

Measuring the progress and outcomes of Integrated Coastal and Ocean Management:

The German Oder Estuary case study

Report to the UNESCO

Intergovernmental Oceanographic Commission



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IKZM-Oder Berichte

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von

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Das Projekt IKZM-Oder ist in das „International Project on the Development and Application of Indicators for Integrated Coastal and Ocean Management“ der Intergovernmental Oceanographic Commission der UNESCO (IOC) eingebunden. In diesem Zusammenhang wurden drei Indikatorensets für die Bereiche „governance“, „ecology“ and „socio-economy“ für die Odermündungsregion getestet und evaluiert. Die Ergebnisse wurden im vorliegenden Bericht zusammengefasst und der IOC vorgelegt. Weitere Informationen finden Sie im Internet, unter <http://ioc.unesco.org/icam/contents.php?id=10>.

Impressum

Die IKZM-Oder Berichte erscheinen in unregelmäßiger Folge. Sie enthalten Ergebnisse des Projektes IKZM-Oder und der Regionalen Agenda 21 „Stettiner Haff – Region zweier Nationen“ sowie Arbeiten mit Bezug zur Odermündungsregion. Die Berichte erscheinen in der Regel ausschließlich als abrufbare und herunterladbare PDF-Files im Internet.



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Das Projekt „Forschung für ein Integriertes Küstenzonenmanagement in der Odermündungsregion (IKZM-Oder)“ wird vom Bundesministerium für Bildung und Forschung unter der Nummer 03F0403A-H gefördert.



Die Regionale Agenda 21 „Stettiner Haff – Region zweier Nationen“ stellt eine deutsch-polnische Kooperation mit dem Ziel der nachhaltigen Entwicklung dar. Die regionale Agenda 21 ist Träger des integrierten Küstenzonenmanagements und wird durch das Projekt IKZM-Oder unterstützt.



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1 Background: Oder Estuary region

1.1 Location

The Oder (Polish: Odra) estuary region forms the border between Germany and Poland and is located at the south-western Baltic Sea. This estuary region is also called Oder/Odra coastal zone and covers an area of 30-60 km landwards from the sea-shore as well as the entire Pomeranian Bay (up to 50 km seawards) (Figure 1). The coastal zone on land covers an area of about 7,000 km² and consists of two administrative districts on the German side (Ostvorpommern and Uecker-Randow) as well as three administrative districts (Goleniowski, Kamienki, Policki) and two urban districts (Szczecin and Świnoujście) on the Polish side.

The report and the application of indicators are restricted to the German territory of the Oder Estuary.

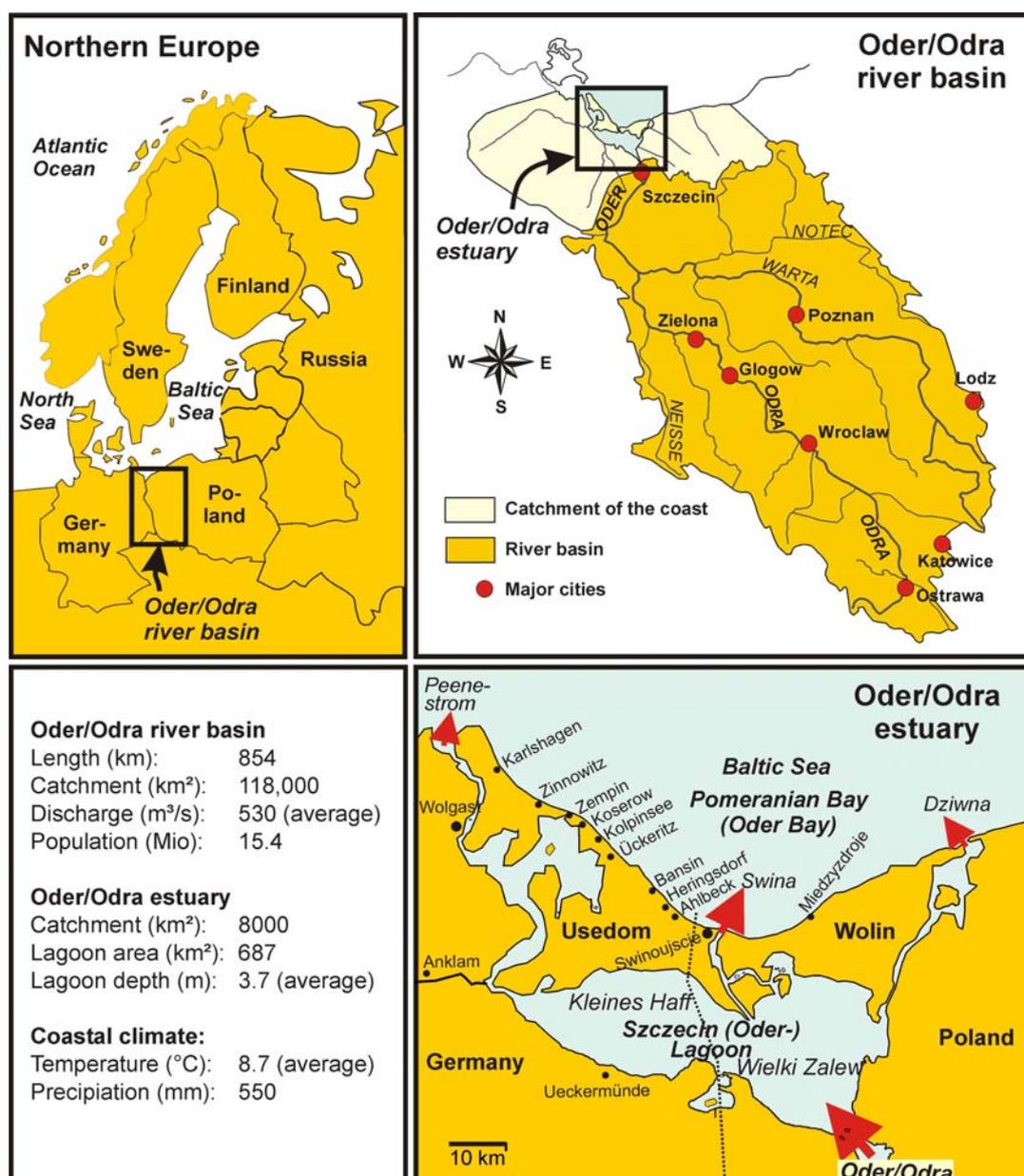


Figure 1: The German-Polish Oder Estuary region and its adjacent river basin (Schernewski et al. 2005)

1.2 Ecological characteristics

The coastal zone is dominated by the discharge of the river Oder (Odra) into the Szczecin (Oder) Lagoon. With its length of 854 km and a river basin of 120,000 km², the Oder is one of the most important rivers in the Baltic Sea region. The average annual Oder discharge is 17 km³ (530 m³ s⁻¹) and it contributes at least 94% to the lagoon's water budget. The large (687 km²) and shallow (average depth 3.8 m) Szczecin (Oder) Lagoon, is the key element of the Oder Estuary region. The lagoon is subdivided into the "Kleines Haff", located mainly on the German territory, and the "Wielki Zalew" on the Polish territory. The Wielki Zalew covers about 60 % of the lagoon area and volume. The lagoon is connected to the Pomeranian Bay via three outlets.

The bay is part of the Baltic Sea. Seaward boundaries are the Arkona Sea towards north-west and the Bornholm Sea in the north-east. The bay has an average depth of 13.2 m and covers an area of approx. 6.000 km². The bay is influenced by Oder River water, but intensive wind-induced mixing and large-scale currents in the Baltic Sea dominate this system.

Coastal morphology and habitats: The Oder Estuary region has a high cultural and ecological value. The Baltic Sea shoreline of Usedom and Wolin is characterised by coastal forests, cliffs and long sandy beaches. Sediment transport causes pattern of accumulation and erosion areas along the shoreline. In average erosion causes a coastline retreat between 0.35 m and 1.2 m per year, with exception of the surrounding of the Swina outlet (Lampe 1998, Musielak 1995). Especially beach erosion is an important problem for coastal protection and bathing tourism.

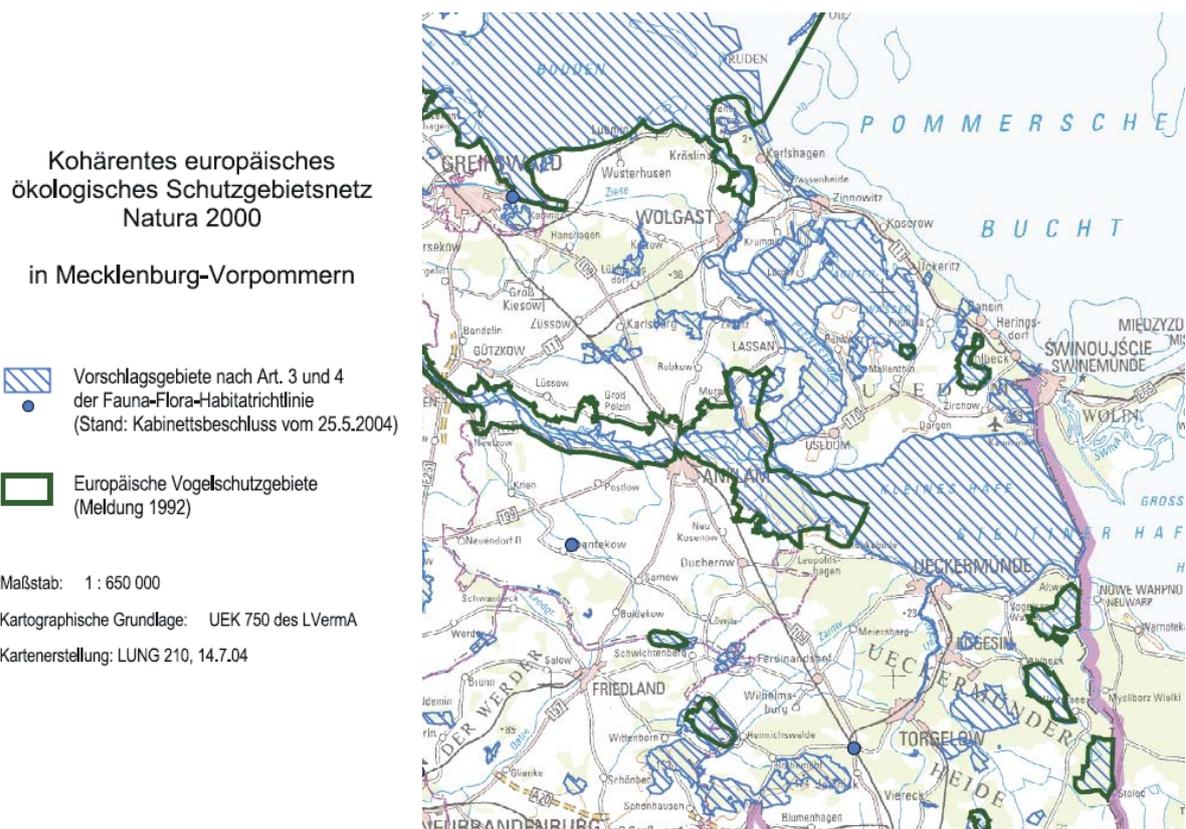


Figure 2: The Natura 2000 network in the Oder Estuary region consists of protected areas, which belong to the European Bird Directive (79/409/EEC) (bold outline) and/or the European Habitat Directive (92/43/EEC) and habitat / FFH areas (hatched) (Source: Umweltministerium Mecklenburg-Vorpommern; <http://www.um.mv-regierung.de/>)

The whole region is characterised by ecologically important habitats, wetland (fens, peat bogs and marsh areas) and dry habitats (inland dunes, forests). Due to the outstanding ecological value and

scenic beauty, most of the coastal zone has become a nature-protected zone. Protected areas are located on the islands Usedom and Wolin, near the inner shoreline as well as in the hinterland. On the German side the island Usedom and the region south of the Szczecin Lagoon are nature parks with a total area of about 630 km² and 650 km², respectively. Another nature park is planned.

Areas of coastal flooding and marshes are important resting areas for migrating birds as well as wading and water birds and have the highest biodiversity (Feilbach 2004). Therefore, 1,100 km² have been designated as special protected areas for the conservation of wild birds (European Bird Directive 79/409/EEC). Large areas will be under protection of the European Habitat Directive (92/43/EEC) and become part of the Natura 2000 network, in future. European Natura 2000 networks link important habitats and ensure their conservation (Figure 2). The Pomeranian Bay with the Oder Bank and shallow coastal waters are of high ecological value, as well, and are supposed to become European Marine Protected Areas (MPAs).

Hydrography and eutrophication: Groundwater, inner coastal waters, lakes, brooks and rivers determine the hydrographical character of the Oder Estuary. Almost the entire coastal zone belongs to the Oder River basin. Between 1980 and 1999, the annual Oder discharge varied between 9.5 km³ (1990) and 25 km³ (1980), with an average of 17 km³ (530 m³/s) (IMWM 1980-1983, 1987-1999). The combined discharge of all other rivers entering the lagoon amounts to 1 km³/a (Wielgat 2002).

69 % of the discharge leave the lagoon (and enter the Pomeranian bay) by via the Swina channel. The Peenestrom (Dziwna) have an average share of 17 % (14 %) (Mohrholz & Lass 1998). The Swina Channel is part of the main shipping channel across the lagoon, linking the Oder River and the harbour of Szczecin with the Baltic Sea. It is constantly dredged to maintain a depth of more than 10 m. The dredging removed about 1.5 m³ sediment per year over the last few decades. Therefore, most of the sediment entering with the Oder River, as well as large amounts of nutrients and pollutants are removed from the lagoon and stored on land.



Figure 3: The Szczecin (Oder) Lagoon suffers from severe eutrophication (Schernewski et al. 2005).

The brackish lagoon shows a salinity between 0.05 and 0.2 ‰ in the central part. Periodic intrusions of Baltic water with a salinity of 0.6 ‰ into the lagoon usually occur via the Swina Channel (Bangel et al. 2004). These salt-water influxes are usually spatially limited and affect mainly the bottom (Radziejewska & Schernewski, in press).

The Oder and its high load of nutrients and pollutants are responsible for the poor water quality of the lagoon and its heavy eutrophication. The nitrogen (N) and phosphorous (P) loads in the Oder were already high in the early 1970's and increased further until the 1980's. At that time, loads of 116,000 t N/a and 16,000 t P/a were observed. Because of economic changes, warmer and drier years as well as improved sewage treatment the loads were reduced to 94,000 t N/a and 8,500 t P/a in the late 1990's. The lagoon serves as a transformer and storage pond (due to dredging) for sediment, nutrients and pollutants originating entering with the Oder. The lagoon protects the Baltic Sea, to a certain degree, from pollution (Schernewski et al. 2005).

Biology: The lagoon has a long eutrophication history and phytoplankton concentrations are very high (sometimes over 200 mg Chl.a m⁻³). Intensive (toxic) algal blooms, low water transparency, oxygen depletion in some parts, and fish kills are common features. Depending on the trophic system adopted, the present trophic state of the lagoon is polytrophic or hypertrophic. The primary production in the lagoon is largely light-limited, nutrient limitations may play a role during spring and summer.

Usually, two phytoplankton biomass peaks are observed: Diatoms in spring (e.g. *Cyclotella* sp., *Diatoma elongatum*, and *Fragillaria crotonensis*) and blue-green algae in summer (e.g. *Microcystis aeruginosa*). The gross primary production is around 600 g C m⁻²a⁻¹. The recent data on zooplankton is limited. Rotifers and veligers of the bivalve *Dreissena polymorpha* dominate zooplankton abundance, rotifers and cladocerans supply the bulk of the biomass.

The fish fauna is composed of fresh- and brackish water (e.g., roach, perch, pikeperch, bream, ruffe), migratory (e.g., eel, sea trout), and marine (e.g. herring) species. Most species of commercial importance (e.g. pikeperch, perch, roach, whitefish) form populations migrating between the lagoon and coastal Baltic Sea, eel and herring migrate even further.

