the Baltic Sea Ecosystem) a joint Baltic Sea typology was developed. The suggestion in the EU-CIS Working Group 2.4 Guidance Document formed the basis.

Salinity was used as the main obligatory factor. For the Baltic Sea typology residence time and depth/mixing conditions were additionally used. The typology is not meant to replace national typologies. It is developed as an umbrella, which allows the integration of the national typologies and a further subdivision according to regional demands. It therefore serves as a link or an integrative element for the national typologies. The Baltic Sea typology covers the entire Baltic Sea and is not limited to the definition area of the Water Framework Directive.

1 Introduction

To create a typology for the Baltic Sea means to develop a classification scheme, which unifies water bodies with a similar characteristic and separates different water bodies from each other. A typology generalizes the complex and diverse Baltic ecosystem into simplified units and makes it accessible for spacious analyses and comparisons. The underlying parameters used for a classification or typology depend on its objectives and purpose. Several schemes, which are close to a typology, already exist for the Baltic Sea. Against the background of the EC-habitats directive, for example, a mapping and classification of marine habitats was carried out. A habitat classification for the Baltic Sea is supported or independently developed by organizations like ICES, EEA and HELCOM, too. Most important in this respect are the demands arising from the EC-Water Framework Directive (WFD). The WFD asks all European member states to develop a national typology for their coastal and transitional waters. This typology has far reaching implications. It is, for example, the basis for the definition of reference conditions, water quality classification schemes and will cause significant adaptations with respect to monitoring.

The implementation of the WFD as well as the development of a national typology is the responsibility of national authorities. The typology for every country has to be finished by the end of 2004, and monitoring programs should be operational by the end of 2006. As a result, every country develops or has already developed an independent typology. The Baltic Sea is defined as one Ecoregion in the Water Framework Directive, and the coastal waters are of international character. It is expected that some types will be intercepted at country borders and a very similar water body can belong to very different types. Independent national typologies further bear the danger of different national water quality reference states, different water quality classification schemes and finally different definitions of a good ecological state. Many national typologies would complicate large scale comparisons across the Baltic Sea. Therefore, a joint approach towards typology is required for all Baltic coastal waters.

Despite the fact that the Baltic Sea is defined as an Ecoregion, the Water Framework Directive is restricted to a coastal strip of only 1 nautical mile off the baseline. The narrow strip of coastal waters is artificially divided from open waters. This concept violates the suggested ecosystem approach for the Baltic Sea as defined in the EC-Marine Strategy. It further means that types are truncated artificially and a comprehensive Baltic system concerning reference conditions, water quality classification schemes and monitoring is hardly possible. The problems arising from the limitation of coastal waters call for a typology which covers the entire Baltic Sea.

In December 2001, an EU project entitled “Characterization of the Baltic Sea Ecosystem: Dynamics and Function of Coastal Types” (CHARM) was launched aiming, inter alia, at testing and validating a methodology for establishing coastal types in the Baltic Sea Ecoregion. Furthermore, by analyzing coastal ecosystems dynamics and function in relation to anthropogenic pressure, the objectives of the project were to develop recommendations on reference conditions and monitoring strategies for facilitation of the Water Framework Directive implementation for all Baltic Sea coastal waters. All Baltic states (except Russia) participated in the project.

Our work represents the project approach, formulating a general typology – a classification system – for the Baltic Sea Ecoregion. The aim is to cover the entire Baltic Sea in a flexible manner and to keep the system general enough, that it can serve as an “umbrella”, linking all national approaches to coastal waters typology for all Baltic countries under one scheme.

2 Background: The Water Framework Directive and Typology

In year 2000 the Water Framework Directive - WFD (Directive 2000/60/EC) entered into force. This Directive is a result of a long process of discussions in the field of water policy and replaces as well as unifies water related laws in Europe. It introduces new principles of modern water management and promotes sustainable water use based on long-term protection of water resources. The goal of the Directive is not only to prevent further deterioration of water bodies but also to protect and enhance the status of water resources to the level of quality defined as “good”. According to the Directive requirements, all water bodies must reach at least “good water status” before year 2015. This means that the water quality must be improved close to the reference or background conditions reflecting natural, undisturbed conditions of the certain water type. The Directive provides a framework for protection of all types of waters: inland surface waters, groundwater and waters of the coastal strip for all seas around Europe.

There are two general types of waters considered in the coastal seas around Europe: coastal and transitional waters. WFD defines coastal waters as bodies of surface sea waters reaching up to one nautical mile on the seaward side from the baseline from which the breadth of territorial waters is measured (Figure 1). According to the Directive ‘transitional waters’ are bodies of surface sea waters in the vicinity of river mouths which are substantially influenced by freshwater flows”. In the present work we consider only coastal waters, since most Baltic States do not intend to identify any transitional waters along their Baltic Sea coast. However, a final decision on defining some areas as transitional waters will be taken on the national level, when all Member States decide on the final classification scheme of the WFD in their coastal zone.

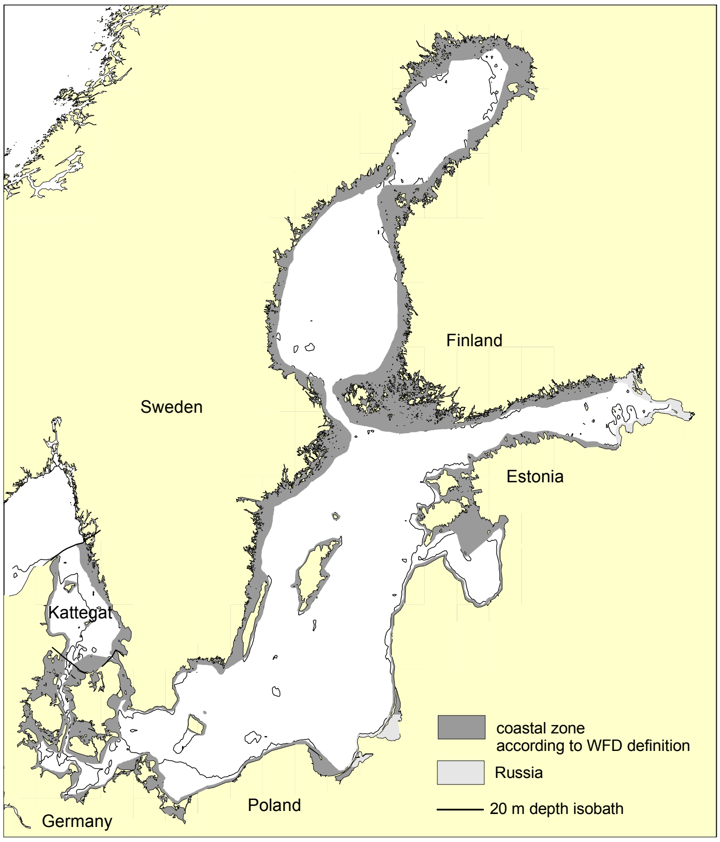


Figure 1: The coastal waters of the Baltic Sea Ecoregion as defined by the Water Framework Directive based on the baseline delimitation. Coastal waters limits as defined by national baselines correspond mostly with the 20 m isobath which is also shown.

The Directive requires that all surface waters including waters in the coastal zone of the seas - transitional and coastal waters - shall be divided into types, based on physical factors. The classification system is defined in the Directive as typology, and factors to be used for classification are specified. Formulating typology would mean dividing the entire coastal strip around Europe into types of water based on physical factors, such as e.g. depth, water residence time or exposure of the water type. This classification will form a background for all other Directive activities, such as: defining the present status of the water quality as compared to the natural, background status which is specific for each type, managing of waters in order to prevent further pollution and enhance the water status to the "good" level. For the purpose of the WFD implementation each type will have to be monitored and the monitoring program must reflect the need to identify the water status.

The EU Member Countries agreed to develop a Common Implementation Strategy (CIS) for the Water Framework Directive to be worked out within the framework of the Commission. Among other working groups established to support this Common Implementation Strategy, the EU-CIS Working Group 2.4 was supposed to produce a practical guidance document on the implementation of the Directive for transitional and coastal waters. The working group included representatives from each Member State as well as experts from other countries. The Document "Guidance on typology, reference conditions and classification systems for transitional and coastal waters" (Vincent et al. 2002) is non-legally binding. Instead, it aims at providing a practical advice for implementing WFD. The document suggests a unified, Pan-European approach. However, it is not detailed enough to answer all questions, it sets certain direction of work for WFD implementation in coastal and transitional waters and therefore can be considered as a framework for all tasks.

The Water Framework Directive (Directive 2000/60/EC) formulated scientific basis to be used for classification of water bodies which are specified in the Annex II of the Directive document. According to the Directive requirements, the classification system – a typology – can be done based on two alternative schemes: System A or System B. System A classifies all coastal regions into Ecoregions and the Baltic Sea is one Ecoregion under System A classification. The next classification factors in system A are: salinity and depth. If the System A is not sufficient, System B can be used alternatively. The obligatory factors in System B are: Latitude/Longitude, tidal range and salinity and then optional factors can be used: current velocity, wave exposure, mean water temperature, mixing characteristic, retention time (of enclosed bays), means substratum composition and water temperature range.

Based on the two Systems the EU-CIS Working Group 2.4 formulated one classification scheme in Guidance Document (Vincent et al. 2002). It suggested a Pan-European approach in typology to achieve a generally uniform classification system for all national typologies. A hierarchical approach is recommended and, so called; obligatory factors should be used for main classification in both systems. These are: Latitude/Longitude = Ecoregion; Tidal range; Salinity.

Factor	Range	Range value
Salinity	freshwater oligohaline mesohaline polyhaline euhaline	< 0.5 0.5 to 5 – 6 5 - 6 to 18- 20 18 – 20 to 30 >higher than 30
Mean Spring Tidal Range	microtidal mesotidal macrotidal	< 30m 1 m to 5 m > 5 m
Exposure (Wave)	extremely exposed very exposed, exposed moderately exposed sheltered, very sheltered	
Depth	shallow intermediate deep	< 30m 30 m to 50 m > 50 m
Mixing	permanently fully mixed partially stratified permanently stratified	
Proportion of Intertidal Area	small large	< 50% > 50%
Residence time	short moderate long	days weeks months to years
Substratum	hard (rock, boulders, cobble) sand-gravel mud mixed sediments	
Current Velocity	weak moderate strong	< 1 knot 1 knot to 3 knots > 3 knots
Duration of Ice Coverage	irregular short medium	< 90 days 90 to 150 days > 150 days

Table 1: Factors recommended in the EU-CIS Working Group 2.4 Guidance Document to be used for development of typology.

If obligatory factors are not sufficient, thy can be followed by optional factors that are most applicable to the ecological situation. Range for each factor is pre-defined in the Guidance but it is justified to aggregate or split ranges. All factors and their ranges recommended in the Guidance Document are listed in the Table 1.

3 Methodology

Our work closely followed the suggestions of the WFD guidance document on typology. Since most countries will comply with these recommendations we wanted to ensure that our typology generally can be accepted as an umbrella. The Baltic Sea has been defined in the guidance as one Ecoregion – as equivalent to the first classification factor Latitude/Longitude – and this approach was the basis for our work. Thus, from first obligatory parameters, salinity remained as the main classification factor for the Baltic Sea. The Baltic Sea is a micro-tidal sea and the tidal range is not suitable as a classification factor. Other parameters related to tides, e.g. proportion of the intertidal area, cannot be used for the Baltic Sea as well.

Exposure is a very suitable parameter for open oceanic shores. In a shelf sea, with sub-basins, complex coastal structures and many islands, like in the Baltic Sea, this parameter is of limited use. It would create a very small scale pattern of shelter and exposition, besides there was also no extensive data available covering this aspect within the entire Baltic Sea. Therefore, exposure along the Baltic Sea coast was not considered. The same is true for current velocity. This parameter is very important in systems with pronounced tide currents. In the Baltic Sea, currents are mainly wind driven, vary very much in time and space and hardly ever reach a force comparable to the Atlantic coast. Therefore this factor is not very suitable for the Baltic Sea. Instead, other parameters, as discussed below, were chosen to differentiate between the open coastal waters and more sheltered areas in the inner coast: Lagoon and inner archipelagos.

Sediment maps were also collected within CHARM project to obtain information on the bottom substrate. Despite many problems in detail (different size fractions, methods and spatial resolution), bottom sediment maps are useful for the southern Baltic, soft bottom regions. In rocky areas, like in Scandinavia sediments show high and small scale variability. Even first approaches to introduce soft and hard bottom as a parameter in the typology did not yield satisfying results, because of the high variability.

Information on the duration of the ice cover for the Baltic Sea was considered as a parameter in our typology as well. Ice cover is of importance for the Baltic Sea, since the sea extends from about 54oN to 66oN ranging from temperate to subarctic climate. If the classification ranges given in Guidance Document on the duration of ice coverage were applied to the Baltic Sea, a zone of long ice cover above 150 days could be distinguished in the northern part of Gulf of Bothnia. The rest of the sea could be classified as one class with respect to the duration of ice cover. The ice cover data were supplied in a form of a map by the Finnish Environment Institute (SYKE) based on data about the ice conditions for the winters 1963/64 - 1979/80 - 17 winters in total (Finnish Institute of Marine Research 1988). This parameter is important and allows a subdivision of types on a hierarchical level under our umbrella typology. However, it not used in the umbrella typology because of its regional importance limited to the Gulf of Bothnia.

Finally salinity, depth/mixing and water residence time of enclosed areas (residence time) were used as factors in classification of water types. It was agreed within the CHARM project that results of the typology classification should be displayed on maps and the program used was Surfer. A Baltic Sea basemap with a high resolution coastline (1 x 1 km and 100 x 100 m) for the entire Baltic Sea was obtained from the Baltic Sea Research Institute Warnemünde in Germany (IOW). In the present paper the first, coarser map is used. Most long-term data sets used in the project were for the 1990-2000 period.

3.1 Salinity

Salinity was defined as one of the obligatory factors in the WFD and also in the CIS Working Group guidance document, since it is always the first factor defining community composition in every water body and classifications of water bodies into salinity classes have been studied for decades.

The calculation of salinity was done on the basis of data provided by the Department of Systems Ecology, Stockholm University, Sweden (SUSE). It was stored in the Baltic Environmental Database (BED 2002) and the data sets were obtained from institutes from Baltic countries, which participated in the CHARM Project, as well as public data set available in the BED archives.

The calculation was carried out for the period 1990-2000, a period for which the data set is most comprehensive. Only surface data up to the 5 meter depth were considered, in order to achieve comparison between shallow coastal waters and more open, deeper sea areas. The resulting surface salinity for the whole Baltic Sea is shown in Figure 2. Salinity thresholds used to differentiate between types were chosen in line with Water Framework Directive System A and CIS Working Group Guidance ranges and according to the well accepted Venice system:

- Freshwater < 0.5 PSU
- Oligohaline waters 0.5 – 6 PSU
- Mezohaline waters > 6 – 18 PSU
- Polyhaline waters > 18 – 30 PSU

Thus, there are three salinity classes in the Baltic Sea typology; from oligohaline to polyhaline waters.

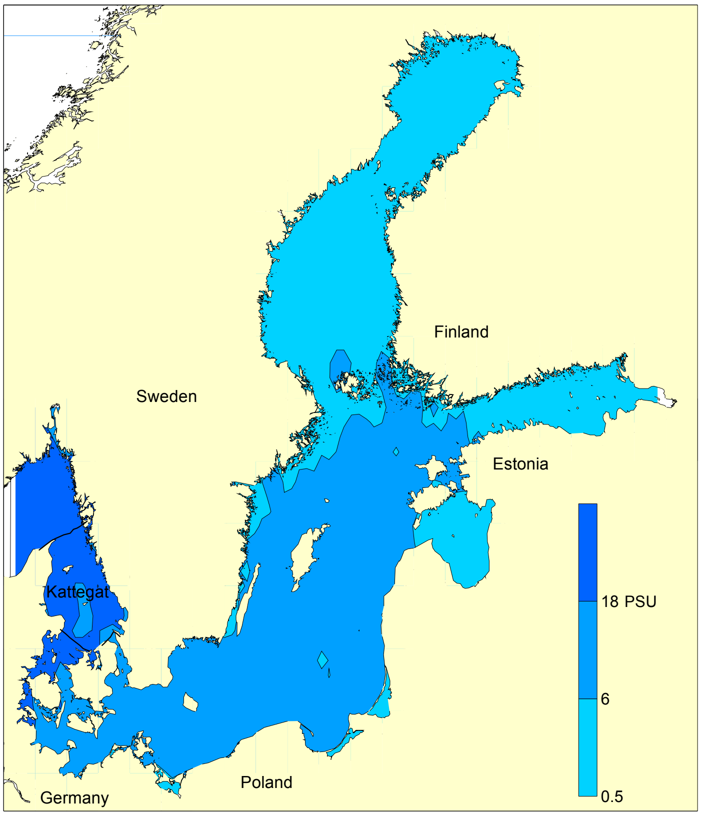
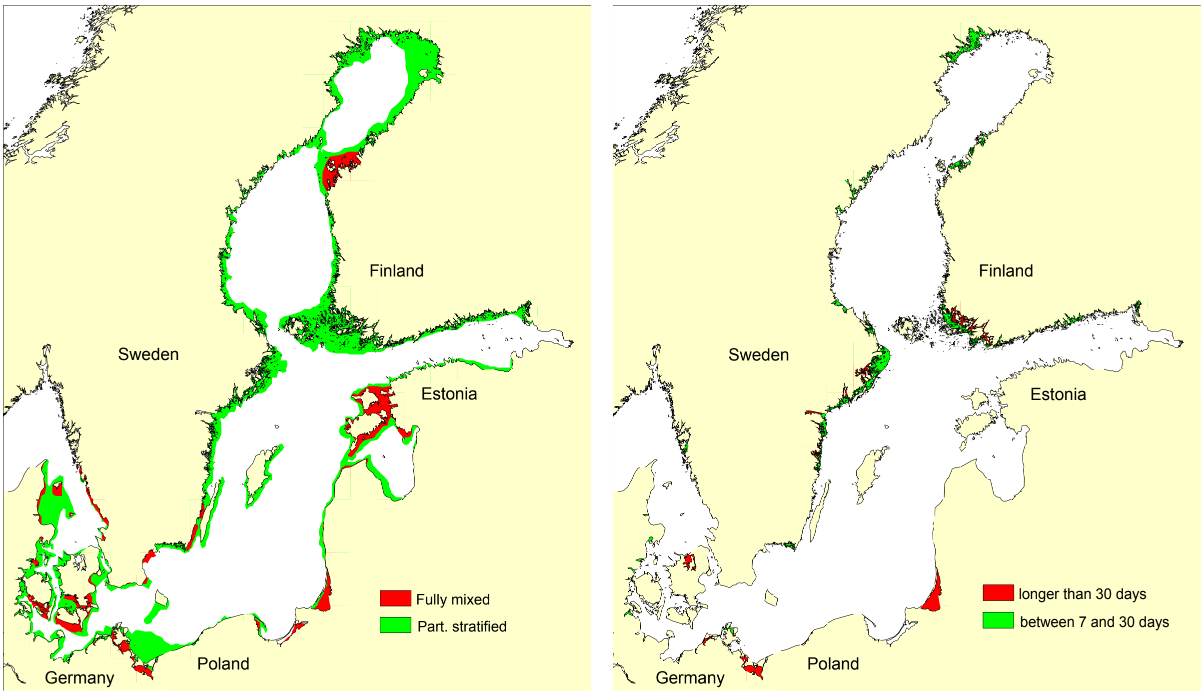


Figure 2: Distribution of salinity in surface Baltic Sea waters up to 5 meters depth. Based on data collected from all institutes participating in the CHARM Project, available via Baltic Environmental Data Base, Stockholm University (BED 2002).

3.2 Residence time and stratification

Water exchange is regarded as an important factor in the coastal sea zone. The water exchange has a great impact on the concentration of substances in the water column and the sediment/water exchange in the system. It is known, that enclosed systems differ from the open coast waters since many chemical as well as biological parameters depend on the water replacement time, both in freshwater and marine systems (Nixon 1996; Scheffer 1998). Water exchange was also one of the major factors used in the Swedish typology (Johansson 2002) for which three water classes according to the water exchange time were used: 0-10 days, 10-40 days and > 40 days. This approach in differentiating open coastal waters from enclosed areas and inner archipelagos was used in the present work. On the basis of morphological data from all CHARM partner countries, 91 prioritized semi-enclosed bays/inshore areas in Baltic Sea were delimited as separate geographical units. For these areas, water residence time and stratification calculation were carried out by use of numerical models. For open waters residence time is not a suitable parameter, because it depends on the size of the area, which is considered.

For the reconstruction of representative forcing, which are relevant for coastal processes, a 3-dimensional baroclinic model of the Baltic Sea was set up for the 10-year period (1991-2000). It simulated the exchange with the open sea for each of the prioritized semi-enclosed bays. Input parameters were freshwater discharge and wind. The data were collected from all countries participating in CHARM for the 1991-2000 period. In order to calculate the stratification and water exchange in the inshore areas in Baltic Sea, a modified version of the WMM model (Gustafsson 2000a; 2000b) was used. The model uses meteorology, freshwater supply, and offshore stratification as input. The model calculations were carried out by Björn Sjöberg from the Department of Systems Ecology at Stockholm University, Sweden (SUSE) for 31 out of 91 prioritized areas. A first very general partition of the coastal zone was made based on estimates of residence time based on the exchange between the open sea (>30 days, 10-30 days and <10 days) and stratification (fully mixed, partially mixed, stratified) was done (Figure 3). The results were monthly averages of temperature and salinity stratification. Averages are calculated for the whole integration period, 1991-2000. The output has been compared with observations. A dispersion model was also used to estimate turnover time, transit time and age.



Stratification Residence time

Figure 3: Stratification (left) and water residence time (right) in selected inshore areas of the Baltic Sea calculated for the CHARM project (Björn Sjöberg from the Department of Systems Ecology at Stockholm University, Sweden (SUSE)).

In the present CHARM typology only one threshold of the water residence time calculation was used. Enclosed coastal habitats, such as: lagoons and boddens in the western and southern Baltic Proper, as well as the innermost archipelagos located primarily along the Danish, Swedish and Finnish coast, with water residence time longer than 30 days were separated from the open coast with frequent water exchange based on the model calculation for these areas.

3.3 Water depth

An additional factor used in the typology was depth. Depth is regarded as an important factor in the WFD, e.g according to System A, salinity and depth only can be used as classification factors in typology. Depth affects many other aspects of habitat characteristics such as mixing and stratification of the water column, light penetration and influences sediment characteristic.

A depth model (with a resolution of 2 x 1 nautical miles) for the entire Baltic Sea was provided by T. Seiffert, Baltic Sea Research Institute Warnemünde, Germany (Seifert T. personal comm.). In the CHARM typology it was assumed that the coastal waters delimited by the WFD rules - 1 mn from the baseline - correspond mostly with the 20 m isobath, as shown in Figure 2. It was therefore assumed in the typology for the Baltic Sea Ecoregion that the 20 m is a depth limit for most of the WFD coastal zone. Only within a few locations coastal waters delimited by baseline are deeper than 20 meters and in such locations this typology leaves areas which, if needed, should be further classified as separate types based on the additional depth classes (e.g. under national typologies).

The 20 m isobath is fairly in agreement with the outer limits of the water framework directive, but are not a suitable boundary within a typology. One biologically important parameter is the depth of the thermocline. In a detailed analysis based on results with the Baltic Ecosystem model ERGOM showed that the average depth of the thermocline in summer in the Baltic Sea is in a depth of about 10 m. Therefore, the 10 m isobath was used to distinguish the shallow coastal zone, which is always fully mixed within the entire water column from open waters. Also, the 10 m depth threshold describes the euphotic zone in coastal areas, where water transparency is lower than in the open sea areas (Aarup 2002), as well. Thus, the typology has two depth classes dividing coastal waters into waters shallower and deeper than 10 m.

3.4 Typology and spatial type distribution in coastal waters

The present classification of types within the Baltic Sea is based on three main factors (Figure 4):

- surface salinity,
- water residence time which separates open coast from semi-enclosed bays/inshore areas which were delimited as separate geographical units
- depth, which corresponds to the mixing of the water column.

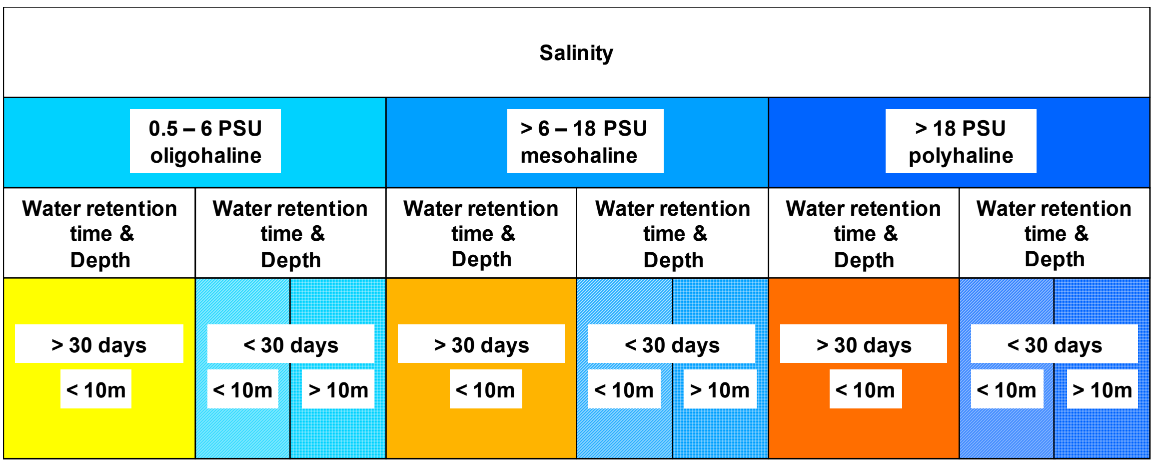


Figure 4: Simple umbrella typology for the Baltic Sea according to the WFD.

Figure 5a and Figure 5b present the type distribution along the coast of the Baltic Sea showing types within the WFD up to the 20 m depth line and for the whole Baltic Sea area. Since the Water Framework Directive is restricted to a coastal strip of only 1 nautical mile off the baseline, the narrow strip of coastal waters is artificially divided from open waters. The present Baltic Sea typology approach allows the extension towards the entire Baltic Sea. It allows a more comprehensive view concerning reference conditions, water quality classification schemes and monitoring (Figure 6).

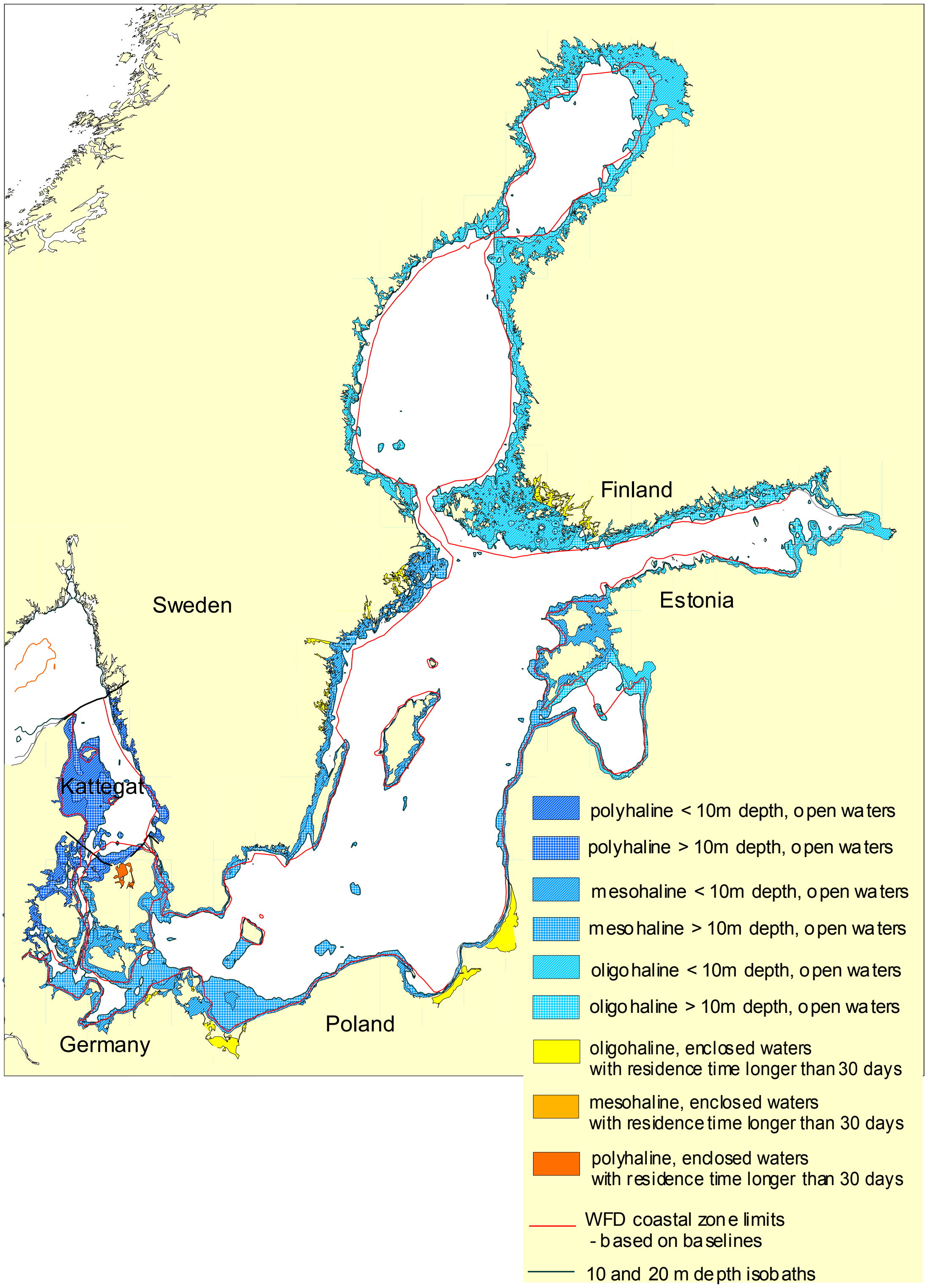


Figure 5a: Distribution of types in coastal waters up to 20 m depth according to the Baltic Sea typology (whole Baltic Sea area).

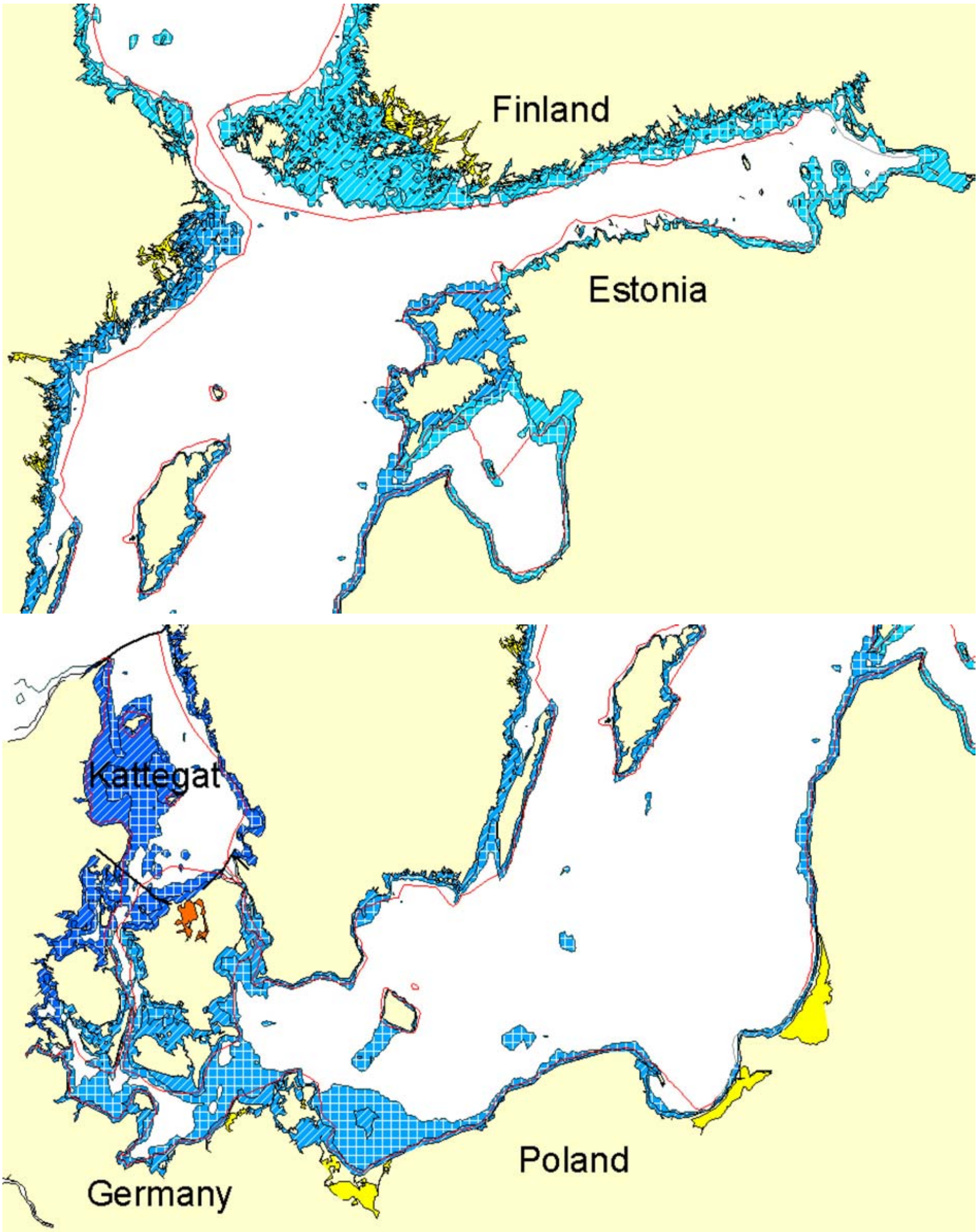


Figure 5b: Distribution of types in coastal waters up to 20 m depth according to the Baltic Sea typology (western and central Baltic Sea).

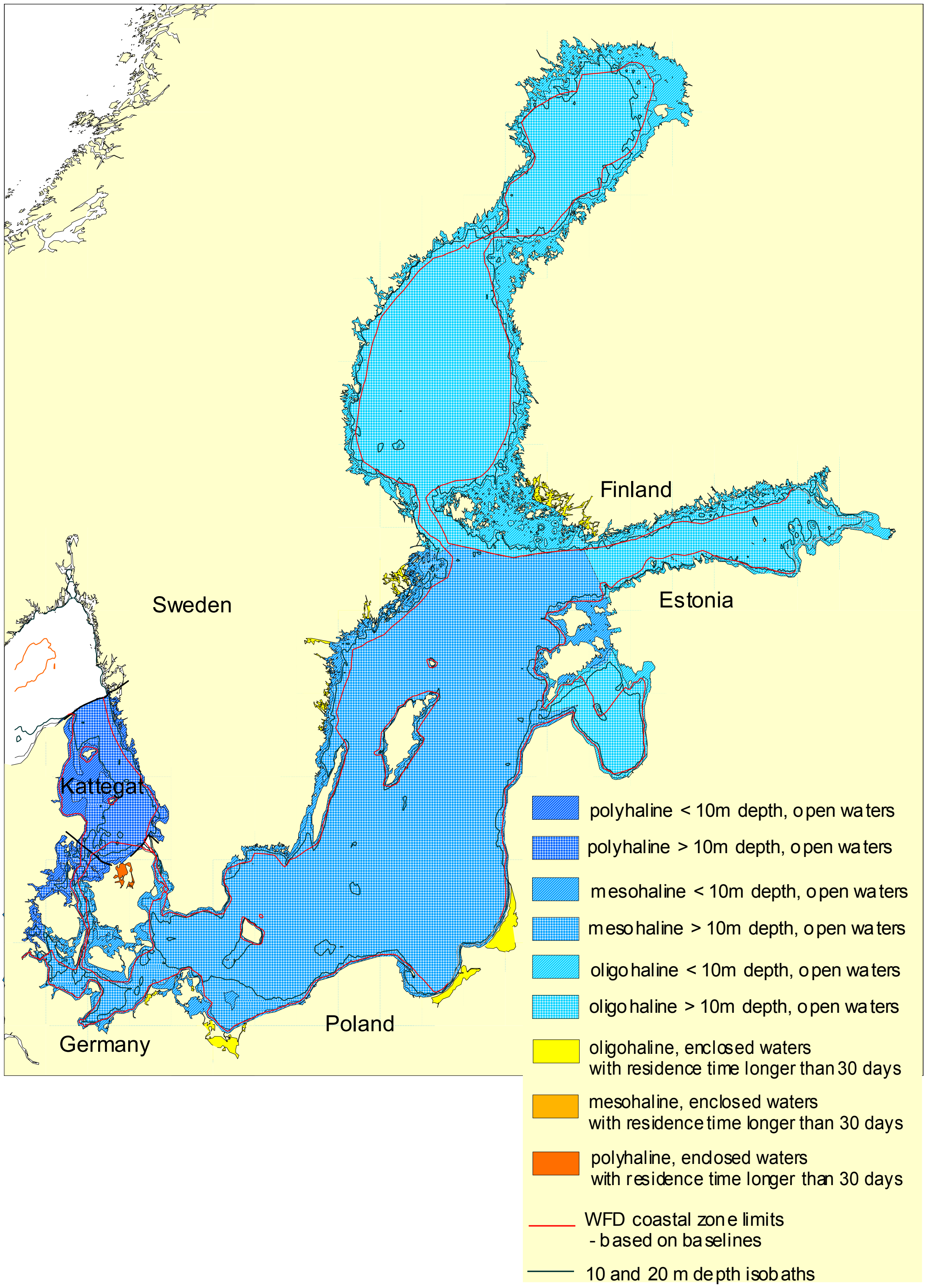


Figure 6: Distribution of types for the entire Baltic Sea typology.

4 Umbrella approach for national typologies

In the first CHARM approach to the Baltic typology the entire Baltic Sea was subdivided into nearly 30 types. The large number of types automatically caused significant differences compared to the national typologies. The acceptance of a complex typology for the entire Baltic Sea was poor and specific regional aspects were not reflected. Against this background we changed our strategy and tried to work out the most important parameters for a typology. We tried to simplify our typology as much as possible and to develop it towards an umbrella system. Umbrella system means that the typology allows a further subdivision according to regional demands and allows the integration of the national typologies. It serves as a link between and integrative element for the national typologies.

The salinity boundaries used in our typology was used by most countries since it is based on the well established Venice system. All national typologies accept the main thresholds from 5 to 6 between oligo- and mesohaline waters and from 18 to 20 PSU between mesohaline and polyhaline waters. The strongest surface salinity gradient occurs between the Kattegat and the western Baltic Proper and salinity plays a very important role in national typologies of this region. In the German typology e.g. 3 PSU, 5 PSU in oligohaline class and 10 PSU in mesohaline class was used to subdivide basic four types further. Also, in countries, where all waters are oligohaline additional divisions might be suitable. In the Finnish national typology according to system B additional salinity threshold - 4 PSU is used and in the Swedish typology, there is also an additional threshold subdividing oligohaline waters – 3PSU.

All Baltic states have chosen System B of the Water Framework Directive. Except for Germany, none of the national typology presented here is a final version and changes in approach and spatial distribution of types can be expected. However, almost all countries have now drafted prepared their own classification systems for the Baltic Sea waters. Available drafts are compared to the umbrella typology and the classification is discussed below (Figure 7).

4.1 Southern coast of central part of the Baltic - Latvian and Lithuanian draft national typologies

Latvian and Lithuanian coast represents the open sandy or mixed sandy-hard bottom sediment coast of the central Baltic. The Latvian typology considers the following factors: salinity, depth, wave exposure, mixing, residence time, bottom substratum and ice coverage. The governing factors in the Latvian typology are salinity and substratum. Water salinity in the coastal water of Latvia is in general lower then 6 PSU within the Gulf of Riga and along the open Baltic coast exceeds this value (Albinus et al. 2004). Thus, there are two salinity classes in Latvian typology. Division into two classes according to salinity reflects also wave exposure, since waters within the Gulf of Riga were classified as moderately exposed and the outer Baltic coast as exposed. Latvian coastal waters as defined by the WFD usually do not exceed 10 - 15 m depth along whole Latvian coast (with one exception when the coastal water stretch has mean depth of about 13 m), and the average depth is 7 m (Albinus et al. 2004). Within the salinity classes it is substratum that defines water types along the cost and coastal water stretches have been identified according to the dominant bottom type (Albinus et al. 2004). The Latvian typology can therefore be included into the CHARM umbrella classification as show in Figure 7.

The Lithuanian typology considers similar factors (Ansbæk & Schwærter 2004): salinity, depth, wave exposure, mixing, and bottom substratum. The open Lithuanian waters are classified as mesohaline. The other governing factor used for open coast classification is bottom substratum. The Curonian Lagoon is classified in the Lithuanian typology as transitional waters, but the open coast classification – which is not complex in the Lituanian part of the Baltic coast can be classified under the CHARM umbrella (Figure 7).

Both in the Latvian and Lithuanian typologies the large river plumes (the Daugava River and the outlet of the Curonian Lagoon) are classified as transitional waters. This is a different approach to the approaches taken by most other countries and also differs to the CHARM approach, and it calls for additional classification means – such as e.g. defining the river plume border.

4.2 From Kattegat to western Baltic coast Danish and German draft national typologies

Danish waters belong to the two Ecoregions: North Sea and the Baltic Sea. There are strong salinity gradients in Danish coastal waters due to the specific strong water stratification in Danish Straits region and extension of the coastal waters strip: from the North Sea to the open mesohaline waters of the central Baltic. Therefore, the first factor used for classification in Danish typology is salinity of the bottom layer with the generally acceptable thresholds. Further, the Danish classification is based on the assumption that open waters require use of different factors for classification then enclosed basins such as fiords. Thus, there are two classification systems used in the Danish typology: for open waters and for classification of fjords. Types in open waters are categorized according to:

- Bottom salinity,
- Exposure
- Tidal range.

Types in fjords are categorized according to:

- Bottom salinity,
- Degree of stratification
- Degree of sensitivity to land-based input of water (Danish EPA 2004).

In a very general sense it can be said that the open waters are separated from enclosed waters in the Danish typology and the classification is based on the geographically defined areas. This first step is comparable to the CHARM umbrella approach; however further classification factors used for Danish waters are specific to this national typology (Figure 7).

German coast also faces a quite strong salinity gradient in the western part of the Baltic and salinity is the main classification factor in German typology. All open coast waters are classified as mesohaline with the exception of deeper, stratified areas, where bottom waters are of higher salinity classified as separate type – mixohaline waters. The open coast is divided into two types: open and inner mesohaline coastal waters. The inner lagoons and boddens are classified as oligohaline due to the fresh water inflow and the entire). Thus, there are four types in the German typology (Institut für Angewandte Ökologie 2003; Weber et al. 2002). The German typology can be classified within the CHARM umbrella typology (Figure 7).

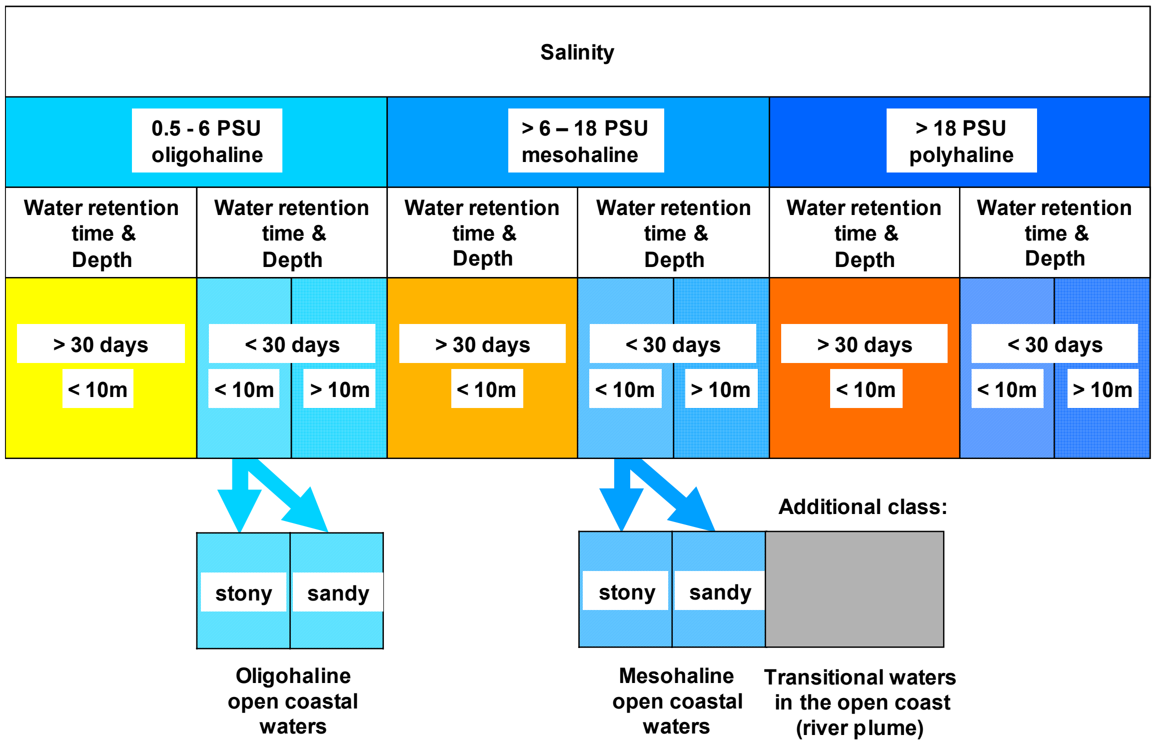
4.3 Swedish draft national typology

Sweden has the longest coast line amongst all Baltic countries stretching in the all three salinity classes from polyhaline waters in Kattegat to oligohaline waters in the Gulf of Bothnia with a complex coast structure. In the Swedish national typology non-hierarchical approach is used and types are classified on the basis of two or tree governing factors out of the following list: salinity, water exchange of bottom waters, substratum, stratification, wave exposure, ice days. Depth is also considered for the type description. Salinity is considered for most regions as a main governing factor. To differentiate between open coast areas and inner, more enclosed cost types, wave exposure and water exchange are considered as factors defining types, but in some other regions bottom substratum and stratification are taken into account. In the Gulf of Bothnia one of the main governing factors is ice cover (Swedish – EPA 2004). This is a different strategy than hierarchical approach used in other countries, and also differs from the CHARM approach (Figure 7).

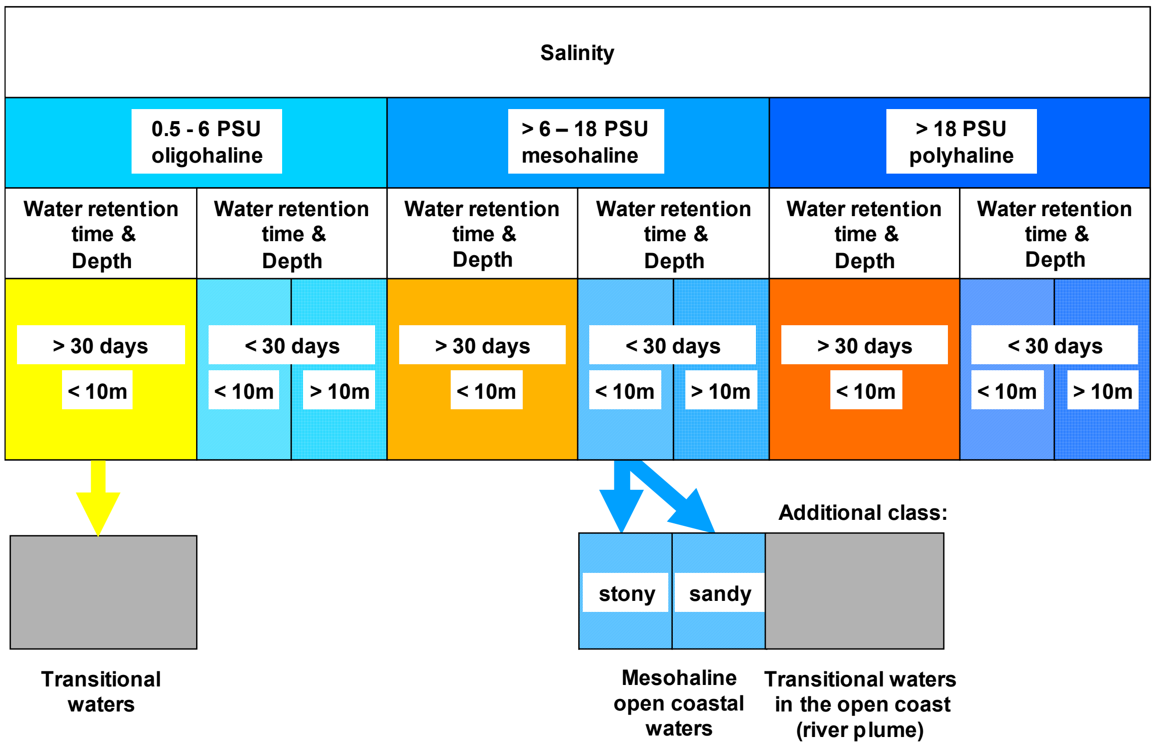
4.4 Finnish draft national typology

In the Finnish typology according to system B the coastal areas are oligohaline and are subdivided based on additional salinity thresholds 4 PSU and 1 PSU. Further subdivision of archipelago waters identifies most inner archipelago waters, intermediate type and open water type – with deep most exposed coast (Finnish Coastal Expert Group 2001). This approach can be classified under umbrella typology. At the moment, the Finnish typology is under revision and some changes in the types and their distribution can be expected.

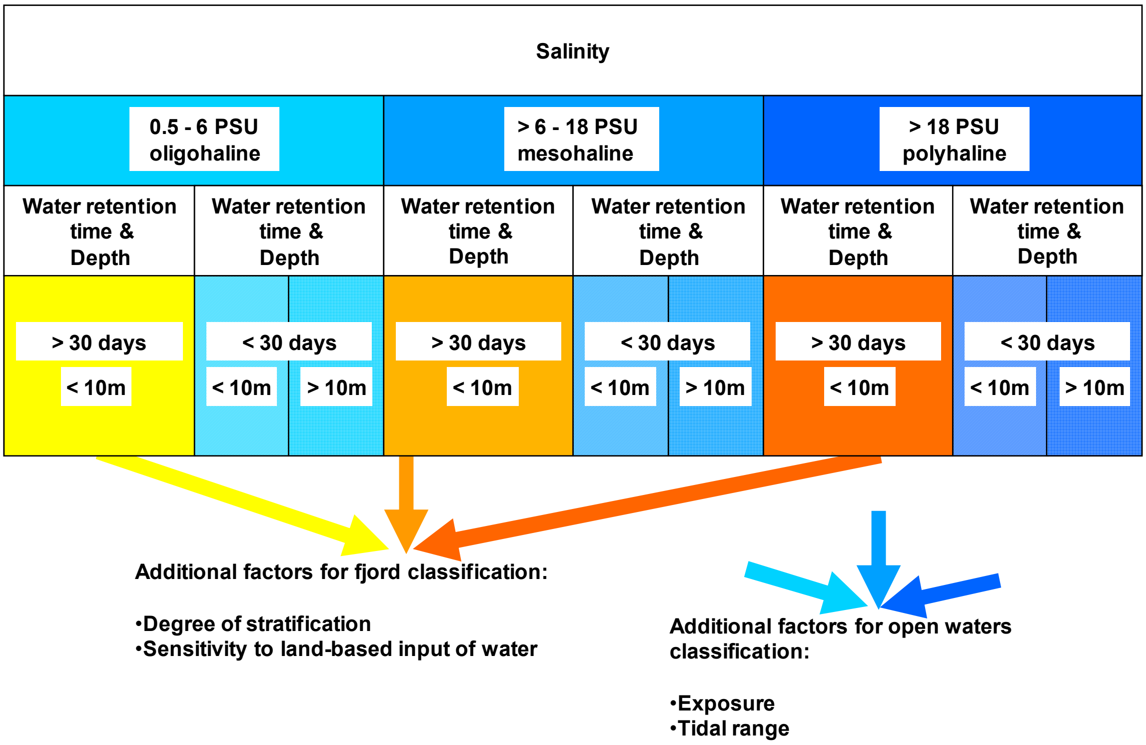
The Baltic typology subdivided according to the national Latvian typology



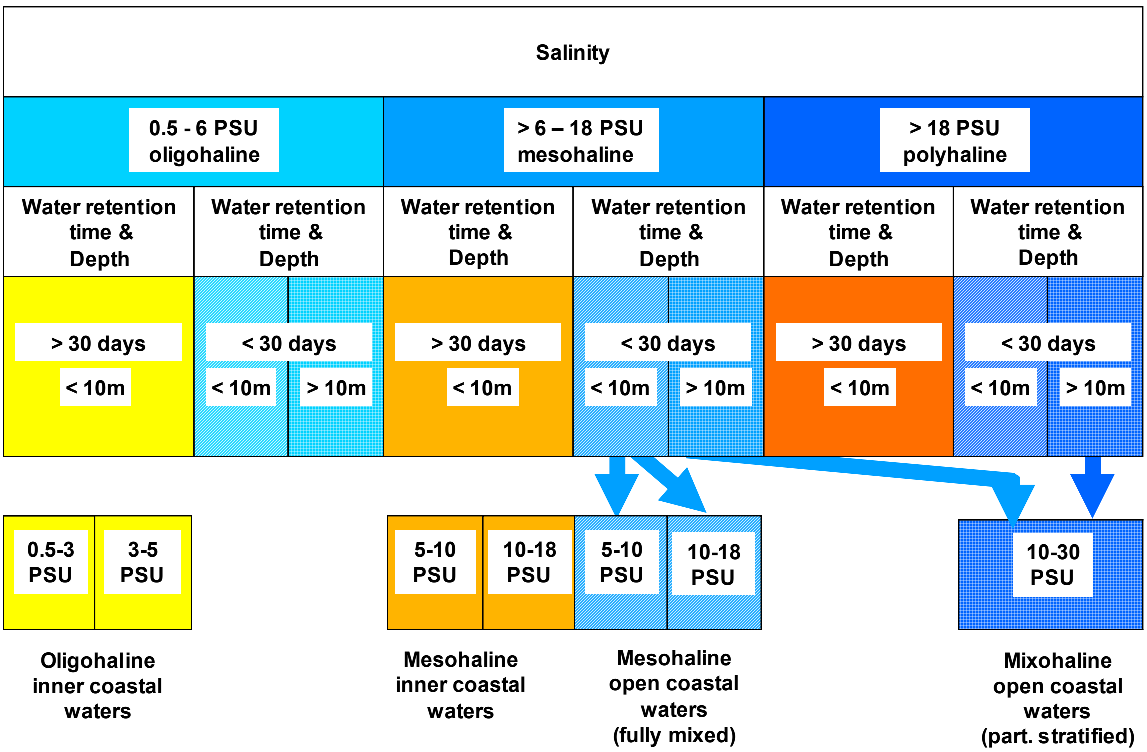
The Baltic typology subdivided according to the national Lithuanian typology



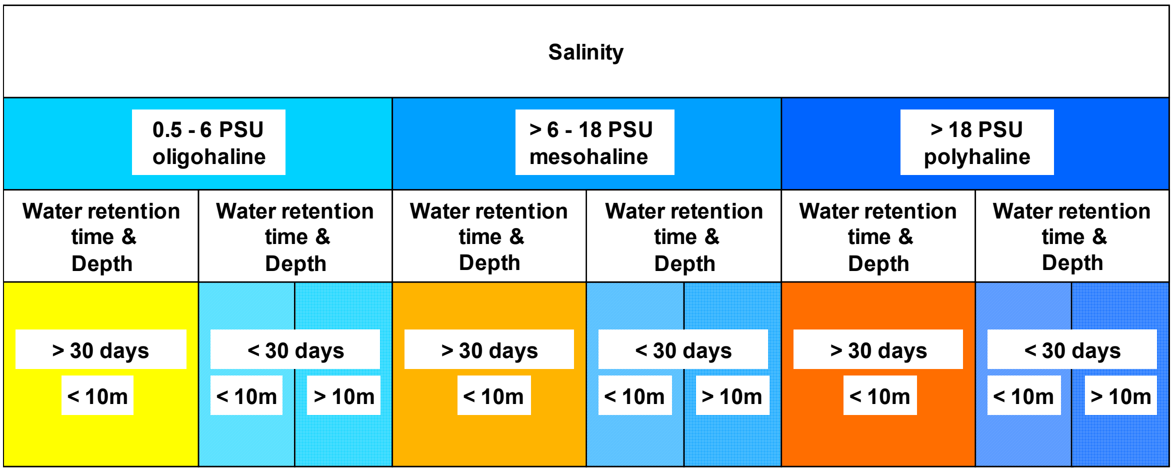
The Baltic typology subdivided according to the national Danish typology



The Baltic typology subdivided according to the national German typology



The Baltic typology subdivided according to the national Swedish typology



Swedish typology uses non hierarchical approach with following factors:

- **Salinity**
- **Water exchange - bottom waters**
- **Stratification**

Wave exposure
Substratum
Ice days

The Baltic typology subdivided according to the national Finish typology

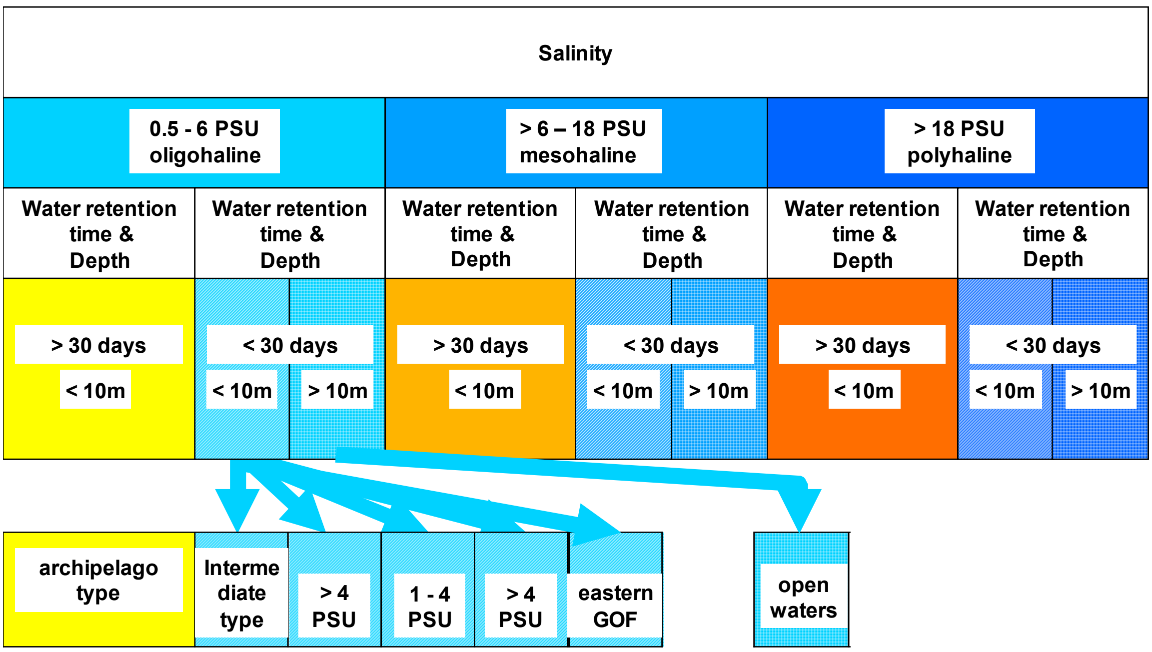


Figure 7: The Baltic typology subdivided according to the available national typology.

5 Data sources/Acknowledgements

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- National Environmental Research Institute (NERI)
- Finish Environmental Institute (FEI)
- Aabo Akademi University (AAU)
- Environmental Institute, Joint Research Centre (JRC/EI)
- Klaipeda University, Coastal Research & Planning Institute (CORPI)
- Baltic Sea Research Institute, Warnemünde (IOW)
- Estonian Marine Institute (EMI)
- University of Latvia, Institute of Aquatic Ecology (IAE)
- Stockholm University, Department of System Ecology (SUSE)
- Sea Fisheries Institute (MIR)
- University of Greifswald (EMAUG)

The data used for salinity calculation was supplied by the Department of Systems Ecology, Stockholm University, Sweden. It was stored in the Baltic Environmental Database (BED). Different research institutes contributed to BED by providing data from several monitoring programs.

This article is available in color under: http://www.eucc-d.de/baltcoast2004/papers.html.

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An expert judgement approach to designating ecosystem typology and assessing the health of the Gulf of Gdansk

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Abstract

The Gulf of Gdansk is comprised of a number of different hydro-geo-morphological regimes that represent different ecosystem units - lagoons, bays, river mouths, and sheltered and open coastal areas. Several classifications of the Gulf of Gdansk exist and most of them are based on morphological and/or hydrological parameters (salinity, temperature, nutrients). The classification proposed in this paper places stress on the morphology and dynamics of water masses and thus on bottom sediments.

The Gulf of Gdansk is subjected to different rates of anthropogenic pressure; this means that environmental quality status varies in the different parts of the coast. The following parameters were used in the quality assessments of different hydro-geo-morphological units of the Gulf of Gdansk: 1) sanitary conditions - number of coliform bacteria in a pre-determined volume of water, 2) phytoplankton - species composition, abundance and biomass, 3) macroalgae and angiosperm - species composition and biomass, 4) macrozoobenthos - species richness, composition and biomass, 5) ichthyofauna - information compiled from various sources in the literature, 6) basic hydrographic and hydro-chemical conditions - Secchi depth, temperature, salinity and oxygen.

The quality status of different environmental units, assessed according to criteria proposed by the Water Framework Directive, versus the selected reference period of the 1950s, is assessed in four quality ranges (bad, poor, moderate, and good). This is assuming, as the present authors believe, that high status, which is due to excessive eutrophication, does not exist, even for open Baltic Sea water masses.

1 Introduction

The area selected for identifying natural sub-systems and describing their quality status is the diverse and complex ecosystem of the Gulf of Gdansk. This area has been divided into several sub-systems according to morphology and dynamics. These sub-systems are also considered as “managerial units” where specific action should be taken to combat anthropogenic pressure.

Environmental quality assessment is traditionally based on physical, chemical, and biological parameters. It is usually assessed within administrative borders, and has often not recognized natural borders within the selected ecosystem. This approach is changed significantly in the EU WFD (2000), which requires that natural boundaries should be recognized. The EU WFD also stipulates that ecosystem quality assessments have to be based on measurements of the status of phytoplankton, macrophytobenthos, macrozoobenthos and ichthyofauna. The authors of the current paper also included sanitary conditions of coastal, bathing waters. Sanitary conditions are unsatisfactory in many polluted river mouths in the Baltic and in some areas close to ports and at sewage discharges. This is the biggest concern of both coastal communities and local authorities.

In the authors’ opinion, the desired level of ecosystem quality should be the environmental status of the Baltic Sea from the pre-industrial period. Essentially, this refers to the period before the intense development of industry and the advent of agriculture supported by chemical fertilizers, pesticides and herbicides. The prevailing opinion is that this level of environmental quality existed from the time soon before World War II or even soon after it. Subsequently, the authors propose the 1950s as the reference period. This proposal is supported by other important arguments such as 'human memories' of a clean marine environment and a good body of knowledge regarding the Baltic Sea.

2 Materials and methods

A large amount of documentation on the environmental conditions of the Gulf of Gdansk exists in the combined published and unpublished data literature. Historical data regarding the Gulf of Gdansk are available even from the early twentieth century (Lakowitz 1907, 1929) and from the period prior to and immediately following World War II (Demel 1927a & b; Demel, 1935; Bursa et al. 1939, 1947; Wojtusiak et al. 1950). More recent publications are also available (Ciszewski et al. 1991, 1992a & b; Kruk-Dowgiallo 1991, 1996, 1998; Kruk-Dowgiallo & Dubrawski 1998; Osowiecki 1998, 2000; Plinski 1982; Plinski & Wiktor 1987; Plinski & Florczyk 1990; Andrulewicz & Witek 2002).

For the purpose of this paper, the aim of which is to develop a practical approach to the task, provide advice to managers, and meet WFD requirements, the authors have utilized existing knowledge from various sources - published papers, "grey literature", books and unpublished documentation. The authors believe that utilizing existing knowledge and an expert judgement can be utilised for solving the typology and health assessment problems of the Gulf of Gdansk.

The parameters considered for the different sub-areas (Fig. 1) are presented in Table 1.

Parameters	Inner coast			Outer coast		Open areas		
	I	II	III	IV	V	VI	VII	VIII
Phytoplankton	+	+	+	+	+	+	+	+
Macrophytobenthos	+	+						
Macrozoobenthos	+	+	+	+	+	+	+	+
Ichthyofauna	+	+	+	+	+	+	+	+
Chemical	+	+	+	+	+	+	+	+
Sanitary	+	+	+					

Table 1: Parameters considered for the assessment of the quality status of the Gulf of Gdansk.

3 Results and discussion

3.1 Identification of hydro-geo-morphological units

The Gulf of Gdansk is comprised of a number of different hydro-geo-morphological regimes that represent different ecosystem units. Several classifications of the Gulf of Gdansk exist (Lazarienko & Majewski 1975; Andrulewicz 1996; Nowacki & Jarosz 1998), most of which are based on morphological and/or hydrological parameters (salinity, temperature, nutrients). The classification proposed in this paper is based on the morphology and dynamics of water masses that determine the living conditions of bottom vegetation and fauna as well as the environmental quality of coastal water masses.

Morphology of the Gulf of Gdansk recognizes lagoons, river mouths, and sheltered and open sea areas (Fig. 1). Obvious division based on bathymetry and morphology of the coast is as follows: inner coastal area (0 -10 m), outer coastal area (10 - 20 m), and open areas (>20 m). Therefore, the Gulf of Gdansk can be divided into the following units (Fig. 1):

Inner Coast (0 -10 m)

1. Puck Lagoon (internal Puck Bay) - a shallow, sandy, semi-enclosed water body subjected to strong anthropogenic pressure and inhabited by freshwater and marine species;
2. Sheltered coast of the western Gulf of Gdansk, not dynamic and partly covered by vegetation, under strong anthropogenic pressure;

3. Open coast of the eastern Gulf of Gdansk, very dynamic, lacks vegetation and under strong anthropogenic pressure;
4. Vistula River plume and Vistula Lagoon (including River Pregel) plume – polluted freshwater plumes. Their size and direction depends on wind-driven surface currents.

Outer coast (10 - 20 m)

5. Sheltered outer coast of the Gulf of Gdansk with abundant benthic fauna, under moderate anthropogenic pressure;
6. Open outer coast of the Gulf of Gdansk with abundant benthic fauna, under moderate anthropogenic pressure;

Open areas (> 20 m)

7. Open areas between 20 - 40 m are still under coastal influence, but are also impacted by open seawater masses. Benthic fauna is more abundant as depth increases;
8. Open areas deeper than 40 m - most of these southern Baltic Sea water masses are not under direct coastal influence, the sediments are well oxygenated with a high benthic biomass (particularly between 40 - 60 m.). Bottom sediments become more anoxic and more contaminated as depth increases, therefore benthic biomass decreases towards deep deposition areas (80 -100 m).

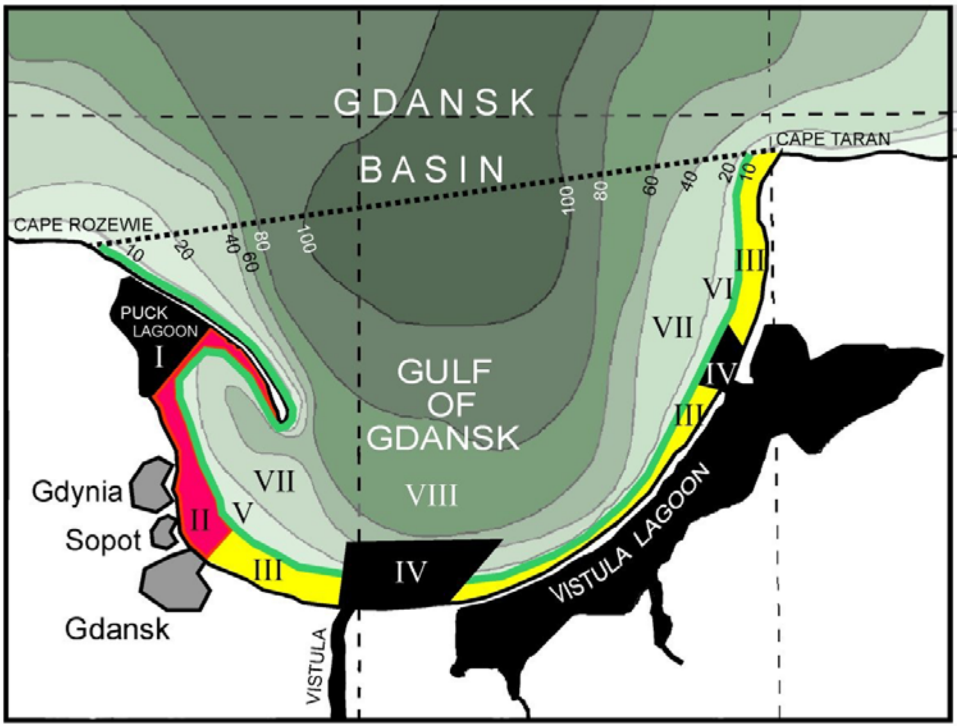

Figure 1: Divisions into natural sub-systems or typology in the Gulf of Gdansk

3.2 Environmental quality assessment

Sanitary conditions

Determinations of the sanitary conditions of the coastal waters of the Gulf of Gdansk are based on coliform bacteria measurements. These are supplemented occasionally with determinations of *Salmonella* and *Shigella.* Nearly all of the Gulf of Gdansk beaches were closed to bathing in the 1980s, but the sanitary state of these sites has been improving systematically since the 1990s and presently less than 25% are closed (WIOS 1999-2002). Efforts at both the local and national levels to improve sanitary conditions have focused primarily on constructing sewage treatment plants in coastal and watershed areas. However, the sanitary conditions of the Vistula River and its plume as well as the Vistula Lagoon and some places close to sewage outfalls remain unsatisfactory and require further effort. In general, coliform bacteria concentrations decrease from coastal to open sea areas, *i.e.*, from the Puck Bay to the open Gulf of Gdansk and from the Vistula River mouth to offshore areas (Czerwinska & Dubrawski 1998).

Phytoplankton

The nutrient accumulation process in the open coastal areas of the Gulf of Gdansk is similar during the winter season, as is the development of blooms during the spring and summer seasons. Thus, the productivity and composition of phytoplankton throughout the year in the Gulf of Gdansk is similar. However, the Puck Lagoon has different nutrient utilization dynamics - filamentous alga blooms develop in early spring and later form thick algal mats on the bottom of the lagoon.

Flagellate and Dinophyceae have dominated the abundance and biomass of the phytoplankton in the Gulf of Gdansk since the 1980s. An increase of approximately one hundred-fold in the overall abundance of phytoplankton and a ten-fold increase in diatoms confirm that the trophic state of the gulf was higher in the 1980s than in the 1970s. The phytoplankton bloom period, which is longer in comparison to that of the 1920s, has a negative impact on the gulf environment. This is especially true of blooms of potentially toxic species such as *Aphanizomenon flos-aquae*, *Nodularia spumigena, Dinophysis acuminata* and *Dinophysis norvegica* (Niemkiewicz & Wrzolek 1998).

Persistent, strong phytoplankton blooms enrich water and bottom sediments with significant amounts of autochothonous organic material and nutrients, which in turn intensify the process of internal eutrophication and generate blooms in the following year (Kruk-Dowgiallo & Dubrawski 1998).

Macrophytobenthos

There is an impressive amount of documentation for the changes in phytobenthic communities caused by anthropogenic pressure over the last twenty five years (Kruk-Dowgiallo 1991, 1996, 1998; Kruk-Dowgiallo & Dubrawski 1998; Plinski 1982; 1990; Plinski & Wiktor 1987; Plinski & Florczyk 1989). Macrophytobenthos is a good indicator of the ecological status of waters where bottom flora occurs; this applies above all to the Puck Lagoon and the sheltered coastal zone of the western part of the Gulf of Gdansk.

In the Puck Bay, algae and vascular plants occur together. The underwater meadows that cover the bottom of this basin are the largest of their kind in the Polish coastal zone and are a unique feature of this area. The vascular plants that occur in the Puck Lagoon include *Zostera marina, Potamogeton pectinatus* and *P. filiformis, Myriophyllum spicatum, Ranunculus baudotii,* and *Zannichellia palustris.* The algae here include the rare species *Chara baltica* and *Tolypella nidifica.*

The sandy-stony bottom of the sheltered coastal zone of the western part of the Gulf of Gdansk is dominated by algae, including the red algae *Furcellaria lumbricalis,* which is now rare in the Gulf of Gdansk.

Changes in the phytobenthos have been observed since the mid 1970s, especially in the Puck Lagoon. These have included the following:

- disappearance of the algae *Fucus vesiculosus* and *Furcellaria lumbricalis* that dominated until the late 1960s and many other non-dominant species - this has led to the deterioration of the quality of underwater meadows;
- decreasing size of bottom areas overgrown by *Zostera marina* and *Potamogeton spp.* and declines in their biomass;
- distinct domination (of up to 70%) in the overall biomass of one group of vegetation, the so-called filamentous brown algae *Pilayella littoralis* and *Ectocarpus siliculosus* - the domination of this species fell to 30% in the 1990s;
- decided decline in the overall phytobenthos biomass.

Additionally, the vertical range of occurrence of bottom vegetation in the Gulf of Gdansk declined significantly from a depth of 25 m in 1885 (Lakowitz 1907) to 6 m in the 1990s (Kruk-Dowgiallo 1998).

Eutrophication has been intensifying steadily since the 1950s; one result has been the disappearance of the occurrence of the perennial alga *Fucus vesiculosus* and *Furcellaria lumbricalis* in the gulf. These species do not reproduce generatively, which is very disadvantageous to survival when negative changes occur in environmental conditions. Due to this, they began to be replaced by the abundant development of filamentous brown algae, mainly *Pilayella littoralis*. These species employ various reproduction strategies depending on environmental conditions; this attests to the powerful regenerative capacity of the filamentous brown algae. Thanks to this ability, these algae beat other species, including phytoplankton, in competition for nutrients in the Puck Bay, where environmental conditions have been changing continuously since the 1950s.

Macrozoobenthos

The benthic fauna of the Gulf of Gdansk is relatively well documented in the scientific literature as it is close to scientific centres and is accessible to researchers. The first negative changes were observed here in the 1960s and were related to the restructuring of the macrophytes composition in shallow areas. Although changes in various parts of the Gulf of Gdansk were complex and sometimes divergent due to significantly diverse environmental conditions in the area, they were related primarily to taxonomic composition and structure, abundance, and biomass distribution. In general, however, these changes did not fully correspond with conceptual models that describe processes occurring in benthic macrofauna communities under the influence of marine eutrophication (Osowiecki 2000).

It is reasonable to assume that the continuous process of eutrophication and pollution is the primary factor responsible for changes in the Gulf of Gdansk macrozoobenthos. Sediments that were overloaded with organic matter underwent a structural transformation that prompted adaptive changes in the composition of the benthic fauna. The macrophytes meadows that grew on the sandy bottom and that were so common in the shallow zone of the Puck Bay (western part of the Gulf) in the 1960s are now practically extinct. They have been replaced by sandy-silt and silt sediments, which create more favourable conditions for the development of deposit feeders that tolerate greater degrees of environmental pollution.

The quantitative and qualitative changes that have occurred in the macrozoobenthos during the last decades are significant, but definitely not as spectacular as those that have occurred in the phytobenthos and sediments. Some non-indigenous species appeared in the Gulf of Gdansk in the 1990s, although it has not been confirmed if any of them have succeeded in mass-colonizing the region, except a case of a polychaete *Marenzelleria viridis* in the Vistula Lagoon where it constitutes up to 95% of a total macrozoobenthos biomass (Zmudzinski 1994).

Ichthyofauna

The fish occurring in the Gulf of Gdansk include marine, diadromous, and freshwater species of commercial importance such as *Platichthys flesus*, *Clupea haregus*, *Salmo salar*, *Anquilla anquilla*, *Stizostedion licioperca*s and *Perca fluviatilis*. The coastal areas provide habitats for many small species and the young stages of non-commercial fish species. This includes some protected species such as the small goby and sand goby, as well as "pest fish" such as *Gasterosteus aculeatus* and *Neogobius melanostomus*. The latter has widened significantly its area of distribution in the coastal zone in recent years (Jackowski 2002). The coastal zone is the location of the feeding grounds of many species of commercial fish and the spawning grounds of herring. The spawning migration route of salmonids also passes through this zone.

