THE BALTIC SEA: ITS PAST, PRESENT AND FUTURE

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Introduction

The current presentation provides a summary of the history and importance of the Baltic Sea region, as well as how the unique and potentially productive Baltic Sea ecosystem has been degraded over the last 50 years or so by harmful and unsustainable human activities and practices. However, moves towards concerted collaboration are now gaining momentum to enhance cooperation between the coastal countries and the main international institutions involved in the science advice and management of the fisheries and the environment of the region, with a view to recovery of the Baltic Sea Large Marine Ecosystem (BSLME) in order to provide sustainable socioeconomic benefits for the coastal nations and their communities.

Geography, history and political developments

For many people around the world, the Baltic region is probably primarily known because of its resources of amber. Amber is a resin product resulting from the substantial sub-tropical pine forests that covered the area between 35 and 50 million years ago. The resin sometimes encapsulated and embalmed parts of plants and small animals before being buried in the soil. Often eventually picked up and transported by water, it is frequently found today washed up on the beaches. We know from archeological finds of amber artefacts in civilizations around the Mediterranean such as ancient Greece, Egypt and Rome, that a substantial part of this amber came via the 'amber trade route' that connected Mediterranean with the Baltic Sea.

Geologically, biologically and in terms of human beings, the Baltic is a young (about 10,000 years old), relatively shallow, semi-enclosed sea with a surface area today of about 413 000 km^2. However, about 100,000 years ago, the whole of Scandinavia and what is today the Baltic Sea was covered by a thick ice belt. Between about 13,000 and 10,300 years before the present day (or BP) the ice started melting and a freshwater Baltic ice lake was established. In the next stage, from 10,300 to 9,500 years BP, a wholly marine area called the 'Yoldia Sea' developed. Then from about 9,500 to 8,000 years BP, a freshwater enclosed 'Ancyclus lake' again developed, before the formation of the marine 'Littorina Sea' between 8,000 and 4,000 years BP. At its present state of development, the marine life of the Baltic Sea is less than about 4,000 years old.

Jumping forward to about a 1,000 AD, the region became a 'Barbarian Sea' dominated by heathen Vikings. The Vikings from the west of Denmark and Norway mostly went westwards on their travels, while the Swedish Vikings went eastwards, even as far as the Black Sea and the Mediterranean. In the eastern Baltic, the Coronian peoples -- according to some Scandinavian sagas -- stubbornly fought the Vikings and occasionally defeated them. About 1,400 AD, substantial unions emerged around the Baltic, notably the Hanseatic League, which advanced trade between cities such as Lubeck, Rostock, Danzig and Riga, and also reached as far as Novgorod in Russia and Bergen in Norway. The Hanseatic League competed with tradesmen and military forces from Scandinavia, especially the Gotland area.

In more recent times, for almost 50 years until the early 1990s, an Iron Curtain separated the socioeconomically underprivileged peoples of the eastern Baltic dominated by the Soviet Union to the east, from the richer countries to the west. In 1991, a major transformation began in the region that eventually resulted in the recognition of the following nine coastal Baltic Sea countries: Russia, Poland, Estonia, Latvia, Lithuania, Germany, Denmark, Finland and Sweden. The accession to the European Union (EU) in 2004 of Estonia, Latvia, *Lithuania and Poland leaves Russia as the sole coastal Baltic Sea country outside the European Union. The enlargement of the EU will have significant effects on the land, coastal and marine policies of the States of the Baltic Sea region, especially in the fields of agriculture, transport, environment, fisheries, water resources and scientific research.*

Unfortunately, since about the 1940s, accelerated industrialization and exploitation of natural resources has resulted in the deterioration and degradation of the Baltic Sea Large Marine Ecosystem (BSLME). Today, more than 85 million people inhabit the Baltic Sea drainage basin, and, as may be seen from the following sections of this document, their activities are able to impact and change the state of the Baltic Sea environment for better or for worse.