Table 1: Pelagic biological components of the Szczecin Lagoon (Radziejewska & Schernewski (in press))

Secchi depth (m) (range and average):	0.2 - 3.0; 0.9 ¹	Fish species (number)	56 ⁵
Bacteria (10 ⁶ ml ⁻¹):	no data	Dominant species	<i>Rutilus rutilus</i> , <i>Abramis brama</i> , <i>Perca fluviatilis</i> ^{5,6,11}
Phytoplankton (µg Chl.a dm ⁻³)	70 ¹	Seston (mg dw dm ⁻³)	9 – 60 ⁷
Phytoplankton (mm ³ dm ⁻³)	15 ²	POC (mg C dm ⁻³)	15.4 ⁸
Dominant species	<i>Microcystis aeruginosa</i>	DOC (mg C dm ⁻³)	32.5 ⁹
Flagellates (mg ww dm ⁻³):	no data	C/N in POM	no data
Ciliates (mg ww dm ⁻³)	no data	Primary production (g C m ⁻² a ⁻¹)	591 – 648 ¹⁰
Metazoa (mg ww dm ⁻³)	0.80 ³	Bacterial production (µg C dm ⁻³ d ⁻¹)	no data
Dominant species	<i>Keratella cochlearis</i> , <i>Daphnia cucullata</i> ^{3,4}	Metazoan production (g C m ⁻² a ⁻¹):	no data
		Fish catches (t a ⁻¹)	2,528 ¹¹

¹averaged over April-August; Bangel et al (2004); ²averaged for Kleines Haff; Lampe (1999); ³Wolska and Piasecki (in press); ⁴Chojnacki (1991); ⁵Wysokiński (1998); ⁶Dunin-Kwinta (2000); ⁷T.Radziejewska & H.Dworczak, unpubl. data; ⁸Total particulate carbon (POC+PIC), averaged for Kleines Haff; Lampe (1999); ⁹Günther (1998); ¹⁰Westphal & Lenk (1998); ¹¹2003 total in Wielki Zalew; Szostak et al. (2004)

The invasion of non-native species in the Oder Estuary region, like amphipods and crabs, is an important problem. They are often carried in the ballast water of ships or enter the coastal area through the Oder River. The Oder is linked to other European rivers through a complex channel system. These alien species altered the ecosystem structure and biodiversity in of the coastal waters already significantly. Numerous rare plants and animals live permanently or periodically in the Oder estuary.

1.3 Socioeconomic characteristics

The coastal region has about 840,000 inhabitants. 414,000 live in the largest city, Szczecin, in Poland. With about 50 inhabitants per km², the countryside is sparsely populated. The whole region is suffering from economic problems. The high unemployment rate of 25 % is a major problem and causes an ongoing decline of the population. Especially young people leave the region. Further, strong social and economic gradients between Germany and Poland as well as between coast and hinterland exist.

Tourism is the exclusive economic factor along the coastline, and altogether more than 10 million tourists visit the estuary region per year (Schernewski et al. 2005). Tourism shows a strong seasonality. Tourists visit the region mainly during summer and public holidays in spring and autumn. Major activities are bathing, sailing and angling. The short tourism season creates problems to maintain the tourist infrastructure and offers only seasonal income. There are plans to reduce the pressure on the coastline and to develop a tourist infrastructure in the hinterland, as well. Holidays on farms, bike and ride tourism as well as trips through nature parks are new offers.



Figure 4: The Baltic Sea coast (Ahlbeck, Usedom) with traditional architecture and flourishing tourism (Schernewski et al. 2005).

Shipping is an important economic activity in the coastal zone. The large Polish harbours Świnoujście, Szczecin and Police have a joint annual turnover of more than 22 million t (2002). The German harbours are of minor importance, eight harbours have a turnover of only 400,000 t/a each. More than one million ship passengers arrive annually.

Agriculture is a traditional economic sector, but lost its dominating position. Especially cattle-breeding still plays an important role. Fishing is another traditional economic sector, but is nowadays only of minor importance and in decline. At present, 40 professional fishermen on the German territory and about 260 on the Polish territory exploit the fish resources (using mainly stationary gear) of the lagoon (Fenske 2003; Wysokiński 1998). The landings are about 3,000 t per year. Pikeperch, perch, roach and whitefish as well as eel and herring migrating between lagoon and Baltic Sea are of most commercial importance.

Financially supported by the European Commission as well as German and Polish ministries, the development of renewable energies (mainly wind parks) took place. In 2002, renewable energies contributed already 23.7 % to the total energy production of Mecklenburg-Vorpommern. Further, sand, gravel, oil and gas are exploited in some areas of the Oder Estuary.

1.4 Goals and objectives: The Water Framework Directive

The European Water Framework Directive (WFD) is the major activity towards Integrated Coastal and Ocean Management (ICOM) in Europe and its needs and requirements are the background for the indicator application.

Ecological indicators: Objective of the European Water Framework Directive is a good ecological status in all surface waters, indicated by composition, abundance and biomass of phytoplankton, benthic invertebrate fauna, fish fauna and other aquatic flora. Our goals are:

- to evaluate the benefit and suitability of the ecological ICOM-indicators for measuring the ecological state of aquatic ecosystems,
- to evaluate to what extent the ecological indicators are suitable for an application within the Water Framework Directive,
- to compare indicator applications based on different years and to evaluate to what extent temporal changes in the ecosystems are reflected in the indicator results. Questions are, how to deal with temporal variability or seasonal effects in data and how to measure the progress towards ecological sustainability.
- to evaluate the meaning of spatial variability in data for the indicator applications. How can we ensure that the indicator is representative for the entire ecosystem or region?
- to elaborate the problem of defining a good ecological status. What are the thresholds for a very good, good and poor status? How to determine the reference conditions (very good status) as a basis for an ecosystem quality classification system?
- to elaborate on the problem how to aggregate very different indicators (different scales etc.) into one indicator; called ecosystem quality,
- to evaluate the benefit of the WFD-indicators (and the ongoing development efforts) for the improvement of ICOM indicators.

Socio-economic indicators: The European Water Framework Directive focuses on ecological quality but asks for an integrated river basin-coast management plan and external measures to reach or to ensure a good water quality during the next decade. Our goals are:

- to evaluate, if the socio-economic drivers and pressures in general allow a good ecological state of the coastal waters.
- to elaborate on the problem of linking socio-economic and ecological indicators,
- to discuss, if socio-economic indicators are beneficial for the Water Framework Directive.

Governance indicators: To be successful, the European Water Framework Directive needs enabling conditions. As a response to an insufficient ecological state, regulations, laws or conventions are required. Our goals are:

- to evaluate, if the governance is suitable to control the socio-economic drivers and pressures and to ensure a good ecological state of the coastal waters.
- to discuss, if governance indicators are beneficial for the Water Framework Directive.

Finally, a comparison with other indicator systems (e.g. ICARM, EU) shall help to find an optimal indicator set for this regional approach.

This report reflects first preliminary results.

1.5 Legal framework, management plan and institutional arrangements

International legal background: During recent years, European environmental policy became a major driver and has legislated several important directives (laws) and recommendations, the Marine

Strategy, the Recommendations on Integrated Coastal Zone Management (ICZM), the Habitat Directive (Natura 2000) and the Water Framework Directive (WFD).

Most important is the **Water Framework Directive** (2000/60/EC), which has the aim to ensure good water quality in all EU member states. It is a framework for the protection of inland surface waters (rivers and lakes), transitional waters (mostly estuaries), coastal waters and groundwater. The WFD is a cross-border, river basin and coastal approach (up to a distance of 1 nm) that requires, for example the preparation of an integrated river basin – coastal water management plan until 2008. The International Commission for the Protection of the Oder River against Pollution (ICPOAP) is responsible for protection of rivers, lakes and the sea. In May 2002, the ICPOAP received the mandate to coordinate the implementation of the WFD within the international Oder River basin. An inventory and a description of the present status of the river basin has been prepared. A river basin management plan has not been developed or implemented up to now. The WFD is the major activity towards ICOM in Europe and will be a core activity for the implementation of the European Marine Strategy (COM 2002). The WFD and Natura 2000 are currently being implemented in Germany and Poland. **Natura 2000** will create a large network of protected areas in the Oder region, which call for an effective management. The **Marine Strategy** has the aim to promote sustainable use of the seas and conserve marine ecosystems.

The European **Recommendations on Integrated Coastal Zone Management** aim at a national stocktaking and a national strategy that should e.g. (2002/413/EC):

- identify the roles of the different administrative actors within the country or region whose competence includes activities or resources
- identify the appropriate mix of instruments for implementation of the principles within the national, regional or local legal and administrative context
- develop or maintain national and, regional or local legislation or policies and programmes which address both the marine and terrestrial areas
- identify measures to promote bottom-up initiatives and public participation
- identify sources of durable financing for integrated coastal zone management initiatives
- include adequate systems for monitoring and disseminating information to the public.

The German ICZM strategy is at the moment being developed by the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU). Germany has to report to the Commission in spring 2006. Due to different situations in the North and in the Baltic Sea, the national strategy will consist of two separate strategies, both including the exclusive economic zone. This work is supported by two national projects – “Zukunft Küste - Coastal Futures” and “IKZM-Oder” (Research for an Integrated Coastal Zone Management in the Oder Estuary region).

Spatial development and plans: The German hierarchical spatial planning system covers most aspects of an ICZM and spatial planners are the main actors in coastal zone management. Sustainable spatial development tries to integrate ecological aspects with spatial demands of economy and society. Spatial planning in Germany is organised in a system of graded responsibilities. The legal competence for spatial planning lies in the Länder (federal states) and the municipalities. The federal national Government has only the competence to set the general framework of spatial planning.

Spatial planning in the federal state (Land) of Mecklenburg-Vorpommern is carried out on two levels. The federal state Ministry of Labour, Construction and Regional Development acts as the supreme spatial planning authority and provides a state-wide Spatial Development Programme. The new state-wide Spatial Development Programme of Mecklenburg-Vorpommern (LEP M-V 2005) covers land and coastal waters as well as different utilisations in the coastal waters up to 12 nm off-shore. It specifies ICZM as a conflict resolution possibility. In 2006, the not binding Spatial Development Programme will be transferred to the regional level.

The federal state of Mecklenburg-Vorpommern is sub-divided into four regional planning regions with four regional planning authorities. These authorities have the task to provide a frequently updated

detailed Regional Spatial Planning Programme for every planning region. The planning region Vorpommern, covers the entire Oder Estuary region and can be regarded as an Integrated Coastal Zone Management plan. In 1996, a first ICZM plan for the Polish part was prepared by the HELCOM PITF MLW Odra Lagoon Area.

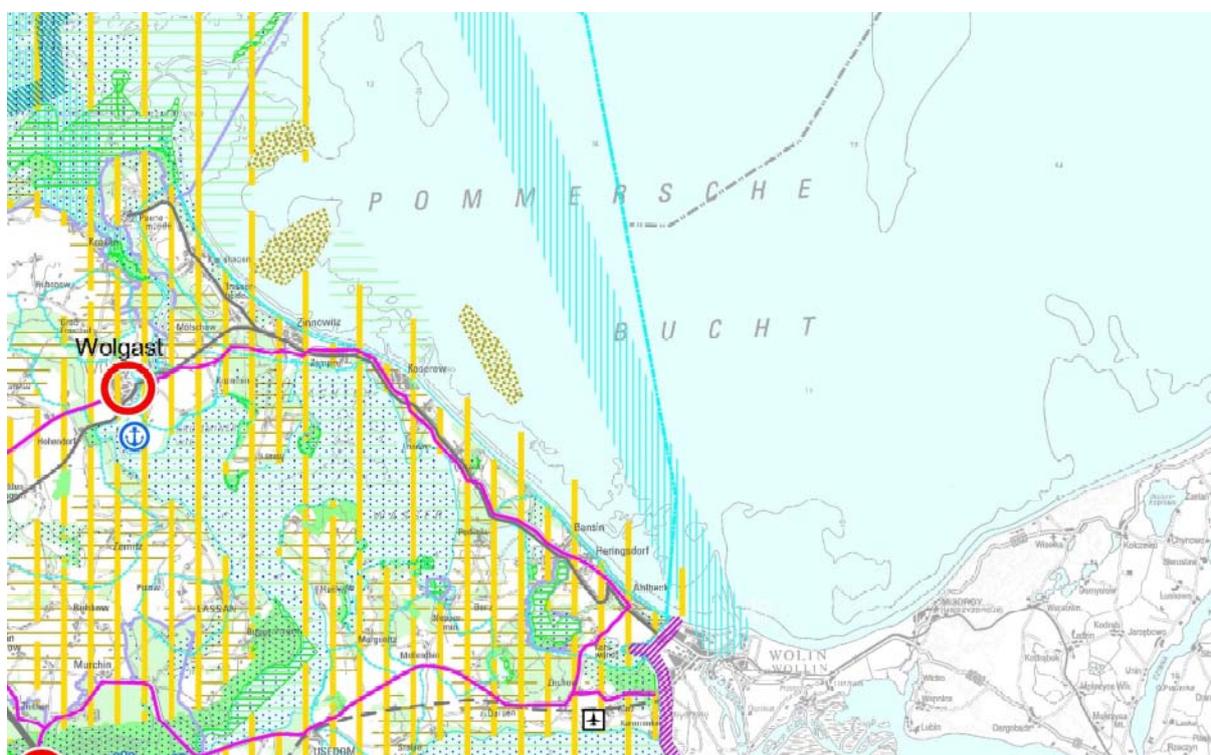


Figure 5: State-wide Spatial Development Programme of the federal state (Land) of Mecklenburg-Vorpommern (LEP M-V 2005): Map of the island Usedom and its adjacent coastal waters showing priority areas for relevant utilisations: e.g. green – nature conservation, yellow vertical - tourism, blue vertical – marine traffic.

International arrangements: Integrated Coastal Zone Management in the Oder Estuary region is based upon the Regional Spatial Planning Programme. To allow a cross-border co-operation between Germany and Poland and to increase public participation, the Regional Agenda 21 ‘Szczecin Lagoon’ has been signed. It is a political agreement between the environmental ministries of Mecklenburg-Vorpommern, Germany and the Voivodship Western Pomerania, Poland. This Regional Agenda 21 mentions coastal zone management explicitly as one major topic for co-operation. Further cross-border co-operations between Germany and Poland are e.g. the joint Euroregion Pomerania, and the joint Environmental Commission.

Several agreements between Germany, Poland and the Czech Republic ensure close cooperation in the Odra River basin. The International Commission on the Protection of the Odra against Pollution (ICPO) has the task to protect rivers, lakes and the sea. In May 2002 the ICPO received the mandate to coordinate the implementation of the EU Water Framework Directive within the international Odra River basin. Another ICPO task is protection from flooding, which is the main issue in the Polish “Program Odra 2006”. So far, however, a river basin management plan has not been developed or implemented.

1.6 Future threats and challenges

The Odra region faces dramatic political, social, economic and natural changes. To measure the consequences of these changes on the estuary region and especially the coastal ecosystems is an important task and requires comprehensive sets of indicators.

Political and social changes: The German part of the Odra region belonged to the former socialistic German Democratic Republic (GDR). With the German re-unification on 3. October 1990 important social, political and economic changes took place and are still ongoing. Despite huge financial efforts the Odra region fell behind the development of other parts of Germany. Ongoing economic problems cause an unemployment rate around 23 %, the movement of labour and a declining population. In 1989 Poland elected its first non-communist prime minister after 40 years of socialism. Like eastern Germany, Poland was subject to social changes and its transitional economy is still facing serious ongoing problems and changes. During the last decade the economic and social developments in Germany and Poland were largely independent and caused strong social and economic gradients. In the coastal area social problems are increasing and the gap between the flourishing seaside resorts and the hinterland is still deepening.

EU-membership and transformations: With Poland's EU-membership in 2004, the entire Odra region became part of the European Union. The new agriculture and industry policy, but also the implementation of new standards will cause dramatic changes. Cross-border cooperation as well as competition will increase and cause social and economic transformations. This will have multiple effects on the Odra basin, the river and the coastal area.