In the first half of the 1960s *Anquilla anquilla* and *Esox lucius* dominated catches made in the inner Puck Bay. In the 1970s, *Rutilus rutilus* began to occur on a massive scale (Ciszewski et al. 1992a; Skora 1993a). Due to the destruction of the natural spawning sites and feeding grounds of freshwater fish and overfishing, the current commercial significance of roach and perch is minimal. Eutrophication and pollution in the Puck Lagoon has resulted in the following:

- the decreased size of underwater meadows has caused the disappearance of herbivorous fish species (pike, roach, perch);
- the limited range of occurrence of the unique species *Nerophis ophidion*, *Syngnathus typhle*, *Spinachia spinachia* and *Coryphoterus flavescens*;
- the expansion of species from the stickleback and goby families. The biomass of the three-spined stickleback currently stands at nearly 98% of the overall fish biomass in the Puck Bay (Skora 1993).
- the area of occurrence of the new species round goby *Neogobius melanostomus* is expanding;
- *Acipenser sturio* has become extinct (Skora 1993), and serious limitations are being placed on local populations of *Coregonus lavaretus* and *Vimba vimba*.

Chemical parameters

The most important sources of nutrient pollution in the Gulf of Gdansk region are the Vistula River, the Vistula Lagoon, waste treatment plants, some industries in Gdansk and Gdynia, and atmospheric fallout.The average river load of the Vistula River amounts 120,000 tons of total nitrogen per year and 7,000 tons of total phosphorus per year ((Andrulewicz & Witek 2002; IMGW 1994-2002).

The enhancement of nutrient concentrations is noted during the winter period, this enables the occurrence of the spring phytoplankton bloom (Trzosinska 1994, Lysiak-Pastuszak 2000) and further phytoplankton blooms throughout the summer season. Oxygen depletion occurs in the deepest parts of the Gulf of Gdansk, usually below 80 meters (Trzosinska & Lysiak-Pastuszak 1996).

4 Results and discussion

According to the author's judgement the present quality status of the identified ecosystem units of the Gulf of Gdansk assessed in light of the historical reference period (1950s) and according the quality scale proposed in the WFD is presented in Table 2.

Inner coast (0-10 m)			Outer coast (10-20 m)		Open areas		
I	II	III	IV	V	VI	VII	VIII
bad	poor	moderate	bad	moderate /good	moderate /good	good	good

Table 2: Estimated quality or health status versus the reference period (1950).

The following are the justification of the quality grades:

- **I. Puck Lagoon – Bad**. More than 75% of the underwater meadows have disappeared and fish landings have diminished by more than 75%;
- **II. Sheltered coast of the western Gulf of Gdansk - Poor**. Diminished depth range of vascular plants (from 25 to 6 m), poor sanitary conditions, and excessive algal blooms.
- **III. Open coast of the eastern Gulf of Gdansk – Moderate**. Sanitary conditions, although acceptable for bathing, are at the low end of the acceptance range, prolonged algal blooms deteriorate the aesthetic conditions of these coastal waters;
- **IV - Vistula River and Vistula Lagoon plumes – Bad**. Poor sanitary conditions and high nutrient concentrations.

- **V and VI - Sheltered outer coast and open outer coast (10-20m) - Moderate/ Good**. No significant changes noted apart from enhanced blooms. Abundant bottom fauna, good sediment and sanitary conditions.
- **VII and VIII - Open areas between 20 m to 40 m and further to the open sea – Good**. No changes noticed apart from changes in the trophic status in comparison with those of the 1950s. Abundant and diversified bottom fauna, good sanitary conditions.

5 Conclusions

Identifying natural sub-systems (ecological units or typology) is the first step necessary in effective management. In total, there were eight ecosystem sub-units identified in the Gulf of Gdansk, but only those sub-units which are situated close to the coast are being proposed for management actions.

These sub-units represent different quality grades resulting from anthropogenic pressure and their natural abilities to absorb this pressure. These grades, versus environmental status of reference period 1950s, are “bad”, “poor”, “moderate”, and “good”. The quality status of “high” has not even been given to the open waters of the Gulf of Gdansk, due to the excessive eutrophication phenomenon.

In order to improve the environmental or ecosystem quality status of the Gulf of Gdansk, the following recommendations/actions are proposed:

- **Area I - Puck Lagoon**: restore the underwater meadows by reintroducing vascular plants and macroalgae (e.g. *Fucus vesiculosus*, *Furcellaria lumbricalis*), restoring spawning grounds and reintroducing selected commercial fish species;
- **Area II - Sheltered coast**: further improve sanitary conditions through more effective sewage treatment and further reduce nutrient loads;
- **Area III - Open coast**: further reduce nutrient loads;
- **Area IV - Vistula River and Vistula Lagoon plumes**: reduce the use of nutrients in the Vistula and Pregel River watersheds, construct sewage treatment facilities and promote effective purification of sewage;

No action is needed in outer and in open of the Gulf of Gdansk **areas V-VIII.** Actions taken in areas I-IV should have a positive impact in areas V-VIII.

The results of this approach regarding typology and a health assessment of the Gulf of Gdansk should be developed further and discussed in open forums to generate and promote general acceptance.

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A Critical Review of Progress towards Integrated Coastal Management in the Baltic Sea Region

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Abstract

This paper presents a review of the development of Integrated Coastal Zone Management (ICZM) processes in the Baltic region. Excellent "State of the Art" reports on ICZM have been prepared that catalogue specific ICZM activities in individual Baltic States. However, these reports do not utilise a well established methodology for analysing the outcomes of the ICZM activities or assess the progress that may have been made towards a robust and sustainable ICZM process.

Available methodologies and indicators that might be used for these purposes are reviewed and the conclusion is drawn that we do not have a competent methodology or appropriate indicators. The author assesses progress towards ICZM in the Baltic based on what has been achieved in respect to well-established elements of good practice, effective management responses and potential outcomes. The conclusion is drawn that substantive progress has been achieved. The challenge we face is to capitalise of this progress by determining what further technical, financial, or other forms of support would help strengthen ICZM and achieve sustainable improvements in the environmental conditions in the Baltic ecosystem and the social and economic welfare of the Baltic States.

1 Introduction

The Baltic is a prime example of a shallow enclosed coastal sea where human development activities continue to have a major influence on the ecology and sustainable use of coastal and marine ecosystems. The Baltic Sea Region is also influenced by climatic changes that influence the hydrology of river basin systems that drain into the Baltic Sea with consequent effects on sea level, salinity and ecosystem productivity.

Historically, the Baltic has formed a focus of human settlement, natural resources production, and international trade. There have been both positive and negative effects associated with these diverse forms of human development. Positive effects include the improvement of human welfare through the expansion and diversification of the economic bases of the Baltic States. There have been a number of negative economic, social and environmental effects associated with the human development process and broader climatic features of global change. These include contamination of terrestrial soils and marine sediments with toxic chemicals and heavy metals, reduction in fish stocks, loss of biological diversity, increasing natural hazards and increased vulnerability of people to natural and man-induced hazards such as flooding The combination of human induced changes to terrestrial and marine systems and natural climatic changes can be referred to as Global Change affecting the Baltic Sea region.

Growing recognition of these adverse effects has stimulated a search for improvements in development strategies, policies, institutional arrangements, laws and regulations, and human resources development as means of achieving more sustainable and equitable forms of development. Integrated Coastal Zone Management (ICZM) forms one of the development planning and management tools widely adopted by the Baltic States in their search for more sustainable forms of development.

The Baltic has enjoyed a substantive international, national, and more local support for ICZM. The author has been asked to comment on how successful ICZM has been in the Baltic Sea Region in respect to the European Union Integrated Coastal Zone Management Strategy (CEC, 1999). This strategy seeks to promote sustainable use of coastal ecosystems and their renewable natural resources, and a move away from a project-by-project approach to the adoption of a strategic approach that provides a stronger enabling environment at Member State level.

From the outset, it must be stated that measuring the success of ICZM is not an easy task, nor can it be measured in terms of a final product**. In essence, what we are searching for is evidence of the development of a robust ICZM process that is capable of sustaining improvements in environmental, social and economic conditions in the context of Global Change.** In the following paragraphs, the author discusses the difficulties of assessing the State of the Art in developing ICZM, including the lack of a suitable methodology and indicators. The author then attempts to assess the progress that has been achieved in the Baltic Sea Region. This is one person's viewpoint and it is hoped the materials presented and conclusions drawn will promote a lively discussion at this workshop!

2 Coastal and Marine Problems and Issues faced by the Baltic States

A number of reports provide detailed accounts of the coastal management problems and issues facing the nations in the Baltic Sea region (see the Progress Report from the HELCOM-WWF project on Management Plans for Coastal lagoons and Wetlands, Baltic Sea, 1999; PROCOAST State of the Art Report, 2000; EUCC ICZM in the Baltic States-: State of the Art Report, 2003). It is important to recognise that some of the problems identified are common to more than one nation while other problems may be experienced by only a few Baltic States.

The Baltic ecosystem is shared by a number of sovereign nations and many of the issues and problems associated with the sustainable use of the Baltic region's coastal and marine resources are common to a number of these nations. Issues such as pollution from land-based activities are common to more than one nation; for example, non-point source pollution derived from agriculture or forestry, or point sources of industrial chemical contamination of waters and sediments. The adverse effects on ecosystems and the production and utility of natural resources may be shared among a wide cross section of interest groups beyond the borders of individual nations where the pollution originated. These issues have an international dimension and their resolution will require international cooperation.

Other problems or issues are specific to individual countries, or are not shared by all Baltic nations. Erosion is a case in point where the causes of erosion may be the result of local actions such as sand mining, or regional climatic change resulting in increased wave energy. The effects may be local or may affect a number of countries sharing the same regional coastline. Relative sea-level rise is another example. In the case of Sweden the geological characteristics of Sweden's Baltic coastline and post glacial isostatic rebound mean that a rise in sea level poses less of a problem for coastal development than in a country where the coastal landforms are dominated by poorly consolidated sediments and where sections of the coastline are eroding and the shoreline is retreating as a consequence of relative sea level rise.

While State of the Art reports are useful in identifying the range of environmental problems associated with coastal development, they tend to indicate which problems or issues have not been resolved in the relatively short history of ICZM in the Baltic Sea region. These reports also tend to assume that there are standard components of an ICZM project or programme that must be in place before tangible results can be achieved.

The Sate of the Art reports do not really measure progress because there is insufficient information to form a baseline from which to assess what has been achieved in resolving problems and issues. The State of the Art reports are helpful in providing an account of what information has been gathered, the number of people participating, and which management plans have been formulated, etc. These are

OUTPUTS and do not tell us much about the effectiveness of investment in developing a competent ICZM project or programme, and whether ICZM is delivering effective OUTCOMES in terms of solutions to perceived problems and issues. In effect, these reports form a baseline for each Baltic State from which we can try to measure progress towards the achievement of outcomes. However there is a danger that this approach can fail to give sufficient emphasis to the obstacles individual countries have overcome in making substantive progress towards developing a robust ICZM process that will deliver sustainable solutions to complex problems.

3 Support for the Development of ICZM in the Baltic

The international dimensions of many of the problems and issues in the Baltic are addressed through global conventions, for example the Convention on Biological Diversity. There are also international measures designed to protect the marine and coastal environment at a more regional level; examples include 1974 and subsequent 1992 Conventions on the Protection of the Marine Environment of the Baltic Sea Area. Although the main objectives of this latter Convention are "to prevent and eliminate pollution in order to promote the ecological restoration of the Baltic Sea Area and preservation of its ecological balance", the recommendations from the governing body for the Convention provide strong support for coastal zone planning and management. See for example HELCOM Recommendation 15/1 of 1994 which suggests that protected areas up to 300 metres landwards and seawards from the shoreline be established and that a "coastal planning zone" at least 3 kilometres inland of the man high tide line be established. Further HELCOM recommendations have been formulated for a system of coastal and marine protected areas (15/5 of 1994) and for conservation of natural coastal dynamics (16/3 of1993).

There has also been innovative international support for spatial planning linked to coastal management in the Baltic Sea Region that pre-dates the EU INTERREG and European Spatial Development Perspective. This is exemplified in the report "Visions and Strategies around the Baltic Sea 2010" (VASAB 2010) presented in 1994 to the Third Standing Conference of Ministers from the Baltic States. This was reinforced at the Fourth Ministerial Conference held in 1996 where priorities and common recommendations for spatial planning of the coastal zone in the Baltic region were adopted.

The "PROCOAST" project for "Harmonisation of the Uses and Interests in the Baltic Sea Coastal Zones" is designed to help translate environmental concerns into practical planning and management solutions for the coastal zones in the Baltic Sea Region (BSR) through the exchange of experience between stakeholders and experts from the Baltic States (PROCOAST 2000). This international initiative is funded mainly through the European Regional Development Fund INTERREG II C. This initiative provides a comprehensive overview of the "state-of-the-art" of implementation of HELCOM, VASAB and other environmental recommendations into coastal plans and management arrangements in the Baltic Sea Region.

The NORCOAST project has similar objectives to the PROCOAST; although it focuses on the North Sea region, it does include countries such as Germany that have both Baltic and North Sea coasts. The NORCOAST project complements the efforts to improve coastal management and spatial planning in the Baltic by focusing on planning methods at a regional level that assist in the delivery of effective integrated coastal management. The recommendations of the NORCOAST project address three main issues, namely:

1. How to facilitate and improve the process of Integrated Coastal Management and Spatial planning;
2. How to apply Planning techniques to the process of Integrated Coastal Management and Spatial planning; and
3. The design of a regulatory framework to provide a stronger basis for coastal planning.

These international measures have been reinforced by the 1996-2000 European Commission Integrated Coastal Zone Management (ICZM) Programme that funded 35 demonstration pilot projects in 17 countries and a series of thematic studies designed to derive lessons learned and examples of good coastal management practice. The principles for coastal zone management and research findings derived from the demonstration projects reinforce those derived for the Baltic from HELCOM and VASAB 2010. The findings of the European ICZM Programme have culminated in a Recommendation that encourages all European Member States to adopt Integrated Coastal Zone Management and to formulate complementary national, provincial and more local coastal management policies, plans and implementation strategies.

The global and international measures, and the measures adopted by the individual Baltic Sea States to protect biological diversity, promote ICZM and spatial planning form a comprehensive and very valuable kit of tools to use in the improvement of coastal planning and management, and sustainable natural resources development.

4 Existing Evaluations of ICZM

The various “State of the Art” reports produced under the PROCOAST project (PROCOAST 2000), VASAB 2010 programme (VASAB 2010, 2000), NORCOAST project (NORCOAST 1999; 2001) and EUCC (EUCC 2003 a; b) have generated a comprehensive overview of how the individual Baltic States have attempted to develop coastal zone planning and management. These are all excellent documents. However, they tend to identify what is missing, or has not yet been put in place, instead of giving full recognition to what has been achieved under often very difficult conditions.

It is clear from these reports that some Baltic States are more advanced in the implementation of ICZM. These countries are generally characterised by high levels of per-capita income, strong public tax bases, well established property rights, strong public institutions with highly qualified and experienced staff, strong NGOs, and active public dialogue on development issues, and strong political recognition of the value of ICZM as a development planning and management tool. At the same time, some of these characteristics can actually inhibit the ICZM process. For example, in Finland the cultural tradition of people enjoying the right to build holiday homes along the coast is proving a constraint to the development of comprehensive coastal management plans and the conservation of habitats. In this case, well-established private property rights may conflict with measures designed to protect a wider public interest in the conservation of habitats and species.

Some of the Baltic States are in transition from the former Soviet system to a free market economic system. This transition poses constraints on the development of ICZM. Examples include, the shortage of public funds to compensate land owners for loss of development rights when coastal areas are designated for conservation purposes; land reform and slow changes in working practices from a collective based system of sectoral management; radical changes in the economic basis of agriculture and forestry to facilitate entry into the European Union, low levels of public participation in forward planning and decision making, etc.

There are also differences in the interpretation of coastal and marine issues and problems and the priorities that are given to their resolution within individual Baltic States. Even where high priority is given to the resolution to a common problem, such as pollution of coastal lagoons and marine waters, the technical ability, institutional capacity and financial resources available to individual Baltic States to reduce the generation of pollutants can differ significantly. There is also a practical limit to the reduction of pollution as in the case of the Odra lagoon where major improvements have been made through the joint efforts of the Polish and German authorities in reducing sources of pollution; however, the residual contamination of sediments in the lagoon is both very expensive and technically very difficult to remove without adversely affecting the marine environment. In such cases, difficult decisions have to be made about the allocation of scarce financial and technical resources in the resolution of competing development issues. Poland and Germany may decide that they will use their resources to solve different problems such as coastal erosion, reducing flooding hazards, relocating people away from flood prone areas, or restoration of degraded habitats.

The legal and regulatory framework available to support ICZM differs significantly from one Baltic State to another. The HELCOM State of the Art report (EUCC 2003a) makes it clear that none of the Baltic States has specific legislation relating to ICZM; however, existing laws and regulation can be used to support ICZM. This report goes on to suggest that the main challenge is to apply ICZM in a systematic manner in each of the Baltic States (EUCC 2003a, page 9). This assumes that the political will and actual ability to use existing laws and regulations is not an obstacle. This may be an incorrect assumption. All of the State of the Art reports identify major gaps in legislation, weaknesses in the application and enforcement of laws and regulations, and -in selected cases- shortage of public funds to finance the implementation of ICZM plans.

The shortage of data and information on coastal systems and how they function is also cited as a weakness in the State of the Art reports. It is assumed in these reports that this will pose a constraint on the "systematic" application of ICZM. It is a common mistake to assume that investment in developing a comprehensive information base and information management system will lead to improved decision making.

A further point to consider in understanding the constraints faced by many Baltic States is that their experience with ICZM if often limited to small-scale projects with a nature conservation focus. While valuable lessons, experience and information may have been gained from the implementation of ICZM in pilot projects, it is often difficult to demonstrate how ICZM would be useful in resolving other issues, such as planning for sustainable tourism, due to the nature protection bias of the original projects. Where specific issues, such as habitat and species protection, form the basis of an ICZM, these can seem remote from broader societal development concerns such as the restructuring of agriculture, human health or employment. ICZM works best where a broad body of public support is developed through raising public awareness of priority issues, enabling stakeholders to take an active part in the ICZM process, and where the public is able to see that issues and concerns that affect their welfare are being effectively dealt with as a result of their participation in the ICZM process. In other words, ICZM can be seen to deliver effective OUTCOMES.

5 Factors to Consider in Assessing Progress to Date in developing Integrated Coastal Management

5.1 Has there been sufficient time and support to allow individual Baltic States to establish effective ICZM projects or programmes?

One of the key lessons we have learned in the thirty or so years that the science and art of coastal management has been practiced is that it take a great deal of time, consistent effort and continuity in funding to achieve substantive improvements in the way societies manage coastal systems and human development pressures. Experience has also shown that at least ten years of consistent effort and funding is required to achieve substantive ICZM outcomes. It must also be remembered that ICZM is not an end product, it is an adaptive management process. Care must therefore be taken to assess progress in developing a robust and sustainable ICZM development process and not to focus on outputs. This is especially true in the Baltic Sea Region where many nations have only recently regained their sovereignty and have witnessed major changes in their political and economic systems. In the relatively short time in which they have been encouraged to develop ICZM, they have also had to face major challenges that have made it difficult to develop their expertise and to demonstrate tangible outcomes.

5.2 Do we have a Competent Methodology and Relevant Indicators to measure The "Success" of ICZM ?

Measuring the "success" of ICZM initiatives is by no means easy nor is it a necessarily a fully scientific and objective process. The nature of ICZM challenges the standard approaches to project and programme monitoring and evaluation. The majority of evaluation methods and criteria used in assessing ICZM initiatives are designed to measure **outputs** (e.g. how many people were trained in the principles of ICZM) rather than **outcomes** (e.g. did the training and institutional development activities achieve a significant improvement in the application of ICZM principles) (see Humphrey & Burbridge 1998; Olsen et al. 1998).

A survey of methods and indicators used by European agencies to evaluate projects and programmes by Humphrey and Burbridge (2003) identifies two main evaluation methodologies. The first is the Pressure-State-Response (PSR), which is designed to help in reporting on national sustainability with respect to Agenda 21. The second is Logical Framework Analysis (LFA). These have typically been designed to look at projects with clearly defined outputs rather than outcomes or the strength of the development planning and management processes. This survey found that some agencies are beginning to tackle the issues associated with monitoring and evaluation of *process* as opposed to *blueprint* projects; however, none of the agencies surveyed have developed specific procedures or approaches for the evaluation of ICZM initiatives. A third approach is to look at stakeholder perceptions of and satisfaction with a project or programme, and the outcomes.

PSR Framework

Considerable effort has gone into developing indicators that are primarily based on measurable changes to the environment or to environmental pressures. Few indicators are based on management responses regarded as prerequisites for sustainability. Relatively little effort has gone into developing social or economic indicators. However, this is being addressed under the LOICZ, EUROBASINS and EUROCAT (see Turner 2004). The majority of indicator sets, which have been developed focus on environmental quality, and thus the emphasis is on pressure and state variables. There are a number of drawbacks with respect to their application to assessing progress towards the achievement of desired ICZM outcomes from individual programmes or projects:

- Difficulties in establishing cause-effect relationships
- Difficulties in attributing outcomes to specific programme actions
- Time-lags or delays between actions and outcomes (relaxation time)
- Most of the sets of variables, or indicators, lack the level of detail required for reporting at the project or programme level
- More comprehensive sets of variables are costly (in time and effort) and may be largely irrelevant to a particular situation.

A more promising approach focuses on assessing the effectiveness of **management responses** - the measures, which, on the basis of experience, contribute to successful ICZM outcomes. This approach has been developed by Plan Bleu to look at water management. Analysis of ICZM "responses" offers perhaps the most feasible and cost effective means to evaluate a project or programme using the PSR framework (Humphrey 2003). However, does this really tell us whether ICZM is being successful or that the ICZM process can be sustained? The structures that indicate the successful development of ICZM (policies, institutional arrangements, revised governance) are *instrumental* outcomes – however, their existence does not guarantee success or sustainability of the ICZM process.

The PSR evaluation methodology is essentially an organising framework for available indicators, few of which represent social or economic factors. If we consider one of the key **management outcomes** identified by HELCOM and VASAB 2010 - that coastal ecosystem dynamics are maintained as a pre-requisite for sustainable natural resources utilisation- the PSR framework for assessing management outcomes may not be of great help. As a model of the coastal system, it presents an over-simplistic view, which at worst may encourage sectoral responses in addressing individual pressures. As has been pointed out by the EU ICZM Demonstration Project- Integrated Planning and Management is the ONLY way to solve problems in areas of intensive use and multiple pressures and/or problems

(CEC, 2000). A characteristic of the Baltic is the complex interrelationships between environmental, social and economic problems and development issues. The PSR evaluation framework is therefore of limited value in assessing how well an ICZM process is developing and whether ICZM is helping to achieve sustainable improvements in the functional integrity of the coastal system, or sustainable improvements to the social and economic welfare of a society.

Logical Framework Analysis

Logical Framework Analysis is increasingly used as a tool for project design and as a basis for appraisal and monitoring, and is a standard procedure used by the WWF and other agencies for project design, planning and monitoring. In the survey by Humphrey and Burbridge (1998) the objectively verifiable indicators (OVIs) used in evaluations relate to specific project activities, and there is a tendency to focus on the project performance and outputs rather than outcomes.

LFA may also be used in project evaluation; although it is recommended by IUCN that it be supplemented by other approaches, which examine relevance and outcomes. The main strengths of LFA are in improving project design and planning.

Analysis of Stakeholder Perceptions

Techniques such as the Balance Score Approach based on interviews with stakeholders in government, other national partners, communities and other interested and affected parties can provide valuable information on the effectiveness of ICZM in terms of the level of satisfaction with project or programme processes and outcomes. Perceptions will in part reflect the degree to which the programme has concentrated on building participatory mechanisms, and on communication, awareness building and education.

Monitoring of stakeholder perceptions and satisfaction should form a central component of programme monitoring and self-assessment. Participatory monitoring techniques are being developed by a number of agencies including IUCN.

The various State of the Art reports do not appear to have utilised these methodologies in assessing progress to date in developing ICZM in the Baltic States.

6 Progress Towards a Robust and Sustainable ICZM in the Baltic Sea States

Having argued that the State of the Art reports for the Baltic are useful documents, but that they do not really help us assess the progress that has been made in ICZM, can we actually assess the effectiveness of ICZM to date in the Baltic? The answer is YES, what we need to do is recognise and appraise what has been achieved through the efforts of international donors, regional organisations such as the Helsinki Commission, VASAB, and of course the individual Baltic States. Because we do not have a truly scientific and statistically sound methodology or relevant indicators, we have to rely of experience and professional judgement. This will of course be open to criticism as value judgements have to be made. Nevertheless, the author believes such an assessment can be useful in illustrating what has been achieved, and in forming the basis of an informed dialogue about what might be the most useful ways to support the development of ICZM in the Baltic States.

6.1 Three key considerations in assessing progress in developing a Robust ICM process and Sustainable Outcomes:

1. A clear and explicit Goal for ICZM with relevant indicators.

Different goals are postulated for different coastal regions depending on perceived management issues and interpretation of what ICZM can deliver. Following the UNCED Agenda 21 most goals for

ICZM projects and programmes provide a basis for defining indicators reflecting progress towards sustainability in three areas: quality of life, biological diversity, and productivity.

Criteria for the selection of indicators have been developed by a number of organisations, for example the OECD (1994). Such criteria stipulate that indicators should be policy relevant, analytically sound and measurable. It is also important to consider the cost, technical difficulty, and time required to gather and analyse indicators that are meaningful. This is particularly important in addressing significant issues that must be addressed in a logical sequence to achieve longer-term ICZM goals. This is by no means a simple exercise when examining outcomes and determining which specific outcomes can be attributed to ICZM project or programme activities (Humphrey 2003).

2. Instrumental outcomes or an enabling environment for ICM

ICZM is complex and many different outputs can have a major influence on outcomes. The creation of an enabling environment in which a robust ICZM process can be created requires substantive support to develop awareness of ICZM issues among relevant stakeholders, well trained personnel, good quality information, an effective coordinating mechanism to allow sectoral interests to cooperate and contribute to the ICZM process. These are substantive governance issues and it is often difficult to distinguish between outputs (training of staff, development of an information system, etc.) and outcomes (enhanced technical skills in ICZM, improved sectoral cooperation, etc.). It may be helpful to consider the development of a robust ICZM process as a series of stages from initial awareness of common issues, to dialogue among stakeholders, to capacity building and human resources development, enhanced cooperation among different interest groups and sectoral agencies, coordinated policy development, coordinated program planning, integrated implementation of strategies and management plans, and finally, impacts on the coastal systems.

Measurements of management efforts, or responses, are an inexpensive and rapid way to look at progress in developing the ICZM process. Experience over the past 30 years has helped to define mechanisms that make ICZM work (see Burbridge 1997; Olsen et al. 1998; Humphrey 2003). However, we still need to objectively evaluate whether ICZM efforts are being successful in terms of their effects on the coastal system and the resulting ability of the system to sustain human development objectives.

3. Sustainability of the ICM Process

ICZM will only be sustained where it is recognized as an effective means of achieving improvements in environmental, economic and social conditions. Features that can be indicators of sustainability will of course include environmental conditions such as the health and productivity of the coastal ecosystems and flows of natural resources that sustain human needs and aspirations. Other features are equally important. For example, the establishment of a sound information and knowledge base- i.e. stakeholders and ICZM practitioners understand the linkages between the coastal ecosystem, environmental processes and human social and economic welfare. Other key features include institutional and human capacity, government commitment, other stakeholder interest, and financial support for recurrent costs. We are still in the process of developing relevant indicators and methods to evaluate theses key features that help to assess the sustainability of ICZM processes and outcomes. An important measure of support for ICZM lies in the perceptions of a wide range of stakeholders from politicians, to people whose livelihoods depend on continuity in the supply of coastal resources and groups who may not depend directly upon coastal systems but have an interest in a specific feature of the coastal system, such as scenic landscape quality or nature conservation. The Balance Score Card methodologies and other means of determining stakeholder satisfaction with the outcomes of ICZM can contribute to such analyses.

6.2 ICZM Progress to date in the Baltic

Based on the author's direct experience in the Baltic and professional judgement, major progress has been made in initiating a wide variety of ICZM pilot projects. The analyses of Strengths and Weaknesses of ICZM initiatives contained in the State of the Art Reviews by PROCOAST, the EUCC, WWF, etc. appear to be accurate. However, these reports tend to give greater emphasis to what may be missing or is yet to be put into place based on a cook book approach as to what should be incorporated into an ideal ICZM project or programme. Outcomes are not effectively dealt with in these reports. This is not a criticism of the very genuine efforts that have been made bay all parties in promoting and supporting ICZM. It is perhaps too early to be able to attempt to accurately measure the long-term effectiveness of outcomes or the sustainability of ICZM projects and programmes.

It is very important to remember is that there is no Holy Grail, or Sacrosanct Rules, Essential Components, or Ideal Way to develop ICZM. Many different approaches have been applied in many different political, economic and social contexts and progress has been made in developing more integrated, and effective means of planning for and managing human development in coastal systems which may well prove to be environmentally sustainable, equitable, and economically efficient. A key criterion to use in assessing the progress of these different ICZM initiatives is whether the sophistication and effectiveness of the ICZM process can continue to develop and adapt plans and management strategies to accommodate global change, including the changing needs and demands of our individual societies. Again we must emphasis that ICZM is a process and not an end product, such as a paper plan or set of idealised "guidelines".

In assessing the progress towards the development of a robust ICZM process in the Baltic it is also important to recognise that different interest groups have different perspectives on what are the key features of ICZM. In this context, it is very interesting to note the shift in emphasis from nature conservation and towards spatial planning that incorporates ecological concerns over the past 7 years in marine and coastal projects and programmes in the Baltic. For example look at the priorities expressed in the HELCOM-WWF supported project to improve the conservation of marine lagoons where the main focus was on nature conservation. Contrast this with the PROCOAST project, which sought to translate environmental concerns into practical planning and management solutions for the coastal zones in the Baltic Sea Region. This is an illustration of the development of a robust ICZM process where nature conservation and the maintenance of the functional integrity of coastal systems and processes are integrated as fundamental considerations in the formulation of development strategies, coastal land water use plans, sectoral management plans and corresponding public and private investment.

International experience in developing ICZM initiatives has shown that the following features signify progress towards achieving both a robust ICZM process and outcomes that are effective:

1. A sufficient level of **AWARENESS** of coastal and marine management problems and issues has been achieved at both a national and international level to facilitate concerted action to resolve common issues. It is recognised that different Baltic States may have different priorities for action. However, there appears to be a genuine **political will** to address issues and problems at both a regional and individual Baltic State level. This is illustrated by establishment of the Helsinki Commission, the development of common principles for promoting sustainable marine and coastal development, the securing of international investment to support ICZM initiatives, and the **spirit of cooperation** among the various Baltic State ministers to work together in developing ICZM as a means of meeting their shared responsibilities for coastal and marine systems and human development activities;
2. Development of a **shared Vision** of how people wish to see the Baltic Sea Region evolve and serve their needs and aspirations as well as those of succeeding generations;
3. **Continuity of political support** from HELCOM and Inter-ministerial working parties in working towards that Vision;
4. Establishment of **common Guidelines** for the development of ICZM that can be shared

5. The **establishment of pilot ICZM programmes** in all of the Baltic States and exchanges of information, experience and lessons learned between the pilot projects;
6. Implementation of **human resources development** programmes that have been effective in helping practitioners from the Baltic States gain new knowledge, skills and experience in using ICZM concepts, principles and proven management techniques;
7. **Institutional development** where staff resources have been strengthened, operating budgets have been enhanced to support additional work associated with developing ICZM, and the development of inter-sectoral coordination bodies. It is realised that this varies from country to country, however, it is happening and is a strong indication that the ICZM process is being strengthened and ICZM is being viewed as an effective development tool;
8. Increasing **sophistication in the application of ICZM** from a focus on nature protection, to nature conservation, to conservation of coastal process, to the integration of terrestrial and marine interests, and more recently- the integration of spatial and economic development planning into ICZM and visa-versa;
9. The principle of **active public participation** is being implemented and is helping to build public support for ICZM initiatives;
10. Applied **research to generate information that will be of use in formulating effective ICZM plans** and implementation arrangements in order to achieve effective outcomes;
11. **Sharing of information and experience** among Baltic Sea States
12. **Formulation of ICZM policies and supporting measures** such as inter-sectoral coordination bodies;
13. Emerging interest in **meeting the spirit of the EU Recommendation on ICZM** among Baltic States seeking entry into the EU;
14. **Application of the EU Water Framework Directive** as a tool to link terrestrial and marine management;
15. There is evidence of **increasing confidence in ICZM as an effective tool for sustainable development;**
16. **Instrumental Outcomes have been achieved-** examples include the Principles and guidelines created and applied with support for HELCOM and Inter-ministerial working parties;

There are weaknesses that detract from the potential effectiveness if ICZM. Examples include:

1. Low levels of involvement of the Private Sector in ICZM processes;
2. Weak integration of spatial, economic and environmental planning between the terrestrial and marine components of the Baltic coastal system;
3. Tools for effective implementation of coastal plans are still be weak in several countries;
4. There is often a gap between the expertise developed through ICZM initiatives formulated at a local or site-specific level and acceptance by and support from district or provincial levels of government. The reverse can be true where district or provincial authorities have stronger technical and financial capabilities and local authorities are sometimes weak and not familiar with ICZM concepts and practices;
5. Poor cooperation and weak coordination between sectoral agencies can inhibit vertical and horizontal integration of policies, plans and management strategies affecting coastal areas;
6. Lack of understanding of natural and man-induced hazards in coastal areas and how these might increase as a result of global change.

Rather than treating these as obstacles to ICZM, we should treat these a challenges where effective management outputs can create positive outcomes that strengthen ICZM processes and help to secure effective solutions of development problems and issues.

Based upon these observations, the author suggests that major progress has been made in a relatively short period and under often very difficult conditions. Main elements of good ICZM practice are available, however there are varying levels of progress in putting these into practice and creating sustainable outcomes.

The challenge we face now is to capitalise on what has been achieved by providing positive encouragement, and working together to determine what forms of political, technical or financial support would be most useful to individual Baltic States. This would help create a stronger enabling environment to help the Baltic States to use ICZM as a development tool to help them achieve their respective sustainable development objectives.

No doubt the participants in the Baltic Coast meetings will wish to add to the list above, or suggest qualifications to the assessment. This is welcomed and many participants will have far greater working knowledge of how individual ICZM initiatives are working.

7 Do We Need a Common Approach to ICZM or A Common Methodology to Promote Learning from ICM Experience

The EUCC State of the Art Report on ICZM in the Baltic (EUCC 2003a) and their proposals for a Common Approach to the Implementation of ICZM in the Baltic Region (EUCC 2003b). Both are very interesting documents that address most of the elements raised in the preceding paragraphs. However, this author hopes that this conference will undertake an active debate about whether a Common Approach to ICZM is the right thing to emphasise at this critical point in time when there may be more to be gained by reinforcing the progress that has been made by the individual Baltic States through their adaptation of basic ICZM principles and elements of good practice in accordance with their own social and economic development priorities. By all means reinforce the Visions and Strategies expressed by the Ministers from the Baltic States in the VASAB 2010 reports, Seek to develop greater regional dialogue, cooperation, and coordination among the Baltic States in addressing common problems and issues. However, caution should be exercised in being too prescriptive in insisting on a "common approach to ICZM" as this may give too great an emphasis to what may be undeveloped in respect to an idealised profile of an ICZM programme and give too little recognition to what may have been achieved under extremely difficult political, economic, institutional, human resources and/or environmental conditions.

A last point I would like to raise is- *Do we Need a Common Methodology to Promote Learning from ICM Experience?*

One of the conclusions of the thematic studies conducted as part of the EU ICZM Demonstration programme was the need for a common methodology to promote learning from ICZM experience (Humphrey & Burbridge 1998). This conclusion is also reflected in a major international study of ICZM programmes conducted for the United Nations development programme (see Olsen et al, 1998). In a recent survey of agencies and practitioners involved in ICZM in Europe by Humphrey and Burbridge (1997) a question was asked "what areas would you like to see addressed by a common methodology". The responses reflected a primary concern with assessing the outcomes of the ICZM initiatives - both instrumental outcomes and environmental/ socio-economic outcomes.

This survey also indicated that practitioners identified a need to take a longer term view of ICZM initiatives than may be needed in more typical projects, recognising that ICZM is a process without a definite end-point (Humphrey 2003). This study and those by Humphrey & Burbridge (1998) and Olsen et al. (1998) indicate a growing concern on the part of donor agencies and national governments that greater efforts are required to ensure the sustainability of the ICM process upon termination of outside financial and technical support.

This suggests that a common methodology should provide mechanisms and approaches to assess and compare progress in three areas:

1. Outcomes and impacts of project or programme activities on the coastal system;
2. Instrumental outcomes or enabling mechanisms/ environment for achievement of ICZM goals; and

3. Sustainability of the ICZM process. (Based on Humphrey 2003)

1. Outcomes and Impacts

Two prerequisites for evaluation on the basis of outcomes are:

- Clear objectives which incorporate measurable targets, and
- Establishment of baseline information by which to measure progress towards these targets, in the context of ongoing and probably contrary trends (See Burbridge 1998 & Humphrey 2003).

The justification for a common methodology assumes a common overall goal or at least direction for ICZM. Most coastal management projects are concerned with sustainability - a term which may be interpreted differently according to the values of different groups and communities but which is concerned with three issues, equity, economics and environment.

- While considerable progress has been made in developing indicators for sustainability, much work is still required to establish acceptable and meaningful targets or standards at different scales to guide management for sustainability in coastal areas.
- Target values may be expected to vary according to the carrying capacity (or assimilative capacity) of a particular environment for a particular activity (or substance) - thresholds which all too often are not determined until after they have been crossed.
- Target values will also vary according to the values, choices and acceptable trade-offs of communities.

The development of a stronger methodology for assessing progress towards developing a robust and very effective ICZM process would help us to make greater use of available technical and financial resources.

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Management strategies for coastal fisheries and aquaculture in Southwest Finland

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Abstract

The management strategy of coastal fisheries is based on the land/water ownership in Finland. The structure of the fishery rights is based on either the share of the common waters or on the other hand the ownership of the separate water segment. The fragmentation of the structure of ownership and in consequence of that, the fragmentation of the waters to smaller-sized units is the biggest structural problem of Archipelago Sea at present. By the aspect of management and utilization the ownership is more and more incoherent. Even starting the co-operation within the local Fishery regions in the 19th century has not significantly altered the structure of the management and ownership. There are still many different interest groups among the owners and users of waters. Common and private ownership at the same waters is stressing the significance of the arranging the dialogue and management policy. Different aspects of management strategies to develop coastal fisheries and aquaculture are discussed. Both commercial and recreational aspects are taken into consideration when sustainable management models are planned.

1 Introduction

Coastal fisheries in Finland are not a scale model of marine fisheries because of substantial differences in the biological and socio-economic resource base and cultural circumstances. Anyway the management of both marine and coastal fisheries represents periods or stages of increasing complexity. Structural changes have during the last 30 years been taking place within the Finnish fishery industry: relative importance of commercial fishing is declining and at the same time the importance of fish farming and recreational fishing has increased. Sources of income other than fishing become more important all the time in the Archipelago Sea (figure 1) but on the other hand the market demands of traceability, safety of the products, quality and ecolabelling indicates the need to establish better conditions for a higher professionalism in the whole chain of fisheries.

Today we face the situation where the fisheries management focus on integrated fisheries rather than solely on fish populations. The significance of mutual understanding between different actors can be seen as a prerequisite of better resource management. The common feature for both marine and coastal fisheries are the three principal paradigms of fishery objectives : 1) conservation (=take care of the fish stocks), 2) rationalisation (= economic efficiency) and the 3) social/community paradigm (= community welfare) (Charles 1992).

The contributions from the LIFE-COASTRA (=Coastal management strategies for the Archipelago Sea of SW Finland) project implemented so far in the pilot area of Uusikaupunki in SW Finland have succeeded in the goal to integrate fisheries management and the management of aquaculture production into the wider concept of the sustainable use of renewable natural resources. Therefore it is accepted by the fishermen and fish farmers that also other aspects of user values must be taken into account in the spatial planning of coastal zones.

Figure 1: The Archipelago Sea: enormous topographic complexity, over 20000 islands, over 15000 km shoreline, mean water depth 23 m, total area 8000 km^2, non-tidal sea, annual ice-cover during winter, salinity 5 to 6 $^{o}/_{oo}$.

2 Results

Values related to natural resources can be divided into use values and non-use values (Randall 1987). In coastal zones the competing usage strategies stated by all different stakeholders put pressure on all the actors and thereby new and more diversified management models are of great need. In the pilot study of Uusikaupunki coastal areas it can clearly be seen that competing groups use both knowledge and gaps of knowledge to define the issues in terms of their own social objectives. In the working group of "Fisheries and aquaculture" the goal has been to produce a picture of nature and the use of natural resources that can be accepted by both the local people and other stakeholders.

In the Finnish fishery system competing usage and joint management of commercial and recreational fishing is a contemporary management problem especially at the local level. Cage culture of rainbow trout has since 1980s been recognised as a source of conflict especially concerning other marine recreational usage activities which are often related to seaside resorts or areas with high densities of summer cottages. The environmental authorities are the key stakeholders in regulating the aquaculture activities: special licences are granted by the Regional Environmental Permit Authorities (Varjopuro et al. 2000).

The Finnish fishery system has a special feature of property rights regimes in the sense that within the limits of the law (The Fisheries Act) most of the near coast situated water bodies are owned by private persons or they are characterized as communal properties (=shared ownership/shareholders). So in Finland a fishing right means a legally protected right to fish in a specified water area and also the right to regulate (although restricted in many ways) on fishing in this water area (Salmi and Muje 2001). State property rights are mostly used at specific conservation areas or national parks and of course on the open sea. At regional level the state fisheries administration is implemented in the Employment and Economic Development Centres/Fisheries Offices.

This kind of institutional structure of possession promotes at its best efficient allocations and consistently it includes the paradigm of conservation but at its worst excludes multipurpose usage strategies. Thus in the Archipelago Sea especially the aspects of commercial fisheries and fish farming meet with opposition when questions of access to fishing waters are raised by the fishermen or fish farmers.

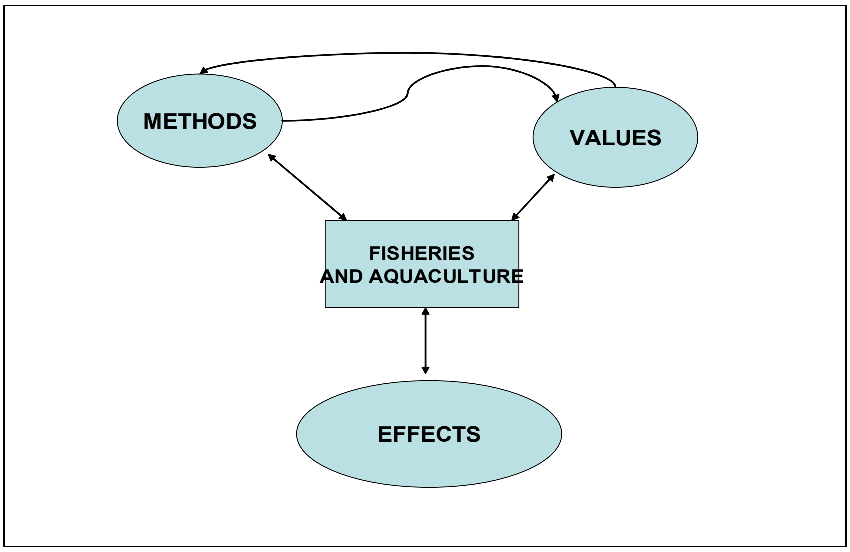

Figure 2: Values based on profession, cultural heritage or stakeholder position affect our way of thinking and conclusions.

Restricted access is of course the principal cause of conflict between commercial and recreational users. So there is a clear need to increase the knowledge of the ecological implications of fisheries and aquaculture. It is of importance to discuss causes and consequences and relate possible effects to different scales of action. Most of the people involved in the process have strong feelings about what is happening in the aquatic environment and there is always a need to point out the guilty one. Depending on peoples cultural heritage, profession or stakeholder position the acceptance of the methods in the use of marine resources are mostly related to one's values. This all contributes to how people find their opinion for or against the usage strategies (figure 2).

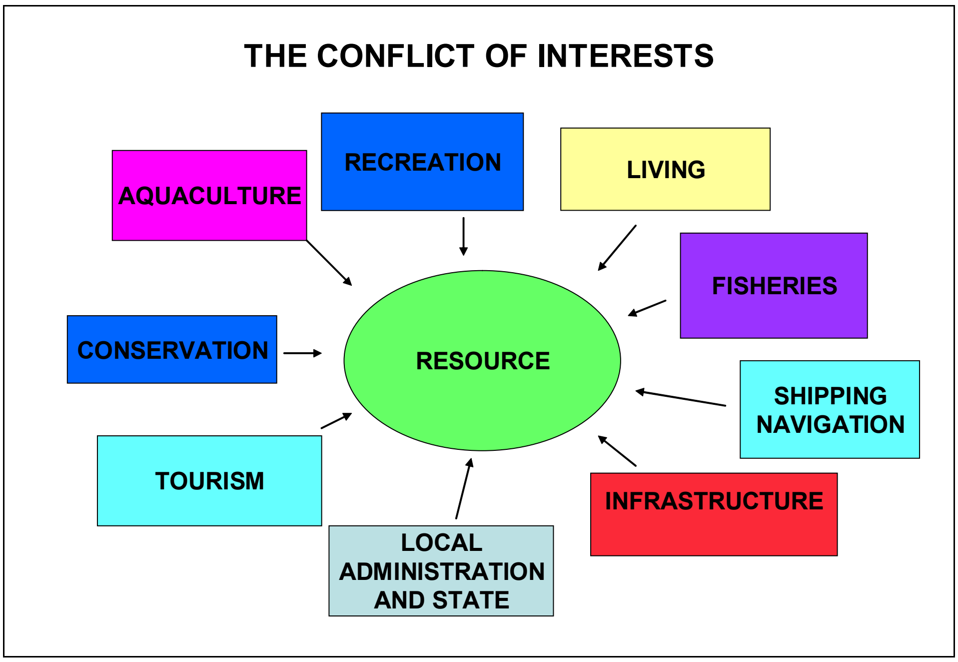

Figure 3: The diversified user strategies causes conflicts of interests; both public and private.

Keeping in mind what is said above a certain educational concept is built in the meetings of the working group to get a better understanding of commercial fisheries and fish farming. Discussions of the public interests versus private interests are also of great importance to get a better understanding of the environment of decision making in the society. Depending on the stakeholder the public and private interests are very diversified but they can also be convergent (figure 3).

3 Discussion

As a result of this it is now understood that restricted access to private waters actually have operated to the exclusion of commercial fishing. Furthermore it must be pointed out that new actors - such as the grey seal population and cormorants - are stepping up the competition of the same resource both in space and certain target species; the only difference is that they have a free access to the fishing waters.

Exclusion of commercial fishermen from private waters at the time when also recreational fishing with gillnets is declining have probably environmental considerations of more importance than ever before. Declining fishing pressure has effects on the structural changes of the fish populations. Simultaneously the eutrophication of the coastal waters indicates a strong favour for cyprinid fish species and this phenomenon means in the long run that commercial target species like perch, zander, whitefish (Coregonus lavaretus), pike and burbot will suffer from harder competition of suitable spawning grounds, biotopes and food.

Building up a co-management perspective means that partners involved are able and willing to take some public responsibility. In the working group of “Fisheries and aquaculture” it is now widely accepted that we have to improve the co-operation between fishermen, fish farmers and other partners (especially water owners). At the institutional level the co-operation model is “anchored” in the Fishery Act which means that stakeholders in a certain water body called “Fishery region” make up a management plan for the fisheries including also the aspects of utilization, conservation, restoration and plans for fish stocking.

The co-management concept has an essential element based on shared responsibility and shared decision-making in the coastal fishery system. It is clear that players outside the “traditional” fishery system are needed in the process because the sustainability is not only a matter of fisheries /aquaculture production regulation. Stakeholders outside the fishery system can provide a better understanding of where the partners involved stand: it means that we have to understand that natural and social processes operate differently at different scales. Thus the role of outside stakeholders is of importance especially when the goal is to improve diversified fisheries and higher professionalism in the production chain.

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Integrated Coastal Zone Management in Forests by the Baltic Sea

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Abstract

In several of the Baltic Sea Region countries, woodlands are essential parts of the coastal zone environment. The land coastal zone based high diversity values are to a large extent situated in the woodlands. Forestry operations are common in the coastal woodlands. For tourism the coastal woodlands are an essential part of the positive experience. The archipelago along the Swedish and the Finnish coasts are unique environments. Incomes from forestry and tourism are essential parts of the economy, which contributes to the possibilities for living in the coastal zone. Large parts of the Scandinavian coastal zones are dealing problems related to a decreasing population and outmoded infrastructure. Nine Swedish partners in SE Sweden are demonstrating how ICZM can be applied on the coastal woodlands, developing better methods for surveys, extension and information. How should the different interests be balanced? How do you identify and protect the high biodiversity values? What do threatened species need? How should coastal zone and river basin forestry operations be carried out to minimise the negative impact on the biodiversity and the water quality of the Baltic Sea? In ICZM of coastal forests how do you contribute to the creation of environmentally conscious attitudes? An international Expert group is going to contribute to the project with experiences form other countries, for the development of recommendations for management of the coastal woodlands.

1 Introduction

1.1 Background

The coastal landscape and the archipelago in southeast Sweden are unique in many ways.

The coastal zone as a boundary between sea and mainland is constituted of many different nature types and biotopes thus contenting a high biodiversity.

The sea coastline is a nursery chamber for life in sea.

The land biodiversity is to a high extent situated in the woodlands but also to meadows and pasture. Often the biodiversity of this landscape depends of former land use and management, and are still depending of similar methods to remain. The forest has earlier been managed in a multitude of ways, often small scaled. Browsing of the forests used to be very common until half decade ago. Polling was also very common.

The management and land use has changed with time and today a different landscape is taking form. Meadows are overgrown by trees, larger areas of older forests are clearcutted and browsing is decreasing. This change depends to a high extent of the decrasing number of inhabitants living here all year around.

The last fifty years the ownership of properties has changed, in the archipelago as many as 60 % of the owners do not live at their properties but in other places. Many of these are using the properties only for summer recreation, and do not have the possibility, time or interest to manage the properties. Knowledge of managing methods is also disappearing with the old generation. Summerhouses are increasing in number and so the use of the forests for recreation. In areas with many summerhouses there is a need for an adapted forestry.

People who live in the coastal zone is often dependent of an outmoded infrastructure and of works that are situated on a long distance form their homes. To be able to earn ones living at the properties you have to be inventive.

The unique landscape and the possibilities to freely be visiting the nature in Sweden make the archipelago and the coast attractive for visitors and the tourism is increasing.

Forestry and tourism have become an important part of the economy for the inhabitants in the coastal zone.

Many interest thus has to be taken care of in the coastal areas, there must be a balance between forestry, high biodiversity values, nature conservation, tourism, inhabitant interests, properties owners and summerhouse keepers. A common strategy is needed. Integration between different decision makers, the inhabitants and the public is necessary.

Some of the main tasks to work with are:

- Possibilities for inhabitants to stay and get a reasonable economy in the neighbourhood
- Identification of high nature values and conservation, preservation
- Forest actions in balance with nature, nature conservation and tourism
- An overgrowing landscape that needs management for keeping the nature values
- Dissemination of knowledge, creation of environmental conscious attitudes

Figure 1: Browsed deciduous forest, St Anna Archipelago, Östergötland, Sweden (Photo, S. Björklund 2003)

1.2 The Coastal Woodland project

The Coastal Woodland project is a LIFE-environment demonstration project with the aim to develop useful models for integrated management and nature conservation for forests in the coastal areas.

The main tasks of the project are:

- Establishing of an Expert Advisory Group for the ICZM strategy and demonstrations. Establishing linkage to other ICZM initiatives in the Baltic Sea region.
- Demonstrations of models for integrated inventories and conservation actions.
- Demonstrations of models for more effective use of existing methods and legislation for nature protection and principles for sustainable management.
- Demonstrations of models for integrated local participation and influence.
- Demonstrations of models of models for integrated forestry methods and systems.
- Demonstrations of models for development of environmentally conscious attitudes towards land use.

The project area is the archipelago and parishes adjacent to the coast in Kalmar and Östergötland county (Figure 2). The total area is 169 000 hectares. In this area there are 3400 properties with 4900 owners. The archipelago contents 5900 islands, about 1000 of them are covered by forest. The mainland is to a large extent covered by forest.

There are nine project members representing public authorities, municipalities, forest industry and environmental organisations. Contacts are taken with local organisations and individuals to make a broad attendance.

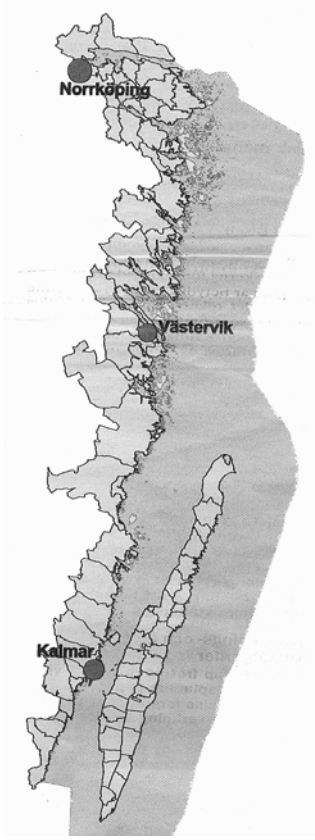

Figure 2: Project area of the Coastal Woodland project. (SVS archives, Bo Thor 2004)

2 Activities

To achieve the objective of the project there is a spectrum of activities going on. Some of the activities are of a larger scale, some are smaller projects. Inventories and reports that are made underlie the further work with nature conservation and forest management. Information and dissimilate of knowledge is a very important part of the project. There have been meetings with local organisations and inhabitants where the project is discussed. A larger seminar about ICZM was arranged with about fifty participants representing forest owners, sawmill industry, municipalities and local organisations. Exhibitions and information signs are other ways of dissimilating information within the project. Below a selection of the present and completed activities are described.

2.1 Key Habitat Inventory

The Key Habitat inventory was made to get knowledge about the interesting sites of high nature values within the area. These kinds of inventory were made in the bigger part of Sweden during the years 1993 to 1999. (Skogsstyrelsen 1999) The results underlie decisions about nature conservation and managing of forests and are part of the environmental planning of the landscape. The inventory was not made in the archipelago formerly.

A woodland key habitat is a part of the landscape where endangered, vulnerable, rare or care demanding species of animals or plants exist or can be expected to exist. The term serves as a stamp of quality for valuable woodland.

The inventory was made as a cooperation project between Skogsvårdsstyrelsen Östra Götaland and The County Administration, the later inventorying valuable meadows and pasture. There were several advantages with the integrated form, in the archipelago there are big areas of old wooded pasture which contains values for both inventories. The surveyors were able to calibrate the methods and to avoid collecting data from the same places.

All property owners were offered to come to meetings for information and to discuss the inventory both before the inventories and after, when also the results were presented. These meetings showed to be a very important forum between land owners and the authorities.

The inventory serves as a base for planning both for authorities and property owners and is central in the Coastal Woodland project.

The results from the inventory shows that there is a very high percent of key habitats in the archipelago, about 10% at a total, some islands has more than 50 % of their area covered by Key habitats! As a compare the whole region of Kalmar and Östergötland county has a Key habitat content of 1,3 %. (Regional Forestry Board, Östra Götaland 2003)

2.2 Conservation and Preservation actions

There are three main forms for nature conservation and preservation that are used in Sweden. Nature reserves, Biotope Protection Areas and Voluntary Nature Conservation Agreements.

When valuable areas have been identified and described, priorities can be made. The landowner or the authorities´ takes contact about an area with high nature values and a negotiation is started with the landowner. If a decision is made about Nature reserve or Biotope Protection the state offers the landowner compensation for the lost possibilities of land use.

If an agreement is made about Voluntary Nature Conservation the landowner is offered some compensation and an agreement of management of the area for fifty ears is made.

One of the objectives of the project is to increase the amount of conservation and preservation agreements within the project area and to make existing methods for it more effective.

There has been an increase in protected areas; above all the voluntary agreements have increased. This might depend on the increase in contacts between landowners and the authorities that have been made but also of, “rings on water” effect between landowners that have made agreements.

By meeting the landowners and making them aware of their valuable biotopes, informing about species found and to give advice about possible managing, the awareness is increasing. The process is getting more effective and more initiatives are taken by the landowners.

2.3 Models for management of coastal forests

Forestry management in the coastal zone has to be adapted to the special conditions that are found there. The landscape is a mosaic of fertile and very poor conditions. There is a high percent of Key Habitats, big areas are old woodland pasture-some that are still browsed. The woodlands in the coastal zone have a high percent of mixed deciduous forest with oak as the main species, this is the eastern part of the famous Oak Landscape in Östergötland. Pollard trees of all species are common. There is a large problem with overgrowing meadows and the deciduous forests turning into conifer dominated forests. There are also many cultural leavings which need special care.

Within the project area demonstration objects and demonstration trails are planned and designed. Cuttings and restoration work have been done in several properties along the coast. The demonstration objects are going to be used as examples and for inspiration for other forest owners.

Features of the made cuttings are; small clearcuts-often part of a restoration of old pasture, both meadows and woodland pasture. Cuttings to expose old oak trees, also exposing of old pollard trees which are pruned again. Cuttings to expose walls and cairns have been done in some cases.

Figure 3: Pollard tree in Gryt archipelago, Östergötland, Sweden (Photo, Stefan Björklund, 2003)

2.4 Analysis of transports of wood in the archipelago

A great problem for the foresters in the archipelago is the transports of wood. There are few quays that can take heavy machines and barges that are fetching the wood and there are no harbours that have the capacity to store wood. Barges in use are often too small to take the quantities needed. If the forestry in the archipelago should have a possibility to expand, and the problem with overgrown land be solved with necessary cuttings, a better transport system has to be planned. A group of forest owners, representatives for the industry and the County Administration are working with different solutions. Larger barges, or better processing of wood before leaving the islands is possible solutions. The later solution could have economical effects in form lower transport costs, more jobs for the inhabitants and environmental advantages. Today all transports to paper industry goes by lorry on the mainland, which is not a good environmental solution, with the development of one or two bigger harbours with more capacity to load and unload and to store wood there would be an environmental profit in transporting more wood by the sea.

2.5 A new policy

One of the main targets of the Coastal Woodland project is to develop a new policy for forestry and nature conservation in the coastal areas of Kalmar and Östegötland counties. This work has just started. With the experiences of many different inventories and surveys that has been made in the archipelago the last ten years, new inventories made in the Coastal Woodland project, models for forestry, landowners experiences, the legislations for Swedish forestry a policy is going to be worked out. There is also a former policy for the archipelago in Östergötland made fifteen years ago as a cooperation project between thirteen organisations and landowners, which will have influence on the new policy (The County Administration 1988).

2.6 Exhibition in Kolmården

It is important to disseminate knowledge, and make people understand the possibilities and problems of the coastal zone and the archipelago. At Skogsgården, within the boundary of Kolmården Zoo which have almost half a million visitors a year, an exhibition about the coastal zone is ready to open. It is directed to both grown ups and children. Making children aware of the unique environment that the coast is, is a great investment for future. Here they can feel, taste, listen and learn a lot about the coastal woodland. It is an exhibition for all senses.

2.7 Planning in populated areas-The Händelö project

Norrköping municipality is one of the partners of the project. The municipality is very ambitious in environmental questions and they have a very extensive programme for nature conservation and preservation**.** Within the project the have made an inventory-The Händelö project-this is different from other inventories made as it is made in a high populated area; Norrköping City.

Händelö is an island situated close to the city of Norrköping. It is an island with great values of nature and at the same time a place of many important industrial activities.

Here you can find large areas with very old oak trees, part of the areas are included in the European network of protected nature-Natura 2000. The old oak trees have an exceptional fauna and flora and as many as 35 species that are rare or threatened has been found in the area.

The combination of a vulnerable nature and industrial activities demands a good planning and a balancing between interests. An analysis of part of the ecology of the oaks and threatened species has therefore been done. The structure of ages, the geographic spread of the oaks and the demands for the different species to be spread has been investigated.

Karl Olov Bergman Ph D at Linköping University made the analysis. In his report he describes the prerequisites of the area today, he also describes some targets that are necessary to be working with and what has to be done in the future to make the area remain as valuable as it is today. He finds out that larger coherent areas has to be created, this can be done by making corridors between the areas which today are separated in different smaller areas. Planting of new oak trees, clearing and management has to be done to keep the continuity and the unique flora and fauna.

Norrköping municipality are about to make a new plan for the area, the planning will be made with respect of this report (Bergman K-O. 2003).

3 Discussion

The objective of the Coastal Woodland project is to develop useful models for integrated coastal forestry management and nature conservation, to show good examples for dissemination and use in a wider perspective.

The responsibility for a long-term durable land use lays on a multitude of decision-makers.

The great amount of properties owners, which is almost 5000 in the project area, makes their attitudes and awareness very important. Other actors in the coastal woodlands is for example forest and tourist entrepreneurs, employees of forestry-from industry and the public authorities, the municipalities and visitors. Their knowledge, awareness and attitudes are also important to catch.

Making possibilities for the inhabitants to stay, earn their living in the neighbourhood and to take care of their special knowledge of forestry and land use in the coastal zone is of great importance. The high biodiversity, both in forests and in meadows and woodland pasture, is to a large extent depending on active management. A living forestry and agriculture is needed.

Some areas needs preservation to maintain their high values, this can be done by different agreements and by making protected areas. It is the beautiful mosaic of the managed landscape and the unspoiled countryside that make the area so interesting for tourism.

With an integration of the management there can be large profits for the inhabitants, the nature- and cultural environment and for the forestry.

Only active work with information and dissemination of knowledge from all parts can create environmental conscious attitudes. This is also the fundament purpose of the project.

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Coastal co-operation in SW Finland: Problems and challenges

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Abstract

The Archipelago Sea in SW coast of Finland is a valuable and vulnerable area where various interests regarding the use of the coastal area collide. The main problem affecting practically every other issue in the area is the eutrophication of the waters which is harmful for both nature and man. Agriculture is the biggest source of nutrient load, and it being a non-point source presents a major challenge for reducing the nutrient load. Development around more environmentally friendly cultivating methods and reducing erosion and nutrient runoff is active, but the effects are not very quickly visible in the Archipelago Sea itself. Nutrients from the waste waters of scattered settlements are being tackled by more strict regulations that have recently come into operation. Fish farming is the most debated issue whenever the state of the coastal waters is discussed and it presents a model example of conflict between a source of livelihood and environment. There are indications that the sea bed is leaking stored nutrients back into the water; the magnitude of this process is not yet known but it may be considerable. This process is hard to have an influence on, which often leads to doubt regarding the possibilities of improving the state of the coastal environment. Cross-sectoral co-operation based on the principles of ICZM has proven to be a good tool for addressing these problems but it is a challenge in itself to keep up a long-term co-operation when the fruits of it may be picked no sooner than after a few decades time.

1 Introduction

1.1 The Archipelago Sea: a valuable part of the Baltic

The Archipelago sea is one of the world's largest archipelago areas with more than 20 000 islands and over 14 000 kilometres of coastline (Granö &Roto 1991). This coastal area of 8 300 km2 has high biodiversity as well as cultural diversity, and it has distinctive zones that contribute to the complexity of the archipelago. The Archipelago Sea is very shallow, the mean depth being only 23 metres. The drainage area is intensively cultivated, and a large number of cultivated land is prone to erosion.

Water currents generally flow through the Archipelago Sea from the Gulf of Finland and on to the Bothnian Bay, and the archipelago is said to be functioning as a filter between these two. The exchange of water in the sheltered archipelago environment is quite slow and often poor. The archipelago is also an area of upwelling, where nutrient-rich water from closer to the bottom also affects the biological processes. (Kirkkala 1998)

The coastal area has multiple uses and users. It is at the same time a tourist attraction, an agricultural area, a protected national park and an important fishing area just to mention a few. Still, especially the outer archipelago is slowly becoming desolate when people move to municipal centres on the main islands. In many cases permanent settlements are turning into summer residences, a schools and other year-round services vanish in lack of demand. This may lead to a vicious circle development. In spite of this, the goal is to keep the archipelago viable also in the future. The amount of developed shoreline in the Archipelago Sea is a little over 30 % (Granö, Roto & Laurila 1999).

1.2 Nutrient load form various sources

The special characteristics of the Archipelago Sea make the area especially susceptible to eutrophication. The general estimate is that about half of the nutrient load comes from outside the drainage area itself. The major anthropogenic sources of nutrient load in the area are agriculture and waste waters from scattered settlements. Atmospheric load is the most significant source of nitrogen. The distribution of the nutrient load (phosphorus and nitrogen) by source is indicated in figure 1.

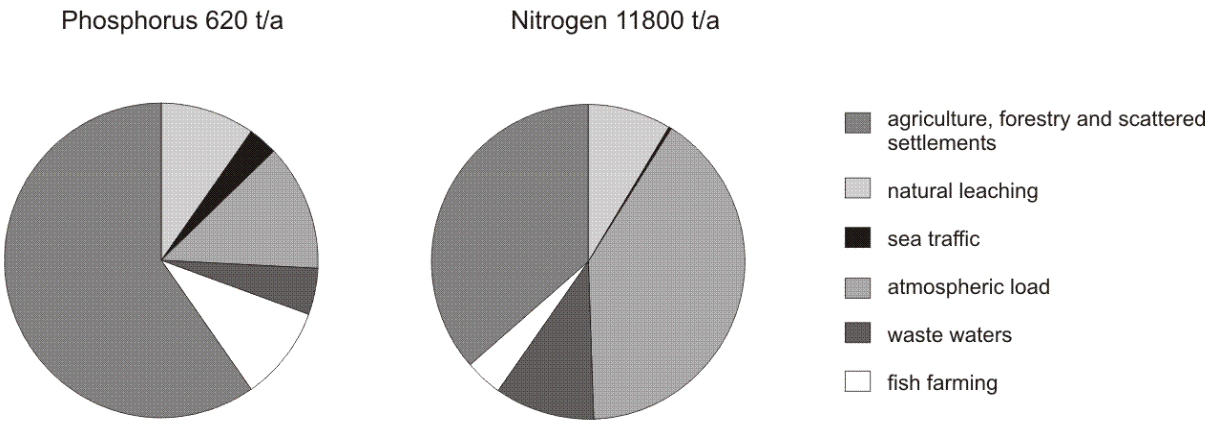

Figure 1: Sources for nutrient load of the Archipelago Sea in the mid-1990s (SW Finland regional environment centre 1999)

Regional goals for reducing the nutrient load have been set in the environmental program of Southwest Finland (Liski, Madekivi & Rauhala 2000). They are based on the decision-in-principle of the Council of the State on water protection goals for the year 2005. These goals are shown in table 1. Achieving these goals also forms a base for an initiative taken by three of the region's central authorities in 1999 to start a forum for coastal co-operation in order to improve the state of the Archipelago Sea (Southwest Finland Regional Environment Centre 1999).

Sector	Goal P	Goal N	Reference level (year)
Farming	- 50 %	- 50 %	1990
Fish farming	- 30 %	- 30 %	1993
Industries	- 50 %	- 50 %	1995
Scattered settlements	- 30 %	not specified	1990
Communities	- 35 %	- 50 - 70 % (communities of over 10 000 inhabitants)	1990

Table 1: Goals for 2005 for nutrient load reduction from different sectors (Liski, Madekivi & Rauhala 2000)

1.3 Problems and challenges on the regional level

In the last few decades significant decreases in the nutrient loads have been achieved, and improvements in the quality of water have been observed locally. Still, in some closely monitored areas an increase in the phosphorus content of the water has been observed, and every summer there are massive blooms of bluegreen algae especially in the outer parts of the archipelago.

The biggest challenge regionally is to decrease the nutrient load from agriculture. The agricultural sector generally has a very positive attitude towards the environmental actions, and much has indeed been done. The problem is that there are no ways to make this happen fast, as there is a large storage of nutrients in the soil which will not be consumed very quickly even if we stop adding fertilisers altogether.

Industries and their nutrient loads are mostly controlled by environmental permits, so they have a legal obligation to stay within given limits. Regional co-operation has encouraged the companies to be more active and go even further than required in decreasing the nutrient load as well as other pollutants.

Fish farming is very much a scale-related issue. On the Baltic scale it is not a major source of nutrients, but at the local scale it can be significant in some sheltered area, where the exchange of water is poor. Nutrient load from fish farming has the most effects in the middle archipelago, and because of its local effects, it gets a lot of attention.

Concerning scattered settlements, municipalities should be further encouraged to expand the centralised sewer networks, through which the waste waters are led to a sewage treatment plant. Where this is not possible or cost-efficient, smaller networks should be established for several households or for villages. Careful land use planning is an important factor in achieving this. In waste water systems for individual houses one of the problems is proper maintenance, which is crucial for the systems to work and efficiently catch the nutrients.

There is also a large nutrient storage at the bottom of the sea, and its role in the eutrophication process is not very well known. Nutrient load from the Gulf of Finland and St. Petersburg in Russia affects the outer archipelago, but closer to the continental coastline domestic load is the most important source.

Apart from human activities, weather plays an important role in the nutrient cycle. In the past five years there have been both exceptionally rainy and exceptionally dry years in SW Finland. In dry years the amount runoff is small, and so is the amount of phosphorus brought to the sea by the region's rivers. It has been estimated that during the year 2003, which was dry, the amount of phosphorus load from the rivers was as much as about 70 % smaller when compared to an average based on information from the period of 1990 – 2002 (Suomela 2004).

2 Results

Among many other actions, through regional co-operation introduced by the Archipelago Sea forum Pro Saaristomeri, there are continuous efforts to decrease the nutrient load and to improve the state of the Archipelago Sea. This cross-sectoral co-operation is organised into seven working groups, which generate projects and initiatives. Many innovative projects have been carried out, including the ongoing work of forming a regional coastal management strategy to better identify the conflicts and solutions to them. The effects of more effective co-operation alone are difficult to measure, but clearly a lot of things have happened that wouldn’t have been done without it. About 50 different projects have been carried out with total budgets adding up to 3,5 million euros.

Fish farming is the only sector to already have achieved the goals set for the reduction of nutrients presented in table 1 (Silvo et al.). This is mainly a result of development in fish feeding methods and in the feed itself. The declines in the number of fish farms as well as the amount of fish produced have also contributed to this. A positioning system for fish farms is under development to help decrease the effects of local eutrophication around the farms.

The nutrient load from communities has already reached the goal of nitrogen reduction, but being able to do the same with phosphorus would require special actions. Phosphorus load from scattered settlements is estimated to have decreased about 15 %, and with new, more strict regulations it is possible to achieve the goal in the beginning of 2010s.

It is difficult to estimate the changes in nutrient load from agriculture, but it is estimated that the goals won't be achieved by 2005. Pro Saaristomeri co-operation has initiated many regional projects around agricultural issues that have had good results. These projects are important steps forward in improving the state of the Archipelago Sea.

Pro Saaristomeri has provided a neutral forum for coastal co-operation which has had success in bringing together different regional actors to share views and to discuss common problems. Information on what other actors are planning and doing has also been actively disseminated, and this has led to more effective coastal work.

3 Discussion

It is clear that improvements in the water quality of the Archipelago Sea cannot be achieved in any short period of time, but long-term actions are needed to tackle this problem. Coastal co-operation following the principles of ICZM is an important part of guiding these actions, taking into consideration all relevant aspects of any given issue.

Nutrient loads from sectors like industries, fish farming and other sources of livelihood are mostly regulated by law. In these sectors one of the ways to improve environmental friendliness is to tighten the regulations, which often contradicts with the economical side of business. Taking care of the environment is a part of practically every company's agenda, though, and lots of improvements take place through projects that are carried out voluntarily. This is where national and EU-level financial support is often a key factor, and this is also where the networks and coordination provided by organised coastal management can be extremely helpful. Improving the state of the coastal waters is long-term work, and motivation for carrying out projects or actions tends to abate when you don't see results very quickly.

Every day individual people make decisions that affect the environment. It is important that they have the necessary information in order to make the right decisions. The choices and dedication of individuals are also important in waste water treatment of scattered settlements, although the law sets the basic standards for this. Closer co-operation between municipalities would also help in this sector. Further research is needed, since we still don't know enough of all the natural processes of the coastal environment. For example the magnitude of the nutrient leakage from the sea bed sediments remains unclear.

Even though there already is much co-operation, a more holistic approach is needed to tackle the problems and find solutions to the challenges concerning the state of the Archipelago Sea. ICZM provides a good tool for this, and it will be interesting to see if regional coastal strategies will become more common in other parts of Finland and the Baltic Sea. International coastal co-operation in the Baltic Sea will also become more important in the future, as solutions for our common environment are developed further.

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Municipality of Uusikaupunki as a pilot for Coastal Management Strategy for Southwest Finland

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Abstract

The target of the project of coastal management strategy for Southwest Finland is to create tools to intensify planning and guiding concerning the use of the coastal and water areas. These tools can be used for benefit of the state of environment and the means of livelihood. In the second phase of the project the pilot of municipality of Uusikaupunki is in a central role. The inventory data and results of the analysis will be applied to formulating the management strategy.
The pilot of municipality of Uusikaupunki was started by the opening seminar and by meeting and formation of the workshops of local stakeholders in September 2003. In seminar was appointed four different workshops.
The working process of the workshops was started by gathering information of demands of different stakeholders and by completing the inventory data with local special features. Needs and hopes will be collected and published by map presentation, which will present the areas with several different pressures of use or contradictions.
The other target of the project is to visualize, in which way the coastal management is organized in practise at the moment and how the co-operation of different stakeholders is being intensified in the future.

1 Introduction

1.1 ICZM in Europe and Finland

European Parliament and Council gave on 30th of May 2002 a recommendation concerning the implementation of Integrated Coastal Zone Management, ICZM (European Parliament and Council Recommendation 2002). According to that recommendation the member states have to make an evaluation of the coastal area stakeholders, their interests and tools in use, for instance of legislation. On grounds of the evaluation the national strategy is being formulated in close association with different stakeholders.

About the preparation of the strategy will be reported to the European Commission at the beginning of the year 2006. In Finland the Ministry of the Environment is responsible for the ICZM strategy work. The work got started in February 2003 by the seminar for interest groups (Tihlman 2003). The phase of evaluation is in progress and in order to formulate the strategy the co-operation group is called together in spring 2004 for the purpose of steering the work.

It is also included into the Finland's national ICZM strategy included the regional and local level. In strategy it will be treated the coastal zone, which contain the water and land areas both sides of the coast-line. It is crucial that formulating the strategy every important authorities and stakeholders of the area will be participated. The objective is to find out the means for more resistant exploitation and management of the coastal areas than at the present time. Very good means are already in use, but there will still be something to improve. In the interest group seminar came out for instance the relevance of the smooth-running co-operation especially in those cases when the lines of action and steering are widely differed. For example, the exploitation of the water and land areas is different and in those areas it is acted by different traditions and principles.

1.2 Life COASTRA project

In 2001, the Coastal Management Strategy for Southwest Finland (COASTRA) project was established to promote the introduction of Integrated Coastal Zone Management (ICZM) into the Finnish planning tradition.

The Archipelago Sea is a unique part of the Baltic Sea. It is relatively shallow, has a low salt content, no significant tidal activity and is characterized by a land uplift of 4-5 mm/year (Mälkki 1987). It is also one of the world's most complex archipelago areas with more than 41,000 islands, half of which are within the province of Southwest Finland (Granö et al. 1999). The vitality and preservation of the natural values of these islands are very important for cultural and natural heritage. The economy is strongly dependant on the health of the environment. More and more islands are being deserted, as stable means of employment as well as basic public services are no longer abundant (Siivonen & Grönholm 2002).

In Finland, ICZM is still being developed, as there is no ICZM framework or strategy currently in place. Since 1999 the Pro Saaristomeri – ohjelma (an Archipelago Sea Co-operation programme and regional coastal forum) that established the COASTRA project, has also been working to achieve the goals of sustainable development in the coastal area (Numminen 2002).