The unique environment and biodiversity of the Baltic Sea

More than 200 rivers empty into the Baltic Sea, providing a catchment or drainage area of about 1,700,000 km^2 that is approximately four times larger than the sea itself. This catchment area is viewed as belonging to the Baltic Sea Large Marine Ecosystem (BSLME (Figure 1). Thus management actions to conserve and restore the BSLME must be carried out both on land and in the sea. This situation is made even more pertinent as the Baltic Sea is a semi-enclosed brackish water area, the second largest in the world after the Black Sea. It is characterized by a persistent vertical stratification of its water layers, and a residence (turn-over) time for full exchange of its water mass estimated at 25-30 years. These features greatly increase the susceptibility of the Baltic Sea to the accumulation of pollutants.

The Baltic comprises three deep basins: the Arkona Deep inside the entrance to the Baltic Sea, the Bornholm Deep and the Gotland Deep farthest inwards. Saltier, heavier and oxygen-rich water from the North Sea enters the Baltic Sea through the shallow, narrow entrance and propagates along the deeper regions, while a counter current of freshwater flows outwards at the surface. This results throughout most of the sea in two essentially vertically stratified parts of the water column, which rarely mix. This stratification significantly limits the passage of oxygen from the surface into the deeper waters. The inflows of oxygen-rich water from the North Sea cause a flushing of the deeper voluminous water masses with a resultant increase in their oxygen levels. These flushing events also reduce the concentration of pollutants, including lowering the concentration of over-elevated nutrients from land-based run-off, in the water masses as a whole. Thus, the inflows of oxygen-rich water are of vital importance for the well-being and productivity of the biota as well as determining the environmental quality of the aquatic ecosystems of the Baltic Sea. Unfortunately, these inflows causing flushing of the Baltic Sea are unpredictable and infrequent, with periods of stagnation between the flushing events lasting as long as several decades, such that oxygen levels decline over time between each inflow due to the biological oxygen demands of living organisms and the breakdown of organic material. Although the influxes are basically random and connected with climatic variability that is not due to human influences, it appears that these influxes during the second half of the 20th century are decreasing in both frequency and magnitude.

In Europe several Pleistocene glaciations reduced the diversity of the brackish water fauna and flora. As the glacier covering the Baltic basin started its withdrawal about 15,000 years ago, a large freshwater lake appeared at its periphery. The lake became an arm of the sea, and, as mentioned above, then underwent another freshwater phase before re-establishing a connection with the sea. After a lengthy and more saline period, the environment became less saline and brackish water conditions have characterized the Baltic Sea for about the last 4,000 years. Because of this history and its brackish environment, the Baltic is characterized by having a lower number (biodiversity) of plant and animal species than in more saline waters. The brackish water is too salty for most freshwater species and too fresh for most *marine species. For example, the number of macroscopic and microscopic animal species west of Sweden is roughly 1,500, but in the southern Baltic there are only about 150, in the water around Gotland only about 80, in the Åland region some 50 and in the Bothnian Bay about 10. The same applies to fish: the Kattegat has around 100 marine fish species, while the Sound has only 55 and the Archipelago Sea only about 20. The remainders of the species are representative of those normally found in freshwater lakes and rivers all over the region, so during fishing in the Bothnian Bay, a single catch may consist of a unique combination of cod, herring, perch, and pike. The salinity gradient is paralleled by a climatic gradient with up to six months of ice cover and a productive season of 4-5 months in the northern Gulf of Bothnia, and an 8-9 months productive season in the southern sounds near its entrance. Besides these variations in diversity of the biota, it is typical that the few species penetrating into brackish waters are typically slower growing and of smaller size than in their original habitats, irrespective of whether their original habitats were marine or freshwater. Thus, the Baltic Sea environment and its biological diversity are unique and its associated biota are facing a special challenge in living under a difficult natural environment that is particularly vulnerable to pollution and other human-caused stresses.*

Despite the limited number of species, the structure and functioning of the BSLME is not simple. As is typical, in food chains of up to about five levels energy flows from the primary production, originating from plants living in the sea and coastal areas, via grazing by herbivorous animals (e.g. zooplankton), and successive levels of predation to the higher level predators such as fish, seabirds and shorebirds, and marine mammals. Besides this typical 'grazing' food chain, we also have a microbial food chain that is longer and less efficient, but no less important. The whole picture is complicated by important multi-species interactions, e.g. predator-prey relationships, interlinking the various food chains into a food web. The abundance of the various species and the structure and function of the food webs and the ecosystem undergo variability that is a result of both changing environmental conditions and human impacts.