Legal challenges: The active European environmental policy has led to the Marine Strategy, the recommendations on Integrated Coastal Zone Management, the Habitat Directive (Natura 2000) and the Water Framework Directive (WFD). Especially the WFD and Natura 2000 are now being implemented in Germany and Poland. Natura 2000 will lead to a large number and a network of protected areas in the Odra region which require a management. Even more important is the WFD which has the aim to ensure a good water quality in all member states. The WFD is a cross-border and river basin - coast approach and requires e.g. the development of an integrated catchment-coast management plan during the next years.

Climate change: Climate change scenarios predict an increased risk of extreme weather events. Ongoing sea-level rise and a sinking coast as well as changes in precipitation in the catchment, with subsequent changes in river discharge, will increase the flooding risk in the river basin and at the coast. Along the Baltic Sea coast, an increased risk of storms and storm surges will have immediate negative effects on coastal erosion, protection measures and tourism infrastructure (sport boat harbours, beaches, piers, promenades). The problem of an extreme release of phosphorus from the sediments in the lagoon under anoxic conditions (internal eutrophication) might become an increasing problem in future.

1.7 Major issues

The European Water Framework shall ensure a spatial integration of the river, coastal lagoon and the coastal sea. Water bound, river basin – coastal area interactions are therefore of major interest:

Eutrophication and water quality: Intensive agriculture, industries and cities cause loads of heavy metals and organic pollutants and especially high loads of the nutrients nitrogen and phosphorus. The river water quality suffers from these loads, but the major consequences are visible in the coastal area. The lagoon can be regarded as a hypertrophic, degraded ecosystem. It largely lacks a submerge vegetation, suffers from severe algae blooms (partly of toxic species) and the water transparency in summer is often below 50 cm. On sunny days without wind, anoxic situations temporary occur and cause fish kills as well as a damage of benthos. Untreated sewage water of the city of Szczecin is

source of human pathogenic viruses and has potentially negative impacts on the hygienic (bathing) water quality. Due to regular dredging of the canal and denitrification processes, the lagoon still serves as a retention pond for nutrients and protects the Baltic Sea to a certain degree from pollution, but the poor water quality hampers bathing tourism and nature protection.

Flooding: The Odra is a lowland river with only a low hydraulic gradient. The tides in the Pomeranian Bay are in the range of only one decimetre. Strong northerly wind can cause storm water levels at the Baltic Sea coast of one meter and more. During these situations backwater in the Odra is observed far south of Szczecin and a temporary intrusion of Baltic Sea water with a salinity of 6 ‰ into the lagoon is observed. A sinking coast and climate change caused a relative water-level rise of about 1 mm/a during the last century in the region. An even faster increase is assumed for this century. Therefore the effect of storm surges on the river water level will increase, backwater will penetrate even farther into the river basin and cause a hazard. Climate change will affect not only the coast but also the river basin itself. Recent calculations do not suggest a significant increase in precipitation in the Odra basin, but the likelihood of extreme events and floods might become higher. The region has to face danger from two sides, due to sea-level rise as well as due to increased floods. Therefore, an integrated coastal and flood protection is needed.

Shipping and technical measures: Shipping plays an important role in the coastal area and the river. To increase transportation, to allow larger ships to enter the harbour of Szczecin and to increase the importance of Szczecin as a gateway to Berlin and the cities in the river basin, the canal through the lagoon shall be deepened from 10.5 m to 14.5 m. In the Peene Strom, close to the lagoon, a deepening of the water way to 7.5 m will be carried out until 2006 to foster maritime tourism. According to the programme Odra 2006 the water level and flow in the middle and lower Odra shall be regulated to allow the passage of class 3 ships. Further, new polders and storage reservoirs and a new barrage near Brzeg Dolny are planned. The flood protection systems and dams of major cities in the upper river shall be modernised, as well. All these measures will alter the course and flow velocity of the Odra, endanger ecologically valuable ecosystems and bayous and might enhance the risk of floods. An integrated concept for nature and flood protection, taking shipping and technical measures into account is required.

Species migration: Linked river-coast systems provide a convenient path for the spreading and migration of species. Intensive shipping caused the intrusion of many alien species in the Odra system, which partly already replaced the original fauna. So far over 20 makrozoobenthos species are spreading in the coastal waters and the river. Much more alien species are expected and are a serious threat for the ecosystems. Several fish species, like eel, salmon and trout migrate within the Odra water system or enter it to spawn. The degradation of the ecosystems in the river and the coast is a serious threat and altered the fauna already. The huge number of technical obstacles in the river hampers the fish migration seriously. The suggested large number of Natura 2000 sites in the Odra system calls for an integrated river-coast nature protection management.

1.8 Existing monitoring and evaluation

Environmental monitoring programmes as well as socio-economic surveys provide reliable and detailed long-term data for the region. The state authorities for statistics in Germany and Poland collect a wide range of data and publish it on an annually basis (CSO 2005; SLMV 2005). An overview of the data for the German and the Polish part of the Oder Estuary region is provided by the Regional Information System, which was developed by the research project IKZM-Oder (http://www.ikzm-oder.de/de/daten_und_fakten.html). Another important source is the Max Planck Institute for Demographic Research in Rostock, Mecklenburg-Vorpommern (<http://www.demogr.mpg.de/>). It carries out research on mortality, longevity as well as aging and focuses mostly on issues in the study of contemporary fertility and family dynamics.

The following institutes provide e.g. environmental monitoring data for the German part of the Oder Estuary region:

- Germany's National Meteorological Service (DWD) – meteorological data
- Federal Maritime and Hydrographic Agency (BSH) – Surveys in the Baltic Sea, prediction of tides, water levels, and storm surges as well as monitoring of the marine environment
- State office for Environmental Protection and Geology Mecklenburg-Vorpommern (LUNG) – Monthly (or two-week) investigations of chemical water parameters (like e.g. temperature, secchi depth, salinity, oxygen and nutrients) and biological water parameters (dissolved organic carbon, chlorophyll a, phytoplankton, macro-zoobenthos and macro-phytobenthos) as well as heavy metals (German coastal monitoring programme of Mecklenburg Vorpommern with more than ten stations in the Oder Estuary, thereof five within the German part of the Lagoon)
- Institute of Coastal Research, GKSS Research Centre Geesthacht – three gauging stations in the Szczecin Lagoon for measurement of hydrographical and meteorological data (ODE01, ODE02, ODE03)
- Baltic Sea Research Institute (IOW) – measurement of wind, temperature and light on the Oder bank in the Pomeranian Bay (ODAS OB)

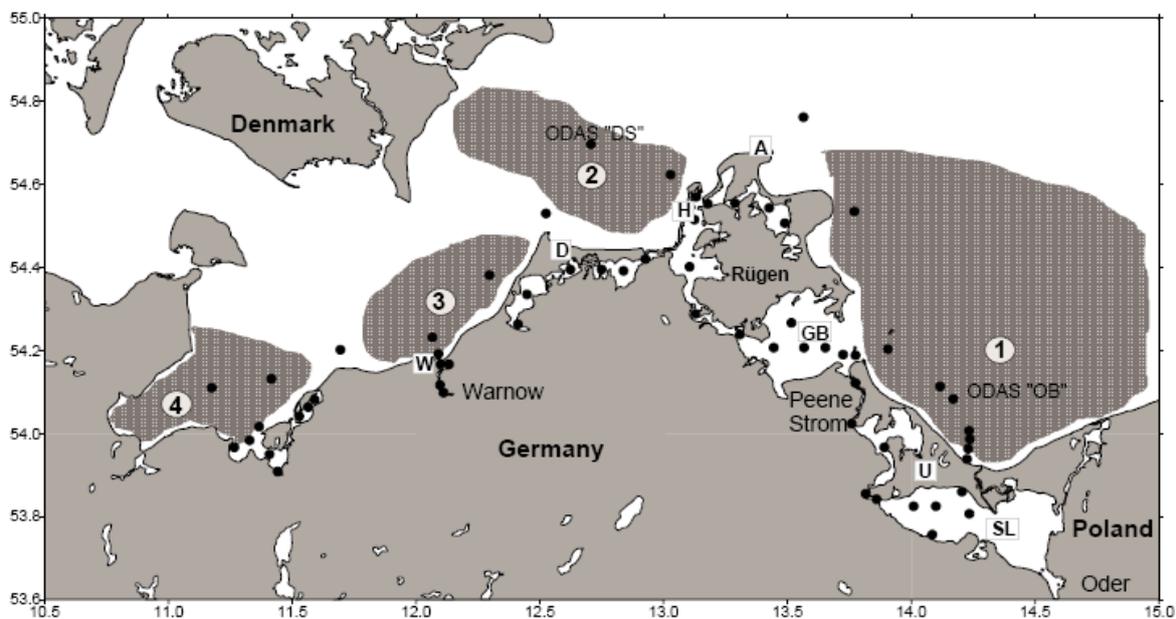


Figure 6: Map of the western Baltic Sea showing the stations of the German coastal monitoring programme of Mecklenburg-Vorpommern (black dots), locations of wind registrations (A, Arkona; ODAS'DS', ODAS Darss Sill; ODAS'OB', ODAS Oder) in the four main areas (1, Pomeranian Bight; 2, Hiddensee-Darss; 3, south-eastern Mecklenburg Bight; 4, Luebeck Bay) (Siegel et al. 2004)

Further, universities and research institutes, like the University of Szczecin and University of Greifswald as well as many research projects carried out detailed studies on the state and functioning of the coastal ecosystems. Several evaluation systems are existing.

1.9 Key outcomes and constraints

Major improvements towards an Integrated Coastal and Ocean Management (ICOM) are visible in Germany. Much more problematic is the required cooperation between river basin and the coast as well as the cross-border cooperation.

The major issues in the Odra region clearly reflect the growing need for a coastal area - river basin cooperation and management, but it still receives only minor attention. A survey among authorities and regional stakeholders as well as a media analysis has been carried out to get an impression of the

public perception of river basin – coast problems and issues. Especially regional authorities are well aware of major problems and clearly see the links between catchment and coast, but without taking action. The public awareness of water related problems and the consequences of a lacking integrated management is only poor. Future threats, like climate change and sea level rise, and their potential consequences are not well perceived. Problems and issues in the neighbouring country are not sufficiently reflected in the media, as well. In the Odra case, an awareness and information deficit clearly exists.

The coast mainly suffers from activities in the river basin, but at the same time, the coastal area is small compared to the large catchment. Experiences concerning the implementation of the WFD in other river basins revealed that a small coastal community usually faces many representatives from the river basin. Therefore, the coastal community is not well able to attract attention for their issues and problems.

The trans-national Odra region reflects the cultural, economic and social differences especially between Germany and Poland. Therefore, focus of recent efforts was to improve the cross-border cooperation between Germany and Poland and to foster a joint regional development. In general, the lack of a joint language reduces the efficiency of cross-border activities.

There is a general need to raise awareness about river related problems, to improve cross-border information and to promote the integrated management of the Odra river and coastal zone. Cross-border coastal dialogues are required (and were already initiated) to bring together the coastal community and to develop a joint identity. In a next step, coast-river dialogues, addressing a concrete topic like the EU-WFD, are important to support the river basin – coastal zone planning. The coastal perspective needs to be included in priority actions and the International Commission on the Protection of the Odra against Pollution (ICPO) should be supported in the development of implementation programmes.

Large river systems like the Odra, with a large population, a high number of authorities and organisations as well as complex political and legal structures require high ranking political commitments, clear objectives and structures as well as an adequate body as a basis for cooperation and management. In this respect, the ICPO is a suitable body. However, their coastal perspective is not well developed. Recent EU-directives have accelerated the cross-border cooperation. Due to clear time schedules, they ask for concrete plans and actions until a given deadline. Especially the EU-Water Framework Directive is nowadays the major driver for cooperation in the river basin and, hopefully, will enhance basin-coast activities as well.

2 Applying the handbook

2.1 Selection of indicators

In a first screening, we had a look at all governance, ecological and socio-economic indicators. The concrete selection of the indicators, which we applied in our case study, was carried out using four criteria:

1. Based on the **DPSIR (Driver, Pressure, State, Impact, Response)-framework** we classified all indicators. Every indicator was allocated to Drivers, Pressures, State, Impacts or Response. Aim was to select a set of indicators that represents the entire DPSIR cycle and reflects the dependencies in our coastal system (Figure 7).
2. Evaluation, if an indicator is suitable and beneficial for the European Water Framework Directive (WFD) and fits to our aims: In general, a division into two groups is possible: the directly applicable indicators and the additional beneficial indicators. The directly applicable indicators are those ecological indicators, which directly provide information about the ecological status of our coastal ecosystems and directly meet the objectives of the WFD. The additional beneficial indicators are mainly socio-economic and governance indicators. The WFD does not ask for these

indicators, but they clearly can be beneficial to get a more comprehensive picture of the entire coastal system with all its dependencies. They can be valuable for the implementation of the WFD and help to allocate problems e.g. show the reasons why a good ecological status cannot be achieved.

3. Evaluation of the data availability: Is the data needed for a certain indicator available, is the quality, the temporal and spatial resolution sufficient and is the data available for at least several years?
4. Estimation of the needed resources: How fast can we get access to the needed data, do we have qualified staff to analyse the data needed to apply a certain indicator, and is the work feasible within the given time period?

The results of this screening are shown in the following tables, together with some additional information. The estimation of the needed resources is not explicitly stated, but will be discussed later.

We finally decided to select and apply the following indicators:

- Governance indicators: G1-G5, G9, G10
- Ecological indicators: E1, E3, E8,
- Socio-economic indicators: S4.

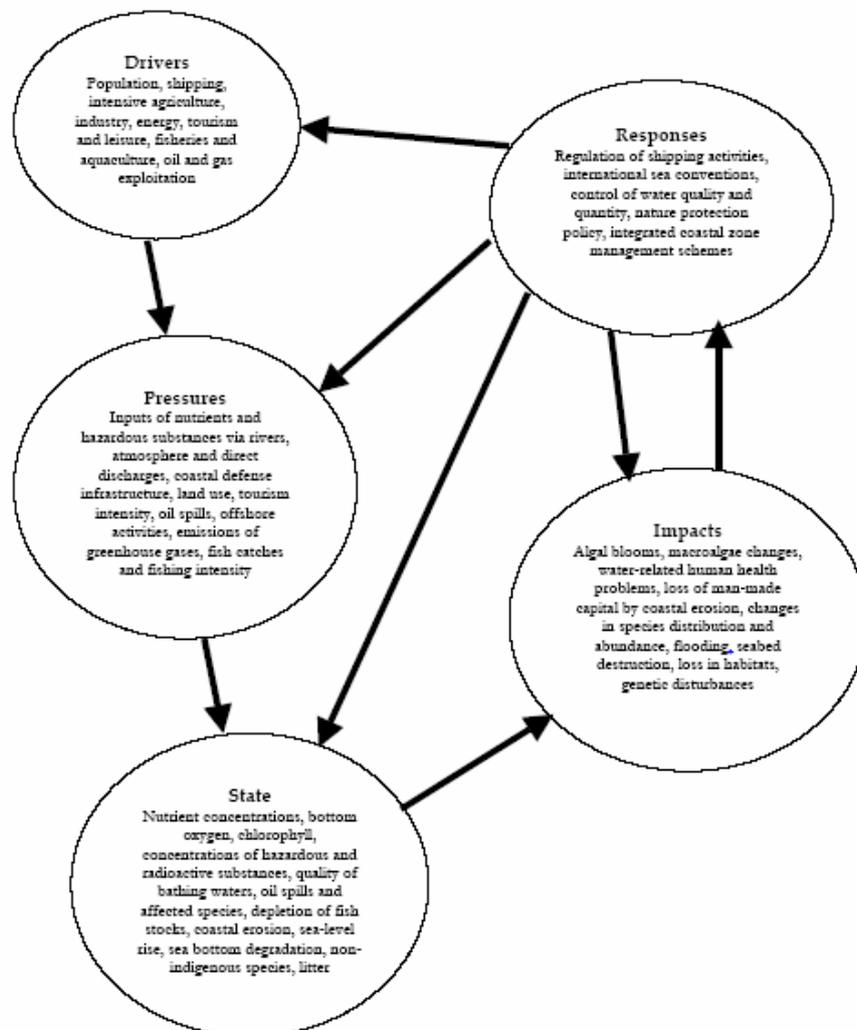


Figure 7: The DPSIR framework applied to the marine environment (IOC Indicator handbook after EEA 2000)