The main goal of COASTRA is to fit together the economical and environmental needs to form a sustainable base for the development of the coastal area. COASTRA plans to achieve this through development and implementation of more modern approaches towards coastal planning and management. Some of the central themes within the coastal area and the project are the fishing industry, tourism, the quality of coastal waters, holiday- and permanent settlements and nature protection.

The project is implemented in two phases. First, by gathering information and analyzing it the conflicts between sources of livelihood and nature, and their backgrounds caused for the water areas will be examined. As an outcome a framework will be compiled to prevent and reduce the conflicts. In the second phase the framework will be implemented and tested in practice in the municipality of Uusikaupunki, for which a comprehensive coastal management strategy will be compiled.

The main goal is to increase regional co-operation, to advance the balance between environment and industries and especially to intensify the planning concerning use of the water areas. The project produces recommendations on how the different components can be combined to form a coherent Coastal Management Strategy within Southwest Finland and the Archipelago Sea area. The partners – Regional Council of Southwest Finland, Southwest Finland Regional Environment Centre, University of Turku, Employment and Economic Development Centre of Southwest Finland and Municipality of Uusikaupunki - see this project as a continuum that begins from the local pilot project and extends to the regional level.

1.3 The pilot project area

Coastal area faces many different usage demands and expectations. This situation brings out a lot of various questions and conflict situations, for example how different assets and viewpoints should be balanced. Conflicts in the area are usually related to the matters like economic development, human activities, conservation, preservation and reconditioning the coastal zone.

The municipality of Uusikaupunki is a versatile centre of industry, tourism, fishery and services. The pelagic environment and nature of the city is of paramount importance. It provides rich experiences not only for its residents, but also for to many summer inhabitants and boaters. Uusikaupunki has 16,851 residents and 3,665 summer cottages (Tilastokeskus 2001).

As a part of COASTRA, a pilot project that started in September 2003 in municipality of Uusikaupunki is designed to test and develop the regional ICZM proposal at a local level. Important issues in this project are following stocktaking, conflict assessment and compiling of a draft management proposal. As a result of the pilot a regional ICZM strategy will be formed.

1.4 Used methods of the pilot

Regional planning in Finland has traditionally mainly been concentrated on land areas, although there is a clear need for similar planning in the marine areas, which are locally characterized by complex ownership conditions. The effects of shoreline land use planning for the marine area also needs to be considered more thoroughly in order to preserve natural values as well as the economic life.

The central part of the ICZM is to become aware of the fact that in the ongoing and becoming processes of the nature are included quite many uncertainties, which are indirectly impacting to the human actions and qualifications of action in coastal area. A starting-point is going to be an aspiration for to develop the democratic mechanisms, through which the organizations and individuals from all sectors of society are able to be involved in a meaningful way in this process.

ICZM presumes participation and co-operation of all those parties, which have some interests to control or the actions carried out in the area are affected. In practice this means that especially the inhabitants of the area should have a strong role in creation of the model.

There have been different authorities for different administrative tasks in Finland and little or no co-operation in this top-down system, which has led to delays and information gaps. Also, the general public has felt that they have little influence on the decision-making concerning their environment.

The aspiration of the pilot is to define and think over the rules and recommendations for the possible practical implementation. Furthermore, there is an aspiration to increase the regional co-operation, further the balance between the environment and business and especially intensify the planning connected with the use of water areas.

In practice this has been carried out by dissemination, seminars and public occasions, workshops and counseling. Essential themes of the project are for instance, the processes guiding the use of areas, transportation, fishery, water quality and pollution, tourism, leisure housing and recreation, use of natural resources, nature conservation, landscapes, cultural heritage and agriculture. There are four open workshops established to the pilot area for the stakeholders (fishery, industry, tourism and recreation and environment). Within those workshops the practical challenges, which are related to the themes of interests, are interfered.

By counseling the stakeholders will be guided into the independent data collection, for instance using the public Internet-map-server produced by the project. In pilot it will also be arranged a possibility for a sector-crossed co-operation between different authorities, which is partly new in local planning tradition.

2 Results

For taking forward the Uusikaupunki pilot, workshops have to be considered as an important way of working. In those workshops the representatives of different interest groups have been able to bring up freely the conflicts considering their interest groups. As an essential part of this kind of way of working has been a conversation arisen from the grass-root level. One important factor in this process is seen to be the mobilization of grass-root level for a part of the planning process. This kind of bottom-up way of action has been a central reason for that that by means of the pilot there has been in early phases a possibility to resolve certain problems and conflicts considering the fishery.

The results of the pilot have been and are still going to be introduced in different occasions and seminars for the local people and also for the decision-makers. Those occasions are kept as a good channel to bring up the reached results. On the basis of the results will be accomplished a coastal management strategy for Uusikaupunki area and also the conflict areas will be described by map presentations. The purpose is to exploit also wider the experiences and results achieved from the pilot, for instance in formulating the national ICZM strategy.

An essential implementation of the project's objectives is to invest in the dissemination and to the public accessibility of information. Life COASTRA includes increased regional co-operation and especially intensified planning concerning the use of water areas. One of the biggest outputs of this project thus far is the opening of the public Internet-map-server, which is an important tool in the dissemination process and for supporting sound decision-making.

The internet-map-server includes very wide range of GI-based data covering the entire area of Archipelago Sea. It can be kept as a very excellent tool for furthering interaction and supplying information between the stakeholders of the area. Also establishing the map-server has been developing the co-operation between the authorities.

3 Discussion

It is expected that co-operation within all levels involved and especially between regional authorities and organizations will be intensified. Improved horizontal management practice integration amongst different sectors of activity and vertically from regional to local levels together with increasing public participation and interest in coastal management are encouraged. Guidelines will be shaped for proper waste and wastewater treatment practices concerning existing and new free time settlements or summer cottages.

The key to the problems faced in Southwest Finland is integrating the special knowledge possessed by the partners of this project and a wide perspective towards the complexity of the coastal area. The use of the coastal area must be based on natural processes of the area also in the long run, since decisions made today must leave options open for the future as well. Common consensus will be achieved through comprehensive participation of authorities, organizations, groups and people. Different tools such as research, dissemination, legislation and agreements will be used in solving the conflicts of the coastal area.

Should there not be a management procedure for the project area, it is probable that the state of the environment will continue to degrade and the viability of the archipelago area will suffer greatly. The economy cannot function without an environment that is at a good state, the number of jobs will decrease and permanent residents start moving towards larger population centers. This in turn leads to desolation of the outer parts of the archipelago and to vanishing of the distinctive natural and cultural environment.

Attaining a cleaner and at the same time more appealing coastal area would have a definite employing influence, since more people create a demand for more services. As a consequence of the project the image of the area will also improve and it will preserve its viability.

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Das Subprojekt "Warnowregion"

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Warnowregion e.V.

Abstract

The Subprojekt Warnowregion is part of the Workpackage 4 (Preparation and execution of measures for regional development in coastal areas).
The Warnowregion lies in the coastal zone hinterland. It contains the catchment area of the Warnow and its tributaries.
There are various interactions next to the entries of the Warnow into the Baltic Sea between the from Mecklenburg east sea coast and the Warnowregion.
A challenge for the implementation and elaboration of broader spatial use strategies and regional development concepts is the strong administrative dissection of the Warnowregion.
The primary objective is the development of regional identity. A "forum of the Warnowregion" was initiated. It is an honorary work organ and unites this one in the partial rooms responsible administrative and other structures. Two conferences of the forum took place, a logo competition as well as two specialist conferences and a first Warnow regional show. Thematic working groups arose. - Methodical problems arose because the recording of the "experience room ice age" shall be in a decentralized system carried out with a simple software.

1 Ausgangslage

Unter „Warnowregion" wird der Raum im Einzugsgebiet der Warnow verstanden. Die Hauptachse erstreckt sich zwischen Schwerin und Rostock, die wichtigste Nebenachse entlang der Nebel bis in den Krakower Raum. Die Region endet im Stadtgebiet der Hansestadt Rostock. Der Raum an der Unterwarnow rechnet nicht mehr zur Warnowregion.

Die Warnowregion ist ein Mosaik einzelner teilräumlicher Verwaltungszuständigkeiten: Auf Landkreisebene sind vor allem die Kreise Bad Doberan, Güstrow und Parchim zuständig, ein kleiner Teil des Einzugsgebietes unterliegt der Verantwortung des Kreises Nordwestmecklenburg. Zwei Industrie- und Handelskammern und zwei Handwerkskammern arbeiten in ihren Teilbereichen engagiert, aber noch ohne Blick auf die gesamte Region und ihre Entwicklungschancen. Ähnliches gilt für die beiden Tourismusverbände. Das trifft auch auf die Landwirtschaft, den Umweltschutz und die Raumordnung zu. Zwei regionale Planungsverbände sind für die Region anteilig zuständig. In der praktischen raumplanerischen Arbeit spielt die räumlich-funktionale Einheit des Warnowgebietes noch keine angemessene Rolle.

Die beiden größten Städte Mecklenburg-Vorpommerns sowie die Stadt Güstrow beeinflussen die Warnowregion in vielfältiger Weise, nicht zuletzt durch eine starke Ressourceninanspruchnahme. In den „Kerngebieten" sind der ländliche Raum und seine Entwicklung weitgehend sich selbst überlassen.

Die Warnowregion hat neben den vielfältigen indirekten Beziehungen zur mecklenburgischen Küste zwei unmittelbare Wirkungen auf die Küstenregion:

- Auf dem Wasserpfad gelangen alle im Einzugsgebiet der Warnow an die Fließgewässer abgegebenen Stoffe letztendlich in die Ostsee.
- Als Küstenhinterland der Tourismusregion zwischen Wismar und Rostock besitzt die Warnowregion zumindest entlang ihrer Hauptachse ein großes zusätzliches Potential für die

Touristikbranche an der Küste selbst, das auch wesentliche Entlastungsmöglichkeiten der Küste und Küstenstädte bietet.

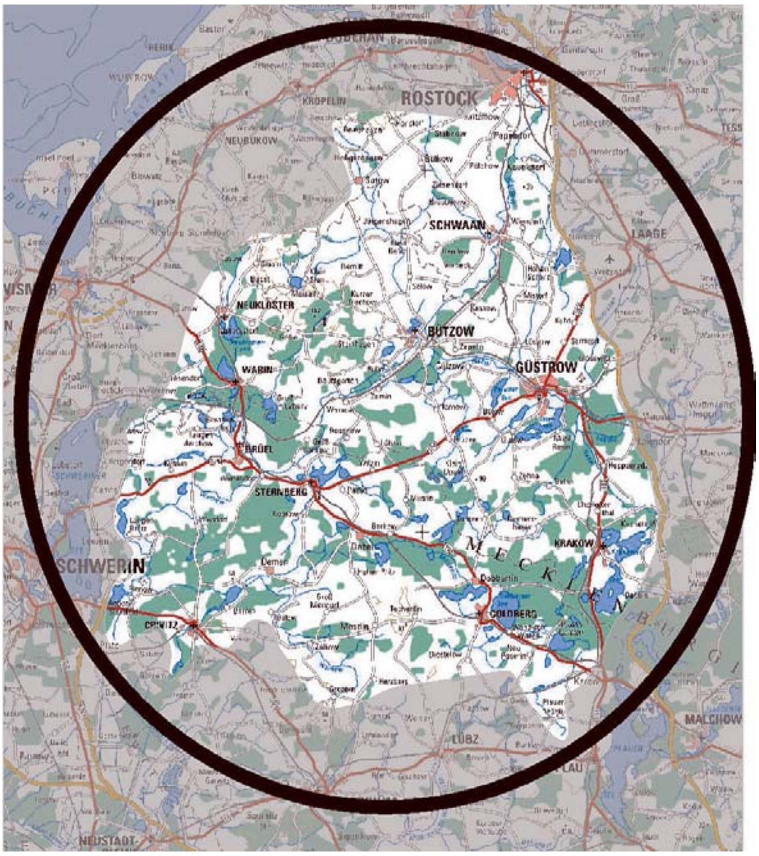

Abbildung 1: Die Warnowregion

2 Entwicklungsziele

Die Schwerpunkte der angestrebten Entwicklung in der Warnowregion werden mittel- und langfristig durch folgende Ziele geprägt:

1. Die Entwicklung einer regionalen Identität (einschließlich eines entsprechenden Namens und Logos), die die Motivationsbildung fördert und gleichzeitig für Produkte und Dienstleistungen (insbesondere ländlicher Tourismus) ein Markenzeichen und in Folge auch ein Qualitätssiegel wird.
2. Die Entwicklung der Eigenpotentiale der Warnowregion.
3. Die Entwicklung flexibler Netzwerke der verschiedensten Ausprägung. Zielfunktion ist die Kommunikation und damit letztendlich auch die Integration der verschiedenen Fakten, Interessenlagen, Motivationen, Handlungen im Sinne einer zukunftsfähigen Entwicklung des ländlichen Raumes.

Diese Ziele sollen im Rahmen des BaltCoast-Subprojektes durch zwei Themenkomplexe umgesetzt werden:

1. Forum der Warnowregion
2. Erlebnisraum Eiszeit

2.1 Das Forum der Warnowregion

Es gibt noch keine Struktur im Warnowraum, die für die gesamte Region zuständig ist oder zuständig werden könnte. Es ist deshalb sinnvoll, ein „Forum der Warnowregion" zu bilden, das die in den Teilräumen zuständigen Strukturen vereinigt. Als ehrenamtliches Arbeitsorgan initiiert bzw.

unterstützt es die Kommunikation und Koordination der Hauptaktivitäten. In diesem Sinn leistet das Forum Regionalmanagement, ohne in die teilräumlichen Zuständigkeiten der Regionalmanager, Kommunen, Behörden usw. (die ja Mitglieder des Forums sind) einzugreifen.

Der vom Forum zu organisierende und zu begleitende Dialog- und Kooperationsprozeß wird konsequent als *Prozeß* verstanden.

Inhaltliches Hauptanliegen der Arbeit des Forums ist – unter Einbettung des Regionalen Entwicklungskonzeptes des Planungsverbandes Westmecklenburg und der Regionalen Agenda des Planungsverbandes Mittleres Mecklenburg/Rostock - die Entwicklung des Einzugsgebietes der Warnow und ihrer Nebenflüsse zu regionaler Identität als „Warnowregion“. Es ergeben sich folgende Arbeitsschwerpunkte:

- Das durch die gegebenen Teilzuständigkeiten jeweils in Teilräumen der Region erfolgende Verwaltungshandeln soll durch das Forum abgestimmt und koordiniert werden. Die vielen naturräumlich wertvollen Räume und die gleichzeitig erwünschten („sanften“) touristischen Nutzungen sowie die anzustrebenden Querverbindungen touristischer Aktivitäten zur mecklenburgischen Ostseeküste erfordern detaillierte und zugleich auf das regionale Gesamtanliegen bezogene Planungs-, Entscheidung- und Umsetzungsprozesse, die das Forum informell unterstützen kann. Das betrifft vor allem die Handlungsfelder der Wirtschaft, Landwirtschaft und des Tourismus.
- Die wirtschaftlichen Nutzungspotentiale im Spannungsfeld von FFH-Restriktion und EU-Wasserrahmenrichtlinie sind auszuloten.
- Weitere Aktivitäten sind u.a.:
  - Berücksichtigung und Einbindung anderer regionaler Entwicklungsansätze (Lernende Region usw.)
  - Das Forum organisiert die in der Projektlaufzeit für das Anliegen der Entwicklung des Warnowraumes zur Region notwendigen Vernetzungen zwischen Entscheidungsträger und anderen Akteuren.
  - Bedarfsweise werden Informationsveranstaltungen, Seminare usw. durchgeführt.
  - Es berät und veranlasst Marketingmaßnahmen für die Region und lässt ein Logo für die Warnowregion entwickeln.

2.2 Erlebnisraum Eiszeit

Im Kerngebiet der Warnowregion sind die eiszeitlichen Bildungen und viele Zeugen ur- und frühgeschichtlicher Besiedlung der eiszeitlich geprägten Landschaft sowie die auf den glazialen Strukturen basierenden Kulturlandschaften intensiv erlebbar, aber kaum erschlossen. Der „Erlebnisraum Eiszeit“ soll zu einem Signet der Warnowregion werden.

Durch dieses Vorhaben sollen folgende Ziele erreicht werden, die (a) eine produktive Zusammenarbeit der Verwaltungseinheiten und (b) durch Zusammenarbeit mit der benachbarten Mecklenburgischen Ostseeküste erfordern:

- Erschließung eiszeitlich und ur- und frühgeschichtlich geprägter Erlebnis- und Informationsinhalte
- Einbezug interessierter Dienstleister zur Sicherung attraktiver Erlebnisprodukte.
- Herstellen von kommunikativen Querverbindungen zur Mecklenburgischen Ostseeküste als einem wichtigen Einzugsgebiet (mit der Option einer Qualitätsverbesserung in der Angebotspalette für Küstenurlauber bei gleichzeitiger Entlastung des Nutzungsdrucks direkt an der Küste und einem saisionverlängernden Effekt für Küstenurlaubs-Angebote).

3 Der Bearbeitungsstand

3.1 Das Forum der Region

Tagungen des Forums

Es fanden zwei ganztägige Tagungen des Regionalforums statt (September 2002 und November 2003). Zwischenzeitlich sind thematische Arbeitskreise aktiv.

Regionalschau

Die erste Tagung des Regionalforums empfahl die Durchführung einer Regionalschau. Die erste fand im November 2003 statt. Es nahmen 90 Aussteller teil. Die kofinanzierenden Ämter gewannen Vereine und Gewerbebetriebe als Mitaussteller. Durch die Regionalschau entstanden zwischen den Ausstellern vielfältige Kontakte, die auf andere Art nur schwer zu vermitteln waren. Die Intensität dieses Effektes ging weit über die Erwartung des Veranstalters hinaus.

Die zweite Regionalschau wird im November 2004 durchgeführt.

Abbildung 2: Stände auf der 1. Warnow-Regionalschau

Logo-Wettbewerb

Im Ideenwettbewerb für ein Logo der Warnowregion erhielten wir 66 Einsendungen von teilweise hoher künstlerischer Qualität. Die Jury wertete in den vier Kategorien Schüler, Studenten, interessierte Laien und Profis. Es gab sehr anspruchsvolle Beiträge. Keiner ist jedoch für eine unmittelbare Nutzung als spezifisches Logo der Warnowregion geeignet. Auf der Grundlage der eingereichten Vorschläge wird bis zum Sommer 2004 das Logo der Region entwickelt. Es soll auch als Herkunfts- und Gütesiegel dienen.

Abbildung 3: Entwürfe aus dem Wettbewerb „Die Warnow braucht ein Logo!“

Der Logowettbewerb vermittelte öffentlichkeitswirksam das Anliegen der regionalen Identität und Entwicklung.

Die 66 eingereichten Vorschläge wurden auf der 1. Warnow-Regionalschau ausgestellt. Die Auszeichnung der Preisträger erfolgte auf der Regionalschau. Die preisgekrönten Entwürfe sind auch auf der Website www.warnowregion.de veröffentlicht. Beides verstärkt die öffentliche Wahrnehmung und Diskussion regionaler Entwicklung.

Fachtagungen

Es fanden zwei Fachtagungen statt zu den Themen "Ortsbilder" und "Regenerative Energien". Für beide Tagungen konnten hochkarätige Referenten gewonnen werden. An der Tagung "Ortsbilder" war ECOVAST (Deutsche Sektion) beteiligt. Es nahmen entgegen aller Erwartung nur wenige kommunale Entscheidungsträger und Architekten teil. Die Tagung "Ortsbilder" war als Auftakt einer thematischen Reihe konzipiert. Im Vorfeld der nächsten Veranstaltung müssen wir deutlich machen, dass der Erhalt und die Entwicklung der Ortsbilder einen hohen wirtschaftlichen Stellenwert besitzt. Das Thema sollte im kommunalen Planen und Handeln eine hohe Priorität bekommen.

Kommunikation und Kooperation öffentlich geförderter Projekte in der Warnowregion

Die mit öffentlichen Mitteln geförderten Projekte in der Warnowregion zusammenzuführen, ist ein wichtiges Anliegen des Forums der Region. An einem ersten Projekttreffen nahmen 20 von insgesamt 40 Projektträgern teil. Es geht darum, die Projektträger miteinander bekannt zu machen. Durch Kommunikation und Kooperation können Doppelarbeit vermieden werden und wichtige Synergieeffekte entstehen. Auch bereits abgeschlossene Projekte sollen mit ihren Ergebnissen einbezogen werden. Das ist nicht nur bei Integrierten Regionalen Entwicklungskonzepten wichtig.

3.2 Erlebnisraum Eiszeit

Beim Teilthema "Erlebnisraum Eiszeit" konnte der Zeitverzug noch nicht vollständig aufgeholt werden, der durch die späte finanzielle Klarheit entstand (die Arbeit begann bekanntlich rund 6 Monate später als ursprünglich geplant). Die Erfassung der Erlebnispotentiale in dem ausgewählten Teilraum ist weitgehend abgeschlossen. Die konkrete Einbeziehung touristischer Anbieter wird in den kommenden Monaten erfolgen. Die kartografische Erfassung setzt die Lösung eines in der Projektplanung noch nicht erkennbaren Problems voraus. Vorgesehen war die Datenerfassung mittels der Software TK 50 des Landesvermessungsamtes Mecklenburg-Vorpommern. Diese Software ist kostengünstig und begünstigt dadurch die dezentrale Datenerhebung und Aktualisierung durch Akteure vor Ort. Sie besitzt jedoch keine Import- und Exportfunktionen. Dadurch sind einige Projektpartner auf eine leistungsfähigere Software ausgewichen, die jedoch nicht für kommerzielle Zwecke genutzt werden darf. Ziel unserer Arbeit ist jedoch die touristische Nutzung der kartographisch dargestellten Erlebnispotentiale, Dienstleister usw. Die methodische Klärung wird im 4. Meilenstein erfolgen.

4 Website

Die vorgestellten und die weiteren Projektergebnisse werden auf der Website www.warnowregion.de im Detail dargestellt.

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The modern tourist's perception of the beach: Is the sandy beach a place of conflict between tourism and biodiversity?

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Abstract

As economic growth gave people more free time, since the 1950s coastal areas have become increasingly desirable holiday destinations, and beach tourism has grown at an enormous rate, becoming a mass phenomenon. Next to their ecological importance as bio-filters, sandy beaches in Europe tend to be of great economic value through tourism. Although, modern tourists are largely peaceful, tourism itself creates much damage to the environment. Nowadays a common feature of the European seas is the diffusion of plastic debris on the coasts, either abandoned by beach users or deposited by the sea during storms.

There are some 4 to 8 million tourists vacationing each year on Polish beaches. What is the purpose of their visit to the beach? What things do they most dislike there? What is the perfect coastal landscape of the sea for them? What is their imagination of the beach life? Questionnaire surveys, carried out during summer 2003, aimed at ascertaining what public opinion was/is regarding the beach, were useful to answer these questions. At each site, from 80 to 160 people filled out the questionnaires asking what their opinion was of the beach, scenery, animals and aesthetics.

In a modern, democratic society, the public stakeholders, not the experts are having the final word. It creates, however, problems with public opinion: there is seldom direct experience (visual, practical), and there is no common perception of values. Do we really have similar values? For many, the plastic net covers on cliffs and the coastal motorways are more attractive than underdeveloped shore.

1 Introduction

1.1 Human impact on the coastal zone due to tourism

Exposed sandy beaches are highly hydrodynamic. These ecosystems usually present low biodiversity and high specialization, due to the regime of permanent abiotic changes that governs their functioning. The tiny number of species, however, hide high biomass and production rates along all the trophic web, and the surf zone has been recognized as a nursery for many marine fish species (Brown & McLachlan 1990). Also, coastal regions of Europe have witnessed human settlement and economic activity for thousands of years. Depending on the definition used, 20-50 % of Europe's population live within the coastal zone and depend on it for their living and quality of life (ESF Marine Board 2002). Caffyn et al. (2002) report that 50-70 % of humans live within 60 km of the coast and this proportion is increasing. Furthermore, by the year 2020, 75% of the world's population will live within 60 km of marine coasts and estuaries. Influxes of tourism add to this human impact on the coastal zone as well. In the mid 1990s, the Mediterranean coastline alone received annually an estimated 75 million international and 60 million domestic tourists (ESF Marine Board 2002). Montanari (1995) reports that over 200 million tourists visit the Mediterranean basin every year, 80% choosing European Union countries as their travel destination. The biodiversity of, and the impact of tourism on, sandy beach biodiversity is a subject currently generating great scientific interest in Europe. It is the key topic of the international research programme "Sandy", which involves scientists from 12 European countries and has recently been funded by the European Commission. Part of this concern is expressed in initiatives like the SCOR Working Group 114 on permeable sediments (SCOR 1998; http://www.scor-wg114.de). The Importance of Critical Transition Zones (including sandy beaches) was the focus of the SCOPE meeting (Levin et al. 2001). To meet the challenge of progressing integrated coastal zone management (ICZM) and governance, baseline interdisciplinary research is required (Emeis et al. 2001). The importance of those ecosystems for the countries in different regions (e.g. Europe, South America, South Africa, Australia) has been pointed out in the workshop "Beaches: what future?" (Florence, 2001, Proceedings in press, ECCS). This focused on adaptation of communities and populations along the world's coasts and it highlighted the need of common protocols and frequent exchanges between the partners of the research network on beaches (Scapini 2002). It set out to fill important gaps in our knowledge concerning sandy beach biodiversity in Europe, and to link beach biodiversity to tourist impacts, using both a descriptive and an experimental approach.

Scientists, resource managers and medical experts today widely accept the idea that human society is dependent upon a healthy environment and that continued environmental degradation threatens the quality of life (Bickham et al. 2000). Although direct links between ecological effects and human health have proven difficult to establish, the use of wildlife species as sentinels of environmental problems is the conceptual basis for this connection (Colborn 1994). Furthermore, considering the principles of sustainable management of marine and coastal areas, defined in the Rio conference of 1992 (Chapter 17, Agenda XXI), the topic of sustainable management has acquired a fundamental role in the country policies all over the world, and must be faced at an international and multidisciplinary level. The intervention through management plans and the use of supporting tools in decision-making acquires particular importance for relatively fragile ecosystems such as sandy beaches.

This paper is not concerned with the ICZM aspects of implementation and assessment, but is a pilot project as to how the public perceive a beach. In essence, are beach landscapes, aesthetics, and nature acceptable, or unacceptable, or is the public indifferent to them?

1.2 Methodological strategies

The purpose of questionnaire surveys, carried out at 3 beaches on Northern coast of Poland (Hel, Gdynia, Sopot) during the summer at 2003, was to ascertain what public opinion had been regarding beach perception (Figure 1). At each site, from 80 to 160 people filled out the questionnaires asking what their opinion was of the beach, scenery, animals, and aesthetics. Questions related to the perception of the visual world - after the classic research works of Gibson (1950, 1966, 1979), and specifically were geared to:

- the aim of the visit to the beach,
- things that people most dislike on a beach,
- their perfect coastal landscape of the sea,
- their imagination of beach life - what animals the public know live on a beach and what animals they want to avoid meeting during a visit.

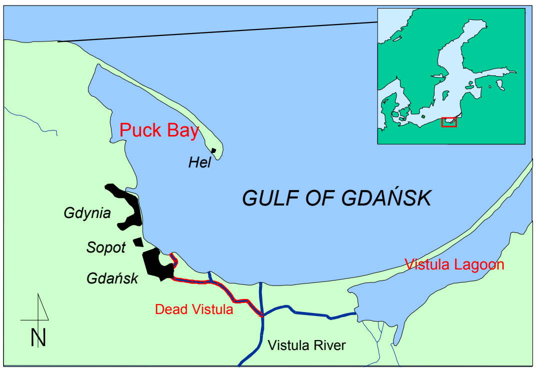


Figure 1: Gulf of Gdańsk - location of study sites (estuarine areas of the 2nd stage marked in red)

2 Results

Table 1 presents the main reasons why people visit the beach. These results are very intriguing and more research needs to be carried out, as to why the public were so interested in fresh air, wildlife, and nature, instead of sunbathing and water sports, which would seem to be the most important aims for visiting a beach. The results suggest that fresh air is the most important 'product' that beaches offer to us in accordance with the concept of ecosystem goods and services from Constanza et al. (1997). Naturally, such activity needs some shore-based recreation infrastructures, i.e. 'promenades', beach access (roads, footpaths, etc.), waterfront housing development, car parks, camp/caravan/picnic sites, playgrounds, swimming pools, service areas, beach facilities (toilets, lifeguards), walkways and walkover structures, costal protection structures (groins, etc.), sand beach nourishment, moorings, boat docks, marinas, navigation canals, reclamation of coastal wetlands, drainage and stream canalisation. It may create, however, many conflicts and adverse impacts, i.e. complexity of interaction between activities, landscape and scenic quality alteration, shoreline modification, erosion, disruption of sediment transport, pressure on local cultural values, water/land space conflicts, ecological disturbances (dunes, reefs, wetlands, etc.), traffic intensity, sewage, litter, oil seepage, water quality, wakes from boats, noise, air pollution, accidents and hazards, dune path network (dunes flattened to build houses and roads), habitat loss and damage, exotic vegetation, higher risk exposure to coastal hazards, reduction of recreational use, and scenic appeal.

PURPOSE	%
Fresh air	26.53
Swimming	18.37
Nature and wildlife	15.65
Walking	15.65
For children's play	9.52
Scenery, scenic watching	6.12
Water sports*	6.12
Sunbathing	2.04

Table 1: What is the reason people visit the beach? (* i.e. sailing, power boating, surfing, shore angling, boat fishing, water skiing, whale watching, sand sports, snorkelling, para-sailing, kiteing)

Table 2 summarizes the results of the public's perception of beach aesthetics and presents issues that tourists dislike the most on a beach. Unsurprisingly, the very low position of groins in Table 2 confirms other studies (e.g. Williams et al. 2003). Some of the reasoning for groin penchant are that they acted as wind breaks, provided a comfort zone (or 'rugged fun zone') for children, are part of our Heritage (sic!) or are natural and give character to a beach. Especially rock ones are warm for the back and give a 'seat' - they 'break up the beach'. The public think that groins are: familiar and epitomise happy seaside holidays, clean and dominant, peaceful and look right, interesting and beautiful, and dilapidated, but still attractive. Litter and man-made debris, poor water quality, crowd on a beach (especially with dogs) and poor facility are issues that beach visitors dislike them the most.

ISSUE	%
•Lack of sand/shingle beach	0,00
•Groins	1,25
•Beach erosion	2,50
•Bed smells from industry	2,50
•Washed-up seaweed	3,75
•Noise from industry and vehicles	5,00
•Difficult access	5,00
•Seawalls	5,00
•Flies and other insects	5,00
•Poor facilities	**7,50**
•Dog waste/excrement	**7,50**
•Crowded beach	**11,25**
•Poor water quality	**13,75**
•Litter and man-made debris	**30,00**

Table 2: What do tourists dislike the most on a beach? (the highest values are bolded)

The public opinion's knowledge of the costal natural environment is best seen in two additional issues (Figure 2): 56% of beach visitors are sure that some small animals live in a beach environment, but 16% think that sunbathers are the only inhabitants of a coastline.

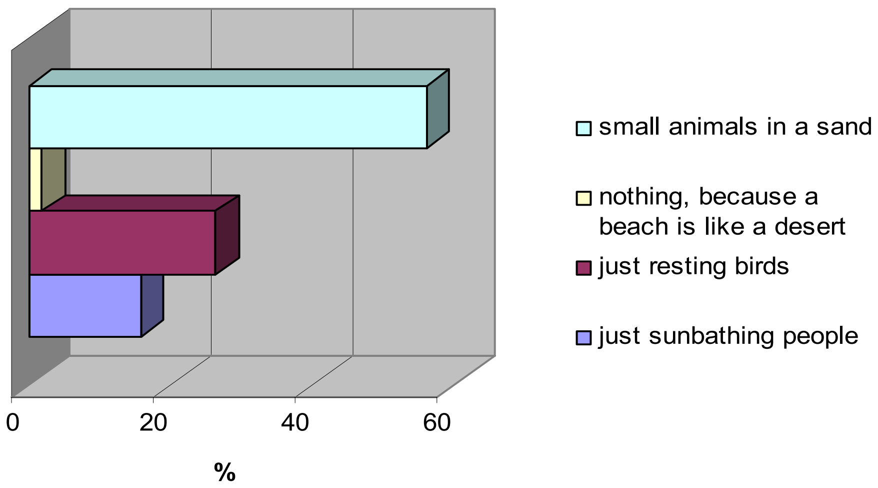


Figure 2: What lives in a beach ecosystem according to the visitor's perception?

Apart from that mentioned above, the beach users rated the vertebrate animals living on a beach to be more attractive than invertebrates (Figure 3): e.g. 9.3% of respondents know that *T. saltator* lives on a beach, but 8.5% of people don't want to meet this animal on a shore. In contrast a lot of people recognise beach birds, and there are no objections to meeting them during his/her stay on a beach. Gregory (1998) has argued that 'perception can affect emotions... some things look beautiful, others ugly'. This comment is exemplified with respect to animals. More research is needed on the findings, especially the question as to whether the perception of risk (danger) equates with a dislike of animals, and is derived from emotional responses rather than reason (Slovic 2000).

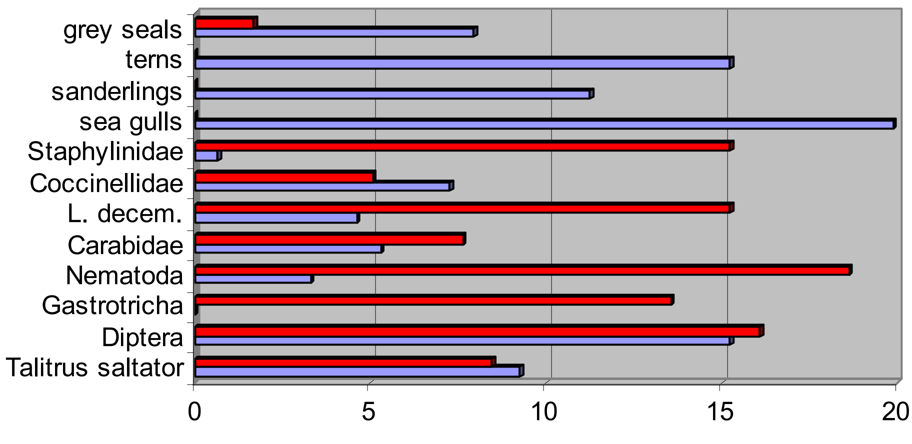


Figure 3: Figure 3: Beach visitors *vs.* beach animals: blue – „Yes, I know that this animal lives on the beach", red – „I don't want to meet this animal on a beach during my stay!".

Results obtained from asking people to rate beach scenery proved to be extremely interesting. Table 3 summarizes the results of the research findings. The only beach interviews that produced clear evidence by respondents of all three study sites was a 'horizon' - here many people chose 'vessels and boats'. It seems to be that the main reason for this was that beaches in the study are directly the vicinity of harbours in Gdańsk and Gdynia and travel paths of ships. It makes the presence of vessels a very familiar view for people resting at neighbouring beaches.

The majority of people visiting beaches in Hel and Sopot wanted to have a very natural environment with dunes. On the contrary, the Gdynia's visitors definitely needed to have a guarded beach with full services. Their opinion about beach scenery was not very clear. However, more than 50% of respondents in Hel and Gdynia preferred pure sand in surf zones. Sopot's respondents were more likely to expect herds of fish when bathing. This is the next interesting issue, as the Hel beach is more 'pristine' than the typical urban beaches of Gdynia and Sopot. More research is thus needed on the above findings.

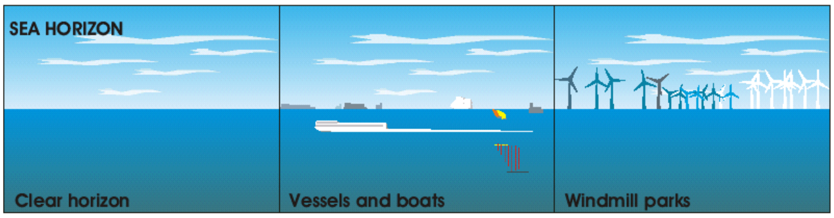
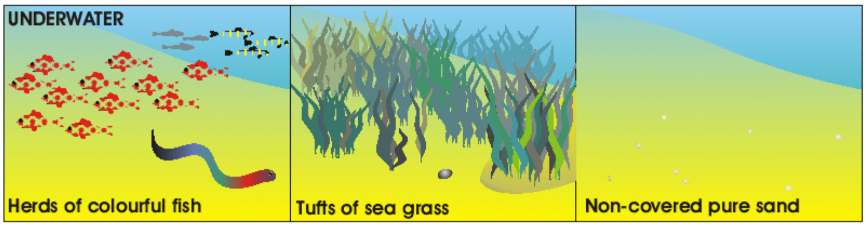
Beach location	SEA HORIZON 			***'I do not know' or 'I do not care about it'***
	Clear horizon	Vessels and boats	Windmill parks	
Hel	20,74	**62,20**	8,53	8,53
Gdynia	20,80	**58,40**	20,80	0
Sopot	32,70	**40,88**	26,42	0
	BEACH 			
	Guarded beach with service	Unguarded empty wild beach	Bulwark and speedway	
Hel	25,00	**66,46**	0	8,54
Gdynia	**64,43**	35,57	0	0
Sopot	29,56	**67,30**	3,14	0
	SEASHORE 			
	Palm lines along the shore	Dunes with sharp-edged grass	Flower beds	
Hel	33,54	**53,66**	0	12,80
Gdynia	22,15	22,15	21,48	20,80
Sopot	18,87	**62,89**	18,24	0
	UNDERWATER 			
	Herds of colourful fish	Tufts of sea grass	Non-covered pure sand	
Hel	37,80	0	**53,66**	8,54
Gdynia	13,42	28,19	**58,39**	0
Sopot	**53,46**	22,64	23,90	0

Table 3: What is an ideal shore landscape? (in %; the highest values are bolded)

However, on the basis of the present results, we know that the choice of the ideal beach is a choice of extremes between a full set of facilities, and the wilderness. According to the questionnaires, the majority of those surveyed would like an uncrowded beach with full facilities (Figure 4).

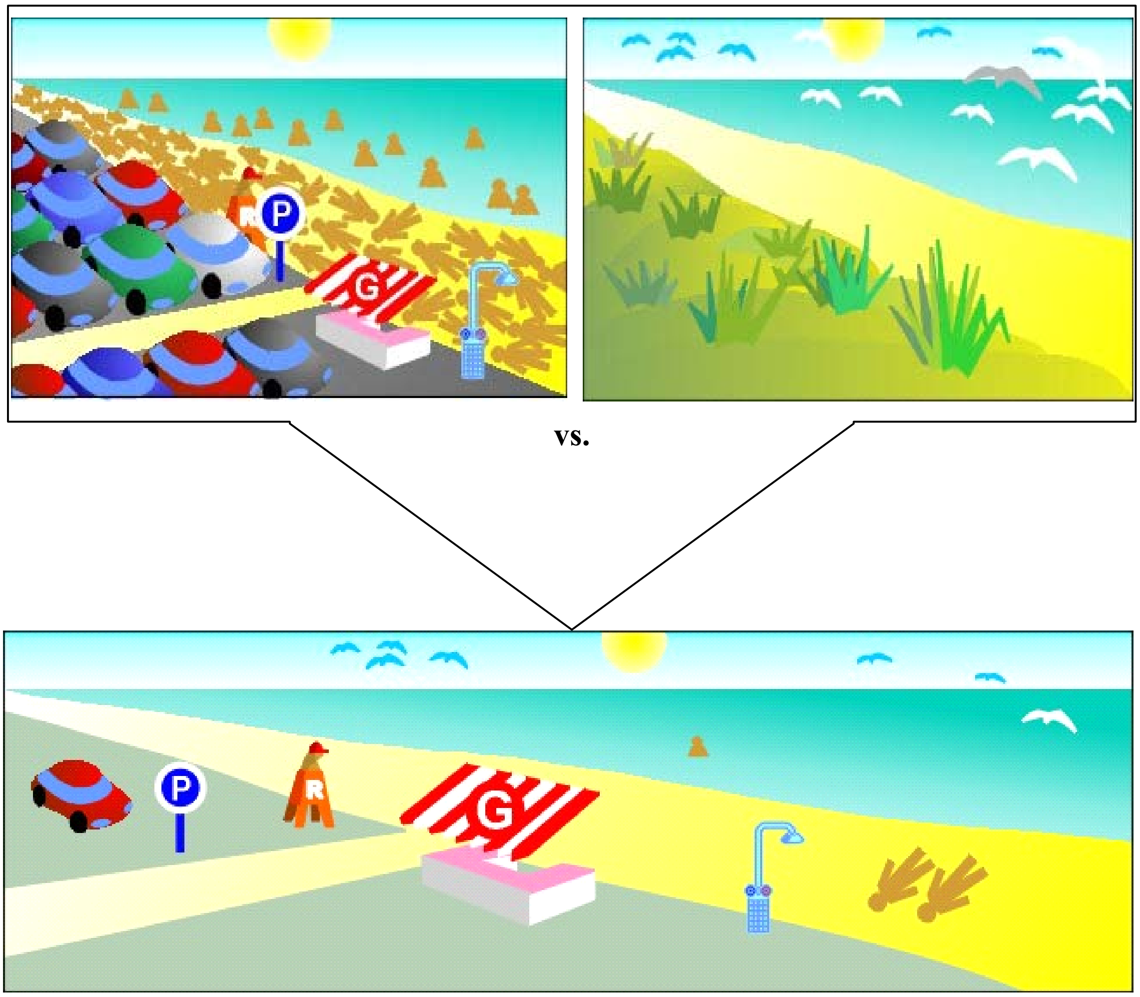


Figure 4: The choice of ideal beach is the choice between extremes – the effect is a theoretical compromise which cannot be applied in practice.

3 Discussion

Nowadays, it is a commonly occurring phenomenon that plastic debris litters the European coasts, either abandoned by beach users or deposited by the sea during storms. Urban residents usually declare their longing for contact with nature and the need to protect the environment. Few realise that contact with nature is intimately related with the giving up of some of the comfort offered by civilisation. Being able to choose, few people sacrifice their time and comfort in order to be able to experience the natural environment. The consciousness of nature is limited to charismatic species and extreme phenomena. Without judging attitudes, we should learn what the predominant approaches are in the European society. The following questions arise: how do people use marine coasts? How many prefer sand over a lounge chair? Will a marble-stone swimming pool replace the sea? How much do people want to spend on marine recreation and what quality do they expect? How many want to keep out of their minds that nematodes also live on the beach? And we have to formulate the final important question: Are we losing something by turning pristine coastlines into leisure industry centres? If so, what is the extent of the loss?

Such questions, of obvious importance in terms of management and planning may, to a certain extent, be approached through model simulations, which appear therefore as a powerful tool. There are many tools that are very useful for such reasons (Caffyn et al. 2002). The easiest is a **beach usage by visitors and tourists** - count and observations to collect various types of data through observational surveys conducted at each beach site. It is important to record the numbers of beach users over time and to distinguish between recreational users and any local people using the beach as part of their business or normal daily lives. Thus regular counts are taken of people on the beach during each day of the survey. In addition to exact numbers, other data are collected such as the types of activities taking place, the types of visitors present and any conflicts or problems observed. Data are recorded on specially designed record sheets and photographic records are also taken each hour. The next tool are **stakeholder analyses** in order to undertake an analysis of stakeholders, their views and priorities, including the different groups of resource users, local people and other non-governmental stakeholders. Each stakeholder is asked to provide similar information – about what they have, what they want, who they interact with and how, and what problems they are experiencing. **Visitor surveys** are the most complex tool in order to monitor the characteristics and views of visitors to beach environments. Visitors are interviewed using a standard questionnaire. This provides much more information than observational methods, as it is possible to ask visitors about their behaviour, views, knowledge, preferences and feelings about the site. The data can be analysed with a mixture of quantitative and qualitative methods to produce statistics about characteristics and opinions but also people's responses about the meaning the site has for them or their views on its management. Sample sizes need to be reasonable to ensure statistics produced are reliable and to monitor trends from one year to the next. It is important to sample at both weekends and during the week as types and numbers of beach users will vary from day to day. Similarly, sampling should take place throughout the season the beach is used, which could be over a six month period or more. The best sampling points should be considered where a large site is being surveyed - as again different users may prefer different areas of the beach.

To date, there has been extremely little published work regarding coastal perception. However, there have been many publications on hazard perception, which can be incorporated into beach studies, as plastic debris on the coasts especially, can be grouped under the term 'hazards'. Kates (1962) was the first to highlight how perceptions differ between individuals. People who denied that flood hazard existed, saw it as a regular occurrence whilst others saw flooding as an 'act of God' and viewed the hazard in a detrimental way. In time, the emphasis shifted from flood hazard to drought by Saarinen (1966) in a perception study of Great Plains farmers. Prior to this study, floods had dominated research attention being the most commonly occurring hazard. In 1967, a collaborative research program carried out by the universities of Clark, Toronto and Chicago attempted to use findings from flood hazards and apply them to other hazards and cultures (White 1973). Hazards including hurricanes, snow, earthquakes, volcano and coastal erosion, were also studied in countries as diverse as Pakistan, Peru and Japan (White 1973). The findings of this extensive research showed not so much public ignorance but public indifference. In detriment-free periods, little interest was shown in hazards and information regarding adjustments.

Why do things look the way they do? Perception is the process in which the brain receives, selects, modifies, and organises impulses and the basis of perception is sensorial knowledge (Sekuler & Blake 1994, Moscovici 2000). Much of what is perceived merely provides raw data that comes to the senses from the object and is assimilated in the brain where perception starts. This sensory information is transferred, elaborated upon and combined to create what a person basically experiences or perceives. This elaboration makes perception a personal process, coloured by the individual and his/her experiences both past and present. Much of the data processing for perception takes place in the eye and this pre-processing is conducted by 120 million receptors down to 1 million optic nerve fibres. However, only a small fraction of the sensory input received at any one time is experienced or perceived. This is because there is a 'focus' and a 'margin' to the conscious experience. Events perceived clearly are in 'focus', whilst those in the 'margin', may be dimly perceived, or not even perceived as such. Many factors direct the 'focus' of our perception. Some of the most important are:

- External: intensity and size - the brighter and bigger, the more one can see it; novelty and contrast - the appearance/disappearance of a stimulus can gain attention; repetition - repeated stimuli, can cause one to ignore/pay attention depending upon stimuli;

- Internal: are concerned with needs e.g. hunger, thirst; interest etc. and are not of great concern in the context of the present study, as people on a beach are usually relaxed having ample food, drink etc.

Very little appears to be known regarding the relationship between perception and behaviour. 'The primary purpose of perception is to identify and classify objects and places and to attach meaning and significance to them. Therefore, it is concerned with the enduring character of objects' (Milner & Goodale 1963). Some of elements of a beach scenery, like vessels and boats or wind parks, human traffic and beach facilities etc. are large-scale, enduring objects and people's perceptions of them, influence behavioural patterns, so that the response is usually either favourable or unfavourable. Emotions also come into play, as these can be the sensations of bodily adaptation to a situation - the James-Lange theory, and these are deeply associated with meaning, which is of vital importance to perception. Slovic (1997) has argued that a 'Worldview' e.g. social, cultural and political attitudes, guides a persons judgements regarding good/bad, beauty/ugly adjectives given to an object, i.e. it is an orientating mechanism directing how people make judgements. All these points merit further indepth investigation, because in the modern, democratic society, the public stakeholders, not the experts are having the final word. It creates, however, problems with public opinion: there is seldom direct experience (visual, practical), and there is not a common perception of the values. The quality of the beach ecosystem generally depends on the shoreline stability, and healthy ecosystems in turn contribute to shoreline stability, as they allow for natural equilibrium. Human intervention, management, and other changes may upset the balance of this equilibrium. Do we really value in a similar way? For many, the plastic net cover on cliffs and coastal motorways are more attractive than underdeveloped shore (Figure 5).

Figure 5: Do we have similar values? An example of various ways to manage the same area: a natural beach ecosystem (left) and an antropogenically-created system with a road (right). From the LITUS website: www.iopan.gda.pl

In the recent study of the Polish coastline, Węsławski et al. (2000a, b, c) showed a marked decline in the localities inhabited by the sandhopper Talitrus saltator and of its average density when these were compared with previous recordings. The sandhopper, the only macroscopic consumer of lignin in marine environment, lives along the whole 500 km of Polish sea coast, but effectively on less than 2 km2. Several reasons such as pollution, climatic changes in storm frequency, severity of winters, the rise in sea level, changes in trophic conditions and the increase in recreational use of beaches are all proposed to have caused the decline in the species. Mechanical cleaning is regarded as an important limiting factor for sandhoppers and it is stressed that amphipods could still recover if several kilometres of less frequently visited beaches between crowded areas were left untouched. There are some 4 to 8 million tourists going on vacation each year on Polish beaches. There are some places with more than 3000 persons crossing each square meter on the water line daily. Poles and Germans tend to aggregate close to the beach entrances, while Scandinavians keep maximal distance from the nearest person on the beach. Considering the number of visitors coming to Sopot, it may be concluded that 60% of the Polish coastline receives more than 100 human steps per square meter daily during the peak summer season. Of course, trampling may have a positive effect on the number of microorganisms, since plant debris is fragmented and mixed with sand grains on this way. It speeds up the process of decomposition and organic matter turnover in the beach. However, the question to be studied is that maybe sandhoppers are victims of increasing tourism activities on a sandy beach?

Regarding the point mentioned above, research on socio-economic issues on a sandy beach seems to be of great importance. An axiom in psychology is that only a fraction of what exists, is perceived and only a fraction of what perceived is responded to. With respect to beach users perception of coastal nature at three Polish costal sites, the general opinion is that it is not very visible and badly linked to the main goals of visitors. A preference was expressed that a beach with a full facilities just for one family was more attractive than a crowded one without such services. A preference for birds was clearly expressed and any invertebrate animals disliked immensely. Age, sex, socio-economic status, visitor or local, had no bearing as to linking/not linking beach scenery.

Acknowledgements

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Spatial and temporal analysis of beach tourism using webcam and aerial photographs

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Abstract

Tourism in northern Germany is focussed on summer season and concentrated along the coast. Large parts of the coast are subject to erosion and natural sandy beaches, which are required for bathing tourism, are rare. The beaches are or might become a limiting resource for further growth in tourism. Therefore, detailed knowledge about the spatial and temporal demands and behaviour of vistors at the beach are required. A new automatic method is presented to quantify the density of visitors on the beach. With a webcam the daily, weekly and seasonal course of visitors was observed. Linked to arial photographs, the data allowed the calculation of the beach area, which was available for every visitor at any time.

The results are shown exemplary for Warnemünde. In Warnemünde the new pier causes the exceptional situation of sand accumulation and a steady broadening of the beach. Despite that, the visitors are concentrated in a narrow strip close to the water, where sand quality is best. The average area available for every visitor in this strip during summer was only between 7.7 and 11.9 m² per person. The beach near the dunes is reserved for roofed wicker beach chairs, which cause a lower density of visitors. In this part, every visitor occupied an area between 28 and 62 m² per person. In Warnemünde the beach is not really a limiting resource, but it is likely that many visitors are not pleased and avoid the beach during the peak hours. Further, the analyses show that an integrated management concept for the coastal infrastructure, dunes, beaches and coastal waters is required.

1 Introduction

Along the southern Baltic Sea coast, in the Federal State of Mecklenburg-Vorpommern, Germany, tourism always played an important role as an economic factor. After the German reunification, the number of tourist beds as well as the number of overnight stays dropped dramatically. During the last decade the structure of the tourist industry changed and a steady increase in guest numbers is recorded, again. Nowadays, the number of tourist beds again exceed 160.000 (2002) with nearly 25 Mio. overnight stays. Tourism in northern Germany is focussed on the summer season and concentrated along the coast. Large parts of the coast are subject to erosion and natural sandy beaches, which are a pre-requisite for bathing tourism, are rare. Most tourist resorts take artificial measures to preserve and extent the beaches as well as to improve their quality. The qualitative and quantitative demands of tourists concerning the beach have increased. With ongoing increase in tourist density the beach quality and quantity becomes a limiting resource for tourism development along the German Baltic coast. A management and sustainable development strategy for beaches, dunes, and the infrastructure is required. This requires detailed knowledge about the spatial and temporal utilisation of the coast and the behaviour of visitors. Further information about the carrying capacity of the beaches is needed.

To supply background information a detailed study was carried out during the summer season 2002 (Kammler 2003). For detailed beach observation, a new automatic method was developed to quantify the density of visitors on the beach. With a webcam the daily, weekly and seasonal course of visitors was observed. Linked to arial photographs, the data allowed the calculation of the beach area, which was available for every visitor at any time.

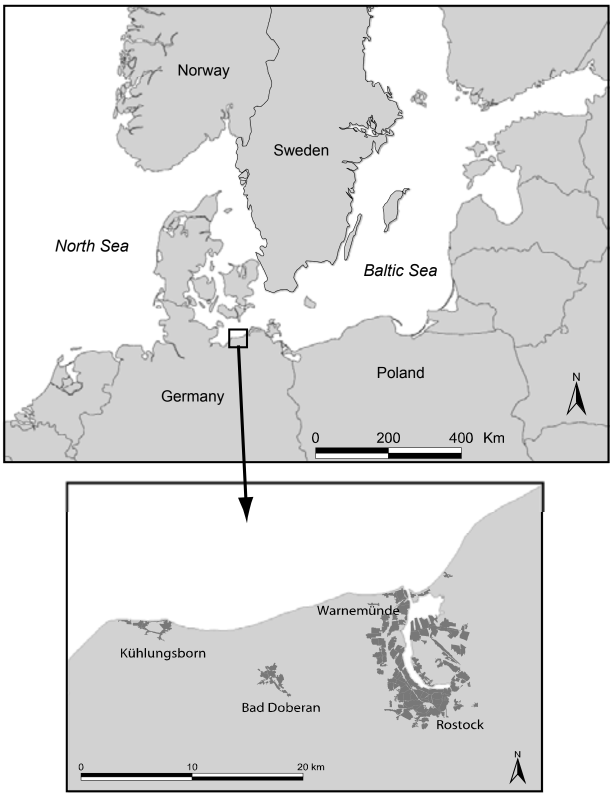

Figure 1: Location of the study area

2 Methods

Two distinct methods of data collection were used to study beach tourism and its intensity at the German Baltic Sea Coast. A webcam located at the upper floor of the Baltic Sea Research Institute Warnemünde, Germany was taking continuously pictures from a beach area of about 15,000 m². The beach area was defined as the stretch of sand between the bottom of cliffs or sand dunes and the water line. These webcam images were used to gain information about the temporal variation of the intensity of beach tourism during five month of monitoring. Aerial photographs were used to investigate the different intensities of tourism along the surveyed beach (pictures were taken from a plane). So, not only temporal but also spatial variations of beach tourism were analysed.

It was possible to monitor beach tourism over a long period of time by using a webcam and to gain information about daily and seasonal fluctuation of beach tourists. From May until the middle of September 2002, the webcam took one picture every half an hour each day from 6 a.m. to 11 p.m. (e.g. Fig. 2.). Due to the high number of images and with regard to their spatial resolution it was necessary to analyse the data automatically. It was assumed that the items on the beach were either people or sand. With this assumption it was possible to analyse the images´ different pixel characteristics. Brightness is one of the image characteristics that is measurable for every single pixel and varying with a changing number of people at the beach. But before the images were analysed, the relevant area was determined. Only the sandy beach areas were important and therefore they had to be cut out from the images (Fig. 2.). Static objects like beach chairs or lifeguard houses were not taken into account and therefore masked out (white areas in Fig. 2.).

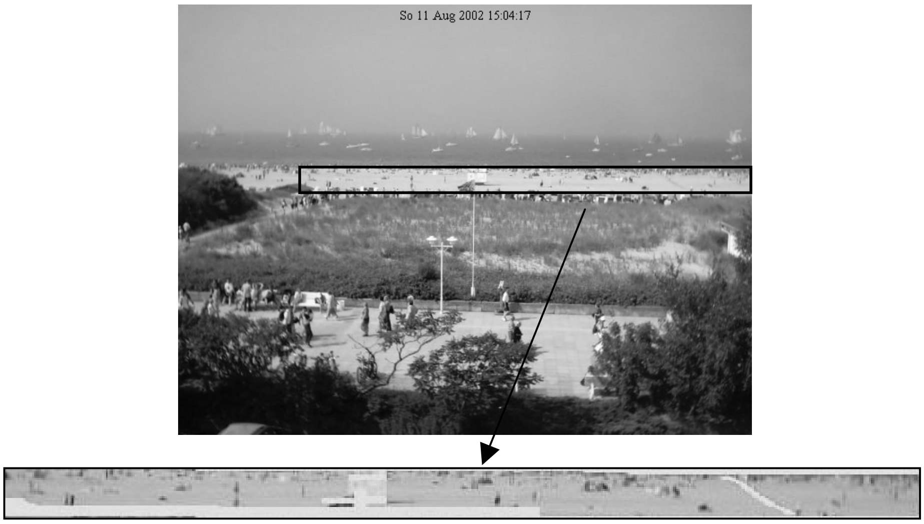

Figure 2: Example of a webcam image and the relevant beach area for the automatical survey (the white areas were masked out).

For image processing the software Matlab by The MathWorks was used. After the RGB-webcam images were changed into 8-byte greyscale images, it was possible to analyse each image´s greyscale histogram.

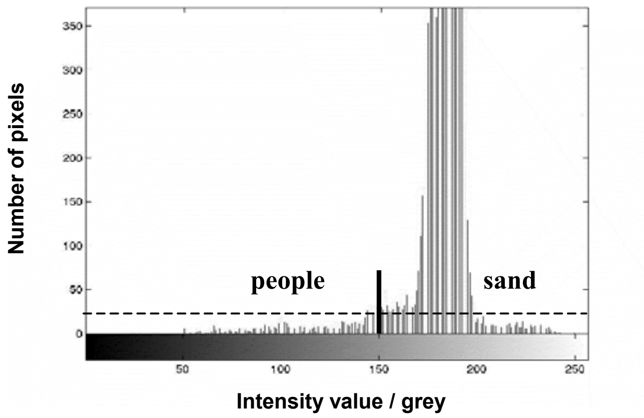

Figure 3: Greyscale histogram of an analysed webcam image

On a histogram (Fig. 3.) the x-axis shows the possible grey tones and the y-axis shows the number of the pixels of each grey tone presented in an image. On Fig. 3. the frequent, lighter grey tones represent beach sand, because sand is the predominant component of the beach. People are represented by darker intensity values (grey tones) and therefore at the lower grey tones near the coordinate origin. On the histogram of Fig. 3. the transition line between people and sand lies approximately at grey tone 150 (vertical line).

Because of different light and weather conditions sand changes its grey tone and therefore the border between sand and people varies. For example, sand has a darker colour in the evening so that the transition line then is at a lower grey tone. This is why the transition between people and sand has to be determined for every image separately. A strong increase in the number of pixels per grey tone indicates the beginning of the grey tone interval representing the beach sand. The beginning of this increase is indicated by the numbers of pixels regularly reaching 20 (horizontal line on Fig. 3.). If three neighbouring grey tones have more than 20 pixels each, the border between sand and people is determined. Three grey tones were needed to avoid the influence of runaways and to find the border’s appropriate position.

After counting the dark pixels that represent the people (left of the border) one can compare the different webcam images and the intensity of beach tourism for every time the camera took pictures. 91 days of monitoring were compared and studied. Some images couldn´t be analysed because of bad weather conditions or technical problems.

In order to validate the used method additional countings of people were carried out. The people on the surveyed beach were counted at different times in order to quantify them.

Aerial photographs, taken on a Sunday with extremely intensive beach tourism, helped to complete the information about the temporal variations of beach tourism with spatial information. Because the area of the coast which was studied was very rast and had changing infrastructure and natural settings, the aerial photographs gave essential information about intensively and extensively used beach areas. More than 140 photos were taken from a motor glider with a digital camera. Since they weren´t orthographic, they couldn´t help to measure the size of the available beach area, but they helped to count the number of people between the resorts Warnemünde and Kühlungsborn.

For the spatial distribution analysis, the beaches were divided into beach strips, that could be found easily in maps. Marine buildings like breakwaters, piers or other clear-cut points marked these borders. In order to compare the different beach areas, the proportion between beach area and people (m^2 / person) was measured. The beach area was determined with the help of digital maps (LVermA M-V 2001), beach measurements (StAUN Rostock 2002 & 2000) and orthographic aerial photographs (Kataster-, Vermessungs- und Liegenschaftsamt Rostock 2002).

3 Results

After analysing 91 days of beach monitoring with the webcam, it was possible to show the daily variations of the intensity of beach tourism and to show how they depend on different characteristics. The influence of weather conditions, seasonal changes and weekly changes were predominately analysed.

The diagrams on Fig. 4. show results of the webcam monitoring. Each diagram shows the number of pixels at different times of the day. The number of pixels (y-axis) representing the darker pixels of the webcam images were classified as people. The monitoring days were classified according to different characteristics in order to find out how important e.g. the weather is. Therefore, five different diagrams are shown on Fig. 4. The proportion between pixels and people couldn´t be determined exactly so that we at this point of time assume that it is linear. As you see on all figures the features of the graphs look in a similar way. Every day, beach tourism reaches its maximum at around 3:30 p.m. Lots of people arrive between 9 and 11 a.m. and after 8 p.m. the beach is almost empty (see Fig. 4.).

By adding all pixels representing people of one monitoring day it is possible to compare the different days and their intensity of beach tourism. The monitoring days were classified after season, month, workday or weekend and weather conditions. Fig. 4.a shows that there were more people at the beach in the peak season (July and August) at any time of day than during early or post season. Since more than twice as much pixels were classified as people during that time. The most intensively beach tourism was during August followed by September that had extraordinary good weather conditions followed by July (see Fig. 4.b). The monitoring data also showed that the beach occupation differs between weekends and workdays, but this difference (30 %) isn´t that obvious (see Fig. 4.c). A very important factor for beach tourism is the weather. The intensity of beach tourism changes a lot with changing weather conditions (see Fig. 4.d). Season and weather conditions were the most influencing characteristics. Combining these two characteristics (see Fig. 4.e) it becomes obvious that beach tourism is even more reliant on very good weather than in peak season. To sum it up the results confirm what had been expected and therefore they support the monitoring method with a webcam as reliable. The validity of webcam monitoring showed that the proportion between pixel and people isn´t linear. Relatively small groups were represented with a lot of pixels in comparison to larger groups of people where the number of pixels increases less than proportionally ("unterproportional?"). Reasons for this are the sloping webcam view and consequently with an increasing number of people an also increasing occlusion of people.

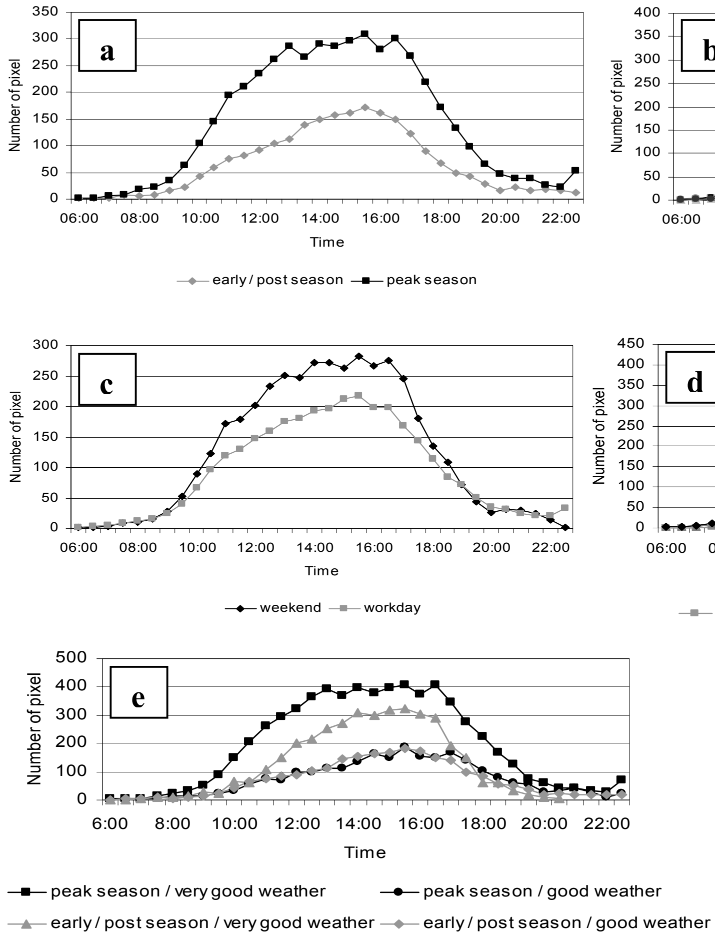

Figure 4: Results of webcam monitoring – Day course of beach occupation at days with different characteristics (a: seasonal variations, b: monthly variations, c: week course, d: weather conditions, e: seasonal variations combined with weather conditions)

The spatial distribution of people showed that the occupation density isn´t homogeneous along the surveyed coast. Different characteristics like infrastructure e.g. parking lots and other facilities, beach accesses and sand quality determine the occupation intensity. This forms a coast with a mosaic of intensive and extensive beach tourism. Occupation values at peak hours vary from less than 10 to > 150 m² available beach area / person. It isn´t surprising that beach tourism in the popular resorts Warnemünde and Kühlungsborn is intensive but there where also beaches that show a high occupation value which had almost no infrastructure.

Figure 5 shows the measured occupation values for Warnemünde with a beach of 2.5 km length. Along the beach of Warnemünde the occupation values also vary, because of infrastructure, beach width or sand quality.

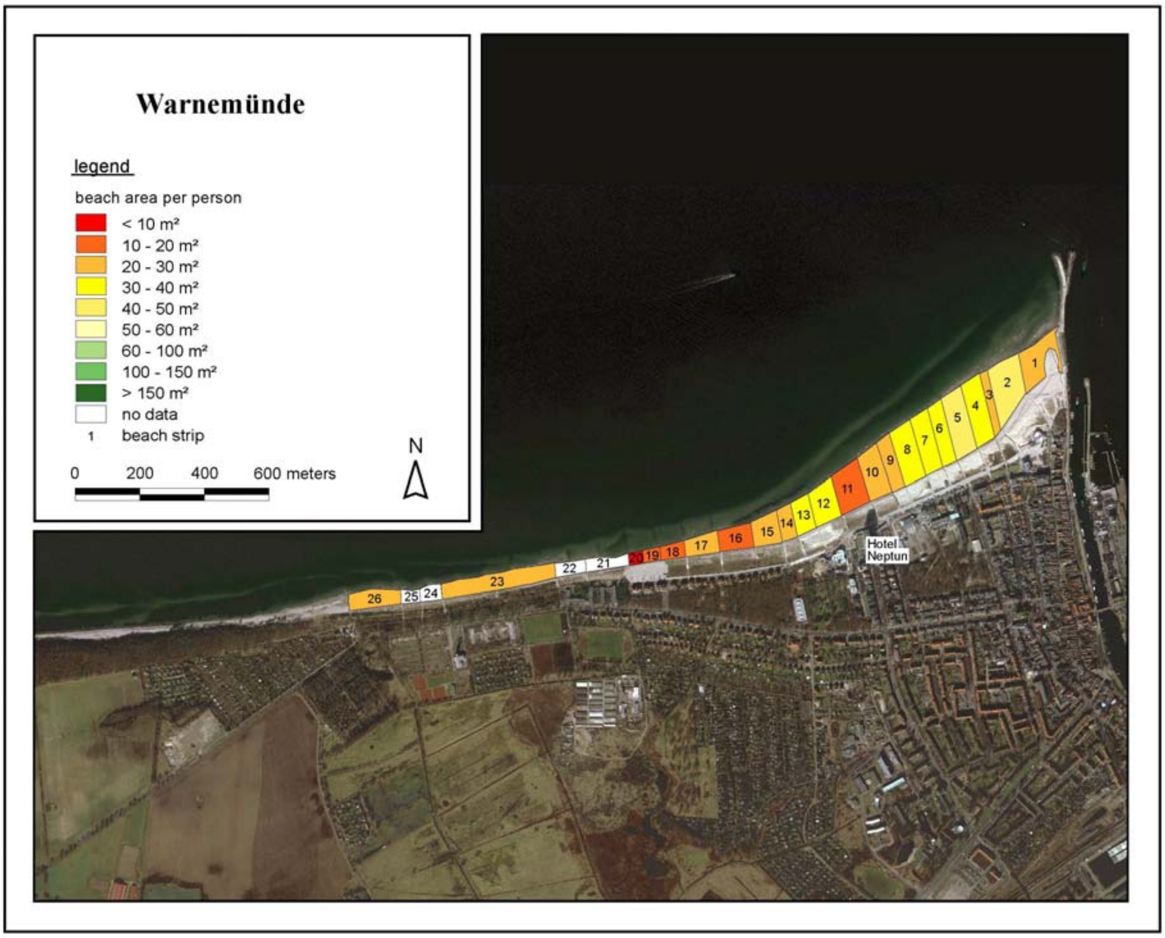

Figure 5: Beach area per person at the beach of Warnemünde (aerial photograph: Kataster-, Vermessungs- und Liegenschaftsamt Rostock 2002).

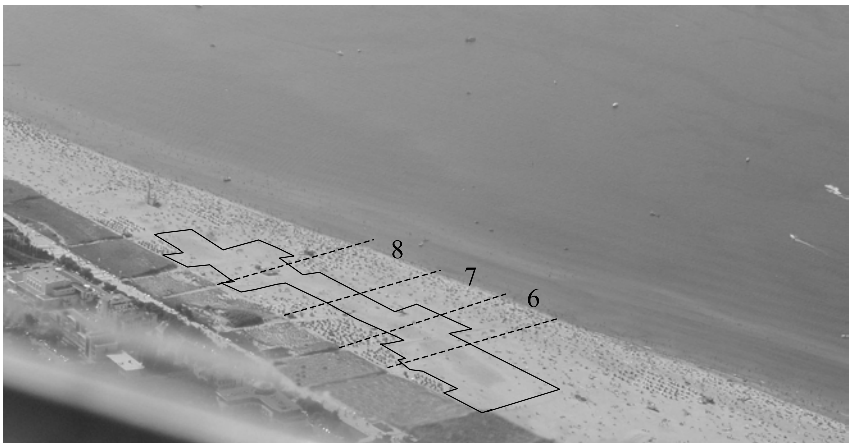

Figure 6: Overview of Warnemünde beach.

Up to here it has only been analysed when and where most of the people are at the beaches between Warnemünde and Kühlungsborn. But especially in Warnemünde, where the beach is partly 180 m wide or more, it is obvious that the occupation intensity also changes with distance to the water. Fig. 6. shows an overview of the beach of Warnemünde where the framed area marks the most extensively used beach parts. Detailed photographs were taken from Hotel Neptun (Fig. 5.) that offered a good overview of the beach. The results of a detailed analysis of the occupation value within a beach strip can be seen on Fig. 7. The plot is not a true to scale top view of the beach strips shown in Fig. 6. The available beach area changes a lot between water line and dune, where a large number of beach chairs is located. The most extensively used areas are the central beach areas. In beach strip eight for example 80% of the people use 12 % of the beach area. That shows the different priorities people have. A reason for people to use the beach area close to the dunes could be that they think of the area near the waterline as being too crowded.

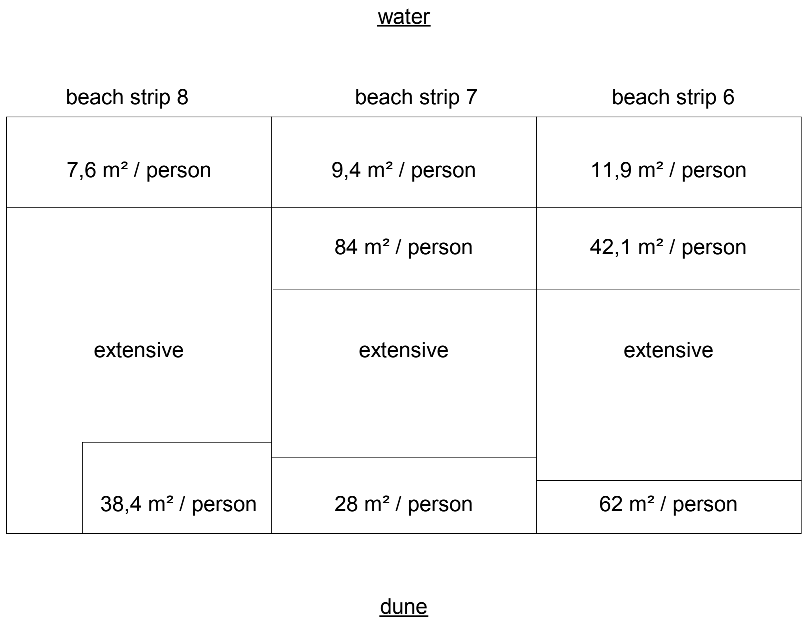

Figure 7: Detailed top view of the beach area per person at the beach of Warnemünde

4 Discussion

The permanent observation of a beach with a webcam is an efficient method to get a spatial and temporal picture of visitor density and behaviour. Beach utilisation is depending on season, day, time and weather, is highly variable and hard to predict. Therefore, traditional manual counting methods carried out only on several days per season yield an incomplete picture. The webcam overcomes these problems and is relatively cheap but still requires technical improvements. A higher resolution of the pictures would be valuable, the sloped view of the camera complicates the analysis and disturbances by objects at the beach (umbrellas, roofed wicker beach chairs, wind shelters) cause uncertainty. Details are given in Kammler (2003). However, the linkage of aerial photographs, webcam observations and traditional counting methods (for calibration purposes) form a successful strategy for beach observations.

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Coastal dune development under natural and human influence on Swina Gate Barrier (Polish coast of Pomeranian Bay)

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Abstract

In present times coastal dunes are rapidly changing by human impact and by waves due to increasing sea level. The most important factors in natural dune development are aeolian processes, dune vegetation cover and wind factor. In Poland different dune development stages affected by every mentioned factor may be studied on Swina Gate Barrier localised on Wolin and Uznam Islands along 16 kilometres of dune coast. On this area investigations are carrying by author since 1996. The aim of undertaken researches is to discover relations and connection between natural and antropogenic processes that are influences on coastal dunes. Driven researches consist of: (i) dune relief changes, (ii) plant vegetation dynamics, (iii) human or animal influence, (iv) storm surges impact, (v) wind factor impact, (vi) sediment diversification and dynamics analyses (surface and structures dynamics). These investigations are repeated four times per year according to the different seasons.

West winds (common during dune plants activity period) favour to dune development in contribution with dense plant cover in middle part of barrier. Strong Northeast winds (common in cold period) bring sandy material from abraded on NE cliffs. Storm surges are causing abrasion of the dunes but supply beach with material. Low thickness of sand helps in aeolian transportation along barrier beaches. Absence of mass tourism in middle part of barrier lead to natural development of this part and a lot of people on Świnoujście town beaches stops new dune development. Coast erosion and human presence in Międzyzdroje town lead to dune regression there. Since 1997 is observed increasing of the new dune ridge on developing beach on Wolin Island.

1 Introduction

Morphodynamic interactions in dunes are not well understood because the chaotic relief of many coastal dunes defies simple description (Carter, et al. 1990). Along many coast dunes threaten by storm surges are retreating. On many coast dunes are completely destroyed. The most important factors in dune development are aeolian processes, dune vegetation cover and wind factor. Other factors as human impact and storm surges also play important role in dune environment dynamics. In recent times human impact, especially tourism has a negative influence on the dunes development. Men activity causes changes in dune relief and vegetation cover (Carter 1980, Pye 1990, Olsauskas 1996, Isermann and Krisch 1995 and others).

Polish Baltic coast is also threatened by high waves and strong storm surges (Zeidler et al. 1995). Majority of Polish coast is being eroded by sea and retiring on the south (Zawadzka-Kahlau 1999). Accumulation on the coast is observed only in a few places. One of them is the Swina Gate Barrier (Musielak 1995) localised on Wolin and Uznam islands on the Pomeranian Bay coast. In Polish borders barrier has about 16 kilometres from morenic plateau in Międzyzdroje (Wolin Island) to country border in Świnoujście (on Uznam Island). The barrier is also continuating on German side along the Uznam coast. Both islands building barrier are crossed by Swina channel outlet, which is connecting Szczecin Lagoon and Pomeranian Bay (Figure 1). This barrier grown as a result of sea sand accumulation that comes from nearby abraded cliffs on Wolin and Uznam (Keilhack 1912).