International management and advisory systems

In the Baltic Sea the management of fisheries (e.g. setting of total allowable catches, or TACs, and quotas) is conducted by the International Baltic Sea Fishery Commission (IBSFC, based in Warsaw, Poland) and the management of environmental issues (e.g. pollution and biodiversity conservation) is conducted by the Helsinki Commission – Baltic Marine Environment Protection Commission (HELCOM, in Helsinki, Finland). These management bodies receive the best available, politically neutral, scientific information and advice for regulatory purposes from the International Council for the Exploration of the Sea (ICES, in Copenhagen, Denmark). The scientific information and advice provided by ICES uses consensus-based peer-review involving national representation, whose fundamental inputs are the annually compiled reports of its numerous oceanographic, environmental and fisheries working groups that address key practical tasks as required. HELCOM and IBSFC use the ICES advice to make decisions. They are not obliged to act exactly in accordance with the advice but they cannot function without the assistance of ICES. In the case of IBSFC, it has during the last decade frequently set TACs that are substantially greater than those proposed by ICES, and accordingly the majority of the most commercially important fish stocks in the Baltic Sea are classified as 'outside safe biological limits' (i.e. the result of unsustainable fisheries).

The major human pressures threatening the Baltic Sea today

Many human activities in the region, on land and at sea, pose serious threats and result in substantial impacts on the Baltic Sea. The most serious human pressures currently impacting the BSLME have been assessed as being eutrophication, overfishing, toxic contaminants, and alien (i.e. foreign) species.

Eutrophication

Eutrophication literally means 'overfeeding', and in the marine environment it starts when increasing amounts of nutrients cause increased production of plant biomass, which in turn leads to elevated amounts of organic matter in the ecosystem. This organic matter requires more oxygen both when it is alive and when it is decaying. In the Baltic Sea, which experiences only rare major flushing events, the result is frequently serious oxygen depletion and the formation of toxic hydrogen sulphide in the deeper regions. This has given rise to so-called 'dead bottom' areas, nearly devoid of typical sea-bottom animals and fish, covering nearly a third of the bottom area of the Baltic Sea. The input of nutrients to the Baltic Sea has increased greatly since about the 1940s, with nitrogen and phosphorous reaching three to five times the 1940s levels. The nutrient load during the 1940s was probably only slightly higher than at the start of the 20th century.

The most important human-related source of these nutrients in the Baltic is agriculture, where farmers use excessive manure and artificial fertilizers and the surplus runs into the sea via streams and rivers. Additionally, the situation is exacerbated by changes in land use and the loss of wetlands, as well as the discharge of sewage from urban and industrial sources. One of the first signs of eutrophication in the sea is the unusually large biomass development of microscopic plant plankton (phytoplankton) and filamentous green benthic algae, which thrive on the nutrients and then die and decay. Some of the plankton production often gives rise to harmful blooms such as the blue-green cyanobacteria blooms that can be seen from satellite imagery. These excessive blooms and associated decay cause problems of reduced water quality, including oxygen deficiency, increased turbidity, and difficulties in meeting bathing water standards on the beaches. Thus, eutrophication is often associated with declining recreational and tourist amenities. Furthermore, increased levels of nutrients lead to the loss of rare species and habitats. Although the frequency of these blooms has increased with eutrophication, it is also clear that unusual blooms of phytoplankton were known at least several centuries ago, for example as noted by the Lutheran priest Gothard Friederich Stender (1714-1796), who lived in Latvia.