IOC-Indicators	DPSIR-character	Usefulness for WFD (- - o ++)*	Meaning of IOC indicator for the WFD	Existence of information / data (- - o ++)	Availability of data and information as well as important documents and publications
Governance indicators					
G1: Existence and functioning of a coordinating mechanism	R	++	The ICPOAP and related ministries are the statutory framework for a coordinating mechanism.	++	German spatial planning act (1998); WFD (2000/60/EC); Agreement of the ICPOAP (1996); LEP M-V (2005)
G2: Existence and adequacy of legislation	R	++	WFD and the German water act form the legal basis. They follow principles of sustainability, information and participation.	++	German spatial planning act (1998); Water act of Mecklenburg-Vorpommern (1992) ; WFD (2000/60/EC); Agreement of the ICPOAP (1996); LEP M-V (2005)
G3: Environmental assessment	R	+	WFD asks for EIA, SEA as well as CCA. It is too early for an evaluation.	++	Acts for EIA and SEA existing, equivalent for CCA; LEP M-V (2005); ESPOO-Convention (1991); regional concepts
G4: Existing and functionality of conflict resolution mechanism	R	+	Participation of stakeholders shall minimise conflicts before preparation of a management plan	+	Spatial planning includes conflict resolution mechanisms; a lot information available, but few information about efficiency
G5: Existence, status and coverage of ICOM plans	R	+	A management plan is under preparation and shall include coastal waters up to a distance of 1 nm	+	Plan under preparation; the LEP M-V (2005),) and the WFD (2000/60/EC) as well as the report by the ICPOAP to the European Commission (2005) form a good basis
G5: Existence, status and coverage of watershed plans	R	++	A management plan is under preparation, coverage and contents are given by the WFD	+	Suitable WFD (2000/60/EC) plan is under preparation which fulfills ICOM demands
G5: Existence, status and coverage of management plans for coastal and marine ecosystems	R	+	A management plan is under construction, coverage and contents are given by the WFD	+	WFD plan under preparation and partly suitable; parallel activities concerning protection of ecosystems are Natura 2000, Marine Strategy and Marine Protected Areas
G6: Clearly defined, understood, and respected enforcement procedures of ICOM	R	+	At present not well defined, but responsibilities and procedures will be given in the WFD management plan. It is too early for an evaluation.	o	At present only some activities and basic information in the LEP M-V (2005)
G7: Monitoring, evaluation and adjustment of ICOM initiatives	R	+	At present not well defined. Monitoring programme will be modified to meet the demands of the WFD and the management plan. It is too early for an evaluation.	o	The existing monitoring systems are suitable for ICOM, but ICOM is not mentioned explicitly; a comprehensive evaluation is lacking.
G8: Sustained availability and allocation of resources for ICOM	R	+	At present not finally discussed, but resources for implementation of the WFD are available. It is too early for an evaluation.	-	Resources are allocated to several authorities and bodies; detailed information about administrative resources are hard to obtain.
G9: Existence, dissemination and application of ICOM-related scientific-related research	R	++	Scientific research plays a major role for the implementation of the WFD	+	Many scientific activities have been carried out done (e.g. projects, publications), scientist are involved in management processes, but the communication between ICOM relevant managers and scientists is insufficient.

* scale: -- very poor; - poor; o moderate; + good; ++ very good ...: Selected and applied indicators

IOC-Indicators	DPSIR-character	Usefulness for WFD (-- o ++)*	Meaning of IOC indicator for the WFD	Existence of information / data (-- o ++)*	Availability of data and information as well as important documents and publications
G10: Level of stakeholder participation in ICOM decision-making processes	R	++	Plays a major role in the WFD, already for the preparation of a management plan.	+	Many stakeholders (ministries, NGOs) are involved in projects concerning ICOM, also in development of the national ICZM strategy; but few information about their satisfaction of participation and outcomes
G11: Existence and activity level of NGO and community organisations supportive of ICOM	R	o	NGO are stakeholders and will be involved during implementation of WFD; in ICPOAP NGOs are not involved	+	A lot of NGOs are involved in ICOM activities, but there is no direct information about the level and the influence on the advancement
G12: Incorporation of ICOM into educational and training curricula	R	+	So far only minor activities, but the WFD requires educated people and training activities are already increasing. It is too early for an evaluation.	+	Many activities have been carried out (summer schools, seminars, traineeships), but a quantified estimation is not possible
G13: Use of technology to enable and support ICOM	R	+	It is an aim of the WFD to use best technologies for limitations of emissions and to promote technologies for a sustainable utilisation of water. It is too early for an evaluation.	+	Many technologies are used for ICOM related activities (e.g. environmental monitoring; GIS; buoys)
G14: Use of economic instruments in support to ICOM	R	+	Considered in the WFD. It is too early for an evaluation.	--	Although it's useful for implementation of ICOM, practically there is nothing available
G15: Incorporation of ICOM into sustainable development strategy	R	-	At present not provided for implementation of the WFD, but in near future important for implementation of the Marine Strategy	o	A national strategy concerning ICZM is under development, but there is not any official information; ICZM is a working task in the regional Agenda 21 Szczecin Lagoon
Ecological indicators					
E1: Diversity	S, I	++	Major indicator in the WFD to evaluate the status of aquatic ecosystems	++/-	Existing long-term monitoring programme; amount and quality of data depends on biological element (e.g. phytoplankton, fish)
E2: Distribution	S, I	-	Not considered in the WFD	o	Few data and single results from research project
E3: Abundance	S, I	++	Major indicator in the WFD to evaluate the status of aquatic ecosystems	++/-	Existing long-term monitoring programme; amount and quality of data depends on biological element (e.g. phytoplankton, fish)
E4: Production and reproduction	S, I	o	Might become an additional indicator in the WFD	o	Existing long-term monitoring programme partly useful; additional data from single research projects (phytoplankton)
E5: Trophic interactions	S, I	o	Might become an additional indicator in the WFD	-	Only data from single research projects
E6: Mortality	S, I	o	Might become an additional indicator in the WFD	+	Data from single research projects and catch statistics (fish)
E7: Species health	S, I	o	Might become an additional indicator in the WFD	-	Only data from single research projects

* scale: -- very poor; - poor; o moderate; + good; ++ very good ...: Selected and applied indicators

IOC-Indicators	DPSIR-character	Usefulness for WFD (-- o ++)*	Meaning of IOC indicator for the WFD	Existence of information / data (-- o ++)*	Availability of data and information as well as important documents and publications
E8: Water quality	S	++	Important supporting indicator in the WFD	++	Existing long-term monitoring programme
E9: habitat quality	S	o	Beneficial indicator in the WFD	+	Existing information
Socioeconomic indicators					
S1: Total economic value	D, P	-	Not relevant for the WFD	+	
S2: Total employment	D	-	Not relevant for the WFD	++	
S3: Sustainably managed exploitation	R	o	Might become a beneficial indicator in the WFD	+	
S4: Pollutants an introduction	P	++	Beneficial indicator for the WFD	++	
S5: habitat alteration	P	o	Might become a beneficial indicator in the WFD	+	
S6: Disease and illness	I	++	Beneficial indicator for the WFD	++	
S7: Weather and disaster	D	o	Might become a beneficial indicator in the WFD	o	
S8: Population dynamics	D	-	Not relevant for the WFD	++	

* scale: -- very poor; - poor; o moderate; + good; ++ very good ...: Selected and applied indicators

2.2 Assessing Progress in Governance

G1 Existence and functioning of a coordinating mechanism for ICOM

According to the indicator, a functioning and comprehensive management for ICOM in the Oder Estuary region does not yet exist, because there is no special authority ensuring the coordination of different actors at all levels.

Nevertheless, in a wider sense different activities on different levels form a suitable coordinating mechanism for ICOM. Especially in relation with the WFD, spatial planning itself or other involved authorities can be regarded as a coordinating framework. The International Commission for the Protection of the Oder River against Pollution (ICPOAP) and regional authorities for spatial planning supervise relevant processes towards a sustainable development of the coastal zone (see 2.4, legal framework). There is no direct exchange between both authorities yet, but the implementation of the WFD will ensure a cooperation in future.

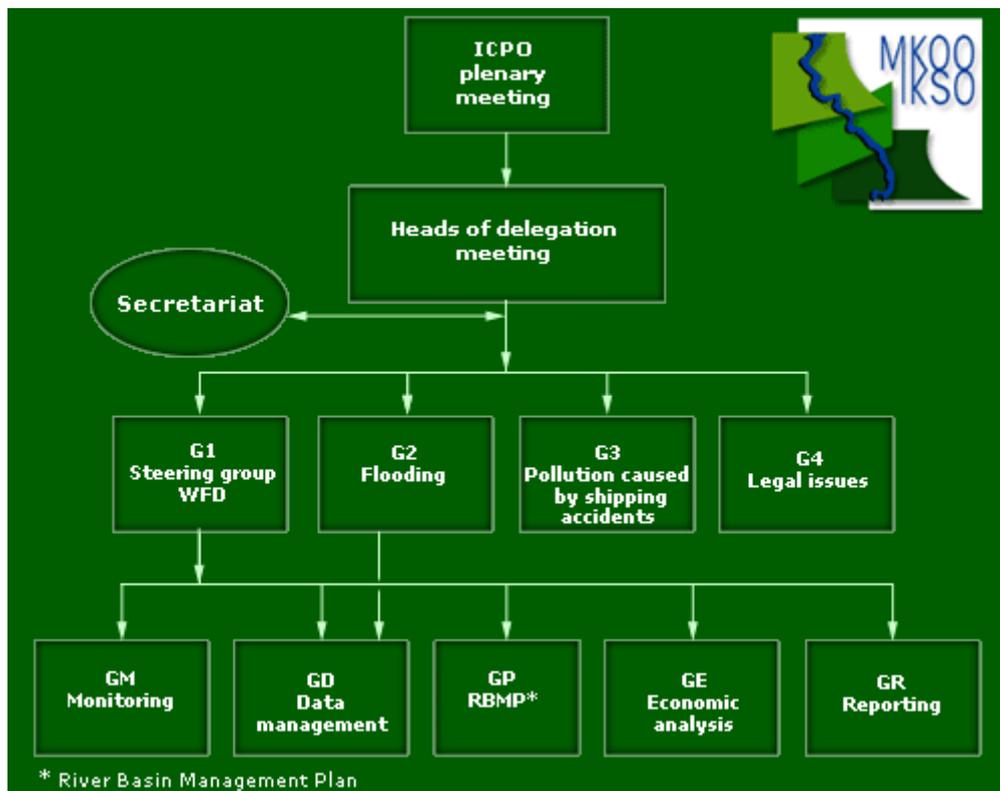


Figure 8: Organisation chart of the ICPOAP (<http://www.mkoo.pl/>). The ICPOAP was signed by the Governments of the Republic of Poland, the Czech Republic and the Federal Republic of Germany and by the European Community. Until 2007, Germany provides the chairmanship.

Both authorities, e.g. the Regional planning association of Vorpommern, responsible for the German Oder Estuary region, and the ICPOAP consist of different working groups of representatives of regional authorities and ensure stakeholder participation. Thus, e.g. regional managers, investors as well as representatives of national parks, universities and tourism are involved formally or informally in regional planning processes. This is true for all administrative districts in the Oder Estuary region. Both the ICPOAP as well as the regional planning association of Vorpommern publish regularly reports and inform the public.

At this stage it is not possible to provide any detailed assessment of the effectiveness of the coordinating mechanism concerning ICOM, because a management plan concerning the WFD is still

missing as well as the direct link between the WFD and regional planning. However, the indicator application is subjective. It is not clear how to measure the effectiveness, functionality and sustainability of this coordinating body.

G2 Existence and adequacy of legislation

Several national German laws as well as EC directives support the implementation of ICOM goals. Concerning the Oder Estuary region two laws are most important: the Spatial Planning Act as well as the WFD. Furthermore, commitments in view of the HELCOM (Helsinki Commission) and acts concerning water resources (Wasserhaushaltsgesetz (WHG), Landeswassergesetz (LWaG)) of Mecklenburg-Vorpommern have the aim to protect coastal waters and seas up to a distance of 12 nm (German territorial waters).

The WFD has the purpose to establish a framework for the protection of ground, surface, transitional and coastal waters. The Spatial Planning Act is a framework for spatial planning on different levels. The new, not binding, State Spatial Development Programme of Mecklenburg-Vorpommern (LEP M-V 2005) covers land and the coastal sea and shows the different uses and demands, for the first time. Moreover, it specifies ICZM as a conflict resolution possibility. This programme will guide spatial planning on the regional level in future, and ensures an extension of the planning towards the coastal sea.

In this context, there is a need for supportive activities that promote the legislation and its application. Different organisations like the German-Polish cross-border commissions on spatial planning and environment as well as the Regional Agenda 21 Szczecin Lagoon help with concrete projects, regional conferences and environmental education to establish legislation. Moreover, informal initiatives like spatial development concepts with regional guidelines and action plans support ICOM goals.

The indicator should be improved in a way that it becomes possible to reflect processes, activities strategies and plans, which support the ICOM aims. Guidelines showing how to measure the awareness and understanding of ICOM legislation would be beneficial.

G3 Environmental assessment

EIA, fixed by law of 12.02.1990, as well as SEA (fixed in 2004) are parts of formal planning processes in Germany. In Mecklenburg-Vorpommern EIA is mandatory by law (09.08.2002), but not for all projects and plans. The impacts on the environment are to be summarised (environmental report) and to be submitted to the public and responsible bodies. Comments are to be considered in the planning. An EIA is mandatory for e.g. intensive fish farming with discharge of substances in surface or coastal waters (output 1.000 t per year), construction of dikes and motorways. An individual testing is mandatory for construction of harbours, dunes and land reclamation on the coast.

The Convention on Environmental Impact Assessment in a transboundary context¹ (ESPOO-Convention, 25.02.1991) is also relevant for the Oder Estuary region. In this context, “the Parties shall, either individually or jointly, take all appropriate and effective measures to prevent, reduce and control significant adverse transboundary environmental impact from proposed activities.” Poland and Germany signed the convention in 2003, but the ratification is still missing. In addition, the Joint Environmental Commission between Mecklenburg-Vorpommern and Voivodship Westpommern has the goal to compile policies for environmental impact assessments in a transboundary context (still outstanding).

In the case of the federal state (Land) spatial development programme of Mecklenburg-Vorpommern (LEP M-V 2005) an EIA for the whole area has been carried out to ensure an early planning process without conflicts. This EIA is based on the environmental framework report of Mecklenburg-

¹ http://www.bmu.de/files/pdfs/allgemein/application/pdf/konvention_espoo.pdf

Vorpommern (LAUN 1996) and includes a FFH impact assessment (flora fauna habitat). The following topics have been tested for their impacts on the environment:

- industrial locations
- suitability areas for wind energy plants
- routes for cables and pipes in marine areas and
- priority marine areas for resources.

Altogether 81 parties (citizens, responsible bodies and institutions) made comments in the first step of the participation procedure, in the second step 223 parties. Some results have been included in the programme. A summary of statements are publicly available (online, only in German²).

For planning of large tourist projects as well as other buildings, a spatial impact assessment (spatial impact analysis) is necessary. This assessment replaces the carrying impact assessment (CCA) that does not exist in Germany.

In Mecklenburg-Vorpommern, many institutions (water authorities, forest authorities, etc.) ensure that the environmental effects of projects are reviewed. There is no special agency responsible for all kinds of assessments. For this reason, it is not possible to get adequate information about detailed plans in the Oder Estuary region. Often they are not publicly available. Moreover, it is not possible to give an overview about the interventions relevant to the coastal and marine environment.