Dune ridges covering barrier are coming from different accumulation stages since Atlantic period - 5 000 BP (Keilhack 1912, Prusinkiewicz and Noryśkiewicz 1966). They differ from each other by the morphology, lithology and ridges direction showing following phases of spit increase and development (Keilhack 1912, Osadczuk 2001). Also soil processes and plant succession is changing on older and younger ridges (Piotrowska and Celiński 1965, Prusinkiewicz and Noryśkiewicz 1966, Piotrowska 2002).

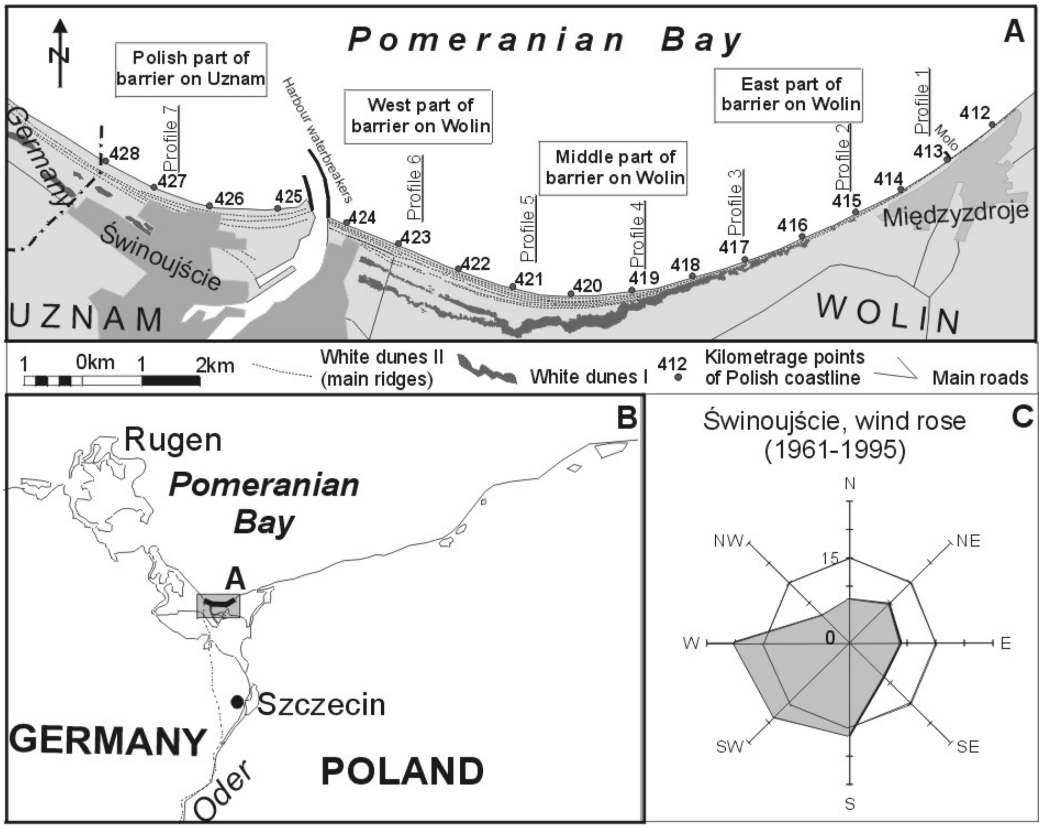

Figure 1: Study area. A - Polish part of Świna Gate Barrier with specified areas of development. Profiles relief see Figure 2. B - Location on South Baltic coast, C - Wind rose for Świnoujście.

2 Aim and methods of the study

Area of detailed fieldwork is situated on coast of Polish part of Świna Gate Barrier and stretches between 412 kilometre and 428 kilometre of Polish coastline classification (Polish Maritime Institute classification).

The aim of undertaken researches is to discover relations and connection between natural and antropogenic processes that are influences on dunes developing on the barrier. Driven researches consist of: (i) dune relief changes, (ii) plant vegetation dynamics, (iii) human or animal influence, (iv) storm surges impact, (v) wind factor impact, (vi) sediment diversification and dynamics analyses (surface and structures dynamics).

Majority of the measurements depended on levelling of beach and dune ridges and checking distances among forms and width of beaches on the same profiles (every one kilometre) and on very dynamics places. On these profiles also is marked kind vegetation (plant species and communities). Additional measurements on the profiles are: range of waves and storm surges and wind stream changing caused by obstacles (plants ant others) and dune relief on the profile. Surface relief changes and vegetation dynamic are checked on small plots (5x5m) localised on different part of dunes. During field measurements were used geodesic tools, as leveller and theodolite. Also were used measure tapes and carpenter's metres. Wind parameters are measured using anemometers. Information about human impact on the dunes refers to: people effect on dune relief and vegetation, trash and savage presence left by tourist and thrown from the sea by waves. These investigations are repeated four times per year according to the different seasons.

The plots, profiles and other data are marked using topographical maps of this region (1: 25 000, 1: 10 000), Photointerpretation Atlas of Pomeranian Bay coastline made in scale 1:5 000 and map of technical belt of Polish coastline (1: 2 000). In many not measured areas were done numerous sketches of dune and beach relief, and drawing examples of the plants causing accumulation. Also photos of the plants, dune relief and human impact were made (for other information about fieldwork area see web page http://bramaswiny.szc.pl).

3 Coastal dune development

Obtained results give a lot of information about coastal dune environment on investigated area. They can be divided as a natural factors as: dune development, plants succession, sea impact, wind fields ect. and antropogrenic as: new infrastructure levelling dunes and beach surfaces (military and tourism buildings), tourists trampling, trashes and savages and protection management.

3.1 Influence of the natural factors

Average sea level and waves in Świnoujście are lower from other open Baltic coast stations (ASL in Świnoujście is 497.1 cm - Zeidler et al. 1995). Probability of strong storm surges is one of the lower from the Polish open Baltic coast (Zeidler et al. 1995). Lower part of the barrier is dangered by increasing sea level and increasing storm surges (Rotnicki, Borówka 1990). Many times in the past dune ridges of the barrier were broken by strong waves and water flooded land. Last such invent taken place in autumn 1995, when during strong storm (sea level about 1.6 m higher than ASL) dunes were badly abraded and water flooded Świnoujście streets closest to the harbour and land in few places behind dunes.

During last 3 years storm surges were often in autumn and winter 2001 (Table 1). In that time foredune ridge was badly abraded in middle part of barrier on Wolin and wash over along many sections in west and east part of Wolin barrier (Figure 2, profile 3 & 7). Then in end of the winter of 2002 ice sheets covered beach (no bigger storms). And again in winter 2003 storm has broken foredune again in west and east part of Wolin barrier. During these storms strong wind caused aeolian accumulation on surfaces so far fixed by mosses and lichens.

Date	**Storm surges**		**Wind**	
	Sea level [cm]	Sea waving [B]	Direction	Velocity [m/s]
02.11.01	573	5-4	NW-W	9-12
09.11.01	596	6	N	11-13
12.11.01	563	5	N-WNW	10-13
15.11.01	597	6	NW-NNE	11-14
22.11.01	598	7	NW	13-15
01.01.02	604	7	NNE	13-15
21.02.02	635	10-11	NE	16-18
06.04.03	586	7	NNE	14-15
06.12.03	594	7	N	14-16

Table 1: Storm surges during last 3 years noted in Świnoujście (497.1 cm ASL) that abraded foredune ridge (with 0.6 m higher sea level than ASL). (Storm data from Polish Maritime Inistiute)

Wind is the main factor of dune development. The effectivity of long period winds noted in Świnoujście (1961-1993) favours to transportation of material from beaches and accumulation at the back of the beach (Borówka 1999). The most numerous are winds from west and south directions (for years 1961-1995, see Table 2): S, SW and W (Łabuz 1998). Also old measurements (1876-1900) show dominance of south and west wind directions (Wernicke 1930). Winds from the west are often all the year. During winds blowing from west is observed material transportation along beach from west part of investigated area (nearest breakwater of Świna channel) to central area (Labuz 2003). Most strong winds blow from northern direction; NE and N. Probability of wind appearance from northern section also is greatest in spring, when plants start to grow (Łabuz 2003). Winds from north directions (especially from NE) causes the heaviest storm surges in autumn-winter period. In these seasons beach and dunes are suffering biggest abrasion. During field measurements of the wind were collected data showing wind stream velocity changes above surface topography. During the off shore winds the biggest velocity wind stream have over middle, upper beach and foredune (measurements 1 –1.5 m above the surface). The smallest one is just behind foredune and on older dune covered by shrubs. Also plant cover significantly stops wind (f.e. during the same wind conditions 4 m/s, wind behind the grass clump is one half smaller).

Years	N	NE	E	SE	S	SW	W	NW	calm
1876-1900	9.25	11.50	7.75	11.75	12.50	16.00	17.00	10.50	3.75
1961-1995	7.63	9.68	8.91	8.46	16.29	18.49	20.25	6.72	3.57

Table 2: Percentage wind directions in Świnoujście 1976-1900 (Wernicke 1930 after Hartnack 1926), 1961-1995 (Łabuz 1998)

Main source of sand for the dune building is coming not from adjoining beach (where sand deliveries depends on rare wave accumulation during season of main dune development) but is blowing by the wind from neighbouring beaches. So sand is drifting along the beach with prevailing winds until the obstacles stop it. Vegetation presence cause very rapid accumulation. If plants are growing on the beach sand is trapped there and is not transported on foredune. In this time foredune becoming stabilised and plants from next succession stages climb up on leeward (landward) slope. During long term stable winds from one direction a new embryo (shadow) dunes are built up on the beach (in places where grasses or other obstacles exists). But rapid change of the wind direction (on opposite) and increasing of its' velocity can blow out recently built hillocks. But still plants may fix part of the material until the very strong wind appears.

Special plant habitats are situated directly along the coast where the marine influence is highest (Piotrowska and Celiński 1965, Piotrowska and Gos 1995). These habitats are typical for flat accumulation coasts and rare on abrasive coasts. The process of sand accumulation and the appearance of plants, especially dune grasses like *Agropyron junceum*, *Ammophila arenaria, Calammophila baltica* (hybrid grass between *Ammophila baltica* and *Calammagrostis epigejos*), *Elymus arenarius* is there strongly visible (Figure 2, Table 3). On older partly fixed dunes appears *Helichryso-Jasionetum* - habitats less tolerant to moving sand. The final stage of succession on open dunes without shrubs or trees is a continental dune habitat with *Corynephorus canescens* and *Carex arenaria* (Piotrowska and Celiński 1965, Wojterski 1964). On forested dunes pine forests grow (*Empetro-nigri Pinetum*) (Wojterski 1964). On German side of Uznam there are similar kinds of vegetation on coastal dunes. Their width is also connected with dune relief and coastal dynamics. The widest habitats are on accumulated part of dunes and narrower on abraded part (Isermann 2000).

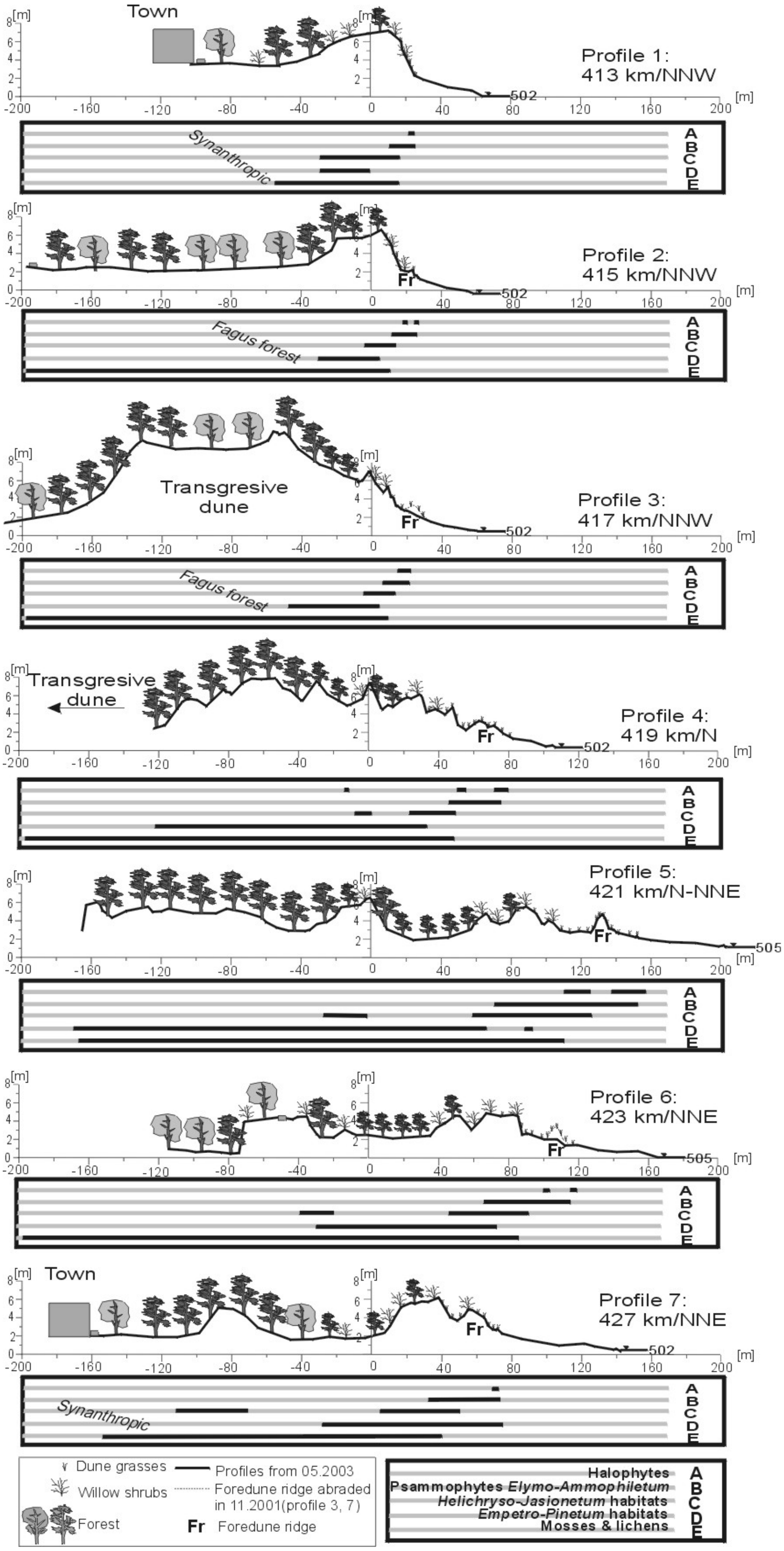

Figure 2: Morphology and plants habitats of the White Dunes of Świna Gate Barrier in year 2003 (profiles localisation marked on figure 1).

The wideness of plant habitats and species number is changing along the barrier with changing wideness of beach, dune ridges and deflation gutters between them (Figure 2). The widest habitats grow in middle part of Wolin barrier. On coast where accumulation is low or not existing these habitats grow together on one abraded dune (in Międzyzdroje direction).

Plants	Dune hillocks			Blowouts		
	very dense	dense	rare	very dense	dense	rare
Honckenya peploides	+			+		
Ammophila baltica	+				+	
Ammophila arenaria	+					+
Elymus arenarius	+					+
Festuca rubra ssp. arenaria		+			+	
Cakile maritima		+			+	
Salsola kali		+			+	
Agropyron junceum		+				+
Petesities spurius			+			+
Phragmities communis			+			+

Table 3: Plants growing on the initial foredune field on the upper beach, Wolin part of Swina Gate Barrier (Łabuz 2003)

3.2 Influence of the human impact

Present day human impact on dunes is especially caused with increasing of tourism. On Polish part of barrier tourism is localised in two centres: Międzyzdroje and Świnoujście. Especially in touristic season human impact is the biggest one. Świnoujście and Międzyzdroje are health resorts opened whole year. In these towns beaches are „covered" by tourists. Beach management for tourism and recreation is causing beach plant vanishing as halophytic *Honcenya peploides*, *Cakile maritma* or *Salsola kali* and dune grass psammophytes (*Ammophila arenaria, Elymus arenarius*); (Figure 2, profile 1 & 7, lines A, B). This is clearly visible in Świnoujście town where a new dune due to wide beach should already be built but absence of plants (trampled all the year by people) on the beach lead to sand movement on still growing old foredune. People exploring (when tourists are doing physiological needs, sightseeing and heating) and crossing dunes are causing plant trampling and sand movement. In that way blowouts are appearing along footpaths on earlier fixed dunes. Only in middle part of Wolin barrier between 421 km and 418 km there are no tourist on dunes. Only beach is used for walks between these towns. So if tourists are rare there plants and dune relief can develop in natural conditions. Against tourists in these towns youngest dunes are fenced by steel line.

Sea sand sedimentation is greatest just next to the breakwaters as well as along the central part of the flat coast on Wolin. But increasing of the coast is the biggest on both banks of channel Świna protected by breakwaters. For example on air photos from 1937 waterline is localised where in 1996 existed second ridge – so increasing of coast and dune ridges is clearly visible. In Międzyzdroje exist mole that is crossing dunes and breaking sand transport along the coast from cliffs (Baraniecki and Racinowski 1996). Also close to the cliffed coast in east part of Międzyzdroje exist fishery harbour which completely destroyed dunes. In Świnoujście exist big harbour which completely changed dune surface on the Świna channel banks. Also touristic infrastructures in mentioned towns are localised on the dunes. But in Świnoujście due to coast progradation they are localised farther from the beach (there since 1942 to 2002 grown 300 m of the coast with two - three dune ridges).

In XVIII century during coastal harbour's development many of the forests were cut off. This was the beginning for transverse dunes development also on Świna Gate Barrier (Keilhack 1912, Prusinkiewicz and Noryskiewicz 1966). Aeolian processes caused landward transportation of uncovered sand from dunes. Now their heights reach 22 meters. Later, newly planted pine forests fixed them once again. Since that time a new white dunes have been growing.

On middle part of Wolin barrier on older dunes exist military area and a lot of fortifications from the Second World War that have been completely changed dunes ridges relief.

In relationship of coast accumulation coast protection on describing coast is still low. Only in towns, dunes are protected by branch fences against deflation and steel line fences against tourists. Also Świna channel mouth is protected by two long waterbreakers. Only in Międzyzdroje protection consist of dune nourishment and some other interventions due to hotel Amber protection which is localised on first dune ridge. This structure is still dangered during winter storms. On the other hand people management leads to changes in specimen vegetation cover. The youngest pine plantation planted to stabilise dunes increased rate of forest habitat succession on herb dune habitats. In this way natural dune plant habitats are vanishing and with them vanishing some plant species (f.e. Sea holly - *Eryngium maritimum*).

4 Specified areas of coastal development

Along the barrier number and morphology of youngest ridges as dynamics of the beach are different in west, middle and east part of Wolin Island. Also on Uznam Island coastal dunes are different. The dynamics of these areas is different and caused by character of affecting on dunes factors, for example exposition on main wind stream, storm waves, human presence, plants dynamics.

4.1 Polish part of Uznam Island – Świnoujście town

On Uznam Island beaches are wide (110 – 130 m wide) but without plants and hillocks (caused by human impact). Accumulation exists only on the back of the beach - on old foredune ridge (7 m high). Very small embryo dunes and rare plants on beach are existing along 4 km of this part. Excerpt 426 km, where human impact is the biggest (it is the middle of the town beach). New foredune ridge is growing slowly on 427/428 km near country border (worth mention is wider and denser plants „carpet” covering more developed, 20 m wide piece of dunes laying between border fences) and faster on 425km - close to the waterbreaker. On 426 km where a lot of tourists are on the beach, accumulation exists only on the old dune. This ridge is still growing in height and intensive human impact stops new dune development (Figure 2, profile 7).

4.2 Western part of barrier on Wolin

In west part of barrier localised on Wolin Island ridges are smaller and closer each other (Figure 2, profile 6). The heights of dunes exceed 4 m. Depressions between them are narrow – about 15 m. Beach is flat, wide (100 m) and covered by small hillocks. But most common material on the beach is shell deflation pavement. Small embryo dunes and plants are there on upper beach. They become bigger in east direction. Since 1997 a new foredune ridge appeared on beach (1 – 2 m high) but was heavy affected during storms in autumn 2001 (water level 596-635 cm, see Table 1). This new, now cut of in many places ridge, starts to be rebuilt but again heavy storm in December 2003 (water level 594 cm) damage it. Human impact is there small because of difficult access caused by harbour areas.

4.3 Middle part of barrier on Wolin

In middle part ridges are higher but narrower. Depressions between them are wider (figure 2, profile 4, 5). Beach is still wide (70-90 m) and covered by large number of plants and by biggest dune hillocks. The field of aeolian accumulation on the beach is there the biggest one. Also there is the biggest number of youngest not-forested ridges. Since 1997 to 2001 a new foredune ridge appeared on beach (1 m high - now have 3 m). Year by year beach has been wider and covered by larger number of plants. These plants caused accumulation on the beach far from old foredune. In this way was built up a new foredune. It is consists of several hillocks jointed into irregular ridge. This new first ridge is also shaped by storm waves and then becomes real ridge parallel to the coastline. In east direction became wider but smaller (profile 4) and near Międzyzdroje exist as an embryo dunes/ hillocks on the beach (profile 3). Human impact is there the lowest one with only persons walking along waterline. This area has the biggest aeolian supply thanks to NE and W winds blowing all the year. Also plants succession on dunes seem to be the faster one.

4.4 Eastern part of barrier on Wolin – Międzyzdroje town

In east part (416 – 412 km) dunes are again high but narrow with mostly steep seaside slope (figure 2, profile 2, 1). Depressions and beach are narrow. Also plant number is smaller than in other parts. Near Międzyzdroje ridges, depressions and plants on the beach are vanishing. In Międzyzdroje exist only one ridge mainly covered by shrubs and artificially planted grasses. Beach is about 40 m wide. Also human impact on dunes and beach is again existing there.

5 Discussion

Decisive influences on development of sandy barriers have waves energy and constant delivery of sand (Bird 1969, Hesp, 1984, Psuty 1988, 1990, and others). Rate of every new dune development is not constant. It is varying in time due to wind and storm event presence. One year /season may be abundant in storms (like winter season 1995/6, 2001/02 or 2003/04 on studied area) or may be scare of it but very cold and abundant in ice sheets on coast, preventing beach against waves and stopping sand movements by wind. So climate changes have decisive influence on this process – may stop it, break or accelerate.

Coastal dunes come into being in result of aeolian accumulation of material blown from constantly supplied beach (Bird 1969, Hesp 1984, Carter, and Wilson 1990). Process this can reach the best development thanks to favourable wind speed, directions and influence of pioneer dune vegetation (Bird 1969, Psuty 1990, Hesp and Thom 1990, Arens 1994 and others). Winds existing in Świna Gate Barrier favour to dune development. This process is very rapid in middle part of Świna Gate Barrier.

The biggest efficiency for aeolian accumulation on beach has oblique wind to beach/ dune (Hesp and Thom 1990, Arens 1994). On investigated area the heaviest winds are oblique for part of coast exposed on NW and NE directions – outside of coast part on Uznam Island and west and eastern part of middle part of barrier on Wolin Island. That why there are observed the biggest embryo dunes covered by dense grass carpet. This is the visible sign of aeolian accumulation on the beach.

Plants break the wind speed causing sand accumulation and building up dunes (Bird 1969, Hesp 1984, Carter and Wilson 1990, Arens 1994 and others). A lot of plants growing on beaches of barrier causes aeolian accumulation also contemporary rare storms let to increasing of this process. Only increasing human impact can stop this development (Isermann and Krisch 1995). Now this process is observed in two towns localised on the barrier coast - Międzyzdroje and Świnoujście where aeolian processes are weak.

6 Conclusions

Developing coast and progradating dune system of middle Świna Gate Barrier is a rare phenomenon on Baltic coast. In present day on studied area belonging to Świna Gate Barrier are existing good conditions for dunes development. Mentioned factors favour to dune ridges development and vegetation succession. The wideness of plant habitats and species number is changing along the barrier with wideness of beach, dune ridges and deflation parts of coast.

First of all middle part of barrier on Wolin Island shows accumulative character of dunes. Other parts are under abrasion conditions (near Międzyzdroje) or under human impact (Świnoujście and Międzyzdroje). Seeing these processes Świna Gate Barrier can be divided into few different parts. One of them lies on Uznam Island where human activity stops aeolian accumulation on beaches. Second one lies on Wolin Island where we can find three different kinds of development. One of them is observed close to the waterbreaker in Świnoujście where shore sedimentation is big but aeolian accumulation is lower than in middle part. In middle part exist the biggest aeolian accumulation expressing in dune ridges growing. And last one near Międzyzdroje where abrasion and human activity stops aeolian processes and development of dunes is smaller than in other Wolin barrier parts.

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Plant diversity dynamics on dunes of Swina Gate Barrier: a largely undisturbed accumulative coast

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Abstract

The southern Baltic sandy coast areas are highly dynamic and under continuous natural and manmade change. Today complex dune habitats are rare and more and more affected by coastal defence measures and recreational activities. Natural or almost natural dune environments exist only in a few places. One of them is the middle part of Swina Gate Barrier on Wolin Island (Poland) where typical plant communities in different stages of vegetational succession and dune development can be found. Five dunal ridges can be observed in the central part of the barrier. The influence of human activities in the vicinity of the towns of Świnoujście and Międzyzdroje can clearly be seen, but the aim of this study was to survey and document undisturbed plant communities and dune dynamics. It could be shown that plants closely reflect the ecological conditions of the dunes creating a number of distinctly different habitats with mosses and lichens playing an important role in the different stages of succession. Sand accumulation is initiated and enhanced by psammophilous plants on the upper beach whereas a complete plant cover on older dunes will, e.g., result in a higher accumulation of humus. Sand accumulation, plant-cover and dune development depend on a continuous sand supply from the see and can be seen as ongoing processes compared to the more abrupt changes caused by heavy storms. Future studies will aim at comparing undisturbed sites with sites disturbed by recreational activities.

1 Introduction

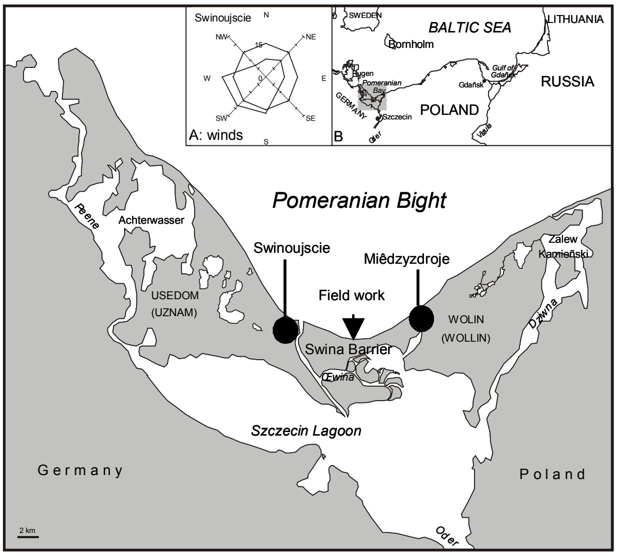
Today most of the Polish coastal and Baltic coastal habitats are threatened by human activities (Herbich, Warzocha 1999; von Nordheim et al. 1998). In order to analyse human impacts on dunal ecosystems it is necessary to first look at relatively undisturbed dunes like the remote middle part of the Świna Gate Barrier which is only accessible by foot (fig. 1). Accumulation of sand results in a prograding coastline (Keilhack 1912, Rosa 1963, Racinowski, Seul 1996) and an extensive dune ecosystem including the formation of new dune ridges (Łabuz 2002a, 2002b).

In future this coastline may also become more and more negatively affected by human activities (growing numbers of tourists in the region), as described for other parts of the southern Baltic coast (Piotrowska, Stasiak 1982, Isermann, Krisch 1995, Herbich, Warzocha 1999).

So far, research has focused mainly on the sand accumulation, and historic development of the coast (Keilhack 1912, Musielak 1995, Racinowki, Seul 1996). However, recent studies do not cover the youngest, still growing dunes. Work concentrated on the morphology (Osadczuk 2001) or vegetation of the older dunes (e.g. Bosiacka 2001, Piotrowska, Gos 1995). Only studies by Piotrowska and Celiński (e.g. 1965, 2002) included the vegetation of older and younger dunes.

2 Material and Methods

The study area is situated about 4 km west of Świnoujście and about 5 km east of Międzyzdroje (fig. 1). With limited public transportation and only few parking areas available, the beach along the middle section of the barrier is only visited by very few people and the impact from recreational activities is still minimal (Łabuz 2002b, 2003), whereas the beaches in Międzyzdroje as well as in Świnoujście are crowded popular holiday resorts.



A 20 m long section of the coastline was chosen for the study. The dune ridges (roman numbers) and depressions (capital letters) were labelled and three transects each about 10 m apart and two additional cross sections were laid, distances and elevations were measured. For all three profiles the vegetation and its range on the dunes was documented along a 2 m wide area. All trees, the larger shrubs and open sandy patches were marked as well (fig. 2).

Figure 1: Study area on Swina Gate Barrier (Wolin Island, A: Prevailing winds; B: Southern Baltic Sea region).

Vegetation was further documented along the western edge of the study area. 60 Plots of 2.5 m lengths were set up. Two plots for each different dune zone or vegetation type were made. The width of plots depended on the homogeneity of the vegetation and the extent of morphological forms in each section. The method described by Braun-Blanquet (Barkmann et al. 1964) was used and species (vascular plants, mosses) as well as their abundances were documented. “Zeigerwerte” or ecological indicator values (Ellenberg et al., 1992) of the different plots were calculated (fig. 5) for the parameters light (L), moisture (F), soil-acidity (R), and nitrogen (N); (Table 1).

3 Results

3.1 Morphology

Dune ridges and depressions

On the dunes 5 ridges and 5 depressions can be identified. Fig. 2 gives an overview of dune ridges and depressions showing elevation and extent of each feature as well as the development of the youngest dune along the three measured transects. The depressions between the ridges are generally less exposed to wind as well as sun. Whereas the older ridges I to III are similar grey dunes and differ mostly in width and height, ridge four (IV) is very narrow with steep slopes. It is an old white dune or a young grey dune showing the beginning accumulation of humus. This ridge was situated right at the beachfront in 1997 (Łabuz 2002b). The latest and youngest depression (E) is the widest and most heterogenic (fig. 2). It is divided into a flat deflation area and into an accumulation area with numerous hillocks (up to about 0.5 m high). The winter storms of 2001/02 abraded and partly cut first ridge. Organic material such as driftwood, dead plants or parts, seeds and garbage accumulated in the gutter. The land side slope of the youngest ridge (V) is very steep. The seaside slope (sometimes a small cliff) has signs of strong abrasion from winter storms (winter 2001/02). In some parts of the coast this youngest ridge was completely destroyed by winter storms. At the time of the study sand was already accumulating again and partly covering the dunal cliff.

Beach

On the Świna Gate barrier beaches are the widest (50-60 m, typical for an accumulation coast) of all Polish coasts. The beach may be divided at the drift line into a lower and an upper beach. The drift line represents the high water marks or swash marks of the latest winter storms and is characterized by a lot of organic debris (as well as garbage). Further up the beach primary dunes have started to develop where sand could accumulate around plants or other obstacles such as driftwood.

3.2 Vegetation

The vegetation and the morphology of the dunes are highly interdependent. Fig. 2 shows the range of selected species on the study area, table 1 gives a complete species list (vascular plants and some mosses) and fig. 4 and tab. 2 show the ecological indicator values. Plants characteristic for forested dunes slowly advance into the younger dunes. Their numbers decrease in second depression (B). *Pinus sylvestris* and *Salix daphnoides*, however, still cover more than ¾ of its surface. The most abundant grasses or herbs are *Deschampsia flexuosa, Polypodium vulgare*, and the *mosses Pleurozium schreberi, Dicranum polysetum, D. scoparium, Hypnum cupressiforme*.

The habitat under mature willows is characterized by a greater diversity within the herb layer than habitats under pine trees (in depression B on ridge II). Older grey dunes have the highest species richness (fig. 4) with higher species numbers generally inside the sheltered dune slacks A & B or the respective slopes.

On sandy sunny areas psammophilous plants adapted to high temperatures and stabilized sand reach their biggest density on and between the second and fourth ridge (fig. 2 + 3). Species like *Helichrysum arenarium, Jasione montana, Hieracium umbellatum, Festuca polesica, Corynephorus canescens, Sedum acre* and mosses like *Polytrichum piliferum* or *Ceratodon purpureus* are characteristic for grey non-forested dunes. Some sandy surfaces are only covered by a few *Corynephorus canescens* and some dying *Ammophila arenaria* indicating a secondary succession and an earlier naturally or anthropogenic disturbance (fig. 2).

Vascular Plants:	**Mosses:**
Achillea millefolium ssp. millefolium L. *Agropyron junceum (L.) P.B.* *Agropyron repens (L.) P.B.* *Ammophila arenaria L.* *x Calammophila baltica (FLÜGGE ex SCHRADER) BRAND* *Anthoxanthum odoratum L.* *Anthyllis vulneraria* L.* *Artemisia campestris L.* *Betula pendula ROTH.* *Cakile maritima ssp. baltica. (JORDAN EX ROY et FOUC.) HYL* *Calamagrostis epigejos (L.) ROTH* *Cardaminopsis arenosa* ssp. *arenosa (L.) HAYEK* *Carex arenaria L.* *Cerastium semidecandrum L.* *Chondrilla juncea L.* *Conyza canadensis (L.) CHRONQUIST* *Corynephorus canescens (L.) P. B.* *Deschampsia flexuosa (L.) Trin.* *Epipactis atrorubens (HOFFM. EX BERNH.) BESSER* *Erigeron acris L.* *Festuca polesica ZAPAL.* *Festuca rubra* L. ssp. *rubra* *Festuca rubra* ssp.*arenaria (OSBECK) SYME* *Galium verum L.* *Helichrysum arenarium (L.) MOENCH* *Hieracium lachenalii C.C. GMEL.* *Hieracium pilosella L.* *Hieracium umbellatum L.* *Honkenya peploides (L.) EHRH.* *Hypochaeris radicata L.* *Jasione montana L.* *Knautia arvensis (L.) COULTER* *Leymus arenarius (L.) HOCHST.* *Luzula campestris (L.) DC.* *Monotropa hypopitys* agg. *Moneses uniflora (L.) A. GRAY* *Orthilia secunda* L.) House* *Petasites spurius (RETZ) RCHB.* *Phragmites australis (CAV.) TRIN. EX STEUD.* *Pinus sylvestris L.* *Polypodium vulgare L.* *Pyrola minor L.* *Quercus robur L.* *Salix daphnoides VILL.* *Salsola kali L.* *Sedum acre L.* *Taraxacum spec.* *Trifolium arvense L.* *Vicia hirsuta* (L.) S. F. GRAY	*Aulacomnium androgynum* (HEDW.) SCHWAEGR. *Brachythecium albicans* (HEDW.) B.S.G. *Brachythecium rutabulum* (HEDW.) B.S.G. *Bryum argenteum* HEDW. *Cephaloziella spec.* (NEES) SCHIFFN. *Ceratodon purpureus* (HEDW.) BRID. *Dicranum polysetum* SW. *Dicranum scoparium* HEDW. *Eurhynchium swartzii* (TÜR.) CURNOW *Hypnum cupressiforme s.str.* HEDW. *Lophocolea bidentata* (L.) DUM. *Lophocolea heterophylla* (SCHRAD.) DUM. *Plagiomnium affine* (FUNCK) KOP. *Pleurozium schreberi* (BRID.) MITT. *Pohlia nutans* (HEDW.) LINDB. *Polytrichum juniperinum* HEDW. *Polytrichum piliferum* SCHREB. EX HEDW. *Ptilidium ciliare* (L.) HAMPE *Rhacomitrium elongatum* FRISV. *Scleropodium purum* (HEDW.) LIMPR.
(species marked with * occurred just outside the actual study area)	

Table 1: List of all vascular plants and mosses found inside the study area (or nearby).

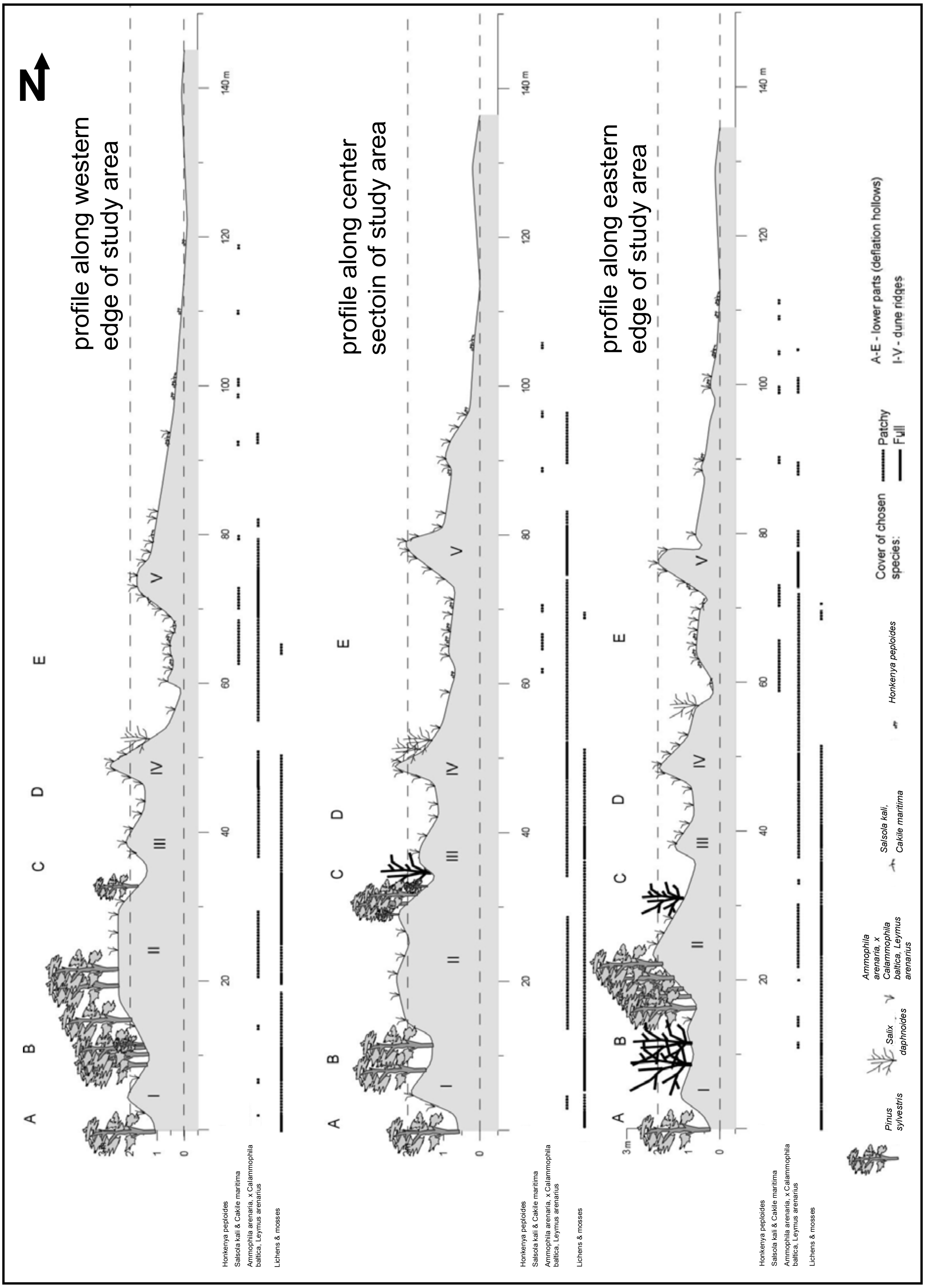


Figure 2: Three transects (south – north) with the distribution of selected plant species, typical for different dune zones (summer 2002).

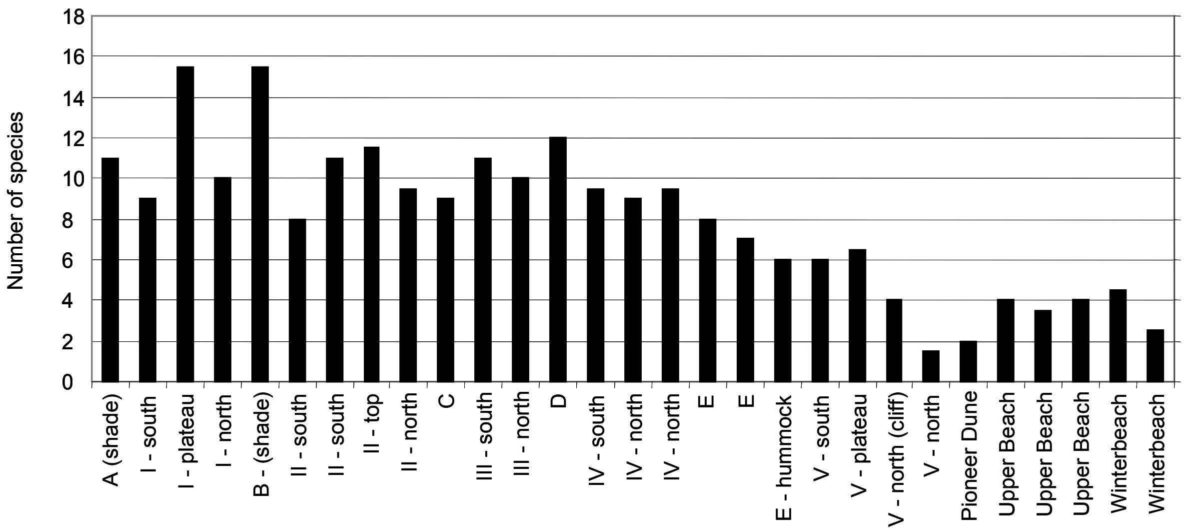


Figure 3: Number of species in the different beach and dune zones (always mean of two parallel plots).

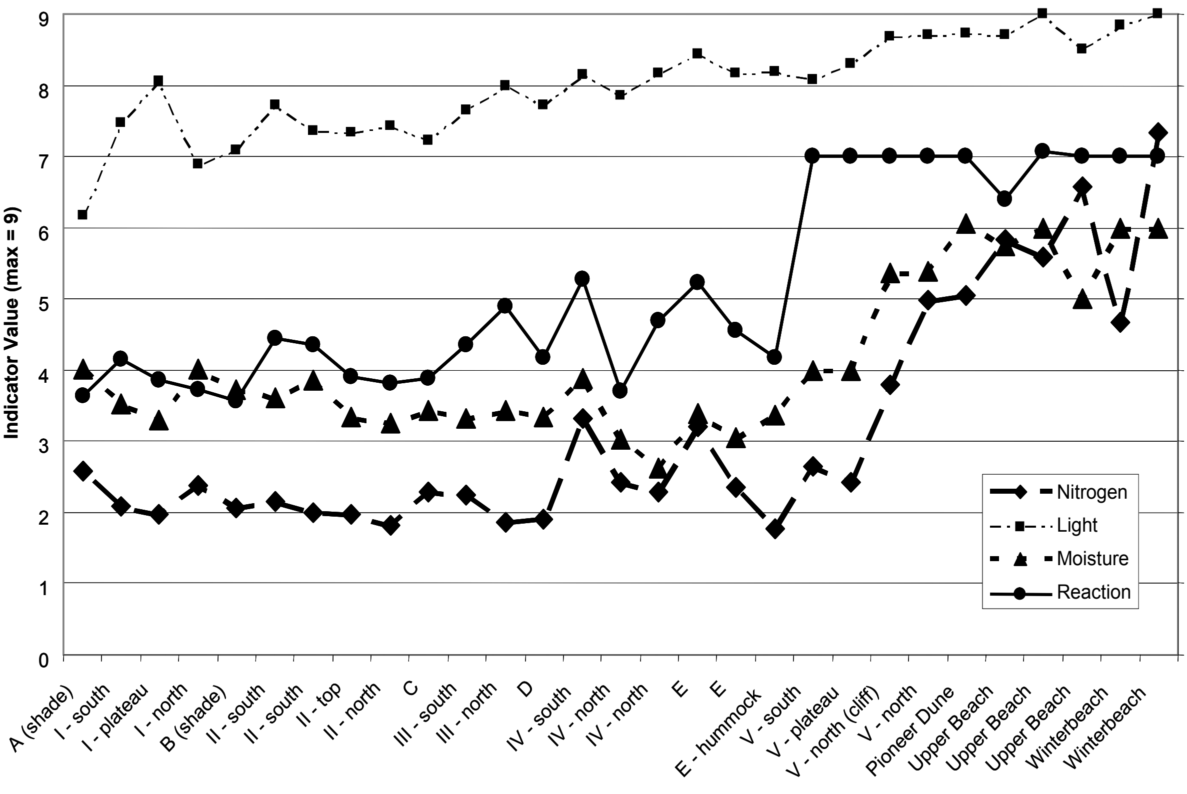


Figure 4: Ecological indicator values (mean of two transects) for vegetational plots on the central Swina Gate Barrier (mean of two parallel plots).

In dune slacks C and D as well as on the smaller ridge III the species numbers decrease and only few vascular plants have been able to establish themselves so far (fig. 3). Pinus sylvestris is just establishing itself in the narrow depression C. Lichens and mosses as well as some vascular plants typical for dry sandy habitats on older open dunes become less abundant. Behind fourth ridge towards the sea only few typical pioneer species are growing indicating the growing influence from moving sand. The hybrid x Calammophila baltica is more dominant than Ammophila arenaria or Leymus arenarius. Honkenya peploides, Salsola kali and Cakile maritima grows mostly on the upper beach.

Under …	tree cover	Num. of species	L (light)	T (temp.)	F (moisture)	R (acidity) low value = high accidity	N (nitrogen)
Salix daphnoides	approx. 45 %	14	5,63	4,32	4,36	3,74	2,48
Pinus sylvestris	approx. 19 %	12	6,9	4,75	3,48	2,97	1,17

Table 2: Ecological Indicator Values (Ellenberg et al. 1992) for herb layer (including mosses) in two typical dune habitats under trees (maximum value: 9, minimum: 0).

4 Discussion

On older stabilised ridges (I-III) and neighbouring depressions it is possible to identify at least four different habitats. Two habitats can be distinguished on the open sandy areas: One is characteristic for undisturbed areas with Festuca polesica, Carex arenaria, Helichrysum arenaria, Jasione montana mosses and lichens (e.g. Helichryso-Jasionetum) whereas the second one shows signs of natural or anthropogenic disturbance and secondary succession with a higher abundance of Corynephorus canescens and the appearance of Ammophila arenaria and x Calammophila baltica (e.g. Violo-Corynephoretum festucetosum) The third and fourth habitat types are associated with deciduous or coniferous trees (table 2). The habitat under Pinus sylvestris is much dryer, warmer and less shaded (indicator values F, T & L) than the one under willow shrubs and trees. The needles make up much of the organic litter, which decomposes much more slowly than litter from broadleaf trees and leads to a higher soil acidity (lower indicator value), but lower level of available nutrients (indicator values R & N). If the conditions are very dry only few grasses such as Festuca rubra, herbs like Cardaminopsis arenosa, Vicia hirsuta and some mosses and lichens will grow. If conditions are a little moister species like Polypodium vulgare, Dicranum scoparium (moss), Deschampsia flexuosa, Epipactis atrorubens will grow (especially on northern slopes). They are also common under willow trees, but here also Taraxacum spec., Trifolium arvense, Brachythecium rutabulum (moss), and others grow. The almost complete absence of Carex arenaria is surprising, since it otherwise common in the area as well as further to the west on Usnam (e.g. Isermann 1997).

Plants growing on younger more dynamic ridges are mostly psammophilous grasses whereas most other species (Honkenya peploides, Helichrysum arenarium, Corynephorus canescens, and Artemisia campestris) are mostly restricted to the depression. Some of them were washed away by winter flooding in 2001/02. During the study the remaining gutter was not densely covered by plants (some Corynephorus canescens seedlings). Some species, normally typical for the beach or fore dune communities, managed to germinate in this special pioneer habitat (Honkenya peploides). On the other hand plants typical for older dunes such as Helichrysum arenarium, Sedum acre, Hieracium umbellatum, and Epipactis atrorubens grow inside the depression on the small hillocks or next to young willow shrubs where they are sheltered from wind and sand burning.

Some pioneer species are flourishing where sand is still accumulating and providing nutrients needed by the plants (Ammophila arenaria, x Calammophila baltica). The indicator values R (acidity) and N (nitrogen) show the leaching of carbonates and nutrients from the sand along the transect (fig. 4) to the beach (high carbonate levels = low acidity) towards the older dunes (lower carbonate levels = high acidity). On older stabilised dunes these nutrients have been leached out and other plants, which can cope with the poor soils, but are less tolerant to being sand burial, move in and slowly replace the pioneer grasses. Plants from forest habitats are sensitive to direct and strong sun radiation and prefer the shade where conditions are generally a little cooler, moister and some accumulation of humus provide more nutrients. This is also reflected in the ecological indicator values for moisture (F) and light (L). The mean values (fig. 4) decrease moving from the beach onto the dunes and then F slowly tends to increase again on the older dunes, especially in the dune slacks near the forest.

Honkenya peploides plays an important role in sand accumulation (e.g. Reinke, 1920) and habitat creation for typical initial dune grasses like Agropyron junceum and Leymus arenarius characteristic for the Agropyro-Honkenyetum peploides and Elymo-Agropyretum communities. Cakile maritima, Salsola kali characterise the Cakiletum maritimae - a typical annual drift zone community (Piotrowska, Celiński 1965, Piotrowska, Gos 1995). Species from the genera Atriplex, Rumex or Chenopodium are very rare in the central part of the barrier, but quite common further to the west near Świnoujście. The annual drift zone communities are not well developed on this part of the barrier; which may be a result of more organic material being deposited along the western part of Wolin Island and more sand supply along the central parts of the barrier. The indicator values for moisture and nitrogen (F and N) show the highest values on the beach and a steep decline behind the youngest ridge (fig. 4).

After surveying mostly intact beach and dune ecosystem, it is now possible to look at disturbed sites, e.g. in the vicinity of holiday resorts. Here morphodynamics and vegetation are also changed by trampling and beach management (mechanical stress and eutrophication). On the other hand this little disturbed section of the coastline may itself become more and more negatively affected by tourist activities. Now changes and especially negative effects from recreational activities can be monitored and management measures can be taken.

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COSA: Coastal Sands as Biocatalytical Filters

Translating scientific results to the general audience and policy makers

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Abstract

Marine coastal zones are of significant socio-economical value and have to cope with intensive use and material input from land, rivers and atmosphere. A thorough understanding of the processes governing the functioning and cycling of matter in these environments is essential to ensure their sustainable use. The EU-funded project COSA was initiated to assess the role of sandy sediments in the coastal cycles of matter, and is based on an interdisciplinary approach combining the complementary expertise of seven participating institutions. This presentation addresses the multilevel organization of the COSA project, which was designed to ensure optimal implementation of the scientific results into environmental and social objectives. Emphasis is placed on the ways of making the research understandable for public and policy makers. Publication and translation of the scientific results into a language understandable to the general audience and policy makers is fundamental for implementation of the results into environmental strategies and concepts, and critical to ensure the sustainable use of coastal environments. As political pressure by a large fraction of the society is one of the most efficient ways to influence decision makers and investors, the need for working out a common "language" seems to be at least as weighty as the generation of scientific results and tools supporting the managers in making environmentally important decisions.

1 Introduction

1.1 Addressing coastal zone problems

Public awareness of coastal zone problems is rather low, because the marine ecosystems are not as accessible to people as terrestrial ones, and research results or scientific papers are not suitable information material for the community and people with non-scientific background. The establishment of a "translating bridge" between two quite different worlds (scientific and non-scientific) allows to present coastal problems with the proper importance. This "translating bridge" could be established by environmental agencies, which are responsible for extracting the conclusions and consequences from the scientific processes, and then translating them into an accessible and understandable format for the general audience and policy makers. As the advisory bodies, they are able to affect the political decision and, through the educational and cultural activities, can promote public awareness. This is the most important step in the dissemination of the scientific results, which brings coastal problems actively to the attention of the local public and decision makers. Through this step, information is provided to policy makers and pathways and measures are suggested that can help to reduce or remove coastal zone problems. The EU project COSA integrates research institutions and environmental agencies within one project in order to ensure and optimize the implementation of the scientific results into environmental strategies and public awareness. This integration requires a "translating bridge" within the project. Here we outline how the generation of scientific results, their translation and implementation is organized within COSA.

1.2 Scientific challenge

Research in the North and the Baltic Seas and its coasts are excellent examples of the systematic effort of the marine science community to understand the processes and the human influence on these ecosystems. A focal point of this research are the coastal sediments that contribute significantly to the cycling of matter in the oceans and represent major storage reservoirs for organic matter, nutrients and also pollutants. Large sections of the European coasts are dominated by sandy sediments, and despite the small area sands cover relative to the total size of the ocean floor (approximately 5%) they are of great importance. Sandy coastal zones provide the most productive fishing grounds, are major sources for a variety of raw materials (oil, gas, water, and minerals), and form recreational beaches. At the same time, coastal zones are seriously affected by habitat destruction, water contamination and resource depletion.

Permeable coastal sands have been poorly studied up until now with respect to their role in the coastal cycles of matter. Due to the lack of quantitative data, they are not well represented in coastal management and monitoring programs, and public and policy makers are not aware of their importance. Consequently these environments and their resources are not protected sufficiently relative to their socio-economical value.

In November 2002, a new project funded by the European community was launched: COSA – Coastal sands as biocatalytical filters. Seven institutes from four European countries participate in this project, which focuses on the ecological role and management of nearshore marine sandy sediments. COSA research investigates processes in sand sediments at two field sites located on Polish and German coasts that represent typical sandy environments of the North and Baltic Seas (Fig.1). The project tasks include intensive field campaigns and time series measurements of key parameters. Special attention is given to the filtration and decomposition processes and ensuing fluxes of dissolved and particulate matter, and the impact of animals, plants and micro-organisms on biogeochemical reactions.

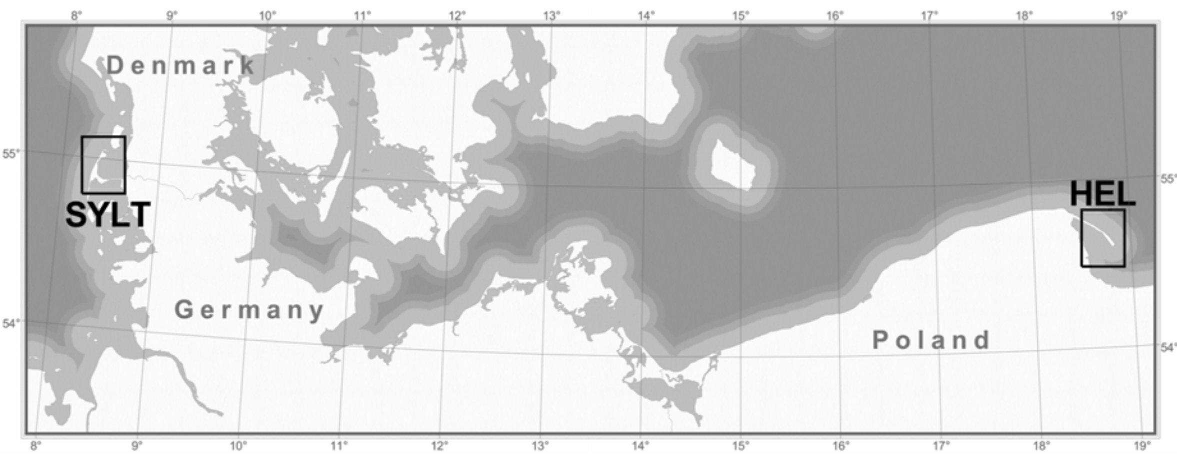

Figure 1: Map of Europe with study sites indicated.

2 Results

2.1 An integrative project approach

The concept of COSA combines scientific research and the implementation of the scientific results into management strategies within the project and, thus, integrates scientific and socioeconomical objectives.

In brief, the scientific goals are to generate a comprehensive database comprising the physical, biological and chemical parameters that govern the ecological functioning of coastal sands and to integrate these data in a model. The latter can be used as a predictive tool. The scientific goals can be achieved by investigations ranging from the analysis of historical data to physical, chemical and biological measurements. This is accomplished by the interdisciplinary combination of complementary expertise provided by the participants of COSA.

The socioeconomical objectives of the COSA project are 1) to implement generated scientific knowledge and results into monitoring programs and environmental management concepts of the two nature preservation organisations participating in COSA, 2) to produce recommendations for the sustainable use of coastal environments, and 3) to increase the awareness of the public and policy makers regarding the importance and value of permeable sands.

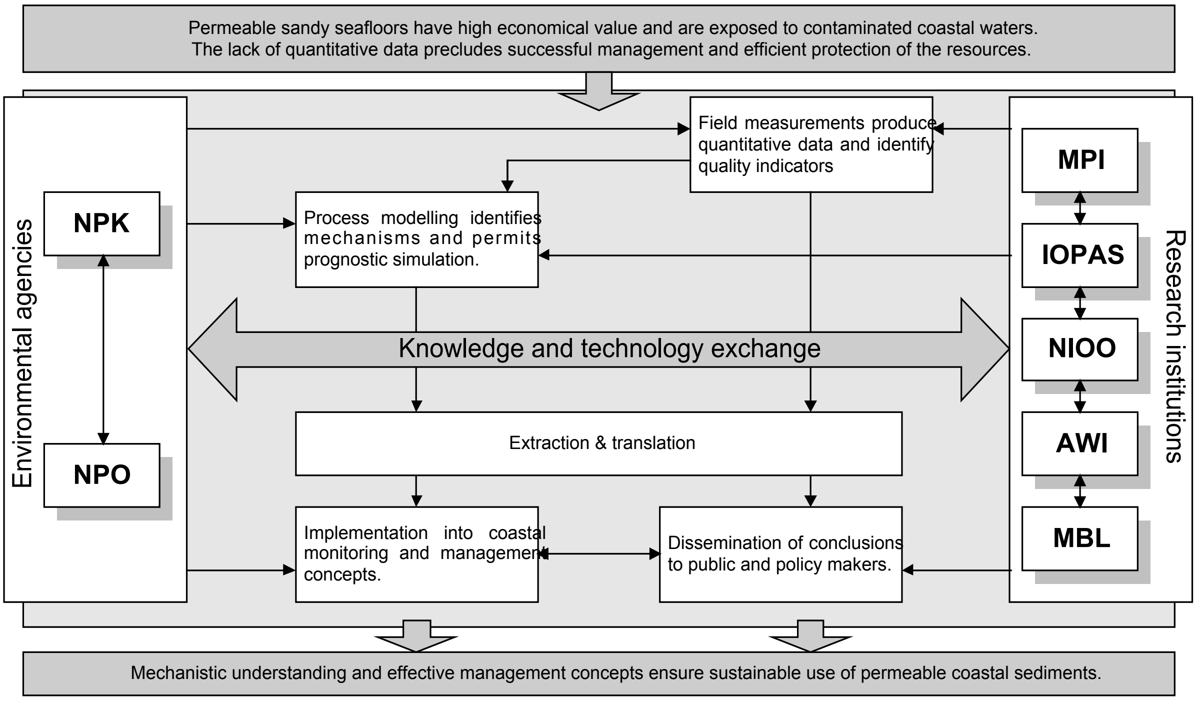

Figure 2: The concept of COSA. Research institutions as well as environmental agencies are integrated in the project to ensure optimal implementation of the scientific results into environmental objectives.

The participants of the European Project COSA are the research institutions:

- Max Planck Institute for Microbiology, Germany, (MPI)
- Institute of Oceanology, Polish Academy of Sciences, Poland, (IOPAS)
- Netherlands Institute of Ecology, Netherlands, (NIOO)
- Alfred-Wegener-Institute, Germany, (AWI)
- Marine Biology Laboratory, University of Copenhagen, Denmark, (MBL)

and the nature preservation institutions:

- Nadmorski Landscape Park, Poland, (NPK)
- National Park Office Schleswig-Holstein Wadden Sea, Germany, (NPO).

Within the work program of the project, the scientific tasks, the translation of the scientific results to the public and policy makers and the pathways for the implementation of the results into management concepts and decision making are described in detail. COSA now is operating successfully within its second year, and the integrative concept was proven to be an excellent approach to ensure the effective translation and implementation of scientific results. We show that the typical pathway from scientific research via scientific publications, news media to the general public and policy makers and finally to the environmental agencies can be abbreviated, accelerated and optimized by including the environmental agencies within the project. Thereby the translation, dissemination and implementation of the scientific results can take place almost simultaneously with the generation of the results, saving time and minimizing the loss and distortion of valuable information.

Figure 3: Participants of COSA at the study site at Hel (Poland).

To give a specific example, Nadmorski Landscape Park, one of the environmental agencies participating in COSA, promotes awareness with respect to sandy coastal environments and the implementation of scientific COSA results via:

- educational programs:
    - teacher training workshops
    - lectures for school children
- seminars with local policy makers
- cooperation with the media (radio, TV)
- information exchange (research institutes, environmental agencies, nature preserve organisations)
- publications
- websites
- information materials, newsletters in the visitor centres.

Through the education of NPK personnel within COSA with respect to the processes in sandy coastal environments, and through exchange of information between the NPK and NPO (Nationalparkamt Schleswig-Holsteinisches Wattenmeer, the second environmental agency participating in COSA), monitoring and management concepts of the these two environmental agencies are adapted and optimized according to the scientific information generated within COSA.

3 Discussion

3.1 Two-way flow of information

The integration of scientific institutions and environmental agencies within one project permits direct information flow and immediate feedback between these institutions, promoting focused research on the dominant problems identified by the environmental agencies. The integrated approach enhances the efficiency of applied research, while boosting fundamental research associated with these investigations. In COSA this is demonstrated through the development and deployment of novel instrumentation for the investigation of coastal sediments (Fig. 4).

Figure 4: Advection chambers for the investigations of sediment-water exchange in permeable sediments constructed for COSA during a deployment at Hel.

The new instruments permit new insights in the functioning and the processes governing the cycling of matter in permeable marine sediments and, thus, generate fundamental data, which are needed to promote our understanding of this complex environment and to efficiently protect the coastal zone. Through increasing the knowledge and awareness concerning the sand ecosystem and introduction of improved assessment methods, COSA preserves European economical value by providing guidelines for the sustainable use of sandy coastal ecosystems. A better understanding of the sandy coastal seafloors will not only help to preserve a healthy coastal ecosystem but also ensure the quality of life, health and safety in the coastal zone and human population.

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Assessing catchment-coast interactions for the Bay of Gdansk

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Abstract

While eutrophication creates impacts on coastal ecosystems and can result in negative impacts on coastal ecosystem services, its source is often located far away from the coast, related to nutrient emissions from river catchments. Within the EU funded EUROCAT project a chain of tools and models were applied to assess these catchment-coast interactions. Aim of the project is to support Integrated River Basin Management (IRBM), as targeted in the Water Framework Directive (WFD), in order to mitigate possible externalities induced in the coastal zone by socio-economic development in the catchment. The DPSIR-approach of the European Environment Agency was selected as the analytical tool to handle this complex man-ecosystem interactions. Scenarios represent possible futures in which environmental risk perception, societal interpretation of environmental risk and (coastal) vulnerability will influence political targets, such as the WFD implementation. Some society drivers and related policies are qualitatively assessed under each scenario and the resulting ecological impact on ecosystem integrity is quantified by applying ecosystem models. The Vistula catchment is one of several case studies within EUROCAT. The presentation will outline the assessment framework of EUROCAT focussing on the link between scenarios, DPSIR-indicators and potential impacts. Modelling ecosystem changes for the Bay of Gdansk using the eco-hydronamic model ProDeMo and related to different scenarios for development within the Vistula catchment will then be presented as a Baltic Sea example to illustrate the approach.

1 Introduction

The coastal zone is under heavy pressure from land-based activities located in the catchment of rivers. Traditionally, both scientific research and the governance framework have treated catchments and coasts as separate entities. However, it is increasingly recognised that they should in fact be treated as an integrated whole, encompassing both environmental and socioeconomic and political systems.

The EUROCAT project was established with an integrated perspective and analytical framework in mind. Across seven regional case studies, local teams of natural and social scientists used a common interdisciplinary strategy to:

- Identify the impacts on the coast
- Interface biophysical catchment and coastal models with socio-economic models
- Develop regional environmental change scenarios (2001-2020)
- Link scenarios with the modelling toolbox to evaluate plausible futures
- Evaluate research outcomes with regional boards consisting of stakeholders and policy makers.

Aim of EUROCAT is to promote and assist Integrated River Basin Management (IRBM), as targeted in the Water Framework Directive 2000/60/EC (WFD), in order to prevent and mitigate possible externalities induced in the coastal zone by socio-economic development in the catchment. Implementation of the WFD can be expected to form a major issue in future debates on local as well as regional level which makes the EUROCAT approach relevant for future discussions concerning sustainable regional development.

In EUROCAT initially five case studies were performed, focussing on the following river catchments and coastal areas:

1. Rhine-Elbe catchment and North Sea (RebCAT);
2. Humber catchment and Humber estuary (HumCAT);
3. Vistula catchment and Bay of Gdansk (VisCAT);
4. Po catchment and North Adriatic Sea (PoCAT);
5. Axios catchment and Bay of Thessaloniki (AxCAT);

In 2002/2003 two additional case studies were added:

6. Idrija catchment and North Adriatic Sea (IdriCAT);
7. Provadijska catchment and Black Sea (ProvaCAT);

The seven systems cover all coastal types (with the exception of fjords) in Europe and different socio-economic settings. The rivers Vistula, Rhine, Elbe Idrija and Axios are transboundary rivers. Eutrophication and in one case pollution (metals) were identified as major issues for the coastal zone.

Figure 1: Case study areas in EUROCAT.

The Vistula River Catchment and the Baltic Sea Coastal Zone Case Study (VisCAT) was undertaken as a part of the EUROCAT project. The Vistula river carries polluted waters from its catchment (over 100 000 square kilometres area) to the Gulf of Gdansk. These riverine waters, rich with nitrogen and phosphorus compounds, have an effect on the coastal waters, particularly on the Gulf of Gdansk. A research of response of marine ecosystem to inflowing contaminates has been undertaken within VisCAT using mathematical modelling.

The ecohydrodynamic model ProDeMo has been applied for investigation of biogeochemical processes at the water environment of the Gulf of Gdansk. Detailed examinations were conducted for period 1994 – 2002. However, forecasts for the gulf ecosystem behavior were evaluated according to three scenarios. These assumed that the riverine loads of nitrogen and phosphorous are reduced according to expected policy targets related to the three scenarios (Kowalewski et al. 2003).

2 The VisCAT case study area

2.1 Vistula Basin

The Vistula Basin covers 54% of Poland and is principally located in this country. It is essentially an agricultural catchment (63% of land use) with an important proportion of forested area located on fluvio-glacial soils less apt to agriculture. The major features of human pressures on the basin are the following (figure 2, Meybeck at al. 2004):

- The Silesia mining district is located in the headwaters of the catchment upstream of the city of Krakow. Until now this region is responsible for major contamination sources (metals) and for marked salinisation of the river.
- Many major cities of Poland are located on the main branch of the river since their origins as Krakow, Warszawa, Woklawek, Torun, Bydgoszcz. The cities of Gdansk and Elblag are located at the edge of the river delta, in the adjacent coastal zone.
- Some of the greatest reservoirs of Poland are located on the main river (Goczalkowichie and Woklawek Reservoirs) or near confluences with major tributaries (Bug R., Debe or Zegrzynskie Reservoir). These reservoirs are extended (30 to 70 km2) but are characterized by low fall height. Their retention capacity of particulates is therefore limited. For the Woklawek reservoir, the sediment transport reduction is estimated to 30-65%. This reservoir is now eutrophic and hypoxic at low flows and may also store total P (10-25%) but total N is barely affected (3.7% only). The Goczalkowichie reservoir is probably retaining some part of the highly contaminated sediments of Silesia, thus protecting the medium and lower course of the Vistula.

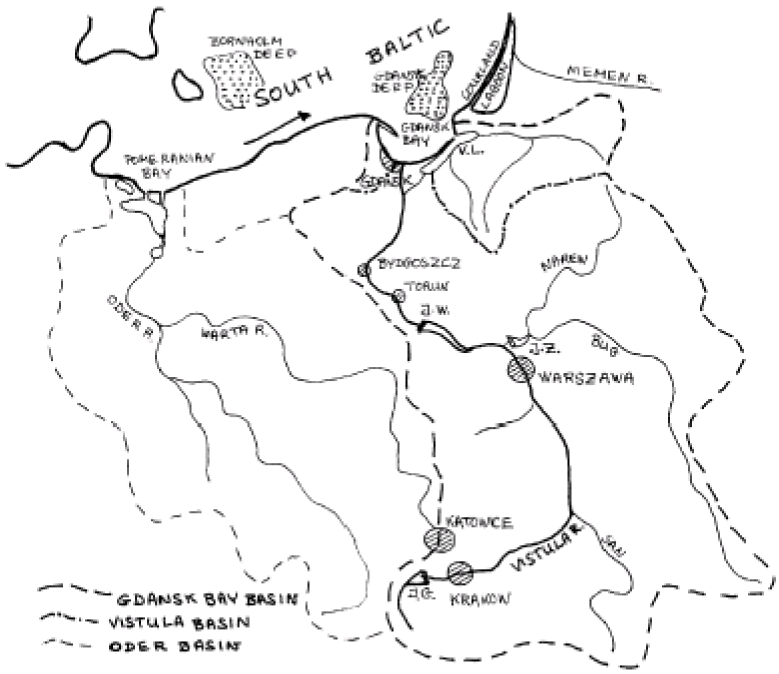

Figure 2: The South Baltic catchment. The Gdansk urban area is located on the west side of the Vistula Delta entering Gdansk Bay. Part of the Gdansk Bay drainage area is actually discharging to the Vistula Lagoon (VL) a nearly enclosed coastal entity (Meybeck et al. 2004).

2.2 Vistula Delta, Gdansk Bay and Vistula Lagoon

The original Vistula Delta extends over about 1000 km^2 of lowland. This area was probably a single wetland system when Gdansk city was founded, a thousand years ago. Both Gdansk and Elblag, the second city of the delta, have been built at the limits of the flood plain on the edges of the Delta. Originally the Vistula river had multiple arms as the Nogat branch that reaches the Vistula Lagoon (Meybeck et al. 2004). Now the Vistula river is channelized to allow navigation up to Wlokawek City and the river mouth is now constrained by dykes. Few km upstream of the mouth a former natural and now channelized branch of the Vistula goes to Gdansk (figure 3, B). The treated effluents of the Gdansk-Sopot-Gdynia conurbation (Tricities, 1 million people) are now injected near the river mouth. Gdansk sewage treatment has begun in 1871, from 1932 onwards at the old Zaspa treatment plant, rebuilt in 1967. This treatment plant will be closed in 2006 and be replaced by the Wschod major treatment plant located between Gdansk and the river mouth that will treat the effluents of the tricities. The Gdansk refinery effluents are discharged directly to the bay near the Vistula mouth.

The Vistula Lagoon is separated from Gdansk Bay by a sand bar more than 20 km long (Mierzeja Wislano). The border between Poland and the Russian enclave of Kaliningrad crosses the sand bar and separates the Vistula Lagoon into two parts. This sand bar has a narrow opening at Baltijsk (Pillau) which allows the Russian fleet of the Baltic to reach Kaliningrad a major navy base. The Paslewa and Pregolia rivers are direct tributaries of the Vistula Lagoon which should be considered as a subset of Gdansk Bay. Direct pollutants inputs to the Vistula Lagoon (Zalew Wislany and Kaliningrad zaliv) include agricultural inputs from the Paslewa and Pregolia basins, smelters and industrial inputs (Cu, Zn and Ni) from Elblag and from Kaliningrad (navy shipyard). Most of these pollutants are likely to stay in the lagoon but their dissolved parts can seep through the sand bar. The management of this coastal lagoon adjacent to the bay of Gdansk and shared between Russia and the European Union - after 2004 - will probably be a difficult one (Meybeck et al. 2004).

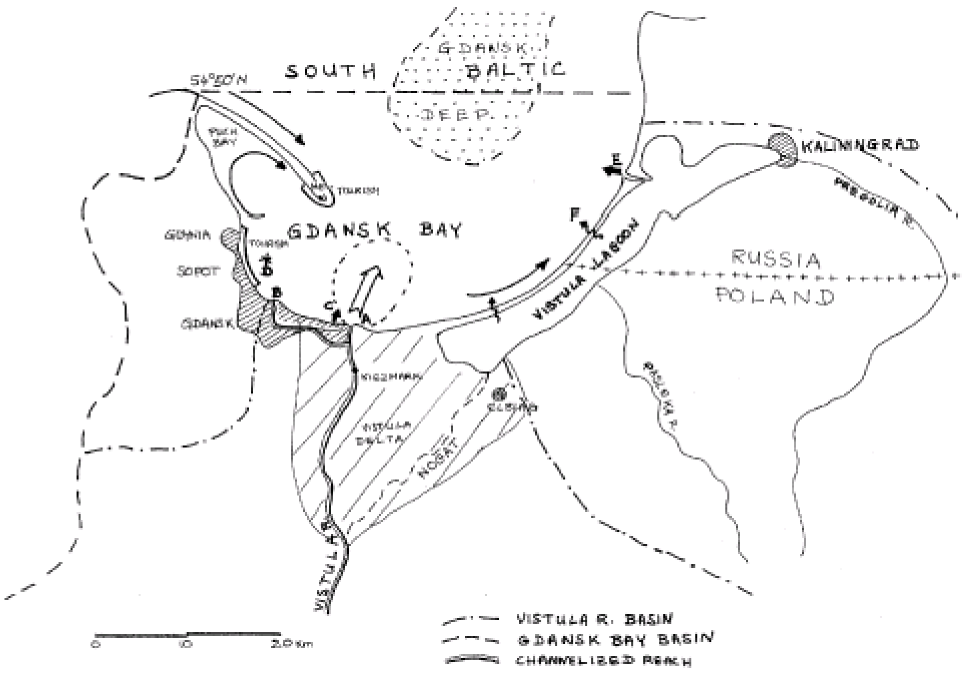

Figure 3: Gdansk Bay coastal area. The Vistula River is connected to the bay through an extended delta in which the river is now channelized for navigation and flood control, and partially drained. The former active Nogat branch is connecting the river to its lagoon, which extends accross the Russia-Poland border (Kaliningrad enclave). Most of the pollutants loads received by the Vistula Lagoon are trapped there: the exchange through the opened channel (E) or across the sand bar (F) are probably limited. The active Vistula mouth (A) corresponds to a river plume extending 10 km sea-wards. An old river branch (B) connecting the Vistula to the Gdansk port and ship yard is regularly maintained. The treated effluents (C) of the Gdansk-Sopot-Gdynia conurbation are now injected near the river mouth. Point sources of contamination in the Bay include an oil tanker wreck (D). The ultimate deposition of fine material received by the Bay is the Gdansk Deep, a major feature of the South Baltic. Coastal tourism is particularly important around Sopot and in the nature conservation area around the Hel peninsula. The Viscat coastal zone limit is placed at 54°50'N (Meybeck at al. 2004).

On the other side of Gdansk Bay the very narrow Hel peninsula is another very active sand bar. Now mostly converted into a nature conservation area, it was previously a Polish army camp, which experiences now limited mass tourism. The Hel peninsula is limiting the Puck Bay, which is very shallow and mostly undeveloped. The tourism has mostly been developed around Sopot. A sunken oil tanker form World War II battles is now an important permanent pollution source of hydrocarbons in Gdansk Bay around which fishing is now prohibited.

The Vistula river plume (10 km long) is generally directed northward. The ultimate depository of fine particles is the Gdansk Deep one out of two major South Baltic Deeps, with the Bornholm Deep North of the Oder River mouth (figure 4). The Gdansk Deep is now characterized by a permanent hypoxia part of which can be attributed to the organic pollution originating from Gdansk Bay and its catchment. Although the Viscat limit has been placed at 54°50'N (figure 6.3.b), the Gdansk Bay influence extends to the Gdansk Deep (Meybeck at al. 2004).