Fisheries

The total annual catch of the commercially dominant open sea fish stocks in the Baltic has increased tenfold in the past half century (Figure 2). Catches remained at about 120,000 tonnes until the 1930s, increased to about 500,000 tonnes by the late 1950s and almost reached a million tonnes by the end of the 1970s. During the past two or three decades overfishing and the failure to maintain sustainable fisheries have become increasingly pronounced. Nearly all commercially important fish stocks, including cod, wild Baltic salmon, herring and sprat—are outside of safe biological limits. From a maximum annual catch of cod in the mid-1980s of nearly 450,000 tonnes, the nominal catch declined by 1992 to about 50,000 tonnes and has been around 100,000 tonnes since then. Over the last 20 years, as the IBSFC and its member countries have frequently set cod TACs above the levels advised by ICES, the stock size of Baltic Sea cod reached its lowest level on record in 1991 and levels since then have barely risen. Overfishing of larger fish-eating fish such as cod has allowed increased industrial fishing of sprat and herring. The economic yield per unit biomass of the fishery has declined, with a smaller proportion of the catch being directed for human consumption and food security. Unsustainable fishing has also harmed the marine ecosystems through by-catch and discarding of fish, bottom living animals, seabirds and marine mammals, and the degradation by bottom trawling of vulnerable habitats. These effects have caused negative changes to ecosystem structure and function. Fisheries statistics and control and enforcement are not sufficiently effective. Where regional international regulatory commissions have agreed on remedial action there is often a lack of political will at the national levels to take the steps necessary to restore depleted fish stocks and protect marine ecosystems.

Toxic contaminants

Many toxic substances threaten the Baltic Sea environment. They include heavy metals, persistent organic pollution (POPs), oil pollution, artificial radionuclides and dumped munitions. Many of the heavy metals and POPs can become magnified upwards to the higher levels in the food chain.

Heavy metals (e.g. cadmium, copper, lead, mercury, zinc) may be harmful to marine organisms and, following transfer and accumulation via the food web, may even constitute a problem for humans. The anthropogenic loads of cadmium, lead, and mercury to the Baltic Proper are 5-7 times higher than the natural loads, and the copper and zinc loads are double the natural loads. Recently formed sediments from the Baltic Proper can contain 10 times more cadmium and mercury than the deeper layers, 3-5 times more lead and zinc, and about 2 times more copper. Studies of sediments from the Baltic Sea Proper show metal concentrations rising during the 1950s and reaching a peak in the 1960s and 1970s. Although metal concentrations have decreased since the 1980s, they are still significantly higher than in the 1940s. However, sediment concentrations are dependent on the amount of organic matter sedimenting to the bottom and are linked to the eutrophication process. Thus, the apparent reductions in heavy metals in sediments in the 1980s may be masked by eutrophication signals.

Halogenated hydrocarbons such as polychlorinated biphenyl congeners (PCBs), the pesticides DDT and Lindane, including their metabolites and isomers, or unintentional by-products of combustion processes, are classed as xenobiotics, i.e. unknown to the environment before their human production. Most are potentially accumulated in the fatty tissues of organisms, and many are harmful even at low concentrations. Over the last decades, their content in different compartments of the marine environment has increased. Because of their continuous input, and their often low degradation rates, they have been termed as POPs (Persistent Organic Pollutants).

Large-scale production of PCB started in the 1930s and intensified in the 1960s and the early 1970s. The use of DDT started after World War II and culminated in the Baltic Sea area during the 1960s and 1970s. As a result of their intensified use, the concentrations of these compounds increased in living organisms in the Baltic Sea in the 1950s and 1960s. Since the late 1970s, after international measures were implemented to reduce and ban the input of PCB and DDT, concentrations have declined. During the 1980s, concentrations of PCB and DDT continued to decrease and are now comparatively low and stable. This has inter alia been registered in reduced levels in body tissues and increased breeding success in a number of Baltic Sea animals, including grey seals, guillemots, and white tailed sea eagles, such that there populations have been substantially restored. In the case of the seals, this has not pleased the fishing industry because it means increased competition for diminishing resources of fish.