Environmental assessment is a supporting instrument for achieving ICOM goals. Nevertheless, the assessment depends on conditions that can be subjective e.g. definitions of limiting values or of a good ecological status. In the context of the WFD, scientists are at the moment discussing classification schemes and try to define ecological reference conditions.

G4 Existing and functionality of conflict resolution mechanism

Spatial planning itself and connecting processes are conflict resolution mechanisms. They are a kind of conflict avoidance. Planning programmes define areas for special utilizations; master development plans define the concrete implementation. Several projects implicate spatial impact analysis and environmental assessments. In the coastal area of the Oder Estuary region, different utilisations exist (Figure 4), which lead to conflicts mainly because of the proximity to Poland. Cross border cooperation and meetings help also to overcome such conflicts and to discuss the projects. In this context, the Joint environmental commission and the ICPOAP are important. Stakeholders are often involved in meetings, but seldom the public.

Another way of conflict resolution is the “citizens' decision”. It is like an opinion poll, initiated by a regional action group. Opinion polls as well as public relations (newspapers, etc.) help to inform and to realize problems. Moreover, decision support systems contribute to conflict resolution.

Because of the dimension of the Oder Estuary region as well as different responsibilities concerning spatial planning, EIA and SEA, in the time frame of the indicator test to compile a list with relevant conflicts concerning the coastal zone, especially concerning the water quality.

G5 Existence, status and coverage of management plans

As mentioned before (see 2.4, legal framework, G1 and G2), a management plan for ICOM does not exist so far. But especially the State spatial development programme (LEP M-V 2005) covers most aspects. It defines objectives and principles for utilisations as well as for nature conservation in the coastal area and in coastal waters up to a distance of 12 nm.

² http://www.am.mv-regierung.de/raumordnung/aktuell_neuaufstellung_aufruf.html

The programme contains 12 guidelines; four affect ICOM in the Oder Estuary region:

- Guideline 1: cooperation with Poland and joint development
- Guideline 5: improvement of (cross border) infrastructure (maritime transport, ferry traffic, transit etc.)
- Guideline 7: nature conservation and cautious use of unspoiled nature and coastal areas; coastal and flood protection
- Guideline 12: protection and sustainable utilisations of coastal areas/waters by coordination of different and competitive uses in the framework of Integrated Coastal Zone Management
- In addition, ICOM is mentioned as an important conflict resolution mechanism.

Regarding a watershed plan, the WFD asks for a management plan for the entire Oder River basin until 2008. This plan will be developed by the ICPOAP in coordination of all relevant countries (Germany, Poland, and Czech Republic). The first status report was published and reported to the European Commission in 2005 (ICPOAP 2005). The management plan will consider the entire river basin as well as the inner and outer coastal waters up to a distance of 1 nm. It will focus only on water quality and its management. Detailed contents and time frames of the management plan are specified in the WFD.

With regard to a management for coastal and marine ecosystems, there is no concrete plan for the Oder Estuary region. But the Habitat Directive (Natura 2000; figure 2) and the Marine Strategy have an equivalent status and specify contents and time frames to a certain degree.

Different types of management on different levels exist in the Oder Estuary region. They partly overlap and influence each other. To reduce connected conflicts and to achieve a sustainable development of the entire coastal zone, there is a need to combine these approaches in the future.

The IOC handbook could possibly provide guidance toward a management plans. At the moment, the indicator is focused on an existing ICOM plan. ICOM is often under development (without mentioning the term ICOM) or is covered by existing legislation. The indicators should evaluate existing instruments and approaches, and reflect the progress towards an ICOM, rather than evaluate only the final result, the management plan.

G9 Existence, dissemination and application of ICOM-related scientific-related research

Scientific research plays a major role for achieving ICOM. Due to its size and ecological importance the Oder Estuary region, especially the Szczecin Lagoon, has been intensively studied by a lot of fine-meshed monitoring programmes. Moreover, large interdisciplinary projects (e.g. Lampe 1998, Humborg et al. 2000, and Schernewski et al. 2004) have investigated ecological connections as well as socio-economic challenges and their affects on the environment. The interdisciplinary research project IKZM-Oder, funded by the Federal ministry of Education and Research, carries out different activities, e.g.:

- ICZM stocktaking and evaluation according to the EC-recommendations on ICZM
- Recommendations towards a national ICZM-strategy
- Harmonisation and integration of German and Polish ICZM-tools and plans
- Integration of coastal waters in planning
- Development and application of indicators for sustainable development and ICZM
- Suggestions towards a sustainable tourism
- Research on river-coast interactions (climate change, awareness rising)
- Analyse important issues and relevant stakeholders for an ICOM.

In the framework of the project, several tools have been developed to enable coastal zone management: a public available GIS, a decision support system as well as online learning modules concerning ICOM in the Oder Estuary region. In close cooperation with the office of the Regional

Agenda 21 Szczecin Lagoon relevant project results have been disseminated. In this regard, conferences, workshops as well as publications in scientific journals, newsletters and regional newspapers are beneficial.

This indicator is highly relevant to ICOM in the Oder Estuary region as well as to the implementation of the WFD. Problems arise because of the great amount of scientific literature and its specific input into ICOM initiatives. Furthermore, there is no clear approach to measure the use of scientific outputs by ICOM managers.

G10 Level of stakeholder participation in ICOM decision-making processes

A steering committee, consisting of 11 representatives of regional authorities, ministries and associations, participates regularly in project meetings and conferences. They help the project to be of practical relevance and to ensure the regional use by stakeholders.

Stakeholder participation took place during the development of the national ICZM strategy, as well. A working committee of about 40 representatives of universities, federal and regional authorities as well as associations discussed in two meetings the expectations and contents of a national strategy. A third and final meeting will take place in spring 2006.

In addition, stakeholder as well as public participation is recommended by the WFD. Stakeholders are involved in the working groups of the ICPOAP (Figure 4).

This indicator is relevant for ICOM as well as for the WFD, but it is too early for an evaluation. Neither all relevant stakeholders have been identified nor can the level of satisfaction of stakeholders with their participation and with ICOM outcomes be measured so far. Many interviews are necessary to measure the satisfaction of stakeholders. Such an activity is not planned so far. The indicator overlaps strongly with the indicator G1.

2.3 Application of ecological indicators

Governance indicators consist of concrete questions and their succession describes a process cycle (planning, implementation, monitoring). The application can be carried out on the basis of existing documents. However, a concrete evaluation remains difficult.

The ecological indicators are quite different and their application is much more complicated and time-consuming. This is especially true for biological indicators. The indicators “water quality” or “biodiversity” or “abundance” can be regarded as umbrella indicators and the “units of measurements” mentioned in the handbook (e.g. nutrient levels, turbidity) themselves form separate, largely independent indicators. Therefore, we practically face a large number of indicators and not all of them can be applied. The choice of the most relevant “units of measurements” depends on the aim of the indicator application. In our case, the European Water Framework Directive (WFD) defined the objectives. After agreeing on the concrete indicators (e.g. phytoplankton diversity) one has to decide how to measure these indicators. The methods in the handbook remain very general and concrete information, e.g. how to measure biodiversity, is lacking.

A concrete evaluation of the state of the biological diversity and abundance in the Oder estuary is difficult. Classification schemes defining a very good, good or poor state are lacking so far. Usually this kind of classification scheme requires the definition of reference conditions or a very good state. In practise this is a complicated task, because all our aquatic systems are heavily influenced by human activity and/or eutrophication processes and are far away from a very good state. For the WFD several approaches to define reference conditions were suggested: Comparison with existing undisturbed sites, use of historical data and information, model applications and expert judgement. The work for the WFD is ongoing. The results might contribute important aspects to the IOC-indicators and might help to concretise the handbook. The result is that the application of biological indicators remained on a data analysis level.

E8 Water quality

Definition: This indicator is to describe the physical-chemical and oceanographic properties of the water column and assess the seawater quality, in terms of its ability to sustain the marine life and biological processes (definition according to the handbook).

Unit of measurement: Surface seawater temperature (SST), salinity and concentrations of suspended matter, turbidity levels of nutrients and dissolved oxygen (eutrophication parameters) as well as concentrations of contaminants like heavy metals, Persistent Organic Pollutants (POPs)*, hydrocarbons, organo-tins, waste and debris.

Objective: Evaluation of the ecological status of coastal water ecosystems. The WFD focuses on biological parameter but chemical and physico-chemical elements supporting biological elements are of interest as well. Explicitly mentioned are: Transparency, thermal conditions, oxygenation conditions, salinity, nutrient conditions, pollution by priority and other substances.

Therefore, most “units of measurements” are suitable for an evaluation according to the WFD. In this cases study we focus on eutrophication parameters (nutrient levels, biomass). The following evaluation is based on previous work by Bangel, Schernewski et al. (2004).

Data analysis: The application of indicators requires long-term data and a comprehensive understanding of the processes in the aquatic system. The detailed data analysis underlying this indicator application is exemplary presented for total phosphorus (Pt). Beside nitrogen, phosphorus is a major element that usually limits the primary production in coastal ecosystems. This analysis serves as a background for some critical remarks. Information about other relevant “units of measurements” can be found in Bangel et al. (2004).

The total phosphorus (Pt) consists, as a rough average estimation, to about 50 % of phosphate and to 50 % of organic compounds. In similarity to nitrogen, the ratio between inorganic and organic compounds depends on the season.

The data shows a long-term Pt-reduction of nearly 40 % in the lagoon. With about 50 %, this is reduction is even more pronounced in the Pomeranian Bay. The annual dynamics of Pt is similar to phosphorus, but weaker. During May, when inorganic phosphorus is largely depleted in the water column, organic compounds have the highest portion in Pt.

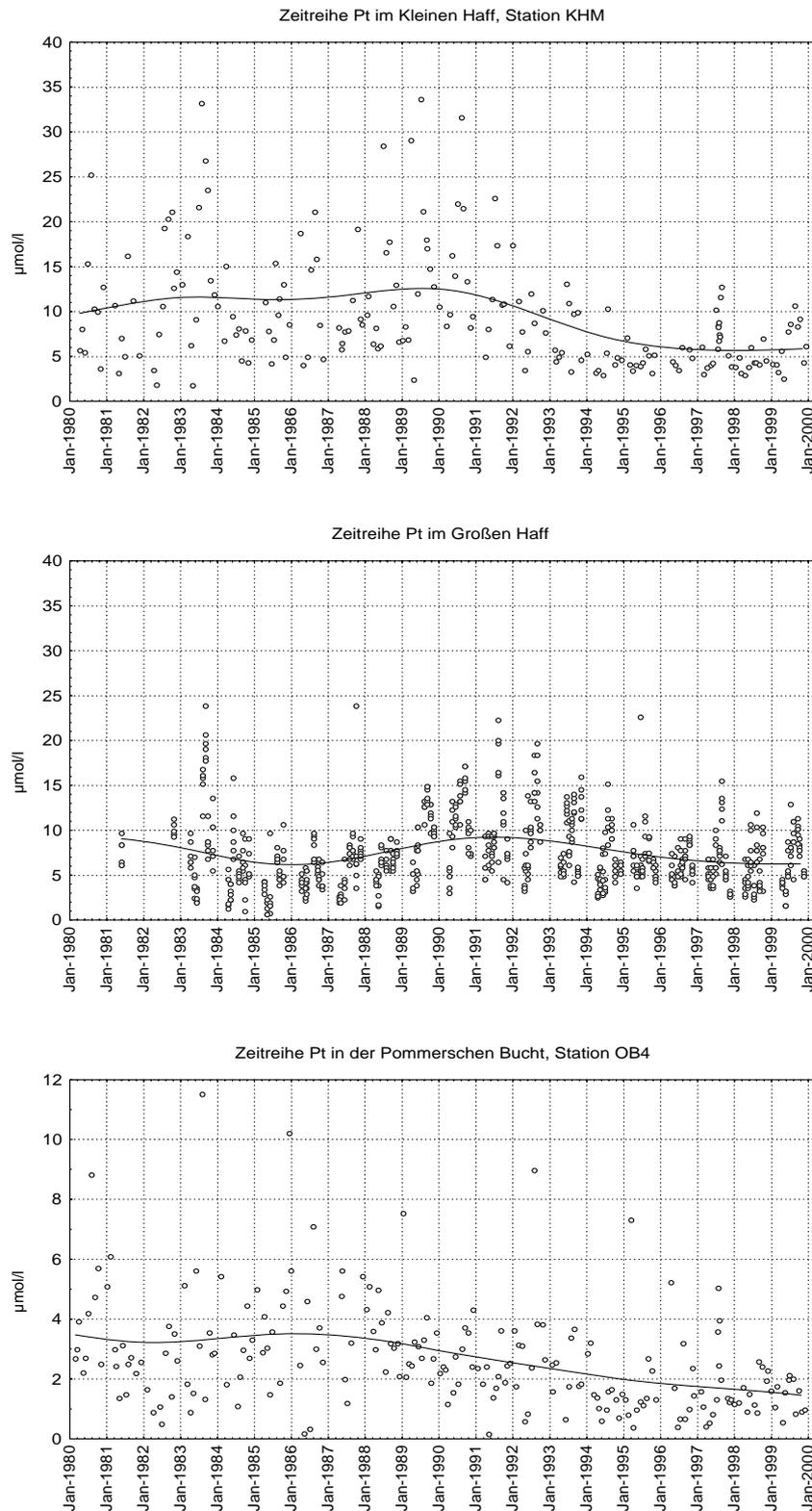


Figure 9: Total phosphorus (μmol) in the Kleines Haff (top), Wielki Zalew (middle) and the Pomeranian Bay (bottom) between 1980 and 2000. The line indicates the moving average. For the Kleines Haff and the Pomeranian Bay only single sampling stations were considered (KHM, OB4). Data source: State Agency of Environment, Protection of Nature and Geology Mecklenburg-Vorpommern (LUNG) and West Pomeranian Voivodeship Inspectorate in Szczecin (WIOS) after Bangel et al. (2004).

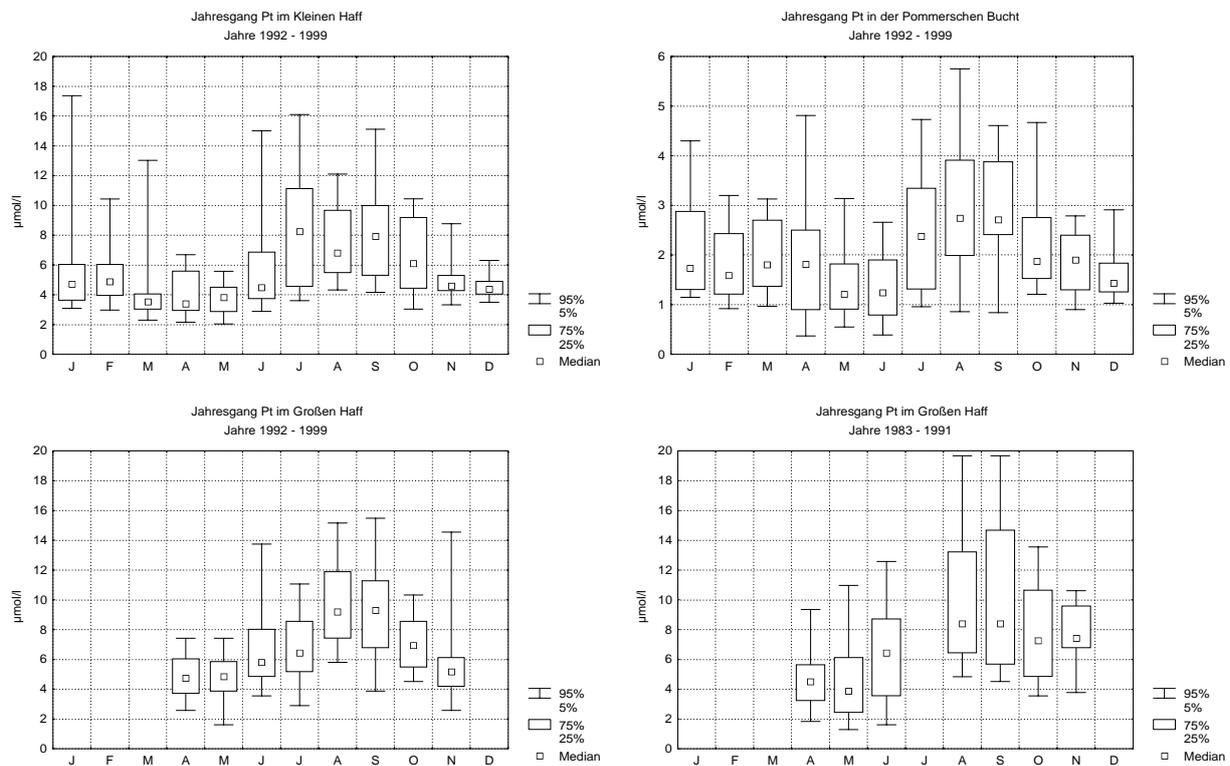


Figure 10: Annual course of total phosphorus concentrations ($\mu\text{mol/l}$) in the Kleines Haff (top, left), the Pomeranian Bay (top, right) and the Wielki Zalew (bottom, left) and the (bottom) for the period 1992 – 1999. The figure at the bottom, right displays the data for the Wielki Zalew between 1980-1991. Data source: State Agency of Environment, Protection of Nature and Geology Mecklenburg-Vorpommern (LUNG) and West Pomeranian Voivodeship Inspectorate in Szczecin (WIOS) after Bangel et al. (2004).