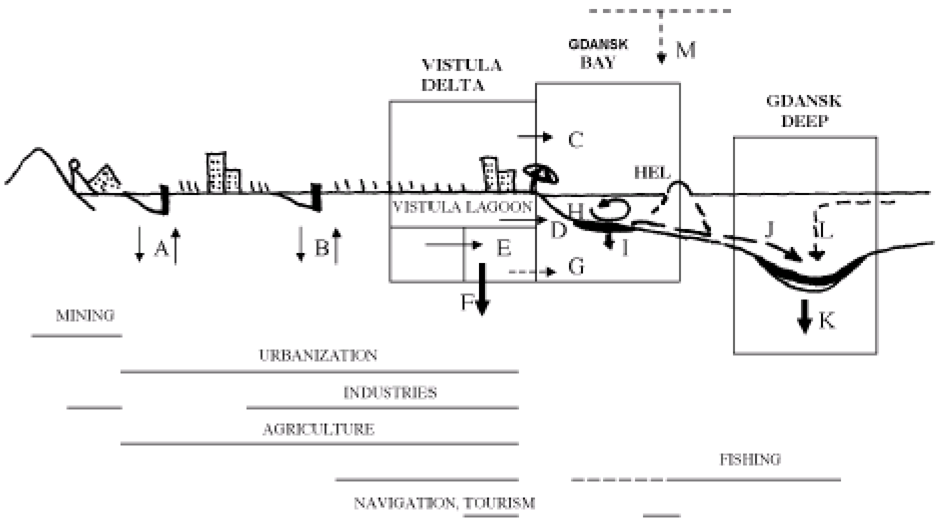

Figure 4: Schematic fluxes and connexions between the Vistula catchment and the coastal zone. The upper Vistula mining products are partially retained in the Goczalkowichie reservoir (A). In the middle basin inputs from Krakow and Warszawa and the Bug sub-basin are also partly retained and/or processed by reservoirs (B). After draining over the last 100 years the Vistula Delta is not any more a major wetland area and the Vistula Lagoon drainage basin (E) is now greatly reduced. Most of inputs to Vistula Lagoon remain in this subcomponent of Gdansk Bay (F) although percolation of dissolved nutrients through the sand bar (G) should be checked. The major inputs to the Bay are those of the Vistula River (D) controlled at Kiesmark gauging satation and of Tricities effluents (C). Nutrients and pollutants are recycled in the Bay (H) then are eventually sedimented or resuspended (J) until they reach their final depository (K) in Gdansk Deep. Direct inputs of material (L) from the open South Baltic to the Deep, now hypoxic and atmospheric inputs (M) of nutrients or pollutants to the system remain to be determined (Meybeck et al. 2004).

3 Assessment approach

The Driver-Pressure-State-Impact-Response-approach (DPSIR) is the analytical framework selected in EUROCAT (in accordance with international programs like LOICZ, GIWA, the EEA and others) to handle these complex humankind-ecosystem interactions. The definition of these terms had to be adapted to the needs of the EUROCAT project. To assist the assessment along the catchment-coast contimuum the partners in workpackage 2 (Indicators and Scenario Assessment) of EUROCAT decided that Drivers, Pressures and Responses need to be formulated for the river catchments as well as for the coastal areas. As the focus of EUROCAT is to view the coastal zone as receptor area of catchment activities, State and Impact indicators need to be developed only for the coastal area. On the other hand State and Impact have to be subdivided into ecological State/Impact and socio-economic State/Impact (Conlijn et al. 2002).

In order to assess drivers, pressures, state, impact and responses as well as their cause-effect relationships, several tools had to be linked with each other (figure 5). Scenarios have been used to identify and assess major drivers and their changes under different socio-economic conditions and different regulation frameworks. A full description of the approach including a comparison of the several EUROCAT case studies is given in Kannen et al. (2004).

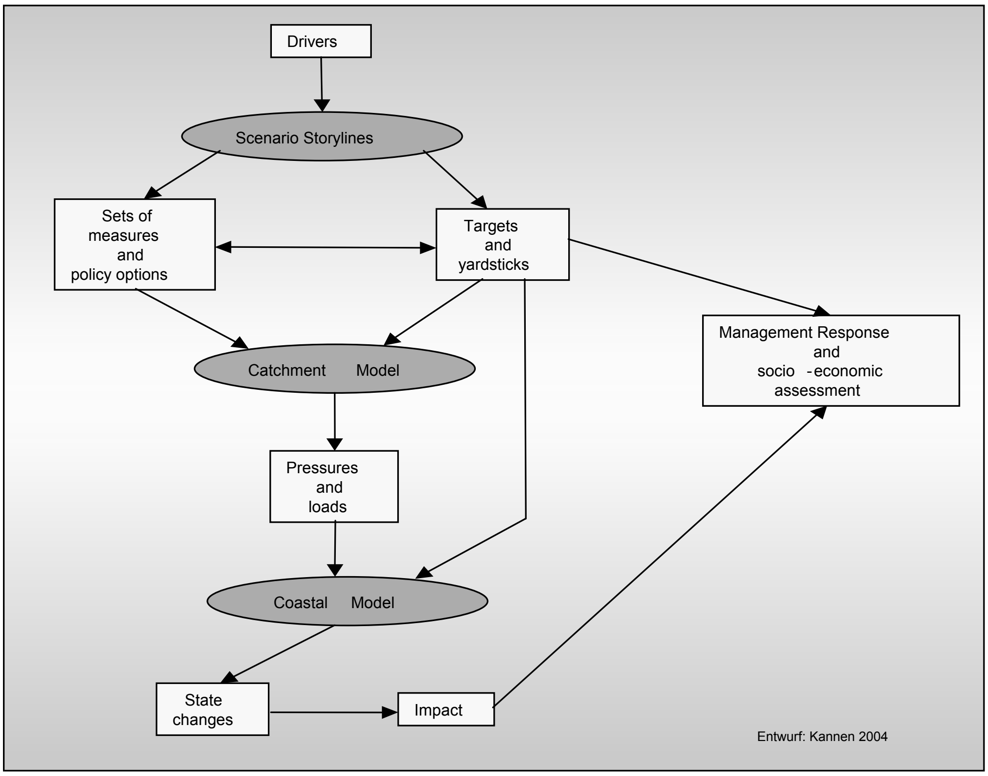

Figure 5: Assessment chain along the catchment coast continuum in EUROCAT (Kannen et al. 2004).

Scenarios represent a preview how different human activities could come into existence, thus causing an impact on the environment and potentially damaging the (coastal) ecological integrity. Furthermore scenarios represent plausible images of the future, in which environmental risk perception and therewith interpretation of environmental risk and (coastal) vulnerability will considerably influence political targets and their implementation (Nunneri et al. 2002).

The scenarios used for the VisCAT case study link economic development with population projections, agriculture policy as well as transport development. The scenarios focus on the political and economic potential to implement environmental standards of the EU in Poland. They result in estimated reductions of nutrient loads that form the input for modelling exercises in the river catchment and in the Bay of Gdansk. This paper will focus on the translation of scenarios to inputs for coastal modelling, using the VisCAT case study as an example.

4 Scenarios for the Vistula case study

In the Vistula-Bay study (VisCat) three basic scenarios defining the rate of economic growth, population projections, agriculture policy as well as transport development have been considered in the assessment (Kowalewski et al. 2003).

1) Policy targets - high scenario. This scenario assumes a 5-6% increase in the GDP rate in 2004-2020. The high rate of economic growth enables the realization of the National Program of Municipal Wastewater Treatment (according to Directive 91/271/EEC). There is a 75% reduction of the discharged nutrient loads in Polish agglomerations above 2 000 p.e. A 1% growth of the population in years 2000-2015 is expected. There will also be a20% rise in migrations to the cities. In agriculture policy application of the Code of the Good Agriculture Practise limits uncontrolled pollution of the environment by natural fertilizers (manure), but the use of mineral fertilizers increases.

2) Policy targets – low scenario. This scenario assumes a lower economic growth between 2 and 4% in 2004-2020. Hence it is not possible to fully implement the National Program of Municipal

Wastewater Treatment (according to Directive 91/271/EEC). Wastewater treatments to be constructed by 2010 will be on line by the Coastal Impact Assessment end of 2015. In agriculture policy, the storage of manure is not improved, but at the same time the use of mineral fertilizers is not increasing either.

3) Deep green scenario. This scenario accomplishes all the objectives of the scenario Policy Targets concerning construction of wastewater treatment plants. Except for this, ecological awareness of the society and the campaign against usage of the laundry detergents with phosphates causes their removal from the market. As a result of this the share of the laundry detergents without phosphates is 90%. Furthermore, it results in lower discharge of phosphates in sewage, thus the load of phosphates from wastewater treatment plants declines by 20% in comparison to Policy Targets scenario. Good Agricultural Practise is introduced and the use of mineral fertilizers is decreasing.

The detailed description of the scenarios is given in the report: Viscat, Report on the redefiniton of scenarios by Bartczak et al., 2003. These scenarios have been investigated within the Vistula River catchment area by using the MONERIS – river catchment nutrient emission model. The results of the application of the MONERIS model, the discharge of total nitrogen and total phosphorus from the Vistula River to the Gulf of Gdańsk, determines the input data for the calculations of the N and P loads from the Vistula River to the Gulf of Gdańsk. The projections of loads are given in table 1.

Scenarios	Load from the Vistula River [10^3 tons/year]							
	N-Tot				P-Tot			
	2002	2005	2010	2015	2002	2005	2010	2015
Policy targets low	114.6	111.7	104.9	104.5	5.86	4.38	3.61	3.46
Policy targets high	114.6	104.8	104.2	104.6	5.86	3.61	3.46	3.47
Deep green	114.6	104.0	104.3	103.5	5.86	3.30	3.32	3.19

Table 1: Loads of total nitrogen and total phosphorus to the Gulf of Gdańsk in three Scenarios (Kowalewski et al. 2003).

In 2002 the total loads of nitrogen and phosphorus were equal to $114.6*10^3$ and $5.86*10^3$ tons. These loads represent 85 % and 79 % of total input from rivers and atmosphere to the Gulf of Gdańsk (including rivers inflowing to the Vistula Lagoon) respectively.

5 Coastal Impact Assessment

5.1 The ecosystem model ProDeMo

The mathematical model of production and destruction of organic matter (ProDeMo) describes basic biological and chemical processes taking place in the sea environment. The ProDeMo model includes 18 state variables, which can be divided into several functional groups: phytoplankton, zooplankton, nutrients, detritus, dissolved oxygen and nitrogen, phosphorus and silicon compounds in sediment (figure 6). The present version of the ProDeMo is a further development of the previous versiontowards complex marine ecosystem model (Kowalewski et al. 2003).

There are two main developments in present version comparing to the previous one. Firstly, the phytoplankton pool has been extended from two to five groups. This feature allows to better describe the seasonal variation of the phytoplankton biomass. Secondly, the sediment layer has been divided into two layers: active and inactive. In the active layer nutrients enter the sediment phase by sedimentation and the model allows their release from the sediment phase to the water phase via mineralization. In the inactive layer there is only a one way nutrient deposition process from the active layer. Phytoplankton includes autotrophic organisms divided into five groups: spring diatoms, dinoflagellate, green algae, blue-green algae and autumn diatoms. Zooplankton is restricted to a group of organisms feeding on phytoplankton. Detritus includes all dead matter (dead phytoplankton and zoological plankton and excrements), which undergo mineralization. Inorganic forms of nutrients include: nitrate nitrogen (N-NO3), ammonium nitrogen (N-NH4), phosphate phosphorus (P-PO4) and silicate silicon (Si-SiO4). Inorganic forms of carbon were not included in the ProDeMo model structure because they do not limit the growth of phytoplankton (Kowalewski et al. 2003).

Due to this the ProDeMo model involves only a partial carbon cycle including phytoplankton, zoological plankton and detritus. Nitrogen, phosphorus and silicon cycles are closed with regard to exchange with bottom sediment and atmosphere. It is similar with the case of dissolved oxygen (O_2) where mass balance equations includes processes taking place in water column, as well as the use of oxygen for mineralization of compounds included in bottom sediment and the exchange through the sea surface. Moreover, the ProDeMo model describes penetration of sunlight inside the sea depth in relation to concentration of phytoplankton and detritus. Processes affecting the change of concentration of particular state variables are described using parameters in the shape of proper mathematical formulae. The result was a set of equations including 151 coefficients whose values were established in course of an extended calibration process. The complete model setup is described together with calibration exercises and simulation in Kowalewski et al. (2003).

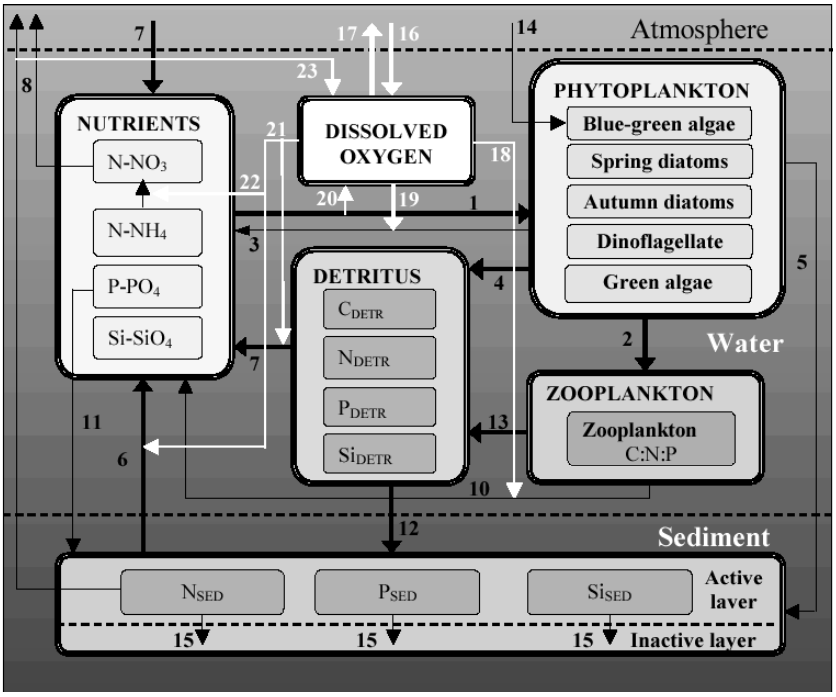

Figure 6: Scheme of the ProDeMo Model. Processes included in the ProDeMo: 1) nutrient uptake by phytoplankton, 2) phytoplankton grazing by zooplankton, 3) phytoplankton respiration, 4) phytoplankton decay, 5) sedimentation, 6) nutrients release from sediment, 7) atmospheric deposition, 8) denitrification, 9) mineralization, 10) zooplankton respiration, 11) sedimentation of phosphorus adsorbed on particles, 12) detritus sedimentation, 13) zooplankton decay, 14) nitrogen fixation, 15) nutrient deposition. Processes influenced the dissolved oxygen: 16) reaeration, 17) flux to atmosphere due to the over saturated conditions, 18) zooplankton respiration, 19) phytoplankton respiration, 20) assimilation, 21) mineralization, 22) nitrification, 23) denitrification (Kowalewski et al. 2003).

The calibrated and validated ProDeMo model has been applied in order to assess the influence of the different economic development scenarios on the ecological state of the Gulf of Gdańsk. The environmental state of the Gulf of Gdańsk has been evaluated for the 2003-2015 projections. The simulations have been carried out as the continuation of the ProDeMo model calculations for the years 1994-2002. Year 2002 has been chosen as a reference year. Loads of total N and total P from the Vistula catchment have been calculated by the MONERIS model (Behrendt et al. 2000) for the

2005, 2010 and 2015 years and these data determined the input data for the ProDemo application in the Gulf of Gdańsk.

A linear distribution has been apply in order to calculate the load values between the years with given data. For the estimation of partition of total nitrogen and total phosphorus into organic and inorganic forms the 2002 distribution pattern has been used. All the remaining input data for the ProDeMo: meteorological conditions, atmospheric deposition, discharges and loads from the other rivers have been defined as in the 2002 year. The forecast of the Gulf of Gdańsk has been investigated by analyses of the following parameters and processes: Total nitrogen and total phosphorus budget calculations, spatial distributions of total nitrogen and total phosphorus, deposition of nitrogen and phosphorus in the sediment, N/P ratio, phytoplankton biomass and primary production. The results from the last year of model simulations, 2010, for each scenario have been compared with the reference year 2002 and the results of the simulations have been compared between each other. A full description of the model application, the calibration and the results is given in Kowalewski et al. (2003).

5.2 Interpretation of model results

The total nitrogen discharged by the Vistula River is reduced in each scenario comparing the forecasts for the year 2015 and the year 2002. Depending on the scenario the reduction of total nitrogen is equal from 8.8 % for Policy target low scenario to 9.7 % for Deep Green scenario. This leads to two conclusions: firstly, the reduction of total nitrogen in all scenarios is rather small (does not exceed 10 %) and secondly the difference in the projections of total nitrogen discharge between the scenarios are very small and can be neglected.

The reduction of total phosphorus discharge for the year 2015 is much larger and is equal from 40.9 % for the Policy target low scenario to 45.5 % for the Deep green scenario. The difference between low and high policy targets scenarios in 2015 are very small. However; in the Policy target high scenario the significant reduction of total nitrogen and total phosphorus is observed even in 2005 year, whereas in low scenario is rather gradual in the 2002-2015 period.

As an example of the many modelling results the N/P distribution for the scenarios is shown in figure 7. The distribution of the N/P ratio has been calculated to analyse the potential limiting conditions (winter conditions) and the real limiting condition under the intensive growth of phytoplankton (summer time). It has been observed that in the reference year 2002, which represents recent biogeochemical conditions, the nitrogen is the limiting nutrient in the large part of the Gulf of Gdańsk ($N/P < 16$), whereas in all scenarios in 2015 phosphorus limits the growth of phytoplankton in the whole Gulf ($N/P > 16$). Therefore, there is much less inorganic nitrogen during summer in the reference year 2002 than at the same time of the year during the scenarios projections. On the other hand, the distributions of phosphorus is the opposite.

Primary production depends on three basic factors: nutrient availability, solar radiation and the water temperature. The modelling results show a general tendency: the further from the land towards the open sea, the lower the rate of the primary production. The values for the central part of the Gulf of Gdańsk are almost half the values in the Eastern part of the Gulf. The rate of primary production in the open waters of the Gulf of Gdańsk does not vary significantly among the scenarios, so this part of the Gulf seems to be less sensitive to nutrient changes. The areas with most visible difference between the reference year 2002 and the Policy targets high scenario are located to the North of the Vistula River outlet and along the Hel Peninsula. Here, the loads of nitrogen and phosphorus from the Vistula River have a strong direct impact on the rates of primary production.

N:P ratios in river waters and consequently in the sea water determines effects on the productivity of the water environment. If nitrogen is the limiting nutrient then the reduction of phosphorus loads may not cause any reduction in primary production unless the reduction reaches a certain level (N:P=16). Below this value phosphorus limits the growth of phytoplankton.

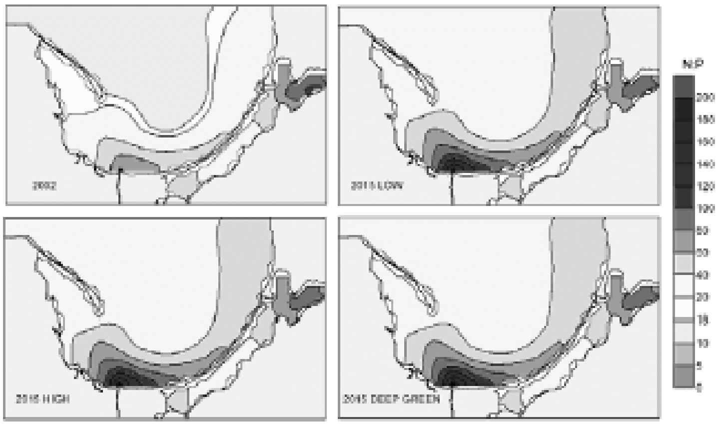

Figure 7: Nitrogen/phosphorus ratios in the Bay of Gdansk for various scenarios (Kowalewski et al. 2003).

Even though the considered scenarios vary in terms of assumptions (economic development, agriculture policy), they do not vary significantly in respect of the total nitrogen and total phosphorus discharged to the Gulf of Gdańsk: the differences in nitrogen loads can be neglected, while the differences in phosphorus loads are rather small (less than 5%). These conclusions have important impact of the analyses of the influence of the Gulf of Gdańsk on the three considered scenarios (Kowalewski et al. 2003):

- The reductions of biological productivity for all scenarios are not very significant comparing to the reductions of phosphorus loads: depending on the scenario from 40.9 % for the Policy target low scenario to 45.5 % for Deep green scenario.
- The lowest biological productivity has been obtained for the Deep green scenario: the primary production is 7.5 % less than in the reference year 2002. The reduction in biological productivity for the Policy targets low and high scenarios are 7.0 % and % 7.1 respectively less than in the reference year 2002.
- The costal waters are the most biologically productive areas of the Gulf of Gdańsk including the recreational area along the beaches in Gdańsk and along the Vistula Lagoon. In the analysed scenarios, the reduction of primary production rate in these areas is rather low.
- The distributions of phytoplankton biomass contents in the Gulf of Gdańsk for the calculated time series are very similar. The differences between three scenarios in the phytoplankton distribution can be neglected.
- Due to the fact that in the analysed scenarios the reduction of phosphorus loads is much higher (more than 40 %) than nitrogen loads (less than 10 %) the phosphorus became a limiting nutrient in the Gulf of Gdańsk. Further reduction of phosphorus load should lead to the reduction of biological productivity in the Gulf of Gdańsk.
- In order to observe further reduction in the biological productivity longer forecast time is necessary.
- Furthermore, the policy targeting on the reduction of nutrients should not limit to the single gulfs or bays but has to cover the whole catchment of the Baltic Sea.

These conclusions highlight the complexity of the impact of catchment inputs impacts on the Gulf of Gdańsk. The coastal waters are the most biologically productive areas of the Gulf of Gdańsk and include recreational areas along the beaches in Gdańsk and along the Vistula Lagoon. The scenario assessments showed that the reduction of primary production rate in these areas is rather low. Because the reduction of phosphorus loads is much higher (more than 40 %) than nitrogen loads (less than 10 %) phosphorus became a limiting nutrient in the Gulf of Gdańsk under the conditions of the scenarios. Therefore, it could be assumed, that further reduction of phosphorus load should lead to the reduction of biological productivity in the Gulf of Gdańsk (Kowalewski et al. 2003).

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The role of Coastal Engineering in Integrated Coastal Zone Management

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Abstract

Wide parts of coastal areas were used by humans from time immemorial, in Germany since more than 1000 years. Nowadays, coastal zones are utilized for various purposes e.g. human settlements especially in towns and villages, agriculture, aquaculture, human recreation, handling of goods, industrial and commercial development, energy generation, nature preservation and preservation of cultural heritage, which can be – more or less – summarized as "human activities in the coastal zone".

The development of the human activities in the coastal zone is strongly related to the development of coastal protection and the construction of flood protection structures e.g. dwelling mounds, dykes and dyke openings. All those constructions were designed and built up with the support of -now called- coastal engineers. Coastal engineers (and their predecessors) were coastal zone managers long before the term "coastal zone management" was coined. With the by and by change in the use of the coasts, the demand for an overall management of the coastal zone arose, including administrative-, socio-economic-, biological-, regional development-, regional planning-, civil engineering- and coastal engineering aspects. Since the functional and constructional design of all coastal structures are performed by coastal engineers, and the assessment of the possible development (appearance) of the coast is impossible without the knowledge and work of coastal engineers, coastal engineering plays an important role for the management of coastal stretches.

1 Introduction

The role of Coastal Engineering in Integrated Coastal Zone Management ICZM can only be characterized on the basis of a definition of the term Integrated Coastal Zone Management. Many definitions or descriptions on what ICZM is can be found in publications and also in the Internet. A good definition maybe the following of Cicin-Sain & Knecht (1998).

„Integrated coastal (area) management can be defined as a continuous and dynamic process by which decisions are taken for the sustainable use, development, and protection of coastal and marine areas and resources. ICM acknowledges the interrelationships that exist among coastal and ocean uses and the environments they potentially affect, and is designed to overcome the fragmentation inherent in the sectoral management approach. ICM is multi-purpose oriented, it analyzes and addresses implications of development, conflicting uses, and interrelationships between physical processes and human activities, and it promotes linkages and harmonization among sectoral coastal and ocean activities".

Hence, theoretically in Integrated Coastal Zone Management a wide number of sciences are involved, including Law, Oceanography, Sociology, Economy, Regional Planning, Traffic Planning, Geology, Geography, Physics, Biology, Ecology, Chemistry and Coastal Engineering.

In practice of ICZM all those sciences have to be managed by a coastal manager, which should - at least in Germany - come from a governmental authority. Also a Communicator is needed for the public participation and to ensure the public awareness.

Coastal Engineering may be defined as a field of Hydraulic Engineering, which itself is part of Civil Engineering, In Coastal Engineering a wide field of disciplines are integrated. In fig. 1 an overview on Coastal Engineering and the related fields is schematically presented.

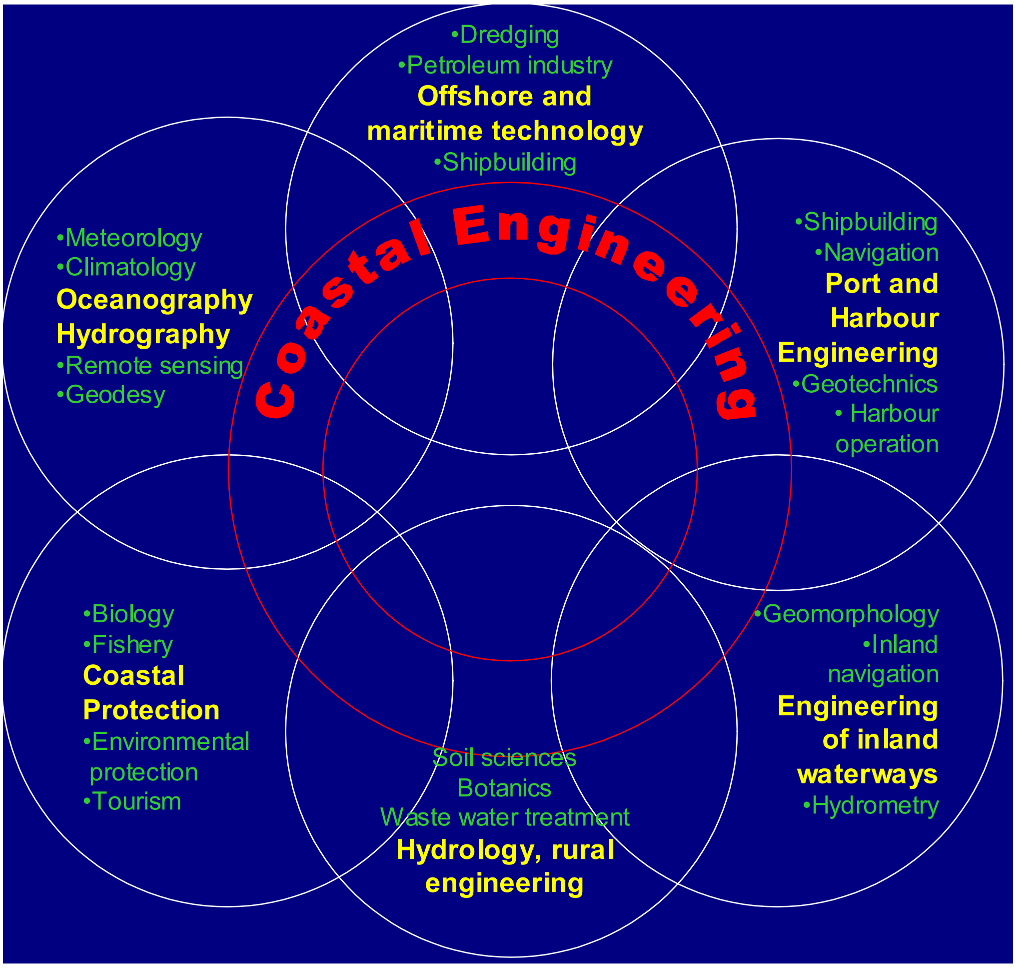

Figure 1: Coastal Engineering and the fields involved

Many publications and research results on ICZM indicate that from the wide field of Coastal Engineering works, Coastal Protection, Port and Harbour Engineering and Offshore and Maritime Technology are important for ICZM. For example, Pickaver (2004) stated that Coastal Erosion and Tourism are most important sectors in ICZM in the international focus. Gee et al. (2004) identified „the sea as a public good, ports, shipping, fishery, wind farms and marine protective areas“ as the key themes on the coast in Germany.

2 Coastal Engineering works for ICZM

In this part of the paper some examples for Coastal Engineering works are presented. They show the necessity of the work and especially the result of these works for the intention of ICZM. The examples are taken from the fields of Coastal Protection and Marina Planning to cover the key themes Coastal Erosion and Tourism / Ports, Shipping, Fishery and the Sea as a public good.

Coastal protection consists of two general parts, flood protection and management of erosion. In fig. 2 and fig. 3 two examples are shown to indicate that flood protection has the same importance for the use of a coastal stretch as erosion protection. It can be seen that in both example areas the erosion is in the order of magnitude of 30m to 100m per century. 70% of the coast of Mecklenburg-Vorpommern is eroding permanently, 23% of the coast are stable and in only 7% of the coast accretion and accumulation of sand can be observed.

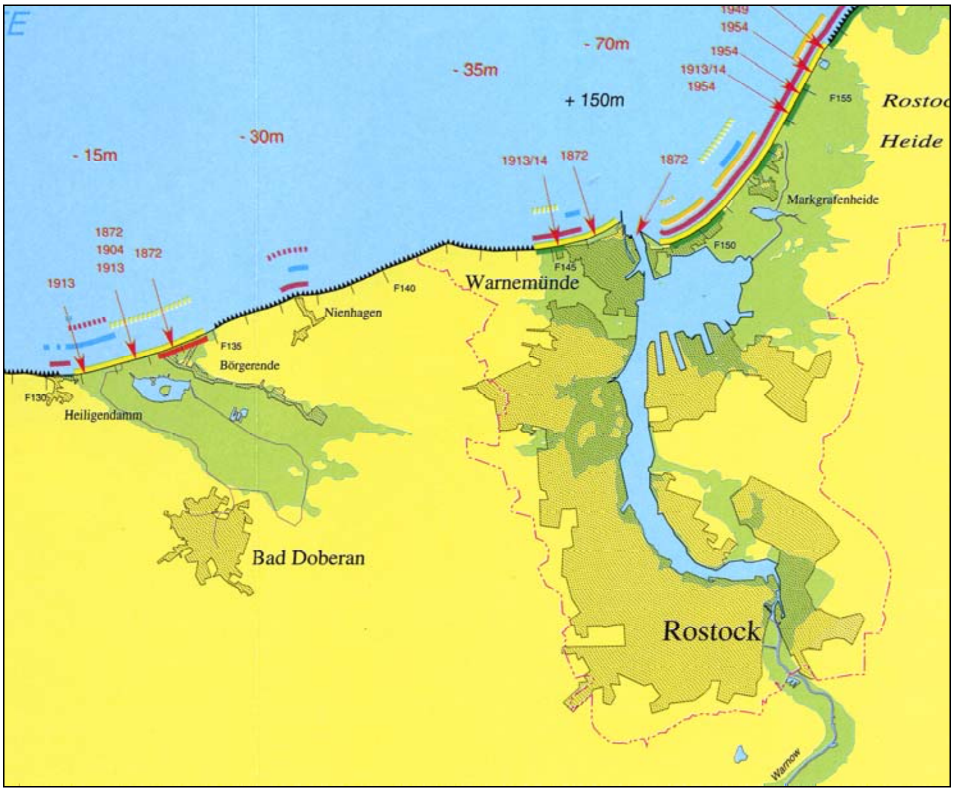

Figure 2: Coastal Erosion, Coastal Protection Works and Low Lying Coastal Areas for the area of Rostock, Mecklenburg-Vorpommern (from Master Plan Coast Conservation Mecklenburg-Vorpommern, 1995).

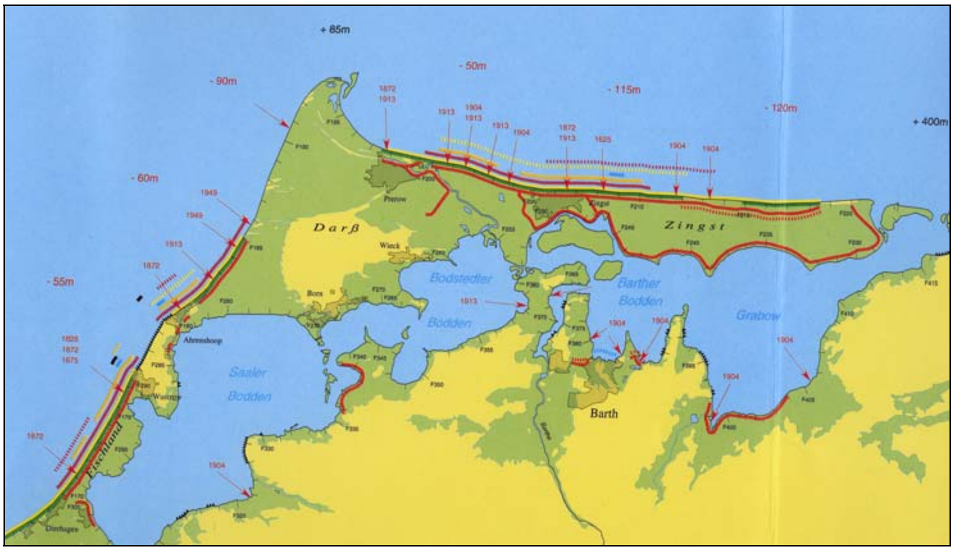

Figure 3: Coastal Erosion, Coastal Protection Works and Low Lying Coastal Areas for the Fischland, Darss, Zingst Area of the Coast of Mecklenburg-Vorpommern (from Master Plan Coast Conservation Mecklenburg-Vorpommern (1995).

Besides the information on the erosion (and accumulation) rate of the coast the low lying areas are marked with green colour. These areas would be flooded during extreme storm events without flood protection measures on the coast. It can be seen in fig. 2 and fig. 3 that also parts of the cities at the coast are affected without flood protection. Approx. ¾ of the Fischland – Darss – Zingst Area would be flooded during severe flood events without flood protection and so would be lost for human use.

An example for coastal protection works at the Streckelsberg / Usedom Island is given in fig. 4. A combination of beach nourishment, groins and offshore breakwaters are installed to fix the Streckelsberg and to stabilise the adjacent coastal stretches. The overall aim of the complete system is to ensure the flood protection of the low lying areas north-west of the Streckelsberg.

Figure 4: Coastal protection/flood protection works with a system of offshore breakwaters, groins and beach nourishment at the Streckelsberg / Usedom Island (Photo: Dr. B. Gurwell).

For coastal protection and flood protection there exists a wide number of technical solutions. The general possibilities for technical solutions for the protection of sandy beaches are given in fig. 5. They can be divided into active and passive measures, where active measures include sand bypassing structures, beach fill and beach nourishment works. Passive measures consists of constructions normal to or in direction of the shoreline as, e.g., groins, breakwaters, revetments. For practical projects often combinations of active and passive measures are used, as the Streckelsberg example in fig. 4 shows.

As an example for the second key issue "tourism / ports / fisheries" marinas are used. Marinas are planned all over the Baltic Sea and are – sometimes – heavily discussed in public. Conflict potentials and conflict parties are manifold. For example: investors, environmentalists, private, public and administrative interests have to be considered in various fields including: economics, environment, tourism, sports, coastal and flood protection, local and general eco systems and aestethic aspects.

Investigations on the influence on coastal and flood protection but also on the influences on the morphological development of adjacent areas are typical coastal engineering tasks related with the planning of marinas within a comprehensive ICZM. An overview of the major topics within the planning of marinas and related coastal engineering tasks is given in fig. 6.

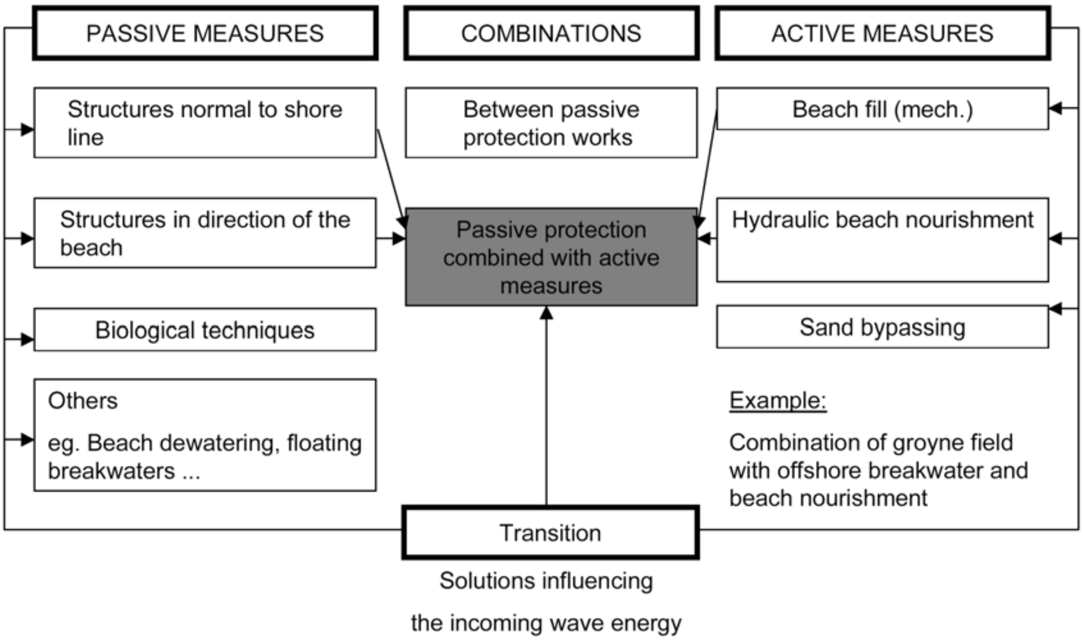

Figure 5: Technical solutions for the protection of sandy beaches (after Kohlhase 1991).

Figure 6: Planning steps and Coastal Engineering tasks for design and construction of marinas.

The general influence of a marina on a sandy coast on is illustrated in fig. 7. Since the marina breakwaters are crossing the zone of the main sediment transport, the transported sediment is deposited on the luff side of the marina and, hence, the coastline is eroded on the downdrift (lee) - side. The main objective for the assessment of the morphological development of the coast is to calculate the local sediment transport and to determine the influences of the structures on the sediment transport.

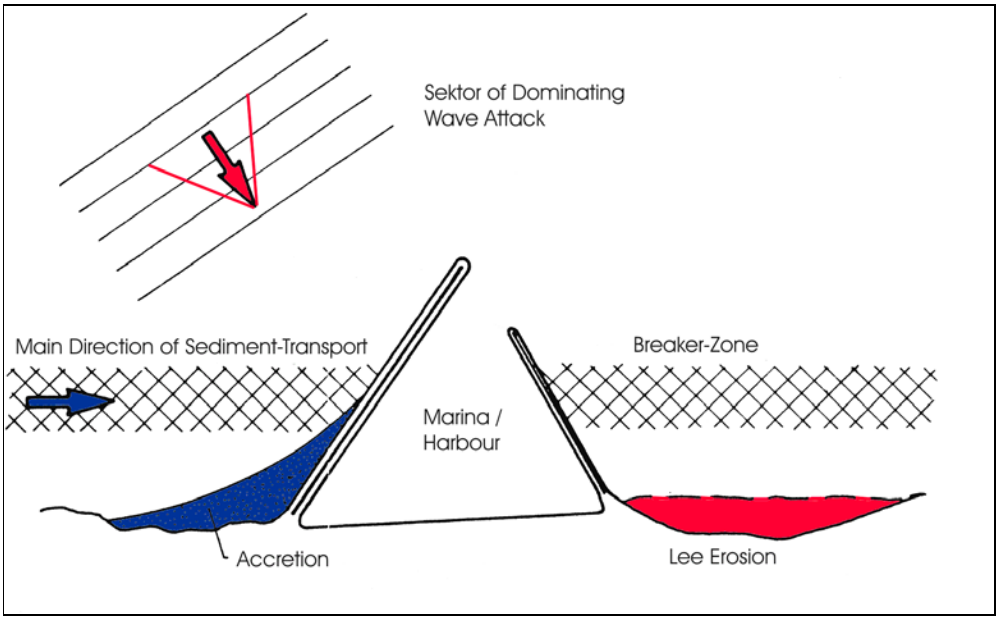

Figure 7: General influence of a marina on sediment transport (Kohlhase 1983).

For the calculation of the local sediment transport and the assessment of the influence of a marina on the morphological development of a coastal stretch several engineering methods are available. Numerical models are nowadays widely used. Fig. 8 shows an example result of a numerical model with a marina installed on an open coast beach.

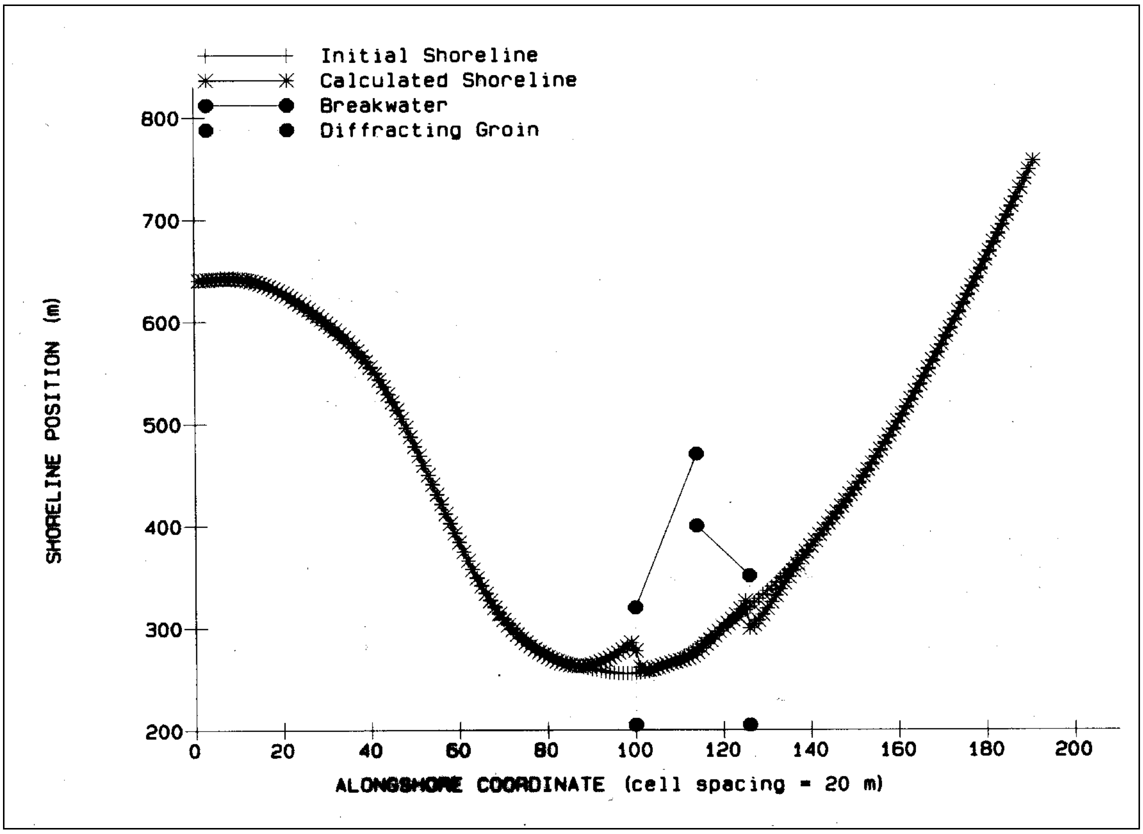

Figure 8: Influence of a marina on the morphological development of a coastal stretch. Example results calculated with the numerical model GENESIS.

If necessary, the negative influence of a marina has to be controlled by technical measures. As outlined before, technical measures include:

- beach nourishment,
- groin fields,
- offshore breakwaters,
- artificial reefs / submerged offshore breakwaters and others.

Since all coastal engineering constructions have positive (desired) influences but also negative (undesired) effects, the influences of all technical measures have to be carefully assessed. Usually, detailed investigations have to be carried out for any coastal engineering project.

3 Conclusions

Very often coastal engineering projects and coastal engineering constructions have a significant influence on the development of the coastal area. In the paper two illustrating examples showing the role of engineering within Integrated Coastal Zone Management are presented.

In summary and with respect to Integrated Coastal Zone Management it can concluded, that:

- Coastal Engineering problems play an important role in Integrated Coastal Zone Management.
- Coastal Engineering works and constructions are the basis for human use of the coastal zone and in general for all human activities in the coastal zone.
- Coastal Engineering includes the assessment of all possible positive <u>and</u> negative effects of the constructions.

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Analyses of Variations in Water Level Time-Series at the Southern Baltic Sea Coastline

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Abstract

The results of an investigation intended to provide information about the trends of the Mean Water Levels along the German Southern Baltic Sea coastline in comparison to the German North Sea coastline are presented. Four gauging stations at the German Southern Baltic Sea coastline were combined to so called mean normalized gauges to be able to make more general statements about the variations in the Baltic Sea water levels.

The time series were examined with linear and non-linear adaptation functions. A special emphasis lies on the detailed description of the water level time-series considering the influences of the nodaltide. With several analysis methods an estimation of the water level development up to the year 2020 was carried out.

As well as the Mean Water Level (MW), the annual High Water (HW) and annual Low Water (LW) for the Southern Baltic Sea were examined. The results show that the MW is increasing up to now and a further rise can be expected. All results of the investigations lead to the assumption that the tidal dynamics in the North Sea, and thus also the water levels in the Baltic Sea, have changed or are still changing.

1 Introduction

Changes in the global sea level have far reaching consequences for both humans and the natural environment. The entire German North Sea and Baltic Sea coastlines are protected against storm surges mostly by dykes in order to protect the partially lower lying hinterland. Particularly in highly industrialized countries, as, for example, Germany, space requirements for population and industry are increasing. The existing space is used intensively and, in the case of flooding, high significant monetary and ecological damage will result. The population and the economy must be protected against flooding. To achieve this, knowledge of long, medium and short-term trends of the water levels is important.

2 Data

Annual water level data from 4 Baltic Sea gauges are the basis for the current investigations. The four gauging stations are Travemünde, Warnemünde, Wismar and Sassnitz (Figure 1). In this Paper, the investigations and results of the changes of the Mean Water Levels (MW), Low Water Levels (LW) and High Water Levels (LW) at the Southern Baltic Sea will be discussed. The Mean Water (MW) in the Baltic Sea is defined by the arithmetic mean of the daily measurements at 12 o'clock. The data of the Baltic Sea gauges Warnemünde, Wismar and Sassnitz are normally referred the gauge datum "Höhen Null". The data were transformed to the gauge datum "Normal Null (normal zero)" by the formula:

W [cmNN] = W [cmHN] – 514 cm + Δ [cm]

with: W [cmNN]: water level [cm "Normal Null"]

W [cmHN]: water level [cm "Höhen Null"]

Δ: local system differences between HN and NN; Warnemünde (12.1 cm), Wismar (9.8 cm), Sassnitz (11.0 cm) (Stigge 1989)

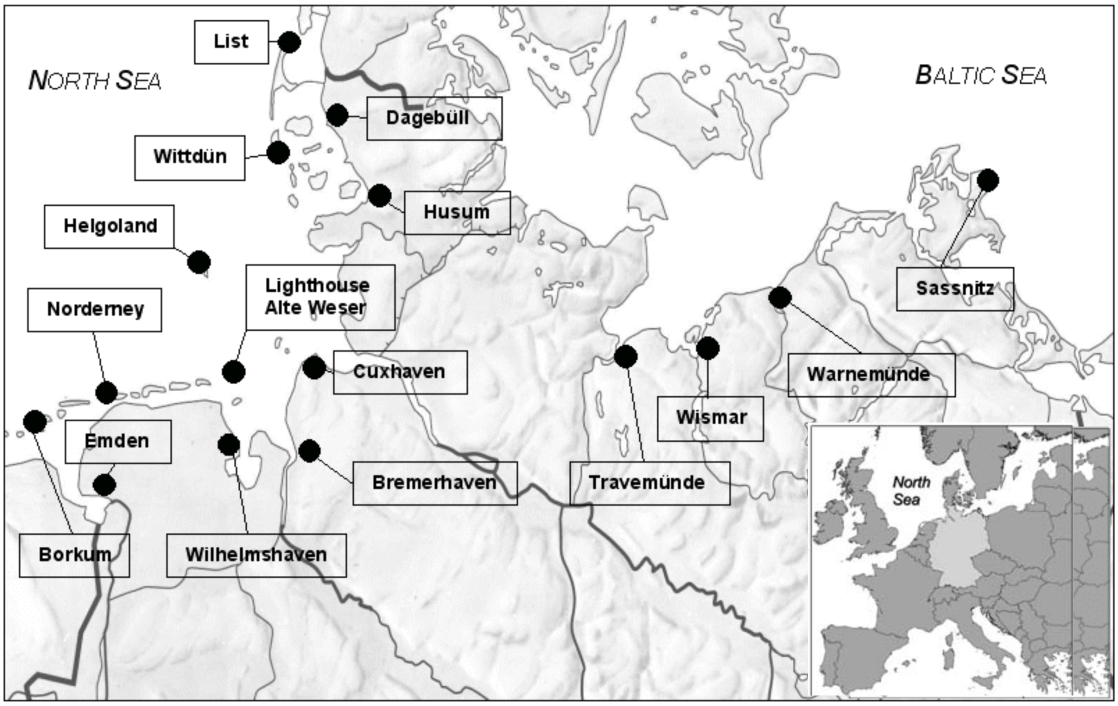

Figure 1: Gauging sites at the German North Sea and Baltic Sea

The aim of the investigation was to derive generalised statements about the trends of the water levels at the German Baltic Sea. Consequently, not all time series were analysed separately, but rather normalized and combined to one group, called mean normalized time series. It was determined a normalized gauge Baltic Sea for MW, LW and HW. The mean normalized time series are created using the original time series normalized by the mean of each and then calculating the arithmetic mean of the four time series. By creating a group of 4 time series, the following topics must be considered: Due to the fact, that not all time series have the same span of time, some effects are important. In the range where e.g. not all time series have data except one, the created normalized time series is determined by one time series only. By means of this the linear trend of the normalized time series can have a deviation in comparison to the arithmetic mean of the single trends of the time series. This effect is not so strong, so that the advantage of analysing only one times series for a parameter is more important. But for all interpretations of the results this effect must be considered.

These time series are shown in Figure 2. It can be recognized, that the gauge Travemünde has the longest time series from 1826 up to 2001. The shortest time series is Sassnitz with a span from 1936 up to 2001. In this figure only the original MW-time series are represented, but also the LW and HW time series were analysed. For the interpretation of the results of the analyses of water level time series at the Baltic Sea it must be considered, that the Baltic Sea is still influenced by e.g. tectonic movements. Along the Southern Baltic Sea coastline these relative movements between land and seasurface are smaller than the sea level rise.

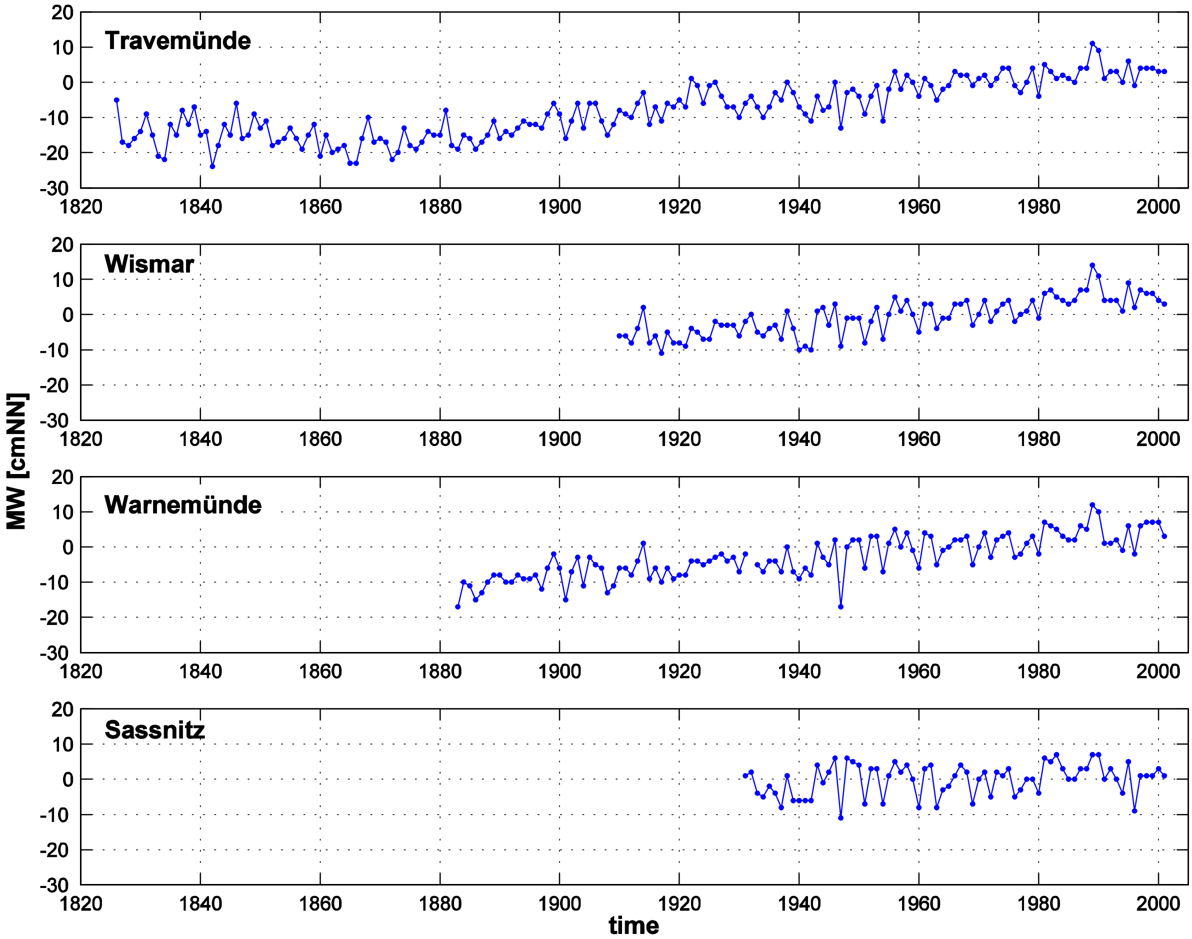

Figure 2: observed MW time series of the investigated gauges

3 Analyses and Results

In the present investigation, a statistical analysis of the time series was carried out. Basic statistical parameters, such as, for example, mean values, standard deviations and linear trends, were calculated for all time series. Further analyses, such as adaptation functions, were carried out only for the normalized time series. In Table 1, the mean values of the four Baltic Sea gauges are shown with the standard deviations.

gauges	time series	HW [cmNN]	± σ	LW [cmNN]	± σ	MW [cmNN]	± σ
Travemünde	1826 - 2001	112	38	-125	25	-8	8
Wismar	1910 - 2001	126	30	-121	26	-1	5
Warnemünde	1883 - 2001	107	25	-105	22	-3	6
Sassnitz	1931 - 2001	92	22	-85	19	0	4

Table 1: Mean values with standard deviations of the investigated gauges

With the aid of different adaptation functions, statements about the trends of the Mean Water Levels at the Baltic Sea coastline can be made up to the year 2020.

In Figure 3, the time series of the MW of the mean normalized gauge Baltic Sea is shown. First of all, a low-pass filter was calculated to generate a smoothed run of the time series. This low-pass filter is calculated using the moving average of the time series with a span of 19 years. The calculated mean value is used as the middle of the span in each case. The span of 19 years is chosen in order to consider the influence of the nodaltide (t = 18.61 years) (Jensen and Schönfeld 1990). The first and the last 9 values of the smoothed curve are calculated with a smaller span. The smoothed curve shows a linearly increasing trend starting from approximately 1900. To obtain a better description of the linear trend, two different linear regression lines were fitted to partial time series (Jensen 1984, Jensen, Bender and Blasi 2001). One regression line was fitted to the entire time series. A further regression line was fitted for the years 1965 to 2001, which corresponds to the cycle of two nodaltides. By interpretating the results it must be considered, that only the second regression line includes the influence of the nodaltide exactly. The other regression line were fitted from the beginning of the time series, in order to take into account the large quantity of data.

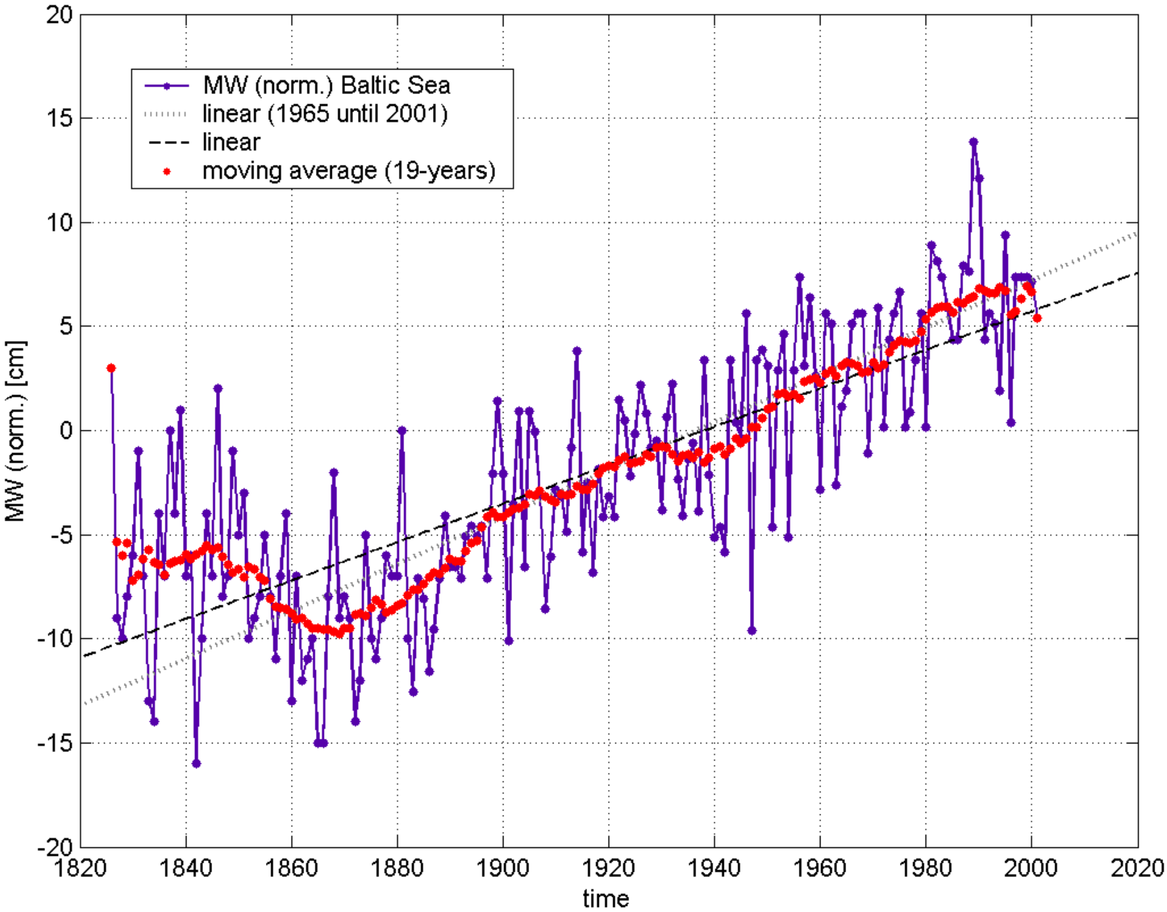

Figure 3: Time series plot of mean normalized gauge Southern Baltic Sea with moving average (19 years) and linear regression lines

The results show that the slopes of all regression lines quite greatly differ from each other at low and high water. Considering only the Mean Water the differences are not so strong; the secular trends (sT) vary between 10 and 16 cm/100 years, except of Sassnitz, where the trends are much smaller. In all figures it is important to know, that the zero line is not equal to the 0 cmNN. The zero line is just the mean value of the normalized time series. In Table 2, all trends of the original and normalized time series are shown.

Gauges	$s_{T(\text{whole time series})}$ [cm/100 years]	$s_{T(1965 \text{ to } 2001)}$ [cm/100 years]
	HW	
Travemünde	21 (1826 – 2001)	18
Wismar	22 (1910 – 2001)	43
Warnemünde	18 (1883 – 2001)	27
Sassnitz	12 (1931 – 2001)	21
HW (norm.) Southern Baltic Sea	15	28
	LW	
Travemünde	3 (1826 – 2001)	-18
Wismar	28 (1910 – 2001)	1
Warnemünde	23 (1883 –2001)	20
Sassnitz	-10 (1931 – 2001)	-15
LW (norm.) Southern Baltic Sea	1	-3
	MW	
Travemünde	13 (1826 – 2001)	10
Wismar	15 (1910 – 2001)	16
Warnemünde	14 (1883 – 2001)	15
Sassnitz	6 (1931 – 2001)	5
MW (norm.) Southern Baltic Sea	9	11

Table 2: Secular trends s_T of the investigated time series for different parameters

A more detailed description of the trend can be achieved by considering the influence of the nodaltide with a nonlinear adaptation function, which contains a linear portion with the trend and the portion of a sinus oscillation of the nodaltide with the amplitude H_N, period T=18.61 years, time t and phase shift φ (Jensen and Mudersbach 2002a) (1):

$$f(x) = a + s_T \cdot t + \frac{H_N}{2} \cdot \sin\left[2 \cdot \frac{\pi}{T} \cdot (t + \varphi)\right] \qquad (1)$$

The results are shown in Figure 4. For the time series, two adaptation functions for different time periods are determined: One from the beginning of the time series up to 2001, and the other from 1965 up to 2001. The results show that the adaptation function for the time span 1965 to 2001 shows a stronger rise and the amplitude is larger. In total, the result does not show any significant differences projected onto the year 2020. The nodaltide is considered only mathematically and not physically.

To describe the set of the **whole** time-series with **one** function, non-linear adaptation functions are needed. Due to the variations in the time-series it is not possible to do so with only **one linear** function (Jensen and Mudersbach 2003).

From this basis, further non-linear adaptation functions were examined which can describe the given time series better. The disadvantage of these adaptation functions lies in the fact, that they cannot be used so well for extrapolation. Therefore, particular care must be taken while using nonlinear adaptation functions at the point when the functions are ”running away”.

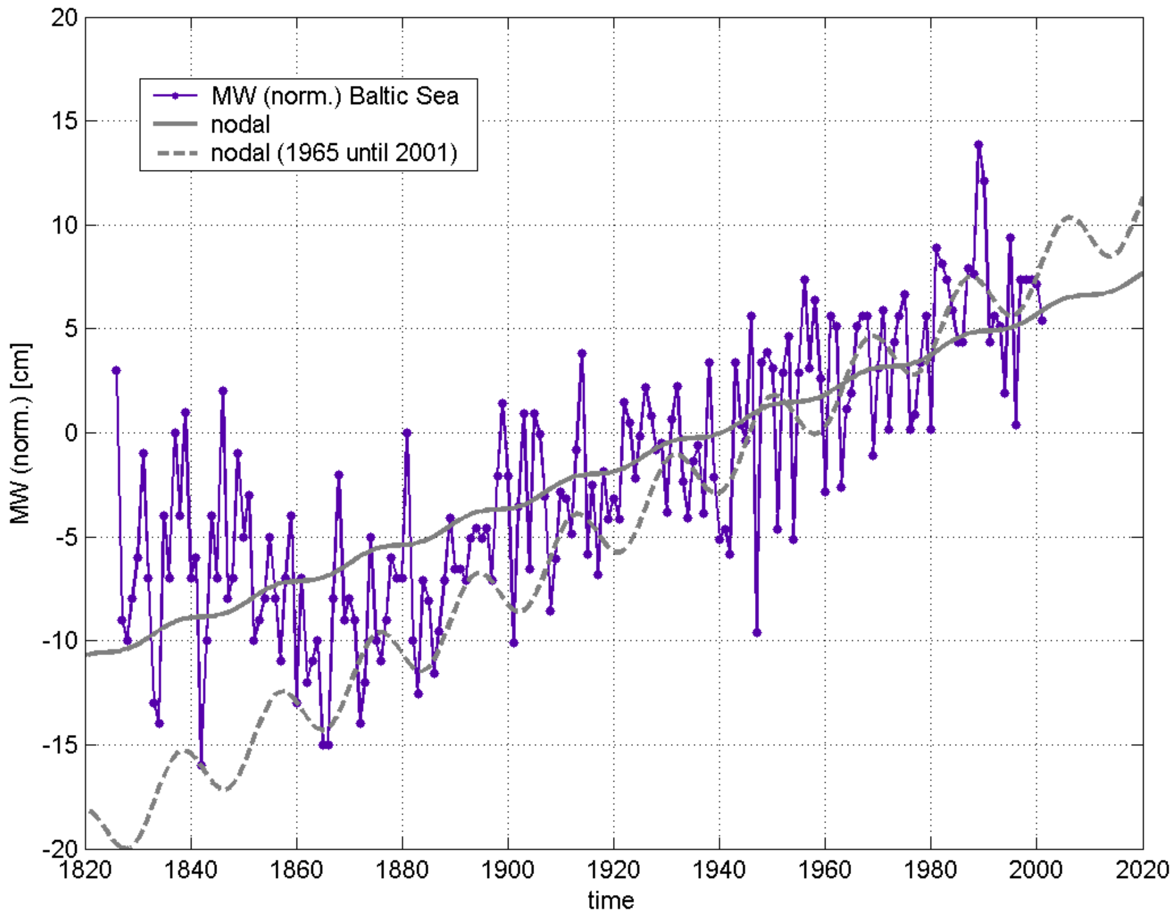

Figure 4: Time series plot of mean normalized gauge Southern Baltic Sea with fitted curve linear plus nodaltide

The investigations show that a polynomial adaptation function of the 3rd degree is a useful description of the behaviour of most of the time series (2).

$$f(x) = ax^3 + bx^2 + cx + d \tag{2}$$

A further adaptation can be achieved if the polynomial function is overlaid with the nodaltide (3).

$$f(x) = ax^3 + bx^2 + cx + d + \frac{H_N}{2} \cdot \sin\left[2 \cdot \frac{\pi}{T} \cdot (t + \varphi)\right] \tag{3}$$

The results are shown in Figure 5. The polynomial function describes the time series quite well (in the range of observed data) and clearly flattens between 2000 and 2020. The combined function (polynomial plus nodaltide) does not flatten between 2000 and 2020 and indicates a value of approximately 8 cm greater for 2020.

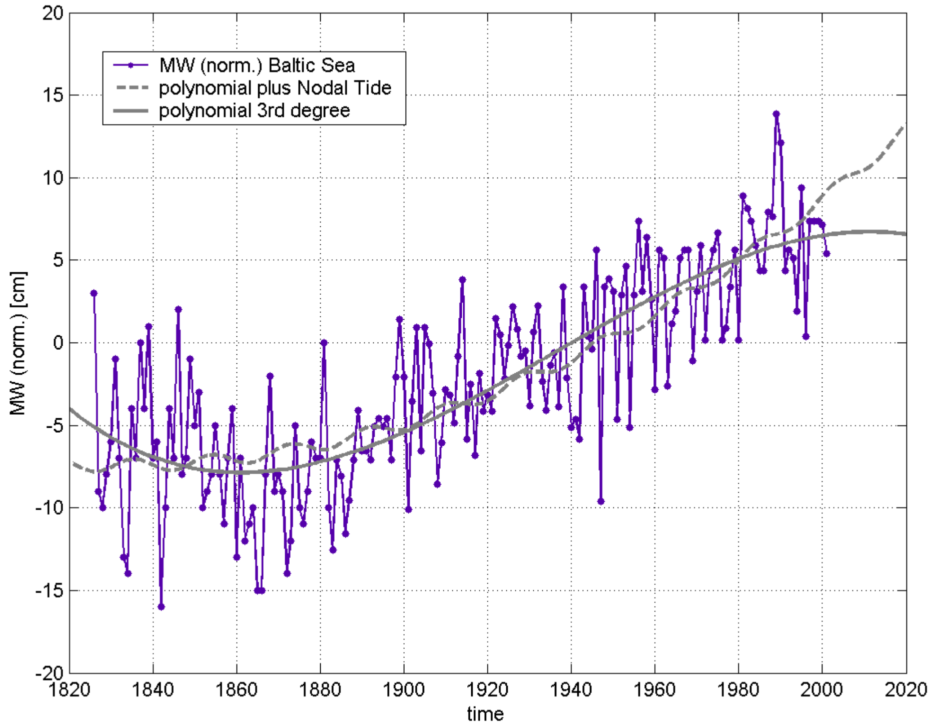

Figure 5: Time series plot of mean normalized gauge Southern Baltic Sea with fitted curve polynomial plus nodaltide and polynomial 3rd degree

For the year 2020, a value of the mean normalized MW (Baltic Sea) between 7 and 14 cm is indicated. If this value is added to the mean value of a corresponding MW time series, the approximate value of the water level can be derived up to 2020.

Using the root mean squared error (RMSE) as a parameter for the goodness of the fit for the adaptation functions above (a value closer to zero indicates a better fit), the best fit is the polynomial function 3rd degree (Table 3). But due to the problem of the instable behaviour in the range of non-observed data, as mentioned before, the combined fit with a polynomial part and the oscillation of the nodaltide shows also good results.

function	**Root Mean Squared Error**
linear	3.99 (Figure 3)
polynomial 3rd degree	3.66 (Figure 5)
polynomial plus nodaltide	3.82 (Figure 5)

Table 3: Goodness of fit of adaptation functions

The normalized HW time series (Figure 6) is especially marked by the extreme event in the year 1872 at the gauge Travemünde. It seems that the amplitude of the yearly High Water Levels becomes smaller, but there is an increasing trend of s_T = 15 cm/100years for the whole time series. Of special interest is the trend from 1965 up to 2001 which reaches a value of s_T = 28 cm/100 years.

For the normalized LW time series (Figure 7) there is no significant trend. The trend for the whole time series is about s_T = 1cm/100 years and the trends for the partial time series is about s_T = -3cm/100 years.

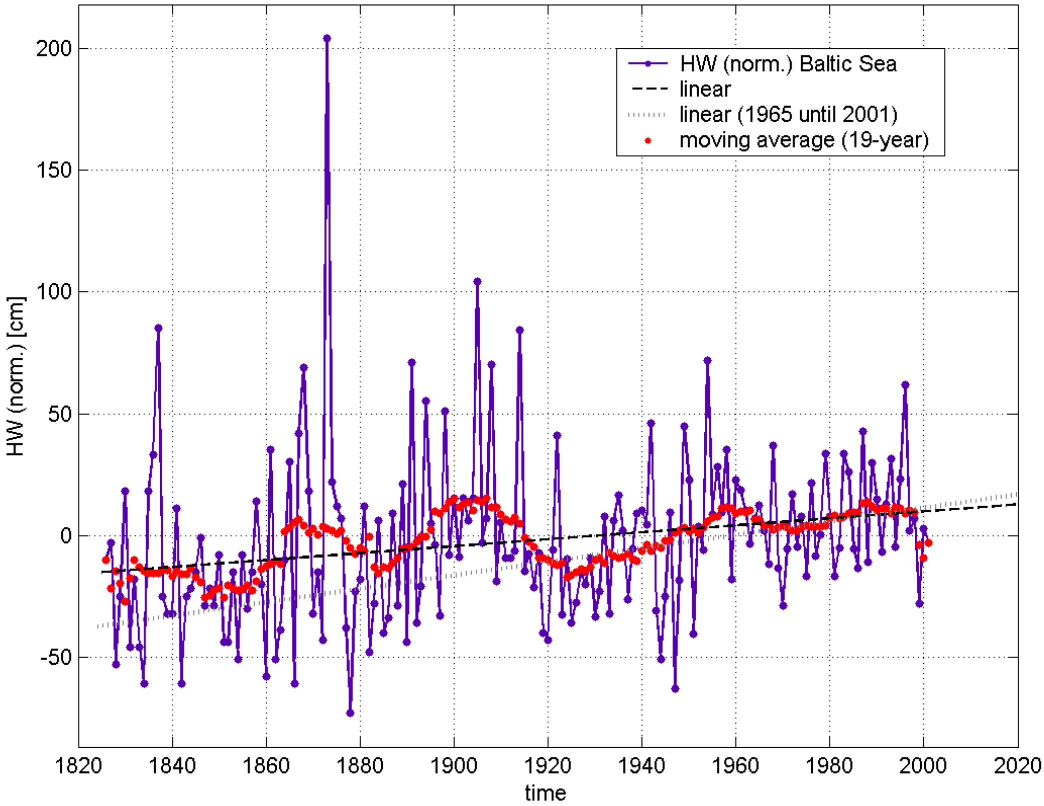

Figure 6: Time series plot of mean normalized gauge Southern Baltic Sea (HW) with moving average and linear trends

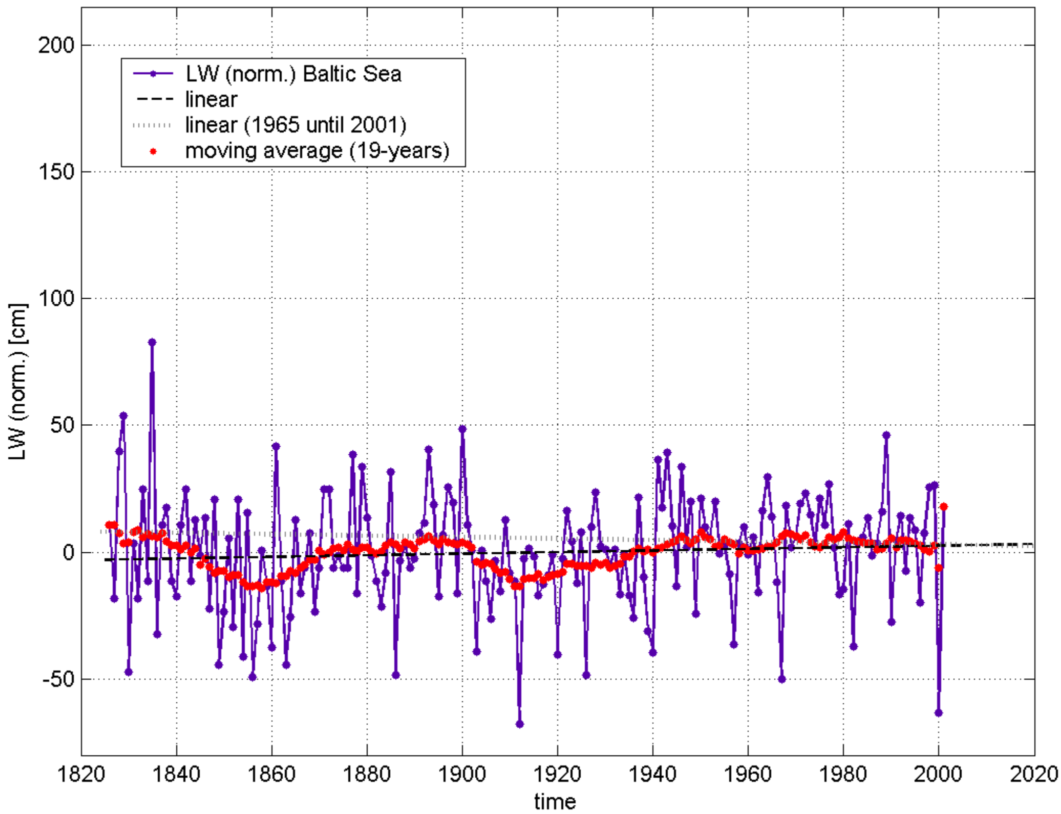

Figure 7: Time series plot of mean normalized gauge Southern Baltic Sea (LW) with moving average and linear trends

Another interesting question is, how the MW of the North Sea and the MW of the Baltic Sea are related to each other. Due to the small tidal range in the Baltic Sea, the Baltic Sea can be considered as a damped gauge of the North Sea. A correlation between the Southern Baltic Sea MW and the MW of the island-gauge North Sea shows these relationships (Figure 8). Within these correlation two spans of time are considered. The correlation from 1891 up to 1964 has approximately the same slope, than the correlation from 1965 until 2001. But it can be seen, that a parallel deviation of the correlation lines took place and so an indication for the rising water levels is given. Due to the slopes of the correlation lines it can be seen, that a buffering of the North Sea water levels in the Baltic Sea take place. More detailed statements about the correlation between North and Baltic Sea with annual values are not possible. For this questions further analysis with monthly or daily values are necessary.