The DDT pollution problem, and to a lesser extent that from PCBs, has been tackled through legislation and governance. Furthermore, since the implementation of the HELCOM 1988 Ministerial Declaration, the load of hazardous substances to the Baltic Sea has diminished by 20-50 per cent. Unfortunately, many hundreds of potentially hazardous chemicals are still emitted to the Baltic Sea and some new contaminants have recently been reported that may create environmental problems in the future. In this context one can mention endocrine disrupting chemicals, polybrominated flame retardants (PBBs and PBDEs), complex chlorinated chemicals from pulp and paper mills, and dioxins that accumulate in fatty fish such as herring and sprat.

During the 1980:s the use of chlorinated chemicals in the pulp and paper production in Sweden were shown to cause several specific disease symptoms in fish in the effluent areas of *these industries. These symptoms included jaw deformities of pike and fin erosion of perch, the former of which gave the public a "face" of the detrimental use of chlorine for bleaching paper (Figure 3). Legal actions were taken and the industries were forced to change their processes and with the marked improvement of the effluent treatment the fish diseases disappeared. With the improved awareness of the public of the issue in question they were also accepting less whitish, non chlorine bleached paper on the market.*

Petroleum-derived hydrocarbons in the Baltic environment stem from different sources, and are composed of numerous single substances that give rise to different problems. Exploration and exploitation of oil in and around the Baltic Sea is becoming an increasing concern, notably accidental oil spills from ships. Oil pollution is expected to increase, due inter alia to increasing trade in oil in the Baltic Sea countries, increasing fleets, old vessels, inferior control, unqualified crews, and general difficulties in implementing international treaties. The biologically most harmful substance group within the petroleum-derived hydrocarbons are the polycyclic aromatic hydrocarbons (PAHs). They occur in tiny amounts within fossil oils, and are mainly anthropogenic products of many combustion processes with oil-products or coal, but can be synthesized by micro-organisms. Their concentrations in the Baltic Sea are about three times those in the North Sea, and atmospheric deposition is the main source of these compounds. Currently, due to a number of recent prominent shipping accidents, several Baltic Sea countries are showing interest in having the International Maritime Organization (IMO) declare the Baltic Sea, or parts of it, as a particularly sensitive sea area (PSSA) needing special protection because of its ecological importance and sensitivity to threats from shipping. PSSA status is meant to avoid or reduce accidents, intentional pollution and damage to habitats. Because PSSAs are marked on sea charts, the crews of ships are expected to be particularly careful. Upon request by the countries concerned, the IMO can also decide on special measures, e.g. restricted areas, traffic separation areas, coastal traffic and deep water areas, special rules for waste disposal, compulsory pilotage, mandatory reporting or ship traffic management.

The dominating artificial radionuclides in the Baltic Sea environment are ^{137}Cs *and* ^{90}Sr*. Their occurrence is mainly based on four sources that have contributed very differently to their total input. Until 1991, about 4,850-5,750 TBq* ^{137}Cs *and 720 TBq* ^{90}Sr *entered the Baltic Sea, i.e. 1) up to 80% of the* ^{90}Sr *fallout of the Chernobyl accident of 1986, 2) up to 19% for* ^{137}Cs *and 83% for* ^{90}Sr *from the global fallout due to atmospheric nuclear weapons testing during the 1960s, 3) about 5% each for* ^{137}Cs *and* ^{90}Sr *from discharges of the reprocessing plants at Sellafield (Windscale/Irish Sea, UK) and La Hague (Channel, France), that partly are transferred to the Baltic Sea with salt-water inflows, and 4) only about 0.01% for* ^{137}Cs *and about 0.04% for* ^{90}Sr *from nuclear installations within the drainage area of the Baltic Sea. Since, at present, the contribution to humans from marine radionuclear contamination adds about 1% of the total exposure to radioisotopes, this source is not considered as a matter of major concern for the general public in the Baltic Sea region. Nevertheless, there is significant concern about the increasing age and safety standards of the former Soviet nuclear reactors in the area, e.g. in Lithuania.*