Results:

- The Pomeranian Bay and the Oder Lagoon show very different levels of nutrient concentrations and very different processes. One sampling station can hardly be representative for the entire estuary. In the Oder Lagoon exist very strong spatial concentration gradients. One sampling station can hardly be **representative** for the entire lagoon.
- Wet and dry years have strong influence on nutrient levels, are the reason for the strong interannual variability in the lagoon and cover possible long-term trends. An indicator application based on only one year might lead to wrong results. Averages over several years are necessary when indicators shall be used to analyse trends. For this purpose **long-term data** is necessary.
- Nutrient concentrations show a strong annual dynamic. Indicator applications based on data taken at a certain date cannot be compared with results based on data taken from another date. An indicator application requires knowledge about the annual dynamics. Further, nutrient concentrations show a strong variability from one week to another. **Averaged data** is needed to get stable results.
- Concerning water quality, an **evaluation** of the present situation is possible because several classification systems are available. According to the OECD (1982) classification scheme, the Oder Lagoon has to be regarded as a hypertrophic system. The Landesamt für Umwelt, Natur und Geologie Mecklenburg-Vorpommern (LUNG) uses an own, more detailed classification system. It differentiates between heavily eutrophied, polytrophic and hypertrophic. After this scheme, the lagoon has a state between heavily eutrophied and polytrophic, depending on the considered year. The trophic state of the Pomeranian Bay, close to the Swina mouth, is between eutrophic and heavily eutrophic.

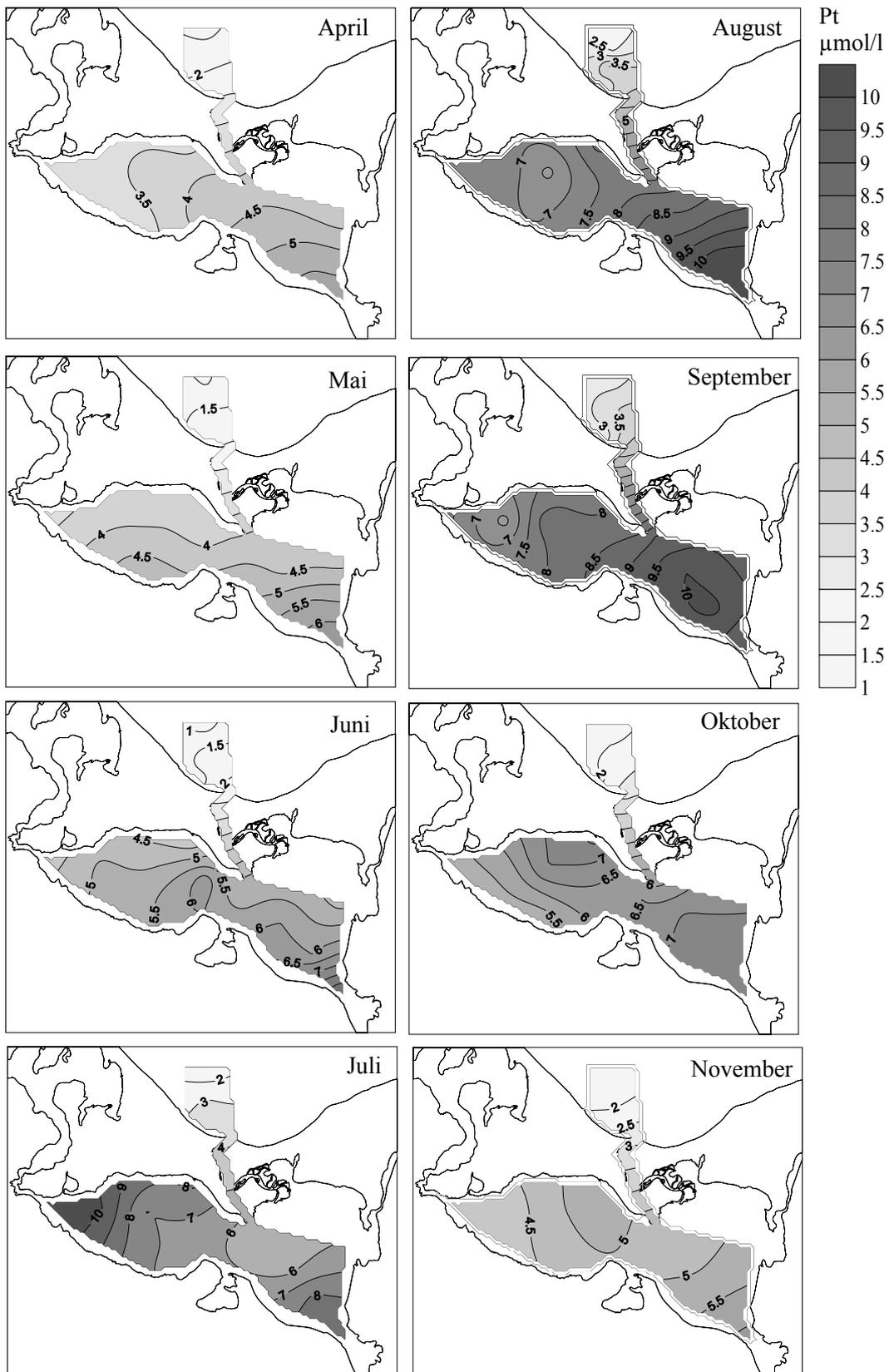


Figure 11: Average (median) spatial pattern of total phosphorus concentrations ($\mu\text{mol/l}$) between April and November during the period 1992-1999. Data source: State Agency of Environment, Protection of Nature and Geology Mecklenburg-Vorpommern (LUNG) and West Pomeranian Voivodeship Inspectorate in Szczecin (WIOS) after Bangel et al. (2004).

E1, E3 Biological diversity and abundance

Definition: The biological diversity (or biodiversity) is the variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes the genetic diversity, species diversity, and diversity of ecosystems. The abundance of living organisms is the quantity of living matter (biomass, new organic matter produced by marine organisms) or the number of individuals, which is present in a given unit – population, area or volume of water column (definition according to the handbook).

Objective: Evaluation of the ecological status of coastal water ecosystems takes place according to the European Water Framework Directive (WFD). The WFD focuses on the biological elements phytoplankton, aquatic flora, benthic invertebrate fauna and fish.

Problem: To treat biological diversity and abundance as two separate and independent indicators does not make sense in practise. The WDF approach, to focus on biological elements like phytoplankton, aquatic flora, benthic invertebrate fauna and fish and to analyse the diversity and abundance of these biological elements jointly, is reasonable. Usually, every biological element requires a separate monitoring programme, which is very different compared to the one for other biological elements. Data collection and data availability in practise is biological element oriented and the data analysis has to be, as well. Therefore, the first step is to decide which biological element or organism group one wants to consider.

Data analysis: The data analysis for benthic invertebrate fauna and phytoplankton is presented on the following pages.

Phytoplankton:

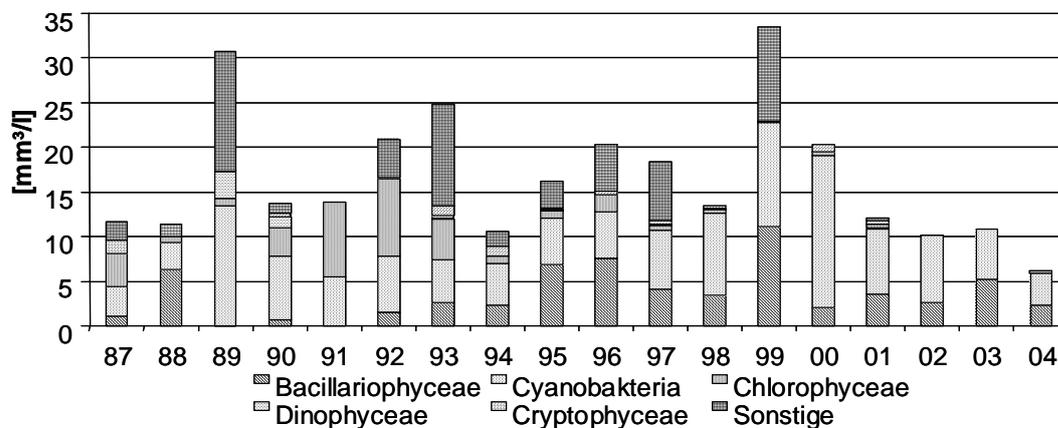


Figure 12: Phytoplankton composition in summer in the Kleines Haff (Oder Lagoon) between 1987 and 2004. The species are aggregated into six major taxonomic groups. Data source: State Agency of Environment, Protection of Nature and Geology Mecklenburg-Vorpommern (LUNG).

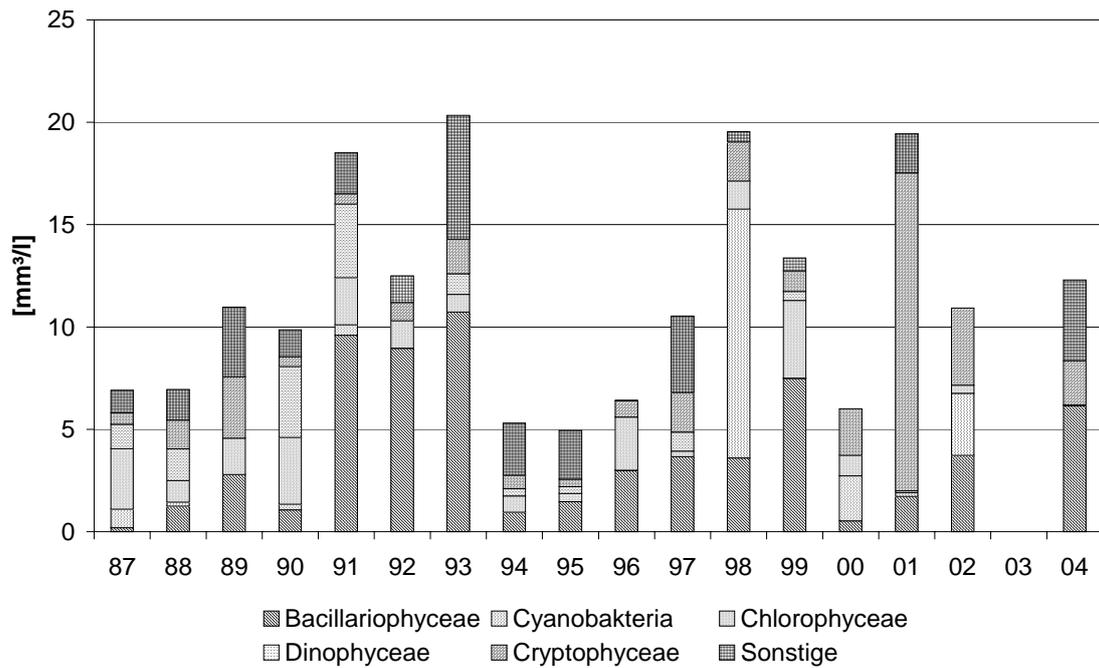


Figure 13: Phytoplankton composition in spring in the Kleines Haff (Oder Lagoon) between 1987 and 2004. The species are aggregated into six major taxonomic groups. Data source: State Agency of Environment, Protection of Nature and Geology Mecklenburg-Vorpommern (LUNG).

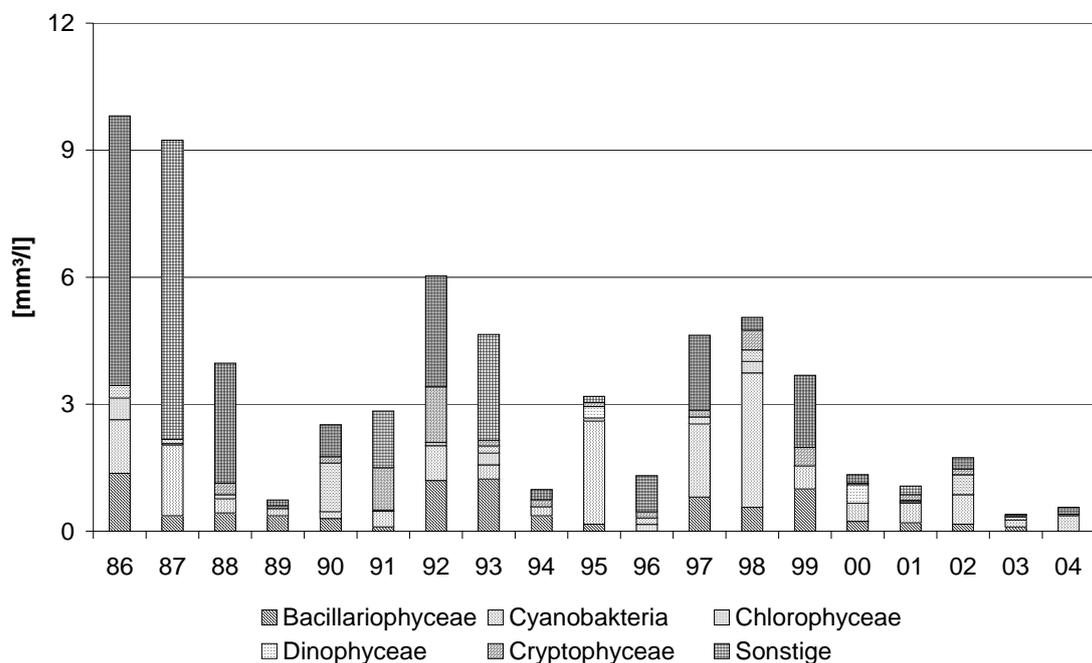


Figure 14: Phytoplankton composition in summer in the Pomeranian Bay (Baltic Sea) between 1986 and 2004. The species are aggregated into six major taxonomic groups. Data source: State Agency of Environment, Protection of Nature and Geology Mecklenburg-Vorpommern (LUNG).