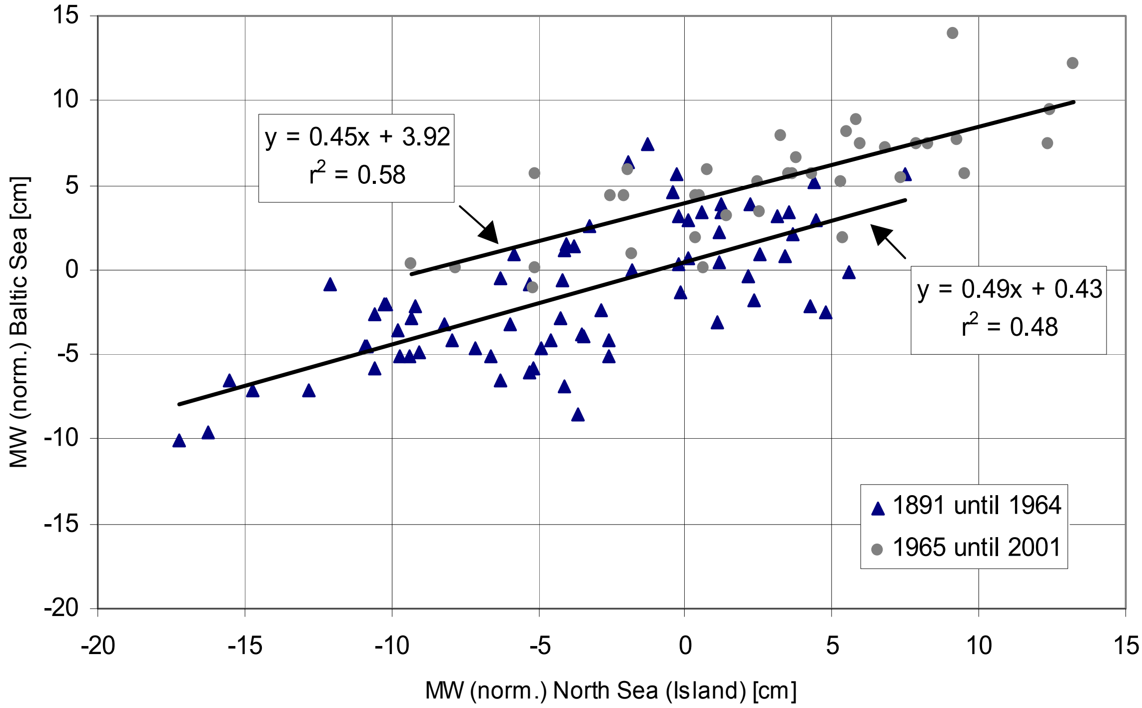

Figure 8: Correlation of MW (norm.) Baltic Sea and MW (norm.) North Sea (Island)

A comparison of the secular trends (1965 up to 2001) of the German North Sea (Island and Coastline) and the Southern Baltic Sea shows (Table 4), that the trends in the North Sea nearby equal (approx. 19cm /100 years) and the trend of the Baltic Sea is much smaller (11.4 cm/100 years). By the interpretation of this results must be considered, that the MW of the Baltic Sea and the North Sea namely are comparable, but not equal in detail because of the different definitions of the Mean Water Level. Nevertheless the results are important and expressive.

Linear trends	**linear trend (1965 – 2001)**
MW (norm.) North Sea Island	19.5 cm/100 years
MW (norm.) North Sea Coastline	18.8 cm/100 years
MW (norm.) Southern Baltic Sea	11.4 cm/100 years

Table 4: Comparison of secular trends of the German North Sea and Southern Baltic Sea coastlines

4 Conclusions

The results of the present investigation basically confirm the investigations of the IPCC 2001 concerning the rise of the mean water levels. For practical questions, the knowledge of specific trends of the water levels at the different gauging sites is of special importance. With the aid of this investigation, such questions can be answered better.

The results show, that the Mean Sea Level of the Southern Baltic Sea is increasing. The intensity of the rise in the Baltic Sea and the rise of the North Sea is different, but it can be recognized that the Mean Sea Level is increasing more strongly in the last 40 years. These analysis show, that a further rise of the MW and HW in future can also be expected All results lead to the assumption, that the tidal dynamics in the North Sea, and thus also the water levels in the Baltic Sea, have changed or are still changing.

The trends of the water levels have to be observed and analysed exactly in future. Further investigations are needed.

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Impacts of sea level changes on coastal regions – a local study for SEAREG

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Abstract

SEAREG analyses socio-economic and environmental effects of climate and sea level changes in the Baltic Sea Region (BSR). The result of the project will be a decision support frame which is addressed to planning authorities. Within the project, the Swedish Meteorological and Hydrological Institute (SMHI) develops scenarios of future climate and sea level for the year 2100 which will then be connected with regional data. These are morphological data for calculating the coastal dynamics and an elevation model to search for flood-prone areas.

Coastal dynamics was estimated for the next 100 years, considering the island of Usedom as an example. The changes of the historical shoreline of Usedom were determined by maps and aerial photographs from the year 1825 up to now. The results show an abrasion of 216 metres at Streckelsberg and an accumulation up to 185 metres at Ahlbeck in the last 175 years. Future coast lines were calculated with the model of Wagner (1999). Data of the different SMHI climate scenarios were used for this calculation.

A high resolution elevation model of the Island of Usedom was generated to estimate flood-prone areas depending on different sea level rise scenarios. The potential flood-prone areas was intersected with economical and ecological data sets. Two types of results were produced for the planning authorities, firstly maps and tables showing the affected economical and ecological areas and, secondly, a classification map of the affected areas to establish a priority list of actions.

1 Introduction

The discussion about the future evolution of the sea level and its consequences is getting more important. While previous models were concentrated on global sea level changes, the project SEAREG is focusing the local relationships of the Baltic Sea Region. The main goal of the project is to develop the Decision Support Frame (DSF) for planning authorities (see article Staudt et al. in this booklet). The Swedish Meteorological and Hydrological Institute (SMHI) calculated future climate and heights of sea level up to the year 2100 on the basis of two different models. Both models are used for different scenarios. The possible physico-geographic and socio-economic consequences of these scenarios were estimated and discussed for the Usedom Island. The aim of the first part was to find a practical method to calculate the future development of the outer coast. In the second part a geographic information system (GIS) shall be implemented in a DSF. However, these methods shall be transferable to other coastal regions.

2 Investigation area

The Island of Usedom is the easternmost part of the West Pomeranian coast. The area of interest extends from the Peenemünder Haken up to the Polish border with approximately 406 km² and a coastal length of 231.5 km (41.5 km sea coast, 190 km lagoon coast). The island consists of Pleistocene sediments and Holocene deposits (fig. 1). During the Littorina transgression the sea level rose rapidly from -20m at around 7800 BP to –2 m at 5800 BP (Lampe 2003). Afterwards it became more stable, rose with only minor oscillations to about –0.5 m at about 1000 BP. In this period abrasion material was deposited in bay-like depressions, building barriers, on which dunes were built up. During the following sea level rise peat has accumulated on sheltered lowlands behind the dune belt. Drainage of fenlands started in the 19th century which initiated peat degradation. The surface of the fenland is now at or below the sea level due to strong decomposition. The area is mainly used for tourism, farming and forestry. While tillage predominates on the moraine areas, the peatland is used as grassland and feedlot.

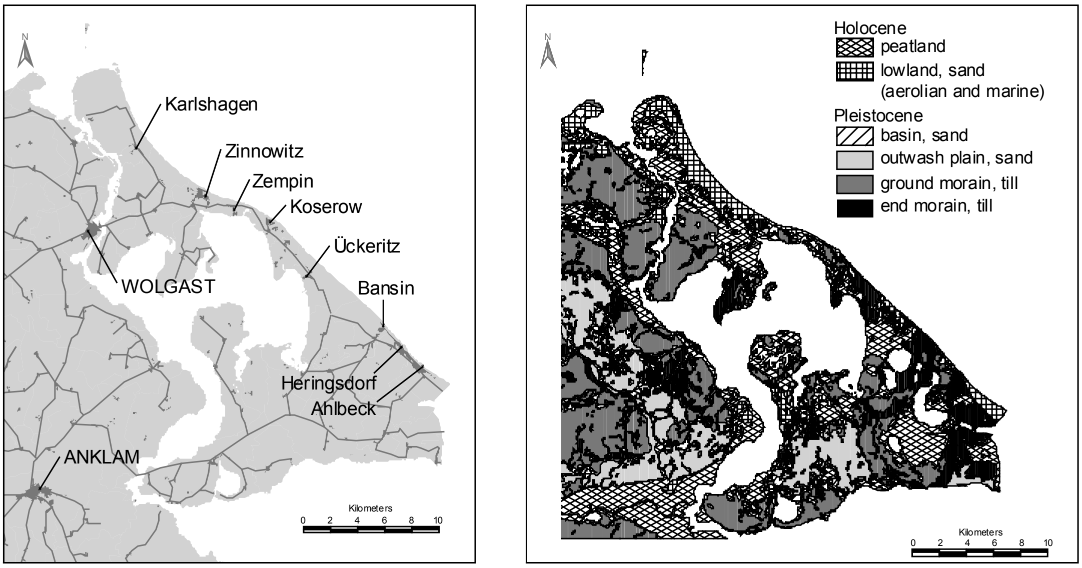

Figure 1: General and geological maps of the Usedom Island.

3 Evolution of the sea coast

The sea coast of Usedom is characterised by processes of accumulation and abrasion. In spite of abrasion and exposure to storm floods nine settlements are located close to the sea and require coastal protection for many decades. The government of Mecklenburg-Vorpommern invested 202.6 million € in coastal protection from 1991 to 2002 (STAUN 2004). Therefore, future development of the coast is of great interest. To get information about the magnitude of accumulation/abrasion historical maps and aerial photographs were evaluated from the past 200 years. In a second step abrasion and accumulation rates were calculated for the next 100 years combining methods of Wagner (1999) and Stephan & Schönfeldt (1999). The practical application for planners is discussed in paragraph 3.3.

3.1 Coastal evolution during the past 200 years

Methods

Romond (1993) investigated the coastal change since 1695, using historical maps. We revaluated this material using Arc View, which lead mainly to higher accuracy of the data. However, the revaluation started with the map from 1829, because the Swedish maps of 1695 are inaccurate in many details.

The following maps and aerial photographs were used:

Preußisches Urmeßtischblatt	1829
Meßtischblatt	1885
Hansa Aerial Photograph	1937
Aerial photograph	1998

Some problems such as the low number of bench marks needed for georeferencing of historical maps, distortions due to the scanning process, faults on historical maps and arguable delineation of shorelines on aerial photographs could not be solved completely and restrict the attainable accuracy.

The maps and images were scanned and combined to a coherent picture using Photoshop software. These pictures were then georeferenced in Arc View 3.2 with extension Image Warp, using the Topographical Map 1:10.000 (Transverse-Mercator projection with Bessel ellipsoid) as base map. Afterwards shorelines, cliff edges, cliff and dune bases were digitised. The distances between the lines were measured every 250 m.

Results

Changes of coastlines

Despite the described problems, the results might give a quite realistic picture of the evolution during the last 200 years. Figure 2 shows the historical shorelines. Therefore, the Usedom sea coast can be divided into 3 morphodynamical sections: northwest Usedom from the Peenemünder Haken to Zempin, central Usedom from Zempin to Heringsdorf and southeast Usedom up to the Swina barrier.

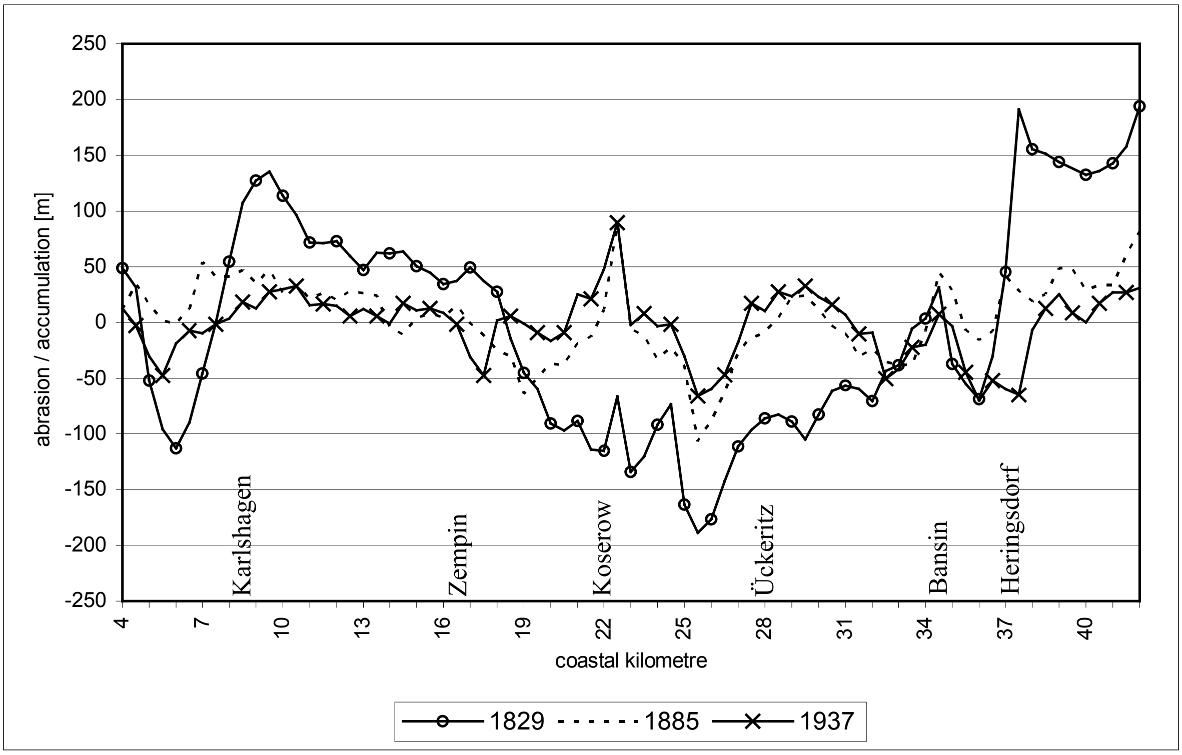

Figure 2: Shoreline changes since 1829, 1885 and 1937 (the x-axis represents the shoreline of 1998).

The sections can be described as follows:

Northwest Usedom (up to the coastal kilometre (ckm) 17.50) is characterised by accumulation, which increases from southeast to northwest. The average accumulation rate between 1829 and 1998 is 0.23 m/yr. The highest one occurred in the period from 1829 to 1885 amounting to 1.87 m/yr (ckm 8.75). However, an area of abrasion can be observed at Kienheide (ckm 6.00) with a length of approximately 3 kilometres. The transition to central Usedom is located in the section between Zempin and Lütten Ort and marks the change from accumulation to abrasion.

Central Usedom (17.50 – 36.00 ckm): This coastal section is characterised by cliffs with a maximum height of 56 metres at the Streckelsberg near Koserow. The average abrasion rate is 0.47 m/yr with a maximum of 1.14 m/yr at Kölpinsee. South-eastwards of Kölpinsee an accumulation area is attached up to Bansin. Again abrasion predominates between Bansin and Heringsdorf.

Southeast Usedom (from ckm 36.00 on): The average accumulation rate is 0.86 m/yr with the tendency to rise in eastern direction. In the period 1829 - 1885 the highest increase can be found.

Dynamical interactions

The comparison of the abrasion and accumulation rates between the three periods shows temporal variations of coastal behaviour (fig. 3). Several reasons are responsible for these differences:

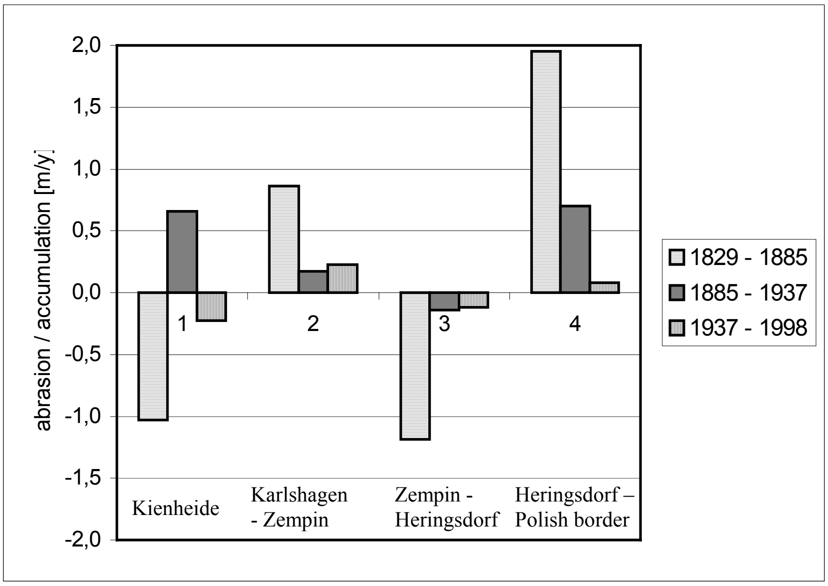

Figure 3: Shoreline changes of the areas northwestern Usedom (Kienheide and Karlshagen to Zempin), central Usedom (Zempin to Heringsdorf), southeastern Usedom (east of Heringsdorf) in the periods 1829 to 1885 (1), 1885 to 1937 (2) and 1937 to1998 (3).

Coastal protection

Especially coastal protections off the Streckelsberg cliff near Koserow have affected all other coastal areas of Usedom and the recent coastline does not show natural dynamics. In 1865 a fascine fence was constructed off the Streckelsberg and in 1895 the first wall was built at the toe of the cliff. The accumulation rates of northwestern and southeastern Usedom were much bigger in the period between 1829 and 1885 (period 1) than in the periods between 1885 and 1937 (period 2) and between 1937 and 1998 (period 3). The accumulation peaks at the Streckelsberg during the 2nd and 3rd periods were caused due to the construction of detached wave breakers and sand nourishments (1996) (fig. 2, ckm 22,00). Another example is Lütten Ort, a place near the village Zempin. In the last 300 years there have been 8 breakthroughs caused by storm floods, which were all closed artificially (Schumacher 2003).

Wave direction

The amount of sediment transported depends on wave power and direction. Both are coupled with wind directions and fetch. Stephan & Schönfeldt (1999) compared wind data of the term 1885-1939 to those of the term 1940-1984. The authors concluded that in the term 1940-1984 the wind from east and south increased and the wind from west and north decreased, which could cause alterations in sediment transport directions and quantity. Therefore for every 250 m along the Usedom coast the angle of the shoreline normal related to North was determined (fig. 4). The curve shows, that the angle has the highest value in the northwestern part of the island. The area Kienheide is located there from ckm 4 to ckm 7.25, where a change from accumulation (1885-1937) into abrasion (1937-1998) took place (fig. 3). Probably this phenomenon can be explained by the wind alteration observed by Stephan & Schönfeldt (1999).

Isobathes

The inclination of surf zones is another factor influencing the wave energy. To evaluate this factor the distance between the shoreline and the 10 m isobath was determined and depicted in fig. 4. The 10 m-line forms a "funnel" in the area off Kienheide. Also, the 10 m isobath off Kölpinsee is closer to the coast than in the west or east of this section. This steeper shoreface, caused probably by the spatial distribution of sediments of different resistivity, allows that higher wave energy can affect these sections.

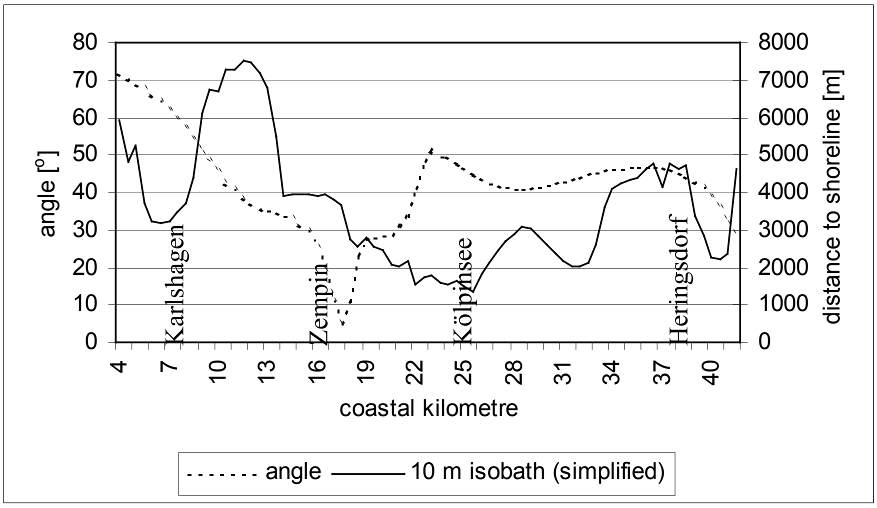

Figure 4: Angle of shoreline normal related to North and distance of the 10 m isobath to the shoreline.

3.2 Calculation of accumulation and abrasion rates by means of coastal evolution models

The coastal form is influenced by the action of wind energy, waves and currents as well as by the sea-level rise and anthropogenic impacts. Several methods exist to calculate dynamic processes of coasts, e.g. those of Stephan & Schönfeldt (1999) or the program GENESIS. The aim was to find a practical method to predict a one hundred year evolution of the sea coast of Usedom. It should be a method which can be applied flexibly to the data available. The methods mentioned above have proved to be unsuitable for this. E.g., the methods are very complex because many initial parameters are needed. However, a method from Wagner (1999) was used for the calculation of the theoretical sediment transport of sandy sediments.

Methods

The following data were available for the calculations: Wind time series with speed and direction of the 4 SMHI-scenarios for the period 2070 to 2100 as well as for the two control runs between 1960 and 1990; data of the wave model SGBAL from Germany's National Meteorological Service (Deutscher Wetter Dienst - DWD) for the time period between 1995 and 1999 (DWD 1995) with wind speed, wind direction, wave height, wave direction and peak periods (no data were available for a longer time period). Measured wind data from the station Arkona (Rügen Island) were used for comparison. The SMHI calculated 3 scenarios of sea level changes for the next 100 years (1cm, 41 cm and 82 cm rise). A sea level scenario with 24 cm was also used, which was published by Stigge (2003). Topographical maps 1:10.000 were used as georeferenced grid data.

Classified wind speeds and directions (12 classes each) were used for the consecutive calculations. The four SMHI scenario data sets were subtracted from the data of the control runs to identify changes in the scenario wind distributions. These changes were added to the DWD-1995 data set to obtain forecast data for the year 2100, leading to four different data sets (DWD-2100 a-d).

In the next step the theoretical sediment transport along the sea coast was calculated using a method described by Wagner (1999). Due to the NE-exposure of Usedom´s coast only 6 wind categories from

150o to 300o were used in the following calculations. From the calculated sediment volume [m³a-1] the annual shoreline shift was estimated according to Stephan & Schönfeldt (1999) and extrapolated for a 25-year period and 250 m sections, from which a new shoreline could be constructed. Shoreline changes were calculated with DWD-1995 data set for the next two 25-year periods. For the two periods 2050-2075 and 2075-2100 the 4 DWD-2100 scenarios were used. The shoreline shift caused by sea level change was calculated separately and added to the previous results (Stephan & Schönfeldt 1999).

Results

The DWD-2100d scenario is believed to be most probable whereas the DWD-2100a scenario has the lowest probability (see article Staudt et al. in this booklet). In the following only these two scenarios were considered. Figure 5 shows the calculated wind distribution. The impact on Usedom is higher in DWD-2100a because this scenario predicts a higher probability of easterly winds. That means, that coasts with an exposure to the West will experience a higher impact in the DWD-2100d scenario, e.g. the coasts of Fischland, Darss and Hiddensee Island. Similar results were found in the distributions of wind speed in the two scenarios.

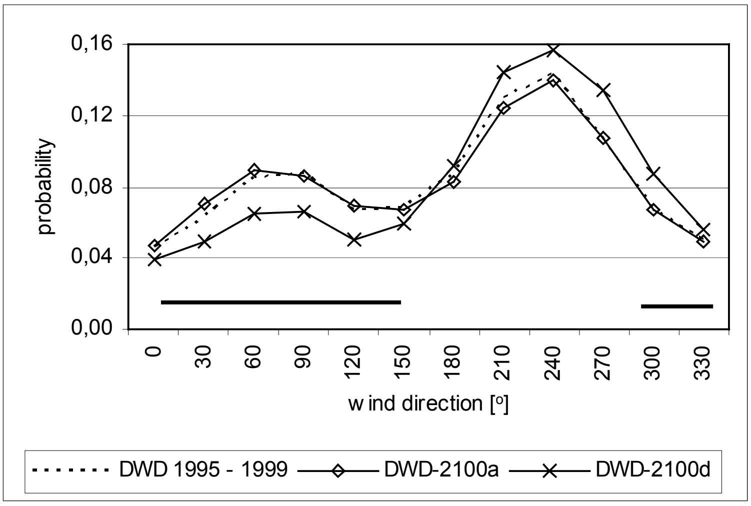

Figure 5: Comparison of the probability of wind distributions. The bars show the wind directions, relevant for Usedom´s sea coast.

For the less probable, but less favourable scenario DWD-2100a the coastline changes were calculated for three different sea-level rise predictions (fig. 6). The shoreline of the scenario with 0.01 m rise show no significant changes compared with the scenario with no rise. In case of a 0.82 m rise three areas would experience approximately 50 m additional abrasion. They are located around Zempin/Lütten Ort, Ückeritz and Bansin.

The results show that the trend in the coastal evolution observed in the historical record will continue in the next 100 years. Only for the area around Kölpinsee a contrary trend was found. Due to the exposition of the coastline to the prevailing wind direction accumulation was predicted, instead of the abrasion observed.

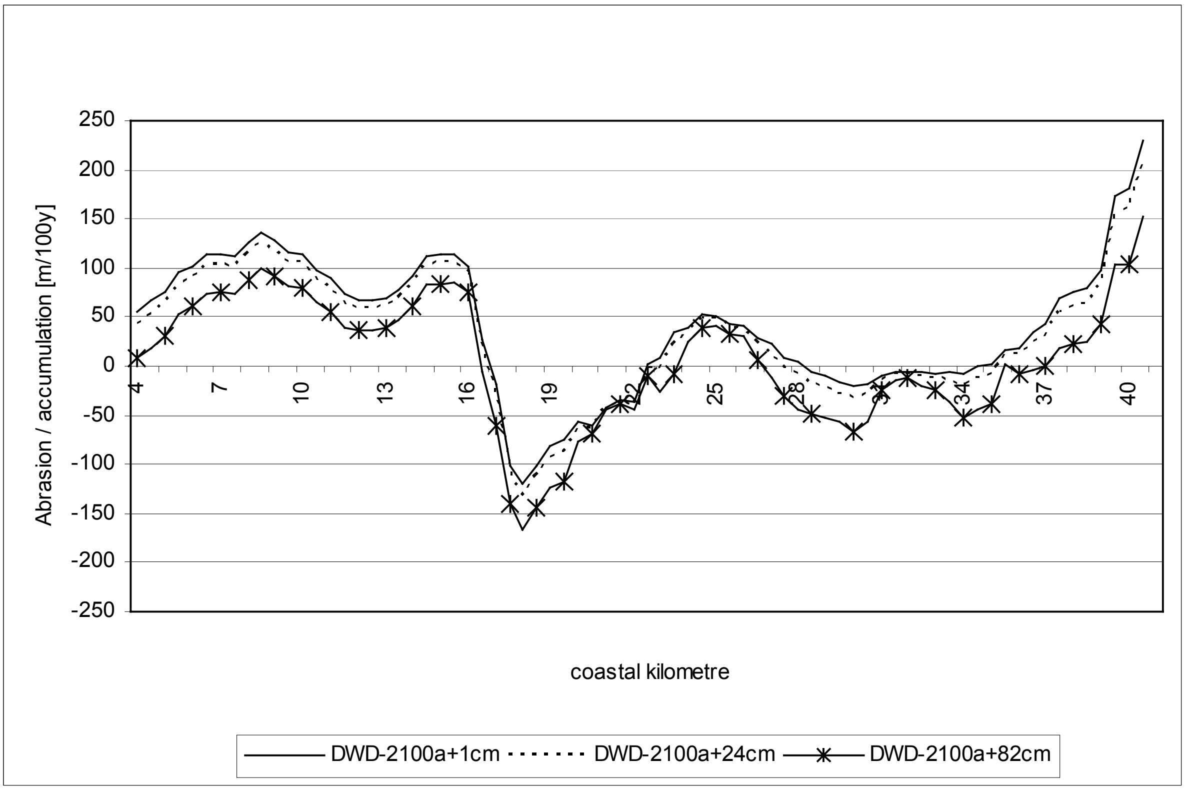

Figure 6: Impacts of different sea level rise scenarios calculated by the climate scenario DWD-2100a.

3.3 Application for planners

The application of the results could be carried out in two ways:

1. The historical evolution can be integrated as a theme into a GIS. Used in a GIS application as programmed by Röber (see below) the planner would be enabled to evaluate the evolutionary trend of a coastal area to be developed.
2. The methods to calculate future shoreline evolution should be integrated into a computer programme, which allows easy adaptation to other coastlines and climate scenarios. The results could then be presented as GIS themes and may be used in subsequent GIS applications.

4 Implementation of a geo information system in the Decision Support Frame

The aim of Part II of the local study Vorpommern is a GIS supported vulnerability assessment of endangered areas. This analysis shall enhance the reproducibility of decisions by planners and other actors for their own authority and district.

4.1 Data base

At the first step recent data, which are available for planners, have been analysed. There are two focuses: the first is a high resolution elevation model and the second is a high quality regional thematic data set.

For the region Vorpommern (or parts of it) several elevation models are available, for example:

GTOPO 30 - from the United States Geological Survey (USGS),

DGM 50 - from the state agency of country survey,

Greifswalder Bodden model - from the University of Greifswald,

Island Usedom - from the State Agency of Nature and Environment.

None of these models has the required geometrical resolution and map projection. Therefore a new model was produced on the basis of the Topographic Map 1: 10 000.

The thematic data sets are very heterogeneous in their geometric accuracy and in their information content. E. g. the data set "BNTK" (biotope type and land use map) is very accurate and available for the whole federal state Mecklenburg-Vorpommern. The dataset "ATKIS-DLM" (digital landscape model, cartographic vector data) is also available, but there are many overlaying polygons which may cause problems during the calculation of area sums etc. The data sets from the Agency for regional planning Vorpommern cover their own planning region. Two data sets of them have been tested, the set of the regional spatial plan and the one of the automatic planning cadastre.

4.2 GIS as a tool for DSF

The analysis of all these data sets leads to the second step: an open tool for processing several data sets from different actors. The processing result is a map which displays a vulnerability assessment on the basis of used data.

"Open tool" means, that the user can choose the method, the data, the area of interest, the resolution and the predicted sea level change.

The implementation from a GIS in a DSF will be realised with Avenue in Arc View 3.2.

The choice of different input themes is necessary to open the tool for actors from different authorities and countries. The data analysis has shown that each country and each office has its own data structure and so it is not possible to determine a fixed data structure on the input side.

The choice of resolution (a raster of squares) and area of interest (states, counties, parishes or land use plans) enables the user to produce different levels of analysis results.

The choice of sea level change (in 5 cm steps) means that the user can adapt his results to the current prognosis of climate changes and sea level changes or he can analyse all areas below a defined elevation level.

There are three methods of classification – an absolute, a relative and a verbal one. The tool reads the objects from the input theme and the user fills in or loads a table of assessment. The values of the table are cash value per hectare for absolute classification, factors for the relative and a fuzzy scale (very low, low, middle, high, very high) for the verbal classification. It is necessary to differ between dominate or highest value per square at the verbal classification.

The tool will standardise the single theme results for analysing many themes for one result map before they will be merged together.

Figure 7 shows four steps of processing: a) the input theme (BNTK from NW Island Usedom), b) a set of communities, c) sea-level rise by 70 cm and d) a classification of endangered areas with a resolution of 250 m.

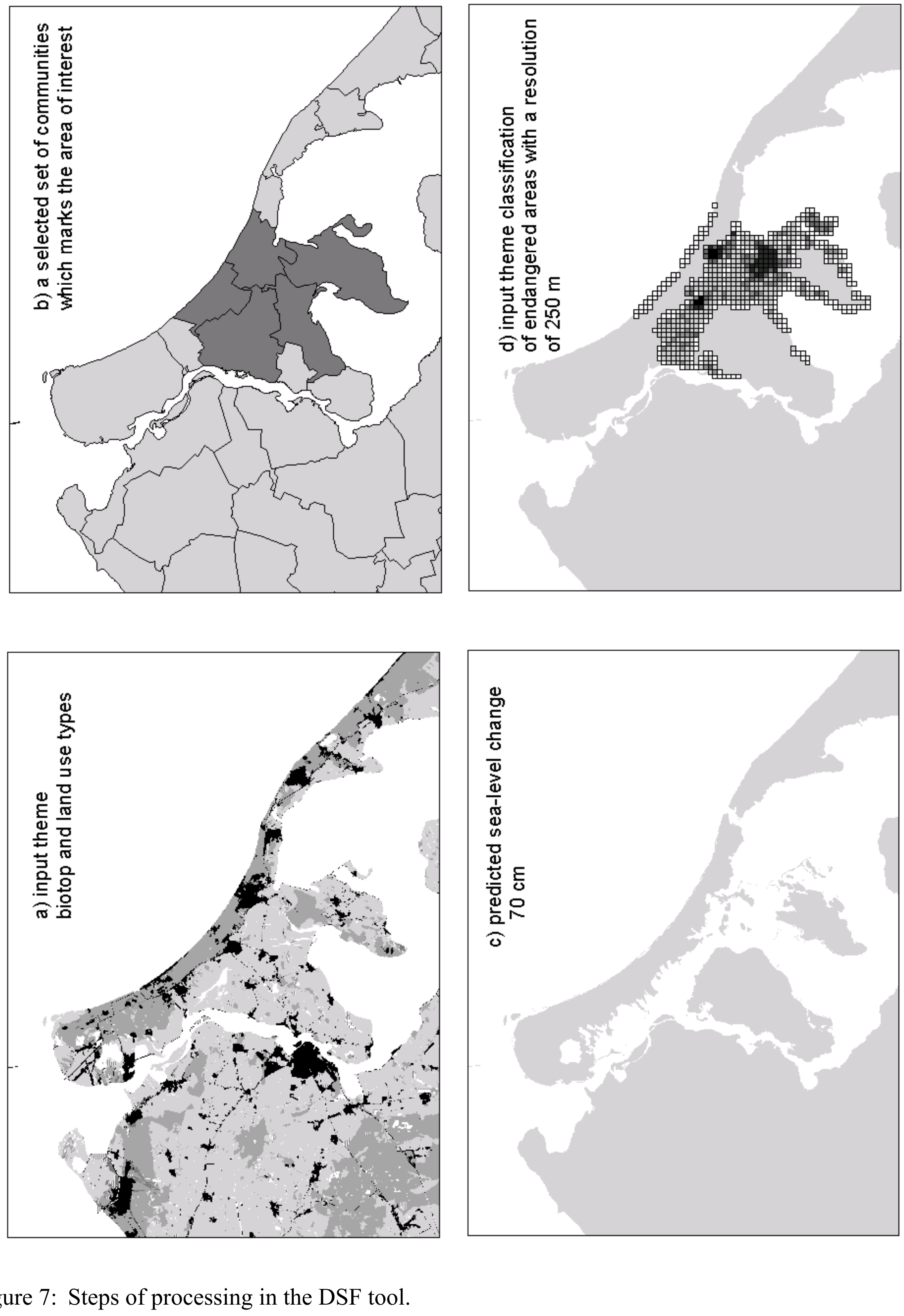

Figure 7: Steps of processing in the DSF tool.

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Modelling a future sea level change scenario affecting the spatial development in the Baltic Sea Region – First results of the SEAREG project

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Abstract

This article summarizes the first results of the Interreg IIIB project "Sea Level Change Affecting the Spatial Development of the Baltic Sea Region" (SEAREG). The effects of climate change scenarios have been widely discussed in public and within the scientific community in recent years. The SEAREG project addresses socio-economic and environmental aspects of sea level rise in the Baltic Sea region (BSR) by finding appropriate applications of climate modelling in local and regional planning systems. A rise of the sea level might lead to major flooding events, having severe impacts on the spatial development of cities and regions of the BSR. One basic task in the SEAREG project is to outline the major impact zones caused by sea level rise in the Baltic Sea region by using GIS-based methods. Ocean model and land uplift rate are factors that must be taken into account in addressing flood prone areas. The Swedish Meteorological and Hydrological Institute (SMHI) utilized two emission scenarios (A2 and B2) by IPCC to calculate the RCAO model (Rossby Centre Atmosphere Ocean model). Superimposing this ocean model with a digital elevation model as well as land use data, the effects and spatial extent of sea level change can be evaluated. The results are grid based cartographic presentations showing estimates of sea level changes 100 years after present. In cooperation with spatial planners the e project is developing a Decision Support Frame (DSF) for impact and vulnerability assessment. The DSF will address planning authorities, decision makers and stakeholders in the case study areas and in the BSR cooperation on spatial planning in general.

1 Introduction

Currently it is widely understood that the earth's climate is warming up and the sea levels are rising. The question is, in what speed and to what extent the climate will get warmer. Climate modelers therefore try to inform about the trends in climate change and assist in delineate areas that could be affected by sea level rise and/or flood patterns in 100 years time.

Within the SEAREG project a regional climate model (RCAO-hca2) has been applied to calculate future sea level changes for the Baltic Sea, applying two global general circulation models (GCM) to represent the recent climate (time slice 1961-1990). Applying two control simulations, four future climate scenarios are produced, based on two different emission scenarios called A2 and B2 that predict a time slice 2071 to 2100. The A2 scenario assumes larger and continuously increasing emissions of the major anthropogenic greenhouse gases. The B2 scenario predicts a slower increase of these emissions. In the B2 scenario the air temperature rise amounts to 2.4º and 2.6º C and in the A2 3.3ºC and 3.4ºC, respectively, depending on the global general circulation model used.

In the SEAREG project the following models/ emission scenarios are used:

- HadAM3H from the Hadley Centre (U.K.) (GCM)
- ECHAM4/OPYC3 from the Max Planck Institute for Meteorology (Germany) (GCM)

- RCAO (The Rossby Centre of the Swedish Meteorological and Hydrological Institute (SMHI) produces the regional model used in the SEAREG project. The model is limited to Europe, Fennoscandia (including some parts of the North Atlantic) and the Baltic Sea.)
- A2 and B2 future emission scenarios (provided by the Intergovernmental panel for climate change (IPCC))

The results of the models will be downscaled and plotted into regional and local maps. The maps will be discussed with planners. This dialogue shall lead to a better understanding on both sides with the result that scientists understand how planners can make better use of their models.

1.1 Calculating future sea level change in the Baltic Sea Region up to the year 2100

The two most important factors affecting the mean sea level on the Baltic Sea coast are the land uplift and/or land subsidence on the one hand and the global mean sea level rise (eustatic rise) on the other hand. The relation between these two determines, whether the sea level is generally rising, maintaining stable or lowering in relation to the present coastline (Johansson et al. 2001).

1.2 Baltic Sea wide land uplift

The land uplift data used in the project are based on the research introduced by Ekman in1996. Ekman's consistent map of the recent postglacial rebound of Fennoscandia was constructed on the basis of sea level records, lake level records and repeated high-precision levellings. The sea level records Ekman used are based on 56 reliable tide gauge stations around the Baltic Sea with time series spanning 60 or more years of observation. A fairly smooth apparent uplift (uplift relative to mean sea level) is shown from a maximum rate of 9.0 mm yr-1 in the north of the Baltic Sea to minimum rate of -1.0 mm yr-1 (i.e. land subsidence) in the south (see Figure 1) (Ekman 1996).

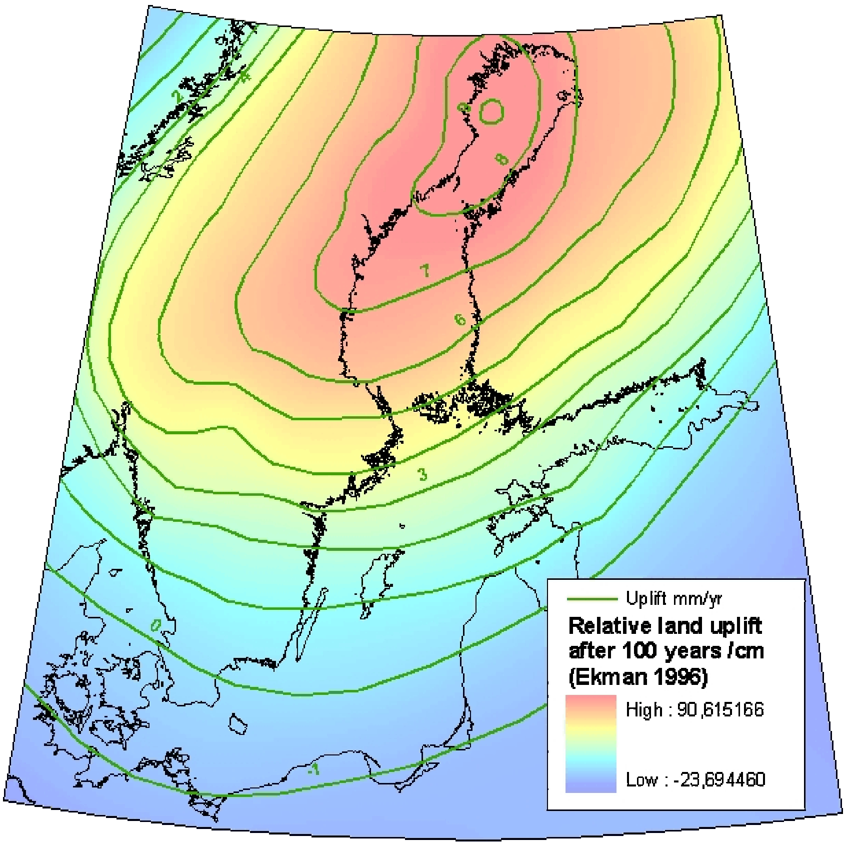

Figure 1: Ekman's consistent map of the recent postglacial rebound of Fennoscandia (1996).

1.3 Changes of the mean sea level

A general rise of the mean sea level is observed since the beginning of the 20th century. This rise has been linear in the limits of observation accuracy (Johansson et al. 2002). The current estimate for the rise amounts to 1-2 mm yr^{-1}, according to Church et al., 2001. The eustatic rise chosen in this project is 1.5 mm yr^{-1} (Gornitz 1995). In the future, the linear behaviour of the global mean sea level might change. According to the Third Assessment Report of IPCC the sea level will rise 9-88 cm from the level of 1990 up to the year 2100 (Church et al. 2001). The RCAO-hca2 average model within the SEAREG project takes into account this past time linear sea level rise as well as the future accelerated rise. The sea level rise, in general, is and will be mainly caused by thermal expansion (Church et al. 2001). The modelled accelerated sea level rise (RCAO-hca2, upper limit) for the Baltic Sea is shown in Figure 2.

To calculate the mean sea level rise up to the year 2100, both, the land uplift layer and the mean sea level rise layer should be converted to represent the situation relative to geoid. The geoid is usually defined as the equipotential surface (level surface) in the Earth's gravity field that coincides with the mean sea level of the ocean. Because mean sea level is almost an equipotential surface but not quite, the national height systems are located in potential surfaces that slightly differ from each other (Ekman, 1994). It is necessary to adopt a height system that is common to the whole area. Ekman presents a unifield height system (NH60) designed for comparisons between geodesy and oceanography for the Baltic Sea area (Ekman et al. 1994).

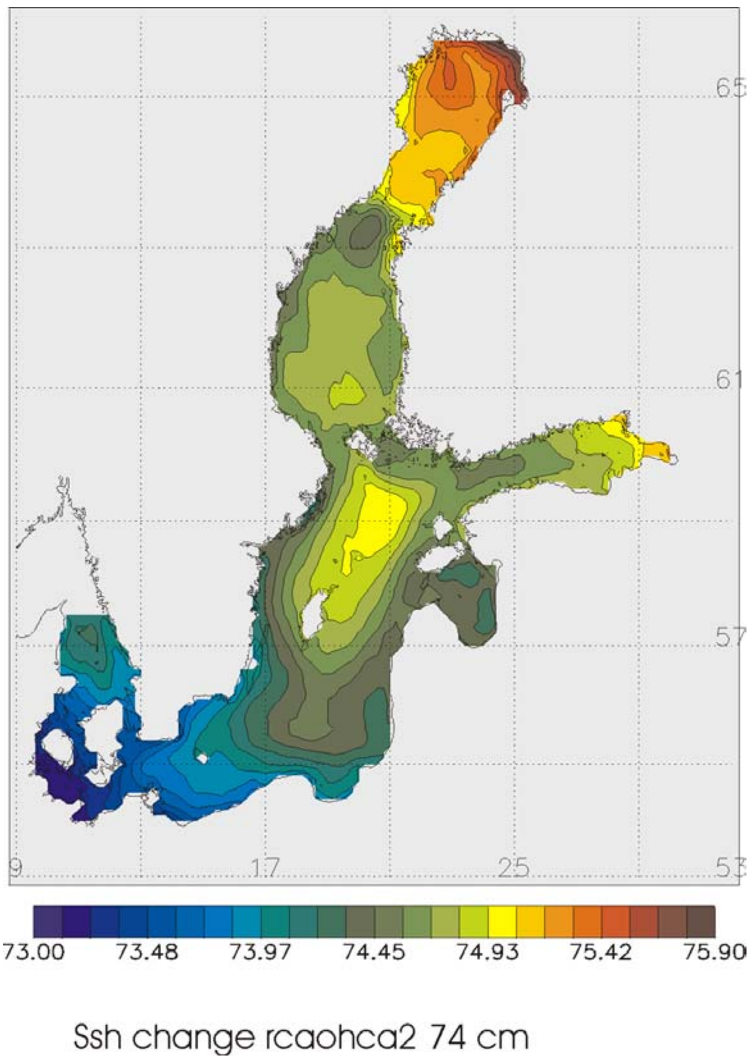

Figure 2: Calculated change of SSH (modelled) for sea level rise up to the year 2100.

2 Results

The sea surface height change (SSH) for the RCAO-hca2 model already has its zero level in the NH60 equipotential surface and there is no need for any conversion. The land uplift was calculated relative to the mean sea level, not the geoid. This leads to a situation where land uplift rate seems to be lower than it really is, because of the continuous rising mean sea level. The following steps were taken to gain the resulting overview map of sea level rise after 100 years in the Baltic Sea Region (Figure 3):

- The land uplift relative to the mean sea level is summed up with eustatic sea level rise to get *the land uplift relative to geoid.*
- *The land uplift relative to geoid* will be subtracted from the SSH change for the RCAO-hca2.

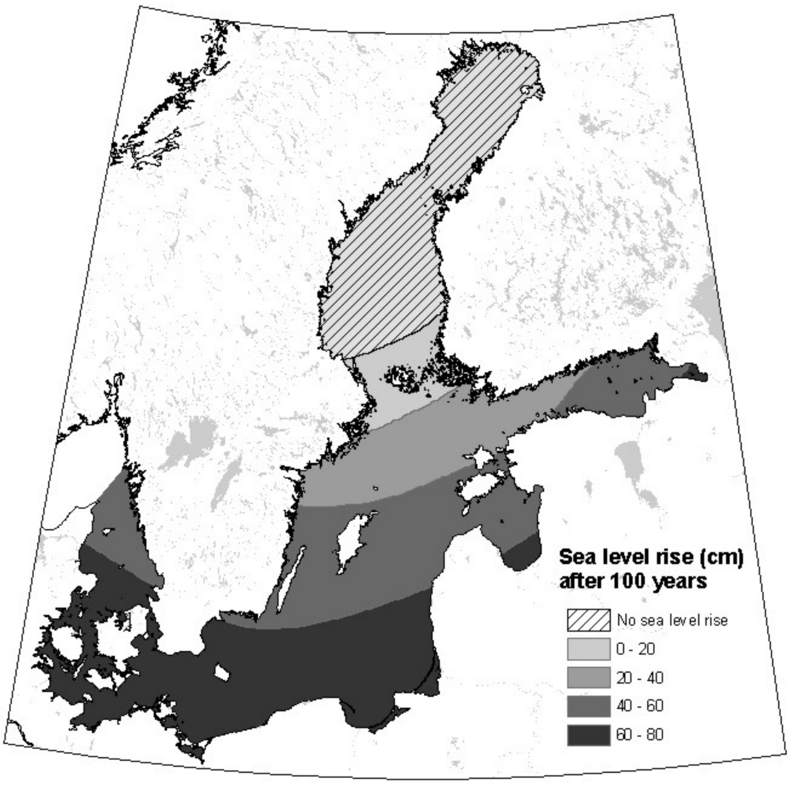

Figure 3: Overview map of sea level change up to the year 2100.

The resulting map shows five major zones illustrating that the future sea level rise in the Baltic Sea is declining form the south coast towards the north. The center of the uplift experiences no sea level rise (Bothnian Sea).

3 Discussion

To estimate the impact of uncertainties of the global and regional model results and of the emission scenarios of anthropogenic greenhouse gases SMHI calculated three sea level scenarios. For the first overview map only the "worst case" scenario was used applying the regional model results with the largest sea level increase (RCO-hca2) together with the upper limit for the global mean sea level rise of 88 cm (Church et al. 2001). However, one should keep in mind that the projected sea level rise in the global IPCC scenarios on the regional scale differs significantly (Church et al. 2001).

As all model predictions of the future, also the downscaling process from the overall BSR model scenario to regional and local scale contains uncertainties. In the several case study areas the different sea level rise scenarios will be applied at local scale (1:10 000). The SEAREG project develops a Decision Support Frame (DSF). This DSF contains a vulnerability assessment that analyses possible impacts of sea level rise, including the coping capacity of the studied areas. The DSF is further described in Klein et al. "Sea Level Change and Spatial Planning in the Baltic Sea Region: findings of the SEAREG project", in this report.

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Sea Level Change and Spatial Planning in the Baltic Sea Region: findings of the SEAREG project

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Abstract

The SEAREG project (Sea Level Change Affecting the Spatial Development of the Baltic Sea Region) is financed by Baltic Sea Region Interreg III B programme and is focusing on socio-economic and environmental assessment of the effects of climate change on the sea level in the Baltic Sea region (BSR). A rise of the sea level can lead to major flooding events, having severe impacts on the spatial development of cities and regions as well as sustainable development of the entire BSR. The project has benefited from an intensive discussion with several local and regional authorities from the case study cities and regions of Helsinki, Stockholm, Gdansk, Pärnu and Greifswald. The main result of the project will be a Decision Support Frame (DSF) that addresses local and regional planning authorities in the case study areas and the BSR area. The DSF shows ways how spatial planning can take the impacts of modelled future environmental changes into account. The DSF consists of modelling and GIS applications, impact and vulnerability assessments, a knowledge base and a discussion platform. The cooperation and learning processes around the DSF shall help involved parties in understanding each others' points of views and motivations for taking action. The appropriate dissemination of the results shall consequently lead to adequate implementations of appropriate actions, such as ICZM in the case of sea level rise.

1 Introduction

One of the basic ideas of the SEAREG project is to improve the communication between planners, social and natural scientists. The development of a Decision Support Frame (DSF) enables decision making with a firm scientific background and supports finding appropriate measurements in case of sea level rise in the Baltic Sea Region (BSR). The DSF (Fig. 1) consists of four major parts amending each other: Modeling and GIS applications, Impact and Vulnerability Assessments, Knowledge Base and Discussion Platform (Schmidt-Thomé 2003).

1.1 Modelling and GIS Application

Sea level 100 years after present (2071 to 2100) is estimated based on a high-resolution regional ocean model taking into account local land uplift or subsidence rates. The sea level rise is projected referred to the NH60 equipotential surface. Two general circulation models (GCM) provide the boundary conditions for the regional ocean model accomplished by using two emission scenarios (A2 and B2) by IPCC. The modeling is further described in “Modeling a future sea level change scenario affecting the spatial development in the Baltic Sea Region -Findings of the SEAREG project”(Staudt et al., this report). In the case study areas of the project the gained data will be processed in a GIS environment and the areas of inundation and flood prone areas are outlined for each case study area (Schmidt-Thomé 2004).

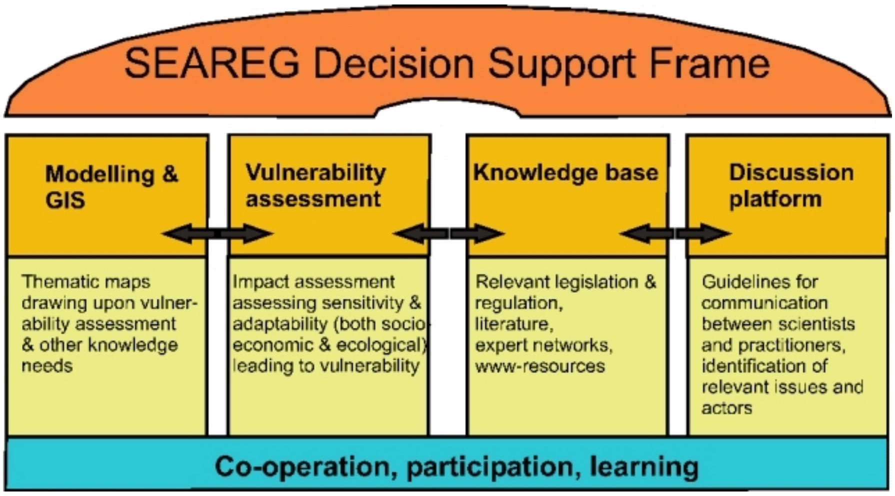

Figure 1: Basic structure of the Decision Support Frame

1.2 Impact and Vulnerability Assessment

The aim of the Vulnerability Assessment (VA) is to highlight endangerments due to future sea level change. It is carried out under the responsibility of local authorities and planners. To gain most significant results VA uses all sources offered by the DSF.

The GIS application provides a set of sea level rise maps, displaying the effects of sea level rise on an area. These maps are based on a digital elevation model (DEM) of the case study areas and a range of regional sea levels.

The first step of the VA is a screening assessment based on a screening matrix. The screening matrix gives a first overview on the possible impacts of sea level rise, clearly distinguishing the two main effects of general inundation by a risen sea level and resulting new flood prone areas. The screening matrix does not assess the impacts but serves as a checklist for the latter vulnerability matrixes.

The second step is the impact assessment that estimates the impact of the two main effects, inundation and flooding, to the socio-economic and ecological system. Whereas inundation and flooding depends mainly on the topography of a case study area, the impact considers the strong dependency on the properties of the affected entity. The socio-economic and ecological impacts are assessed jointly taking into account the strong interdependency of the two systems. The Knowledge Base and Discussion Platform contribute to enhance the results' reliability and acceptance among planners, stakeholders and decision makers.

The final step assesses the vulnerability. The vulnerability results from the possible impact and the capacity of an actor or organization related to the impacted entity, to withstand or to cope with it.

1.3 Knowledge Base

As Nicholls (1998) outlines a mismatch between available data, the level of effort and the sophistication of the assessment model lead in some cases to results that don't fulfill the expectations to the VA. The Knowledge Base as well as the Discussion Platform helps to balance the data availability, effort and expectations to the VA.

The VA requires best-available and possibly best-needed data and expertise. The knowledge base offers information about legislation and regulations and simplifies the access to expert networks, literature and www-resources.

1.4 Discussion Platform

The idea of the Discussion Platform is to analyze and enhance the communication process between planners and scientist and activate an exchange of information. Based on this analysis guidelines for communication are developed and relevant issues and actors identified. Instruments to analyze the communication process are round table discussions, e-mail questionnaires and interviews. So far three round table events were conducted. The participants of the first two round table discussions were either planners or scientists. In the third discussion scientist, planners and politicians took part (Schmidt-Thomé 2004).

2 Results

As the development of the Decision Support Frame and its implementation in the case study areas takes place at the same time, the results for the case study areas are in an unsettled status and will improve continuously.

2.1 Case Study Area Pärnu – Estonia

Figure 2 shows as an example of a sea level rise map. This map visualizes the upper edge of sea level rise modeled by the regional ocean model taking into account the local land uplift.

The screening assessment reveals further impacts besides the obvious land loss in Pärnu. Strong impacts are expected to the third sector, because Pärnu will lose major parts of the beach as a major tourist attraction. The current flood prone area during storm surges will move landwards according to the changed coastline. This will cause socio-economic impacts, affecting the infrastructure, industrial development and housing. Taking into account the present groundwater salinity a rising sea level will increase the problems of drinking water supply. Ecological impacts are caused by the loss of coastal habitat.

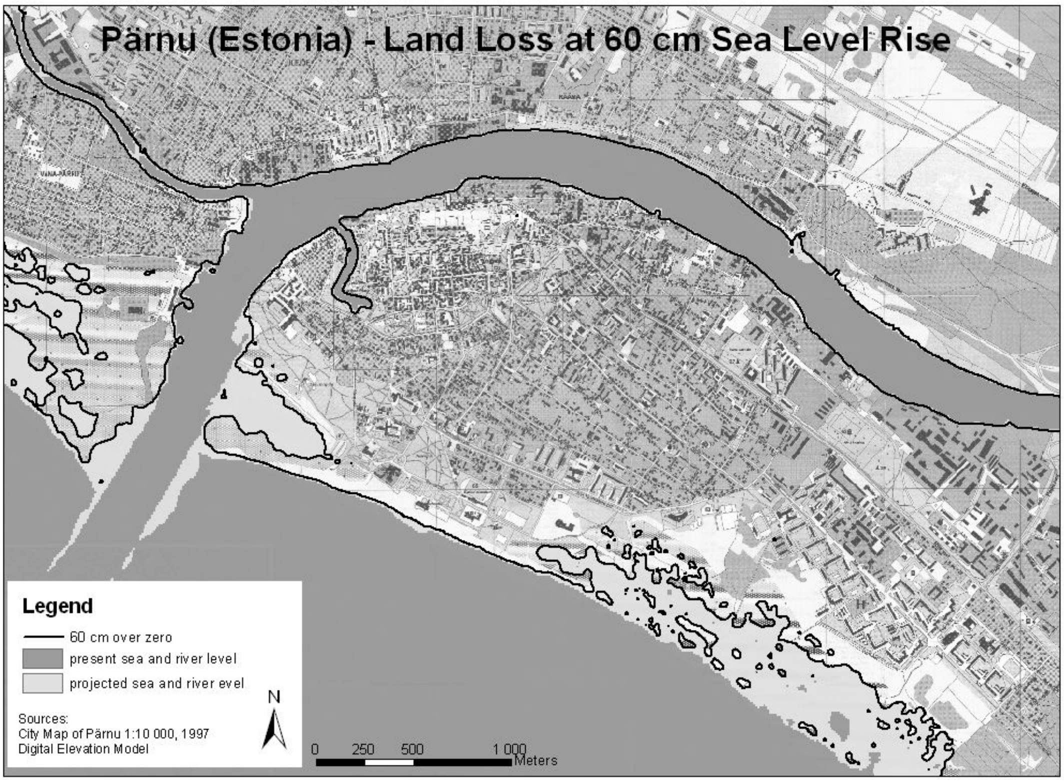

Figure 2: Preliminary map of Pärnu displaying land loss due to 60 cm sea level rise. This is according to the worst-case scenario provided by the regional ocean model and land uplift data.

3 Discussion

A main challenge of the DSF is the connection of climate modelling and spatial planning. The differences in scale are considerable. Although the regional ocean model down scales the information give by the GCM to a regional level, a remarkable gap in the exactness of spatial planning scales and climate modeling precision remains. Compared to the area of the City of Pärnu (about 50 km2) the climate model scales are very rough.

The VA is designed to cope with different quality and availability of data. However, the data availability may influence the outcomes of the VA for the case study areas. Whereas in Germany the ATKIS database (Amtliches Topographisch-Kartographisches Informationssystem) offers a consistent and extensive source of geo-data (see also “Impacts of sea level changes on coastal regions – a local study for SEAREG” Röber and Rudolphi, this report), the data for the Pärnu case study area derive from miscellaneous and partly unspecified sources.

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Operational hydrodynamic model as an environmental tool in the Oder Estuary

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Abstract

The Oder Estuary with a large Szczecin – Swinoujscie port is both of significant economical and recreational importance. So in the region it is important to improve safety of navigation and work in ports as well as protect against ecological hazards. To fulfil these tasks it is necessary among others to possess current information on hydrological conditions in the estuary. So a 3-D operational hydrodynamic model, developed at Institute of Oceanography, Gdansk University was applied in order to forecast hydrological conditions in the estuary. The model was based on the coastal ocean circulation model known as POM (the Princeton Ocean Model), which was adapted to the Baltic conditions and for the 48-hour digital meteorological forecast of ICM (Interdisciplinary Centre of Mathematical and Computational Modelling, Warsaw University). Because of backwater occurrence in the Oder mouth there was developed a simplified operational model of river discharge based on water budget in a stream channel. Linking the Oder discharge model with the hydrodynamic model of the Baltic Sea as one system made possible to simulate operationally hydrological conditions in the Oder Estuary. The model enables to forecast water levels, currents, water temperature and salinity in the estuary. Good agreement between observed and computed data allowed to consider the model as a reliable environmental tool. Quick access for hydrological forecast (on a website) allows potential users to take a lot of advantages of it in different areas of living.

1 Introduction

1.1 The research area presentation

The Oder Estuary, situated at the southern Baltic Sea, is of significant economical importance. The location of the large Szczecin – Swinoujscie port in the mouth of the Oder River and the convenient system of waterways linking Silesia with the Baltic Sea offer an excellent transportation opportunity. Navigation of ships and barges, the port operations such as transport, freight handling and storage of goods depend to a large degree on actual local weather conditions. The area is exposed among others to storm surges caused by fluctuations of the large-scale wind field over the Baltic. Thus forecasts of water level, currents as well as water physical features are crucial for emergency command centres and services, responsible for safety of navigation and work in ports, flood protection of coastal areas, especially protection of depression areas, polders and areas close to river.

On the other hand the region is of vital recreational importance because of seaside resorts situated along the inner and especially outer coasts of the estuary. But the area is exposed to increased water pollution introduced by the Oder River. This results that the estuary is one of the most polluted coastal waters of the southern Baltic Sea. As good water quality is an important factor for further tourism development the estimation of ecological hazards in the estuary is essential.

Numerical modelling became an essential tool in coastal management and environmental protection of the Oder Estuary. Generally the modelling is carried out for two sub-areas: the lowest part of the Oder River and the Szczecin Lagoon – the Pomeranian Bay (Jasinska et al. 2003). For describing water flow and levels in the branches and channels of the Lower Oder 1-D model was applied successfully by Ewertowski (1988). For describing hydrodynamic regime of the Szczecin Lagoon – the Pomeranian Bay area mainly 3-D models have been used. IBW PAN in Gdansk developed a three-dimensional model known as ESTURO (Jasinska & Robakiewicz 1999). The Warnemünder Ostee Model (WOM) based on the GFDL ocean circulation model was also set up successfully (Lass et al. 2001). A 3-D operational numerical model HIROMB was developed in BSH in Hamburg, and then extended in cooperation with SMHI in Norrköping (Funkquist 2001). Maritime Institute of Gdansk built up the model for the Polish zone (Kalas et al. 2001). Hydrodynamic forecast, realized on the base of the meteorological analysis and the 48-hour forecast, is given for the whole Baltic Sea and its particular parts.

1.2 3-D operational hydrodynamic model of the Oder Estuary

In our study a three-dimensional operational hydrodynamic model, developed at Institute of Oceanography, University of Gdansk was applied in order to forecast hydrological conditions in the Oder Estuary. Theoretical and numerical solutions of the model were based on the coastal ocean circulation model known as POM (the Princeton Ocean Model), described in detail by Blumerg & Mellor (1987) and Mellor (1996). The model (Fig. 1) was adapted to the Baltic conditions and for the 48-hour digital meteorological forecast of ICM (Interdisciplinary Centre of Mathematical and Computational Modelling, University of Warsaw). To parameterize vertical mixing processes, the scheme of second order turbulence closure was used as in POM (Mellor & Yamada 1982). Firstly the model was designed for the whole Baltic Sea and the Gdansk Bay as a part (Kowalewski 1997). To obtain a proper approximation of water exchange with the North Sea, the Baltic comprises also the Danish Straits. The open boundary was situated between the Kattegat and Skagerrak where radiation boundary conditions were accepted for flows.

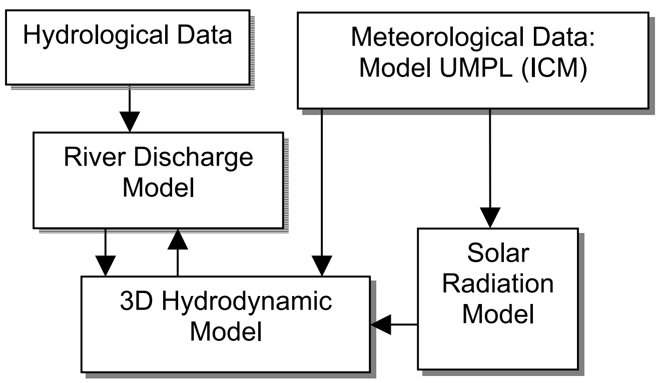

Figure 1: The scheme of 3-D operational hydrodynamic model of the Oder Estuary.

In order to obtain a proper resolution and reliable data two grids with different spatial steps were applied: 5 nautical miles for the Baltic Sea and 0.5 NM for the second region that comprises the Pomeranian Bay, the Szczecin Lagoon to Police at the Oder mouth. The computational grid can be denser for some regions like for Szczecin-Swinoujscie shipping channel. Because of backwater occurrence in the Oder mouth in addition a simplified operational model of river discharge based on water budget in a stream channel was developed. Discharge calculations are performed automatically assimilating water level data from three gauging stations situated in the Oder mouth (Gozdowice, Widuchowa and Szczecin), published on the website of Institute of Meteorology and Water Management (IMWM). Linking the Oder discharge model with the hydrodynamic model of the Baltic Sea as one system made possible to simulate operationally hydrological conditions in the Oder Estuary and give 48-hour forecast for the Oder Estuary. The model forecasts water levels, currents, water temperature and salinity in the Pomeranian Bay as well as in the Szczecin Lagoon with special emphasis put on the Szczecin – Swinoujscie Fairway. The results of the model are given day by day on websites of University of Gdansk and Szczecin.

Verification of the model was based on empirical and calculated series of water level, currents, water temperature and salinity in the Pomeranian Bay as well as in the Szczecin Lagoon. The empirical series of data from 2002 were taken from websites of IMWM (Poland) and BSH (Germany). In addition the observations of meteorological and hydrological conditions along the Szczecin-Swinoujscie Fairway obtained from Master's Office of Szczecin-Swinoujscie Harbour as well as IMWM (Poland) were included.

2 Results

For the given observations and numerical simulations of water level, water temperature and salinity as well as currents standard statistical parameters as average value (AVG), maximum value (MAX), minimum value (MIN), standard deviation (STD) and variation coefficient (VS) have been calculated. Additionally t-test for independent samples was carried out and correlation coefficient (R) was computed between empirical and predicted data. The calculated statistics for observed and calculated series of water level and water temperature are given in Table 1.

A/ Water level								
Location	**Type of data**	**N**	**AVG**	**MIN**	**MAX**	**STD**	**VS**	**R**
Swinoujscie	Observation	2189	505.10	413.00	633.00	22.370	0.044	0.939
	Model	2189	505.36	417.16	649.99	21.220	0.042	
Trzebiez	Observation	2185	510.72	458.00	596.00	22.190	0.043	0.955
	Model	2185	511.58	454.59	593.08	21.030	0.041	
Koserow	Observation	6389	506.71	428.00	639.00	22.220	0.044	0.946
	Model	6389	503.17	421.89	644.81	20.780	0.041	
B/ Water temperature								
Location	**Type of data**	**N**	**AVG**	**MIN**	**MAX**	**STD**	**VS**	**R**
Swinoujscie	Observation	365	10.41	0.00	22.00	7.273	0.699	0.991
	Model	365	10.02	-0.20	21.28	7.103	0.709	
Trzebiez	Observation	365	11.33	0.00	23.20	7.815	0.690	0.987
	Model	365	10.98	-0.10	24.05	7.566	0.689	
Ueckemuende	Observation	1819	14.32	2.90	24.40	7.794	0.544	0.994
	Model	1819	13.88	3.09	23.11	7.377	0.531	
Oder Bank (Depth 3m)	Observation	1920	11.06	0.02	21.75	6.733	0.609	0.996
	Model	1920	11.04	0.25	20.11	6.131	0.555	
Oder Bank (Depth 12m)	Observation	1799	11.78	1.06	20.33	6.085	0.517	0.996
	Model	1799	11.67	0.33	19.44	5.763	0.494	

Table 1: Basic statistical parameters for observed and modelled series of water level and water temperature.

The comparison between observed and predicted data of water level showed that the average values of observed and computed data series were almost the same for Swinoujscie gauging station. For all the locations variation coefficient values were very low however both standard deviation and variation coefficient values were larger for empirical data than for modelled ones. The highest correlation coefficient between empirical and modelled values was achieved for Trzebiez gauging station, but it should be emphasised that calculated correlation coefficients (between 0.94 and 0.96) were highly statistically significant for all the stations.

Comparing empirical with modelled data of water temperature one can see very good agreement between them. Calculated basic statistics and achieved highly statistically significant correlation coefficients (R exceeded 0.99) prove it. As for water level standard deviation and variation coefficient values were insignificantly higher for empirical data than for modelled ones.

Modelled salinity and current values (at the Swina mouth) were weaker but of statistically significant importance (0.566-0.727 and 0.663 adequately).

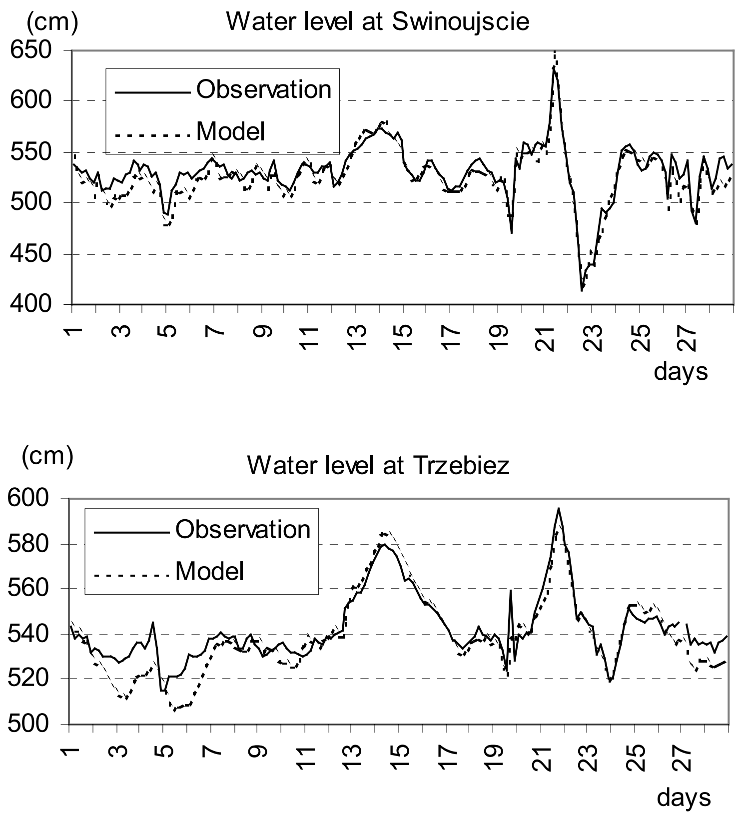

Figure 2: Comparison between modelled (dash line) and observed (solid line) water level as measured at Swinoujscie and Trzebiez gauging stations during storm surge in February 2002.

Good agreement between empirical and predicted data encouraged to check accuracy of the model during extreme events in 2002. From 19 to 27 February 2002 the significant storm surge at the coasts of the Southern Baltic Sea was observed, which caused invasion of sea waters inland and flooding event in some seaside towns (Swinoujscie, Lübeck). The surge was the result of low-pressure systems passage over the Baltic Sea. On 19th February there was observed the decrease of water level in Swinoujscie until 472 cm caused by the prevailing south to west winds (Fig. 2). From 20th February sea level began to rise and on 21st February it reached the value of 635 cm as a result of the shifting of deep low centre over the Southern Baltic Sea (Fig. 3). On that day the flooding event in Swinoujscie occurred. Next the low went away over Scandinavia and joined with other lows over the Northern Atlantic Ocean and caused the rapid fall of sea level in Swinoujscie to 415 cm on 22nd February. On 23rd February the system of lows over Western Europe came together and one extended system over Northern Scandinavia occurred causing only slight changes of sea level.

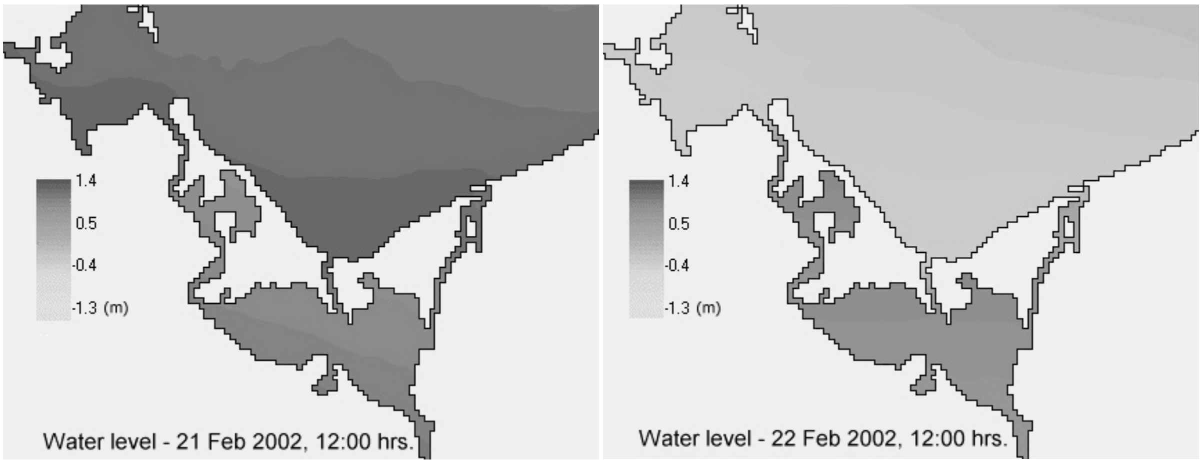

Figure 3: Simulation results with the 3-D operational numerical model of the Oder Estuary during the storm surge in February 2002 (on left – the surge, on right – the fall of water level).

During that storm surge at Trzebiez (the Szczecin Lagoon) there were observed significantly weaker changes of water level. From 19th to 21st February the systematic increase of water level was recorded until the maximum value of 596 cm. The increase of water level followed with 8-hour lag in comparison to sea level maximum in Swinoujscie. Then water level in the Oder Estuary systematically lowered till 24th February. During next few days in the estuary only slight changes of water level were recorded. We conclude that our model correctly approximates the changes of water level and reflects properly all the phases of that storm at both gauging stations (Fig. 2 & 3).

3 Discussion

Linking the Oder discharge model with the hydrodynamic model of the Baltic Sea as one system made possible to simulate operationally hydrological conditions in the Oder Estuary. The model enables to forecast water levels, currents, water temperature and salinity in the Pomeranian Bay as well as in the Szczecin Lagoon.

The best agreement between observed and computed data series was achieved for water level and water temperature of the Pomeranian Bay as well as the Szczecin Lagoon. Modelled salinity and current values (at the Swina mouth) were of weaker but statistically significant importance.

Good agreement between observed and computed data allowed to consider the model as a reliable environmental tool for forecasting the extreme events like storm surges. In the situations of high amplitude and rapid changes of water level like in February 2002 the model reflects properly the hydrological situation.

Quick website access to the hydrological forecast allows potential users to predict day by day processes that may affect different areas of living and can be useful for improvement of safety of navigation and work in ports, flood protection of coastal areas as well as for studying coastal processes in the estuary. Further improvement of the model will be performed in order to acquire better agreement between observed and computed data.