Large amounts of chemical weapons were produced and stockpiled by Germany in World War II between 1939 and 1945, comprising several agents that include mustard, nerve and tear gases, and the lung irritant phosgene. During 1945-1948, on the orders of the allied occupying forces, both chemical munitions and conventional ammunition were sunk in the Baltic Sea area, such as east of Bornholm and southeast of Gotland. There are also reports of other smaller dumpings in the later 1940s. Surveys of the dumpsites have shown a range of chemical munitions from completely corroded shells free of warfare agents, to intact munitions. Because of the precarious state of many of these munitions and uncertainties in making reliable predictions about their future progressive state, it has been decided that the safest course is to leave them on the seabed.

Alien species

Alien species (also called non-indigenous, exotic, invasive, etc.) are those that have moved beyond their natural geographic range of habitat, and represent all phyla, from microorganisms to various plants and animals. The issue of alien species has been identified as one of the most critical environmental issues facing aquatic species and habitats, and biodiversity in general. Introductions of alien species are potentially threatening in terms of ecology, biodiversity and socioeconomics, and there are several international conventions and agreements requiring the prevention, reduction and control of the introductions and transfers of alien species. The Baltic Sea is known to host about 70 alien species (>100 recorded; but not all of them fully established). Shipping is the most important vector today transporting aquatic organisms, occurring mainly by the transport and discharge of ballast water and by the transport of fouling organisms on hulls. Having been introduced to an area, natural transfer processes (e.g. current systems) may supplement the further spread of the alien species. The aliens that have been transported to the Baltic Sea area originally come from North America (e.g. Great Lakes), and the Ponto-Caspian area and other distant areas, although intermediate transfers frequently occur within Europe. In turn, the Baltic Sea can act as a donor of foreign species to other areas of the world. This "biological pollution" results in ongoing 'alienization' of aquatic animal and plant life and, in the context of global change, to homogenization of aquatic life worldwide. Examples of such introductions to the Baltic Sea are the Chinese mitten crab (Eriocheir sinensis), the planktonic crustacean Ceropagis pengoi, the round goby (Neogobius melanostomus) and the parasitic nematode worms from Asia that have infected the swimbladders of the European eel and affected the Baltic Sea eel population.

Baltic Sea Regional Project and Large Marine Ecosystem concept for the future

As is evident from the previous sections, human activities at sea, in the coastal zone and in the surrounding land-based catchment area are the main causes of the problems in the Baltic Sea region. Thus, it is necessary to work together to benefit the marine ecosystem and the human communities living around it. To this end we have developed the Baltic Sea Regional Project (BSRP) as a mechanism for enhanced management of the common resources of the Baltic Sea ecosystem. It aims to address international environmental concerns associated with the sustainable production of biomass, the conservation of living marine resources, and the control of pollution from agriculture. Measures will also be taken to improve decision-making at the regional, national, and local level by strengthening assessment and monitoring systems and supporting the development of a series of indicators. A core part of the BSRP lies in its Baltic Sea Large Marine Ecosystem (BSLME) concept, facilitating cooperative action and coordination between the main regulatory and advisory bodies in the region (i.e. HELCOM, IBSFC, ICES) and their associated coastal countries, with a view to developing integrated approaches to land, coastal and marine management.

Information for monitoring, assessing, and managing the BSLME is organized according to five interrelated modules focused on:
Ecosystem productivity, related to carrying capacity;
Fish and fisheries;
Pollution and ecosystem health;
Socioeconomic conditions;
Governance protocols.