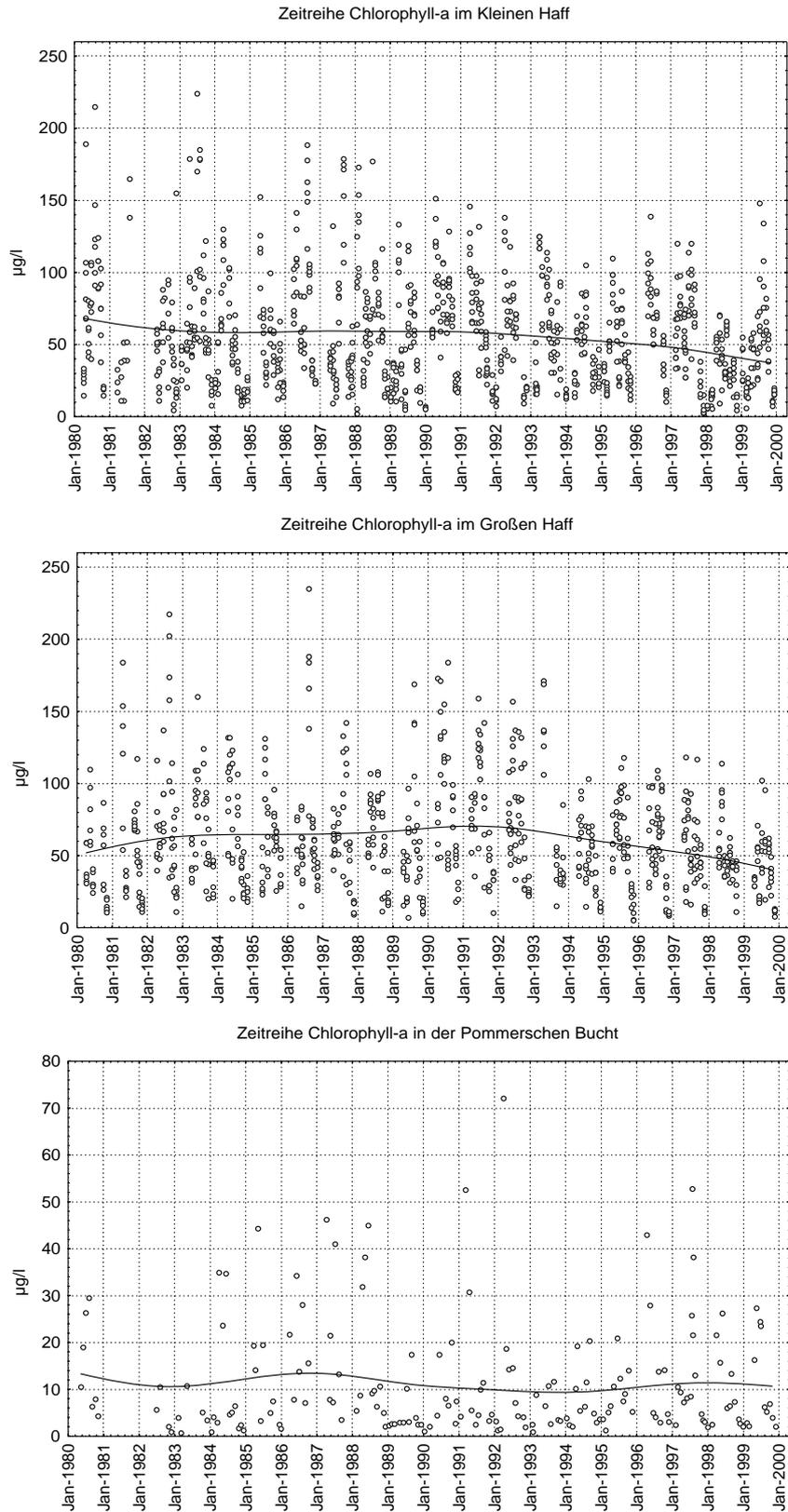


Figure 15: Chlorophyll-a concentrations ($\mu\text{g/l}$) in the Kleines Haff (top), Wielki Zalew (middle) and the Pomeranian Bay (bottom) between 1980 and 2000. The line indicates the moving average. Only one sampling location is considered for the bay (OB4). Data source: State Agency of Environment, Protection of Nature and Geology Mecklenburg-Vorpommern (LUNG) and West Pomeranian Voivodeship Inspectorate in Szczecin (WIOS).

Chlorophyll-a is the major indicator for phytoplankton biomass. Similar to nutrients, chlorophyll-a concentrations show a high annual and inter-annual variability and long-term trends in the Oder estuary are problematic and uncertain. In the 1990's, the averaged median concentrations in the lagoon started to decrease by about 20 % (compared to the mid 1980's) and this process still goes on. This reduction is well in agreement with the reduction of nutrient concentration.

Chlorophyll concentrations describe a typical annual cycle, with high concentrations during the spring bloom in April, a high level during summer and decreasing concentrations towards winter. In the lagoon the annual course of chlorophyll during the 1980's is less even. Winter algae blooms were observed as well as significant peaks in August. Similar to the lagoon, the mass development of algae in the Pomeranian Bay started earlier, already in March during the 1980's. The concentrations during spring became more pronounced during the 90's.

The spatial chlorophyll pattern in the lagoon is influenced by the Oder River during several months. It is well known that phytoplankton forms patches, which are driven by wind and currents, and show strong vertical concentration gradients. These effects create an intensive patchiness, which cannot be represented by the existing few sampling locations.

The nitrogen as well as the phosphorus concentrations in the lagoon are very high and nutrients are abundant most of the time. Like in other temperate zone estuaries nitrogen becomes a scarce resource during late summer. Phosphorus can play a role as a limiting element for algae biomass in spring, indicated by low PO_4 values between April and June. The same is true for silicate. However, especially in the eastern part of the lagoon even intensive phytoplankton blooms during summer usually do not deplete nutrients. One reason is the constant nutrient supply by the Oder River and another reason is the mineralization of organic material, which is an important source for nutrients. Due to self-shading effects and high water turbidity as a result of sediment resuspension, light is the most important resource in the lagoon. In winter low temperatures play a role, too. With decreasing nutrient loads with the Oder River during the 1990's, the importance of nutrients in the lagoon slightly increased.

In the Pomeranian Bay nutrients, especially nitrogen, plays a more important role as limiting resources for algae biomass.

Benthic invertebrate fauna:

We focussed on makrozoobenthos, invertebrate animals living on the sea bottom with a size above 1 mm. Makrozoobenthos covers very different animals, with very different live strategies and behaviors, like bivalves, crustacean, annelids, molluscs or gastropods.

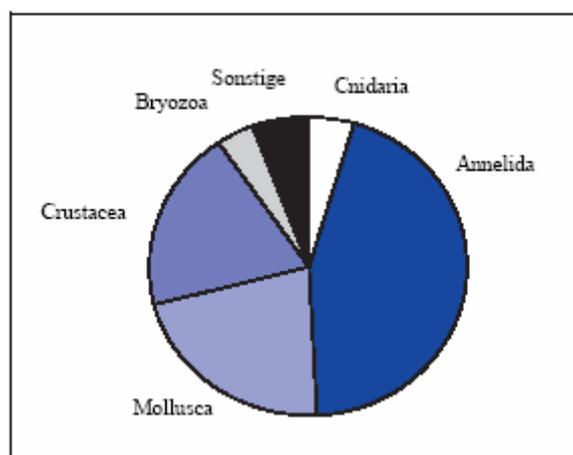


Figure 16: Distribution of species among taxonomic groups (total number of species = 106) in Baltic Sea coastal waters of Germany (2002)

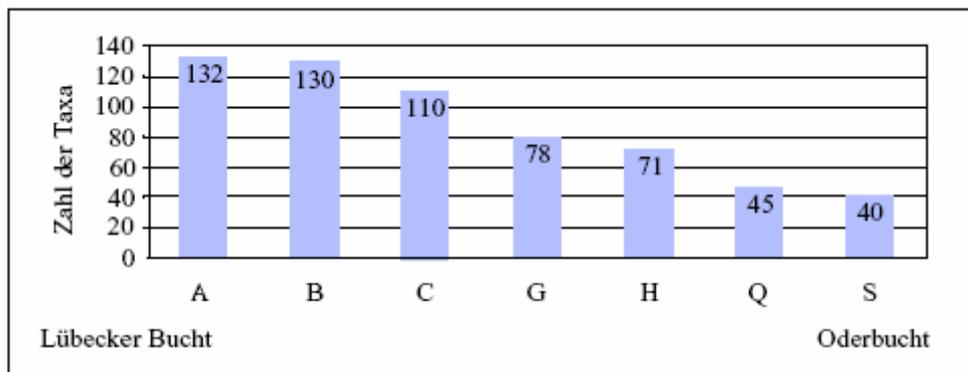


Figure 17: Total number of species along a transect (Lübeck Bay – Pomeranian (Oder) Bay) in the Baltic Sea coastal waters in Germany (1994 – 2002)

In average, only 15 to 17 makrozoobenthos species are found in one sample in the Pomeranian Bay. This allows a detailed analysis on the species level and we can observe shifts in species composition, the presence of new invasive species or the extinction of single species. Substrate, oxygen, salinity changes as well as water quality changes are major drivers for a modified species composition. Altogether, makrozoobenthos composition seems to be suitable indicator for the ecosystem state, provided that the sampling takes always place at the same substrate.

Results:

- **Spatial aspects:** The Pomeranian Bay and the Oder Lagoon show very different phytoplankton and makrozoobenthos species compositions and levels of biomass. Strong salinity gradients modify the species composition. Substrate and oxygen conditions plays an additional major role for makrozoobenthos. One sampling area can hardly be representative for the entire estuary. Patchiness (phytoplankton) and small scale spatial (meters) variability (makorzoobenthos) plays an important role especially in the lagoon and limits the representativeness of data from one sampling station.
- **Temporal aspects:** The phytoplankton species composition shows a very strong interannual variability. Long-term trends are hardly visible. An indicator application based on only one year might lead to wrong results. Averages over several years are necessary. Phytoplankton shows a strong annual dynamic, as well. Indicator applications based on data taken e.g. in spring cannot be compared with results based on data from summer. An indicator application requires knowledge about the annual dynamics. Further, phytoplankton and biomass (chl.a) concentrations show a strong variability from one week to another. Averaged data are needed to get stable results.
- **DPSIR:** Phytoplankton in the lagoon does not show a close relationship to water quality. During most of the time, nutrients are available in abundance and do not limit primary production. It means that the dependency structure in the DPSIR framework does not work. The driver “nutrient load” has no impact on the state of the system.
- **Evaluation:** We find a large number of species with very different behaviour and reaction to changes. To aggregate the species into one indicator is difficult. A concrete evaluation of the state of the biological diversity and abundance in the Oder estuary is problematic, because classification schemes defining a very good, good or poor state are lacking so far.
- **Indicator structure:** To treat biological diversity and abundance as two separate and independent indicators does not make sense in practise. The WDF approach, to focus on biological elements

like phytoplankton, aquatic flora, benthic invertebrate fauna and fish and to analyse the diversity and abundance of these biological elements jointly, is reasonable. Usually, every biological element requires a separate monitoring programme, which is very different compared to the one for other biological elements. Data collection and data availability in practise is biological element oriented and the data analysis has to be, as well. Therefore, the first step is to decide which biological element or organism group one wants to consider.

2.4 Application of socio-economic indicators

The socio-economic indicators cover a wide range of topics and aspects and the single indicators are of very different type and structure. Our chosen indicator “pollutants and introductions” and its application (and the problems linked to it) shows many similarities with the ecological indicators.

S4 Pollutants and introductions

Definition: The indicator is a measure to the total volume and sources of all types of pollutants, discharges and introductions into coastal zone (definition according to the handbook).

Unit of measurement: Total nutrient loads (nitrogen and phosphorus) and total heavy metal loads (Zn, Cu, Pb, Cd, Hg) - loads subdivided into the amount of point-source discharges and the amount of non-point-source discharges - both subdivided into types of sources like e.g. amount of discharges from rivers, amount of wastewater from UWWT plants, amount of discharges from plants according to the IPPC directive or from food factories ≥ 4.000 p.e. for point-sources and e.g. amount of discharges from erosion, from groundwater, surface runoff for non-point-sources:

Objective: Evaluation of the state and identification of pressures on coastal waters. The implementation of the WFD asks for an inventory of significant pressures on a waterbody. Discharge regulations, changes of the water morphology, patterns of land use and other anthropogenic pressures as well as discharges from point-sources and non-point-sources are of importance (Borchardt & Mohaupt 2002, LAWA 2003). In our case study, we focussed the work and the discussion of results on the discharges from point-sources and non-point-sources.

Data analysis: The application of the indicator requires information about the amounts of the loads coming from the Oder River as well as about the discharges entering from the drainage area of the Oder Lagoon. Information about the different types of sources is necessary to give information about the main sources and sectors (driving forces) which influence water quality. It is further required as a basis for the development of strategies.

Because the Oder River is the main source of pollution to the Oder Lagoon and the Pomeranian Bay, these data have the greatest importance for the description and analysis of the pressures to the water bodies. For a convincing description of the development and for the identification of changes, long-term data have to be used. The loads from the Oder River are compiled in Behrendt & Dannowski (2005). An overview of the discharges from the drainage area of the Oder Lagoon is given in Bachor (2005) for the German side and by Wielgat (2002) for the Polish side. For the German side, data can also be found in the report about the inventory according to chapter 5 and 6 of the WFD – report B (UM MV, MLEUV 2005).

As mentioned before, the Oder River is the main source of pollutants to the Oder Lagoon and the Pomeranian Bay. Figure 2.10 shows the relation between the discharges to the Oder Lagoon coming from the Oder River and the German and Polish drainage area of the lagoon (for nitrogen in three time periods from 1986 to 2000). Results from the mid-nineties show for instance that approximately 60% of the nitrogen loads, 80% of the phosphorus loads and 85-95% of the heavy metal loads enter with the River Oder (Bachor & Schöppe 2004).

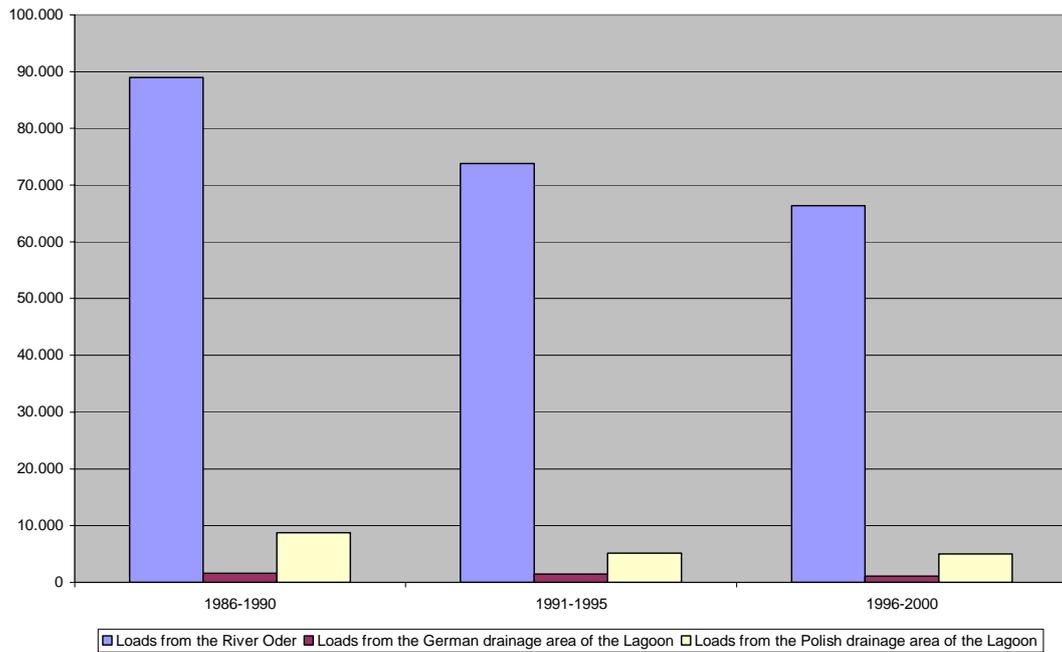


Figure 18: Total nitrogen loads (t/a) to the Oder Lagoon from different sources and for three successive five year periods (based on results in Bachor 2005 and Wielgat 2002)

Figure 19 shows the different sources for nitrogen and phosphorus in the Oder River. Similar overviews for the German and the Polish side of the drainage area of the Lagoon can be found in UM MV, MLEUV (2005) and Wielgat (2002) (including detailed data about the subdivided groups e.g. of point-sources like UWWT plants, plants according to the IPPC directive or food factories). Additional single hot spots are described for the Oder River (for instance by HELCOM 2003) which allow to focus activities on the main sources of pollutants.