Acknowledgements

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Towards Operational Monitoring of the Baltic Sea by Remote Sensing

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Abstract

Satellite remote sensing technology allows the assessment of various physical, biological and ecological parameters of water bodies on global and regional scales. Significant research effort was spent during the last years to develop and validate algorithms and processing schemes for operational monitoring applications. The paper reviews available sensors and technologies as well as results for different applications in the Baltic Sea, such as mapping of Phytoplankton and suspended matter, algal blooms by ocean colour or dynamic features using sea surface temperature. In this context it is evident, that automation and standardization of value added product derivation is an important basis to support near real-time request from the users side. A special focus will be put on coastal waters observations.
The BMBF funded "MERIS Application and Regional Products Project" (MAPP) and the "Satellitengestütztes Interpretations- und Bewertungsinstrument für das Küstenmonitoring des Landes Mecklenburg-Vorpommern" (SIBIK) will be discussed as key research activities to develop and promote operational use of satellite data for monitoring and understanding processes in the Baltic Sea. Based on these results planned future activities and perspectives for contributions to operational monitoring systems will be presented.

1 Introduction

Remote sensing from satellites has become a mature technology for a lot of different applications, among them assessment of oceanographic key parameters, such as sea surface temperature (SST), wind and wave fields, ice cover and different water constituents. The technology allows the characterisation of geo-biophysical state as well as the description of dynamic processes on different scales, ranging from local to global in space and from short term (days) to decadal in time. However, most use of remote sensing technology and derived information has been made in environmental sciences, global change and climate research and modelling, not so much in regular environmental monitoring by authorities on local, regional or continental levels. Exceptions are ice mapping and SST as well as demonstrational activities in nationally or EU-funded projects.

There are several reasons for this situation. Partly it is caused by mission constraints, not allowing continuous and regular (i.e. operational) provision of data. A second issue is the availability of validated, reliable data products on regional scale as, for example, water constituents in optically complex (coastal) waters. As a third, necessary data processing and dissemination infrastructure has developed only during recent years realising networking capabilities including research institutes, service providers and value-adding enterprises as well as authorities and other users on different levels. Another topic which has developed rapidly in recent years is the user preparedness to integrate remote sensing information into daily business. Finally, data policy and costs are an issue heavily influencing the acceptance to utilize remote sensing data.

The "remote sensing community", i.e. space agencies, data centres, research institutes and value-adding companies, is aware of the growing needs and demands from the user perspective. This is resulting in a stronger commitment of research and development to the requirements of the user community, aiming to provide remote sensing based information as a regular monitoring tool.

On a European level the joint EU-ESA initiative for "Global Monitoring for Environment and Security" (GMES) has established the corresponding political and financial framework for the next decade. In the following we will introduce results from national German projects with special focus on ocean colour and discuss potential future developments towards operational monitoring.

2 Satellite Capabilities

This paragraph will briefly review the capabilities of satellite remote sensing for oceanographic and coastal applications. Main emphasis will be ocean colour, since the projects discussed in detail below are focussing on this subject.

Passive microwave and active radar measurements allow the mapping of meteo-marine parameters, such as surface wave and wind fields and ice cover independently of cloud cover or weather conditions. The technology has been established during the missions of European Remote Sensing Satellites ERS-1 and -2 and is continued by the European Environmental Satellite ENVISAT. Currently it is integrated as regular information source for weather forecast and hazard warning at several national weather centres and ECMWF. The problem with radar data, however, is a lack of coverage and repetition rate especially on local and regional scales.

A well established service provided by several authorities is the mapping of sea surface temperature, e.g. in Germany by German Aerospace Centre (DLR) or the Federal Maritime and Hydrographic Agency (BSH). Currently derived mainly from thermal infrared data of the NOAA-AVHRR instrument, this will be complemented in future also by European instruments on METOP platforms. For regional and coastal applications limitations apply to SST due to coarse spatial resolution of 1 km. On a short term, cloud coverage may heavily hinder the data availability.

Beside physical processes imaged by radar or infrared sensors, biological activity and ecological state of ocean and coastal waters are an essential part of environmental research and monitoring. Satellite remote sensing in this field contributes the mapping of different water constituents, such as phytoplankton, suspended and dissolved matter in the water column as well as turbidity and other water quality indicators. Since the first ocean colour satellite CZCS (NASA) in the late 70ies the methodology has become mature and provides operational phytoplankton products for the open ocean, where mainly Chlorophyll and covarying constituents appear (case-1 waters). Currently SeaWiFS and MODIS (both USA) are used to generate these products. Limitations in applicability of these sensors occur in coastal and optically complex water: due to coarse spatial resolution of 1 km on one hand and insufficient spectral resolution on the other.

Optically complex waters (case-2) may be characterised by the fact that several optically active components (water constituents), which may vary independently, are influencing the water colour. Thus, almost all coastal waters may be referred to case-2 waters, also some larger basins with limited exchange to the open ocean, such as the Baltic or the Black Seas. From remote sensing point of view these waters show a multivariate optical behaviour, which requires higher spectral resolution measurements (i.e. more spectral bands) to be able to discriminate and quantify the single constituents by the retrieval algorithms. Better spectral resolution also allows the necessary adaptation of algorithms to regional and seasonal specifies of optical properties.

In 1996 the imaging spectrometer MOS was launched on board the Indian satellite IRS-P3. Developed by DLR, it was the first instrument in space providing higher spectral resolution data at medium spatial resolution (500 m). It was an experimental proof-of-concept mission focusing on the development of case-2 algorithms for coastal waters. However, due to its experimental character the mission did not provide the necessary coverage and repetition rate for monitoring applications.

In May 2002 ESA launched ENVISAT, which carries among a broad variety of instruments the imaging spectrometer MERIS. Also focusing on coastal waters MERIS has similar spectral parameters as MOS. With a large swath and even better spatial resolution of 300 m it realises the spatial and temporal resolution necessary for coastal and monitoring applications (see fig. 1). From the user perspective, however, the uncertainty of continuation after ENVISAT's lifetime seems to be a critical gap. Table 1 summarises currently available ocean colour instruments.

The table above is not ment to be exhaustive, more satellites carrying ocean colour sensors are operated by several agencies, such as from India or China. But due to certain constraints in data availability they are not considered here.

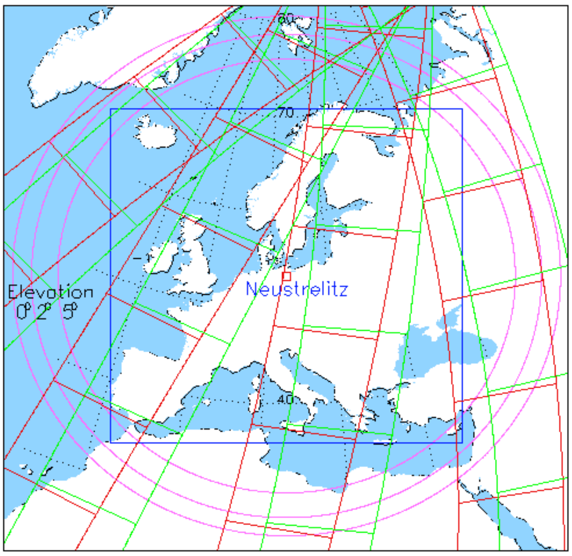

Figure 1: 2-day coverage of MERIS for Neustrelitz ground station.

Instrument/ Satellite	Agency	Launch	No of Bands*	Swath Width (km)	Reso-lution (Nadir)	Repe-tivity	Main Focus	Monitoring
SeaWiFS	NASA	1997	8	2800	1.2 km	2d	open ocean	pre-operational
MODIS/ Terra, Aqua	NASA	1999	9	2330	1 km	2d	open ocean	operational
MOS/IRS-P3	DLR	1996	17	200	500 m	23d	coastal Waters	experimental
MERIS/ ENVISAT	ESA	2002	15	1150	300 m	2d	open ocean coastal waters	pre-operational

Table 1: Overview of Ocean Colour Sensors (*) VIS-NIR spectral range).

The planning for the future is going in two directions. Essential for monitoring applications is the continuity of data from space. Currently only NOAA/NASA seem to have a robust plan to continue MODIS-type observations on the future polar platform program POEM. Unfortunately ESA's plans for MERIS follow-on, may be in the frame of the Earth Watch program, are not settled yet.

A second direction is the development of enhanced instruments, such as spatial high resolution hyperspectral imagers and ocean colour imagers on geostationary platforms, which will add new capabilities to satellite monitoring.

3 Recent Developments and Results

This paragraph will discuss two demonstrators to provide (pre-) operational monitoring tools for water constituents on a regional scale, in particular for the Baltic Sea.

3.1 MOS-Chlorophyll Map of the Baltic Sea

In the period from March 1998 up to October 2003 an operational processing chain for deriving a chlorophyll map of the Baltic Sea on basis of MOS-B data was running at the ground station in Neustrelitz. The maps were produced at the same day as data acquisition. Furthermore, the corresponding quick look product was published via internet. For the years 1996 and 1997 some exemplary data were reprocessed. A statistical overview of available maps is given in Table 2. This long time test clarified the ranges of application of the remote sensing in the context of near-real-time requirements as these would be formulated e.g. by multinational or bilateral environmental agreements to the management of the Baltic Sea. Beside the experimental character of the MOS sensor the maps have given support in studying seasonal and regional variation of the chlorophyll concentration. For example, figure 2 shows an increased concentration within the Bay of Riga.

Especially monitoring and warning systems as basis for the sustainable management of such a damageable ecosystem as the Baltic Sea have to be very stable in their functioning, timely and spatially efficient in their information extraction. These aspects can be only fulfilled, if those systems are physically based, connected with necessary quantitative statements, so that the subjectivity of operator is minimized.

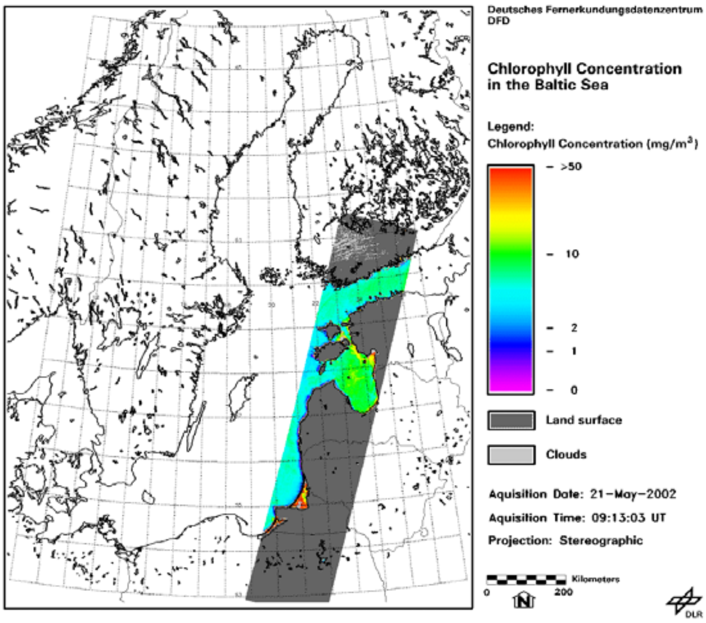

Figure 2: Quick look of a chlorophyll map from MOS, May 21, 2002.

	Feb.	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Maps total
1998	-	17	14	14	-	-	6	17	21	17	106
*	-	5	4	7	-	-	3	10	8	-	37
1999	-	12	16	24	3	10	-	-	-	-	65
*	-	5	6	18	2	5	-	-	-	-	36
2000	4	20	17	17	-	-	12	12	5	-	87
*	1	5	6	12	-	-	7	7	4	-	42
2001	2	13	9	19	16	17	15	9	7		107
*	-	3	2	12	10	14	8	2	1		52
2002	-	14	16	13	15	16	19	14	4		111
		3	9	8	11	11	15	8	1		66
2003		12	16	16	17	20	11	18	4		114
		6	6	8	15	11	4	11	1		62

Table 2: Statistic overview of available maps per month and year of automatic processing. The lines signed with *) show maps with more than 50 percent cloud free water region after rough evaluation.

3.2 MERIS Value-adding

ESA is providing standardised MERIS products using "global", generic algorithms to derive phytoplankton pigment, suspended matter and dissolved organic material. The data products represent geo-referenced maps of derived parameters in sensor projection on a scene basis (data level 2). The products are provided off-line by ENVISAT processing facilities. Compositing of data for larger areas or computation of time averages (data level 3) has to be done by the user. For a large number of applications, in particular regular monitoring, this situation is unsatisfactory.

In front of this background and to foster the preparedness for MERIS utilisation in Germany the Ministry of Education and Research (BMBF) co-funded the national "MERIS Applications Project" (MAPP) aiming the develop regionally optimised MERIS algorithms and extended products compared to ESA. A second goal was to develop and implement the technical infrastructure for operational processing and product dissemination to users. The project was a cooperative effort of DLR, GKSS Institute of Coastal Research, Free University of Berlin and Brockmann Consult. After algorithm development the MAPP-value-adding (MAPP-VA) processor was implemented and integrated into the data base and management system at DLR Remote Sensing Data Centre DFD. DFD is also realising the reception of MERIS data at its ground station in Neustrelitz. Currently the processor and the algorithms are under evaluation and validation, the goal is to reach operationability by mid 2004. Table 3 lists the MERIS value added products relevant for ocean monitoring. It is planned to deliver for all products daily maps of full overpasses of MERIS for the Baltic and North Seas as well as weekly, monthly and seasonal means at full spatial resolution (300 m) mapped onto a uniform grid.

	Level-2	**Level-3**
Water	• Chlorophyll • Yellow substance • Suspended matter (North Sea, Baltic Sea, Bodensee)	• Baltic Sea- same params, monthly means
Atmosphere	• Aerosol type • Optical thickness in coastal zones • Cloud top height • Cloud optical thickness • Cloud albedo • Water vapour	• same, monthly means • ISCCP cloud types (or extension) • Water vapour in ISCCP cloud categories • Statistics in vertical layers of: - Cloud frequency - Cloud optical thickness - Cloud top height • Water vapour
Land	• NDVI	• NDVI monthly & yearly mean • Land cover classification

Table 3: MAPP-VA data products.

3.3 MERIS Products for the Baltic Sea

The Baltic Sea must be considered more or less completely as case-2 water, mostly characterised by relatively high concentrations of dissolved organic matter (DOM, Gelbstoff) and several point sources of suspended matter (river mouths). An additional phenomenon are strong algal blooms, typically occurring during spring and early summer. Thus, optically the water is complex, very different to other basins and open ocean water. This demands for specific retrieval algorithms adapted to the optical properties of the Baltic Sea.

State-of-the-art inversion schemes are based on physical models describing the multivariate behaviour of the water body. The specifics are introduced by the inherent optical properties of the different constituents under consideration. Radiative transfer models are used to compute simulated spectral radiances representing the satellite measurements depending on water constituents' concentrations, atmospheric turbidity as well as viewing and Sun geometry. These simulated data sets are used to "train" inversion algorithms to compute the concentrations from the spectral radiance measurements. In the case of the Baltic Sea the algorithm is based on a principal component inversion (PCI, KRAWCZYK). The bio-optical model incorporating the specifics of the Baltic Sea was developed in cooperation with H. Siegel of the Baltic Sea Research Institute.

As mentioned above the processing system and the algorithms are currently being tested and validated and it is planned to enter first demonstration phase in May 2004, regular operation is envisaged for mid of the year.

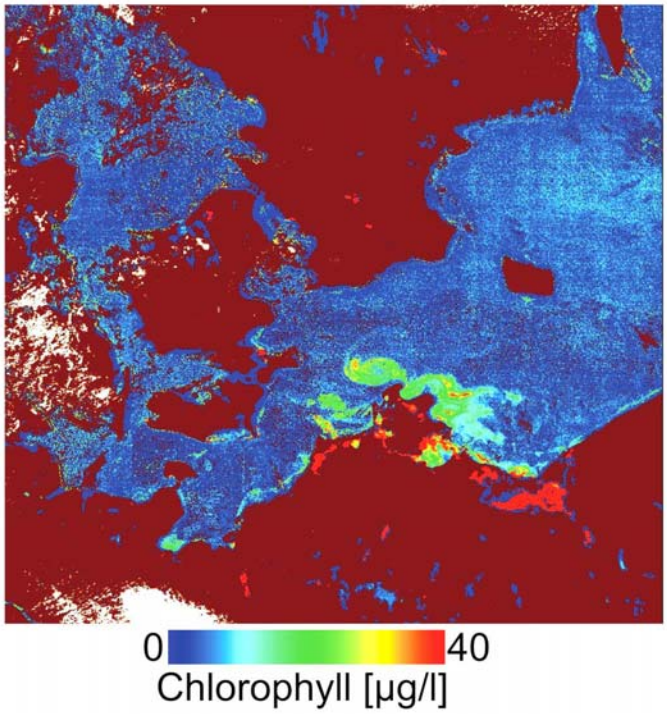

Figure 3: Chlorophyll concentration derived from MERIS full resolution data, August 13, 2003.

Currently additional algorithms are under development, such as for detection and monitoring of harmful algal blooms.

4 Outlook

4.1 Operationalisation

In contrast to temporally limited campaigns with in-situ measurements, automation of remote sensing data interpretation makes it possible to monitor ecosystems over a long time at minimal cost and to detect special phenomena. Furthermore an interactive data interpretation is not applicable to process a large number of data sets, within a time interval acceptable for a user. An additional aspect consists in operator's subjectivity in the data processing. This is complete in conflict to the requirements of objective and transparent monitoring.

Furthermore, the integration of remote sensing in monitoring and warning systems or in environmental models requires beside automation of data processing the standardization of algorithms for deriving information. Especially the last aspect is important for combining different sensor types. Both, automation and standardization of value added product processing are important to support near real-time request of users. For this background, the "Chlorophyll Map of the Baltic Sea" is a pre-cursor demonstration for the stability of a remote sensing monitoring. The processing chain itself is a result of close cooperation between former "Institute of Space Sensor Technology", the "Institute of Baltic Sea Research Warnemuende", and the German Remote Sensing Data Centre. The processing chain is described in more detail in Wolff et al. (1998). After this first successful step the connection of the remote sensing based monitoring to a comprehensive environmental monitoring of the Baltic Sea must be carried out.

The operationalisation of monitoring and warning systems on basis of remote sensing includes both, the technical solution of the system and its implementation into the decision making process of the environmental administrative. The technological aspects are defined by a large number of processing chains, different types of data, and a high level of user service, which require a corresponding environment, as provided by the German Remote Sensing Data Centre in its Data and Information Management System (DIMS). With help of Processing System Management (PSM) software, the different components of a processing chain are controlled, comparable with the production process in a large factory. A strong request by users is the inclusion of mistake analysis, providing the user of a remote sensing product with the range of validity, including the limits of applicability. Guiding principles are necessary for the derivation of a product and its use in legal proceedings.

These aspects are the major preconditions for the implementation of such a system into the decision making process of the environmental administrative. Full-coverage information on the basis of satellite based remote sensing data will gain importance if legally binding statements can be included in data interpretation.

Arguments for such a tendency are given by the international activities for protecting nature and the environment in connection with bilateral and multilateral agreements, for example the EU Water Framework Directive.

4.2 Availability and Access

The MAPP-VA system will provide the data through a web-based user interface called EOWeb (http://eoweb.dlr.de:8000/index.html). According to current data policy the data are provided online (ftp) free of charge, for copies on CD or other media a copy fee will be charged.

According to ESA's policy this approach is allowed for research and demonstration activities. The conditions and pricing for regular, operational monitoring need to be negotiated with ESA. DLR is prepared to go into these discussions together with users once operational state has been demonstrated.

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Dynamical processes along the German Baltic Sea coast systematized to support coastal monitoring

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Abstract

Satellite data of different spectral and spatial resolution were combined with model simulations and ship-borne measurements to investigate dynamical features and processes along the Baltic Sea coast of the German federal state Mecklenburg-Vorpommern (MV). Systematization in relation to the local wind was performed to develop an interpretation instrument for the coastal monitoring (SIBIK) of local authorities (LUNG). Satellite data of sea surface temperature and ocean colour of the sensors NOAA-AVHRR, SeaWiFS und Landsat 7 ETM+ were applied. Model simulations were focused on the western Baltic with the coast of the state MV (3-D model) as well as on the Szczecin Lagoon (2-D model) at the border between MV and Poland. The results summarized in a catalogue support the interpretation and the assessment of acquired in situ data as well as optimization of the monitoring program. Regional particularities in the coastal dynamical features and processes are presented for the main wind directions and for changes between dominant wind situations. Consequences for coastal zones and its monitoring programme are discussed.

1 Introduction

The German federal state Mecklenburg-Vorpommern (MV) is located at the western Baltic Sea the transition area between the Baltic and the North Seas. The hydrography of the western Baltic is embossed by a strong structured bottom with the Darß Sill, coastal topography, and different driving forces, which operate in diverse temporal scales. Continuing wind situations may establish large scale sea level differences between the Baltic and the Kattegatt leading to barotropic currents in the area of investigation. Because of the shallow bathymetry the current field and the stratification is strongly influenced by the local wind which may change in scales of hours to a few days. The positive water balance due to the river inflow produces a long-term outflow. Furthermore, the western Baltic is influenced by coastal discharge. The most important coastal outflow from the Oder River enters the western Baltic in the Pomeranian Bight. Systematic investigations of the river discharge in relation to the dominating wind directions were provided by Siegel et al. 1996 and 1999. The results have been applied for the interpretation of Oder flood data in 1997 (Siegel et al. 1998, Siegel and Gerth, 2000).

The Federal State Authority for Environment, Nature Protection and Geology (Landesamtes für Umwelt Naturschutz und Geologie, LUNG) of MV performs a monthly monitoring program of fixed stations for the collection, documentation and evaluation of the environmental conditions.

The measurements at all stations take a few days.

Due to the highly variable dynamical system of the western Baltic Sea the hydrographic situation can change completely in the measuring period. Synoptic satellite data may support the monitoring investigations. Two different ways are conceivable. The operational supply of current satellite data is the most important way for future applications but reliable if the data access for different sensors is improved. Additionally, the cloud coverage in the western Baltic Sea is an important limiting factor.

Therefore, the second way was chosen and the systematic investigations performed in the Pomeranian Bight were extended to the entire coast of the German state MV. Synoptic satellite data of different spectral and spatial resolution were combined with model simulations of circulation processes and ship-borne measurements to validate the derived patterns and to understand the processes producing the dynamical features. Wind data were used to derive the dominating wind directions. The investigation results in a Satellite based Interpretation and Evaluation Instrument for the Coastal Monitoring of Mecklenburg – Vorpommern (SIBIK). The main product of SIBIK is a detailed catalogue containing systemized dynamical features in relation to the wind direction.

2 Area of investigation, methods and database

The area of investigation is the entire coast of the German federal state Mecklenburg–Vorpommern. From a dynamic point of view the coastal area shown in Fig. 1 can be divided into four main regions.

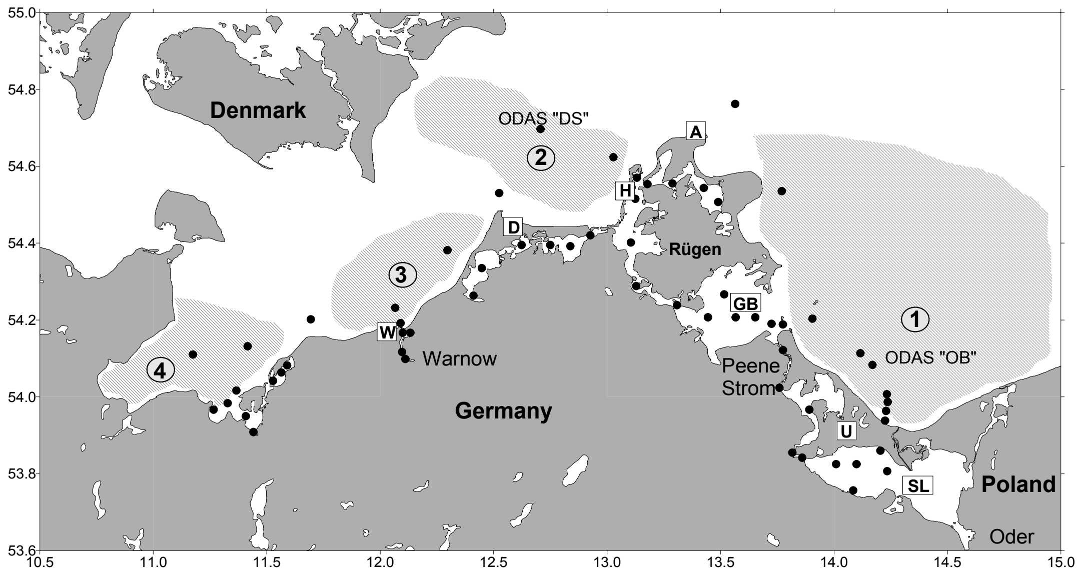


Figure 1: Map of the western Baltic Sea including the four areas under investigation (1, Pomeranian Bight; 2, Hiddensee–Darss; 3, south-eastern Mecklenburg Bight; 4, Lübeck Bay), locations of wind registrations (A, Arkona; ODAS'DS', ODAS Darss Sill; ODAS'OB', ODAS Oder Bank), special locations (W, Warnemünde; D, Darss Peninsula; H, Hiddensee Island; GB, Greifswald Bay; U, Usedom Island; SL, Szczecin Lagoon) and the stations of the coastal monitoring programme.

The stations of the German coastal monitoring programme of MV are illustrated in the map.

The database includes satellite data of different spectral and spatial resolution, wind data, ship-borne measurements, and model simulations. The satellite data evaluation was focussed on sea surface temperature (SST) due to the high repeating rate and availability. The SST was derived from the Advanced Very High Resolution Radiometer (AVHRR) of the National Oceanic and Atmospheric Administration (NOAA) weather satellites provided by the German Federal Maritime and Hydrographic Agency Hamburg (BSH) (Siegel et al. 1994). SST data of the years 1996-2002 were used for automatic derivation of typical patterns for the 8 main wind directions and the period 1990-2002 was included for scenario of special situations. Satellite data of the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) provided by NASA were analysed to retrieve water constituents. Satellite data of high spatial resolution of the sensor Landsat 7 ETM (Enhanced Thematic Mapper, 30m resolution) designed for land applications were used for the investigation of regional characteristics in the Szczecin Lagoon and in individual coastal regions. The sensor has a repeating rate of 16 days but due to the cloud coverage only a limited number of scenes are available.

Wind data for the period from 1980 to 2000 were analysed. The data were taken from the weather station Arkona and from the Oceanographic Data Acquisition Systems (ODAS) 'Darss Sill'. Ship borne measurements were performed during different cruises at selected stations with a CTD cast and with a through-flow system.

For the simulation of dynamical processes in the western Baltic and the Szczecin Lagoon two different models have been used. The 3D Baltic Sea model is based on the Modular Ocean Model MOM 3.0 (Pacanowski and Griffies, 2000). The model was adapted to the Baltic by the digitised bathymetry of Seifert et al. (2001). Because of strong fresh water discharge the free surface option and the consistent, tracer conserving scheme for fresh water input after Griffies et al. (2001) are of importance for the Baltic. A high grid resolution of 1 nautical mile is necessary to resolve the dynamical scales in the western Baltic (Schmidt et al., 1998). The model is driven by meteorological fields as wind stress, air pressure, air temperature, humidity, insolation, and cloudiness. Model simulations with realistic forcing were carried out to show the typical dynamical patterns and the spreading of drifters in the western Baltic which might be compared with satellite images. Idealized model experiments were forced by the dominating wind situations derived from the wind analysis.

In the shallow Szczecin Lagoon the 2D finite element flow model Femflow2D was applied. In Femflow2D, the system of shallow water equations is discretized with the modified Utnes scheme (Utnes, 1990) which is characterized by a semi-decoupling algorithm. The continuity equation is rearranged to Helmholtz equation form. The upwind method by Tabata (1977) is used to approximate the convective terms. A detailed model description is given by Podsetchine & Schernewski (1999) and Schernewski et al. (2000).

3 Results

The different steps for the development of SIBIK are illustrated in Fig. 2. The NOAA SST data were automatically classified for different wind situations to derive the typical SST patterns. These features are directly implemented in the catalogue. From high-resolution satellite data detailed information was derived about regional characteristics in individual coast regions, particularly around Rügen with erosions at the peninsula Jasmund, discharge from the Strelasund between Darss and Hiddensee, as well as thermal fronts and temporary occurrence of eddy structures in the Mecklenburg Bight and Lübeck Bay. The wind data were statistically analyzed to derive the dominating wind directions. The wind analysis for the period 1980-1992 performed in the systematization of the Oder River discharge in the Pomeranian Bight (Siegel et al. 1996) have shown that easterly and westerly winds are dominant for all seasons. The compiled wind statistics for 1992-2000 shows besides the high variability that the wind directions with the longest coherent wind situations were east and west, the dominating number of all wind events west and south, i.e. the wind blows predominantly from western and eastern directions and turns frequently over south. These information has been used to investigate the distribution patterns for changing wind directions from one dominating direction to the other on the basis of satellite data and model simulations of current, temperature and particle transport. The results are systematized in the catalogue and presented with a detailed description.

Hints for the handling of the catalogue are implemented. Based on a systematic intercomparison of all observations the user might assess the position of individual monitoring stations in relation to the dynamical features.

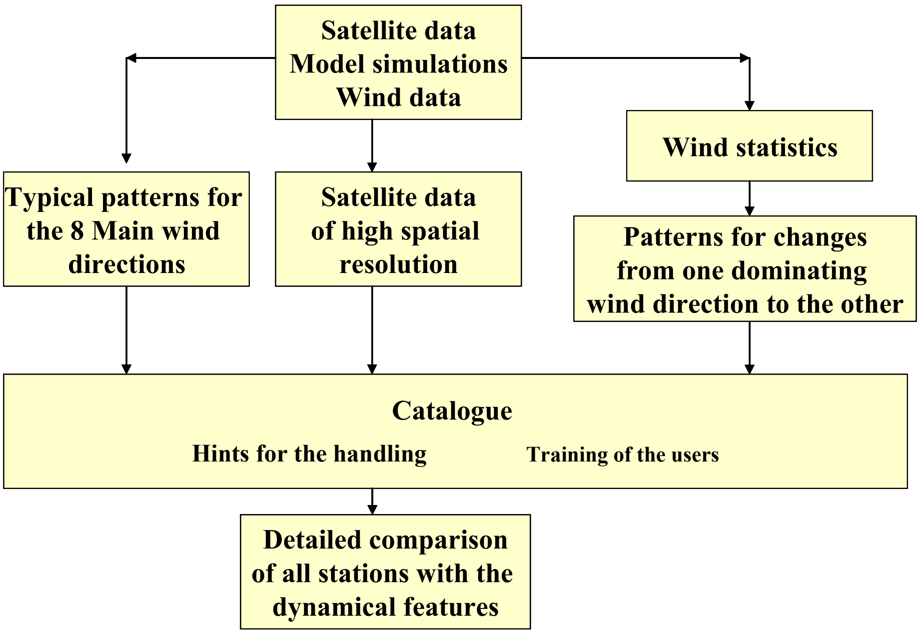


Figure 2: Scheme of the development of SIBIK-catalogue.

The layout of the catalogue is shown in Fig. 3. In chapter 2.1 typical dynamical features for the main wind directions are presented on the basis of satellite data of SST, model experiments and realistic simulations in form of temperature and current snapshots. Spatially high resolution satellite data are utilized to discuss particularities in coastal sub-regions. In chapter 2.2 dynamical features and processes produced by changes in the wind direction are systematized. Response patterns in temperature and current are analyzed for all possible transitions from one main direction East (E) and West (W) to the other and vice versa. In the model experiments additional drifter sources (7 coastal and 3 open sea sources) are implemented and the particle transport is described in detail.

0. Introduction
1. Data base and methods
2. Dynamical features in the western Baltic Sea

2.1 Typical patterns for different wind directions on the basis of SST distribution, model simulations and Landsat TM Scenes

- 2.1.1 N-Wind
- 2.1.2 NE-Wind
- 2.1.3 E-Wind
- 2.1.4 SE-Wind
- 2.1.5 S-Wind
- 2.1.6 SW-Wind
- 2.1.7 W-Wind
- 2.1.8 NW-Wind

2.2 Typical patterns during changes in the wind direction (Main wind directions) on the basis of SST, model simulations of current and particle transport

- 2.2.1 East-North-West (ENW)
- 2.2.2 East-South-West (ESW)
- 2.2.3 West-North-East (WNE)
- 2.2.4 West-South-East (WSE)

3. Dynamical features in the Szczecin Lagoon
3.1 Typical current pattern for the main wind directions
3.2 Particle transport for the main wind directions in different time steps

Figure 3: Table of Content of SIBIK- catalogue.

In chapter 3 the particularities of the Szczecin Lagoon are presented in terms of current and particle transport for the main wind directions based on vertical integrated model simulations.

4 Discussion

In the following, selected results from the SIBIK-catalogue will be presented.

In the overview about the dynamical features during the 8 main wind directions (chapter 2.1) the conditions are discussed on the basis of SST, model experiments and realistic simulations. The example in Fig. 4 show the general patterns for easterly winds in the SST image and modelled surface temperature and current. The LANDSAT ETM composite and drifter simulation represent regional particularities in the Darss-Hiddensee area. In the catalogue the patterns along the entire coast of MV are described in detail as follows for the easterly winds.

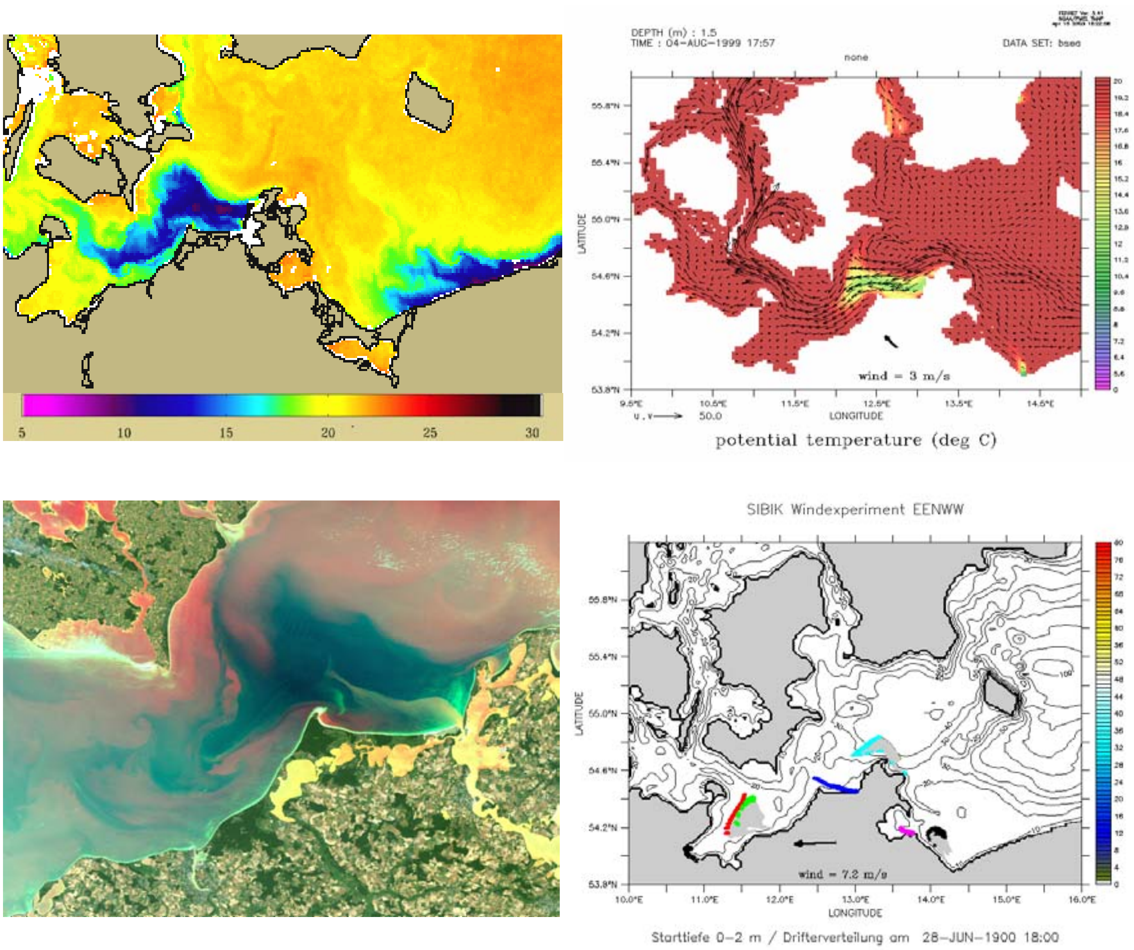
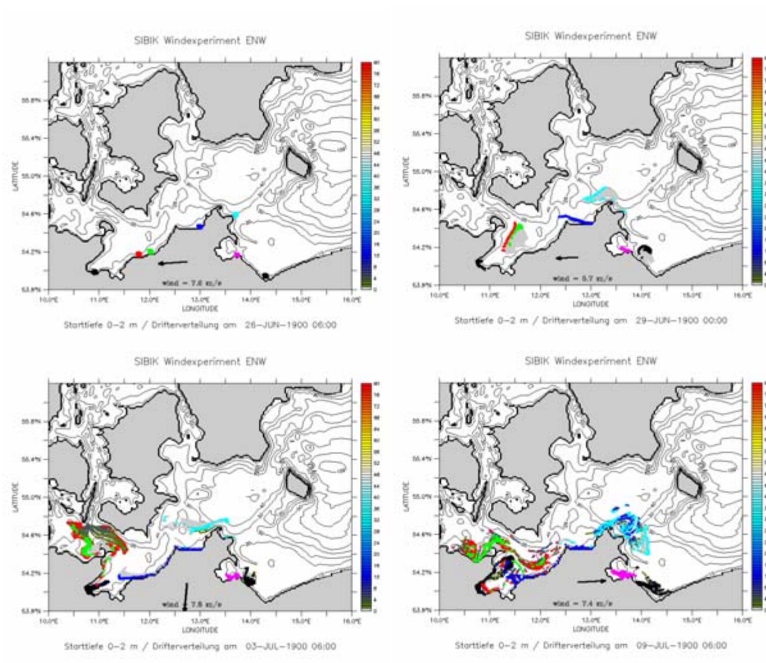


Figure 4: East wind situation: SST distribution, model simulation of temperature and current, LANDSAT ETM composite and drift simulation.

Cold upwelling filaments off Hiddensee develop in the summer months and warm filaments in winter, which cannot be often observed with satellite data due to high cloud coverage. The cold water leaves the Baltic through the Fehmarn Belt. The Mecklenburg and Lübeck Bay are not affected by the outflow regime, a thermal front establishes in the Mecklenburg Bay. The Warnow River water flows due to Ekman transport and induced upwelling north-westwards and does not reach the west beach of Warnemünde. Upwelling water in the area Hiddensee - Darss comes from different sources: In front of Hiddensee it is mainly from intermediate water of the Arkona Sea whereas upwelling off the Darss sucks deep water from the Darss Sill. During long continuing east winds water from Greifswald Bay is pressed through the Strelasund between Hiddensee and Darss and transported in a narrow band north-westward as seen in the Landsat image and in the particle tracks. The discharge of Oder water through the Swine takes place pulsating due to water level variations. Mixed Pomeranian Bight water including the discharge of Oder and Peene Rivers will be transported along the coasts of the islands of Usedom and Rügen and may reach the central Arkona Sea. Upwelling water, which develops along the Polish coast, penetrates into the Pomeranian Bight and guides the PB water. The water level in Greifswald Bay rises strongly by the east wind and the Peene no more flows in Greifswald Bay, but to north. Upwelling occurs at the north coast of Greifswald Oie and at the south coast of the Tromper Wiek. Eroded material of the peninsula Jasmund is transported to the north outside of the Tromper Wiek due to the Ekman transport and induced upwelling. Such detailed visualisations and descriptions are implemented for each wind direction in chapter 2.1.



ENW
Oder,
E: towards NW along Usedom
N: Ekmandrift to Usedom coast
W: to SE and to the Polish coast
Peene,
E: in GB
N: along the south coast
W: stay at South coast
Saßnitz,
W: to NW up to eastern Darß Sill, Eddies during changes
N: North coast Rügen
E: Eddy outside Tromper Wieck and to SE again in the direction of Sassnitz
Strelasund,
E: to NW until about Warnemünde
N: all drifters at the coast between Strelasund und Kühlungsborn
W: all other drifter stay at the coast
Warnow, Kühlungsborn,
E: to W around the deeper part of MB and to Fehmarnbelt
N: at the coast west of Fehmarn
W: partly back until the coast around Warnemünde
Trave,
E: to W as a cloud in the inner Bay
N: to NE separates from the coast
W: completely transported to N

Figure 5: Particle transport for wind changes ENW at starting point, after the east, north and west wind phases, including a detailed description for all coastal sources.

In the chapter 2.2 typical patterns during changes in the dominating wind direction are presented on the basis of SST, model simulations of current and particle transport additionally, and textual interpretation. The reactions are analysed for all possible transitions from one main direction East (E) and West (W) to the other and vice versa. An example is given in Fig. 5 for changes from East over North to West. The figure shows the modelled particle tracks at starting points, after the east, north and west wind phases, including a detailed description for all 7 coastal sources representing coastal discharge or important regions. Looking for example at the source between Darss peninsula and Hiddensee island the particles will be transported during easterly winds in a narrow band north-westwards. During the north wind phase these particles might be distributed at the entire coast between Kühlungsborn and the source. The user can watch a computer animation of 6-hourly snapshots to study the changes in detail. The same presentation is implemented for the particle transport for the 3 open sea sources in the Fehmarnbelt, Kadettrinne and east off Saßnitz.

In the third part the particularities of the Szczecin Lagoon are presented where the vertical integrated model simulations are divided in current field for the 8 main wind directions and in particle transport for the 4 main directions within different time steps. The example in Fig. 6 shows the particle transport of the Oder River in the lagoon in 5 time steps up to 24 days. During easterly wind the main transport occurs along the north and south coast into the western part of the Lagoon. A counter current establishes in the central part. Therefore, the Oder river load propagates along the southern coast into the western part and cannot cross the counter current at the entrance.

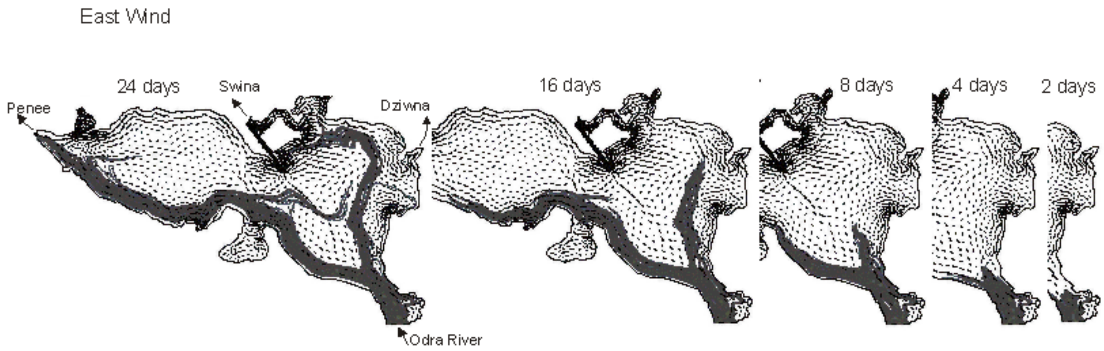


Figure 6: Current and particle transport in the Szczecin Lagoon during easterly winds.

The described SIBIK-catalogue of systematized typical dynamical patterns for dominating wind directions and their changes supports the interpretation of monitoring data and contributes to an optimization of the coastal monitoring programme of regional authorities. Furthermore, the results allow forecasting of transport processes during special events, such as plankton blooms, floods or accidents and of hazard potentials for certain coast regions.

The user may work interactively with the SIBIK-catalogue (Fig. 3). In preparation the user has to determine the wind direction in the period of investigation. The wind data of the MARNET stations in the Baltic Sea are available from the BSH webpage. With this information the user is able to find the illustrated description for the derived pattern for the certain wind situation. The chapter for the selected wind direction contains figures of the satellite derived SST features, extracts of the model simulations and a description of the regional distinctions, which may occur along the coast of MV. The presented model results for the illustration of current features and particle transport during changing wind directions can be studied also by video presentations starting interactively.

LUNG applies SIBIK for interpretation of measurements and in future also operational during the field campaign.

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Shipping in Coastal Regions – State of the Art and Current Research for Emission Reduction

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Abstract

Shipping generally is an environmentally-friendly means of transport with relatively low CO_2 emissions. Due to concentration of ship traffic in coastal areas and due to the emission behaviour of ship diesel engines at low and instationary loads, a further reduction of emissions from shipping is desirable and necessary. The formation of emissions inside diesel engines is of a complex nature. Measures which reduce a certain emission component will increase another component at the same time. The EMI-MINI project at the University of Rostock investigates fuel sprays from modern common-rail diesel injectors for ship engines in order to find measures that reduce emissions and maintain the already existing advantages of modern ship diesel engines. Within the project, state-of-the-art laser measurements are applied to determine the influence of injection parameters on the properties of fuel sprays inside the cylinders of large diesel engines.

1 Shipping in coastal regions of the Baltic Sea

1.1 Shipping in the Baltic Sea

The Baltic Sea is an area of high ship traffic density. The total number of port calls in the Baltic Sea (including ferries) was estimated to be 426,000 in 1998. Due to the annual increase in ship traffic, this number is expected to double by the year 2017 compared to 1995 (Rytkönen et al. 2002). For obvious reasons shipping activities are concentrated in coastal areas.

Shipping plays a key role in the economic and social life in coastal zones. It is often a central column for local industry and tourism at the same time. Ports and industries connected with them form the economic backbone of many cities along the Baltic coast line. Besides industrial goods, ferries attract and transport considerable numbers of tourists and are, therefore, an important factor for the tourist industry. In 2002, 7954 ships called at the port of Rostock, 5774 of them were ferries. The ship traffic in and out of the port is surely part of the tourist attractions of Rostock and other Baltic port cities, with the large cruise liners, visiting for instance the passenger quay in Warnemünde, being a particular highlight.

From an environmental point of view shipping has the advantage of relatively low CO_2 emissions due to the outstanding efficiency of modern ship diesel engines and due to the general efficiency of the transport system “ship”.

Nevertheless, shipping contributes significantly to the air pollution, especially in the coastal regions as can be seen in Figure 2. Regarding acidifying gases, ships belong to the major emitters within the European Community. The pressure to reduce these emissions from shipping will increase due to increasingly reduced emission limits imposed on other sources and due to increasing demands, not only from the tourist industry, for improved air quality in coastal regions (e.g. spas, climatic health resorts etc.).

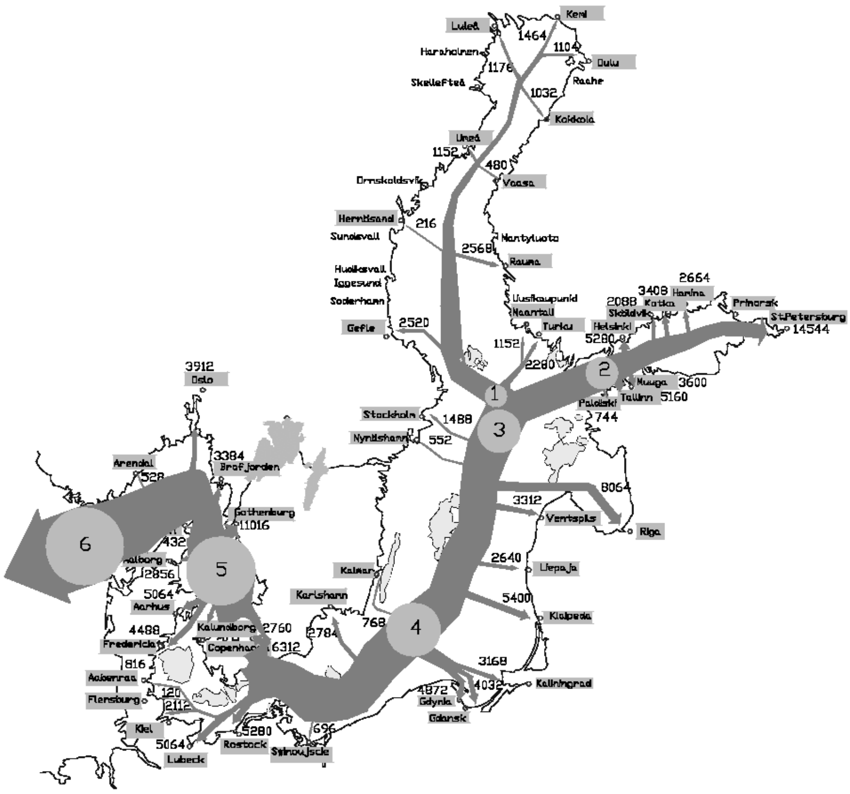

Figure 1: Main ship traffic routes in the Baltic, excluding ferries (Rytkönen et al. 2002).

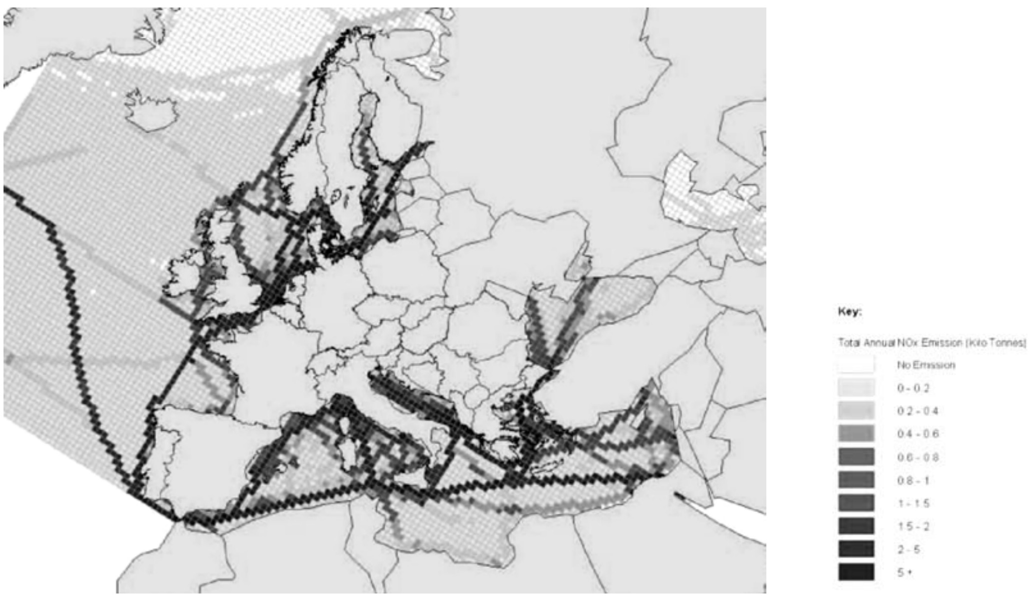

Figure 2: Total annual NOX-emissions from shipping in European seas in 2000 (Chris Whall et al. 2002).

1.2 Modern ship diesel engines

The vast majority of merchant ships uses diesel engines to supply the propulsion energy as well as all electric energy for shipboard use. These engines have outputs from 1 MW up to 60 MW, piston diameters from 15 cm up to nearly 1 meter and rotation speeds from up to 1000 rpm down to less than 100 rpm. This is a very broad range of engines, representing an even broader range of specific design data and technical solutions. Nevertheless, the basic emission behaviour of these engines and the general emission generation processes are comparable.

Modern large diesel engines are still the most efficient supplier of mechanical and (in combination with a generator) electrical energy. These engines reach efficiency values of up to and above 50%. A modern, large ship diesel engine requires approximately 170 grams of fossil fuel (i.e. diesel or heavy fuel oil) per kWh output, whereas a modern diesel engine of a passenger car requires a minimum of approximately 210 grams of diesel oil per kWh. A state-of-the-art gasoline-engine consumes around 245 grams per kWh. This outstanding efficiency of modern ship diesel engines needs to be kept in mind when discussing the overall environmental balance of such engines.

1.3 Fuel quality

Fuel quality is of central importance when discussing emissions from large ship diesel engines. Large merchant ships and ferries are operated with Marine Diesel Oil (MDO) or Heavy Fuel Oil (HFO) which is essentially a residual oil formed from the final fractions of the crude oil.

MGO is available with sulphur contents between 0.05% and 0.2 %. HFO can have sulphur contents of up to 4.5%. In the Baltic Sea the permitted maximum sulphur content in HFO is 1.5%.

Tough economic competition in international shipping and increasing fuel prices led to the use of HFO as the main shipping fuel in the period after the oil crisis. Generally, HFO represents the final residue of the crude oil after all “light” components (gasoline, on-road diesel fuel, gas oil etc.) have been extracted in the refinery process. HFO is not a standardised fuel quality with clearly defined properties. It is simply the category name for a broad range of residual oils and oil blends from various sources and locations. The chemical and physical properties of HFO can very considerably. HFO needs to be processed aboard the ships (heated up to 150°C, separated and filtered) before it can be used in the engine. Apart from the use in ship diesel engines, there are only few alternative applications for HFO.

2 Airborne emissions from ship diesel engines

2.1 Emission of carbon dioxides

The emission of CO_2 is directly linked to the amount of fossil fuel which is burnt in an engine to produce a certain power output. A reduction of CO_2 emissions can be obtained either by reducing the power which is required for a certain task (e.g. the propulsion of the ship), or by improving the engine’s efficiency, i.e. reducing the amount of fuel which is required to produce a certain output.

As already discussed in Section 1.2, the major advantage of modern, large ship diesel engines is their outstanding thermodynamic efficiency which leads to relatively small CO_2 emissions.

During the combustion process, the temperature and pressure levels inside the cylinders of marine diesel engines are extremely high. Compression temperatures (before the start of combustion) reach up to 900 K, whereas flame temperatures during combustion can reach 2700 K at combustion peak pressures of 175 bar and above (compared to maximum pressures of approx.135 bar in car diesel engines). Due to thermodynamic laws, these extremely high process temperatures are the reason of the engines’ outstanding efficiency (Buchholz et al. 1999).

2.2 Emission of nitrogen oxides

Unfortunately, the high process temperatures, which lead to low CO_2 emissions, are at the same time responsible for increased NO_X emissions. NO_X is formed during the combustion process in those zones inside the cylinder where high temperatures (above 1800 K) and air excess are found for certain periods of time. In these zones, the following continuous reaction cycle takes place:

$$O + N_2 \leftrightarrows NO + N$$
$$N + O_2 \leftrightarrows NO + O$$
$$N + OH \leftrightarrows NO + H$$

This reaction-kinetic law of NO_X generation was named after its founder Zeldovich (1946).

2.3 Particulate emissions

Exhaust gas components which can be caught on a filter and do not vaporise at temperatures below 52°C are described as particulate matter (PM). In case of diesel engines, particulate emissions consist mainly of soot (unburnt carbon and longer or cyclic hydrocarbons) and ashes (oxidised metallic components, especially in case of heavy fuel oil operation).

The particulate emissions from large marine diesel engines can generally be low, at least when the engine is in stationary operation mode at increased load levels (50% of nominal output or higher). This is typically the case if the ship is sailing across the sea/ocean.

Increased, clearly visible particulate emissions can appear if large marine diesel engines are operated at very low load (during and immediately after engine start-up and during slow speed), when the engine is accelerated or the load is increased (manoeuvring). As can easily be seen, such operation modes are typical for ships sailing close to the shore or within ports and rivers, i.e. within coastal zones.

Other reasons for increased particle emissions can be poor fuel quality and increased sulphur content in the fuel (Prescher et al. 2000). These cannot be influenced by engine design. Here, the same comments as made in Section 2.5 Emissions of sulphuric oxides apply.

2.4 Emission of CO and unburnt, gaseous hydrocarbons

Hydrocarbon and CO emissions are the result of incomplete combustion processes. For large diesel engines these emissions are typically low, due to the high temperature and pressure level of the internal combustion process and due to the relatively slow process frequency. An increase in these emissions can occur during low load and during transient engine operation. New fuel injection technology in combination with improved engine management can reduce hydrocarbon and CO emissions during these engine operation modes.

2.5 Emission of sulphuric oxides

Fuel oil for ship diesel engines has significantly higher sulphur contents than fuel for land-based traffic. In the European Community, a maximum sulphur content of 0.035 % (to be reduced to 0.005% in 2005) is permitted in diesel fuel for on-road applications. Marine Gas Oil (MGO) can have up to 0.2% and HFO up to 4.5% sulphur (for shipping in the Baltic Sea limited to 1.5%).

During combustion in the cylinder of the diesel engine, virtually all sulphur from the fuel is converted to SO_2 and subsequently emitted into the atmosphere. This cannot be prevented by any engine internal measures. External measures to scrub the exhaust gas from the SO_2, although available for land-based power stations, are hardly technically feasible aboard ships.

The only efficient measure to reduce SO_2 emissions from shipping is the reduction of the sulphur content in the marine fuels. At the moment, availability and price of such fuels prevent their broad application. Major investments in the petrol-chemical industry seem to be necessary to supply sufficient quantities of low-sulphur fuel without significant price penalty.

3 Basic strategies for emission reduction

First NO_X emission limits for ship engines were introduced by the IMO in 2000. Although not ratified by a sufficient number of member states, the IMO “Technical code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines” (IMO 1997) became a virtual standard for all ships built after the 1st January 2000. The IMO code basically requires a 30% reduction in NO_X emission compared to the engine-specific NO_X emissions levels of 1997.

During a period of intense research and development, a number of engine internal measures were developed and applied to obtain the required reduction in NO_X emission without any or without significant fuel penalty. Such measures are: improved injection nozzles, improved engine control systems and adapted engine settings, adapted turbo-charger matching, changes in combustion chamber design. Today, IMO compliant marine diesel engines are available from all engine manufacturers.

Additional engine internal measures are generally known and are also applied aboard some ships, when further reduction in NO_X emission is necessary. Examples for such measures are the use of fuel-water emulsions instead of pure fuel which can reduce NO_X emissions by up to 30% without significant increase in fuel consumption or the injection of pure water during the combustion process. Further research in this field is taking place at the University of Rostock, too.

External measures, i.e. exhaust gas after treatment, are very difficult to apply aboard large merchant vessels. Due to the properties of HFO, its high contents of sulphur, and the varying quality of HFO a reliable operation of any kind of catalyst is very difficult and costly. The only proven technology available is the SCR-catalyst for the reduction of the NO_X emissions. Urea or ammonia is used inside these catalysts to reduce the NO by producing N_2 and H_2O. The installation of these bulky catalysts within engine rooms of ships is often difficult. The costs for the reducing agent (urea or ammonia) are significant. In order to guarantee a reliable operation of the catalysts over longer periods the use of better-quality, low-sulphur HFO is recommended which also increases operation costs. However, using such catalysts, the NO_X emissions can be reduced by well over 90%. In Swedish ports the use of such environmentally friendly technology is rewarded with reduced port fees.

The research carried out to fulfil the IMO requirements on NO_X emissions showed the potential of engine internal measures for further emission reductions. Better understanding of the emission generation processes and new technology to control the combustion process could lead to even more reduced emissions levels at unchanged engine efficiency. Regarding the reduction of NO_X, it will be necessary to find means to reduce local and temporal temperature peaks during combustion without reducing the overall temperature levels in order to maintain engine efficiency. Emissions of particulate matter (especially soot), unburnt hydrocarbons and CO could be reduced by improved injection and air supply especially at low load and instationary engine operation.

Emission reduction techniques which are until now primarily developed for normal, stationary engine operation at upper load levels (the most important operation mode of ship diesel engines) need to be extended onto low load conditions and instationary operations, as these load conditions are especially important for shipping in coastal zones.

4 Current research at Rostock University

The Chair for Combustion Engines at Rostock University has a long tradition in research for modern, environmentally-friendly combustion engines and marine diesel engines in particular. Several test beds are available for the experimental investigation of new engine and engine operation concepts, for the investigation of new, alternative fuels (e.g. fuel-water emulsions, rape seed oil, natural gas etc.) and the analysis of engine internal combustion processes (Hassel et al. 2003). Equipped with modern measurement technology and state-of-the-art simulation tools, basic research projects are carried out to broaden the understanding of engine internal processes and emission generation. Since spring 2004, a state-of-the-art four-stroke medium-speed ship diesel engine has been available for basic and applied research projects. This engine can be operated with heavy fuel oil to investigate emission reduction measures and other engine developments under conditions which are relevant for standard marine applications.

4.1 Influence of the injection process on combustion and emission generation

The fuel injection process has a decisive influence on the combustion process and, therefore, on the emission generation inside diesel engines. Emissions from ship diesel engines can be further reduced if new injection technology allows to control and to "design" the injection process according to the specific requirements of an environmentally optimised combustion process.

This approach requires three basic prerequisites: a flexible injection system, the definition of the requirements on environmentally improved combustion processes and the definition of the injection parameters which are necessary to obtain such combustion processes over the whole engine operation range. With the development of the common-rail diesel injection system a major step to fulfil the first prerequisite has been made. The second prerequisite, the definition of the requirements on environmentally improved combustion processes is subject to many research projects not only at the University of Rostock but at many research institutes and at engine manufacturers world-wide.

Target of the current EMI-MINI-project at the University of Rostock is the investigation of the influence of injection parameters on the fuel sprays generated inside the engine's cylinder. It contributes to the fulfilment of the third prerequisite mentioned above.

4.2 EMI-MINI Project

To get a better understanding about the influence of injection parameters on the fuel spray properties and on the subsequent combustion, laser based measurement technologies have been applied during various recent research projects at the University of Rostock (Hopp et al. 2003).

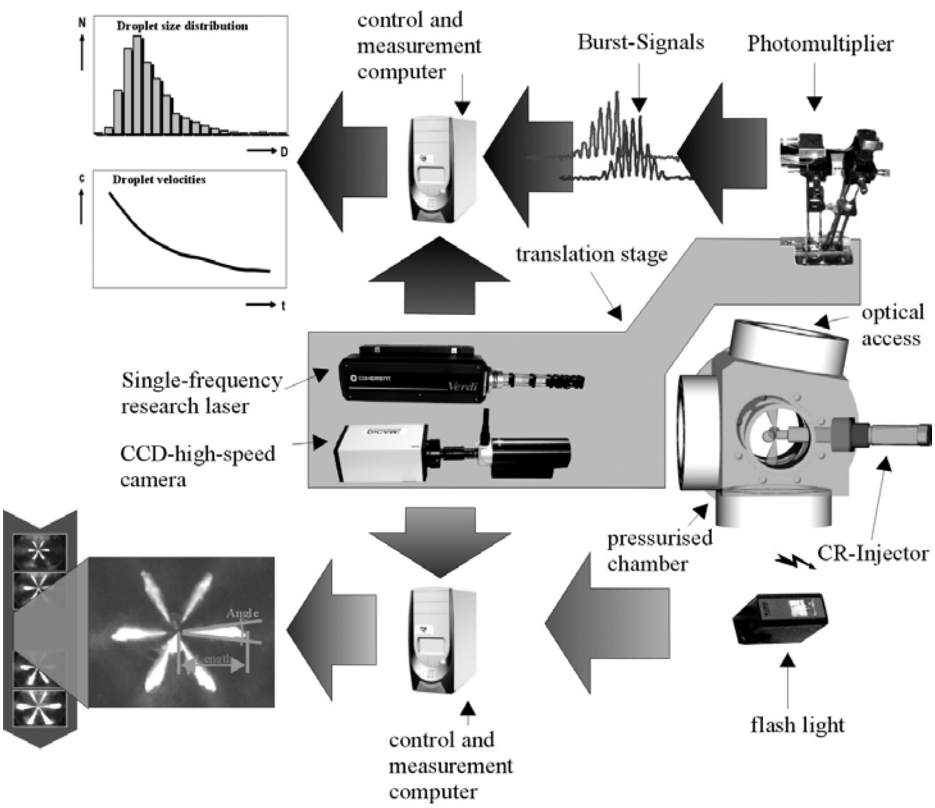

Figure 3: Experimental setup for the measurements of fuel spray parameters within the EMI-MINI Project.

Within the EMI-MINI Project modern laser-based PDA-measurement technology (phase-doppler-anemometry) is applied to investigate the fuel droplet sizes and velocities inside a fuel spray of a modern common-rail diesel-injector for large ship engines. In addition, photographs taken by a high-speed CCD camera are used to determine the macroscopic spray parameters, such as spray cone angle, spray length, spray tip velocity and spray volume. The common-rail injector is mounted to a special pressurised research chamber to investigate the fuel spray under conditions comparable to those inside a cylinder of a large diesel engine. The research chamber has 3 optical accesses (quartz glass windows). Through these optical accesses the spray can be investigated using the CCD camera or a laser beam. Temperature and pressure inside the chamber can be controlled within a broad range. The basic experimental set-up can be seen in Figure 3.

After a period of intensive redesign and construction of the experimental set-up, the first experiments were carried out. The results which are gathered now and in the immediate future will be evaluated and systemised. Figure 4 shows photographs of the diesel fuel spray that was generated from a common-rail ship diesel injector inside the research chamber. Local segments of the spray, for instance the fuel jet close to the nozzle, can be visualised using a far-field microscope and extremely short closure-times for the camera. More results from latest measurements are shown during the oral presentation at the conference.

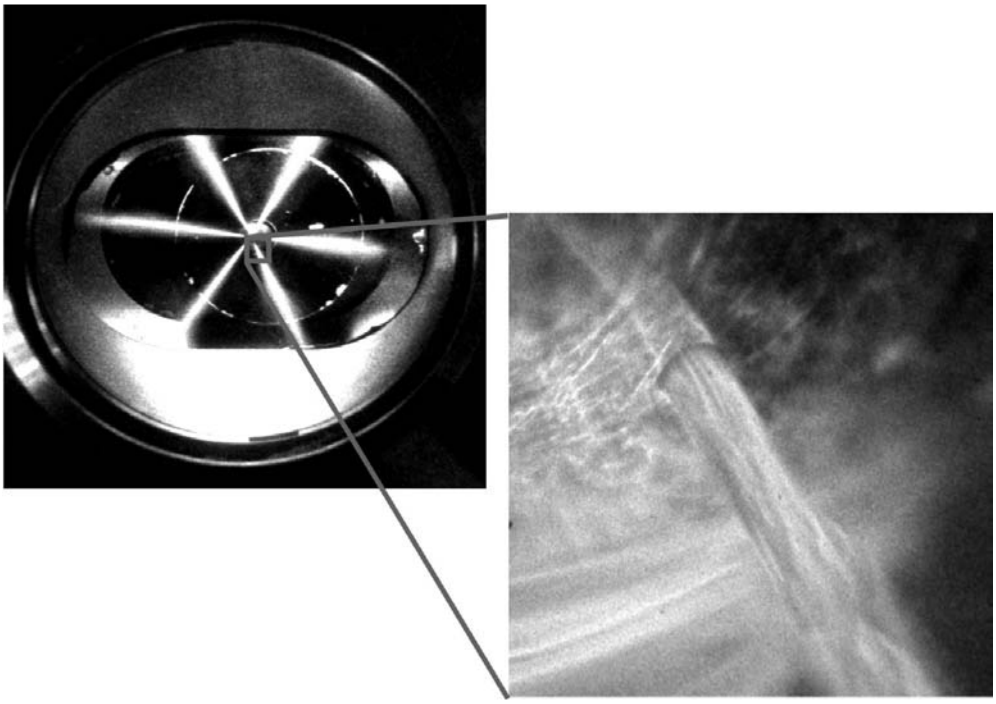

Figure 4: High-speed camera photographs of diesel fuel sprays from a common-rail diesel injector.

The EMI-MINI Project is a joint research project funded by the German Ministry for Education and Research. Apart from the University of Rostock the following research partners are involved:

Caterpillar Motoren GmbH & KG in Kiel

Caterpillar operates a 6-cylinder, medium-speed ship diesel engine equipped with a modern common-rail diesel injection system on their research test bed. The reduction of emission from turbo-charged ship diesel engines at instationary operation mode is Caterpillar’s the task within the joint project.

WTZ Roßlau gGmbH in Roßlau

WTZ carries out fundamental studies regarding soot production at large diesel engines depending on the fuel qualities. WTZ operates a single-cylinder research engine equipped with sophisticated measurement technology.

AVL Deutschland GmbH in Mainz-Kastel

It is AVL's task to use the data from the other partners involved to develop and verify their engine simulation tools. These modern design and development tools will be offered to the engine builders to support them in their increasingly complex task of developing and producing the next generation of environmentally-friendly ship diesel engines.

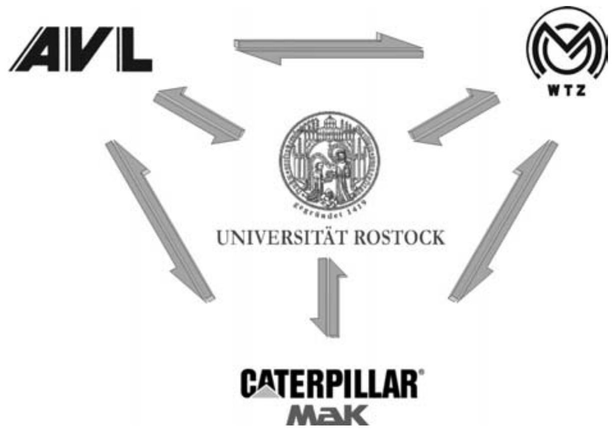

Figure 5: EMIN-MINI Project consortium.

5 Summary

Future emission reduction measures must target the drawbacks of modern ship diesel engines without reducing their advantages. To achieve this demanding target detailed research on all areas of the engine internal combustion process is necessary. The University of Rostock carries out several research projects dealing with emission reduction and use of alternative fuels.

The emissions from ship diesel engines are generated during the combustion of the fossil fuel inside the engine's cylinders. The emissions of sulphur oxides are directly linked to the sulphur in the fuel and can only be reduced by reducing the sulphur content of the fuel. All other emission components can be influenced by controlling the technical combustion process inside the cylinder. CO_2 generation is directly linked to the engine's thermodynamic efficiency, i.e. the amount of fuel needed to produce a certain output power. Here, the outstanding efficiency of ship diesel engines is a major advantage. Unfortunately, due to physical and chemical laws the combustion conditions which lead to this outstanding efficiency cause, at the same time, increased NO_X emissions. This effect is known as diesel dilemma or NO_X - fuel consumption trade-off.

Particulate emissions from ship diesel engines are generally low, but increase during low engine load and instationary engine operation (manoeuvring of the ship). These operation conditions are typically found when the ship is sailing close to the coast or within ports. Therefore particulate emissions from ship diesel engines are a specific "coastal zone problem".

The EMI-MINI Project at the University of Rostock, funded by the German Ministry for Education and Research, applies state of the art laser measurement techniques to the investigation of fuel sprays from modern common-rail injectors for ship diesel engines. An improved understanding of the interaction between injection parameters and fuel spray properties is target of these investigations. Together with the results obtained by other EMI-MINI partners, it will allow to utilise the increased flexibility of modern injection systems to reduce emissions from marine diesel engines especially during low and instationary load without sacrificing their advantages. Following this approach, large diesel engines could become an efficient and environmentally-friendly ship propulsion system of the future having reduced emissions also in coastal zones.

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COASTWATCH – a coastal and marine indicator and water quality service

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Abstract

Integrated with other tools, remote sensing can provide crucial data for monitoring and management of the coastal environment. The COASTWATCH initiative aims at making best use of processed satellite data to provide innovative information services to the coastal management community in support of European policies regulating this sector, in particular the Integrated Coastal Zone Management (ICZM) Strategy of the European Commission, the Water Framework Directive, and the Marine Strategy. This paper gives an introduction to the COASTWATCH services, in particular: a) The ICZM Indicator Service covers for the moment "land take by built-up in the coastal area", "urban sprawl", and "dominant landscape type". COASTWATCH can process satellite-derived data for these indicators at European and national level. b) The Water Quality of Marine Waters Service, providing information products required by the Water Framework Directive, such as Chlorophyll-a maps, suspended particulate matter maps, or primary production maps. Case studies highlight the potential of COASTWATCH services. The discussion refers to improvements and extension of COASTWATCH Services in the near future.

1 Introduction

1.1 COASTWATCH, part of the GMES programme

COASTWATCH is an information service for the coastal management community that makes best use of processed satellite data. It started early 2003 and supports European policies regulating this sector, in particular the Integrated Coastal Zone Management (ICZM) Strategy of the European Commission, the Water Framework Directive, and the Marine Strategy. The European Space Agency (ESA) provides financial support in the framework of GMES, a coordinated effort of the European Commission and ESA to establish an autonomous European Global Monitoring capability for Environment and Security. The COASTWATCH partnership is being led by ACRI-ST (France) and includes a network of experienced service providers delivering high-level earth observation based information on the coastal and marine environment as well as representatives of the user community, including EUCC – The Coastal Union.

The role of Earth Observation and satellite remote sensing is well established as a method of environmental monitoring and mapping. However, its place as a tool for coastal monitoring is less well developed. A possible reason for this is that although many different satellite sensors can be used for coastal monitoring, very few were specifically designed for this application. For example, most satellite sensors are designed to monitor either the land (e.g. Landsat, SPOT, IKONOS) or the marine environment (e.g. SeaWIFS, Coastal Zone Color Scanner (CZCS), MERIS), although land sensors are sometimes used for marine applications and marine sensors for land applications.

Nevertheless, satellite remote sensing does have the potential to contribute to coastal management in a number of ways. Some benefits include:

- Up-to-date data provision, or data (almost) on demand
- Data acquisition without field visits

- Early identification of environmental problems
- The ability of satellites to image large tracts of the Earth. At a broad scale, coastal managers can view whole coastal systems (sediment cells for example)
- Detailed monitoring of coastal landscapes, habitats and processes using higher resolution imagery.

Satellite remote sensing also has a number of limitations, including:

- The spatial resolution of some sensors is too low for detailed coastal monitoring and mapping
- Data for a specific date and time is not always available, e.g. because cloud cover prevents an image from being taken.

Consequently, remote sensing is best used in combination with other methods, in particular in-situ data collection and modelling.

1.2 Objectives of COASTWATCH

COASTWATCH responds to the growing need for cost-effective monitoring information on the coastal environment. COASTWATCH services are established by consolidating, aggregating, and improving existing services with the aim to:

- support organisations in the policy-driven coastal monitoring and compliance process, including routine monitoring, emergency response, and planning
- supply information integrating land and sea, earth observation & non-earth observation data, and models
- provide scientifically sound and validated services,
- ensure seamless access to the service wherever required in Europe.

COASTWATCH services provide basic geo-physical information, such as water quality parameters, integrated information such as indicators, and "decision support"-oriented information.

The initial service portfolio supports policy measures defined at the European level including the Strategy for Integrated Coastal Zone Management (ICZM), the Water Framework Directive (WFD), and the Marine Strategy. The COASTWATCH portfolio is gradually being extended in an open and coordinated fashion incorporating new service providers and new information services to satisfy new users. The long-term objective of COASTWATCH is to establish an operational service for the provision of effective information supporting decision-making in coastal management.

2 Results

In 2003, COASTWATCH developed two services, the Integrated Coastal Zone Management Indicator Service and the Water Quality of Marine Waters Service.

2.1 The ICZM Service

The ICZM Service provides information to support the implementation of the European ICZM Strategy and Recommendations at national, regional, and European level. A set of indicators and maps are delivered according to the standard of the European Environment Agency (EEA). The ICZM Indicator Service contributes to monitoring coastal environment status and land use changes in Europe.

Target groups are the, EEA and European Topic Centres, institutions of EU Member States and acceding countries in charge of the implementation of the ICZM Recommendations (in particular, the EU ICZM Expert Group, WG-ID), and regional sea conventions. In 2003, the EEA, the regional government of Catalonia (Generalitat de Catalunya) in Spain, as well as the INC- Institute for Nature Conservation and the Flemish Coordination Centre for ICZM, both located in Belgium, were the main users.

Coastal Indicator service line

The Coastal Indicator service line is mainly dedicated to the production of regional, national, and Europe-wide indicators as defined by the ICZM National Strategies, the EU Working Group on Indicators and Data set up by the EU Expert Group on ICZM (DG Environment), and the EEA. In this frame, a set of environmental stress indicators has been developed. Coastal indicators delivered by COASTWATCH belong to the "core set of indicators" as specified by the Working Group. The Coastal Indicator service line delivers the following products:

Indicator "Built-up in distance to the coast"

This environmental indicator delivers a percentage of land taken by build-up in coastal areas depending on the distance from the coast. European coverage is delivered in a coastal strip of 10 km.

Indicator "Dominant landscape type in the coastal areas"

The dominant landscape type indicator gives the dominance of major land cover types from CORINE in the European coastal area. This indicator delivers a percentage of dominant landscape in the coastal areas depending on coastal units. The aim of this indicator is to make a current typology of the low coast and high coast in function of 7 aggregated CORINE classes: Urban dense areas, dispersed urban areas, broad pattern intensive agriculture, composite rural landscape, forested landscape, open-semi natural and natural landscape, areas without dominance.