The 'ecosystem approach' points to the need for a comprehensive and holistic approach to understanding and anticipating ecological change, assessing the full range of consequences, and developing appropriate responses to regulate inappropriate human activities, and accordingly restore the typical structure, functioning and integrity of the Baltic Sea *ecosystem. Examples of such regulations are the improvement of the health situation among fish, sea-birds and seals in the Baltic after legal actions towards specific pollutants. Further, the elaboration of Ecosystem Management depends inter alia on exercising a 'precautionary approach' with the elaboration of general methodology for describing ecological quality and the setting of 'target' and 'limit' reference points for ecological quality objectives. By improving the quality and status of the ecosystem, one aims to conserve -- and where needed restore -- the value of ecosystem goods and services that provide the basis for long-term sustainable utilization, for example of the fisheries. In order to make progress, it is necessary to develop a shared vision and political commitment for our mission, as well as to motivate and have the active participation and understanding of a wide-ranging group of stakeholders. It is important to convince society and politicians that there is a socioeconomic cost involved in poor practices and management and that there is a tangible socioeconomic benefit from improved practices and management of the marine ecosystem. The change brought about will benefit both the Baltic Sea ecosystem and future generations living in the coastal countries that are dependent on it.*

A key aspect of this cooperative action is enhanced capacity building, as the current capability to monitor, assess and manage the marine environment and its living resources varies greatly among the coastal countries. The research and development capability necessary for the ecosystem approach to management[1] needs to be enhanced in all the Baltic Sea countries. In particular, the eastern Baltic Sea countries in economic transition require assistance in capacity building, both in terms of human resources and facilities. Research institutions should also be encouraged to further coordinate their collaboration with a view to enhancing capacity interchange in the region. So far, the BSRP has received economic support from the Global Environment Facility (GEF), the World Bank, the UNDP, Finland, Sweden and the USA. It is anticipated that additional generous support will materialize in the coming year or so.

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[1] *Definition:* Integrated management of human activities based on knowledge of ecosystem dynamics to achieve sustainable use of ecosystem goods and services, and maintenance of ecosystem integrity

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Footnote 1
[1] Definition: Integrated management of human activities based on knowledge of ecosystem dynamics to achieve sustainable use of ecosystem goods and services, and maintenance of ecosystem integrity

Figure 1. The main characteristics of the Baltic Sea. The line shows the catchment's area of the Baltic.

Baltic Sea: Main Characteristics

- Semi-enclosed brackish water area
- Persistent vertical layers
- Residence time of water : 25yrs
- Renewal of bottom-water: unpredictable - often stagnation periods
- Plants/animals: in low numbers - stressed
- Large catchment area with land use activities strong effect on water quality - population - 85 million

Figure 2. The nominal landings of flatfish, sprat, herring and cod from the Baltic Sea during 1975to 2001

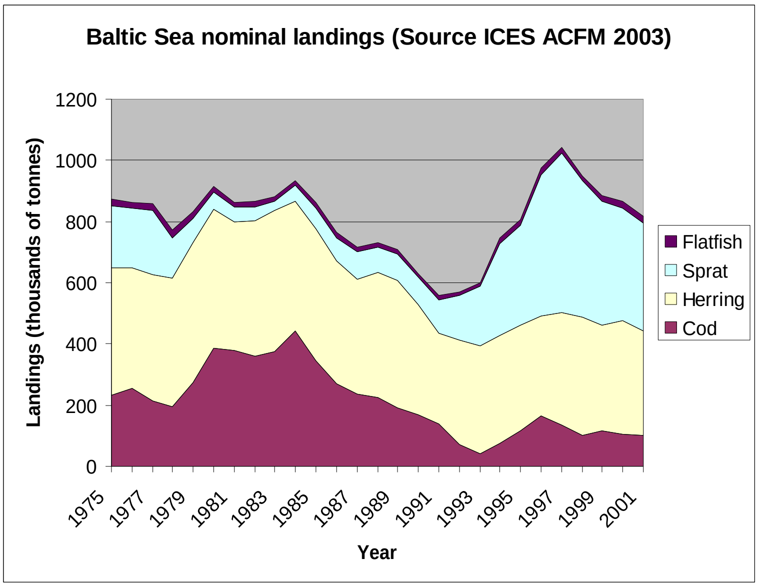

Figure 3. A pike (Esox lucius) with a deformed jaw caught in the effluent area of a pulp and paper mill using chlorine for bleaching.