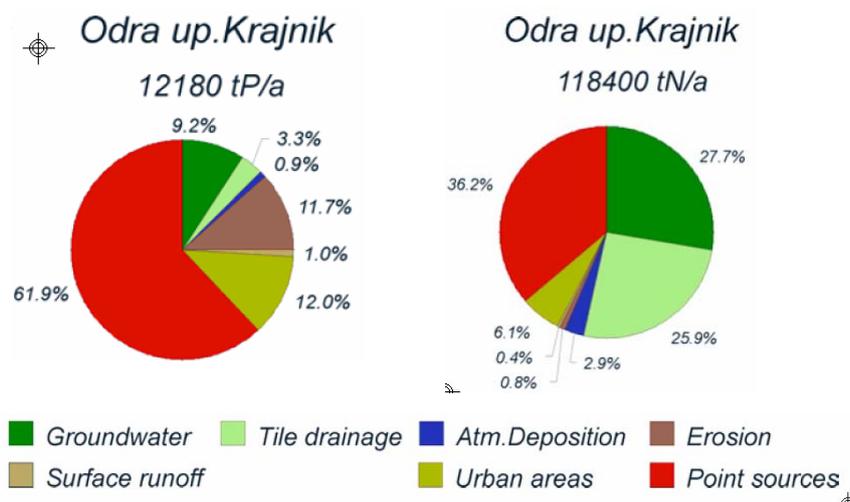


Figure 19: Nutrient sources in the Oder River (Behrendt et al. 2002)

Results:

- **The river basin as a source:** The nutrient loads are one of the main problems identified in the Oder Lagoon and the Pomeranian Bay. This fact underlines the importance of indicators and units of measurements describing the pressures coming from different sectors and sources. Only the short overview shows, how many different sources exist. The main source for the Oder Lagoon and the Pomeranian Bay is the Oder River. The comparison in figure 19 shows how important a comprehensive understanding of the processes in the whole river catchment area is. Only an approach based on the understanding of an Integrated Coastal Area and River Basin Management (ICARM) connecting the techniques of ICZM and river basin management is able to implement strategies, which show significant results in the improvement of the water quality of coastal waters in this region.
- **The selection of the units of measurement** should be related to the function and the target group an indicator shall be used for. Total nutrient loads from the Oder River and the distribution of the loads to different sources are suitable core indicators to describe of the current pressure on the Oder Lagoon. It gives comprehensive information to decision-maker and managers how pressures and drivers are linked to the state of coastal water quality. Much more detailed information is necessary, to develop concrete strategies and projects in the context of the implementation of the WFD. Here, only subdivided groups of units of measurements and detailed data can form a reliable basis for planning. The target group of such a detailed approach are the experts from the different responsible administration units and other involved stakeholders.
- **Temporal variability:** The loads to the water bodies always depend on the water discharge. Rainy years cause a much higher nutrient load than dry years. For instance in the rainy year 1994, the nitrogen loads coming from the river Peene (another river entering the Lagoon) were five times higher compared to the years before. (Bachor & Schöppe 2004) This example shows that it is necessary to integrate data over suitable time-periods to level out temporal variability.
- A comprehensive knowledge about **processes in the lagoon** is necessary for a load compilation, as well. Two examples are internal eutrophication processes and dredging. During temporary anoxic conditions in the water body, a release of phosphorus from polluted sediments has been observed (Schernewski & Wielgat 2001). This release contributes an extra load into the Lagoon and can exceed the monthly Oder River loads. Another influencing aspect is the retention of nutrients due to dredging in the shipping channel in the Lagoon. During the time-period 1949-2000 every year about 1,490,000 m³ of sediment material was taken from the shipping channel including 17% of the discharged amount of phosphorus and 7% of the discharged amount of nitrogen (Minning 2004). Without taking into account these processes an reliable analysis is not possible.
- **Slow response:** An important aspect is the retention time of nutrients in the river basin. Effects of management measures, like changes in agricultural practise, are not immediately visible in altered nutrient loads. Often it takes up to decades, until management interventions in the river basin lead to reduced nutrient loads into the lagoon.
- **Evaluation:** As soon, as we have concrete data and applied the indicator, we face the question, if a certain nutrient load is acceptable or not. If not, to what extent has the load to be reduced to ensure a good water quality in the lagoon. In our case, we applied the critical load concept by Vollenweider and carried out model simulations (Schernewski et al. 2006). The results show, that it is not possible to reduce the nutrient loads to a degree that allows the lagoon to shift into a mesotrophic state. The lagoon is a natural eutrophic system and a good water quality according to the WFD cannot be reached.
- As a result of the high loads, nutrients are always sufficiently available in the lagoon. Primary production is only during short periods limited by nutrients. The major limiting resource is light, due to high turbidity. In this case the **DPSIR system does not work** as expected, because changes

in drivers in the river basin and changes in the pressure “nutrient loads” are not able to cause significant changes in the state of the lagoon.

2.5 Work plan: Implementation and evaluation

A group of three scientists with different background and three diploma-students from the Baltic Sea Research Institute Warnemuende and the University of Applied Sciences Neubrandenburg were involved in testing the ICOM indicators. In advance, we prepared a first schedule for applying the handbook and testing the indicators, including the required working time:

Selecting the indicators:	10 person-days
Planning the test:	34 person-days
Conducting the test:	63 person-days
Communicating results:	35 person-days

Evaluation and experiences:

The **selection of indicators** turned out to be more difficult and time-consuming than expected. In a first step, concrete objectives for a regional indicator application had to be defined. These objectives had to be based on regional needs and demands and required a detailed insight in into recent regional activities, development goals and present legislative demands.

We finally agreed, to accept the objectives of the European Water Framework Directive (WFD), a comprehensive law that is being implemented at the moment. In a second step we classified all indicators according to the DPSIR (Driver, Pressure, State, Impact, Response)-framework, analysed if an indicator is suitable and beneficial for the WFD, evaluated the data availability and estimated the resources needed to apply an indicator. Including the necessary meetings, it took us about 50 person-days to prepare the first screening table (chapter 2.1) and to agree on an indicator-list.

Planning the test required a more detailed knowledge about the indicators, the concrete parameters and methods. Data and information from very different sources had to be collected and compiled. Due to our existing project in the region, most data was already available, so that 34 person-days were realistic.

The time and effort needed to **conduct the test** depends very much on the type of indicator. As mentioned before, governance indicators consist of concrete questions and describe a process cycle (planning, implementation, monitoring). The application can be carried out on the basis of existing documents. Therefore, their application is comparatively fast and we were able to apply all governance indicators (if relevant) within 20 person-days. Additional time has to reserved as soon as a full involvement of stakeholder and/or regional authorities shall take place.

The ecological indicators are quite different and their application is much more complicated and time-consuming. This is especially true for biological indicators. The indicators “water quality” or “biodiversity” or “abundance” can be regarded as umbrella indicators and the “units of measurements” (e.g. nutrient levels, turbidity) in the handbook themselves form separate, largely independent indicators. Therefore, we faced a large number and it was not possible to apply all “units of measurements”. For the application, large amounts of data have to be analysed and prepared. The handbook remains vague concerning the concrete methods and a lot of additional research and literature studies were necessary. In our case study, we already needed 90 days to carry out a basic data analysis for a few parameters and had to stop because of time restraints. A full application of all ecological indicators relevant for the WFD would easily have required one year. The same is true for some of the socio-economic indicators. The time needed for conducting a test, depends on the type of indicator and the depth and accuracy of the application. It can vary in a very wide range.

Communicating the results, including a meeting, a presentation and a report, was possible within the assumed time-period of 35 person-days.

We approximately spent the following time for applying the handbook and testing the indicators:

Selecting the indicators:	50 person-days
Planning the test:	34 person-days
Conducting the test:	90 person-days (without finishing it)
Communicating results:	35 person-days

3 Lessons learned

3.1 Indicator application

The **selection of indicators** requires well defined objectives and a systematic approach. In our case the Water Framework Directive (WFD) allowed us to define generally accepted and regionally relevant objectives.

To get a first overview and to get clear criteria for the selection of applicable indicators, we classified all indicators according to the DPSIR (Driver, Pressure, State, Impact, Response) framework, analysed, if an indicator is suitable and beneficial for the WFD, evaluated the data availability and estimated the resources needed to apply the indicator. The result of this systematic screening was a table that supported the decision-making process about relevant indicators. This approach was not very time-consuming but beneficial.

Governance indicators consist of concrete questions and describe a process. They can be applied based on existing documents, law, regulations and structures relevant for the region. Generally, their application does not require much time and resources. In practise, several problems occurred. The indicators reflect the status of and the process towards ICOM. An ICOM did not exist in our Oder Estuary region but many activities that covered aspects of an ICOM. Several activities support ICOM aims, or will even practically implement an ICOM, without mentioning this term. The governance indicators are, at the moment, not well able to reflect existing activities towards an ICOM. This made the processing, answering and evaluation of every governance indicator a bit more complicated and subjective. We had to evaluate how and to what extent each activity supports one or several aspects of ICOM. This evaluation depended very much on the professional and educational background of the responsible person. An exemplary application of several governance indicators by a second person came to partly significantly different results. Therefore, the governance indicators have only a limited reproducibility. It will not be easy to use them to measure a progress towards ICOM, by applying them at different points in time (e.g. after a decade) again.

Ecological and socio-economic indicators are quite different compared to governance indicators and their application is much more complicated and time-consuming. This is especially true for biological indicators. As mentioned before, the indicators “water quality” or “biodiversity” or “abundance” can be regarded as umbrella indicators and the “units of measurements” (e.g. nutrient levels, turbidity), which are mentioned in the handbook, form themselves separate, largely independent indicators. Therefore, we faced a large number of indicators and were not able to apply all of them. Large amounts of data had to be compiled and analysed, which took a lot of time. The handbook remains vague concerning the concrete measuring method of every indicator and a lot of additional research and literature studies were necessary to carry out the application.

In detail, the preparation of the data and the attempt to specify the indicators revealed many problems. We have to face problems due to **spatial heterogeneity**. The Pomeranian Bay and the Oder Lagoon show very different organism compositions and levels of concentrations. One sampling area can hardly be representative for the entire estuary. Further, patchiness (phytoplankton) and small scale spatial (meters) variability (makrozoobenthos) plays an important role especially in the lagoon and limits the representativeness of data from one sampling station.

Most parameters show a **temporal dynamic and variability**. We observed very strong interannual variability, which covered long-term trends, an annual dynamics as well as strong variability from one week to another. Averaged data are required, to get stable results.

In some cases, expected dependencies were not present and the **DPSIR** framework did not work. Phytoplankton in the lagoon e.g. does not show a close relationship to water quality. During most of the time, nutrients are available in abundance and do not limit primary production. Therefore, changes in nutrient loads have no effect on water quality.

In some cases, the **structure of indicators** was not suitable. One example are biological diversity and abundance. To treat both as two separate and independent indicators is problematic in practise. The WFD approach, to focus on biological elements like phytoplankton, aquatic flora, benthic invertebrate fauna and fish and to analyse the diversity and abundance of these biological elements jointly, is more reasonable. Usually, every biological element requires a separate monitoring programme, which is very different compared to the one for other biological elements. Data collection and data availability in practise is biological element oriented and the data analysis has to be, as well. Therefore, the first step is to decide which biological element or organism group one wants to consider. Every organism group shows a large number of species with very different behaviour and reaction to changes. The next problem is, how to select species as indicators or how to aggregate several species into one indicator.

Another major problem is the **quantification of the results**. A biodiversity of e.g. 10 does not say much. We need a classification scheme to know if it is 'good' or 'poor' to motivate action. Strategies, how to link the results of indicators, as well as classification schemes defining a very good, good or poor state are lacking so far. This reduces the acceptance of indicator sets, makes it difficult to communicate short-comings in the present environmental and/or management situation and makes it difficult to motivate concrete actions by decision makers.

Concerning nutrient loads, we were able to quantify the results, to evaluate the present state and to define management goals, but an unexpected problem appeared. Model simulations show that it is not possible to reduce the nutrient loads to a degree that allows the lagoon to switch from a highly eutrophic to a mesotrophic state. The lagoon is a **natural eutrophic system** and a good water quality according to the WFD cannot be reached. Slight improvements of the water quality are possible, but we have to take the **slow response** of processes into account: An important aspect is e.g. the retention time of nutrients in the river basin. Effects of management measures, like changes in agricultural practise, are not immediately visible in altered nutrient loads. Often, it takes up to decades, until management interventions in the river basin lead to reduced nutrient loads into the lagoon.

A reliable and **accurate indicator application** is necessary to ensure reproducibility and to be able to measure the progress from one application to another (carried out later). An accurate application is very time consuming and requires detailed knowledge about the topic. To prepare a time-schedule for the indicator application is reasonable but especially the applications of ecological and socio-economic indicators are linked to many uncertainties.

To apply very different kind of indicators requires knowledge in different disciplines. Our **interdisciplinary working group** served this purpose well. The same is true for our strategy to **involve relevant experts** and authorities. Time limitations were the major constraint for regional experts not to support our indicator application. Therefore, we had to find a fast and convenient possibility that allowed a wide range of experts to give us their feedback. We prepared a short report, containing our indicator application and our results. We sent around this report and asked for feedback, opinions and critical remarks. During a joint meeting, the comments and results were discussed again and were included in the modified report. This indirect way to involve people, requires a certain personal contact and trust and might not work in all cultures. External regional experts were only involved in governance indicator applications. During this process, we learned that

indicators have to be available in the **national languages** to be accepted. The translation of the indicators caused problems, uncertainties and was a source for different interpretations.

3.2 Recommendations

The **joint application** of governance, ecological and socio-economic indicators is beneficial and gives a more comprehensive understanding of the dependencies in a coastal system. But an accurate indicator application requires a broad knowledge. The application of a wide range of indicators should be carried out by an interdisciplinary working group.

Especially governance indicators have to be applied in close cooperation with regional authorities and experts, to receive reliable and generally accepted results. The strategy how to apply the indicators and how to involve local/regional **stakeholders** depends very much on the cultural background. A documentation and evaluation of different strategies would be beneficial in the handbook.

In most cases, ICOM is under development (or implicitly tackled by existing legislation) and will be a continuous process. Therefore, the indicators should focus on the existing process, evaluate products and existing approaches, and reflect the progress towards an ICOM, rather than evaluate only the final result (**evolution indicators**). This is especially true for governance indicators.

Altogether, we recommend a **simplification** of the governance indicators. The UNEP-ICARM and the EU-ICZM progress marker sets with simple yes/no answers and some explanation are more transparent, faster and have a better reproducibility. They allow a quantification of the results. Shortcomings in the present management situation become obvious and can be communicated to decision makers.

Especially the ecological indicators require **detailed definitions**: Which phenomenon shall be described by what kind of data and how has the data to be prepared (e.g. temporal and spatial resolution, aggregation etc.). The handbook is in this respect not concrete enough and should be improved.

World-wide or **trans-regional comparisons** based on a few pre-selected indicators might motivate people to apply indicators in their region and might support the dissemination of the ICOM indicators. Applications of similar indicators in different countries would allow comparisons and one case study could learn from the other. Possibly, subsets for different purposes could be useful. At least, a priority list of indicators would be beneficial.

The application of an indicator requires a sound understanding of the indicator definition and description. Therefore, a handbook available only in English, will always reduce the acceptance of indicators and the accuracy of the application. World-wide applications will require that basic information is provided in **major languages**. This is especially true, if regional authorities shall be motivated to apply those indicators.

The indicator application and evaluation is an ongoing process, with growing experience. Therefore, indicator applications in existing case studies should go on. Therefore, we strongly support the idea to link all cases studies in an informal **indicator network**. This network could help to promote the indicators and maintain an exchange of ideas and experiences concerning indicator applications. Ongoing regular workshops certainly would be beneficial.

Publications

A full overview about the existing documents and literatures is provided under: <http://www.ikzm-oder.de/>

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