Indicator "Land take by built-up area in the coastal areas"

This indicator delivers a percentage of land take by build-up areas in the coastal zone 10 km from the waterline. It allows comparison on the growing of build-up area among different countries and regions in Europe. Its potential environmental impacts depend on the type of land affected, on the built-up characteristics and on its extension.

Indicator "Land take by diffuse and compact sprawl"

The land take by diffuse and compact sprawl indicator identifies sealing of the land by urban development in coastal areas. It is reflected by land take by urban sprawl in coastal areas, identifying:

- the intensive/compact urban development attached to the core of the city, and
- the extensive development forming disperse urban area.

The indicator shows the expansion trends of urban growth as well as the intensity pattern of the urban development.

Supply features

For the first three indicators, the Coastal Land Cover (CLC) accuracy is that of CORINE Land Cover. All features are digitised from an interpretation of satellite image printouts of the scale 1:100.000 with 150 m positional accuracy, and 25 ha minimum mapping unit. The best resolution is 100 m. Products can be delivered from an archive, starting from 1986 and ending in 1995. The special coverage is from the Faeroes to the Canary Islands and from the Canary Islands to Kastellorizon. The on-earth resolution is 100 x 100 m. Products can be delivered as jpg, xls, or dbf files.

Indicator 4 is being projected as specified by the user. Time coverage is by single year or multiple years. The indicator is calculated based on several cities located at the Belgian coast (Knokke-Heist, Oostende, De Panne). Additional cities can be covered on request. The product is always delivered as shapefile.

Validation

The validation process has been done in strong co-operation with EEA.

Coastal land cover and land use change mapping service line

Regular delivery of coastal land cover and land use change (CLC/LUC) maps is an asset for the monitoring of coastal zones. They present a standardised product for the continuous monitoring of land cover / land use changes in coastal zones and establishing a reporting system on land cover / land use changes based on long term spatial survey (e.g. CORINE Land Cover, LACOAST) and extensive use of high resolution earth observation data.

This service line aims to:

- deliver standardised products for the continuous monitoring of land cover / land use changes in the coastal zone in form of 1:15.000 up to 1:100.000 uni-temporal or multi-temporal maps / difference maps,
- report on land cover / land use changes based on long term spatial surveys, statistical assessment for specified areas (part of the coastal strip) in form of uni-temporal and/or multi-temporal, 1:15.000 up to 1:100.000 maps.

The coastal land cover and land use change maps can be produced for any part of the European coastal strip (EU member states and CEEC countries).

The following products are presently available:

Coastal land cover 100 product

These are small-scale land cover maps for coastal areas derived from high-resolution satellite imagery (e.g. Landsat, Aster, Spot-4 HRV, etc.). The accuracy is 90%.

Coastal land cover 15 product

Large-scale land cover map for coastal areas derived from very high-resolution satellite imagery (e.g. IKONOS, QuickBird, etc.). Accuracy depends on the specific case, but is estimated at 75 %.

Coastal land use change product

Land cover change map for one or several coastal areas (scale 1:100.000 or 1:15.000). Accuracy is typically several times the initial land cover accuracy. The product can be ordered by e-mail or fax.

Examples of service application

COASTWATCH provided the Co-ordination Centre for Integrated Coastal Zone Management of the Flemish region in Belgium with indicators and land cover maps to help them keep track of the current evolution in coastal areas and consequently adjust coastal management plans. COASTWATCH delivered an up to date land cover map of the year 2002 as a reference base for the future.

The European Environment Agency's core task is to provide decision-makers with the information needed for making sound and effective policies to protect the environment and support sustainable development. In this framework, COASTWATCH services support the development of some coastal environmental indicators to be used for improving spatial analysis and assessment at EU and Member States level, and to facilitate the production of reports by the Agency. The main benefits identified by the EEA regarding the COASTWATCH service portfolio are free access to updated data on land and sea, and the ability to obtain homogenous information on the coastal environment at a national level, which will allow them to follow up on the implementation of the ICZM Strategy.

2.2 The Water Quality for Marine Waters Service

The Water Quality for Marine Waters Service provides supplies data and expertise to users for monitoring activities as defined by the Water Framework Directive and marine conventions: surveillance, operational, investigative and protected areas monitoring. It delivers environmental indicators, water quality bulletins and early warning alerts derived from Earth Observation, and particularly ocean colour sensors for environmental monitoring, statistical and operational survey.

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Water Quality Monitoring

Water Quality Monitoring offers an on-line support for e.g. oceanographic cruises, pollution monitoring and survey of anthropogenic discharge, natural resources monitoring, or algal blooms surveys through the supply of maps, water quality bulletins and early warning alerts.

This service line delivers a wide number of qualified and validated geo-physical products over coastal seas (as well as over open seas):

- Sea surface temperature
- Chlorophyll-a concentration
- Suspended particulate matters
- Water transparency
- Photo-synthetically available radiation.

Key users of the Water Quality for Marine Waters Service are national and regional operational organisations in charge of marine, coastal and transitional waters monitoring.

Wave Exposure Monitoring

The Wave Exposure Monitoring service line delivers near real-time sea state information, significant wave height and wind speed, as well as climatologic statistics of waves, namely wave height, mean period and zero-crossing period, and mean direction.

Supply features of the Water Quality for Marine Waters Service

product	level	unit	range	accuracy	sources
water transparency	4	m	[0,100]	15%	MERIS/SeaWIFS/MODIS
Suspended particulate matter	3	$g.m^{-3}$	[0.01, 100]	15%	MERIS
Photo-synthetically available radiation	3	Einstein $g.m^{-3}$ day-1	[0, 75]	15%	MERIS/SeaWIFS
Chlorophyll a	3	$mg.m^{-3}$	[0.01, 64]		MERIS/SeaWIFS
Chlorophyll Case 1	3	$mg.m^{-3}$	0.03, 300]	13%	MERIS/SeaWIFS
Sea surface temperature	3	^{0}C	[-5, 35]	0.2	AVHRR
Wave fields in real-time		m	[0, 25]	0.5 m 10%	ERS-2, Envisat, Jason-1, NOAA

Table 1: A free toolkit for data handling, display and editing is supplied with the products.

Validation

Three types of validation are routinely performed :

- Running validation: L3 outputs are compared to available in situ data. For instance, Sea Surface Temperature data are routinely compared with buoys data. Any discrepancy is registered and reported to the expert in charge of this chain.
- Case by case validation: Inter-comparison with other similar results. Each product delivered to a user is systematically checked before sending.
- Scientific validation: Keeping track of latest scientific results in order to maintain quality on highest possible level.

Examples of service application

Fin whale populations are an indicator for good ecological status of coastal and marine waters, as defined by the Water Framework Directive. The relationship between primary production (measured by earth observation techniques) and the summer distribution of Fin whales (observed by boat survey) in the north-western Mediterranean Sea has led to a predictive model that integrates primary production data over different temporal scales from the beginning of March to the start of whale surveys by ship. In order to take into account the environmental changes and the likely whale movement, the model is being adjusted every eight days. COASTWATCH has provided primary production data and an adjusted model to GREC, a cetacean study group, thereby contributing to a more efficient monitoring of Fin whale populations. Results of a field campaign by GREC have confirmed the relevance of the model and COASTWATCH data.

Another COASTWATCH application example is the support of the GAUSS campaign, the research vessel of the German maritime institute BSH, for surveillance monitoring for Water Framework Directive compliance. The Coastwatch Water Quality Service delivered in near-real time ocean colour derived products (Chlorophyll-a, Total Suspended Matter, Transparency) and Sea Surface Temperature. The results obtained on board showed a very good agreement between measured in situ Secchi depth and the transparency derived from COASTWATCH with the help of MERIS, and consequently helped to validate results obtained in the conventional way.

On Saturday 31st May, 2003, the Chinese freighter “Fu Shan Hai” sank to a depth of 68 m in the Bornholms-gat, Baltic Sea, and caused an oil spill. Although optical remote sensing of ocean colour is generally not used to detect oil spills, the extraction of spatio-temporal information from MERIS imagery was successfully done as a preliminary attempt to demonstrate the use of MERIS as a potential complementary tool to other means of investigation (e.g. SAR). It could be concluded that the detection of small scales structures is definitely possible using MERIS Full Resolution products, and that this technique is certainly of interest to monitor coastal pollution.

3 Discussion

The two thematic COASTWATCH services have been successfully operating during 2003, the first year of the initiative. The quality of the products generated by the ICZM Service is related to the quality of the input databases, which is ensured by the EEA and the ETC-TE (Terrestrial Environment), among others. The robustness of the service has been successfully demonstrated since few anomalies occurred. However, users noted that the resolution of delivered information, especially when addressing local products, is sometimes too coarse (100m) and the updating frequency for some delivered information could be higher (at least every five years). In both cases, the topic is related to CORINE Land cover, which is one of the main input data sets.

3.1 Future of the ICZM Service

With the future EU enlargement, new efforts are needed to achieve a seamless coverage and comparable information to build the indicators. Indicators are mainly based on CORINE, which has a seamless coverage, but the scale and resolution is not sufficient to work on the local and regional level and the updating frequency is around 10 years only. Consequently, a new product is needed, based on CORINE but with better resolution and updated more frequently.

The dominant landscape type indicator will need to be completed by COASTWATCH with statistical data on tourism, population, agriculture, and environment, among others. To this aim, the EEA proposes, that for analysis at regional level, indicators will be elaborated using satellite imagery with a higher resolution (e.g SPOT 5, Quick Bird, IKONOS).

Moreover, COASTWATCH aims to cover more indicators in the near future:

- Rate of development of previously undeveloped land
- Proportion of coastal zone (land and sea) protected by Natura 2000
- Pressure on the coastal ecosystems, both from land and the sea
- Coastal erosion patterns within dominant landscape types (percent of km of eroding and accreting coast, trend in relation to Natura 2000 and landscape types)
- Coastal habitat loss indicator (derived from Coastal Land Cover maps at 1:15.000 scale).

3.2 Coastal Engineering Service

A new COASTWATCH Service will be developed in 2004, the Coastal Engineering Service. It aims to provide COASTWATCH with the ability to deliver information on coastal processes that underpin decision making, such as safety issues or environmental management and planning in coastal zones. The physical parameters required for understanding coastal processes are wind and waves, currents, and sea level. A key focus of this new service element is the ability to deliver this information at the range of scales required by the users from regional to local level by coupling data sources with numerical models. Combining this service with the Water Quality Service can help identify pollutants dispersal and pollutants sources. Combining the service with the ICZM Indicator Service can provide indicators of coastal vulnerability or coastal hazard. Potential users are national and local organisations involved in coastal development, planning, defence, or conservation, or consultants who supply those organisations.

3.3 Validation Bureau

The COASTWATCH Validation Bureau, established in 2003, will be strengthened in 2004 and beyond. It establishes rules to ensure unbiased and independent validation and includes representatives of the service providers and the end user community. Validation of the Water Quality Service will be conducted using in situ data and cruise data.

3.4 Cooperation

Cooperation with related initiative such as the REVAMP project on data harmonisation and the GMES project ROSES - Real time Ocean Surveillance for Environment and Security covering oil pollution and water quality - will be strengthened in order to maximise synergies and use resources more efficiently. Moreover, cooperation with SAGE (Service for the Provision of Advanced Geo-Information on Environmental Pressure and State) is under positive discussion. Furthermore, COASTWATCH will also aim at providing follow-up to information related aspects of EUROSION, a European initiative on coastal erosion management.

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Metadata in Coastal Areas – Perspectives and Experiences

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Abstract

Catalogues have been discussed for centuries in libraries and it is generally accepted that finding relevant books in any science without a well organised catalogue is almost impossible. Nowadays the idea of a library with its catalogue entries is transported to all kinds of data, including books, maps, geographic layers, models. The correspondence to the catalogue entries are metadata, i.e. descriptions of the data. In this paper we present the general idea of cataloguing data electronically making them this way searchable for a broader audience. Additionally we present briefly three metadata system for coastal areas developed within the last four years, namely CoastBase, EUROSION and NOKIS.

1 Introduction

As described in the recent reflection paper of the European Commission ”Towards a European ICZM Strategy” (1999), coastal areas and their natural resources (marine and terrestrial) have a strategic role to play in meeting the needs and aspirations of current and future European populations. Important examples of functional uses include: tourism, shipping, industry and energy, fishing and mariculture, coastal defence and natural development. It is essential that these functions can develop in a sustainable way to support conditions for human health, employment and regional development and environmental quality. The physical and administrative units related to coastal systems and its environmental problems may vary from local up to transboundary and supranational.

Authorities responsible for the management of these areas need to take both socio-economic and environmental aspects of these functions into account. Human pressures pose the risk of destroying habitats and the resource base of the coastal zones, and with them, the ability of the coastal zone to perform many of its essential functions. The EU Demonstration Programme for ICZM and above mentioned Reflection Paper suggest that an integrated coastal management is needed, including communication between all actors representing different sectors and between administrations in different levels.

In this approach access to all relevant information is essential. This information is in general dispersed among coastal institutes and organisations and neither readily available nor accessible. This lack of availability and accessibility of information hampers effective planning and decision making; the need to improve information finding in a distributed and highly heterogeneous environment is the motivation for the development of catalogue systems.

1.1 Outline

The paper is organised as follows. In Section 2, we introduce the basics. In Section 3, 4 and 5 we present briefly three main metadata projects for coastal areas, i.e. CoastBase, EUROSION and NOKIS. An outlook on future work conclude the paper in Section 6.

2 Basics

2.1 Catalogues

In order to react upon complex environmental problems, it is necessary to have information of various application fields at hand which in most cases will be located at different sites. Only if the respective information is sufficiently available it is possible to find complex interrelations, and to mutually use available information. Both the recollection of data that already has been collected and keeping data without any further use because of missing knowledge about the data can be avoided.

The answer to a certain question requires to learn *which* data is available, *where* the data are managed, *how* this data can be obtained, and *how* to interpret the data correctly. The information that is necessary to obtain above mentioned information is called *metadata or meta-information*. This information can be compared to the information of classical index cards in library catalogues, which describe books but are not the books themselves. Due to the present explosion of the volume of data, it becomes even more important for the user to rely on information about existing data in order to find what he or she needs. Equivalent to the library catalogues which contain index cards, meta-information systems or *catalogue systems* are the more general electronic form. Typical examples of environmental catalogues are the German/Austrian Umweltdatenkatalog (UDK) and the Catalogue of Data Sources (CDS) of the European Environmental Agency. Both deal with descriptive information about environmental resources (Kazakos et al. 1998; Swoboda et al. 1999).

2.2 Information Integration

Integration of information from heterogeneous sources has been a major topic in the database related research for several years. Roughly speaking, there are two possible approaches (Widom 1996):

- The materialised (or Data Warehousing) approach. From each source, information that may be of interest is extracted/exported from each source and after filtering, harmonisation and fusion with information from other sources stored in a (logically) centralised repository (the data warehouse. User queries are evaluated at the central repository without connecting to the individual sources.
- The virtual (or mediated) approach. When a user poses a query, this query is sent directly (after necessary transformations) to the appropriate sources for evaluation. Their results are then filtered, harmonised and fused and presented to the user.

Whereas the materialised approach allows to optimise the response times for certain applications and the access reliability, it has serious drawbacks considering the updating of the repository when the information sources change in their content. Here the autonomy of the information sources has to be restricted such that an update policy can be put to work. The virtual approach on the contrary allows to leave the content at its original place. Changes to the information sources are immediately reflected in the query results.

Prominent virtual integration projects like TSIMMIS (Hammer et al. 1997; Garcia-Molina et al. 1997), Information Manifold (Levy 1998), or MIX (Baru et al. 1999) can be more or less accurately divided according to the I³ reference architecture's terminology (Arens et al. 1995) into three main logical components:

- Wrappers overcome the technical and syntactical heterogeneity of the individual sources.
- Mediators overcome the semantic differences (schema/information model) between the sources and fuse equivalent information artefacts.
- Facilitators select the sources needed to satisfy a given user need and combine them appropriately.

3 CoastBase

CoastBase started in January 2000 with 11 partners from 8 European countries. It aims to improve European marine and coastal management. The Project was supported by European Commissions IST programme (5th framework). The project is described in more detail in (Kazakos et. al. 2000) and

(Kazakos et al. 2001). One central part of the project was a virtual catalogue. It is designed to be flexible enough to be used not only in other coastal and marine applications, but also in other application domains.

The overall CoastBase system is based on a 3-tier multi-server architecture. The three tiers are the CoastBase client tier, the CoastBase server tier and the data abstraction tier. Client and server are further divided into sub-components according to the functional decomposition of CoastBase. These are catalogue, data access and manipulation, and feedback. In the data abstraction tier, the wrappers for the inventory data, as well as for the local repositories are implemented.

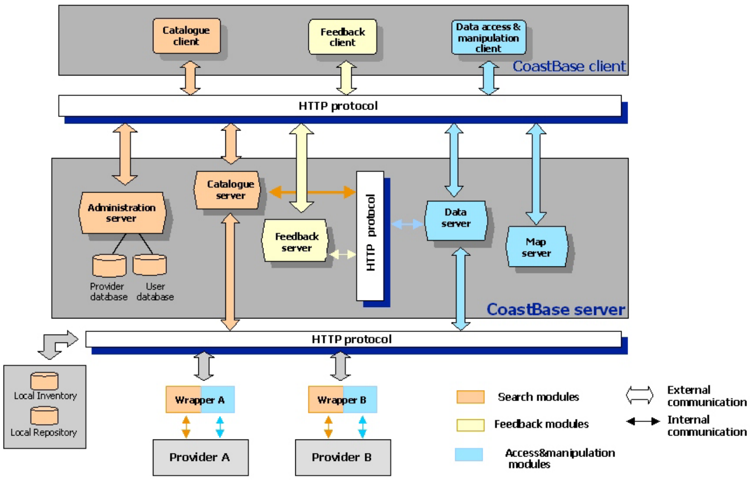

Figure 1: CoastBase general architecture.

The virtual catalogue of CoastBase covers the search and feedback modules. They cover three main functional units needed in every similar type scenario. The administration authenticates and authorises the user according to user groups. The query dispatching and retrieval of distributed inventory data is done by the catalogue server. The feedback server contains a update module, allowing the creation and actualisation of inventory data.

One of the major design goals of the overall system and especially of the virtual catalogue component was the extensive use of XML and XML-based techniques, in order to achieve maximum interoperability with other systems and the reusability of several parts of the system. The user interface for the catalogue client is in HTML and can be used by all typical browsers. The catalogue server implements the main functionality of the virtual catalogue that is able to access distributed, but homogeneous sources with the same domain model.

In order to build a scalable system that makes it easy to integrate new sources, a virtual integration approach was chosen. Except for a local repository into which products generated by CoastBase users are uploaded, there is no centralized database. In fact there is neither a centralized database for the data nor for the metadata. Instead, the existing Internet access points for the sources to be connected are used. The user queries are dispatched at run-time to the sources. In order to overcome the technical heterogeneity, wrappers that translate the queries into queries native to the source, adapt the access protocol, translate the results into XML and transform the structure to fit the CoastBase domain model are employed.

4 NOKIS

NOKIS (North See and Baltic See Coastal Information System; http://nokis.baw.de) is a joint project of KFKI (Kuratorium für Forschung im Küsteningenieurwesen) and BAW (Bundesanstalt für Wasserbau) with the main objectives to establish a metadata information system for the German

North Sea and Baltic Sea coastal regions according to the concept of an open system that permits participation of additional partners at any time.

Seven participating federal and state offices compile local metadata bases related to their data archives and integrate them via the internet. To support them, NOKIS provides a local prototype meta database which is installed in every participating institution and which is integrated via the internet. FZI developed the system for the NOKIS consortium.

The overall architecture of the NOKIS system consists mainly of local meta data bases and a central server located at BAW. In the local data bases, data sources are maintained by the participating institutions. They differ considerably in the data base technology applied to handle data sets and also in the availability of related metadata. There is a need for adding search techniques to the distributed data archives.

The overall concept of NOKIS is also suited to aid the local maintenance personnel and responsible parties who are in close contact with the region and its peculiarities to improve local data handling and documentation by creating appropriate metadata for efficient automated search operations. NOKIS participants are not expected to change their methods of archiving their data, documents, images, etc. They are, however, provided with uniform graphical user interfaces which are used for global search on the central server as well as for local search on their own data bases.

Locally created and maintained metadata bases are uploaded to the central NOKIS metadata server http://nokis.baw.de whenever the participating organizations consider it necessary to update the central metadata base. Any proprietary information is filtered out during this replication process. The contents of the central metadata archive represents the collection of all public meta information provided by participating organizations.

The essential task at the beginning of the project was to decide on the type of metadata which should be applied in a sustainable web portal for the coastal zone. Many proprietary attempts, which provide limited and very specific "data about data" are used in intranet environments. It is often argued that rather comprehensive international standards require too many entries to be successfully applied. However, efficient search facilities, which are needed to handle the information abundance require intensive preparatory effort for satisfactory performance. A number of standards has been developed during the last decade, which are in use world-wide for different purposes. They differ in the granularity of meta information which is an important issue for the functionality that can be built upon metadata.

In co-operation of more than 30 nations, the international metadata standard ISO 19115 has been developed. The Committee Draft 3 released in 2000 was taken as the basis for the NOKIS metadata model. The recommended core metadata for geographic datasets specified by ISO 19115 consists of only 12 mandatory and 11optional elements for information on responsible party, access, quality and description of datasets. The NOKIS metadata model declares 23 elements of the ISO metadata model mandatory to also accommodate information relevant for GIS applications. Thus the NOKIS metadata model is fully compliant with the ISO 19115 standard and guarantees that sufficient meta information is available for documentation and intelligent search methods.

The overall system is developed by following an XML-extreme approach as proposed in (Kazakos et al. 2001), i.e. using XML-technologies as far as possible, to achieve maximum reusability and easy configuration. We further extended our approach, and set up a system architecture that generates all components of a typical metadata repository out of an XML schema definition (XSD).

5 EUROSION

EUROSION is a project commissioned by the General Directorate Environment of the European Commission, which will result in policy recommendations on how to manage coastal erosion in Europe in the most sustainable way.

One quarter of the European Union's coast is currently eroding despite the development of a wide range of measures to protect shorelines from eroding and flooding. The prospect of further sea level rise due to climate change and the heritage of mismanagement in the past - such as inappropriate infrastructure - imply that coastal erosion will be a growing concern in the future. This is why the Directorate General Environment of the European Commission tendered the EUROSION project in 2001, which was won by a consortium led by the National Institute for Coastal and Marine Management of the Dutch Ministry of Transport, Public Works and Water Management. The implementation of the project started in January 2002. The project is expected to achieve its objectives by the end of 2003.

Through supporting the Integrated Coastal Zone Management Practitioners Network and facilitating access to relevant data and information, EUROSION offers a follow-up to the EU demonstration program on Integrated Coastal Zone Management - with an emphasis on pilot projects which focused on erosion management - and is consequently biased towards ICZM strategies.

The overall objective of EUROSION is to provide the European Commission with a package of recommendations for policy-making and information management practices to address coastal erosion in Europe, after thorough assessment of knowledge gained from past experiences and of the current status and trends of European coasts. However the project also aims at producing results of immediate value for policy makers and managers on other administrative levels.

Although EUROSION is a content oriented project one major concern was the publication and dissemination of the result through an internet based platform. disy and FZI are developing currently this platform based on the technologies of CoastBase and NOKIS projects. The general architecture is thus similar to CoastBase. In addition to CoastBase special focus was on incorporating descriptions (metadata) about geographic information, models and reports. To achieve this a metadata model was developed based on the ISO standard for geographic meta-data, ISO/DIS 19115. The system allows search and retrieval based on these meta-information and provides together with NOKIS one of the first Web-based metadata editors for ISO 19115 conformant metadata.

The overall system is developed by following in the main lines an XML-extreme approach as proposed in (Kazakos et al. 2001), i.e. using XML-technologies as far as possible, to achieve maximum reusability and easy configuration. We further extended our approach, and set up a system architecture that generates all components of a typical metadata repository from an XML schema definition (XSD). In addition we are now able to support multi-schema editing providing a customized metadata-editor for each type of information, i.e. from simple links to ISO-19115 compliant metadata for geographic information.

6 Conclusions

One of the major challenges integrated coastal zone management has to face is the distribution and heterogeneity of data needed for the management tasks. Metadata and meta-information systems provide the means to find available data but also to identify possible gaps in the data collections. In this paper we presented briefly three major approaches to search for data and information about coastal zones, focussing on technical aspects only, like distribution and Internet technologies. We believe, that future ICZM has to tackle the issue of setting up meta-information system and agreeing on metadata standards. CoastBase and NOKIS did an important step towards this direction.

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Harmonization of management plans: Natura 2000, Water Framework Directive and EU Recommendation on ICZM

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Abstract

The mentioned European legislation corresponds in general with one very important point: the broad access of the public and the administrative implementation of these acts. The EU Water Framework Directive from 2000 (WFD) basically lays down that water management shall be done by Member States through river basins within river basin districts. Quite recently, this concept of river basin management is being included with the Integrated Coastal Zone Management Recommendation from 2002 (ICZM) to provide the key for the integrated development of the natural, economic and cultural environment within river basins and coastal areas. The EU Flora Fauna Habitat Directive from 1992 (Habitat Directive) lays down the establishment and conservation of the network of sites known as Natura 2000, in this areas the Member States are obliged to promote biodiversity by maintaining or restoring certain habitats and species at favourable conservation status within the context of Natura 2000 sites. These areas could also be so called protected areas under the regime of the WFD. Obviously there is a necessity to collaborate and to integrate different approaches of natural protecting aspects, because the water administrations policy differs in the most Member States with the policy of the natural protection offices. The WFD and the Habitat Directive correspond with important main targets. Both directives strengthen the precautionary principle, which is also mentioned in the ICZM. Furthermore both directives integrate the protection of aquatic ecological systems and species attending the objective of the potential natural condition of the ecological systems. The WFD and the Habitat Directive differ from the administrative approach. The FFH Directive is a more old fashioned act of EU legislation, it founds on the thinking of different districts of national administrations, the WFD has a modern approach with an administration in transnational river basin districts. Therefore the demand of harmonization is evident.

1 Problem

The Habitat Directive, the Water Framework Directive (WFD) and EU Recommendation on the Integrated Coastal Zone Management (ICZM) provide the implementation of management plans. Areas which are recorded by all three management plans effectively have to fulfil the following substantial conditions: (1) According to the Habitat Directive they have to be aquatic sites. These areas are designated for the protection of habitats or species where the maintenance or improvement of the status of waters is an important factor in their protection. Over that Natura 2000 sites can be designated on both land and water. Marine protected areas might include reefs or lagoons, intertidal areas, areas which are always covered by the sea or perhaps land near the sea which is used by marine wildlife. (2) From the point of view of the WFD the areas have to belong to a river basin district which means the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters up to one nautical mile on the seaward side. (3) According to ICZM Recommendation the areas must be finally appropriate in the range of national strategic plans for the coast management of both the marine and terrestrial components of the coastal zone, which is not more near defined.

The concept of river basin management has been included by the EU Recommendation on the Integrated Coastal Zone Management (ICZM) from 2002 to provide the key for the integrated development of the natural, economic and cultural environment within river basins and coastal areas. Natura 2000 envisages the establishment of a coherent European ecological network for the conservation of most seriously threatened habitats and species across Europe designated by the legislation of the Habitats Directive (1992) which complements the Birds Directives (1979). In these areas, Member States are obliged to promote biodiversity by maintaining or restoring certain habitats and species at favourable conservation status within the context of Natura 2000 sites. These areas could also be so called protected areas under the regime of the WFD.

Obviously there is a necessity to collaborate and to integrate different approaches of natural protecting aspects, since the water administrations policy differs in the most Member States with the policy of the natural protection offices.

2 Comparison of laws

The legal form of the WFD and Habitat Directive is binding. However, the ICZM remains as a recommendation therefore optional. Among these legislations, the one which sets up a clear and detailed management plan is the WFD's. WFD's management plan is also the one which is absolutely mandatory. Although the Habitat Directive, as a directive, has more sanction than ICZM, its management plan is somehow facultative ("Member States shall establish…if need be, appropriate management plans…"). ICZM's plan remains facultative but it should be considered as a very crucial guideline, therefore, it is facultative on the legal basis but mandatory for the achievement for the EU's objectives.

Concerning the aquatic zones, Natura 2000 sites can be designated on both land and water. Marine Special Areas of Conservation are always covered by the sea or even land near the sea which is used by marine wildlife. Therefore, they are covered by the WFD's and ICZM's interest as well. All three legislations touch upon the question of cross-border.

The EU Recommendation on ICZM, mentioning about the public participation many times, envisages involving the public in the management process and considers the public as a part of the integrated management itself. It also makes the reports available for the public. The WFD gives a separate article for the public information and requires the public consultation on the management plan. It makes the reports available for the public's comments. The Habitat Directive doesn't really consider the public as a part of its process but takes into account the opinion of the public only after the agreement of national authorities and makes accessible the reports to the public. Furthermore co-operation with stakeholders is highlighted in detail in the EU Recommendation on ICZM.

About the monitoring, the ICZM doesn't bring a new approach but mentions about the „adequate" systems. WFD underlines the need for the establishment of the procedure for the monitoring of freshwater quality and quantity (recital 7 WFD), the need for the standardisation for the monitoring (recital 49 WFD) and gives further details about the monitoring under Article 8 WFD. According to Article 8 WFD, Member States shall ensure the programmes for the establishment of monitoring and these programmes should be operational at latest six years after the entry into force of the directive. In case the monitoring indicates that the objectives are unlikely to be achieved, Member States should review the monitoring programmes and make them appropriate (Article 11 para. 5 WFD). The monitoring programmes are supposed to be reported to the Commission and to any Member State concerned (Article 15 WFD).

3 Comparison of management plans

ICZM insists on the term of "integrated", thus, emphasizes more the co-operation than the management plan itself. Anyhow, it doesn't bring any new implementation of a management plan. The WFD offers a very obvious and unique management plan with the river basin management. On the contrary, the Habitat Directive suggests specific plans for each site. At this point, one can say that, while WFD has a unique plan, ICZM and Habitat Directive have potentially more than one unique plan. Therefore with regard to the scale of the management plans, it is possible to state that ICZM suggests an overall stocktaking, WFD requires a detailed analyse of the river basin district and Habitat Directive requests a detailed list of the habitats and species covering all the relevant area.

According to Article 13 WFD, management plans have to be drawn up for river basin districts. Pursuant to Annex VII WFD the management plan should contain inter alia the following elements: (1) a general description of the river basin district, i.e. of surface waters and groundwater, (2) a summary of all significant pressures and anthropogenic impacts, (3) mapping of the protected areas, maps of the monitoring networks for the bodies or surface water, bodies or groundwater and protected areas (inter alia Natura 2000-sites), (4) a list of environmental objectives for the water use, (5) a summary of all measures and programmes of measures adopted under Art. 11 WFG, (6) a list of the competent authorities, and (7) a summary of public information and consultations measures.

Under the Habitat Directive Member States are required to identify sites of European importance and implement special management plans to protect them, combining long-term preservation as part of the sustainable development strategy. These sites, together with those of the Birds Directive, make up the Natura 2000 coherent network. Member States can choose the mechanisms to implement the relevant conservation measures on its territory. According to Article 6 of the Habitat Directive the management plan for Natura 2000-sites is not mandatory but facultative. The necessary conservation measures can involve "if need be, appropriate management plans specifically designed for the sites or integrated into other development plans".

The Natura 2000, with the Habitat Directive and the Birds Directive remains as an old legislation as it doesn't provide any specific plan. The question "What is the favourable conservation status for each habitat type and species present on the site?" is implying a great lack of the management plan for Natura 2000. Although this latter is still important for giving a detailed list of species of birds and habitats to be protected. Questions such as "Who will initiate the plan?" or "Who will be responsible for the plan?" are still being discussed and implying a problem of the designation of the implementation.

There is a huge variety of management plans according to Member States. For example, Natura 2000's management plans are sometimes considered as the nature protection plans. Management plans are needed for all specially protected areas. In another case, the planning of protected areas has been performed mainly through territorial planning and nature management planning is still under the development. In some countries, by the law all protected areas need a management plan but guidelines for management plans have not been produced yet. The management planning procedure is not clear in many cases. Some Member States have finished the selection and evaluation process of the Natura 2000 sites and the phase for monitoring and informing public has started. The administrative and contractual measures are still being discussed. For the management of the protected areas, agri-environmental schemes are offered as a management tool. Some Member States applied the Forestry law besides the Nature Conservation law, for the management plan.

4 Discussion

4.1 ICZM-Recommendation

Integrated Costal Zone Management shall implement an environmentally sustainable, economically equitable, socially responsible, and culturally sensitive management of coastal zones, which maintains the integrity of this important resource while considering local traditional activities and customs that do not present a threat to sensitive natural areas and to the maintenance status of the wild species of the coastal fauna and flora.

Integrated management of the coastal area is perceived as a constant process with numerous participating sectors, constituted for improving, developing, protecting and planning of the area through integration and inter-sectoral co-operation. It should be assumed that the process compiles and does not substitute plans in particular sectors, like the management plans of the WFD.

Integration concerns undertaken management goals as well as the tools needed for their realisation. The essence of integrated management is the idea of sustainable development of coastal areas. Integrated management concerns both land coastal area and sea coastal area. Therefore the Community promotes integrated management on a larger scale by means of horizontal instruments. These activities contribute to integrated coastal zone management.

Member States take into account the sustainable development strategy and take a strategic approach to the management of their coastal zones. Management plans are not obligatory. But in Chapter II under point h the "use of a combination of instruments designed to facilitate coherence between sectoral policy objectives and coherence between planning and management" is named as a principle. And in Chapter IV the national strategies designated in the recommendation should consider the appropriateness of developing national strategic plan for the coast to promote integrated management. By the way, this is only one of the combination of instruments for implementation of the principles outlined in Chapter II.

Concerning Chapter III Member States conduct or update an overall stocktaking to analyse which major actors, laws and institutions influence the management of their coastal zone. This stocktaking can be compared with the approach of the WFD (Art. 5 para. 1 WFD). Also here a comprehensive analysis is undertaken by the Member States. The ICZM-stocktaking (concurrently the first step to make a plan) should consider resource management (like WFD) and species and habitat protection (like Habitat-Directive).

One of the above-mentioned instruments of national strategies is the public awareness. Particularly, identified measures to promote bottom-up initiatives and public participation in integrated management of the coastal zones and its resources should be taken into consideration. This demand affects even the process of ICZM-management plans. And at least there is a need to ensure coherent action at European level, including cooperative action and consultation with regional seas organisations or international organisations, to address cross-border coastal zone problems.

4.2 Water Framework Directive

Even in the Water Framework Directive a co-ordinated approach within a river basic district forms the central element. The intention of WFD is to facilitate management planning that transcends national boundaries. This demands far-reaching co-ordination between all the parties involved. The success of the WFD therefore depends crucially on a willingness to co-operate beyond regional and national boundaries. This commitment to co-operation is more efficient if the tasks to be performed are made as transparent as possible and the respective responsibilities and competencies are specified clearly and precisely. The appropriate instrument for this is the management plan as defined in Art. 13 of the Water Framework Directive. The objectives agreed and the measures envisaged must be co-ordinated beyond the level of individual survey areas and consolidated for the river basin district as a whole. This requires co-ordination among all the competent authorities and institutions as national and international level.

The river basin management plan must also identify and regularly document the desired outcome of measures along with the use of any exemptions that are made. The management plan becomes the instrument of control for the river basin district management, participants themselves and for the European Commission. Particular attention should therefore be given to the work of drawing up, regularly reviewing and updating the plan.

The river basin management plan must cover an entire river basin district (an ICZM-plan potentially several). The plan itself contains a summary presentation of the whole river basin area and all major factors influencing the overall management of the river basin district. Where river basin districts are large, it may be useful to divide the district into operational areas or sub-basin survey areas. The division into sub-basin survey areas is a matter for the national authorities that share control over a river basin. These sub-basin areas must be defined by hydrographic criteria or, only in demonstrably exceptional cases, by administrative or other criteria. These other criteria may be emanate from ICZM-plans or ICZM-requirements, but this is the exception.

The level of detail required in this work on the management plan is determined by provisions contained in Annexes II and V of WFD. Information and special aspects lay down in an ICZM-plan which go beyond the scope of the plan should be considered independently, since they are not obligatory elements in the production of management plans and implementation of the WFD.

To characterise and determine the status of waters, Art. 5 of the WFD requires that Member States carry out (1) an analysis of the characteristics of the river basin district, (2) a review of the impact of human activity on the status of bodies of surface water and bodies of groundwater, and (3) an economic analysis of in the river basin district as required in Annexes II and III of WFD water use. Above all the surface waters must be mapped within the river basin, the location of river basins must be identified and the catchment area has to be delineated. Here, surface water categories, namely rivers, lakes, transitional waters and coastal waters are included. In the case of transboundary waters, however, we must engage in international coordination to agree in the water body types in areas close to national borders. Building on these initial hydrological surveys and characterisations, one must identify all the significant anthropogenic pressures to which the bodies of surface water are subject. The degree and extent of the survey is mainly determined by the information required under the existing EU directives and recommendations in particular the Habitat Directive and the ICZM-Recommendation that already apply here. To determine the significant anthropogenic pressures identified in this way, we also need to make an assessment on these pressures with regard to their potential threat to good status. The form of the presentation (e.g. in tables, maps or in GIS-based internet-capable formats) has yet to be agreed at European level and in the river basin districts. Here an agreement with the ICZM-plan comes into question.

With regard to the Habitat Directive a further task of WFD-plan is to register and present in the management plan all the existing water-relevant protected areas established under EC directives like the Habitat Directive with its Natura 2000 network. Both the WFD and the Habitat Directive and even the ICZM-Recommendation require from the Member States a range of information in the form of maps. Annexes I and II explicitly refer to a submission of maps in GIS format; most of data must be compiled for characterisation and management purposes is spatially referenced and must be presented in the form of GIS layers. In such case a harmonised procedure is essential. The WFD determines little about the requirements for the maps, so it is more important to reach agreement with the other authorities and through international consultation.

The WFD provides in Art. 14 for active involvement of the public and all interested parties in the implementation. More detailed provisions apply to formalised public consultation while developing the management plan for a river basin district. The information on the management should take place in several stages, so that the public can be informed about and give an opinion in the timetable, the work programme for the production of the management plan, of an interim overview of the significant water management issues and finally of the drafts for the management plan for the river basin. For the programme of measures summarised in the management plan no separate public participation is required by the WFD.

However, in this context another Directive comes into play, the SEA Directive (Directive 2001/43/EC of the European Parliament and the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes). Besides multi-phased involvement the public will be integrated in the production of management plans of WFD, ICZM and partially of Habitat Directive.

In the list of measures to be included within the programmes of measures Part A of Annex VI of the WFD there is of course no link to the ICZM-Recommendation of concerning the implementation of Integrated Coastal Zone Management because the recommendation comes afterwards. Nevertheless it is possible concerning to the non-exclusive list (Part B) of supplementary measures which Member States within each river basin district may choose to adopt as part of the programme of measures required under Article 11 para. 4 of the WFD.

Besides this the relation to the Habitat Directive is remarkable: Under Art. 6 of the WFD Member States shall ensure that a register be established of all areas lying within each river basin district which have been designated as requiring special protection under specific Community legislation for the protection of their surface waters and groundwater or for the conservation of habitats and species directly depending on water like aquatic Natura 2000-sites. The required registers contain all protected areas listed in Annex IV and the water bodies identified in accordance with Art. 7 para. 1 WFD. The register of protected areas established under Art. 6 Habitat Directive thus contains the areas designated for the protection of habitats or species where the maintenance or improvement of the status of waters is an important factor in their protection, including the relevant Nature 2000-sites designated under the Habitat Directive and the Birds Directive.

At least another point is important: According to Art. 4 para. 1 point c WFD Member States shall achieve compliance with any standards and objectives, unless otherwise specified in the Community legislation under which the individual protected areas have been established (here: Habitat Directive). Here we have a ranking between the two directives, in which the Habitat Directive is lex speciales. If the management plan of an aquatic Natura 2000-site says something different in making operational the programmes of measures in the river basin management plan, this has to be considered.

4.3 Habitat Directive

The conservation measures for Natura 2000-sites can take at least two forms: the form of "appropriate statutory, administrative or contractual measures…" and "if need be", the form of "appropriate management plans". The necessary conservation measures can involve management plans specifically designed for the sites or integrated into other development plans. Such management plans should address all foreseen activities, unforeseen new activities being dealt by Art. 6 para. 3 and 4 Habitat Directive.

The word "if need be" indicate that management plans may not always be necessary. If management plans are chosen by a Member State, it will often make sense to establish them before concluding the other measures mentioned in Art. 6 para. 1 Habitat Directive, particularly the contractual measures. Contractual measures will often involve a relationship between the competent authorities and individual landowners and will be limited to individual land-holdings which are normally smaller than the site. In such circumstances, a management plan focused on the site will provide a wider framework, and its contents will provide a useful starting point for the specific details of contractual measures.

The management plan must be "appropriate and specifically designed for the sites", therefore be targeted at the sites of the Natura 2000 network, or "integrated into other development plans". The latter provision is in conformity with the principle of integration of the environment in the other Community policies (even WFD). This integration has to contribute to the coherence of the network mentioned in Art. 3 para. 1 Habitat Directive. In any case it may be necessary to apply Art. 6 para. 3 Habitat Directive to those aspects of the management plan which are not connected to conservation management.

While no indication of the specific contents of management plans can be given, some considerations are necessary in view of the preparation of management plans. Concerning to the procedure the need of the management plan for the site is to clarify. The importance about the site (both natural value and socioeconomic context), the main threats and aims are to be detected and the responsibility for the plan has to be assigned. The objectives of the management plan for the site have to correspond to the ecological requirements of the natural habitats and species significantly present on it in order to ensure their favourable conservation status. They must be as clear as possible, realistic, quantified and manageable. Regarding to public participation the usage of a clear language with concrete formulation will be comprehensible for everybody. It is an essential part of the process to establish a management plan needing a multidisciplinary and professional approach. The issues of monitoring and evaluation are one of the most important parts of the plan, especially for determining whether one is successful with the plan. As with the objectives of the management plan, monitoring has to be clearly and accurately defined, including an analysis of financial matters.

Member States can establish management plans for Natura 2000-sites which superimpose themselves on the other categories of measures. They are not always necessary but, if they are used, they should take into account the characteristics specific to each site and all foreseen activities. They may be stand-alone documents or incorporated into the river basin management plan (as another development plan), when it exists.

5 Conclusions

5.1 Mechanisms coordinated execution

The most important advice, concerning the harmonization of the above mentioned different management plans is given in the Recommendation on the ICZM itself. According to Chapter IV para. 3 point f ICZM-Recommendation each Member State has to "identify mechanisms to ensure full and coordinated implementation and application of Community legislation and policies that have an impact on coastal areas, including when reviewing Community policies." Admittedly, the WFD and the Habitat Directive differs from the administrative approach. The Habitat Directive is a more old fashioned act of Community legislation. While it refers more to national administrative levels, the WFD offers a modern approach with an administration in transnational river basin districts. In this case the co-operation between the nature conservation authorities and the water authorities have to be improved.

5.2 Public Participation

The public can best perceive disharmonies in the different management plans, so that its participation is highly important. While the public is not strongly invited into the developing of Natura 2000 management plans, its participation and access to the relevant information is evidently encouraged in the WFD and the ICZM-Process.

5.3 Systems of monitoring

Harmonization includes adequate systems for monitoring. Management plans should be reviewed and updated over a specific period. These systems should collect and provide information in appropriate and compatible formats to the authorities in case of water management and protection of species and habitats at national, regional and local levels to facilitate integrated management. The work of the European Environment Agency can serve inter alia as a basis for this purpose as it's proposed by the ICZM-Recommendation.

5.4 European Spatial Development Perspective (ESPD)

Further integration of protection and sustainable management of water into other Community policy areas is necessary. The above mentioned recommendation and directives should provide a basis for a continued dialogue and for the development of strategies towards a further integration of policy areas. In this context the European Spatial Development Perspective (ESDP) can provide an important contribution in the field of cooperation between Member States. If ICZM was a legally binding directive, it would be politically the most difficult to agree on since there is a diverse range of the national laws affecting the management of the coastal zone in European States. Therefore, the suggestion of the harmonization doesn't lay down with the idea of making ICZM rather a Directive. The fact that WFD responds to many needs including the management plan doesn't offer the choice to deny the other legislations either. Therefore a new platform for the harmonization is suggested. This could be namely the European Spatial Development Perspective. One of the ESDP main guidelines states: "Development and conservation of the natural and the cultural heritage through wise management. This contributes both to the preservation and deepening of regional identities and the maintenance of the natural and cultural diversity of the regions and cities of the EU in the age of globalisation." ESDP, ICZM, WFD and Habitat Directive with Natura 2000 have spatial focus, but: For the ESDP, this is generic and for the others, this is partial. ICZM aims to take care of coastal zones, WFD surface and groundwaters and Habitat Directive some specific habitats.

A very interesting point concerning the Natura 2000's management plan exists in the ESDP (Point 136): "The extent of protected areas in the EU has grown in the past ten years although most areas remain protected "islands". The objective of a Community-wide network of protected areas – "Natura 2000"– incorporated in the Habitat Directive and other environmental directives is a very promising approach, which has to be harmonised at an early stage with regional development policy. Concerted protection measures for areas which belong to the network must be drawn up and fine-tuned in line with spatial development perspectives. An ecological network and Natura 2000 can also secure and develop the protection of valuable biotopes. There is a role to be played by links and corridors between protected areas, such as hedges, which can assist migration and the genetic exchange of plants and wild animals. In addition, a broader land-use policy can provide the context within which protected areas can thrive without being isolated, including, if necessary, the identification of buffer zones." Herewith, the ESDP cites the necessity of the harmonization of Natura 2000 with regional development policy. The ESDP also mentions about coastal regions and islands in terms of their biological diversity. The point 138 of this framework underlines the necessity of an appropriate integrated development strategies and planning concept as well as suitable forms of management. New approaches should be taken to harmonize nature protection and spatial development.

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The New LOICZ

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Abstract

During the last decade, the international programme of LOICZ (Land-Ocean Interactions in the Coastal Zone) has concentrated on classical biogeochemical research. Considerable achievements have been gained concerning the classification of the world's coastal zone and the identification of major threats to the coast. The New LOICZ aims to overcome disciplinary fragmentation and to treat coastal systems as a whole, including the human dimension. Therefore, New LOICZ is not only a core programme of the International Geosphere-Biosphere Programme, but also of the International Human Dimension Programme, IHDP.

1 Introduction

The world's coastal zone forms a long narrow boundary between land and ocean that is highly valued by human societies. Global Environmental Change (GEC) is the set of biophysical transformations of land, oceans and atmosphere, driven by an interwoven system of human activities and natural processes. Since 1993 the Land-Ocean Interactions in the Coastal Zone (LOICZ), a core project of the International Geosphere-Biosphere Programme (IGBP) on Global Change, has studied this heterogeneous, relatively small but highly productive, dynamic and sensitive area of the earth's surface. The LOICZ International Project Office is hosted by the Royal Netherlands Institute for Sea Research (Royal NIOZ) and funded by the Netherlands government. Major questions that LOICZ addresses on a global scale are:

- Is the coastal zone a sink or source of CO_2?
- What are the mass balances of carbon, nitrogen and phosphorus in the coastal zone?
- How are humans altering these mass balances, and what are the consequences?
- How do changes in land use, climate and sea level alter the fluxes and retention of water and particulate matter in the coastal zone and affect coastal morphodynamics?
- What is the role of the coastal zone in trace gas (e.g., DMS, NO_X) emissions?
- How can knowledge of the processes and impacts of biogeochemical and socio-economic changes be applied to improve integrated management of the coastal environment?

In this report we look back on the LOICZ programme in the context of ES and IGBP development and achievements of the first LOICZ phase, and look forward to the contribution the "New" LOICZ will make to Earth System research and dissemination.

2 The Goal of the "New" LOICZ Approach

An outcome of the first 10 years of LOICZ is recognition of the growing importance of the relationship between coastal zone science and coastal zone management, and this reflected in the development of the scientific themes for the "New" LOICZ. The new Science Plan seeks to articulate not only the research that LOICZ will engage with in the next 10 years, but also the strategy for strengthening operational links with relevant institutions, for instance the National Institute for

Coastal and Marine Management (RIKZ), The Hague, and relevant partners within and beyond the Earth System Science Partnership of IGBP, IHDP, WCRP and DIVERSITAS.

The New LOICZ project aims to overcome traditional disciplinary fragmentation. Therefore the **primary goal** that the New LOICZ II will lead to is:

> *"to provide a framework for integrated analysis of existing information and to act as a means to focus on key issues concerning human activity and resource use in the coastal zone (including to apply the full catchment scale as part of the water-continuum and extending it to include the EEZ)"*

To achieve this goal, the New LOICZ will be required to identify and promote ways to transfer information to and from stakeholders about what needs to be answered by science and what is being learnt from the science. This will include a need to establish and continuously engage in "science – policy – public" dialogue fora and employ early consultation mechanisms addressing key issues of coastal change and use in light of future scenarios of human activity and environmental state change as well as related scientific information needs including implementation issues.

The "New" LOICZ will seek to further the successful collaboration with its existing research community that encompasses a globally distributed network of coastal zone researchers that has grown from about 400 scientists, involved in developing the first Science Plan published in 1993, to a network that now extends to 2,500 scientists in 130 countries. However, the New LOICZ will also seek to engage a wider community of scientists and user groups who can make use of the LOICZ outputs and inform the questions addressed by LOICZ science. To better help promote and co-ordinate LOICZ global research on regional and local scales, the New LOICZ aims to establish a distributed IPO structure with Regional Thematic IPO Research Nodes. Located in different global regions, they are expected to not only increase the visibility and effectiveness of the future LOICZ, but also offer greater opportunities and support of research and increased networking within the regions.

3 LOICZ in the context of ES science and IGBP II

The "New" LOICZ will be one of the six projects that form the core of the second phase of the IGBP – IGBP II (Figure). IGBP II expands on the success of the past decade of intensive research that has led to a comprehensive picture of the mechanisms that determine the fate of Earth and the extent of the impact of human's activities on the Earth system. However, the linked challenges of confronting and managing the consequences of global environmental change whilst addressing and securing a sustainable future remain. To meet these challenges, IGBP II will strengthen and expand its relationship with IHDP, WCRP and DIVERSITAS, as part of the Earth System Science Partnership (ESSP), to provide a more integrated approach that inculcates human aspects within the traditional analytical methods of disciplinary studies that form the backbone of the scientific agenda. Within IGBP II, the major challenge in this new phase is to develop an integrative global change science that assembles research activities in innovative ways to understand the interacting dynamics of the Earth's life support systems. This will also focus on how humans impact and are supported by the planetary system, and policies and practices that will be required to ensure the sustainability of this system. These aims are reflected in the IGBP II Scientific Objective:

> *To undertake a systems analysis of planetary composition and dynamics, focusing on the interactive biological, chemical, geological and physical processes that define Earth System dynamics, the changes that are occurring in these dynamics, and the role of human activities in these changes.*

This objective is synergistic and, complementary to the IHDP, aims to describe, analyse and understand the human dimensions of global environmental change guided by four overarching questions:

- **Vulnerability/Resilience** - What factors determine the capacity of coupled systems to endure and produce sustainable outcomes in the face of social and biophysical change?
- **Thresholds/Transitions** - How can we recognise long-term trends in forcing functions and ensure orderly transitions when thresholds are passed?
- **Governance** - How can we steer tightly coupled systems towards desired goals or away from undesired outcomes?
- **Learning/Adaptation** - How can we stimulate social learning in the interest of managing the dynamics of tightly coupled systems?

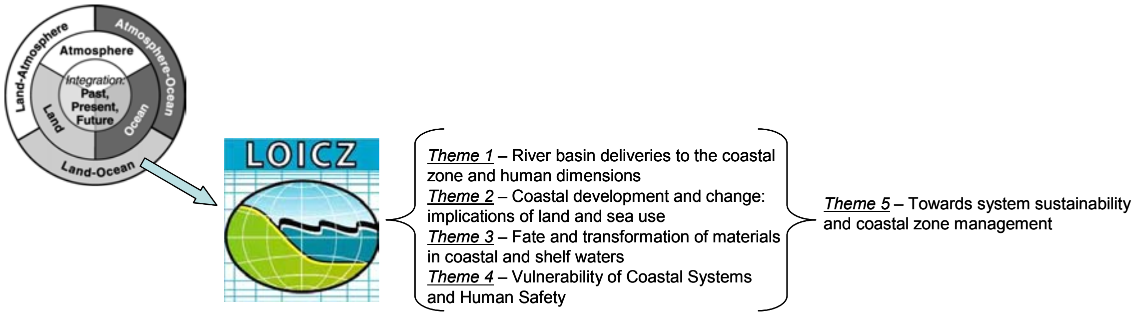

Figure 1: The New LOICZ and IGBP II with the 4 Theme structure of science activities that will be integrated within an overarching Theme to engage in a science-policy-public dialogue.

LOICZ has already begun to introduce the objectives and aims of IHDP into its development through increasingly engaging with the human dimensions community in developing a "Futures" discussion document that has informed this Science Plan. This Science Plan aims to identify the key issues and to develop a new Science Plan, which meets the requirements of the new program. A number of relevant new issues have been identified through recent workshops led by IOC, IHP, SCOR and the European Community; LOICZ SSC members and regional workshops and the Synthesis and Futures Meeting held in Miami in 2002 have provided further suggestions. Funding and core project structures are required to support the "New" LOICZ.

4 The New LOICZ - Statement of Objective

The IGBP Phase II will involve projects dealing with three Earth System compartments (air, land, ocean), three interfaces (land-ocean, land-atmosphere, ocean-atmosphere), and three framework activities (GAIM, PAGES, START). Joint projects (currently water, carbon, and food systems) will be further developed with WCRP (earth climate, mainly physics/chemistry core activities) and IHDP (earth human dimensions, mainly socio-economics). Links to DIVERSITAS are being discussed between the programs. "Futures" think-tank activities are identifying questions and objectives (2000-2002) and a number of themes and questions will feed into the New LOICZ development from "oceans" (IGBP, SCOR) and "terrestrial" (IGBP, IHDP, WCRP, Millennium Ecosystem Assessment) futures working groups.

The original LOICZ science plan is now more than 10 years old and reflects the ideas, concepts and needs prevalent more than a decade ago. Over the past years it has become clear that there have been human-induced changes at the global level and a major increase in human demands on the coastal zone: Concomitant to this is that continued human habitation and exploitation of the coastal landscape and resources is under an ever increasing risk and threat. Examples are major changes in hydrology on global scales, the increase or decreases in fluxes of materials to the coastal zone from river catchments, induced by erosional processes or damming, respectively, but all affecting the coastal ecosystem. Exploitation of its natural resources for food, as well as use of the coastal landscape for human habitation and/or economic activities, such as mineral exploitation, tourism and traffic, poses additional pressures on the coastal system.

LOICZ already plays a crucial role in relating the results from global system research to the regional/national scale and characterising the tapestry of small-scale variability and non-linearity of system functioning which links with larger trans-boundary and regional interconnection processes. LOICZ has made its work available to stakeholders, for example, coastal zone managers (Figure). The human dimension is crucial in modifying directly and indirectly the coastal system as, individually and collectively, humans respond to these and "natural" changes in order to mitigate or resolve problems. We have developed an understanding that human dimensions and natural systems closely interact and are intimately bound together in the various pressures and resultant state and state changes of the coastal domain. At a limited scale, tools have been developed to translate this understanding to management and policy. There is, however, still a lack of both, understanding and tools for a clear differentiation and quantification of these anthropogenic drivers and global environmental pressures. This is crucial information in order to see how they take effect on regional and global scales versus those drivers which are exclusively regional or national in nature: a distinction essential for appropriate coastal zone management.

With these points in mind, the New LOICZ project aims to overcome traditional disciplinary fragmentation. The primary goal is to provide a framework for integrated analysis of existing information and to act as a means to focus on key issues concerning human activities in the coastal zone (including applying the full catchment scale as part of the water-continuum and in the EEZ). Closely related will be the goal to identify and promote ways to transfer information to the stakeholders about what is being learned from the science, and to identify what needs to be answered by science. This will include establishing and continuously engaging in "science – policy – public dialogue fora and employing early consultation mechanisms addressing scientific information needs as well as implementation issues.

To reflect the vulnerability of human uses emanating from the coastal zone, the objective of the New LOICZ is:

"to assess, model and predict the change in adaptive capacity of the global coastal zone as an integral part of the Earth System under multiple forcing, including the contribution of, and consequences for, human activity"

5 LOICZ Project rationale and scope

5.1 The Challenge – The Coastal Zone

The coastal zone of the Earth System is a dynamic area of natural change and of increasing human use. Coastal zones occupy less than 15% of the earth's land surface, yet accommodate between 20.6 and 37% of the world population in the bands of the nearest 30 km and 100 km respectively (estimated in 2002) and roughly 50% i.e. 3.1 billion people in the 200 km range. With three-quarters of the world population expected to reside in the coastal zone by 2025, human activities originating from this small land area will impose an inordinate amount of pressures on the global system. As such it faces the challenge of maintaining the continuity of its goods and services for and of the ecosystem and human society. These interacting changes are threefold:

- global changes which are natural changes, such as climate, and those due to changes in the global economy/trade and policy;
- regional (trans-boundary and supra-national) changes as a result of regional and national drivers and pressures in the coastal zone; and
- regional changes at the river catchment level which affect the downstream coastal zone and in the Exclusive Economic Zone.

Our current limited understanding and uncertainty of regional and global changes that impact coastal systems hamper addressing this challenge.

In comparison with the relatively uniform environment of the photic zone of the open ocean, or the rapidly mixed environment of the atmosphere, the spatial and temporal heterogeneity of the world's coastal zones is considerable. As a consequence, there are considerable methodological problems associated with developing global perspectives of the role of this compartment in the functioning of the total Earth system. Identifying and quantifying this role and developing scenarios of change in the coastal compartment of the Earth system under anthropogenic and geocentric driving forces of change requires a considerable body of research, as well analysis and interpretation that crosses the interface of natural and socio-economic sciences.

Unlike many of the other Core Projects of the IGBP, LOICZ deals with a specific domain rather than a process and that domain is spatially extremely heterogeneous. To achieve the overall goals and objectives a truly global network of coastal scientists has been developed including the active participation of scientists from developing countries that is vital to the ultimate success of this project: Some funding and other support is provided through the Core Project to foster research undertaken in such countries since their coastlines encompass the bulk of the world's tropical shores and encompass areas where the rates of anthropogenically driven change are considerable.

Whilst the objective of LOICZ is not to undertake coastal zone management it is appropriate that LOICZ seeks to provide a sound scientific basis for the future sustainable use and integrated management of these environments, under conditions of global change.

5.2 LOICZ I - The Results to Date: LOICZ Achievements

Between 1993 and 2002 LOICZ has made major advances in our understanding of the biogeochemical and physical role of the coastal zone in global cycles and change by addressing the following major questions on a global scale:

- Is the coastal zone a sink or source of CO_2?
- What are the mass balances of carbon, nitrogen and phosphorus in the coastal zone?
- How are humans altering these mass balances, and what are the consequences?
- How do changes in land use, climate and sea level alter the fluxes and retention of water and particulate matter in the coastal zone and affect coastal morphodynamics?
- What is the role of the coastal zone in trace gas (e.g., DMS, NO_X) emissions?
- How can knowledge of the processes and impacts of biogeochemical and socio-economic changes be applied to improve integrated management of the coastal environment?

The focus of LOICZ research has been on horizontal material fluxes and combining natural and social sciences to elucidate the causes for alterations in these fluxes. Understanding the relationships between scales and integration across scales (see Figure) is an important and challenging part of this combined approach. LOICZ depends on national programmes of research and contributions from individual scientists, and has worked with hundreds of researchers from more than 100 countries to develop collaborative and multidisciplinary projects to meet these goals.

A globally distributed network of coastal zone researchers is carrying out much of the LOICZ research. From about 400 scientists involved in developing the first Science Plan published in 1993, this network now extends to 2,500 scientists in 130 countries. National LOICZ Contacts have been identified in many countries to provide a linkage between national and international LOICZ research activities. These people provide a first point of contact for those interested in getting additional information on local and national LOICZ research. Consequently a major portion of LOICZ global research is and will be carried out by local and regional research projects. More than 1500 peer-reviewed publications have resulted from the LOICZ project, and a first synthesis of work on global change in the coastal zone is being completed for publication. This synthesis will include information for management and will address policy issues. Examples of achievements include:

A. Nutrients fluxes and cycling to address the role of the coastal zone in global cycling
   - Establishment and implementation of “common methodologies” to allow scaled spatial inter-comparisons for first-order estimation of net C, N and P metabolism of the near shore coastal sea, using existing data. At local to regional scales waste and load estimates have been derived; systems metabolism has been estimated; tools and a data base of more than 200 coastal sites

have been developed; data, information and synthesis continues to be made accessible through a dedicated public website (http://data.ecology.su.se/MNODE).

- With the Joint Global Ocean Flux Study (JGOFS), LOICZ established a joint Continental Margins Task Team (CMTT) to evaluate the role of ocean margins in global carbon flux. A regional and global synthesis "Carbon and Nutrient Dynamics at Oceanic Margins" is in progress (LOICZ Newsletter 26, March 2003).

B. The flux of materials to the coastal zone is strongly influenced by changes in river catchments which are mainly human induced but may also be caused or enhanced by global change. Several parts of the LOICZ program have addressed material fluxes.

A "common methodology" was established and implemented to estimate human pressures on material fluxes and changes in river catchments affecting the coastal seas. This has been applied from catchments to continental scale – Africa, Europe (http://www.iia-cnr.unical.it/EUROCAT/project.htm, http://danubs.tuwien.ac.at, www.catchment2coast.org), Asia, South America, Caribbean, Oceania; data and the resulting information and synthesis are available through a new website (http://w3g.gkss.de/projects/loicz_basins); methods have been adopted by other international programs; new regional-scale projects are being derived.

The extent of groundwater flux and its dissolved constituents were largely unknown at the beginning of the LOICZ program. The establishment of targeted research (with SCOR, IOC, IHP) on submarine groundwater discharges, to evaluate their global significance and changes, has resulted in increased awareness of its importance. A global review has been prepared within the limits of existing information; a methodological inter-calibration field campaign is in progress to provide a basis for uniform measurement of groundwater fluxes (for details see LOICZ Newsletter 26, March 2003 and http://www.iugg.org/iapso/grdwater_seawater02.html).

A sediment discharge inventory and database (GLORI) was established during the first five years of LOICZ and is currently being extended. Global sediment transfer functions and processes, and change have been reviewed and target research priorities identified. The databases are increasingly utilized as they are expanded.

Assessment of trace gases (non-CO_2) fluxes and their significance in the coastal zone has highlighted the importance of this transfer and identified key areas for assessment and research.

C. The combination of natural and social science to address the human dimensions of change in the coastal zone has from the beginning been one of the focal points of LOICZ

The DPSIR concept of the OECD was modified and employed as a framework for integration of human dimensions with natural system and resources assessments. Guidelines have been developed and applied in B3 above (LOICZ Reports & Studies No. 11);

A pilot study of integrating natural and social sciences, developed to link the protocols of LOICZ foci 1-4 in South East Asia (SARCS WOTRO LOICZ, SWOL-project, see http://www.nioz.nl/loicz/) has yielded a simple model and emphasized scaling mismatches and potential for new approaches.

D. A typology system of the coastal zone was made operational to meet the needs of the global research community

This typology system is Web-based (http://www.kgs.ukans.edu/Hexacoral) and comprises a global coastal zone database (half-degree resolution; 140-plus variables) linked to an assessment/visualization tool for classification (typology) and scaling (http://palantir.swarthmore.edu/loicz). It is linked to IGBP-BAHC and other terrestrial, coastal and ocean databases. All data and methodologies are website accessible, and the tools and information are being applied within and beyond LOICZ. Research assessments with these tools are linking human dimension and natural systems, and pressures parameters to evaluate change at regional and global scales.

E. LOICZ has not only been an activity focussed on a core research community but has paid much attention to science dissemination through training and capacity building

Capacity building continues through training workshops (in collaboration with START, IHDP, IOC, UNEP and other agencies) on biogeochemical modelling, typology applications, river basins assessments and coastal zone management. Research assessment tools (electronic and printed), manuals and guidelines are website-accessible (http:/www.nioz.nl/loicz). Regional collaboration of scientists underpins training and application of knowledge.

F. Of the numerous other activities, we mention two in particular:

- Novel sea level research is being instituted with IGBP-PAGES and a "standard methodology" for global assessment of vulnerability to sea level change has been implemented by the EU-supported SURVAS task (http://survas.mdx.ac.uk). Further developments are a subject of the DINAS Coast project (see LOICZ Newsletter 27, June 2003 and www.PIK-Potsdam.DE/~richardk/dinas-coast/).
- A working group of scientists and managers under the leadership of the LOICZ Liaison Officer at the Coastal Zone Management Centre of the Royal Dutch Institute for Coast and Sea, RIKZ, The Hague is currently synthesising an evaluation of changes and effectiveness of management in major delta regions of the world: Information is website accessible (http://www.deltasnetwork.nl).

An overarching outcome of the LOICZ work and achievements to date are that there are three major conclusions that can be drawn from the LOICZ research;

1. The coastal realm is both the most dynamic part of the global ecosystem and the most subject to natural and anthropogenic induced global change.
2. A much broader perspective on the critical importance of ameliorating anthropogenic impacts on hydrologic systems, sediment and materials fluxes and energy transfers within catchments is required to:
   - avoid irreversible degradation of coastal systems and reduction of ecosystem functions that help to regulate carbon cycles, material fluxes and energy budgets;
   - reduce the rate of increase in vulnerability of human societies located within coastal regions to natural and man induced hazards.
3. There are specific actions that can be taken within the coastal realm to ameliorate anthropogenic influences on global climate change.

6 The New LOICZ

The aim of a New LOICZ is to draw on the achievements and outcomes from the "Old" LOICZ to further understand horizontal material fluxes and scaling processes in the World's coastal zones through environmental and socio-economic sciences in the context of the revised and up-dated goals of the ESSP and IGBP II.

The challenge of a "New" LOICZ is to improve our understanding of complex coastal change and response options in the context of the Earth System including human society and to assist in the management of these changes, to ensure the continuity of goods and services provided by the coastal zone. To fulfil this role, a future LOICZ will strongly interact with IHDP for the human dimensions aspects and within IGBP with the land system component. The coastal zone, being the interface between the land and the ocean, LOICZ will serve within IGBP as the primary interface between the land and marine and water programmes. Outputs from the New LOICZ will contribute to GAIM (Global Analysis, Integration and Modelling) that explores how the dynamics of the Earth System be better understood through modelling studies, and the analysis and interpretation of the results and of global data? With GAIM, the New LOICZ will work closely with all Core Proejcts of IGBP, and build increasing linkages with the World Climate Research Programme (WCRP) and the International Human Dimensions Programme on Global Environmental Change (IHDP) on the development and analysis of integrated data sets and linked models. The challenge that the New LOICZ will contribute, along with GAIM and its colleagues throughout IGBP, and in the WCRP and IHDP, is to develop and apply a suite of Earth System models spanning a range of complexity that integrates the roles and interactions of physical climate, ecological systems, and human systems.

Discussions on the scientific themes in a new LOICZ within and beyond the LOICZ community has also taken into consideration a sub-set of the "Hilbertian" questions posed in the IGBP-GAIM program. They are shown here following a brief description of what might be expected from the new LOICZ (in bold):

- GAIM question 7: Which are the most vulnerable coastal regions under global change?
- LOICZ Expectation: **A typology of coastal vulnerability to global change on various spatial and temporal scales**
- GAIM question 8: How are abrupt and extreme events processed through nature-society interactions?
- LOICZ Expectation: **Description of the impact on and reaction of the environment and society (as co-evolving systems) to spontaneous and hazardous extremes**
- GAIM question 14: What are the most appropriate methodologies for integrating natural-science and social-science knowledge?
- LOICZ Expectation: **Meeting the general challenge to find ways for successful integration between natural and social sciences and to overcome the traditional disciplinary divide**
- GAIM question 15: What are the general criteria and principles for distinguishing non-sustainable and sustainable futures?
- LOICZ Expectation: **Identification of criteria to distinguish, and consequently the indicators to measure, key parameters of sustainable and less sustainable future developments**
- GAIM question 18: What kind of nature does modern society want?
- LOICZ Expectation: **Elucidation of the question of social choice and people's preferences regarding environmental conditions and standards of living**
- GAIM question 21: What is the optimal decomposition of the planetary surface into nature reserves and managed areas?
- LOICZ Expectation: **Identification of key proxies for land use and cover change that are reflected in coastal functioning and change and thus provide advice on optimal decomposition of the planetary surface into nature reserves and managed areas** and
- GAIM question 23: What is the structure of an effective and efficient system of global environment and development institutions?
- LOICZ Expectation: **Investigation of the institutional dimensions of coastal change, teleconnections and impact-response relationships to provide a scientific basis for advise on effective and efficient systems of global environment and development institutions.**

6.1 The New LOICZ Strategy

In order to act across the broad scale outlined and to become increasingly interdisciplinary the New LOICZ will need to provide a high level of responsiveness through issue-driven science. It is crucial to provide answers to questions in a reasonably short time, which may not allow waiting for results from highly sophisticated new models. However, in acceptance that the objective of a New LOICZ should be to provide both, i) scientific information for advanced Earth System analysis and modelling and ii) better science for better management, implementation of the project will have to provide the mechanisms to satisfy short-term information needs and backing them by in-depth sophisticated interdisciplinary science. This also means that major coastal change issues should play the leading role in driving the science and the new LOICZ needs to capitalize on the gains/success of the first phase of collaborative research by:

- maintaining and enhancing the networks of scientific contributors and peers, which bring different cultural perspectives, science priorities and funding options;

- building on the typology approach/tools to guide questions and actions including statistical analysis regionally and to visualise and map change, vulnerability and risks;
- consolidating knowledge gained at planetary and regional scales (e.g., the biogeochemical budgets);
- applying the full catchment scale in assessment, synthesis and upscaling and identifying those management units (and their key environmental system functions) where intervention (response) can best be implemented;
- pursuing compelling topics (e.g., restoration, mitigation, thresholds, carrying capacity and links to biogeochemical cycles) and move forward to in-depth consideration of different of pressure/impact scenarios;

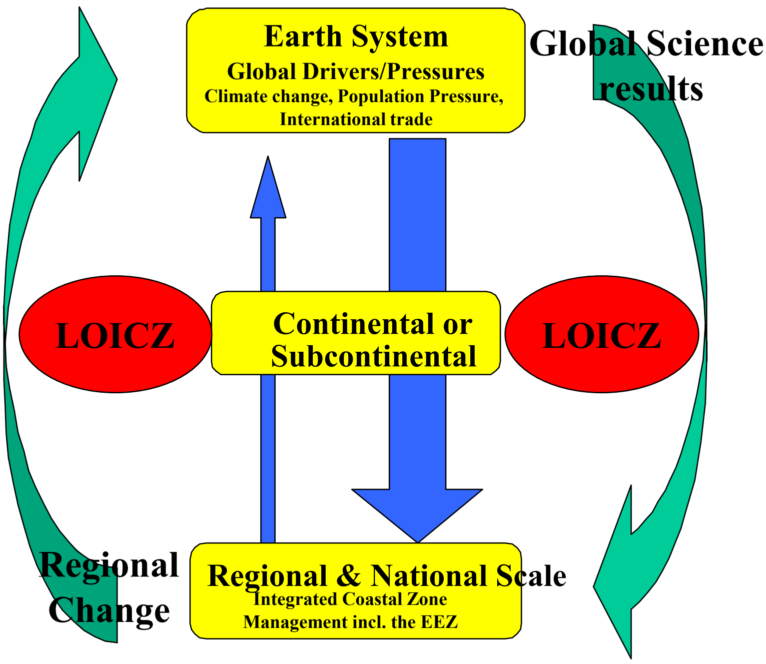

Figure 2: The LOICZ role in integrating regional and national coastal change and use (incl. the EEZ) to the Earth System level and relating global science results for management of the coastal zone.

In general terms this means that the new LOICZ needs to become adaptive in its scientific context and promote this 'adaptive science' to interact with and develop adaptive management options. Therefore the new LOICZ has to improve its user interface by strengthening its outreach. Participatory approaches have to become an integral and up-front part of scientific projects. They serve as the fora where issues and scientific information needs on "desirable future scenarios" in the context of strong and weak sustainability models can be brought to each other's attention. The way will be to foster the development of a "Science/Society/Policy Partnership" with a New LOICZ taking a neutral platform position for brokering the issues, the development of science and on which to generate joint ownership of these issues and activities.

Particular efforts have to be directed towards improved involvement of developing economies. Strengthening the regional collaboration and institutional networking will be facilitating the necessary data and information exchange and lead to inner and cross regional flow of expertise and capacity building. The New LOICZ can support this structurally and provide the platform for regional scientists to play a leading intellectual role here. Scientific agendas relevant for all regions but in particular for developing economies, *inter alia,* need to address topics where International Conventions oblige countries to take action (e.g., Climate Convention, Biodiversity Convention, Wetlands Convention). The Climate Convention, UNFCCC, for example, involves effects of sea-level rise, CO_2 and methane emissions. LOICZ may take on the role of an active partner in the Conventions, helping to foster political will and financial support to resource necessary scientific efforts directly or via regional "aid" organisations. This might have potential to generally advance LOICZ's networking and information transfer.

6.2 Linkages

LOICZ has experienced an increasing demand upon, and recognition of, the project as a source of regional-global expertise and information on the science of the coastal. Maintaining and enhancing the ability of the project to respond to the needs of the scientific and user community is an important consideration in future planning. To fulfil this role, the New LOICZ will strongly interact with IHDP for the Human Dimension aspects and within IGBP with the LAND program and its system components. The coastal zone, being the interface between the land and the ocean, the New LOICZ will serve within IGBP as the primary interface between the land and ocean programmes. The rationale of the New LOICZ plan includes:

- Strong/collaborative links established with IHDP in order to develop the "people dimension" and foster joint tasks, access to expertise, and development of encompassing activities. Human activity in the coastal zone and EEZ need even more attention than in the past. In response the "New" LOICZ will continue and even enhance to bridge the gaps between biogeochemistry (IGBP), coastal system functioning, and the human dimension (IHDP). A partnership between LOICZ and the IHDP has been agreed on by the parties at the recent 14th SSC Meeting held in June 2003, in Banff, Canada.
- Global and regional scale projects are in place which complement and can draw from the LOICZ scientific program, for example, UNESCO-IOC's ICAM & Coastal-GOOS monitoring programs; UNEP-sponsored GIWA, the upcoming Global Marine Assessment, GMA, and EU initiatives in particular the Water Framework Directive (2000/60/EC) and the Water Initiative and the Common Strategy for an Integrated Coastal Zone Management. Dialogue with designers and activities of these programs/activities provide an effective science-user dimension – we have taken steps to consolidate these relationships which should be further strengthened in the "New" LOICZ towards an extended network of operational partnerships.
- LOICZ will continue and improve its close cooperation with the research community and policy-makers at the national level. This can be greatly assisted through the wider establishment of national LOICZ committees, and to have the added effect of attracting more national experts to work under the LOICZ umbrella. A distributed IPO and restructured SSC (see section 5.2) is expected to provide increasing support for improved regional and national performance.
- Communications and transfer of information to targeted agencies and forums are fundamental operational concerns to LOICZ. This requires a funded, operational task team of necessary skills to assist in planning and implementation of a communication strategy, to promote access and use of the resultant coastal science information. Measures are continuously being taken and reviewed to address this within LOICZ and in particular in cooperation with the IGBP.

Clear goals, objectives and thematic priorities have been shaped through extended iterative consultation by the SSC with a broad range of scientific experts involving in particular the Human Dimensions community, agencies and stakeholders since 2001. This includes the Synthesis and Futures Meeting, Miami 29 May - 01 June 2002 and the recent IGBP Congress "Connectivities in the Earth System", Banff, Canada, 20-23 June 2003.

Through its extensive regional network, the New LOICZ will extend this capability to be able to identify regional and national changes in the coastal system, integrate them at a global level and make the results and information available to managers and decision-makers. The magnitude of the task is challenging, especially in making the link between human dimensions and the natural processes.

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